DISTILLERY SPENT WASH AND ITS UTILISATION IN AGRICULTURE

By

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FAITH AND PATIENCE

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For his Ph.D. on Biological indicators of Water Pollution, Dr. Singh worked on the Shannon Index of diversity as an indicator of water pollution for the first time in the country on Benthic algal communities. Dr. Singh has also co-authored a book entitled “Algal Indicators of Water Pollution”, with his mentor and guide, Late Dr. B.N. Prasad. Dr. Singh has also Directed, researched, scripted and written the Commentary for films on Environment and Nature Conservation including those on the Asian Elephant, filmed at Corbett and titled “Gajaraj” ; on the role of water on the breeding activities of wetland avian fauna, titled “An Instinct Denied”, filmed at Bharatpur and a film entitled “The Last Refuge” on the natural history and ecology of the Asiatic Lions filmed at the Gir Forest.

PREFACE

India is a major producer of Potable and Industrial Alcohol. The majority of distilleries use molasses as a feed stock. Some distilleries are grain based. Apart from its use in beverage, medicines, pharmaceuticals and flavouring, alcohol constitutes the feed stock for a large number of organic chemicals which may be used in the production of drugs, rubber, pesticides and solvents. Ethyl alcohol is an important feed stock for the manufacture of various chemicals like acetic acid and butanol, butadiene, acetic anhydride, polyvinyl chloride etc. In terms of ethanol, India is the fourth largest producer of ethanol after Brazil, the United States and China. The Government of India has permitted oil marketing companies to sell Ethanol Blended Petrol with a targetted percentage of ethanol upto 20% as per BIS specifications. During the sugar year 2014-15, OMC's had achieved a blending percentage of 2.3%. Increments in both percent blending and geographical spread are anticipated. The Government is extending all out support to ethanol production. Molasses based distilleries are classified as a 'Red' category Industry by the Central Pollution Control Board. With the amount of highly polluting, spent wash being generated, sustainable options for waste management need to be practiced.

Alcohol, in molasses based distilleries is manufactured by the fermentation of molasses in batch, continuous or bio still processes. The batch process involves separate stages for fermentation and distillation. The continuous process recycles the yeast and the processes of fermentation and distillation are coupled to get a continuous flow of fermented beer for the distillation column. The yeast here is more active and the alcohol yields higher. Biostill is a trade name for one of the continuous processes where molasses is fed to the fermenter at a constant flow rate.

Distillery operations use water both for process and non process uses. The process applications involve yeast propagation, preparation of molasses for fermentation and steam requirements for distillation and the non-process applications include cooling water, wash water, boiler water and water used in making potable alcohol. Waste waters are discharged as spent wash from the analyser column, fermenter sludge, MEE condensate, R.O. rejects, spent lees, cooling water, waste wash water, water treatment plant, boiler as blow down, bottling plant and other wastes.

Average spent wash generation is lowest in the bio still process (6 to 8 liter per liter alcohol), higher in the cascade continuous process (8.5 to 11.0 liter per liter alcohol) and highest in the batch process (11.1 to 15.0 liters per litre alcohol). The concentration of pollutants is highest in the bio still process.

Spent wash exhibits a very high level of Biological Oxygen Demand with a high BOD: COD ratio. It is highly acidic with a pH of 3.0 to 4.5. The recalcitrant nature is due to the presence of melanoidins, caramel, polyphenols and a variety of sugar decomposition products such as anthocyanin, tannins and different xenobiotic compounds. The obnoxious odour may be due to the presence of skatole, indole and other sulphur compounds. Spent wash also contains the major plant nutrients like Phosphorous and Potassium Calcium, Magnesium, Sulphur. Spent wash may also contain metal ions like Zinc, Iron, and Manganese and organic compounds humic in nature. Spent wash has also been reported to contain vitamins, proteins rich in exogenous amino acids and mineral components. Although it does not contain any toxic substances, yet the discharge of this highly polluting effluents to streams causes immense damage to the flora and fauna. The high COD, Total Nitrogen and Phosphate contents of spent wash can result in eutrophication of natural water bodies. The methane emission factor for distilleries is 0.2 kg/kg COD.

Raw spent wash discharge has a highly deleterious effect on fish life. Spent wash also contains significant amounts of recalcitrant compounds which severely pollute the receiving bodies of water and present a serious health hazard to the rural and semi-urban population that depend on such water bodies for drinking water and other requirements. Waste waters are also a source of green house gas emissions (CO_2, methane and nitrous oxide). Uncontrolled discharge of spent wash on land damages soil chemistry and biology and adversely affects land use and agricultural productivity.

Various technology options are available for the treatment of distillery spent wash. They may include biomethanation, biomethanation and secondary treatment followed by irrigation or disposal in surface water, composting after or without biomethanation, controlled land application, sodic land reclamation, activated sludge treatment, concentration and incineration, anaerobic digestion followed by evaporation and composting, coprocessing in cement kilns, reverse osmosis, multi effect evaporators, recovery of potash or disposal into sea or estuary after or without biomethanation.

Distillery spent wash treatment of the yesteryears revolved round the open lagooning system with its inherent problems of land, odour and seepage into and degradation of ground water. Subsequent technologies, from bio-methanation to coprocessing which utilise the energy generating and fertility potential of spent wash, have improved the management of distillery spent wash to change it into an environmentally friendly, socially acceptable, Zero effluent discharge industry. The Honourable National Green Tribunal has adjudicated that the Pollution Control Boards may allow industries to select from the basket of technologies available without insisting on any particular technology. It has stated that the ultimate objective is to meet the standards and not to interfere in the internal management.

In order to gainfully utilize the biomethanated spent wash and/or make it suitable to conform to the requirements of Zero effluent discharge, distilleries generally adopt the practice of anaerobic digestion of spent wash followed by composting. If sufficient filler material (Press mud) is not available the effluent quantities are reduced through reboilers/evaporation/RO to match the quantity of press mud. The concentrated effluent can also be dried in spray driers as powder which can be sold as a fertilizer.

Hybrid Anaerobic Baffled Reactors (HABR) along with advanced oxidation to reduce COD from distillery wastes has also been tried. Membrane bio reactors are also being recognized as an effective method of treatment of distillery wastes. Reverse Osmosis and Membrane Filtration have also been advocated and practiced in distillery effluent treatment. An electrocoagulation process has been applied to biomethanated spent wash using aluminum anode and stainless steel cathode. Another electro dialysis reversal process uses mild electricity to transmit ions and other charged species through membranes. This gives separate purified and concentrated streams.

During concentration and incineration the large quantum of spent wash is reduced by increasing the viscosity then finally it is dried as ash in furnace chambers to let out as solid material. Concentrated spent wash at 55 to 60% solids or spent wash powder can be used to run a specially designed boiler with or without subsidiary fuel. Steam generated can be used to run a steam turbine to generate electricity and exhaust steam can be used for distillery and evaporation plant operation. Distiller's wet grain still age from the MEE can also be used as cattle feed. Concentration and incineration systems are economically better for distilleries beyond 60 KLPD capacity.

Concentration and incineration technologies however present problems of disposal of sludges from storage tanks, condensates from evaporators and rejects from the RO plant.

The co-processing initiatives of the CPCB which involves incineration of concentrated spent wash as fuel in cement/steel industries along with other fuel/raw materials has been successfully tried but this may be limited by the number of industries with a potential to use spent wash in Kilns and Furnaces. The whole process may need changes in the firing systems and impact acceptability.

Coagulation and fungal application to biomethanated spent wash to remove color (85%) and COD (75%) has also been tried as a viable technology option.

The rich nutrient contents of spent wash make its use in agriculture very viable. Pre-sown land application, bio-composting and ferti-irrigation have been variously applied. These technologies had been accepted for implementation through the Charter for Corporate Environmental Responsibility decided between the CPCB and Distillers. The Central Pollution Control Board is however not encouraging stand alone distilleries to practice these technologies. However, distilleries attached to sugar units may follow biomethanation and bio-composting and concentration and incineration technologies. It has also been suggested that attached distilleries which are not achieving the standards should changeover from composting, one time land application and ferti- irrigation in a time bound manner.

Soil reclamation is a major area of potential utilization of distillery spent wash. Application of spent wash to sodic soils followed by leaching with water has achieved effective reclamation and increase in organic carbon content, available nutrient and microbial activity.

Water security has emerged as a vital issue for India and the World Climate change projections forecast an imbalance in water availability and a consequent adverse impact on agriculture productivity. Sugar cane a water intensive crop is expected to suffer a yield reduction of 30% in India because of water related issues. It is in this context that waste waters emerge as a potential source for meeting the water demand after essential treatment. Many industrial effluents contain variable amounts of plant nutrients. If gainfully utilized in agriculture, they have the capacity to replace the use of synthetic fertilizers which are a major environmental concern. Effluent irrigation offers a low cost alternative where both the fertilizing and irrigation aspects of the waste can be utilized and the receptors (Land, air, water etc.) and communities protected against pollution. Carbo,Nitrogen, phosphorous and potassium are valuable nutrients. Waste water irrigated fields generate great employment opportunities also. Effluent reuse has been recognized as an impending reality in developing countries. Aerobic composting, vermi-culture, ferti-irrigation and one time land application have also been recognized as emerging technologies by the CPCB. Reuse in agriculture benefits nations in less pollution, avoidance or reduction of cost of treatment, savings in cost of fertilizers and reduced water management stress and costs.

Distillery spent wash is a potential source of renewable energy. It does not contain any toxic heavy metals and being of plant origin and because of its rich nutrient contents may serve as a good fertilizer for crops, more effective than inorganic or mixed fertilizers being used by farmers. Distillery effluents were once regarded as the most highly polluting effluents. The energy, fertilization and irrigation potential of distillery effluents has helped the industry to build immense social acceptability now. Distillery effluents are a rich source of Nitrogen, Phosphorous and Potassium. Potassium is the most richly represented. It also has appreciable quantities of micro nutrients. Being organic in nature, the nutrients are more rapidly taken up by plants from soil. They also contain large amounts of Ca, Mg, Na, S and Chlorides which can be used as a resource for crop production and reduce the use of inorganic fertilizers. Spent wash irrigation may also lower the incidence of insect pests. Distillery effluents have been found to be more effective than a mixture of inorganic fertilizers and cow dung manure. Technologies of concentration incineration and concentration need heavy expenditure and the potash and other salts present may create a fouling in the evaporators and boiler heat transfer sections. The rich organic and inorganic constituents allow it to bring remarkable changes in the physical, chemical and biological properties of soil. Distillery effluents are used as a supplement to mineral fertilizer in Brazil. Nutrient recycling through the application of vinasse and filter cake to sugar cane crops in Brazil has reduced the consumption of fertilizers as compared to other crops and in other countries. The use of Urea mixed distillery spent wash is widely prevalent in Australia as a single application. Post methanated spent wash application to growing crops is discouraged, instead land application before planting is suggested to be a better option. In Australia spent wash is blended with additional crop nutrients and sold as manure. Spent wash could also be used for composting the trash in fields.

Controlled application of distillery effluents has been observed to bring about increases in yield indicators for wheat, rice, maize, pulses, sunflower, soybean, grasses and sugarcane. In oil seeds an increase in the protein and oil content has also been reported. Spent wash meets the long term requirement for nutrients. A need to balance nutrients by supplementing with other fertilizers has also been suggested. The application of spent wash has not only benefited in supplying nutrients but also favoured the growth of microbial biomass. It has generally been established that crop nutrition through chemical fertilizers is inferior to spent wash irrigation. The application of digested spent wash to the soil benefits it by increasing the uptake of nutrients which ultimately increases crop productivity. The application of spent wash has also been demonstrated to be beneficial for the worms and insects that are essential for germination and nutrient availability. A conjunctive use of spent wash along with chemical fertilizer has been noticed to perform better than only spent wash or only chemical fertilizers.

Diluted spent wash irrigation has been observed to improve the physical and chemical properties of the soil and also to increase the soil micro flora. The soil organic carbon and potassium content along with the uptake of nutrients has registered improvements. The soluble carbon present in spent wash acts as a carbon source and also as a chelating agent supplying all required nutrient. It also binds soil particles, forms stable aggregates and improves the structure, aeration and water holding capacity. Tropical soils are generally deficient in organic carbon content and any addition of organic carbon is always beneficial. III effects if any are temporary and after a certain time the system gets stabilized through the degradation of organic acids. Generally post harvest soils have not been recorded to exhibit any adverse impacts.

The application of spent wash has been observed to increase the pH, EC, cations, anions, Sodium Adsorption ratio, Potassium Adsorption ratio, exchangeable Na and K and exchangeable Ca and Mg. Microbial degradation of organic matter in soil has also been held responsible for increased pH and nitrogen availability in soils treated with distillery effluents. The mineralization of organic matter results in an increased availability of plant nutrients including soil nitrate availability. Available micronutrients like Fe, Mn, Zn and Cu have been observed to progressively increase with the graded application of diluted spent wash. This is due to the direct contribution from the effluent as also the solubilisation and chelation affect of organic matter supplied by the effluent. Damaging impacts on soil chemistry at doses of 300 m^3/ha or lower have generally not been observed.

The biological activity of soils is positively affected by the application of distillery effluents. Bacteria, Actinomycetes, Azetobacter and fungi showed significantly higher counts than in unamended soils. The amylase, dehydrogenase, phosphatase and cellulase activities have been observed to increase but the urease activity remained unaffected. When applied to the soil the color of the effluents is amenable to microbial and photo-degradation without deteriorating the biological composition of soil. Appreciable amounts of growth promoters like Gibberellic acid and Indole Acetic Acid have also been reported in the distillery spent wash. Application of spent wash has also been observed to reduce the incidence of some plant pests.

Spent wash application in agriculture improves the uptake of nutrients from the soil. Distillery effluents used by themselves or as supplements to other fertilizers (N and P) has resulted in the increased uptake of N, P, K, Ca and Mg from soil. Leaching of nitrate from the soil was also reduced when distillery residues were used in soil. The application of diluted spent wash increases the uptake of Zn, Cu, Fe and Mn. Higher uptake levels have been reported at lower dilution levels. Mineralization of organic matter and nutrients in soil has been held responsible for the increased uptake.

The Central Pollution Control Board was of the opinion that biomethanated spent wash with a BOD of less than 7000 mg/L could be used for pre sown irrigation. Studies carried out by Agricultural

Scientists have revealed that most of the food crops show good response to pre sow distillery effluent irrigation and the addition of effluents increases the soil fertility. A significant increase in yield indicators of various crops (20 to 60%) subject to pre sown irrigation has been reported without associated environmental hazards. The addition of spent wash also increase the soil fertility. Post harvest soils have been seen to demonstrate an increase in the available micro nutrients like Fe, Zn, Cu and Mn. Pre-sown application of less than 300 m^3/ha has not been observed to adversely affect soils. There are different observations on leachability of spent wash constituent to ground water. It is generally felt that with a cautious application, the problem could be sufficiently managed without any damage to ground water quality.

Application could be carried out twice in a year. Post harvest fields are usually filled with distillery effluents and after the surface is almost dried, the fields are tilled and the crops are sown. Some estimates point out that one cm of post methanated effluent if applied on one hectare land annually will yield 600 kg of Potassium, 360 kg of Calcium, 100 kg of Sulphates, 28 kg of Nitrogen and 2 kg of Phosphates. Application rates of over 400 m^3/ha have been variously tried. Pre sown application is also practiced in Australia, Brazil, Cuba and Philippines where spent wash has been applied in addition to chemical fertilizers and improved cane and sugar yields obtained.

The CPCB in 2005 had proposed a protocol for one time controlled land application of treated post methanated spent wash as liquid manure. It specified that the BOD should be less than 7000 mg/L and pH over 7. It also specifies a system of sampling, monitoring and evaluation, storage during months of non utilization (30 days), transportation guidelines, ensuring land availability and consents and a crop wise likely volume of utilization. The Central Pollution Control Board has also felt that one time controlled land application is difficult to practice and that new stand alone distilleries may not be allowed to use this scheme for zero effluent discharge. It however does not restrict existing attached distilleries going in for expansion from adopting the practice of pre sown irrigation. The CPCB also recognizes pre sown effluent irrigation to be an emerging technology.

The manure potential of distillery effluents can profitably be used as a supplement to fertilizer along with irrigation water. Most investigators are of the opinion that spent wash at lower concentrations can be safely used for irrigation and fertilization. The CPCB had held that emerging technologies such as ferti-irrigation should be opted by the industries for secondary treatment of wastes and has added that this may not only control pollution at source but also act as an alternative for energy savings for treatment of distillery waste water. It is important that ferti-irrigation and irrigation be differentiated in terms of utility to crops and separate procedures for ferti-irrigation and irrigation evolved. Extending the existing standards of 100 mg/L for irrigation and applying them to ferti irrigation would need reconsideration.

The bio composting system helps distilleries to utilize the sludge materials segregated from the distillery processes, incineration, spent wash and R.O. plant rejects to convert it to valuable bio compost using sugar unit press mud. Bio-compost prepared from distillery spent wash was reported to contain higher Organic Carbon . The pH of the compost was found ideal with a C: N ratio of 15: 1. Spent wash-press mud compost has been observed to improve the stability of aggregates and porosity. Composting also assists in the degradation of colored organics in the distillery effluents which also enrich the compost with nutrients specially potassium. In order to provide a balanced nutritional value and enrich it more, the compost could be enriched with the use of rock phosphate, gypsum, yeast sludge, bagasse, sugarcane trash, boiler ash, coir pith and water hyacinth. Both Aerobic and Anaerobic composting techniques have been suggested requiring about 30 days for active reactions and another 30 days for maturing. Spent wash utilization in aerobic composting is more than spent wash consumptions in anaerobic composting.

Shortage of filler materials, large land requirements and the distribution network of compost appear to be major problems associated with bio composting. The Central Pollution Control Board has also found that, within some of the distilleries studied by it, the composting process has not been up to the standards with problems of press mud availability, unlined areas and problems of leachate etc.

Australia, Brazil, Mexico and some other countries have demonstrated some notable contributions towards the utilization of spent wash in Agriculture. In Australia spent wash is blended with additional crop nutrients and sold as manure. Spent wash has also been used to compost trash in the field. The fields are generally sprayed with spent wash to facilitate the accelerated composting. In Brazil, the application of vinasse and filter cake to sugarcane crops has reduced the consumption of fertilizers as composed to other crops and in other countries. The Sao Paulo Secretariat for Environment has developed a technical standard. It specifies permitted places, doses, protection of master channels and storage etc. There are mills that have applied vinasse to 70 percent of their crop areas. In Mexico, a Ferti-irrigation programme achieved water saving of 40% and an energy reduction of 32%. The Harvested area increased 18% and the yield by 30% giving an internal rate of return of 16% to the Farmers.

In Australia, the Agriculture and Resource Management Council of Australia and New Zealand and the Australian and New Zealand Environment and Conservation council have recommended the storage and use of liquid effluents to be subsequently used in land application with the solids to be used as compost. Land application has been prescribed to be one of the most efficient methods of recycling valuable water along with the effluents nutrient and organic components

Australia markets spent wash blended with nitrogen, sulphur and phosphorous as Bio dunder an organic fertilizer and also as Liquid one shot for application to sugarcane and other crops. A Polluting substance this way, has been turned into a saleable, import replacing product and improved the business position and community acceptance of the generator.

In Romania, the application of vinasse to permanent grasslands at the rate of 4 to 7 t/ha in 1:5 water dilution increased yield by 50 to 81% over control. In Ireland, slops are concentrated and processed to form Pot Ale which can be used for agriculture use. Several major crops are being irrigated successfully with waste waters in India.

Spent wash could also be utilized for composting the trash in the field. In Brazil, the accumulated trash material in the sugarcane harvested field is sprayed with spent wash to facilitate the accelerated composting of the trash in the field itself.

Soil sodicity is characterised by high pH and water soluble and exchangeable sodium. The basic principle in the reclamation of sodic soils is to replace the Na^+ ions from soil exchange sites by cations like H^+, Ca^{++} and Mg^{++} ions. It is accepted that the acidic nature of raw spent wash and the fairly good amount of Ca^{++} and Mg^{++} in it can be exploited for the reclamation of sodic soils by replacing the sodium ions from sodic soil. Exchangeable sodium percentages have been reported to come down from 100 to 2 in the top 15 cm soils. Among the available amendment, gypsum is the cheapest. Iron pyrites, Sulphur and Ferrous sulphate are also used. Spent wash can replace these, particularly round sugar mills and distilleries in the reclamation of sodic soils.. An improvement in saturated hydraulic conductivity, soil permeability and reduction in bulk density of the soils has been noticed over these attributes in the control. Untreated spent wash should generally be used for soils having a pH of 8.5 to 10. Experiments have revealed a tremendous increase in the availability of N, P, K, S, Zn, Cu, Fe and Mn in spent wash amended soils. By serving as a source of food for many soil bacteria, spent wash amendment helps in the rapid buildup of soil microorganisms and consequently increases the acidity of many enzymes. It may also assist in the conversion of unavailable native soil nutrients into available nutrients particularly P and micro nutrients and in the formation of relatively stable chelates with organic ligands. Application should generally be exercised with caution and areas in the vicinity of open/bore well/lakes which are used for purposes of drinking avoided. Continuous application on the same plot of land has to be minutely evaluated.

The Central and State Pollution Control Boards had been insisting distilleries to ensure zero Liquid discharge through concentration /incineration and a number of directions were issued in this regards. The industry finds it both financially and technically unsustainable and associated with a high carbon and water footprint. The issue of Zero Liquid discharge was finally adjudicated by the Honourable National Green Tribunal, India which specifically disallowed zero liquid discharge options and held that zero Liquid discharge cannot be applied across the Board as it would be violative of the rights of the parties and also would not be in consonance with the processions of the relevant environmental acts. The NGT has suggested that ZLD should be applied on a case to case basis. They have also clearly said that the ultimate purpose is Prevention and Control of Pollution and not an internal management of the plant.

Looking into the immense potential of distillery spent wash in increasing agricultural productivity through utilizing the irrigation and fertilization potential of spent wash and the utility of spent wash in the reclamation of sodic soils, the author attempted this review so that it helps the industry and the regulators to understand this huge potential and consider one time land application and sodic land reclamation as highly sustainable options to treat spent wash. It was also thought that with the impending climate change predictions spelling large scale water crisis, replacing conventional fresh water irrigation and chemical fertilizes with spent wash will greatly boost agriculture and help the farming community immensely by socially and economically improving their lot.

Some parts of the book draw from research carried out earlier in 2012-2013 which was financially supported by the Dhampur Sugar Mills Limited, Dhampur, U.P. India. A report on this study was submitted to the Dhampur Sugar Mills in early 2014 by the Author who was ably assisted by Miss Ankita Gujrati. This book covers a wider scope and includes the developments upto February 2019. This was

undertaken by the Author under the aegis of the Wealthy Waste School India (also see www.wealthywaste.com) and is being presented through this publication.

With folded hands I take this opportunity to thank God and my loving parents, who now rest with him, for my very existence and holding me in their arms ever.

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ABBREVIATIONS

AIDA	–	All India Distillers Association
BMD	–	Bio Mass Duration
BMDE	–	Bio Methanated Distillery Effluents
BMSW	–	Bio Methanated Spent Wash
BOD	–	Biological Oxygen Demand
BSG	–	Brewer’s Spent Grain
BSW	–	Biomethanated Spent Wash
CCS	–	Commercial Cane Sugar
CEC	–	Cation exchange Capacity
COD	–	Chemical Oxygen Demand
CSW	–	Crude Spent Wash
CPCB	–	Central Pollution Control Board
CREP	–	Charter on Corporate Responsibility
DAP	–	Di-ammonium Phosphate
DAP	–	Days after Planting
DAS	–	Days after Sowing
DDGS	–	Distiller’s Dried Grain Stillage
DE	–	Distillery Effluent
DNA	–	Deoxyribonucleic Acid
dS/m	–	deciSiemens/metre
DSW	–	Distillery Spent Wash
DWGS	–	Distiller’s Wet Grain Stillage
EC	–	Electrical Conductivity
EDR	–	Electro Dialysis Reversal
EIA	–	Environmental Impact Assessment
ESP	–	Exchangeable Sodium Percentage
ETP	–	Effluent Treatment Plant
FIRCO	–	Fide Icomiso de Riesgo Compartido (Trust Fund for Shared Risk)
FYM	–	Farm Yard Manure

GA	–	Gibberellic Acid
HABR	–	Hybrid Anaerobic Baffled Reactor
HDPE	–	High Density Poly Ethylene
IAA	–	Indole Acetic Acid
IARI	–	Indian Agriculture Research Institute
IDs	–	Irrigation Districts
IIEC	–	International Institute for Energy Conservation
IPCC	–	Intergovernmental Panel on Climate Change
ITK	–	Indigenous Technical Knowledge
KLPD	–	Kilo Litre Per Day
LAD	–	Leaf Area Duration
LAI	–	Leaf Area Index
LOS	–	Liquid One Shot
MBRs	–	Membrane Bioreactors
MCAB	–	Membrane Coupled Anaerobic Bioreactor
MDG	–	Mean Daily Germination
MEE	–	Multiple Effect Evaporators
MF	–	Microfiltration
MLSS	–	Mixed Liquor Suspended Solids
MLtr	–	Million Litres
MoEF	–	Ministry of Environment and Forests and Climate Change
MoPNG	–	Ministry of Petroleum and Natural Gas
MSW	–	Molasses Spent Wash
NF	–	Nano filtration
NP	–	Nitrogen Phosphorous
NIO	–	National Institute of Oceanography
NPK	–	Nitrogen Phosphorus Potassium
NR	–	Nitrate Reductase
NRA	–	Nitrate Reductase Activity
PAR	–	Potassium Adsorption Ratio/Phosphorus Absorption Ratio (as used in context)
PBSW	–	Primary Biomethanated Spent Wash

PMDSW – Post Methanated Distillery Spent wash
PME – Post Methanated Effluent
PPM – Parts Per Million
PSA – Pressure Swing Adsorption
Ptsw – Primary Treated Spent Wash
PV – Peak Value
PVC – Poly Vinyl Chloride
Qha-1 – Quintal per Hectare
RDN – Recommended Dose of Nitrogen
RDFAST – Recommended Dose of Fertiliser after Test
RNA – Ribo Nucleic Acid
RO – Reverse Osmosis
RS – Rectified Spirit
SAI – Soluble Acid Invertase
SAR – Sodium Adsorption Ratio
SLW – Specific Leaf Weight
SPCB – State Pollution Control Board
SW – Spent Wash
SWS – Spent Wash Solids
TDS – Total Dissolved Solids
TKN – Total Kjeldahl Nitrogen
TSS – Total Suspended Solids
UASB – Up Flow Anaerobic Sludge Blanket
UF – Ultrafiltration
USEPA – United States Environment Protection Agency
V/V – Volume by Volume

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INDIAN DISTILLERY INDUSTRY, MANUFACTURING PROCESS, COMPOSITION OF EFFLUENTS, ENVIRONMENTAL IMPACTS, TREATMENT TECHNOLOGIES

SECTION-1

INDIAN DISTILLERY INDUSTRY, MANUFACTURING PROCESS, COMPOSITION OF EFFLUENTS, ENVIRON-MENTAL IMPACTS, TREATMENT TECHNOLOGIES

1.1 ABSTRACT

1.1.1 Indian Distillery Industry

India is a major producer of Potable and Industrial Alcohol. The majority of distilleries use molasses as a feed stock. Some distilleries are grain based. Apart from its use in beverage, medicines, pharmaceuticals and flavouring, alcohol constitutes the feed stock for a large number of organic chemicals which may be used in the production of drugs, rubber, pesticides and solvents. Ethyl alcohol is an important feed stock for the manufacture of various chemicals like acetic acid and butanol, butadiene, acetic anhydride, polyvinyl chloride etc. With the advent of Ethanol blending with Petrol/Motor Fuel, the requirement of Ethanol has increased manifolds. A target of 20% substitution is envisaged for India. In terms of ethanol, India is the fourth largest producer of ethanol after Brazil, the United States and China and if the 5 percent blending of Petrol/Motor Fuel is made mandatory all over the country, the available molasses may be unable to meet the demand. Currently the 5 percent blending is only applicable in 10 States and three Union Territories and requires about 410 million liters of anhydrous alcohol. Increments in both percent blending and geographical spread are anticipated. Molasses based distilleries are classified as a 'Red' category Industry by the Central Pollution Control Board. With the amount of highly polluting, spent wash being generated at 10 to 15 times the volume of spirit produced, it is an area of major environmental concern. The Total installed capacity of molasses based distilleries in the country is about 4230 million litres per annum. The average capacities of Indian

Molasses based distilleries ranges between 30 to 60 KLD. There are very few distilleries above 100 KLD and the largest distillery capacity is 420 KLD. (Office of Principal Scientific Advisor to the GOI, 2014)These Distilleries have a capacity to generate about 52000 M.Ltr/year of spent wash as waste annually.

1.1.2 The Manufacturing Process

Alcohol, in molasses based distilleries is manufactured by the fermentation of molasses in batch, continuous or bio still processes. The batch process involves diluting the molasses to reduce the sugar content from the existing 40-45% to 10-15%. Yeast inoculum is then mixed with this diluted molasses at about 10% concentration, volume/volume (v/v). This is then allowed to ferment for 30-40 hrs. After the fermentation is complete, the yeast sludge is removed from the bottom of the fermenter and the fermenter wash is sent to the analyser column for distillation with steam. A mixture of alcohol vapours and steam is collected at the top of the analyser column and spent wash drained out from the bottom. The alcohol and steam mixture are fed to the rectification column where water and alcohol vapours condense and rectified spirit is formed. The condensed steam is discharged as spent lees.

The continuous process recycles the yeast and the processes of fermentation and distillation are coupled to get a continuous flow of fermented beer for the distillation column. The yeast here is more active and the alcohol yields higher. Biostill is a trade name for one of the continuous processes where molasses is fed to the fermenter at a constant flow rate.

Fuel alcohol or absolute alcohol is produced by the dehydration of rectified spirit through azeotropic distillation or molecular sieve technology. The azeotropic distillation method involves the use of entrainer compounds like trichloroethylene, benzene, toluene, cyclohexane etc. which make the water in the azeotropic mixture of alcohol and water (96:4) more volatile allowing the water from the heterogeneous azeotropic mixture to be removed by decantation and dehydrate the alcohol. The regeneration column allows the water and the entrainment compound to be separated and the entrainer used back in the process. The molecular sieve technology works on the principle of Pressure Swing Adsorption (PSA) and removes water by adsorption on the surface of molecular sieves (zeolite balls) under vacuum.

Distillery operations use water both for process and non process uses. The process applications involve yeast propagation, preparation of molasses for fermentation and steam requirements for distillation and the non-process applications include cooling water, wash water, boiler water and water used in making potable alcohol. Waste waters are discharged as spent wash from the analyser column, fermenter sludge, spent lees, MEE condensate, RO reject, cooling water, waste wash water, water treatment plant, boiler as blow down, bottling plant and other wastes.

The resource utilisation efficiency has a high impact on environmental performance and profitability. There is a need for the bad performers to emulate the better performers.

1.1.3 Composition of effluents

Average spent wash generation is lowest in the bio still process (6 to 8 liter per liter alcohol), higher in the cascade continuous process (8.5 to 11.0 liter per liter alcohol) and highest in the batch process (11.1 to 15.0 liters per litre alcohol). It is possible to reduce the spent wash generation to 3.0 to 5.5 litres per litre of Ethanol produced through the cascade and Biostil continuous fermentation coupled with an integrated heat recovery system. The concentration of contaminants from the Biostil process is however the highest. It has been reported that the 45 billion liters of spent wash produced in the country annually have a potential to produce 1,200 million cubic meters of bio gas (containing 60% methane) and the post methanated water if used carefully can produce more than 85,000 tons of bio mass annually. It has also been estimated that utilization of spent wash may provide 5 trillion KCals energy annually and the post methanated effluents can provide 2,45,000 tons of Potassium, 12,500 tons of Nitrogen and 2,100 tons of Phosphorous annually and that one year's effluents can meet the Potassium requirement of 1.55 million hectare land, Nitrogen requirement of 0.13 million hectares and Phosphorous requirement of 0.025 million hectare lands, if two crops are taken in a year.

Spent wash exhibits a very high level of Biological Oxygen Demand (40,000 to 65,000 mg/L) and Chemical Oxygen Demand (50,000 to 1,40,000 mg/L) with a high BOD: COD ratio. It is highly acidic with a pH of 3.0 to 4.5. The recalcitrant nature is due to the presence of melanoidins, caramel, polyphenols and a variety of sugar decomposition products such as anthocyanin, tannins and different xenobiotic compounds. The obnoxious odour may be due to the presence of skatole, indole and other sulphur compounds. Evaporated spent wash may contain a dry matter of about 30.5%. Spent wash also contains the major plant nutrients like Total Phosphorous as P_2O_5 (400-600 mg/L), Total Potassium as K_20 (10,000-13,000 mg/L), Total Calcium (2,100-3,000 mg/L), Total Magnesium (2,000-3,300 mg/L), Total Sulphur (4,000-5,000 mg/L). Spent wash may also contain metal ions like Zinc, Iron, and Manganese. Organic compounds extracted by alkaline reagents are reported to be of humic nature and similar to these in soil except folic acid which predominated over humic acid. Spent wash has also been reported to contain vitamins (largely group B), proteins rich in exogenous amino acids and mineral components. Although it does not contain any toxic substances, yet the discharge of this highly polluting effluents to streams causes immense damage to the flora and fauna. The high COD, Total Nitrogen and Phosphate contents of spent wash can result in eutrophication of natural water bodies. The methane emission factor for distilleries is 0.2 kg/kg COD. Molasses based Brazilian distilleries also produce spent wash (vinasse) having a high organic matter content, high Potassium (3.5 to 7.6 kg per m^3 of vinasse), relatively poor Nitrogen (0.75 to 0.79 kg per m^3 of vinasse), Phosphorous (0.10 to 0.35 kg per m^3 of vinasse) and Magnesium (0.84 to 1.40 kg per m^3 of vinasse).

The BOD of distillery effluents in Australia may be as high as 35,000 mg/L, a total Kjeldahl nitrogen content ranging from 500 to 1,700 mg/L, total Phosphorous 100 to 400 mg/L and 1,300 to 2,100 mg/L of Potassium.

1.1.4 Environmental Impacts

Raw spent wash discharge has a highly deleterious effect on fish life. Spent wash also contains significant amounts of recalcitrant compounds which severely pollute the receiving bodies of water and present a serious health hazard to the rural and semi-urban population that depend on such water bodies for drinking water and other requirements. Waste waters are also a source of green house gas emissions (CO_2, methane and nitrous oxide).

1.1.5 Spent Wash Treatment

Various technology options are available for the treatment of distillery spent wash. They may include biomethanation, biomethanation and secondary treatment followed by irrigation, controlled land applicaton or disposal in surface water, composting, activated sludge treatment, concentration and incineration, anaerobic digestion followed by evaporation and composting, co-incineration, reverse osmosis, multi effect evaporators, recovery of potash or disposal into sea or estuary after or without biomethanation.

Distillery spent wash treatment of the yesteryears revolved round the open lagooning system with its inherent problems of land requirements, odour and seepage into the ground water. Subsequent technologies, from bio-methanation to co-incineration, which utilise the energy generating and fertility potential of spent wash, have improved the management of distillery spent wash to change it into an environmentally friendly, socially acceptable, Zero effluent discharge industry into surface walis.

The cost of anaerobic bio-digesters can be recovered in 2 to 3 years of installation because of substantial savings in fuels. The generally used reactors are the up or down flow fixed film reactors, up flow partially fluidized bed reactors commonly called the up flow anaerobic blanket reactors and slurry reactors. These reactor systems are capable of bringing down a reduction in influent BOD by about 90 to 95% and produce biomethanated effluents with a BOD of about 5000 mg/L and gas @ 0.4 to 0.5 m^3/kg COD removed which can be used as fuel. Continuous stirred reactors and UASB based digesters have proved to be more suitable than media based and thermophilic digesters. Coupled with Biogas based cogeneration, regeneration of power steam and chilled water and the production of bio compressed natural gas, higher value additions can be obtained. The UASB reactors have been observed to produce methane with high efficiency, a better quality effluent and stable sludge and have been suggested as one of the best options for treatment of distillery waste water, with or without dilution.

In order to gainfully utilize the biomethanated spent wash and/or make it suitable to conform to the requirements of Zero effluent discharge, distilleries generally adopt the practice of anaerobic digestion of spent wash followed by composting. If sufficient filler material (Press mud) is not available the effluent quantities are reduced through reboilers/evaporation/RO to match the quantity of press mud. The concentrated effluent can also be dried in spray driers as powder which can be sold as a fertilizer.

Secondary biological treatment processes (two stages) may also be used after biomethanation to reduce the BOD. The activated sludge process is generally used. Final BOD concentrations of 300 to 500 mg/L can be achieved. Further dilution may be required if it is used for irrigation. Ferti-irrigation requirements may be different from these. Bio filtration systems have also produced impressive results. Here the microorganisms are not suspended in the medium but separated from it and immobilized to the bedding material while the treated effluent flows through it.

Hybrid Anaerobic Baffled Reactors (HABR) along with advanced oxidation to reduce COD from distillery wastes has also been tried. A two stage system could produce a COD of 6,000 mg/L from an initial value of 82,000 mg/L. It is coupled with production of gas and makes the effluents colorless and fit for irrigation.

Membrane bio reactors are also being recognized as an effective method of treatment of distillery wastes. The COD removal efficiency has been reported at 94.7%.

Ultrafiltration and Reverse Osmosis processes have been successfully used for the removal of colour and other contaminants from the distillery effluents. Permeate from the U.F. was also used as a feed for Reverse Osmosis. Nano filtration followed by R.O. hybrid process could be successfully used for the removal of TDS, colour and COD of spent wash.

The disc and tube membranes have been successfully used. There are about 100 distilleries in India that are operating R.O. plants to treat their anaerobically digested or raw vinasse. The permeate can be recycled after proper treatment (aeration to remove dissolved gases and activated carbon adsorption) as make up water for cooling towers for molasses dilution. The operational cost is slightly less than that for the MEE with 50% reduction.

The technique generates about 50% colorless reusable water and the balance 50% concentrate which can be easily composted by available press mud. The concentrated stream contains almost double the levels of COD, BOD and TDS.

Clarification of vinasse by a combined treatment of coagulation/ flocculation followed by activated carbon adsorption has been tried in Brazil. Although significant reduction in colour, turbidily and COD have been observed after coagulation/flocculation yet it failed to remove phenolic compounds. The colour and turbidity also increased after adsorption because of proliferation of yeast cells during adsorption. This adsorption process was not found to be efficient.

Multi effect evaporation is being utilised for water removal and a concentration of 30% can be obtained through present technologies. MEE plant concentrates with a solid content of 33% to 34% may have have very high BOD, COD and TDS. The MEE plants are however susceptible to scaling which may be difficult to remove and the process condensate requires polishing. Concentrated spent wash at 55 to 60% solids or vinasse powder can be successfully used to generate steam in specially designed boilers and the steam can be used to generate electricity and in plant operation. This technology does not appear to have been established yet in India.

Condensates generated from volume reduction of distillery spent wash in multi effect evaporators may contain large amounts of volatile organic compounds causing the COD levels to be as high as 8000 to 10000 mg/L and a volume of about 800 to 1000 cubic meters in a 300 KLD distillery. Spent lees with a volume of about 300 KL in a 300 KLD distillery, is also expected to have a high COD of about 8000 to 16000 mg/L. With a BOD of more than 50% of the COD, these wastes can be treated biologically. Anaerobic digestion followed by a two stage activated sludge process coupled with tertiary treatment through multi media filtration has been tried in some experiments. An overall COD reduction of 96% of the COD has been indicated. It has been claimed that waste waters so treated could be reutilised and replace the water demand by almost 80%. The amount of investment requirement for the project was about 1 to 2% of the capital cost of the distillery.

It has been estimated that concentrating and treating spent wash may involve an expenditure of 400% of the distillery cost .Concentration and incineration is estimated to make the production of Alcohol dearer by Rs. 8-10 per litre of Alcohol produced as compared to the more sustainable technologies.

Spray evaporation, used by some distilleries presents a possibility of suspended particles getting carried away and impacting ambient air quality. State Boards are not allowing this method of vinasse disposal.

It is also possible to gasify concentrated vinasse as such or in combination with other biomass and generate syngas and biochar.

During concentration and incineration the large quantum of spent wash is reduced by increasing the viscosity then finally it is dried as ash in furnace chambers to let out as solid material. Concentrated spent wash at 55 to 60% solids or spent wash powder can be used to run a specially designed boiler with or without subsidiary fuel. Steam generated can be used to run a steam turbine to generate electricity and exhaust steam can be used for distillery and evaporation plant operation. Distiller's wet gram stillage from the MEE can also be used as cattle feed. Concentration and incineration systems are economically better for distilleries beyond 60 KLPD capacity.

Concentration and incineration technologies however present problems of disposal of sludges from storage tanks, condensates from evaporators and rejects from the RO plant.

The co-processing initiative of the CPCB involves incineration of concentrated spent wash as fuel in cement/steel industries along with other fuel/raw materials. This facilitates destruction of wastes at higher temperatures of 1,200 to 1,400 ^{o}C and incorporation of the inorganic contents of the pollutants in the clinker. Any acidic gases released are neutralized in the kiln. It has however found limited application in India.

Decolorization by capillary seepage system through mobilized whole cells incorporated in artificial soil bed and bio methanation coupled with decolourisation and crop cultivation in artificial soil bed has been suggested to be a novel design system which could deliver zero discharge with good ROI through crop cultivation. Many fungi and bacteria have been successfully screened to give upto 44% reduction in COD, either singly or in combination. Some workers report a high COD reduction of up to 99% during simultaneous decolorization and crop cultivation. The soil from the bed could be sold in for kitchen and terrace gardens. Pseudomonas fluorescence, Enterobacter, Aeromonas, Acinetobacter and Klebsiella have been reported to give a maximum of 44% COD reduction either singly or in combination. Several types of fungi have also been found useful.

High rate transpiration technology has also been employed to treat distillery effluents. HRTS is a land application system wherein the waste water is applied in specially designed field layouts with wide ridges and furrows. Trees with a high transpiration rate are planted in the ridges while the waste water is allowed to flow through furrows. The high transpiration rate provides a bio-pump. NEERI has recommended this system as being a cost effective and environmentally acceptable solution to manage coloured waste waters. The HRTS has various environmental benefits ranging from waste treatment, reuse of effluents, biomass production and prevention of air and water pollution.

Wetland plants like Phragmites karka have also been successfully tried for treatment of distillery waste waters both during the post monsoon (hydraulic load of 300 m3/ha/day, COD 10000 mg/L) and premonsoon periods. (Hydraulic load of 500 m3/ha/day with a COD of 10000 mg/L).

Arbuscular Mycorrhizal symbiosis plays an important role in phyto remediation. The system enhances the interface between plants and the soil environment through the fungal mycelia radiating from the colonized root cortex far into the surrounding soil which enhance the uptake of macro nutrients and micro nutrients. Mycorrhiza also help to improve the structure of the soil and act as filters reducing toxicity impacts on plants. They also influence the physiology of their host plants and make them less susceptible to pathogens, soil pollution, salinity, drought and a number of other environmental stress factors.

Coagulation and fungal application to biomethanated spent wash to remove color (85%) and COD (75%) has been successfully tried. The electrocoagulation process has been applied to biomethanated spent wash using aluminum anode and stainless steel cathode. A removal of 99.4% color and 77.58% COD has been reported in 6 hours.

The electro dialysis reversal process uses mild electricity to transmit ions and other charged species through membranes. This gives separate purified and concentrated streams.

The rich nutrient contents of spent wash make its use in agriculture very viable. Pre-sown land application, bio-composting and ferti-irrigation have been variously applied. These technologies had been accepted for implementation through the Charter for Corporate Environmental Responsibility decided between the CPCB and Distillers. Sugar mill effluents may be used as a suitable diluent for spent wash to reduce the pollution load and subsequently used in fertigation with a 1:1 dilution ratio, the BOD has been expected to come down to 3600 mg/L from 51023 mg/L, COD to 62075 mg/L from 90179 mg/L and TDS to 32700 mg/L from 72090 mg/L. The Central Pollution Control Board is however not encouraging stand alone distilleries to practice these technologies. However, distilleries attached to sugar units may follow biomethanation and bio-composting and concentration and incineration technologies. It has also been suggested that attached distilleries which are not achieving the standards should changeover from composting, one time land application and ferti irrigation in a time bound manner.

Some authors believe that distillery effluents being full of renewable energy, organic nitrogen and micro nutrients could be used as an alternative feed substitute in feeding of dairy animals. It has been suggested that 10% of grains could be replaced with bio methanated distillery spent wash in the diet of growing calves without any adverse effect on intake, utilisation of nutrients and blood metabolites.

Soil reclamation is another technology for utilization of distillery spent wash. Application of 500 m^3/ha of spent wash to sodic soils followed by 2 to 3 leaching with water achieved effective reclamation after 60 days with a reduction in soil pH and increase in organic carbon content, available nutrient and microbial activity.

Spent wash has also been used in the preparation of flyash bricks. Some workers have evaluated the compressive strength of flyash bricks where spent wash was used instead of water. It was found that the spent wash treated bricks gave a higher strength as compared to standard flyash bricks.

Waste materials, such as effluent from pulp and paper mill and distillery industries, converted into sugars by pretreatment methods such as acid or enzymes are frequently used across the world for the production of Alcohol. The use of sucrose containing distillery effluents also allows the production of Ethanol at low costs through enzymatic hydrolysis and fermentation. One of the most successful methods for ethanol production from distillery effluents is combination of the enzymatic hydrolysis of pretreated distillery effluent and fermentation in one step, termed simultaneous saccharification and fermentation using Bacillus species prior to S. cerevisae.

The National Green Tribunal has in its judgement passed on 13-07-17, restrained the regulatory authorities from prescribing zero Liquid Discharge and online monitoring systems across the Board. Instead the regulatory authorities have been asked to ensure that the standards are met and ZLD, if necessary, applied on a case to case basis after giving due consideration to technology, financial viability, limitation of the unit and the processes adopted by the Industry but in all circumstances, ensuring that the discharge of effluents from the unit has to be in strict conformity to the prescribed standards.

1.2 Review of Literature

1.2.1 Indian Distillery Industry

Mall (1995) states that distilleries also manufacture rectified spirit and extra neutral alcohol for human consumption and for industrial utilization. The distillery industry today consists broadly of two parts, potable liquor and the industrial alcohol. The potable distillery producing Indian Made Foreign Liquor and Country Liquor has a steady but limited demand with a growth rate of about 7 to 10% per annum. The industrial alcohol industry on the other hand, is showing a declining trend because of high price of molasses, which is invariably used as substrate for production of alcohol. The alcohol produced is now being utilized in the ratio of approximately 52% for potable and the balance 48% for industrial use. Apart from its use for beverage, medicinal, pharmaceutical and flavoring, alcohol constitutes the feedstock for large number of organic chemicals, which are used in manufacturing a wide variety of intermediates, drugs, rubber, pesticides, solvents etc.

Karivaratharaju (1996) reported that there is a possibility of getting about 10 to 11 billion litres of wastewater (DSW) from distillery industries alone.

Zalawadia et al., (1997) reported that India is the largest producer of sugar in the world; alcohol is a product of the fermentation of molasses. The molasses is fermented with yeast and alcohol is distilled from fermented wash, leaving behind a large volume of coloured wastewater, known as spent wash or distillery effluent.

Singh and Bahadur (1997) stated that alcohol, a product of the fermentation of molasses, has great importance for chemical industry, export and as a source of energy.

Chhonkar et al., (2000); Gahlot et al., (2011); Singh et al., (2007); Saha et al., (2005); Shivajirao (2012); Vasic et al., (2012) state that on an average, the volume of spent wash generated is 10 to 15 times the volume of spirit produced, depending on the manufacturing process and the housekeeping practices of the industrial unit.

A Central Pollution Control Board document titled 'Management of Distillery Wastewater' (2001) reported that in spite of the distillery industry in the country being close to 100 years old, the proper and trouble free management of the distillery wastewater has not been possible. On an average, the volume of spent wash generated is 10 to 15 times the volume of spirit produced, depending on the manufacturing process and the housekeeping practices of the industrial unit.

Kaur and Singh (2002) state that the production of alcohol has seen a tremendous rise with more than 285 distilleries functional in the country.

Sukanya and Meli (2004) state that India is the largest producer of sugar in the world. The production of alcohol has seen a tremendous rise with more than 285 distilleries functional in the country.

MoPNG (2004) states that India produces about 2.75 billion litres of alcohol annually. The demand for potable alcohol has been ever increasing with the more liberal attitude, rising middle class (disposable) income and less taboo/stigma in the Indian society. With the advent of ethanol blending with petrol/motor fuel, the requirement of ethanol/industrial alcohol has increased manifold in the country to the extent that in case 5% blending, is made mandatory all over the country, the sugar factory molasses available in the country shall not prove to be adequate for meeting the total requirement of ethanol including its use for potable liquors and other industrial uses. As per the notification number G.S.R.705(E) dated 27th October, 2004, The Ministry of Petroleum and Natural Gas, Government of India, mandates that 5% ethanol-blended petrol (E5), conforming to Bureau of Indian Standards specifications, shall be sold in the following ten states and the union territories:

1. Andhra Pradesh (except Chittor and Nellore districts)
2. Goa
3. Gujarat
4. Haryana
5. Karnataka
6. Maharashtra
7. Punjab
8. Tamil Nadu (only in districts of Coimbatore, Dindigul, Erode, Kanayakumari, Nilgiri, Ramanathpuram, Tirunelveli, Tuticorin and Virudhunagar)
9. Uttar Pradesh
10. Uttaranchal
11. Daman and Diu
12. Dadra and Nagar Haveli
13. Chandigarh

It is also stipulated that government may extend above notification to all states and union territories in phase 2 and enhance the percentage of ethanol in the ethanol blended petrol from 5% to 10% in phase 3.

PIB, Government of India, MoPNG, 2016 informs that the Government of India has permitted Oil marketing companies (OMC's) to sell Ethanol Blended petrol with percentage of ethanol up to 10% as per BIS specification in order to achieve 5% ethanol blending across the country as a whole **(G.S.R. 4E., MoPNG, 20-01-2013**). During the Sugar year 2014-15, OMC'S have achieved a blending percentage of 2.3%.

Ethanol Blending in Petrol results in savings of Petrol to the extent of its blending and consequently foreign exchange. The potential foreign exchange earnings for the sugar year 2014-2015 amounts to around U.S.D. 285 million. Ethanol produced from other non food feedstocks besides molasses, like cellulosic, lingo- cellulosic materials including petrochemical route, have been allowed to be procured. The Ministry of Petroleum and Natural Gas, on the 1st September, 2015 has asked OMC's to target 10% blending of ethanol in Petrol in as many states as possible.

G.S.R. 712 (E) dated 1/09/2010 issued by the Ministry of Petroleum and Natural Gas notifies a list of 20 states and 4 Union Territories where the oil marketing companies shall sell ethanol blended Petrol as per BIS specifications. The Central Government here, retained the powers to modify the areas and prescribe the percentage of Alcohol in ethanol Blended petrol that may be supplied in the respective states or Union Territories and specify the period for the same.

The Office of the Principal Scientific Advisor to Government of India has in a report published in 2014 estimated that the average production of Ethanol in the country from molasses is 2500 million litres/annum and the consumption of ethanol in the potable, chemical and other sectors is about 1800 million liters per the annum. This leaves only 700 million liters per annum of Ethanol for fuel blending against a requirement of 1100 million liters of Ethanol at 5% and 2200 million liters of Ethanol at 10% blending. (The National biofuels policy had envisaged the blending of alcohol to be enhanced to 20% by 2017. This indicates a significant demand for alcohol in the country. Import of Ethanol could be uncompetitive.)

The Ministry of Petroleum and Natural Gas has notified the National Policy on Biofuels-2018 through Gazette notification F. No. P-13032 (16)/18/2017-CC. The said policy recognizes the need to encourage development of non renewable energy sources in a big way. This is expected to augment domestic energy generation and substitute the import of crude oil so as to achieve import dependency by 10% by 2022. The government has prepared a road map to reduce the import dependency in oil and gas sector by adopting a five pronged strategy which includes increasing domestic production, adopting biofuels and renewable energy, Energy efficiency norms, improvement in refinery processes and demand substitution. This envisages a strategic role for biofuels in the Indian Energy basket and aims to increase the use of biofuels in the energy and transport sectors. Bioethanol, is an important Biofuel produced from biomass such as sugar containing materials, like sugar cane, sugar beet, sweet sorghum etc, starch containing material like corn, Cassava, rotten potatoes, algae etc and cellulose materials such as baggasse, wood waste, agricultural or forest residues or other renewable resources like industrial waste. The Governments approach is to promote and encourage the use of biofuels through the Ethanol blended program, using ethanol derived from multiple feed stocks and the development of second Generation (2G) ethanol technologies and its commercialization. A major thrust of this policy is to ensure availability of biofuels from indigenous feed stocks. B-Molasses and Sugar cane juice have been recognized as important feed stocks for production of biofuels in the Country. The policy allows production of ethanol from B-Molasses as well as directly from Sugar Cane juice and from damaged food grains like wheat, broken rice etc. which are unfit for human consumption. Currently C-heavy molasses is being used. With a molasses availability of about 13 MMT this can produce 300 crore liters of Alcohol/Ethanol. Potential raw materials for ethanol are planned to be encouraged. One MMT of sugar sacrificed can produce 60 crore litres of Alcohol. Surplus biomass (120-160 MMT) has been observed to have a potential to yield about 3000 crore liters of ethanol annually.

Baskar et al., (2004) state that the daily cane crushing capacities vary from 800 to 10,000 tonnes per day. On an average, the volume of spent wash generated is 10 to 15 times the volume of spirit produced, depending on the manufacturing process and the housekeeping practices of the industrial unit.

Uppal (2004) states that many factories adjunct to distilleries generate power in order to balance the price of sugar in the open market besides enhancing energy security of the country. A high strength effluent producer, the distillery sector has to meet stringent pollution control regulations. This makes distilleries one of the most suitable areas for energy generation through biomethanation. It is important to note that the distilleries consider the wastewater treatment more as a pollution related problem rather than energy generation vehicle. This is mainly due to the fact that the treatment of the wastewater to an extent that would make it innocuous when disposed in the environment is difficult and costly.

Jain et al., (2005) reported that India is the fourth largest ethanol producer after Brazil, the United States and China. Its average annual ethanol output amounts to 1,900 million liters with a distillation capacity of 3,063 million liters per year.

All India Distillers Association (AIDA) (2008) and Ethanol India (2008) stated that looking to its wide use, it could be inferred that the demand for alcohol is likely to increase in the country and so is the number of distilleries producing alcohol. AIDA and Ethanol India are predicting the birth of many new distilleries along with major expansion in capacity of existing distilleries (AIDA, 2008; Ethanol India, 2008). Due to government promoting ethanol to mix in petrol there will be drastic demand for ethanol, which could overcome the existing unutilized capacity and thus create an excess demand. For example, according to the estimates prepared by the Ministry of Petroleum and Natural Gas, about 410 million litres of anhydrous ethanol (conforming to IS 321: 1964) shall be required to implement 5% blending in the above-mentioned 10 notified states (Ethanol India, 2008).

Khuller, 2015 states that there are 429 distilleries in India of which 216 are connected to sugar factories and 213 are standalone. About 100 distilleries have installed ethanol manufacturing facilities which can produce over 5 billion liters of rectified spirit per year in addition to 2 billion liters of fuel ethanol.

Kannan and Upreti (2008) state that the production of alcohol has seen a tremendous rise with more than 285 distilleries functional in the country. On an average, the volume of spent wash generated is 10 to 15 times the volume of spirit produced, depending on the manufacturing process and the housekeeping practices of the industrial unit.

IIEC, (2010) states that ethanol, an agriculture-based product is known in several forms - Ethyl Alcohol, Alcohol, Spirit and Denatured Spirit. Ethanol is manufactured by two processes, synthetically from petroleum substances and by the fermentation of sugar-bearing or starchy substrates using yeast. Ethyl Alcohol is an important feedstock for the manufacture of various chemicals. These chemicals are primarily the basic Carbon based products like Acetic Acid, Butanol, Butadiene, Acetic Anhydride, Poly Vinyl Chloride (PVC), etc. Ethylene and Ethylene oxide are also produced from a petrochemical route. However, this requires plants of huge scales and thus substantially high investments. Ethanol is a globally traded commodity and is used in fire combustible engines, as a potable drink (in the manufacturing of alcoholic beverages) and consumed in pharmaceutical industry (as a raw material for production of insulin, antibiotics, tonics and several other essential bulk drugs and formulations) and chemical industries across the world.

The use of sucrose containing distillery effluents also allows production of ethanol at low costs. Waste materials, such as effluent from pulp and paper mill and distillery industries, converted into sugars by pretreatment methods such as acid or enzymes are frequently used across the world. One of the most successful methods for ethanol production from distillery effluents is combination of the enzymatic hydrolysis of pretreated distillery effluent and fermentation in one step, termed simultaneous saccharification and fermentation using Bacillus species prior to S. cerevisae. **In Application of distillery spent wash. 16 Chapter pdf (internet)**

Suresh et al., (2011) state that several distilleries have been setup throughout the country in past few decades. The number is assuming an increasing trend owing to the growing demand in terms of export.

The Total installed capacity of molasses based distilleries in the country is about 4230 million litres per annum. The average capacities of Indian Molasses based distilleries ranges between 30 to 60 KLD. There are very few distilleries above 100 KLD and the largest distillery capacity is 420 KLD. (Office of Principal Scientific Advisor to the GOI, 2014)

Table 1 illustrates the number of distilleries in the different states of India, the total number of molasses based distilleries and specifically those attached with sugar mills.(Source: Office of the Principal Scientific Advisor to the Government of India, 2014)

Table 1: State wise numbers of Molasses Distilleries in India (2012-13)

S.N.	State	No. of Distilleries		Annual Licensed Capacity (Million Liters)		Annual Installed Capacity (Million Liters)	
		Total	Affiliated to sugar factories	Total	Affiliated to sugar factories	Total	Affiliated to sugar factories
1	Andhra Pradesh	29	12	203.364	109.750	193.559	105.345
2	Aasam	0	0	0	0	0	0
3	Bihar	9	4	79.950	28.950	79.950	28.950
4	Chattisgarh	2	0	36.000	0	1.800	0
5	Daman	4	0	17.160	0	17.160	0

6	Goa	5	0	4.044	0	5.306	0
7	Gujrat	15	9	168.710	81.260	171.050	83.600
8	Haryana	9	1	85.950	4.550	85.950	4.550
9	Himachal Pradesh	3	0	12.486	0	13.600	0
10	Jammu & Kashmir	5	0	31.949	0	31.749	0
11	Karnataka	40	10	387.089	122.169	374.514	110.369
12	Kerala	10	2	28.328	4.418	23.730	5.520
13	Madhya Pradesh	18	0	298.576	0	308.051	0
14	Maharashtra	81	59	899.272	720.945	849.222	685.545
15	Nagaland	1	0	1.350	0	1.350	0
16	Odhisha	10	3	18.992	3.720	19.005	3.720
17	Puducherry	4	0	22.900	0	11.700	0
18	Punjab	13	4	287.479	36.120	256.847	36.060
19	Rajasthan	9	2	101.700	11.400	93.250	11.400
20	Sikkim	2	0	1.971	0	3.504	0
21	Tamilnadu	26	11	410.150	222.350	416.425	204.350
22	Uttar Pradesh	53	23	1227.374	618.000	1137.482	618.000
23	Uttarakhand	3	1	99.190	15.000	99.190	15.000
24	West Bengal	5	0	35.300	0	35.300	0
All India		356	141	4459.284	1978.632	4229.694	1912.409

Based on the published data in the All India Distilleries Association's Directory of Indian Distilleries (2008 edition), on the capacities and the spread of distilleries in different states in India, International Institute for Energy Conservation (IIEC) has done a detailed estimatation of the quantity of possible outputs from spent wash treatment. Maharashtra, Uttar Pradesh and Karnataka are the three leading states accounting for almost half of the alcohol production in the country.

Suresh et al., (2011) state that molasses based distilleries in India are classified as 'Red Category' because of the large volume of high strength waste water (spent wash) generation. The Central Pollution Control Board (2016) also classifies Distilleries as a Red Category of Industry.

Popat, (Ion-Exchange Waterleau) states that pollution arising from alcohol distilleries has been recognized as one of the most difficult problems to be solved to the entire satisfaction of the Pollution Control Act.

Chandraju et al., (2012) state that the number of alcohol industries has increased two-fold in the last 10 years.

Kamble *et.al.* 2017 say that in India there are 295 distilleries producing 3.20 billion liters of alcohol generating 45 billion litres of waste water annually. This has the potential to produce 1200 million cubic meters of biogas with a capacity of generating 5 Trillion kilo calories of Energy every year.

1.2.2 The Manufacturing Process

Singh Yashpal 2007. Emphasized on the resource utilisation efficiency and its impact on environmental performance and profitability. Based on an environmental performance rating in 2001, from amongst 33 distilleries, it was estimated that the sector could save at least Rs. 100 crores if the bad performers could emulate the better performers.

Bhatt C.S. Dr. and Singh Yashpal Dr. 2010 have analyzed data collected from distilleries in U.P. in terms of their environmental performance over two phases of study covering a period from 1998-2001 and 2004-2007. The first phase of the study was made public. Out of the 24 industries common to both the phases, 22 have shown an improvement by way of total environmental performance, 12 in terms of capacity utilisation, 18 in terms of molasses consumption, 17 in terms of average recovery of alcohol, 18 in terms of water consumption, 10 interms of total energy consumption, 14 in terms of spent wash generation, 13 in terms of bio gas generation and 18 in terms of dilution ratios. Water use over the years had come down by 60% while the total BOD has come down by more than 88%. It has been reported that because of zero discharge techniques, the effluent discharged into streams has also come down by almost 97% and that most of these improvement, apart from generating revenue, are of direct benefit to climate change management.

The Technical Environmental Impact Assessment (EIA) Guidance Manual for Distilleries, (2009) has described the process of manufacture of alcohol from molasses. Molasses, a by-product of sugar industry, is used as raw material by most of the distilleries for production of alcohol by fermentation and distillation processes. The molasses contain about 40-50% sugar, which are diluted to bring sugar contents to 10-15% or 20-25° Brix for further fermentation process. The pH is adjusted by addition of sulphuric acid, if necessary.

Yeast culture is done in the laboratory and propagated in a series of fermenters, each about 10 times larger than the previous one. The diluted molasses is inoculated with about 10% by volume of yeast inoculum. In the fermenters the reducible sugars are broken down to ethyl alcohol and carbon dioxide (CO_2). The reaction is exothermic and cooling water is sprayed on the fermenter walls to maintain the temperature at 29-32 °C. Sludge is produced and discharged from the bottom, while the clear fermented beer from the top is sent to the degasifying section of the analyser column after the heat exchange with the spent wash to preheat it to about 90°C. In the analyser which is a bubble-cap fractionating column, the beer is heated by live steam and fractionated to give a 40% alcohol stream from the top. This stream is further fractionated in the rectifier column to obtain rectified spirit. Part of the rectified spirit is sent back to the column, and the condensed water from this stage, known as 'spent lees' is usually pumped back to the analyser column. The bottom discharge from the analyser column is known as the spent wash, which is drained off after heat exchange with the incoming beer from the fermenters.

The plant practices are practically uniform throughout the country. In the fermenter section there is no variation which has relevance to aspects of pollution. Housekeeping practices regarding wash water collection and sludge disposal vary somewhat. In the distillation section, a few plants have extra fractionating columns for removal of aldehydes and fusel oil (fusel alcohols, also sometimes called fusel oils, or potato oil in Europe, are higher-order alcohols, i.e. alcohols with more than two carbon atoms formed by fermentation and present in cider, mead, beer, wine, and spirits to varying degrees), or for production of so-called silent spirits. These, however, have no practical relevance to pollution.

In general the layout of most distilleries is similar and can be divided into two broad sections. The first section houses laboratory, yeast propagation vessels, diluters, pre-fermenters and fermentation vessels. The second section houses all the distillation columns condensers and heat exchangers.

The first section generally has two floors with equipment like diluter, pre-fermenters, etc., and laboratory placed on the first. Fermentation vessels are laid on the ground floor with their tops extending about 1.5 m into the first floor. The ground floor of the fermenter is usually wet because of the cooling water sprayed on the outer walls of the fermenters. This water splashes on the floor and flows out through open channels on the floor along with fermenter sludge and wash water.

The yeast propagation vessels are generally closed reactors where strict temperature control is maintained. The diluter in most of the distilleries is of continuous type where the molasses and water streams are pumped into two coaxial tubes in a closed vessel. The two streams get thoroughly mixed by the high turbulence before they flow into the fermenters. Generally, the continuous diluter is cleaned once in a day with water and steam. There is no process waste stream produced from yeast propagation vessels, diluter and pre-fermenters except the wash waters used for cleaning after processing cycles. Most of the distilleries have open top fermenters where CO_2 is generally not recovered.

I. In India, alcohol is manufactured by either the Batch or the Continuous process.

(a) Batch process

The molasses obtained from the sugar industry is first diluted to bring down the concentration of sugar from 40-45% to 10-15%. Using a portion of the diluted molasses a yeast culture is developed from an inoculum. After 4-6 hours, when the culture has developed fully, the remaining molasses is mixed and allowed to ferment for 30-40 hours. The pH is maintained around 4-4.5 by addition of sulphuric acid. As the reaction is exothermic, the contents of the fermentation tank are kept at 35-37 ºC by constantly sprinkling cold water on the outer surface of the fermentation tank.

After fermentation is complete the yeast sludge is removed from the bottom and the fermenter wash is pumped to the analyzer column for distillation using steam. The mixture of alcohol vapours and steam is collected at the top of the column and alcohol-free spent wash is discharged from the bottom.

The alcohol and the steam stream are fed to rectification column where water and alcohol vapours condense at different levels and rectified spirit is withdrawn. The condensed water from this stage is called spent lees and forms another waste stream.

(b) Continuous process

In this process yeast is recycled. Fermentation and distillation is coupled to get a continuous supply of fermented beer for the distillation column. The advantage of the process is that a highly active yeast cell initiates the fermentation rapidly and the alcohol yield is also much higher compared to the batch process.

Biostill process is one of the continuous processes, which is a trade name in which molasses is fed to the fermenter at a constant flow rate. The flow rate of molasses is controlled to maintain the sugar and alcohol concentrations in the wash at 0.2% or lower and 6-7% respectively.

The waste streams comprise spent wash which is the main source of wastewater, spent lees and yeast sludge. Spent lees is usually mixed with the spent wash. The yeast sludge is disposed separately after drying. In addition wastewater may be generated from the bottling, fermentation tank cooling and washing and utility sections of the plant.

II. Rectified Spirit

Molasses-based distilleries are more common in India. The main process steps in this operation are listed below.

- Dilution - Preparation of molasses for fermentation
- Fermentation - Production of alcohol from fermentable sugars in molasses solution
- Distillation - Product recovery

a. Dilution

Molasses available from Indian sugar mills has a solid content varying between 76 and 90% while the total sugar content varies between 45 and 55%. The main dilution operation occurs in a diluter where the solid concentration is brought down to 20-25° Brix. The bulk of this diluted molasses is fed to the fermentation tank while a small quantity is further diluted to 10-15° Brix and used for preparation of the final yeast inoculum. Propagation of yeast for the final inoculation is done in successive stages in volumes of 10, 100, 1000 and 10,000 litres where, in each stage, 10 parts of diluted molasses is inoculated with 1 part of yeast culture.

b. Fermentation

Fermentation in the fermentation tank continues for about 30 to 45 hours after the final inoculum is added to it. The basic reaction in the fermentation process is exothermic. Since the reaction is exothermic and proper growth of yeast requires a narrow temperature range, water is sprayed on the outer walls of the fermentation tank to maintain the temperature between 25 °C and 32 °C.

Fermented beer, the main product of this step is decanted and the remaining sludge known as fermenter sludge is discharged from the bottom of the fermenters. The sludge amounts to about 300 to 400 litres (L) per kilolitre (KL) of rectified spirit produced, and is one of the major contributors to the pollution load from distilleries.

c. Distillation

The fermented beer from the fermenter vessel is preheated to about 90 °C by heat exchange with the spent wash flow from the analyzer column and is then fed into the degasifying section of the analyzer column. Low boiling content of the fermented beer such as organic acids, esters and aldehydes along with some alcohol vapours are condensed in the aldehyde condensers. Purified wash from the bottom of the degasifying section enters the top of the analyzer column for steam stripping of alcohol which condenses at the top of the column as 40% alcohol. The down coming discharge from this column is spent wash.

The 40% alcohol stream from the top of the analyzer column is next fed to the bottom of the rectification column where it is maintained at a temperature of about 95 to 100 °C. Water and alcohol vapour condense at different levels in this column and rectified spirit of an equilibrium boiling composition (95%) is withdrawn. Of this rectified spirit, a part is fed back into the column. Spent lees, produced at this step are usually pumped back to the analyzer column. The volume of spent lees is about 1-1.5 KL/KL of rectified spirit produced.

III. Ethanol

Ethanol is produced both as a petrochemical, through the hydration of ethylene, and biologically, by fermenting sugars with yeast. Determining the most economical among the products depends upon the prevailing prices of petroleum and of grain feedstock.

Ethanol for use in alcoholic beverages, and the vast majority of ethanol for use as fuel, is produced by fermentation. When certain species of yeast (e.g., Saccharomyces cerevisiae) metabolize sugar in the absence of oxygen, they produce ethanol and CO_2. The chemical equation below summarizes the conversion:

$$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$$

Ethanol's toxicity to yeast limits the ethanol concentration obtainable by brewing. The most ethanol-tolerant strains of yeast can survive up to approximately 15% ethanol by volume.

The fermentation process must exclude oxygen. If oxygen is present, yeast undergoes aerobic respiration which produces CO_2 and water rather than ethanol. In order to produce ethanol from starchy materials such as cereal grains, the starch must first be converted into sugars. In brewing beer, this has traditionally been accomplished by allowing the grain to germinate, or malt, which produces the enzyme, amylase. When the malted grain is mashed, the amylase converts the remaining starches into sugars. For fuel ethanol, the hydrolysis of starch into glucose can be accomplished more rapidly by treatment with dilute sulphuric acid, fungally produced amylase, or some combination of the two.

Ethanol is the final end product of three processes namely:

- Fermentation Process
- Distillation Process and
- Dehydration Process

a. Fermentation process

Ethanol can be made by the fermentation of sugars. Simple sugars such as sugarcane juice or molasses are the raw material. Zymase, an enzyme from yeast, changes the simple sugars into ethanol and CO_2. The enzymatic reaction carried over by the yeast in fermentation produces mainly ethanol, CO_2 and heat. The fermentation reaction is actually very complex. The impure culture of yeast produces varying amounts of other substances, including glycerin, methanol and various organic acids.

b. Distillation process

Ethanol produced by fermentation ranges in concentration from a few percent up to about 14%; the rest being water and other components. The boiling point of ethanol (78.4 °C) is significantly lower than the boiling point of water (100 °C). These materials cannot be separated completely by distillation. Instead, an azeotropic mixture (i.e. a mixture of 96% ethanol and 4% water) is obtained. Azeotropic mixture of alcohol cannot be further concentrated by distillation. Distillation is used to produce Rectified Spirit (RS).

c. Dehydration of alcohol

Pure alcohol can't be obtained from distillation since it forms azeotrope with water at 96% (v/v). Fuel ethanol or absolute alcohol is produced by dehydration of RS. Commercially available technologies for dehydration of RS are:

i. Azeotropic distillation method

To dehydrate ethanol from azeotropic concentration, a third substance called Entrainer (trichloro ethylene, benzene, toluene, cyclohexane etc.) is added to the mixture of ethanol and water. Entrainer breaks the azeotropic point of ethanol and water, i.e., it alters the relative volatility of water making it more volatile. The ternary azeotropic mixture, formed at the top of dehydration column, allows the removal of water and thus dehydrates alcohol. The azeotropic mixture is heterogeneous and the ‘heavy’ phase, which is high in water content, is extracted by decantation. The regeneration column allows water extraction from the ‘heavy’ phase and entrainer recycling.

ii. Molecular Sieve Technology

Molecular sieve technology works on the principle of Pressure Swing Adsorption (PSA). Here water is removed by adsorption on surface of ‘molecular sieves’ under pressure and then cyclically removed under low pressure at different conditions. This process carries out dehydration of mixed ethanol and water by adsorption of water to zeolite balls, which are molecular sieves. The dehydration unit operates with two adsorbers according to alternate steps of adsorption and desorption. Adsorption occurs in the vapour phase and under pressure. Desorption regenerates water saturated molecular sieves. This step is performed under vacuum. Part of the dehydrated alcohol is used for the molecular sieve desorption. Alcoholic effluent from desorption is regenerated within the distillation column.

IV. Water use

Water uses in molasses-based distilleries are:

a. Process Application
   - Yeast propagation
   - Preparation of molasses for fermentation
   - Water (as steam) required for distillation
b. Non-process Applications
   - Cooling water
   - Treated water for making potable liquor (IMFL) and for boiler use
   - Water and steam required for washing

V. Wastewater

The major sources of wastewater for molasses based distilleries are:

a. Process waste streams
   - Spent wash from the analyser column
   - Fermenter sludge

- Spent lees from the rectifier

b. Non-process waste streams
   - Cooling water
   - Waste wash water
   - Water treatment plant wastewater
   - Boiler blow down
   - Bottling plant wash wastewater
   - Other wastes

Chauhan and Dikshit (2012) state that the first distillery in the country was set up at Cawnpore (Kanpur) in 1805 by Carew and Co. Ltd., for manufacture of Rum for the army. The technique of fermentation, distillation and blending of alcoholic beverages was developed in India on the lines of practices adopted overseas particularly in Europe.

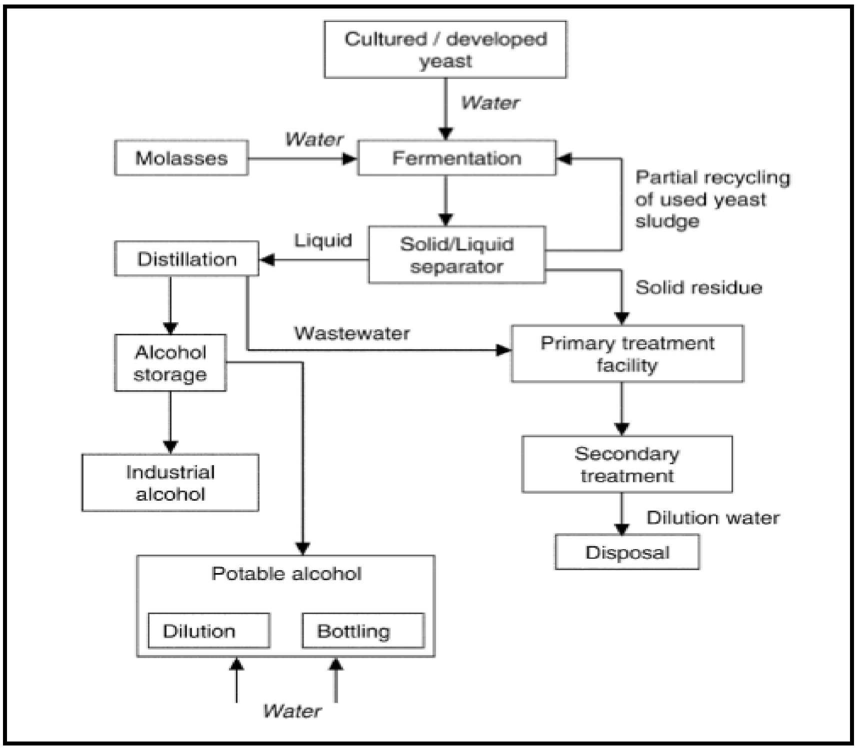


Figure 1: Flowchart of a typical alcohol manufacturing process.

1.2.3 Composition of Spent Wash

Farshi et al., (2013) describe spent wash as characterized by its reddish brown color and a low pH (4.2 to 4.5), high ash content and containing a high percentage of dissolved organic and inorganic matter of which 50% may be present as reducing sugars. 90 to 93% of spent wash is water and 7 to 10% solids. Sugars constitute 2 to 20% and proteins 10-11% of dried spent wash. The metals present in spent wash are Fe, Mn, Zn, Cu, Cr, Cd and Co with an electrical conductivity ranging from 15 to 23 dS/m. The spent wash contains very high amounts of Potassium, Calcium, Chlorides, Sulphates and BOD (40,000 to 50,000 mg/L) and COD (10,000 to 1,25,000 mg/L).

Vasic et al., (2012) have stated that an important characteristic of stillage obtained from molasses-based feedstocks include color components. Phenolics from the feedstock, melanoidins from Millard reaction of sugars with proteins, caramels from overheated sugars and furfurals from acid hydrolyses can contribute to the color of the effluent. Chromium, Copper, Nickel and Zinc were found at levels significantly above detection limits in some distillery effluents, especially in the stillages from cellulosic feedstocks. Some heavy metals are likely to originate from feedstocks used for bioethanol production. The processing equipment used in the pretreatment of cellulosic feedstocks (acid hydrolysis) is often made of corrosion-resistant alloys. Heavy metals contained in these alloys may leach into the feedstock during the hydrolysis, resulting in detectable levels in the stillage. Also, corrosion of piping, reactors and heat exchangers may contribute to heavy metal content in the stillage.

Suresh, (2011) summarizes that molasses based distilleries generate a large volume of high strength spent wash (12-15 litres per litre of alcohol) having a very high BOD of 40,000 to 65,000 mg/L, a COD of 80,000 to 140,000 mg/L and high BOD/COD ratio. Spent wash also possess a high amount of inorganic impurities including Phosphates, Potassium, Calcium, Sulphates, and Chlorides etc. The recalcitrant nature is due to the presence of melanoidins, caramel, polyphenols and a variety of sugar decomposition products such as anthocyanin, tannins and different xenobiotic compounds. The unpleasant odors are due to the presence of skatole, indole and other sulphur compounds, which are not effectively decomposed during fermentation and distillation. Melanoidins are formed by Millard amino carbonyl reaction and have antioxidant properties, which make them toxic to many microorganisms. The high COD, Total Nitrogen and Phosphate content of spent wash can result in eutrophication of natural water bodies. Shivajirao (2012) have also expressed similar views.

Vidyarthi, (2011) has summarized that the average spent wash generation is lowest in the Biostill continuous process (6 to 8 litre per litre alcohol), higher in the Cascade continuous process (8.5 to 11.0 litre per litre alcohol) and highest in the Batch process (11.1 to 15.0 litre per litre alcohol). The concentration of pollutants was however found to be highest in the Biostill process as compared to the Cascade process and in the Batch process where it was reported to be the lowest.

Patil S.V. 2014 states that with Cascade and Biostil continuous fermentation coupled with an integrated heat recovery system it is possible to reduce the vinasse generation to 5.5 to 3.0 Litres per liter of Ethanol produced. According to data presented by him as in table below, the concentration of contaminants from the Biostil process is the highest.

S.NO.	**Parameters**	**Batch Fermentation**	**Continuous Fermentation**	
			Cascade Process	**Bio still process**
1	Volume L/L Ethanol	14-16.0	10.0-12.0	7.5-8.0
2	C.O.D. mg/L	80000-110000	110000-130000	140000-160000
3	B.O.D. mg/L	45000-50000	55000-65000	60000-70000

The IIEC, (2010) has summarized that there are about 579 sugar mills and 325 distilleries in India. The distilleries are responsible for generating about 45.72 million cubic meters of acidic spent wash annually (6 to 15 cubic meters per cubic meters alcohol) and COD: BOD ratio of 2.2 to 2.5. The spent wash may also contain 3,000 to 6,000 mg/L Sulphates, 5,000 to 8,000 mg/L Chlorides, 300 to 500 mg/L Phosphates, 1,000 to 1,200 mg/L Total Kjeldahl Nitrogen, 150 to 2,000 mg/L Sodium and 8,000 to 12,000 mg/L Potash. Although it does not contain any toxic substances, yet the discharge of this highly polluting colored effluents to streams causes immense damage to the aquatic flora and fauna. The methane emission factor for distilleries is 0.2 kg CH_4 per kg COD.

Mohana et al., (2009) state that the main byproduct water of distillery industry is the distillery effluent known as spent wash. It is also called potale, stillage, vinasse, detritus and dunder. After evaporation of spent wash, the left over solid is called distillery sludge. Spent wash is normally a diluted replica of the molasses used in the production of alcohol. The quality of the cane molasses and chemicals used in manufacturing process by the sugar mills are responsible for the complex characteristics of the distillery spent wash. Spent wash has very high Biological Oxygen Demand (BOD) (40,000 to 65,000 mg/l) and Chemical Oxygen Demand (COD) (80,000 to 1,40,000 mg/l).

Krzywonos et al., 2009 state that distillery wastewater contain many components, which are known to have a high nutritive value. They contain vitamins (with large amounts of those classified as group B), proteins rich in exogenous amino acids and mineral components.

Nagaraj and Kumar, (2007) state that the aqueous distillery effluent stream known as spent wash is a dark brown highly coloured effluent and is approximately 10-15 times by volume of the alcohol produced. It is one of the most complex of effluents having extremely high BOD and COD values which also make it a potential source of renewable energy. 295 distilleries in India produce 3.2 billion liters of alcohol generating 45 billion liters of wastewater annually. This has the potential to produce 1200 million cubic meters of biogas (containing 60% methane) and the post methanation wastewater, if used carefully, can produce more than 85000 tonnes of biomass annually. It has also been estimated that if this source of energy is tapped it will fetch additional energy units worth 5 trillion KCals annually. The post methanation effluents can provide 24,500 tonnes of Potassium, 12,500 tonnes of Nitrogen and 2,100 tonnes of Phosphorous annually and one year's effluents can meet the Potassium requirement of 1.55 million hectare land, Nitrogen requirement of 0.13 million hectare land and Phosphorous requirement of 0.025 million hectare land, if two crops are taken in a year.

De Souza, (2007) states that in Brazil, 10 to 15 litres of vinasse are produced for each litre of alcohol (mean flow rate was 10.85 L/L ethanol). This vinasse generally has a high organic matter in molasses based distilleries, high Potassium (3.50 to 7.60 kg per cubic meter of vinasse) and relatively poor Nitrogen (0.75 to 0.79 kg per cubic meter of vinasse), Calcium (1.80 to 2.40 kg per cubic meter of vinasse), Phosphorous (0.10 to 0.35 kg per cubic meter of vinasse) and Magnesium (0.84 to 1.40 kg per cubic meter of vinasse) contents.

Baskar et al., (2003) state that the distillery spent wash is an acidic liquid (pH 3.8 to 4.0) and contains large quantities of organic carbon and plant nutrients like K, Ca, Mg, S etc. The BOD could range from 45,000 mg/L to 55,000 mg/L and COD from 90,000 to 1,10,000 mg/L. Primary treated distillery effluent is near neutral with a pH of 7.8 and a high EC of 24.3 dS/m. The methanated effluents may contain a BOD of 5,600 mg/L and a COD of 45,000 mg/L and total solids of 81,000 ppm. The salts commonly present in these effluents are of K and SO_4 apart from N, P and micronutrients.

A CPCB document titled 'Management of Distillery Wastewater' (2001) gives the characteristics of spent wash generated from the three types of manufacturing processes (Table 2). It is seen that while the spent wash generation per litre of alcohol production is less from the Continuous and Biostill processes when compared to the Batch process, the spent wash is more concentrated.

Table 2: Spent wash characteristics from different manufacturing processes.

S. No.	Parameter	Batch Process	Continuous Process	Biostill Process
1	Volume, L/L Alcohol	14-15	10-12	7-9
2	Colour	Dark brown	Dark brown	Dark brown
3	pH	3.7-4.5	4.0-4.3	4.0-4.2
4	COD	80,000-1,00,000	1,10,000-1,30,000	1,40,000-1,60,000
5	BOD	45,000-50,000	55,000-65,000	60,000-70,000
6	Solids			
	Total	90,000-1,20,000	1,30,000-1,60,000	1,60,000-2,10,000
	Total volatile	60,000-70,000	60,000-75,000	80,000-90,000
	Inorganic dissolved	30,000-40,000	35,000-45,000	60,000-90,000
7	Chlorides	5,000-6,000	6,000-7,500	10,000-12,000
8	Sulphates	4,000-8,000	4,500-8,500	8,000-10,000
9	Total Nitrogen	1,000-1,200	1,000-1,400	2,000-2,500
10	Potassium	8,000-12,000	10,000-14,000	20,000-22,000
11	Phosphorus	200-300	300-500	1,600-2,000
12	Sodium	400-600	1,400-1,500	1,200-1,500
13	Calcium	2,000-3,500	4,500-6,000	5,000-6,500

NOTE: All values from S. No. 4 to 13 are in mg/L.

Baskar et al., (2003); Rajukkannu and Manickam (1997) state that spent wash is of purely plant origin and contains large quantities of soluble organic matter and plant nutrients, which the sugarcane plant has absorbed from the soil.

Chhonkar et al., (2000) state that spent wash has high BOD/COD ratio and emits obnoxious odour.

Pathak et al., (1999) state that spent wash is rich in sulphates and chlorides of K, Na and Ca and contained a considerable amount of plant nutrients.

According to the **Agriculture and Resource Management Council of Australia and New Zealand and the Australian New Zealand Environment and Conservation Council (1998) and the Effluent Management Guidelines for Australian Wineries and Distilleries 1998** the Australian winery and distillery effluents contain simple organic acids, sugars and alcohols from grape and wines. The BOD of distillery effluents can be as high as 35,000 mg/L. Both winery and distillery effluents may have a pH in the range of 3 to 10, moderate salinity, a proportionately high concentration of Sodium relative to that of Calcium plus Magnesium, low amounts of Nitrogen and Phosphorous relative to Carbon and inorganic components from the water supply, alkali wastewaters and processing operations. Apart from a high BOD, distillery effluents in Australia have a Total Kjeldahl Nitrogen content ranging from 500 to 1,700 mg/L, Total Phosphorous from 100 to 400 mg/L and 1,300 to 2,100 mg/L of Potassium.

Rajukkannu and Manickam (1996) illustrate that spent wash contains appreciable amount of K, Ca, Mg, S and moderate amount of N, P and micronutrients.

Bhat (1994) analyzed the distillery effluent of Ugar sugar works Ltd., Ugarkhurd and reported that raw spent wash was acidic (4.03). It also contained large amount of suspended and dissolved solids contributing to increased concentrations of BOD and COD. The concentrations of Ca, Mg and K were higher than that of Na. However, BOD and COD of effluent drastically reduced by lagooning and diluting with water of the Krishna river.

Joshi et al., (1994) state that spent wash has high BOD/COD ratio and emits foul odour.

Devarajan et al., (1993) state that spent wash contains appreciable amount of K, Ca, Mg, S and moderate amount of N, P and micronutrients (Table 3, page 35).

One of the agro-industrial waste materials of brewery industry is Brewer's Spent Grain (BSG). **Mbagwu and Ekwealor (1990)** while studying agronomic potential of BSG found some of the chemical characteristics of BSG. It contained organic Carbon (21 per cent), total N (5.1 per cent), available P (0.4 per cent), K (3.4 per cent), Ca (0.4 per cent) and Mg (0.48 per cent) besides a pH of 4.4 and C: N ratio of 21.5.

Cerri et al., (1988) reported highest organic Nitrogen (N), nutrient and ash in vinasse whereas bagasse reported the least. Organic compounds extracted by alkaline reagents were of humic nature and similar to those in soil except fulvic acid which predominated over humic acid.

Kulkarni et al., (1987) stated that spent wash contains large amounts of secondary elements such as Copper (Cu), Manganese (Mn) and Zinc (Zn). It also contains 29.1 per cent reducing sugar, 9.0 per cent protein, 1.5 per cent volatile solids, 21.0 per cent gums, 4.5 per cent combined lactic acid, 1.5 per cent combined organic acids, 5.5 per cent glycerol and 15.0 per cent wax and phenolic bodies. It contains a large amount of Potassium (K) and high concentrations of Chlorides and Sulphates.

Kulkarni et al., (1987) state that spent wash is characterized by its reddish brown colour, high temperature and high ash content. It contains high percentage of dissolved organic and inorganic matter such as Chlorides, Sulphate, Phosphates, Potassium and Calcium that are critical to environmental pollution; 50 per cent of this may be present as reducing sugars. It also contains about 90 to 93 per cent water and 7 to 10 per cent solids, sugar being 2 to 20 per cent and protein 10 to 11 per cent in the dry spent wash. Its recalcitrant nature is due the presence of melanoidins, caramel, polyphenols and variety of sugar decomposition products such as anthocyanin, tannins and different xenobiotic compounds.

Patil et al., (1987) state that spent wash is normally a diluted replica of the molasses used in the production of alcohol. The quality of the cane molasses and chemicals used in manufacturing process by the sugar mills are responsible for the complex characteristics of the distillery spent wash. Spent wash is a highly acidic liquid with pH ranging from 3.0 to 4.5.

Naylor and Severson (1984) analyzed the brewery sludge for different constituents such as total N (2.59 per cent), total P (0.64 per cent), Ca (16.8 per cent), Mg (0.37 per cent) and Na (0.20 per cent).

Bucknall et al., (1979) also reported that potale has a pH of 3.3. Similar observations were made by **Quinn and Merchant (1980).**

Jadhav and Sawant (1975), while studying the effect of spent wash on physicochemical properties of soil, analyzed the spent wash for its chemical composition. The constituents had electrical conductivity (dS/m) 31.0, total N 400 ppm, total P 1,225 ppm, total K 13,600 ppm, total Ca 100 ppm and total Mg 1,700 ppm.

Deshmane, (1975) observed higher quantities of arabinose, galactose, fructose, glucose and xylose in spent wash solids (SWS). The SWS were rich in inorganic Nitrogen and low unhydrolysable Nitrogen than FYM.

Miller, (1973) states that on an average evaporated spent wash contain a dry matter of about 30.5 per cent. The composition of major plant nutrients like Nitrogen (N), Phosphorus (P) and Potassium (K) are 3.71 per cent, 1.1 per cent and 1.1 per cent, respectively, whereas the contents of Magnesium (Mg) and Sodium (Na) are 0.50 per cent and 0.35 per cent, respectively.

Bajpai and Dua (1972) state that the main byproduct water of distillery industry is the distillery effluent known as spent wash. It is also called potale, stillage, vinasse, detritus and dunder. After evaporation of spent wash, the left over solid is called distillery sludge. It is highly viscous and corrosive type of liquid. Furthermore, they state that spent wash is characterized by its reddish brown colour, high temperature and high ash content. Spent wash has very high Biological Oxygen Demand (BOD) (40,000 to 65,000 mg/l) and Chemical Oxygen Demand (COD) (80,000 to 1,40,000 mg/l). The obnoxious odour of the effluent is due to the presence of skatole, indole and other Sulphur compounds, which are not effectively decomposed during fermentation and distillation. Melanoidins are formed by Millard amino Carbonyl reaction and have antioxidant properties, which make them toxic to many microorganisms.

Table 3: Components of Spent Wash/Distillery Effluent

Parameters	Singh et al (1980)	Patil and Shinde (1995)	Juwarkar et al. (1992)	Pathak et al. (1998)	Rajukkannu (1996)		Devarajan et al. (1993)	
	Spent Wash						Primary Treated	Secondary Treated
Colour	-	-	-	-	Reddish Brown	Dark Brown	Brownish	-
Odour					Unpleasent smell of burnt sugar	Unpleasant	Disagreeable	-
pH	5.0	3.8	4.0-5.0	-	3.8-4.0	3.9	8.0	8.0
EC(dam')	7.5	28.0	-	-	28.0-30.5	27.7	32.5	27.0
BOD (5 D AT 20^0 Clmg/l)	-	-	-	40000-50000	45000-55000	4000	5625	1100
COD (mg/l)	-	-	-	90000-10000	90000-110000	102000	45000	2500
Moisture%	-	91.2	-	-	-	-	-	-
Mineral Matter	-	26.5	-	-	-	-	-	-

% on O.D. Basis								
Total Solids (mg/l)	-	-	--	-	80000-90000	92305	81000	31000
Total Dissolved Solids (mg/l)	-	-	-	-	-	86530	76500	28000
Total Suspended Solids (mg/l)	-	-	-	-	300-500	5975	4500	3000
Total Volatile solids (mg/l)	-		-	-	55000-67000	68900	-	-
Organic Carbon (%)	-	-	-	-	-	25.5	-	-
Total N (mg/l)	-	-	1200-2500	300	1200-1500	1661	1740	1200
C N ratio	-	15.8	-	-	15.5	15.3	-	-
Total P as P_2O_5 (mg/l)	-	640	120-250	45	400-600	428	428	400
Total K as K_2O	10000	12000	9000-	7200	10000-13000	10000	11500	10000

(mg/l)			12000					
Total Ca (mg/l)	-	-	-	-	2100-3000	2714	1050	-
Total Mg (mg/l)	-	-	-	-	2000-3300	2062	2208	-
Total Na (mg/l)	250.7	-	-	-	-	640	610	-
Total S (mg/l)	-	-	-	-	4000-5000	2980	2440	-
Total Zn (mg/l)	-	-	-	-	10.5	7.5	8.0	-
Total Cu (mg/l)	-	-	-	-	4.2	3.8	5.5	-
Total Fe (mg/l)	-	-	-	-	65	52.0	85.0	-
Total Mn (mg/l)	-	-	-	-	5.5	4.4	4.8	-
Chloride (mg/l)	-	-	-	-	5000-6000	10400	11200	-

1.2.4 Environmental Impacts

Shivajirao, (2012) reports that the discharge of wastewaters from wineries and distilleries is becoming increasingly restricted as pressures from environmental regulations increase and as awareness of the negative impacts of seasonal discharges of water containing high nutrient and organic loadings into water courses spreads. Raw stillage discharge has a highly deleterious effect on fish life.

Banupriya and Gowrieb (2012) reported that with the exponential increase in the number of industries, there has been a substantial increase in generation of industrial wastewater, which is discharged either into open land or nearby aquatic ecosystem and causing environmental nuisance, if not properly treated before discharge. This activity promotes varying degree of pollution load in water, soil and air. The distillery effluent if discharged into water, as is the present practice, defiles the ecosystem. Also, this effluent has been designated by CPCB as the most hazardous pollutant of water bodies. Further, it contains huge quantity of macro and micronutrients excavated by sugarcane from the land.

Vasic et al., (2012) considered that looking into the high pollution potential of distillery waste water, it should not be disposed in nature without previous treatment. Stillage disposal in the environment can be adverse. High COD and nutrient content may result in eutrophication of natural waters, colored compounds block out sunlight penetration in rivers and lakes, reducing photosynthetic activity and dissolved oxygen concentration. Disposal of distillery wastewater on land is also harmful and can affect the vegetation and groundwater quality.

Vasic et al., (2011) state that the highly coloured compounds of the spent wash reduce sunlight penetration in water bodies, which in turn decrease both photosynthesis activity and dissolved oxygen concentration affecting aquatic life. Further, it contains significant amount of recalcitrant compounds, which released into water bodies, produce a high degree of organic pollution in both aquatic and terrestrial ecosystems, which poses a serious health hazard to the rural and semi-urban populations that uses stream and river water for agriculture and domestic purposes. Such harmful water is injurious to plants, animals and human beings.

Suresh et al., (2011) reported that the highly coloured compounds of the spent wash reduce sunlight penetration in water bodies, which in turn decrease both photosynthesis activity and dissolved oxygen concentration affecting aquatic life.

Pandey et al., (2011) stated that, the sugar industries are playing an important role in the economic development of the Indian sub continent. The negative effects of various industrial effluents on seed germination, growth and yield of crop plants have captivated the attention of many workers.

IIEC, (2010) and Gahlot et al., (2011) state that a massive quantity of effluent (approximately 46 billion litres) is produced annually, which if disposed untreated can cause considerable stress on the water bodies (ground water is the main source for these operations).

IIEC, (2010) reports that wastewater can lead to methane (CH_4) emissions when treated or disposed anaerobically. It can also be a source of nitrous oxide (N_2O) emissions and Carbon Dioxide (CO_2). However CO_2 emissions from wastewater are not considered in the Intergovernmental Panel on Climate Change (IPCC) guidelines because of these being of biogenic origin. Wastewater as well as its sludge components can produce CH_4 if they degrade anaerobically. The extent of CH_4 production depends primarily on the quantity of degradable organic material in the wastewater, the temperature and the type of treatment system. The rate of CH_4 production increases, with increases in temperature. This is especially important in uncontrolled systems and in warm climates. Below 15 °C, significant CH_4 production is unlikely because methanogens are not active and the lagoon will serve principally as a sedimentation tank. However, when the temperature rises above 15°C, CH_4 production is likely to resume. The principal factor in determining the CH_4 generation of wastewater is the amount of degradable organic material in the wastewater.

The Technical Environmental Impact Assessment (EIA) Guidance Manual for Distilleries, (2009) reported that the conventional approach of in-plant treatment of industrial wastewater even up to secondary and tertiary levels and its disposal in surface water does not provide an environmentally compatible solution to wastewater management.

Singh et al., (2007); Kannan and Upreti (2008) state that distillery industries produce an unwanted liquid waste during the production of alcohol i.e. spent wash, which is one of the most important environmental issues with very high pollution load.

Baskar et al., (2003) have suggested that if the distillery effluent is not utilized in agriculture and finds access into the open drains, it will pose a serious threat to water quality and fragile ecosystem like lowering of pH value of the stream, increase in organic load, depletion of oxygen content, discoloration, destruction of aquatic life and obnoxious odors.

Nandy et al., (2002) state that DSW contains significant amount of recalcitrant compounds, which released into water bodies, produce a high degree of organic pollution in both aquatic and terrestrial ecosystems, which poses a serious health hazard to the rural and semi-urban populations that uses stream and river water for agriculture and domestic purposes. Such harmful water is injurious to plants, animals and human beings.

Misra and Pandey (2002) state that these industries produce an unwanted liquid waste during the production of alcohol i.e. spent wash, which is one of the most important environmental issues with very high pollution load. Further, it contains significant amount of recalcitrant compounds, which released into water bodies, produce a high degree of organic pollution in both aquatic and terrestrial ecosystems, which poses a serious health hazard to the rural and semi-urban populations that uses stream and river water for agriculture and domestic purposes. Such harmful water is injurious to plants, animals and human beings.

Nagaraj and Kumar (IIT, Roorkee); Kumar et al., (1997) report that agricultural utilization of industrial wastewaters offers an ecologically and economically viable solution to disposal of industrial wastewaters.

Joshi et al., (1994) that the distillery spent wash, with its characteristic unpleasant odor, poses a serious threat to the water quality around the world.

Swaminathan and Vaidheeswaran (1991) state that the land application of distillery spent wash often benefits water pollution control and utilization for agricultural production. It also leads to better water retaining capacity of the soil. It has been reported that wastewater from different industries produced continuously could cater the needs of irrigated crops. Thus, the distillery spent wash will not only prevent waste from being an environmental hazard but also served as an additional potential source of fertilizer for agricultural use.

1.2.5 Spent Wash Treatment

Singh Yashpal and Yadav Anurag K. 2007 have edited contributions on distillery industry, process waste management, technical advancements in waste water treatment in distilleries, Charter on Corporate Responsibility for Environmental Protection (CREP), Status of Distillery Units at the National Level and Study on the Environmental performance assessment of molasses based distilleries in U.P. They have stated that with passage of time, one of the worst industries in terms of environmental degradation had realized that there are viable technical and financial options to manage waste and that the dark areas are because of apathy and a lack of will and attitude to bring change.

Singh Yashpal 2017 states that a draft notification has been issued by the MoEF and CC on proposed standards for effluents from fermentation industry. This notification includes the imposition of ZLD as the only option and makes no reference to other sustainable methods like One Time Controlled Land application and land reclamation. It has been represented by the Industry Associations that the Pollution Control Boards may impose technology prescriptions on a case to case basis from the mix of technologies available so that spent wash can be maximally and sustainably utilised as a resource for biogas generation, bio-compost, ferti irrigation, one time controlled land application, irrigation, sodic land reclamation, incineration and coprocessing depending on local conditions. The NGT has as in its various orders NGT 2017 and NGT 2014 also supported this view and passed a judgement which restrains the regulatory authorities from imposing ZLD and continuous on line monitoring systems across the Board.

The Technical Environmental Impact Assessment (EIA) Guidance Manual for Distilleries, (2009) states that the following treatment options are generally practiced in distilleries throughout the world:

- Biomethanation
- Biomethanation and secondary treatment followed by irrigation or disposal in surface water
- Composting, after or without biomethanation
- Presown land application after biomethanation
- Activated sludge treatment system
- Concentrations and Incineration
- Anaerobic digestion followed by evaporation and composting
- Co-incineration
- Multiple Effect Evaporators (MEE)
- Disposal by dilution in sea or estuary, after or without biomethanation

The IIEC, (2010) describes the typical treatment sequence in an Indian Distillery to consist of screening, equalization, biomethanation, ferti irrigation and bio composting with sugar cane press mud. These have been reported to be the most widely used options. Many distilleries in

India are allowing their effluent for application on land as direct irrigation water, spent wash cake and spent wash press mud compost.

Nagaraj and Kumar 2007 refer to methods involving (a) concentration of spent wash followed by incineration (b) anaerobic digestion with biogas recovery followed by aerobic polishing and (c) direct wet oxidation of stillage by air at high temperature with generation of steam followed by polishing. These methods have been reported by them to be very cost extensive (up to 40% of the cost of distillery). Generation of biogas, application on land as direct irrigation water, spent wash cake and spent wash press mud compost and potash recovery have also been suggested as alternatives. The cost of anaerobic biological digesters can be recovered within 2 to 3 years of installation because of substantial saving of coal and other fuels.

Suresh et al., (2011) state that the huge quantities of highly toxic spent wash and high COD load makes conventional technologies insufficient to achieve the prescribed standards of inland discharge of treated effluent.

1.2.5.1 Biomethanation

As per the **Central Pollution Control Board, India, 2001**, biomethanation is now a well-established process. Three types of reactor systems are commonly used, namely, up or down flow fixed film reactors, up flow partially fluidized bed reactors, commonly known as up flow anaerobic sludge blanket (UASB) reactors and slurry reactors. Each system may have different variations in respect of reactor configuration, effluent and sludge recirculation and mixing. One variation employs a two-stage (phase) decomposition.

The above reactor systems, when properly designed and operated are considered satisfactory in carrying out the decomposition of the organic matter. They are capable of treating spent wash having BOD in the range of 40,000 – 50,000 mg/L with an efficiency of 90 to 95 per cent, thus producing an effluent having a BOD equal to 4,000 to 5,000 mg/L. Process failure occurs when the system is overloaded or attempt is made to restart quickly at full load, after a temporary shutdown.

The treatment systems produce gas at the rate of 0.4 to 0.5 m^3/kg COD removed having a composition of 50 to 60 per cent methane, 40 to 50 per cent Carbon Dioxide and 1 to 1.5 per cent Hydrogen Sulphide. The gas is used as a source of energy by the industry for generating steam.

Based on the published data in the All India Distilleries Association's Directory of Indian Distilleries (2008 edition), on the capacities and the spread of distilleries in different states in India, International Institute for Energy Conservation (IIEC) has done a detailed estimate of the quantity of possible outputs from spent wash treatment as shown in Table 4. Maharashtra, Uttar Pradesh and Karnataka are the three Leading states accounting for almost half of the alcohol, spentwash and biogas production in the country.

Table 4: Annual Bio-energy potential of distillery effluent in various states of India. (After International Institute for Energy Conservation 2010))

State	Units	Capacity (M ltr/Yr)	Effluent (M ltr/Yr)	Biogas (M cum)	Total N (Tones)	Total Ka (tones)	Biomass (tones)
			15	0.027	0.31	6	2
AP	28	143	2145	58	665	12870	4290
Assam	1	2	30	1	9	180	60
Bihar	8	54	810	22	251	4860	1620
Goa	6	15	225	6	70	1350	450
Gujarat	10	128	1920	52	595	11520	3840
Karnataka	36	240	3600	97	1116	21600	7200
M P	21	469	7035	190	2181	42210	14070
Maharashtra	72	692	10380	280	3218	62280	20760
Punjab	12	132	1980	53	614	11880	3960

Tamilnadu	22	245	3675	99	1139	22050	7350
U P	46	660	9900	267	3069	59400	19800
Uttarakhand	4	61	915	25	284	5490	1830
W B	6	24	360	10	112	2160	720
Rajasthan	9	18	270	7	84	1620	540
Kerala	10	29	435	12	135	2610	870
Pondichery	4	15	225	6	70	1350	450
Sikkim	2	14	210	6	65	1260	420
Nagaland	1	2	30	1	9	180	60
J & K	7	24	360	10	112	2160	720
H P	3	4	60	2	19	360	120
Haryana	8	65	975	26	302	5850	1950
Orissa	9	27	405	11	126	2430	810
Total	**325**	**3063**	**45945**	**1241**	**14243**	**275670**	**91890**

Devarajan et al., (1998); Rajukkannu and Manickam (1996) state that the spent wash when subjected to bio-methanation process (primary treatment) looses up to 85 per cent of its BOD.

IIEC (2010) illustrates the characteristics of raw spent wash and biomethanated spent wash (Table 5).

Table 5: Characteristics of raw and biomethanated spent wash.

S. No.	Parameters	Raw spent wash Value (mg/L)	Biomethanated spent wash Value (mg/L)
1	Colour	Reddish brown	Greenish brown
2	Specific gravity, SI	1.02-1.04	1.02
3	pH, SI	4.0-4.5	7.0-7.5
4	Temperature, °C	70-80	38-42
5	Total Acidity	5,000-7,000	-

6	Total Alkalinity	-	8,000-10,000
7	Volatile Acids	3000	2000
8	BOD	40,000-45,000	5,000-7,000
9	COD	95,000-1,10,000	25,000-32,000
10	Total Solids	70,000-1,00,000	30,000-35,000
11	Suspended Solids	7,000-9,000	3,000-5,000
12	Total Dissolved Solids	25,000-30,000	20,000-25,000
13	Sulphate as SO_4	4,000-5,000	2,500-4,000
14	Potassium	5,000-6,000	4,000-5,000
15	Total Kjeldahl Nitrogen	1,000-1,200	1,000
16	Phosphorus as PO_4	200-400	100-200
17	Organic Nitrogen	1,500-2,500	-

Patil S.V., 2014 suggests that digesters designed for COD loading rates of 5 Kg COD/M^{3}d give the best results and that continuous stirred tank reactor (CSTR) and UASB based digesters have proved to be more suitable than media based and thermophilic digesters. Biogas based cogeneration plants (Power and Steam), regeneration (Power, steam and Chilled water) and bio-compressed natural gas (CNG after removal of CO_2 and H_2O from biogas) production can offer higher values. **Patil, S.V. 2014** indicates a typical anaerobic digestion plan performance as in the table below.

S.No.	**Parameters**	**Values**
1	pH after digestion	6.9-7.2
2	BOD removal efficiency in %	85-90
3	COD removal efficiency in %	65-70
4	Specific Biogas generation in M^3/kg of COD degraded	0.5-0.69

5	Methane Content of Biogas in %	60-65
6	H_2S content of biogas in %	3-4

Gomes de Barros et al. 2016 evaluated the anaerobic conversion of vinasse into bio methane with gradual increase in organic loading rates in two bench scale UASB reactors. The UASB reactors were operated for 230 days with a Hydraulic retention time of 2.8 days for reactor 1 and 2.8 to 1.8 days for Reactor 2. The Organic Loading rates applied in the reactors were 0.2 to 7.5 g. total COD (Per liter per day) in reactor 1, 0.2 to 11.5 g. total COD (Per liter per day) in reactor 2. The OLR was calculated by dividing the total COD by the Hydraulic detention time. The authors have concluded that the highest total COD conversion into methane of 0.19 L. CH_4 per gram total COD removed, was achieved after 140 days of operation of the UASB reactors with total COD removal efficiencies of approximately 70% and 80% and an OLR of 5.0 to 7.5 g total COD $(Ld)^{-1}$. The highest total COD removal efficiencies were 81% and 82% in R1 and R2 respectively, with an OLR of 2.5 to 5.0 g total COD $(Ld)^{-1}$. Recirculation of the effluent allowed adjustment of influent PH without the need to add sodium Hydroxide. The UASB reactors produced methane with high efficiency, a better quality effluent and stable sludge.

Saini and Lohchab, 2017, evaluated the performance of an UASB reactor at different feed concentrations (25, 50 and 100%) of distillery waste water with a HRT of 20 hours. The initial spent wash was dark brown in colour with a pH of 4.5, COD of 19600 mg/L, BOD of 10600 and total solids of 14780 mg/L (TDS 10980 mg/L). The results showed a reduction of 91%, 83% and 72% at dilutions of 25%, 50% ad concentrated spent wash. BOD and VFA reductions were 89 and 78; 84 and 80 and 72 and 72 percent at different dilutions of 25, 50 and concentrated spent wash respectively. The pollutant removal efficiencies suggest that UASB reactor is one of the best options for treatment of distillery waste water even without dilution.

1.2.5.2 Biomethanation followed by Secondary treatment

The **Technical Environmental Impact Assessment (EIA) Guidance Manual for Distilleries, (2010)** reports that distilleries attached with sugar units can adopt anaerobic digestion of spent wash followed by composting if sufficient filler material is available for composting. In case the filler material is not adequate, the effluent quantity shall be reduced by reboiler/ evaporation/RO to match the quantity of press mud. The concentrated effluent can be dried in spray dryers as powder which can be sold as a fertilizer. The anaerobic digestion followed by evaporation in Multiple Effect Evaporators (MEE) to reduce the volume of the effluent and composting is adopted by some distilleries in Maharashtra and Karnataka. The anaerobic digestion followed by evaporation in MEE and spray drying is followed at The Ugar Sugar Works Ltd., located in Belgaum, Karnataka. The industry shall have to develop suitable system for reduction of effluent as there are no specific guidelines developed for evaporators/reverse osmosis/reboiler/spray dryers.

The CPCB, (2001) describes that in order to reduce the requirement of dilution water to meet the prescribed standards, a secondary biological treatment process is used. The activated sludge process, which is an aerobic biological process, is the most commonly used secondary treatment system adopted. Designs employing two-stage aeration, with intermediate and final sedimentation tanks having arrangements for sludge re-circulation give satisfactory operation. This process is energy intensive and involves high capital and operating cost. Substantial quantity of sludge is also generated in this process and its disposal is also a problem. Going below 1500-1000 ppm BOD is really difficult by aerobic treatment method and therefore, this method has been now abandoned by many distilleries. (Office of the Principal Scientific Advisor to the Government of India, 2014) Studies conducted at the CPCB laboratory and field observations suggest that such a system is capable of reducing the BOD level to about 300 to 500 mg/L. Successful operation of the process depends on the presence of adequate biomass in the aeration tank and re-circulation of settled biomass in the sedimentation tanks back to the aeration tanks. Further, the aerators in the aeration tank must be kept in operation continuously to keep the biomass in aerobic state. Not meeting any of these operational requirements, results in the system failure. The energy requirement for the aeration process in the activated sludge process is directly proportional to the BOD removed. To reduce the input BOD to the system and hence to reduce the energy requirements, another anaerobic treatment unit may be added between the primary biomethanation step and the final two stages aerobic sludge step. Assuming the BOD of the final effluent from the aerobic treatment as 500 mg/L, it will have to be diluted in the ratio of 1 to 5 to meet the effluent standard for BOD for application on land for irrigation. If it is assumed that the treated effluent, in the case of the batch process, has a dissolved inorganic solids concentration of 10,000 mg/L, a dilution ratio of 1 to 5 will also meet the standard for the dissolved inorganic solids. In case the dissolved inorganic solids concentration is higher, the dilution will be governed by the limit prescribed for irrigation water, i.e. 2,100 mg/L. In case the wastewater is to be disposed in inland surface waters, effort should be made to treat the effluent to a BOD level of at least 300-350 mg/L. In such a case the required dilution would be 10 to 12 times to meet the standard of 30 mg/L BOD. Even if the 30 mg/L is achieved by dilution, the problem of colour would still persist. Disposal of such effluent in surface waters would affect the downstream users.

According to **Pawar, (2012**) in common biological treatments, microorganisms are mixed with the waste material. The microorganisms decompose the waste material and convert it to microbial biomass and energy. There is no separation between the microorganisms and the treated waste. One such treatment system is the activated sludge process in which the microorganisms are suspended within the treated liquid. A second step of treatment is needed in this system to separate the microbial biomass from the treated fluid. Bio filtration overcomes such problems.

Biofiltration is distinguished from other biological waste treatments by the fact that there is a separation between the microorganisms and the treated waste. In biofiltration systems the microorganisms are immobilized to the bedding material, while the treated fluid flows through it. Recently, a vast amount of literature has been written on single experiments involving the treatment of fluids by immobilized microorganisms. Several artificial immobilization methods have been examined and impressive results have been achieved in the treatment of fluids with one of the artificial immobilization methods - the entrapment of microorganisms within polymer beads. This method, even though it needs to be improved, seems to have a future potential in commercial biofiltration systems.

The methods of artificial immobilization of microorganisms within biofiltration systems have several advantages, but also suffer from several disadvantages in comparison to the treatment of fluids by naturally attached microorganisms. Understanding the mechanisms and forces responsible for the attachment of microbes to the bedding material, in an attempt to improve this attachment is important.

Further improvement of the artificial entrapment of microorganisms within polymers will allow the exploitation of the advantages of this method in the treatment of fluids. There are two methods of immobilization processes – the self-attachment of microorganisms to the bedding material and the artificial entrapment of microorganisms within polymer beads. Apart from the immobilization process, biofiltration systems can be divided into two different treatment systems based on the phase of the treated fluid, i.e., systems treating gas and those treating liquids. There is a considerable difference in the operation of systems treating different phases of fluid, even though based upon the same bedding material.

In biofiltration systems the pollutants may be removed from the fluid in several ways. They can be adsorbed to the microbial film or to the bedding material. In biofilters treating gas, the pollutants might be adsorbed to the water that clings to the bedding material. The main way of pollutant removal in biofiltration systems, however, is the biological degradation of the waste. In this way the contaminants are incorporated into the microbial biomass or used as energy sources.

Lekshmi, (2013) used anaerobic digestion (Hybrid Anaerobic Baffled Reactor) along with advanced oxidation to reduce COD from distillery spent wash in a lab scale test. The COD of the raw spent wash was reduced from 82,000 mg/L to 17,000 mg/L in the first stage anaerobic digestion (Hybrid Anaerobic Baffled Reactor). Hydrogen peroxide oxidation was used to increase the biodegradability of the remaining organic matter (COD). This was again passed through a second stage HABR to attain a COD of 6,000 mg/L. The entire process was accompanied by Bio Gas production and makes the effluents colourless and fit for irrigation purposes. The author recommends a pilot scale study.

Pawar, (2012) states that Membrane Bioreactors (MBRs) are being increasingly recognized as an effective method for the treatment of industrial (distillery) wastewaters. MBRs offer the advantages of total solids retention at all biomass concentration, low sludge yield and better treated effluent quality. In addition, the high mixed liquor suspended solids (MLSS) concentration encourages the treatment of high strength wastewater. The widespread application of MBRs is however, limited by high initial membrane cost and progressive membrane fouling, which leads to frequent membrane cleaning and eventual replacement, thus contributing to the high operating costs. There are very few investigations on distillery wastewater treatment in an MBR. The COD removal efficiency was 94.7%. Membrane coupled anaerobic bioreactor (MCAB) using 0.2µm polypropylene and 0.14 µm zirconia skinned inorganic tubular membranes has also been investigated for the treatment of 40000 mg/L COD distillery wastewater at 55°C. High COD removal (90%) was observed in both the anaerobic MBRs. Anaerobically treated spent wash from sugarcane molasses based distilleries has a high COD and requires further aerobic treatment. So the objective was to investigate the optimum start up method and continuous operation of aerobic MBR using anaerobically treated spent wash as feed. The main issue behind using MBR was to provide long SRT (sludge retention time) so that the degradation of high molecular weight compounds could be achieved in the reactor. Nylon mesh was used instead of commercial microporous membranes to decrease the cost.

The Office of the Principal Scientific Advisor to the Government of India, 2014, recommends that more than 70% of the distilleries in the country have adopted biomethanation of distillery SW as the primary treatment method. Molasses based distillery effluent treatment through the biomethanation route offers several advantages. The most important advantages include recovery of energy in the form of biogas produced and neutralization of acidic spentwash. Sludge production is significantly lower under anaerobic conditions with the net amount of cell produced being 20-150 g per kg of COD destroyed as compared to 40-600 g during aerobic degradation.

1.2.5.3 Reverse Osmosis / Membrane Filtration

Murthy and Chaudhri, 2009 have demonstrated that the U.F. and R.O. processes can be successfully used for the removal of colour and other contaminants from the distillery Effluents. High concentration waste with a COD of 125000 mg/L was used in the experiment. Ultra filtration effectively reduced the COD to 4600 PPM at 10 atm pressure. In the second stage, permeate from the U.F. was used as a feed for R.O. The best operating conditions for R.O. were observed to be 15 litres/minute feed flow rate and 20 atm applied pressure which gave the rejection efficiency of 97.9% and 96.8% for TDS and COD respectively.

According to **Vasic et al., (2012)** different techniques for distillery stillage purification have been explored. Stillage is usually treated first with a screw decanter to remove solids. Also, centrifugation can be successfully used as a technique for solids separation. Further, stillage can be concentrated in the multi-effect evaporators with the co-production of condensate, which is lower in organics and almost devoid of inorganic salts. However, significant energy required to evaporate the stillage can negatively impact the energy balance of ethanol production. Coagulation and flocculation are also commonly used methods to remove particulates and organic matter from wastewaters. They are usually conducted by adding chemicals such as salts of aluminium and iron and polyelectrolytes. The limitations of coagulation and flocculation are: an increased salinity of the effluent, the storage and handling of corrosive chemicals, need for pre- and post-dosing adjustment of pH and sludge handling. Biological treatment processes such as anaerobic and aerobic digestion, as well as combination of these two methods have been successfully used for stillage treatment. Although the biological processes have several advantages such as the easy access and a large scale operation, the major drawbacks of these processes are high energy consumption, high labor costs, and large variations of the treatment efficiency with the change in feedstocks used for bioethanol production. However, it is hard and sometimes impossible to meet the environmental standards with aforementioned kinds of purification. Membrane separation techniques are widely used for distillery wastewater treatment, offering a possibility to improve the value of stillage and to meet environmental standards. The most commonly used membrane processes for wastewater purification are: microfiltration, ultrafiltration, nanofiltration and reverse osmosis.

The authors also observed that the values of COD, BOD, total nitrogen and dry matter decreased compared to the initial values of the stillage. The removal efficiency of COD for the membranes of 200, 450, 800nm was 36.7%, 37.3% and 38.7%, respectively. The total Kjeldahl nitrogen content was lower by 48.4%, 50.5% and 51.2% respectively, whereas the BOD/COD ratio was the same for all permeates, which indicates that the organic matters that pass through examined membranes are biodegradable. Suspended solids were completely removed from the stillage. The ash content of the permeate obtained after filtration through the membrane with pore size of 200 nm was higher by about 60% compared to initial value in the stillage. Arora et al., reported similar results obtained after the ultrafiltration of thin stillage. Their results showed that ash content of permeate was higher than in thin stillage. They concluded that this may be attributed to the solubility of mineral components in the stillage stream, which allowed them to pass through the membrane. However, ash content was reduced in permeates for the membranes with pore sizes of 450 nm and 800 nm, which can be explained by particles accumulation within pores of the membrane. The sizes and the shapes of particles in stillage are very variable and dependend of the feedstocks used for bioethanol production. Therefore, pores can be blocked with components of large molecular weights. Considering the pore size of the membranes for microfiltration, it cannot be expected to remove all organic pollution from wastewater by their application, but it can be reduced considerably. That makes microfiltration suitable as a pretreatment for ultrafiltration or reverse osmosis.

Pawar, (2012) also describes the various classes of pressure driven membranes and states that Pressure driven membranes have been classified into four categories based on the membrane rejection properties as follows:-

- Microfiltration (MF) membranes: - have the largest pore size (0.1 to 3 micron), require low trans-membrane pressure (1 to 30 psi), and are used for turbidity reduction, removal of suspended solids, parasites like bacteria and some viruses.
- Ultrafiltration (UF) membranes: - have a smaller range of pore sizes than MF membranes (0.01 to 0.1 micron) require low trans-membrane pressure (1 to 30 psi), and are capable of removing viruses as well as some color, odor, and organics removal, along with everything that the MF process can remove.
- Nanofiltration (NF) membranes: - are relatively new porous membranes that have a pore size less than 0.002 micron,

require moderate trans-membrane pressure (75-150 psi), and are primarily used for natural organic matter removal for controlling disinfection, by product precursor, water softening and sulfate removal.

- Reverse osmosis (RO) membranes: - are effectively non-porous membranes that require high trans-membrane pressure (150-500 psi) and are used for monovalent salt removal like Na^+, K^+.

Reverse osmosis technique generates about 50% clean colorless reusable water & the balance 50% concentrate can be easily composted by available press mud. This method thus creates an opportunity to arrive at zero discharge status. Thus it can be concluded that the above mentioned specific membrane configuration has the distinct ability of processing both the raw and biogas treated distillery spent wash, to obtain two streams, one containing clear and colorless water and the other a concentrated spent wash. Their quantitative proportion was average 50: 50.

Thus the processing of the spent wash by this technique offers an opportunity to reduce the volume by 50%, facilitating its convenient composting. The overall press mud and land requirement also is reduced to 50%, thus saving operating cost. The clear & colorless water may offer another opportunity to recycle the same, which could be a great boon to distilleries operating in water scarce areas or those spending large amounts of money for their water supply. Alternatively it can simply be given to irrigation to benefit the farmer.

The Technical Environmental Impact Assessment (EIA) Guidance Manual for Distilleries, (2010) has suggested that distilleries attached with sugar units can adopt anaerobic digestion of spent wash followed by composting if sufficient filler material is available for composting. In case the filler material is not adequate, the effluent quantity shall be reduced by reboiler/evaporation/RO to match the quantity of press mud.

Ramana et al., (2002) have stated that distillery spent wash generally constitutes of large quantity of inorganic and organic salts with high intensity of color and cannot be discharged either on land or water. Reverse Osmosis (RO) helps in reducing the color intensity and reduce the solids to zero level. After the treatment, the fresh water generated from the unit can be used in the process. The cartridge/membrane installed in the RO absorbs the solids and nullifies the pollutant level in the effluent. Economically it is not viable and the cost of installation and treatment cost is somewhat high as compared to other types of treatment.

Suresh et al., (2011) quote that Reverse Osmosis (RO) is a membrane based separation technique that permits the separation of certain species in a fluid by a combination of sieving & sorption mechanisms. The RO is a high-pressure membrane process (15 kg/cm^2 to 60 kg/cm^2) for separating low molecular weight species from a feed stream. The pore size 5-20 Å**,** typically will reject 99% of most ions and most organics over 150 molecular weight cut off.

Popat, (Ion-Exchange Waterleau) states that Reverse Osmosis is also the most acceptable method for colour removal from spent wash. An experiment was conducted using Disc and Tube module. The spent wash was steadily split into two streams, clear colourless water and the other, a dark concentrated spent wash. The average proportion of the streams was 50 per cent. The quality of the clear water was equivalent to or better than the process water. The concentrated stream consisted on an average double the levels of COD, BOD and TDS. Many spent wash samples were tried out to account for their varying characteristics, depending on the geographical origin of the sugar cane. It was found that the results were consistent irrespective of the variations. The only difficulties found were in terms of interference of suspended matter, arising out of the MLSS in the spent wash stream coming out of the biogas plant and the smell of hydrogen sulfide, associated with the colourless water derived. Changing the point from which the spent wash was taken for processing solved this difficulty. The settling tank or the clarifier outlet gave much better results. The smell of hydrogen sulfide was easily removed by bubbling air by fish tank air bubbling device. Since hydrogen sulfide is a small molecule, it must be passing through the membrane. Being volatile and with less solubility in water, mere low pressure bubbling of air removed its contents, as indicated by the smell of thus treated permeate water. Encouraged by these findings, raw spent wash (i.e. without any biogas treatment) too was tried out and the results were found to be equally encouraging. In fact, the raw spent wash posed lesser difficulties in terms of suspended solids & hydrogen sulfide, for obvious reasons. The membranes are not thermally stable, hence raw spent wash was required to be cooled to ambient temperature. Some samples of the concentrated spent wash, obtained by the above technique were sent to verify their suitability for composting. The results were encouraging to show that the same can safely be composted.

Thus, it can be concluded that the above mentioned specific membrane configuration has the distinct ability of processing both the raw and biogas treated distillery spent wash, to obtain two streams, one containing clear and colourless water and the other a concentrated spent wash. Their quantitative proportion was average 50: 50. Thus the processing of the spent wash by this technique offers an opportunity to reduce the volume by 50 per cent, facilitating its convenient composting. The overall press mud and land requirement also is reduced to 50 per cent, thus saving operating cost. The clear and colourless water may offer another opportunity to recycle the same, which could be a great boon to distilleries operating in water scarce areas or those spending large amounts of money for their water supply. Alternatively it can simply be given to irrigation to benefit the farmers.

Dave *et.al.* 2013 concluded that Nanofiltration followed by RO hybrid process could be successfully used for the removal of TDS, Colour and COD of spent wash. At a feed pressure of 20 Atm. and flow rate of 10 litres/minute a rejection efficiency of 97% TDS, 99.8% colour and

99.9% COD was attained. The following characteristics were demonstrated.

Table 6–Characteristics of distillery spent wash after treatment through Nano filtration followed by Reverse Osmosis

S.No.	Parameter	Spent Wash	N.F. Permeate	R.O. Permeate
1	PH	3.2	6.5	6.4
2	TDS (mg/L)	36780	5517	1103
3	Colour pt.co.scale	760	7	1
4	COD (Mg/L)	132000	6600	125

Patil S.V. 2014 suggests that in so far as the distillery effluents are concerned, the disc and tube membranes have been quite successfully used and that there are about 100 distilleries in India which are operating R.O. plants to treat either anaerobic digested vinasse or raw vinasse. The permeate recovery has been reported as 45 to 55% in case of Anaerobically digested Vinasse and 35 to 45% in the case of Raw Vinasse. In five distilleries studied, Anaerobically digested vinasse permeate exhibited a COD to range from 84.0 mg/L to 392.0 mg/L and TDS from 600 to 3500 mg/L. TSS was reported as nil and PH 6.3 to 8.6. The raw vinasse permeate indicated a PH of 2.9, C.O.D. of 620 mg/L, TDS of 400 mg/L, TSS of 220 mg/L. The permeate can be recycled after proper treatment (aeration to remove dissolved gases and activated carbon treatment) as made up water for cooling towers or for molasses dilution. The operational cost is slightly less than the M.E.E for 50% reduction.

The Office of the Principal Scientific Advisor to the Government of India, 2014, suggests that the RO process has been used commonly for advanced treatment of wastewaters to remove dissolved inorganic solids and some recalcitrant compounds. Its use to recover good quality water from polluted waste such as SW is recent in India. This has been made possible due to development of new membranes and membrane module configuration, which allow easy accessibility for cleaning and replacement of membranes.

The majority of the dissolved salts, low molecular weight organic materials, heavy metals, bacteria, viruses and suspended solids etc. are retained by the membrane and are discharged from the system with the brine. A RO membrane typically will reject 99% of most ions and most organics over 150 Molecular weight cut off (MWCO). High pressure of about 35 to 100 atmospheres is required in order to overcome the high osmotic pressure across the membrane for brackish and seawater. For distillery effluent treatment, the disc and tube type membranes have been quite successful.

1.2.5.4 Concentration and Incineration

The Technical Environmental Assessment (EIA) manual guidance for distilleries, (2010) suggest that for standalone distilleries

The concentration and incineration technology has been also adopted by some distilleries in UP, Maharashtra and Karnataka. There are no guidelines developed for boilers. However, the following issues may be considered while adopting this technology.

- Sludge from fermenters/settled sludge from storage tanks which may be around 3-5% of spent wash quantity shall have to be treated/disposed.
- The condensates from the evaporators while concentrating spent wash would have COD concentration between 10,000-15,000 mg/L, which needs to be treated.
- The pH of condensate is around 4.0-4.6 which requires neutralisation. The quantity of condensate generated may be around 50-55% of the effluent quantity generated.
- The suggested treatment for condensates may be biological such as anaerobic followed by aerobic treatment and recycling it as make up water after treatment on RO principles.

- The sludge from biological treatment/reject from RO shall have to be treated either by composting or land fill or any other suitable method.

Ravi, (2013) has stated that the concentration – incineration process for the distillery spent wash treatment has received a lot of attention in the past. The notable efforts and methodologies have been adopted by some of the suppliers, e.g. Praj Industries Ltd, Pune, Thermax, Pune and Kinetic Technologies India.

Different systems varying in design details are available from the above mentioned suppliers. The basic flow sheet of the process is:

(1) Receiving Vessel
(2) Evaporators
(3) Furnace or combustion chambers
(4) Scrubbers for flue gases
(5) Solid ash handling systems.

During the concentration and incineration the large quantum of spent wash is reduced by increasing the viscosity then finally it is dried as ash in furnace chambers to let out as solid material. For concentration and incineration enough steam shall be supplied to the process and partial heat recovery can also be made from process. Scaling and corrosion can be avoided by specified technology adopted. The economic viability of this kind of process helps the industry to think about the zero discharge and prevention from environmental deterioration. However the cost involved for the installation and maintenance of this process is high compare to some alternative technologies.

Suresh et al., (2011) state that concentrated spent wash at 55 to 60 per cent solids or spent wash powder can be used to run a specially designed boiler with or without subsidiary fuel. Steam generated can be used to run a steam turbine to generate electricity and exhaust steam can be used for distillery and evaporation plant operation. The overall system becomes self-sustaining after initial stabilization period. This is a zero pollution system with generation of ash from spent wash. It has been found that the concentration and incineration system of spent wash disposal is not economical for distilleries below 60 Kilo litre per day (KLPD) capacities.

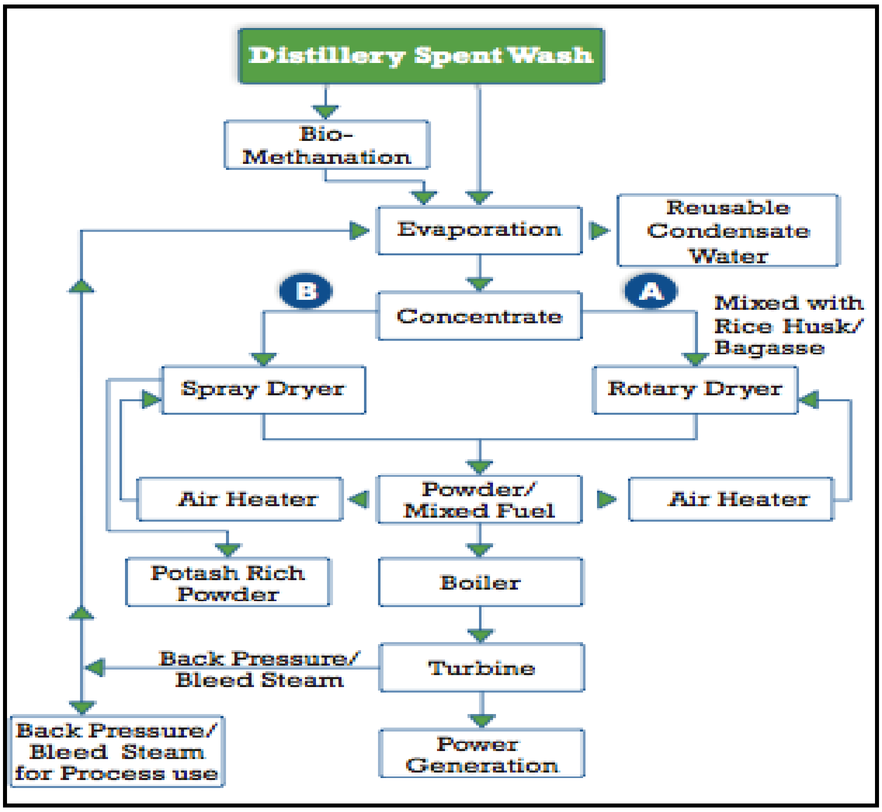
Suresh et al., (2011) state that in MEE the evaporated water is recycled back to fermentation process and concentrate is mixed with the suspended solids separated in decanter. This mixer is rich in nutrients solids and can be used as animal feed. It is called as distiller's wet grain stillage (DWGS). It has high moisture content and putrefies very easily. It increases the shelf life if it is being dried by steam. Distillery can achieve the Zero Discharge Limit through adopting MEE.

SSP Private Limited has innovated the process for treatment of various industrial effluents with economical operation and discharge qualities to meet the stringent pollution control norms. It attempted to reduce the quantity of effluent to maximum possible extent by use of a multiple effect evaporator. Direct spent wash as well as bio-methanated effluent is concentrated in a multistage vacuum evaporator from 4-6 per cent to 40-60 per cent solids. The total process is under vacuum and the vapours generated in the system are compressed in a TVR to economize steam consumption. Condensate water generated from the evaporation system is clear and recyclable for the process. Typical analysis of condensate water is given in Figure 2.

Particulars	Bio-methanated	Direct Spent Wash
BOD	75-100	400-600
COD	200-350	1500-2000
pH	7.0-8.0	3.5-4.5

Figure 2: Typical analysis of condensate water.

Figure 3 illustrates a zero liquid discharge system for molasses based distilleries.



Scheme A entails treatment of direct spent wash. The concentrated effluent is mixed with bagasse/rice husk and dried in a Rotary Dryer to generate mixed fuel. This mixed fuel is burnt in a boiler to generate high-pressure steam.

Scheme B involves treatment of bio-methanated effluent. The concentrated Bio-methanated effluent is dried in a Spray Dryer. The powder generated from spray dryer is mixed with coal and the mixture burnt in a boiler to generate high-pressure steam. It can also be marketed as potash rich fertilizer.

High-pressure steam generated from both the scheme can be used in a turbine system to generate power. The bleed/ backpressure steam is used from the turbine as a heating medium in evaporation system and the generated power is used to meet the power requirement to operate the evaporation and drying system. Surplus power and steam will be available for distillery operation and other uses.

The European Commission (2006) suggests that alcohol can be produced by the fermentation of molasses from sugar beet processing. The slops have a high BOD of 18,000 to 22,000 mg/L. These can be concentrated in multi effect evaporators and processed to obtain vinasse and salts containing Potassium Sulphate. The vacuum evaporator achieves a dry matter content of 70 per cent, which is then centrifuged to separate the vinasse from salts. Vinasse is dark brown syrup containing all inorganic substances and is used in animal feed while the salts are used as potassium fertilizers. The condensed vapours from the slops are passed through cationic exchanges in the E.T.P. to eliminate the ammoniums. The process gives rise to Ammonium Sulphate, which is returned to the evaporator so that the potassium in the slops can be converted to Potassium Sulphate.

Shivaraj Kumar *et.al.* 2017 estimate that spent wash treatment through concentration involves an expenditure of 400% of the distillery cost while anaerobic digestion with biogas recovery followed by aerobic polishing and direct wet oxidation of stillage by air at high temperature (with generation of steam) followed by aerobic polishing and secondary treatment may require an investment of 200 to 300% of the distillery cost.

Apte and Hivarekar, 2014 have stated that the condensate generated through volume reduction of Distillery spent wash in multi effect evaporators contains large amounts of volatile organic compounds because of which the COD is high and could be in the range of 8000 to 10000 mg/L. However, the liquid is clear and hence if treated properly can be utilised as a source of raw water. For a 300 KLD distillery the authors estimate the volume of MEE condensate generated as 800 to 1000 M^3 with a BOD of 3000 to 6000 mg/l.

Spent leese is also expected to be generated at a rate of 200 to 300 m3/day for a 300 KLD distillery. Spent lees generated from the recovery columns of the distillation process may get contaminated with rogue alcohols which get entrained in the Spent lees. This may cause the COD of the Spent lees to vary from 8000 to 16000 mg/L and BOD from 4000 to 5000 mg/L. The characteristic of the condensate and spent lees depict the need of biological treatment. The authors have suggested a biological treatment scheme for 1200 m^3/day of condensate and spent lees with the following unit operations –

(a) 1 day capacity holding lagoon for spent lees and condensate.

(b) Equalisation tank with a retention of 8 hours.

(c) CSTR anaerobic Digestor with pump sparging instead of the conventional agitator based mixing system. The mixing speed was kept at 4 times the inlet flow. The digester after stabilization was continuously fed with effluent for 190 days.

(d) Degasser tower for maximum removal of entrapped gases like NH_3, H_2S etc. which could be toxic to bacteria in the subsequent aerobic process. The degasser was based on diffused air system.

(e) Lamella clarifier to aid in settling of the not easily settleable anaerobic sludge through plate based settling.

(f) Two stage aeration- clarification system based on the Activated sludge process. An extended aeration ASP system working on a low F:M ratio was utilised in two stages. The second stage of the extended aeration system acted more like a tertiary system rather than an extensive biological treatment.

(g) Tertiary Treatment through a multimedia filtration unit for removal of any trace suspensions and an Activated carbon filter to cope with any colour or trace organics was provided.

The authors have claimed that the water after this extensive treatment was enough to replace the water demand of the distillery by almost 80%. The treated effluent was used in fermenter make up, cooling tower make up and other non critical processes in the distillery. The amount of investment required for the project was about 1 to 2% of the capital cost of the Distillery and which can reduce the expenditure of the factory on water considerably. An overall COD reduction efficiency of more than 96% has been indicated.

According to **Patil S.V. 2014**, multi effect evaporation is a cost effective method for water removal and technology exists for concentration upto 30% and a consequent reduction in volume of Vinasse. MEE plants are however susceptible to scaling which may be difficult to remove and the process condensate requires polishing treatment. MEE plant vinasse with a solid content of 33.0 to 34.0% may have a BOD of 96000 mg/L COD of 292000 mg/L and TDS of 280000 mg/L.Spray evaporation has been used in some states and a single spray evaporator unit can operate about 100 to 150 m^3 of water/day. Although it is a low cost technology, there are chances of suspended particles getting carried over to the nearby areas. State Boards are not allowing this method of Vinasse disposal.

Patil, S.V., 2014 states that concentrated Vinasse at 55 to 60% solids or vinasse powder can be fed in a specially designed boiler with or without subsidiary fuel. Steam generated can be used to run a steam turbine to generate electricity and exhaust steam can be used for the distillery and evaporation plant operation. This technology is however not well established in India.

The Office of the Principal Scientific Advisor, 2014 has held that BMSW is rich in potash and nutrients and wasting the BMSW is not desirable since the country depends on import of potash. However, recovery of potash from spent wash by evaporation and incineration would not be an economically viable option. R&D on alternate technologies to recover the potash exclusively from BMSW is recommended. Distilleries are not positive about this technology due to the high capital cost coupled with high maintenance costs. Even after incineration of BMSW, the safe disposal of ash generated with high concentration of inorganic salts will still be a problem.

They also recommend that Multi Effect Evaporation is a cost effective method of removal of moisture. Both biomethanated spent wash (BMSW) and raw SW can be fed to the evaporator. Steam used in the evaporation process and the evaporated water from the SW feed form the condensate or the recovered water. In case of MEE's, steam jet ejectors or Thermo vapour compressors (TVR) are used to increase the thermal efficiency. Types of MEE's used in distillery industry are: Falling film evaporators, Forced circulation evaporators, Fluidised bed evaporators, Combination of falling film and forced recirculation evaporators, Integrated evaporators (in which ethanol vapours are used as heating media).

The report maintains that, concentrated SW at 55 to 60% solids or SW powder can be fired in a specially designed boiler with or without subsidiary fuel. Steam generated can be used to run a steam turbine to generate electricity and exhaust steam can be used for the distillery and evaporation plant operation. It is also possible to concentrate SW upto 40-50% solids. Concentrated SW (40-50%) can be mixed with a suitable biomass (rice husk, bagasse etc.) and dried in a rotary dryer to about 75-80% solids. The dried material can be used as fuel in a specially designed boiler. Presently, there are about 30-35 incineration plants in different distilleries. But the technology is not yet well established in the country and there are some bottle-necks as mentioned below to be overcome before it can be implemented in a successful way.

(i) There are inherent challenges of ash deposits and clogging in the heat transfer areas of the incinerator.

(ii) Boiler cleaning frequency is ranging between 10 to 25 days. Due to frequent stoppages and the cleaning process, the incinerator undergoes a cyclic thermal shock resulting in reduced life of the equipment.

(iii) Boiler is economical for distilleries above 60,000 liters per day capacity.

(iv) Very high capital and operating cost.

(v) Can lead to air pollution problems if not properly designed. Possibility of emissions of Dioxins, Furans and PAHs etc.

1.2.5.5 Coprocessing

The CPCB document of 2011 (Suresh et al.,) states that the co-incineration initiative suggested burning concentrated spent wash as fuel in cement/steel industries along with other fuels/raw materials. The co-processing of spent wash concentrate in cement kiln has been investigated by CPCB and draft guidelines for the same has been prepared. Co-processing of spent wash concentrate in cement kiln has following benefits:

(i) Wastes are destroyed at a higher temperature of around 1200-1400^{0}C and longer residence time.

(ii) Inorganic content gets fixed with the clinker apart from using the energy content of the wastes leaving no residue behind.

(iii) The acidic gases, if any generated during co-processing gets neutralized, since the raw material in cement kiln is alkaline in nature.

(iv) Such phenomenon also reduces resource requirement.

The report acknowledges that even though the initial trials appear to be encouraging, the effect of inorganic constituents in spent wash on the finished product is to be assessed and the applicability of the technology for distilleries, which are located far away is to be assessed in terms of cost effectiveness.

The Office of the Principal Scientific Advisor to the Government of India, 2014 mentions that latest guidelines on co-processing of SW in cement plants/kilns have been issued by CPCB. It involves concentration of SW to 30 to 60% solids at the distillery plant by installing a MEE plant, transporting the concentrated SW to the cement plant and incineration of concentrated SW in the kilns of the cement plants. However, the ratio of cement plants-power plants to distilleries is very less in many states. This makes the technology highly cost intensive due to heavy elements of transportation and storage at both ends. (It also presents a risk of added Air Pollution and high investments in changed design for boilers and Air Pollution Systems)

1.2.5.6 Spent Wash Disposed in Seawater

Disposal of treated effluent in seawater is one of the methodologies to achieve zero discharge. In all distilleries, a biomethanation plant is installed for treating the spent wash primarily. After treatment this treated effluent shall be pumped into the sea by pipeline in to the sea. This can be accomplished without further secondary treatment. The sea eliminates all the pollutant in the treated effluent.

A CPCB document titled 'Management of Distillery Wastewater' (2001) reported that disposal of wastewaters in estuarine water and sea is a feasible alternative provided that

- Such disposal should not interfere with the traditional uses of the water body
- It should not cause environmental nuisance, result in depletion of oxygen in the mixing zone or degrade the existing ecological regime
- There is no biological accumulation of trace toxic substances, which may be present in the waste.

The distillery spent wash does not contain any toxic substances and its disposal in the saline environment of the receiving water will not cause any problem. In order to ensure that it does not cause any depletion of oxygen, the spent wash should be sufficiently treated and diluted for reduction of BOD prior to disposal through a submerged diffuser outfall. The diffuser should be so designed as not to result in any appreciable reduction of the dissolved oxygen in the mixing zone.

1.2.5.7 Other Technologies

The Central Pollution Control Board (2008a) approved the following recommendations for achieving zero discharge.

- Proposals for establishing stand alone distilleries involving composting, ferti irrigation and one time land application of spent wash may not be considered by SPCB/PCC and MoEF.
- Proposals for establishing distilleries attached with sugar mills may be considered if they follow one of the following options-
- Bio methanation followed by bio composting.
- Reboiler/Evaporation/Concentration followed by incineration of concentrated spent wash in boiler (for power generation).
- The proposals of existing stand alone distilleries for increase of production/ expansion based on composting, ferti irrigation and one time land application of spent wash may not be considered by SPCB/PCC/MoEF.
- The existing distilleries (both stand alone and those attached with sugar units) that are not complying with the required environmental standards may be asked to switch over to emerging technologies from the existing technologies of composting, ferti-irrigation and one time land application of spent wash in a time bound manner.

The CPCB appeared to have taken this view on the basis of the management problems associated with bio composting and Ferti-irrigation. It has not recorded any discrepancies in utilizing PTSW for one time land application.

The CPCB has also found similar management problems with RO systems and Multi Effect Evaporation (MEE) followed by incineration and suggested co-processing as an emerging alternative technology, although it attributes management concerns to this also.

Singh Yashpal 2017 has stated that the National Green Tribunal in its judgement passed on 13-07-17, has restrained the regulatory authorities from prescribing zero Liquid Discharge and online monitoring systems across the Board. Instead the regulatory authorities have been asked to ensure that the standards are met and ZLD, if necessary, applied on a case to case basis after giving due consideration to technology, financial viability, limitation of the unit and the processes adopted by the Industry but in all cicumstances, ensuring that the discharge of effluents from the unit has to be in strict conformity to the prescribed standards.

The Office of the Principal Scientific Advisor to the Government of India, 2014 has listed that to concentrate spent wash and reduce effluent generation, reboilers along with distillation column have been installed by some of the old atmospheric distillation based distilleries as well as all new MPR distillation based distilleries. Use of reboilers results in indirect heating of distillation columns and restricts the mixing of steam condensate with spent wash. Steam condensate can be recycled as boiler feed water or can be used as process water. Reboilers coupled to multipressure distillation systems have resulted in direct reduction of spentwash quantity by about 2.0 liters per liter of alcohol produced.

To concentrate the spent wash as per the requirement of downstream bio-methanation or bio-composting systems, Integrated evaporation plants are now being installed in distilleries. Integrated evaporation system uses alcohol vapours as heating media for heating the spent wash thus saving good amount of steam. Integrated evaporation concentrates the spent wash to about 22-27% solids from initial concentration of 12-14% solids depending on the type of fermentation system used, final alcohol concentration in wash and heat integration concept adopted.

Turbo Mist evaporators create a mist of small droplets by pumping Spent Wash through small diameter nozzles placed around the periphery of a duct through which air is blown. The unit is placed at the edge of a lagoon and the SW is pumped. The resulting mist forms a trajectory reaching as high as 18 m and going up to 55 m in horizontal direction. The large surface area of the mist results in evaporation depending on temperature, humidity and wind speed. Turbo-Mist evaporation has been used in some states for evaporation of SW. On an average a single turbo-mist evaporator unit can evaporate about 100 to 150 m3 of SW/day. This can be a low cost technology for disposal of primary treated SW. Since there are chances of suspended particles getting carried over in the nearby area depending on wind velocity and other factors, many State Pollution Control Boards are not allowing this method of SW disposal.

The report also says that gasification of spent wash is a recent technology being explored for complete destruction (zero pollution) of molasses based distillery spent wash. Gasification of coal or biomass is being investigated all over the world for various applications. The process involves controlled combustion of biomass. It is possible to gasify concentrated spent wash as such or in combination with other biomass and generate syngas in a specially designed gasification system. Sugar/distillery industry is the most suitable industry to source biomass such as spent wash, bagasse or sugarcane trash in terms of well-established supply chain. First commercial scale plant installed in Maharashtra has encountered several process and operational problems. Techno evaluation of this technology is necessary before adopting.

In an article on the **Application of distillery spent wash. 16 Chapter pdf (internet)** it has been stated that the use of sucrose containing distillery effluents also allows production of ethanol at low costs. Waste materials, such as effluent from pulp and paper mill and distillery industries, converted into sugars by pretreatment methods such as acid or enzymes are frequently used across the world. One of the most successful methods for ethanol production from distillery effluents is combination of the enzymatic hydrolysis of pretreated distillery effluent and fermentation in one step, termed simultaneous saccharification and fermentation using Bacillus species prior to S. cerevisae.

Bandyopadhya and Paul 2017 have carried out pilot plant studies on simultaneous decolourisation and crop cultivation. They have suggested that the pilot plant is capable to degrade COD to the tune of 96-98% and 98-99% respectively and the process presents a good ROI because of increase in crop yield more than two fold and also selling soil of the bed for terrace and kitchen garden.

Chandra, Ishwar et.al 2018 have reviewed the various treatment options for distillery spent wash viz. Biomethanation followed by irrigation, Biomethanation and secondary treatment followed by irrigation or disposal in surface water, composting with or without Biomethanation, Concentration and incineration with energy recovery. They have stated that the biological removal of colour from the anaerobically digested Spent wash is a plausible option to counter the negative impacts of most technologies. Phenolics (tannic and humic acid from feed stock), Melanoidins from Maillard reactions of sugars (carbohydrates) with proteins (amino groups), caramels from over heating sugars and furfurals from acid hydrolysis mainly contribute to colour of spent wash. The authors have studied the prospects of decolorization by capillary seepage system through mobilized whole cells incorporated in artificial soil bed and suggested bio methanation coupled with decolourisation and crop cultivation in artificial soil bed to be a novel design system which could deliver zero discharge with good ROI through crop cultivation. Pseudomonas fluorescence, Enterobacter, Aeromonas, Acinetobacter and Klebsiella have been reported to give a maximum of 44% COD reduction either singly or in combination. Several types of fungi have also been found useful.

Singh Sanjay *et.al.* 2016 have quoted **Mahimairaja and Bolan 2014** in suggesting that as bio methanated Distillery spent wash is full of renewable sources of energy, organic nitrogen and micro nutrients, it could be used as alternative feed substitute in feeding of dairy animals. There are other studies showing beneficial effects of feeding of distillery by products on nutrient intake, body weight gain, milk production and blood metabolites. **(Sun *et.al.* 2012, Al Tabib *et.al.* 2014, Tamani et.al 2014). Singh *et.al.* 2014** have also indicated that 10% of barley grains could be replaced with bio methanated distillery spent wash in the diet of growing calves without any adverse effect on intake, utilisation of nutrients and blood metabolites. The study was funded by the Dhampur Sugar Mills, Bijnor.

Chauhan and Dikshit (2012) have carried out a study in which pretreatment with coagulation and fungal application was given to post methanated spent wash in order that secondary treatment could be given without dilution. They also observed that coagulation with Polyaluminium chloride removed 62 per cent of the colour and 50 per cent of COD from the post methanated effluents. When exposed to fungal isolates 85 per cent removal of colour and 75 per cent removal of COD was observed.

Pawar, (2012) suggests that Electrodialysis Reversal (EDR) is an improvement over the original electrodialysis process. EDR is an electrochemical separation process that removes ions and other charged species from water and other fluids. EDR uses small quantities of electricity to transport these species through membranes composed of ion exchange material to create a separate purified and concentrated stream. Ions are transferred through the membranes by means of direct current voltage and are removed from the feed water as the current drives the ions through the membranes. This innovation improves both efficiency and the operating life of membranes. Ion exchange membranes are the heart of the membrane process. Cation selective and anion-selective membranes are alternately placed in a membrane. Distillery wastewater flows between the membranes, and when direct current is applied across the stack of membrane, positive ions move toward the cathode and negative ions move toward the anode.

Singh and Sharma (2012) state that Phragmites karka (a marshy wetland plant species) could tolerate a hydraulic loading of 300 m^3 per ha per day with a COD of 10,000 mg/L for 45 days during post monsoon periods (October to January). In the pre monsoon period (February to June) the biomethanated spent wash was treated effectively with an optimal hydraulic load of 500 m^3 per ha per day with a COD of 10,000 mg/L for 45 days. They conclude that various wastewaters can be utilized in forestry/biomass production. The biomass can also be utilized as fuel in biomass based power plants.

Farshi et al., (2013) have observed that electro coagulation processes applied to post methanated distillery effluents, using aluminum and stainless steel as anode and cathode are capable of removing color by almost 97.77%, COD by 70% in 3 hours and 99.4% color and 77.58% COD in 6 hours.

Mane and Kedar (2013) have concluded that the melanoidin content of spent wash is generally considered unsafe for the purpose of agriculture and hazardous to aquatic systems. They further state that melanoidin can be removed by using indigenous microorganism in a cost effective and time efficient manner. The authors have however used spent wash with BOD ranging from 157 to 430 ppm and COD from 152 to 432 ppm.

It is possible to gasify concentrated Vinasse as such or in combination with other biomass and generate syngas and biochar. **Patil S.V., 2014** refers to a gasification plant for treatment 500 m3/day of vinasse in combination with 60 t/day of Press mud. This gasification plant will generate 1 MW electric power and 3 to 6 t/day of biochar. No additional fuel will be needed after initial stabilization of the plant. The whole gasification process will also result in zero pollution/zero discharge. Syngas can also be sued to produce various value added products.

Seixas *et.al.* , 2016 studied the clarification of vinasse by a combined treatment of Coagulation/Flocculation followed by an adsorption process on activated carbon. Tannin –Tanfloc was used as a natural coagulant. On the best conditions (350 ml of tannin solution per litre of Vinasse and 30 minutes of sluggish mixing) the coagulation flocculation process removed 88% of colour, 95% of turbidity and 47% of COD. This clarified solution was subjected to adsorption process that provided an additional decrease of 19% of the COD of the clarified effluent. However there was a slight increase in the colour and turbidity due to proliferation of yeast cells during adsorption. Coagulation/Flocculation could not remove the phenolic compounds. The adsorption process was not observed to be efficient because the proliferation of yeast hindered the effluent clarification.

Balar K.P. *et.al.* 2016, have examined the compressive strength and water absorption capacities of Flyash bricks where spent wash is replaced for water. They found the 100% spent wash treated bricks gave higher strength at the end of 56 days as compared to standard flyash bricks.

NEERI 2015 describes the HRTS technology to state that, HRTS is a land application system wherein the waste water is applied in specially designed field layouts with wide ridges and furrows. Trees with a high transpiration rate are planted in the ridges while the wastewater is allowed to flow through furrows. The high transpiration rates provide a biopump. As all the waste water is utilised in the process, the ground water pollution is obviated. In addition to this, artificial filter media and leaf fall from standing plants provide a thick mat and forms a filter bed which is responsible for retention and assimilation of colour. NEERI recommends that the treatment and disposal of waste water through HRTS provides a cost effective and environmentally acceptable solution to manage the problem of coloured waste waters. The plants work as a biopump, the bed removes colour and the soil acts as a biochemical reactor. The HRTS system has various environmental benefits ranging from waste treatment, reuse of effluents, biomass production, prevention of water pollution. Plants also provide a sink for air pollutants. The HRT system is ecofriendly because it works on natural principles.

Singh and Sharma 2012 have suggested the optimal subsurface loadings of Phragmites karka to tolerate distillery waste water and achieve sustainable zero discharge. The pilot investigations have established that the subsurface loading into soil marix of these plants could treat a hydraulic load of 300 m3/ha/day with a COD of 10000 mg/L during the post monsoon period (October to January). In the period prior to monsoon (Feb to June) the BMSW was treated effectively with an optimal hydraulic load of 500 m3/ha/day with a COD of 10000 mg/L.

The Energy and Resources Institute (TERI) 2018 has tried its High Rate Transpiration Technology (HRTS) to reclaim the effluent loaded site of a distillery in Madhya Pradesh. The technology employs mycorrhizae and a few other useful microbes to restore greenery. HRTS is a land application system wherein effluents are used in carefully designed layouts with wide ridges and furrows and trees that are bestowed with higher-transpiration capacity grown on ridges. A selected species of mycorhizza is applied in the HRTS model, depending on the soil and waste water chemical properties. Plants were grown on solar dried beds using certain species of mycrorhizae that collect and supply essential micronutrients from the effluent loaded soils to the plant. The experiments of **Singh S.K *et.al.* 2008** have suggested that HRTS (High rate Transpiration System) having coconut husk as a bedding material could successfully treat the biologically treated distillery effluent with an average COD load of 0.686 and 2.88 ton/ha/day during the post and pre monsoon periods respectively. There was no significant increase in the organic carbon content of the soil irrigated with Biologically treated distillery effluents. The leachate was within permissible limits. The colour removal was 99 to 100% and BOD and COD were possible to treat with optimum hydraulic loading of biologically treated cdistillery effluents through HRTS planted with Dendrocalamus strictus.

Jatropha plants were sown in effluent disposable lands using HRTS technology to reclaim the distillery effluent loaded site of a distillery in Madhya Pradesh India. The technology employs mycorrhiza and a few other useful microbes to restore greenery. It offers enhanced loading of effluents in unit land area, lower level of ground water contamination and reduced land pollution of the adjoining lands. The mycorrhiza makes available some nutrients from the effluents to the plants thus controlling ground water pollution. Plants were grown on solar dried beds using certain species of mycorrhizae that collect and supply essential micro nutrients from the effluent loaded soil to plants. **Adholeya and Singh, 2007**.

Das Manab *et.al.* 2018 suggest that the arbuscular mycorrhizal (AM) symbiosis which is an ancient interaction between plant roots and Zygomycetous fungi is recognized to benefit plants under environmental stress conditions. The system enhances the interface between plants and the soil environment through extra radical fungal mycelium (ERM) radiating from the colonized root cortex far into the surrounding soil and contribute to plant uptake of macro nutrients and micro nutrients. Mycorrhiza not only provide the plants with water and mineral compounds and help to improve the structure of the soil but have also been shown to act as filters, blocking Xenobiotics within their mycelium resulting into reduced toxicity to plants. They influence the physiology of their host plants making them less vulnerable to pathogens, soil pollution, salinity, drought and a number of other environmental stress factors. AMF (Arbuscular Mycorrhizal Fungi) also directly help the plant to escape from the buildup of phytotoxic concentrations of certain pollutants by secreting specific detoxifying compounds (organic acids). Mycorrhizal fungi are a direct link between soil and roots and consequently of great importance in phytoremediation where it also contributes by biodegradation of contaminatnts in organically contaminated sites.

Malairajah, 2017 used Bio carbon produced by shade drying and charring of garland daisy plants interlaced with inert silica as support material as an adsorbent to treat spent wash with a BOD of 3850 mg/L and COD of 8700 mg/L. He has concluded that bio carbon technology is an ecofriendly technique and can be used for treatment of any type of industrial waste water.

Dhavale and Bhosale 2017, have reviewed the various technologies on distillery spent wash treatment as researched by 12 authors.

1.2.6 The National Green Tribunal And Imposition Of Zero Liquid Discharge In Distilleries

1.2.6.1 General

The issue of imposing concentration and incineration as the sole viable technology for spent wash treatment and disposal was raised for the first time at the NGT in the matter of Krishnakant Singh vs. Simbhaoli Sugar Mills and others. Due to far reaching consequences, Distillery Associations got impleaded as a party and impressed upon the NGT to allow from the mix of all available technologies on a case to case basis rather than insist on a particular technology to achieve Standards.

The Central Pollution Control Board had also issued directions in 2015 that molasses based distilleries including yeast manufacturing units shall achieve zero liquid discharge of effluents. Bio compost was considered as an alternate method for achieving ZLD. (CPCB., F.No. B-410/PCI-111/DIST/NGRBA/2K14-2K15, Dec 7, 2015). The industries were directed to achieve zero liquid discharge of effluent by following either of the two routes as follows.

(a) Installing systems for solids separation for reduction in volume of spent wash and evaporation-concentration or only evaporation concentration so as to reduce the volume to minimum 40% with 30% solid concentration and water conservation by using appropriate technology such as R.O. or M.E.E. or only M.E.E. by December, 31st, 2015, followed by bio composting with press mud from sugar industry.

Industries opting for bio composting were directed to ensure that –

(i) They have a valid registration/certification for the quality of bio-compost as per gazette notification S.O. 2776(E) dated 10-10-2015 under the Fertilizer (Control) Fourth Amendment order issued by the Ministry of Agriculture and Farmers Welfare from the Ministry of Agriculture/ concerned agency.

(ii) The storage of concentrated spent wash shall be restricted to thirty days equivalent of concentrated spent wash (40% by volume of spent wash generated)

(iii) The finished bio compost shall be packed in sealed poly bags super scribed with quality and composition of the bio compost along with the name of the manufacturer industries. Industries will not be allowed to sell bio compost in open tractor/trolleys.

(iv) The bio composting activity will be carried out only in covered processes.

(b) Installing systems for evaporation-concentration by using appropriate technology such as MEE and incinerator boiler (Slope fired/mixed with anxillary fuel etc.) using appropriate technology.

(c) Installing advance process technologies (continuous fermentation, multi pressure distillation, integrated evaporation etc.) for reduction of spent wash generation to 6 to 8 KL/KL of alcohol produced by March 31, 2016 followed by evaporation concentration and incineration using appropriate technology such as MEE and incinerator boiler.

(d) Industries opting for incineration were directed to restrict the impermeable storage of spent wash at any stage to 07 days of production. Excess facilities were to be leveled/dismantled.

Previous to this the CPCB had in January 2015 evolved guidelines for adoption of ZLD in distilleries (CPCB-400/PCI-II/2014-15 dated 19-01-15:Guidelines on Techno Economic Feasibility of implementation of Zero Liquid discharge (ZLD) for Water Polluting Industries. CPCB Jan.2015). The guidelines had proposed the following treatment options-

(a) Bio-methanation followed by R.O. /M.E.E. followed by incineration (slop fired)

(b) Bio methanation followed by RO/M.E.E. followed by drying (Spray Drying)

(c) Concentration through MEE followed by co-processing in cement/thermal power plant.

(d) Bio –Methanation and RO followed by MEE followed by bio composting.

It was recommended that ZLD is achievable.

The Central Pollution Control Board in India, **(CPCB.,Guidelines 2015)** had defined ZLD to refer to "Installation of facilities and systems which will enable industrial effluent for absolute recycling of permeate and converting solute (dissolved organic and inorganic compounds/salts) into residue in the solid form by adopting method of concentration and thermal evaporation. ZLD will be cognized and certified based on two broad parameters that is, water consumption versus waste water reused or recycled (permeate) and corresponding solids recovered (percent total dissolved/suspended solids in effluents).

Later, the Ministry of Water Resources, River Development and Ganga Rejuvenation issued a notification no. S.O.3187 on 7-10-16 which, at rule 6, prohibited the discharge of any untreated or treated sewage or sewage sludge, trade and industrial waste, biomedical waste or other hazardous substances into the River Ganga or its tributaries or its banks directly or indirectly .

As stated above, the issue of imposing concentration and incineration as the sole viable technology for spent wash treatment and disposal was raised for the first time in the matter of Krishnakant Singh vs. Simbhaoli Sugar Mills and others. Due to far reaching consequences, Distillery Associations got impleaded as a party and impressed upon the NGT to allow from the mix of technologies on a case to case basis rather than insist on a particular technology to achieve Standards. The NGT in its orders passed in the above matter (Case no. 299 of 2013) on 16-10-14 specifically observed that:

> "The other contention that Board and or MoEF have even permitted other sugar/distillery industries to adopt the process of bio-composting and bio-methanation, suggesting that the imposition of condition of installation of incinerators is not necessary and is not uniformly complied. This contention is also without merit. Firstly, no person can claim negative discrimination and secondly, imposition of conditions by the

respective authorities while granting consent to a unit to operate has to be decided on case to case basis. It will depend upon technical data, location, activity of the unit and capacity of the unit to adhere to the prescribed norm that would amongst others be the criteria for granting and/or refusing consent to a unit. It was rightly contended by the Learned Counsel appearing for the various authorities that this would depend on the facts and circumstances of the present case. There cannot be a hard and fast rule for imposition of the conditions uniformly as various factors come into play while considering the application of the unit for grant of consent to operate. In the present case, it is an admitted position that the area of the unit is a low lying area and is surrounded by railway, road and canal on other side of the plot. This low lying area has been, according to Respondent No. 7, responsible for flooding of the area and thus, getting the molasses, spent wash and the press mud etc. getting mixed up with the flood water and thus, polluting both the surface and ground water. Despite its efforts, the unit has failed to become zero liquid discharge unit now for years. The unit cannot claim a right to pollute the environment indiscriminately and in perpetuity."

The NGT has further held that:

"---------even the documents published by the CPCB on Corporate Responsibility for Environmental Protection notices that an unit dealing with distilleries could be required to adopt any or combination of the following measures:

I. Compost making with press mud/agricultural residue / municipal waste

II. Concentration and drying/incineration

III. Treatment of spent wash through biomethanation followed by two stage secondary treatment and dilution of the treated effluent with process water for irrigation as per norms prescribed by CPCB/MoEF.

IV. Treatment of spent wash through biomethanation following by secondary treatment (BOD < 2500 mg / l) for controlled discharge into sea through a proper submerged marine outfall at a point permitted by SPCB / CPCB in consultation with National Institute of Oceanography (NIO), so that Dissolved Oxygen in the mixing zone does not deplete.

V. For taking decision on feasibility of one time controlled land application of treated effluent, a study will be undertaken within three months.

The road map for utilization of spent wash by the distilleries to achieve zero discharge in inland surface water courses will be as below:

50% utilization of spent wash--By March, 2004

75% utilization of spent wash --By March, 2005

100% utilization of spent wash—By December, 2005

Till 100% utilization of spentwash is achieved, controlled and restricted discharge of treated effluent from lined lagoons during rainy season will be allowed by SPCB/CPCB in such a way that the perceptible colouring of river water bodies does not occur."

The Tribunal goes on to observe that "This very document further provides that monitoring is essential and feasibility study for adoption of cleaner technologies should be undertaken. The bare reading of the above shows that anyone or a combination of the technologies stated above can be provided by the Board to ensure adherence to the prescribed standards."

This part of the order has not been contested by the Central Pollution Control Board.

The Central and State Pollution Control Boards had earlier also disallowed the use of distillery spent wash in the production of Biocompost. Distillery Associations(notably the All India Distillers Association and the U.P. Sugar Mills Association) mobilised timely discussions on the issue and drafted strong representations , discussed the matter at the highest decision making levels including the Ministry of Agriculture and convinced the CPCB to reconsider its decisions and allow biocomposting. Biocomposting has since been allowed.

The Central Pollution Control Board has now directed Industries opting for Biocomposting to comply with the following within the given time frame.

a. Obtaining valid registration/certification for the production and quality of bio-enriched Organic manure (bio compost) as per Gazette Notification S.No.2776(E) dated 10-10-2015 under the Fertilizer (Control) Fourth Amendment Order, 2015 issued by Ministry of Agriculture and Farmers Welfare (Deptt. Of Agriculture, Cooperation and Farmers Welfare) from the Ministry of Agriculture/concerned agency-within a time period of four months.
b. The final storage capacity of concentrated spent wash after R.O. & M.E.E. or only M.E.E., utilized in bio composting shall be properly lined and made impermeable and shall be strictly restricted to thirty days equivalent of concentrated spent wash (40% by volume of spent wash generated)
c. The finished bio compost shall be packed in sealed poly bags super scribed with quality and composition of bio compost along with the name of the manufacturer industry. Industries shall not be allowed to sale compost in open tractors/trolleys.
d. The bio composting activity shall only be carried out under covered premises.

The bio-organic manure (Distillery Bio-compost) is regulated under FCO norms which required a certificate to manufacture . This has now been relaxed by the FCO, for the ease of Distilleries through Notification no. 2339 dated 23.09.2016. Accordingly, Distilleries have to only obtain authorization letter from specified Government agencies to sell their Bio-compost as per specifications as laid down in FCO.

Distillery Associations had also represented against the provision of covered sheds for all seasons and their contention on the issue has been accepted by the regulators.

The NGT in its orders passed on 4th, January, 2016 in the matter of CWP 3727 of 1985, M.C. Mehta VS. Union of India and others, mentioned that they have been informed that ZLD and provisions of Continuous On Line Monitoring systems is difficult to achieve. The NGT had, therefore, directed the Central Pollution Control Board, Ministry of Environment and Forests, Ministry of Water Resources, Uttar Pradesh Pollution Control Board, Uttar Pradesh Jal Nigam, Uttar Pradesh Jal Sansthan and State of Uttar Pradesh to take and communicate a clear stand with regard to the matter.

The Ministry of Water Resources, River Development and Ganga Rejuvenation issued a notification no. S.O.3187 on 7-10-16 which, at rule 6, prohibits the discharge of any untreated or treated sewage or sewage sludge, trade and industrial waste, biomedical waste or other hazardous substances into the River Ganga or its tributaries or its banks directly or indirectly . This notification was also challenged by some Associations including the All India Distillers Association and the U.P.Sugar Mills Association. It was felt that that the prohibition, if applied to treated wastewaters, is not desirable environmentally, is not good for the river and is not required under law and that if the provisions as above are implemented they would result in stupendous unsustainable expenditures with a high Carbon lifecycle and have deleterious effects on the environment. They would also impact the economic competitiveness of the industries in Uttarakhand, U.P., Bihar, Jharkhand and Bengal in India. Disposal of treated effluents into inland surface waters plays a very important ecological role of maintaining the minimum flows in rivers and augmenting the self cleansing capacities. Asking industries which may not be abutting the Ganga but be considerably removed from it, not to discharge their treated effluents into any drain may be unsustainable and not conducive to achieving minimum flow requirements. Augmentation of flows is a standard practice for utilizing treated effluents. Directions restricting the applicability of this notification were passed by the NGT in its judgement of 13-07-17 in the Ganga Matter.

The Distillery Associations and UPSMA had also represented against ZLD and asked the NGT to allow the use of Biomethanated spent wash for One Time Controlled Land Application also. It was contended that no single technology or group of technologies can under present circumstances be applied to all the distilleries in the country as adaptability conditions differ from place to place according to the local climatic conditions, the terrain and topography and availability of land, equipments and labour etc. according to the location of the distillery and most importantly also the financial health of the unit. It was also contended that there is a need to develop and use a mix of treatment options with adequate protocols and guidelines so that spentwash can be gainfully utilized for biogas generation, bio-compost, ferti-irrigation, one time land application, irrigation, sodic land reclamation and co-processing on a case to case unit wise basis after carefully evaluating the technology in terms of local conditions, availability of land, sodic land, clinker manufacturing units and other furnaces etc.

Biocomposting and use of spent wash in agriculture appears to be the most environmental friendly and ecologically sustainable technology as it regards the waste as a resource. The Distillery spent wash does not contain any toxic heavy metals and being of plant origin and because of its rich nutrient contents may serve as a good fertilizer for crops and the rich organic and inorganic constituents allow spent wash to bring remarkable changes in the physical, chemical and biological properties of soil. Spent wash could also be used for composting the trash in fields.

The CPCB in the draft guidelines submitted by it to the Honourable NGT in October 2015 had observed that the environmental performance of Distilleries adopting fertiirrigation, one time controlled land application and biocomposting exhibits a 60% non compliance. No technical flaw had been observed by the CPCB in the capability of the technologies as prescribed in CREP to meet the desired standards nor did it provide sufficient grounds to impose additional cost burdens on compliant units. The CPCB in this very document had stated that it is in view of the continuous non compliance that the CPCB is insisting all the existing distillery units which are not complying with the required environmental standards to switch over to emerging technologies from existing technologies of composting, fertiirrigation and one time controlled land application. The thrust of the guidelines therefore appeared to be to ask the non compliant units (beyond the standards as prescribed) to shift to emergent technologies and not to all industries across the Board. This has also been the intent of the NGT when it ordered that the regulatory authorities will have to prescribe technologies on a case to case basis.(Simbhaoli Judgement 2014)

The CPCB had estimated that an addition of 6-8 Rs. /litre of product cost shall escalate by installing the systems of MEE, RO+MEE with incineration. It was felt by the Associations that imposing these additional costs on industries already complying with the prescribed norms and having different technology criteria for different parts of the country will induce a competitive disadvantage to domestic products both in the National and International Markets.

The directions to prescribe ZLD introduced a policy shift which would have involved large scale changes and had a potential to create secondary environmental concerns needing an evaluation under the E.I.A. notification of 2006.

The standards prescribed for the disposal of distillery effluents under the E.P.Act of 1986, which are the law in force, still allow discharge of effluents with a BOD of 30 mg/litre and Suspended Solids of 100 mg/litre into inland surface waters and also allow disposal on land. Any effort beyond this is beyond compliance and as earlier practiced by the CPCB should be voluntary and consultative.

A study entitled, “Opportunities for Green Chemistry initiatives Molasses based distilleries”, by the **Office of the Principal Scientific**

Advisor to the Government of India, in 2014, favors bio composting and land application.

The major constraints on adopting incineration as felt by the Associations were:

- High capex of INR 60 crores approximately.
- Very high operating cost of INR 6-8 per BL. Of alcohol.
- Frequent failing of furnace refractory material which affects bed fluidization.
- Refractory repair is undertaken on a periodical basis and in addition to that once in a year entire refractory replacement is done.
- Heavy sludge accumulation in Spent Wash feed tank.
- Choking problem in boilers resulting in stoppages after every 20-25 days.
- Installation of special type of boiler is must which needs to be replaced every 3-5 years due to high wear and tear and quick erosion.
- Disposal of ash after effluent incineration is a concern.
- Incineration without the initial bio-methanation process deprives the distilleries of the opportunity to produce bio gas which is used by the distilleries as fuel instead of fossil fuels. While the use of biogas cuts on expenditure on the fuel expenses it also serves to keep the environment clean. Loss of Bio-Gas, is a huge loss for industry and environment.
- Incineration destroys all important nutrients which are available in the form of N:P:K in the bio-compost, which is an organic manure.
- Owing to above concerns, Incineration is not techno-economically feasible.

A draft notification on the prescribed standards for distillery effluents has been issued by the MoEF&CC (GSR 61SE) in July 2018**(MoEF&CC 2018)** and suggestions invited. The proposed notification includes imposition of ZLD on Distillery Industries and proposes to allow only concentration followed by incineration/ biocomposting for distilleries attached to Sugar Mills and only concentration followed by incineration for standalone distilleries. It fails to allow other technologies which have from time to time been established as viable technologies by the CPCB and are certainly more sustainable than concentration and incineration. Not using spent wash for land application and remediation of sodic soils could waste hundreds of millions of rupees and put additional pressures on fertilisers and water. The Distillery Association has drafted a representation and sent its suggestions to the MoEF&CC and CPCB. Through the said submission it has been requested, that distilleries on a case to case basis, to the satisfaction of the Pollution Control Board, be allowed to use from the mix of technology options so that spentwash can be maximally and sustainably utilized as a resource for biogas generation, bio-compost, ferti-irrigation, one time land application, irrigation, sodic land reclamation, incineration and co-processing depending upon local conditions.

The Honourable NGT has in Original Application No. 130 of 2016 (M.A. No. 416 of 2016), Social Action for Forest & Environment (SAFE) Vs.Union of India & Ors. directed that "No manufacturer will produce Absolute Alcohol without seeking appropriate permission from the Ministry of Commerce, Chief Controller of Explosives and other Authorities in accordance with law. It is in view of the fact that under the Manufacture, Storage and Import of Hazardous Chemical Rules 1989 and Chemical Accidents (Emergency Planning, Preparedness and Response) Rules 1996 as notified under the provision of the Environment (Protection) Act, 1986 such permission is required." A perusal of the said order suggests that the NGT has prohibited manufacture of Absolute Alcohol unless the said permissions are obtained. The order also directs that appropriate permissions should be sought from the Ministry of Commerce, Chief Controller of Explosives and other Authorities. The order also says that such permissions are mandated under the MSIHC Rules 1989 and Chemical Accidents (Emergency Planning, preparedness and response) rules 1996.

1.2.6.2 The National Green Tribunal discussions on ZLD

The Honourable NGT at para 145 of its judgement dated 13-07-17 in the matter of O.A. no. 200 of 2014 (C.W.P. no. 3727/1985) M.C. Mehta Versus Union of India has held that during the course of the hearing, various issues related to the imposition of ZLD have raised serious controversies. At para 147 it was brought to the knowledge of the NGT that the raw distillery effluent if directly concentrated and incinerated would not give beneficial results. It would lead to wastage of energy produced from non-renewal sources besides loss of nutrients present in the spent wash. It was also understood that Bio-composting, Concentration or incineration had not been tested and proven to be correct and environment friendly. The cost of the technology is very high, therefore economically nonviable. It would be impossible for the industries to adhere to this technology. Probably treated effluents could easily be used for irrigation purposes. The small scale Industries are not capable of meeting the ZLD and therefore, CETP would be the proper remedy. Primarily the comments of the Boards were primarily that the incinerator or bio composting or incitation (?) for spent wash and disposal is optional for the industries.

At para 148 of its judgment, the NGT has stated that “From the above discussion, on advantages and disadvantages of the ZLD, it is evident that ZLD cannot be adopted across the board. It must have rationality as its sole criteria, should be unit centric and industry specific oriented----------------------------. To apply same yardstick to all would not be feasible and result oriented. They should be assessed on their own performance and function, however, ensuring in all the situations that the effluents permitted to be discharged on land/drain etc. should be strictly adhering to the prescribed norms. The Board in its advisory capacity may be able to suggest or guide as to the integral technology, which may be feasible for the industries for attaining the prescribed norms. To impose ZLD on such industries would neither be fair nor just. In fact it would not be in consonance with the requirement of law under relevant acts. An industry should be permitted to operate, subject to grant of consent by the concerned board. The CPCB has the competency under law to issue directions under section 18 of the Water Act. The purpose of empowering Boards with certain powers is to restrict and control Pollution. It is not expected from the Boards to stop the natural growth or restrict industries from operating but compliance to the environmental laws is fundamental to exercise of their powers. The Board must take into consideration of the aspects including technology, financial viability, limitations of the unit, process adopted by the industries but in all events ensuring that the discharge of effluents from the unit has to be strictly in compliance with the prescribed standards.

The N.G.T. has further stated that "To put it simply the ZLD directives can not be applied across the board. On the one hand it would be violative of the rights of the parties while on the other hand would not be in consonance with the provisions of the relevant environmental acts. ZLD should be applied on a case to case basis. The concerned Boards should exercise its technical know how to issue appropriate directions in that behalf. The ultimate purpose is prevention and control of pollution and not an internal management of the plant. Effluent discharge must be strictly within the prescribed norms and the Board in appropriate cases could issue directions with regards to recycle, reuse of the treated effluent appropriately. The ZLD as inferred from the notification dated 07-10-2016 is incapable of being enforced across the board without reference to the Member Industries and other relevant aspects afore stated.

Similar directions have also been given at para 182.4 of the judgement which are specific directions with regards to zero liquid discharge, continuous emission monitoring system (CEMS) and on line monitoring systems.

Para 146 of the judgement refers to the notification issued by the Ministry of Water Resources and observes that-

"The MOWR has issued a notification dated 07-10-2016 which require that no person shall discharge directly or indirectly any treated or untreated sewage or sewage sludge into river Ganga, its tributaries or its bank. Similarly, it also prohibits discharge of treated or untreated trade effluent and industrial waste, bio medical waste or other hazardous substance both directly or indirectly into river Ganga or its tributaries or than banks.”

The NGT at para 182.4.7 of its judgement has specifically directed that “the ZLD as inferred from the notification dated 07-10-2016 is incapable of being enforced across the Board without reference to the Member industries and other relevant aspects fore stated.

1.2.7. Guidelines on Techno-Economic Feasibility of Implementation of Zero Liquid Discharge (ZLD) for Water Polluting Industries (Excerpted From CPCB 2015)

1.2.7.1. General Guidelines

It has been estimated that 501 MLD of industrial effluent is being discharged by water polluting industries through drains of tributaries into River Ganga. Water polluting industries (GPI), are mainly of industries discharging effluents having BOD load of 100kg/day or having toxic / hazardous chemicals. There are 2535 industries identified in Ganga basin which includes states of Uttarakhand [74] Uttar Pradesh [993], Bihar [40], Jharkhand [94] and West Bengal [147], Delhi [5], Madhya Pradesh [19], Chhattisgarh [26].

The industries have been persuaded to set-up effluent treatment plants & CETPs and operate them to meet with prescribed standards.

The industries identified as water polluting industries are: - Sugar, Distilleries, Pulp and Paper, Tanneries, Chemicals, Dyeing and Textiles, Refineries, Food, Dairy and Beverages, Electroplating and others. The water polluting industries discharge their effluent having high organic contents measured in-terms of bio-chemical oxygen demand (BOD), and other toxic constituents like metals, organic and in-organic compounds.

The systems available of treating industrial effluent are based on Physico-chemical and biological principles. The operation of effluent treatment plants requires technical skill and regular attention so to achieve compliance to standards for 24 hrs x 365 days.

Standards for compliance have been notified under the Environment Protection Act, 1986.The notified standards permit industries to discharge the effluents only after compliance. However, CPCB and SPCBs / PCCs now, are insisting industries to reduce water consumption and also take measures to not-to-discharge effluents. But, it has been observed that industries are not able to meet all time compliance standards and as a result, rivers like Ganga and its tributaries is carrying high pollution load and it is the dilution available in river water which helps in minimizing pollution load.

After having recognition of problems that many industrial sectors are not able to achieve standards and this ultimately necessitates to work towards Zero Liquid / effluent discharge standard.

Zero Liquid discharge refers to installation of facilities and system which will enable industrial effluent for absolute recycling of permeate and converting solute (dissolved organic and in-organic compounds/salts) into residue in the solid form by adopting method of concentration and thermal evaporation. ZLD will be recognized and certified based on two broad parameters that is, water consumption versus waste water re-used or recycled (permeate) and corresponding solids recovered (percent total dissolved / suspended solids in effluents).

Adoption of Zero Liquid Discharge system will be applicable to zero-down organic load, recover metals and other constituents. Direct installation of ZLD facilities may have technical constraints to operate specialized system. Pre-requisite for ZLD accomplishment would need physical and chemical treatment and followed by biological system to remove organic load. The treated effluents can be then subjected for concentration and evaporation. The concentration process as applicable can be adopted at appropriate stage. The concentration method quite often involves the adoption of Reverse Osmosis (RO) and Nano Filtration (NF) methods. The evaporation methods involve incineration/ drying / evaporation of effluent in multi effect evaporators (MEE).

In the process of achieving ZLD, solids recovered and these are to be utilized. However, in case of not used, they will have to be stored. Cost-wise, achieving ZLD will be costly proposition but, now becoming necessity because rivers need to be rejuvenated. A typical cost indicates that a CETP treating 1 MLD of waste water with conventional physicochemical and biological treatment is around Rs. 3.0 to 4.0 Crores with operation and maintenance cost of Rs. 300-350 per cubic meter (M3), Whereas, cost of combination of conventional ETP with ZLD facilities costs around Rs. 12.0 to 15.0 Crores per MLD. Now, the ZLD adoption is becoming essential rather than imposition.

The significant industrial sectors like Sugar, Distilleries, Tanneries, Pulp & Paper, Textile, Dyeing, and Dairy would need special emphasis for enforcement of ZLD. It is important to mention that in the name of ZLD, no forceful injection into ground water table is to be tried nor utilizing effluents / permeate for irrigation / or horticulture. ZLD would strictly means recycling treated effluent back for re-use in industrial / or domestic purpose but, exclude use / disposed in ambient environment. ZLD is applicable to industries having high BOD and COD load, colour bearing effluents, having metals, pesticides and other toxic / hazardous constituents.

ZLD can be achieved by adopting conventional primary, secondary and tertiary effluent treatment and polishing by filtration and using clean water back into process / or domestic use. In some case, Reverse Osmosis, Micro/Nano Filtration and concentrating with Multiple Effect Evaporators (MEE) can be employed. It has been quite often debated that employing ZLD route is energy intensive and having exorbitant cost / financial burden. But, it cannot be denied that in the present circumstances when ground water table is getting depleted and there is diminishing flow in rivers, permitting industries to discharge even treated effluents, does not seems to be environmentally acceptable proposition. However, industries will be at their technical wisdom and expertise to search for better ZLD achieving practice but with a caution that there will stern actions if, on the name of ZLD, un-acceptable practices are adopted.

In some cases, if any industry feels that a given process needs modification, stopped or substituted, they can do so but, in longer run, treated effluents cannot be disposed. It is also to be understood that in absence of ZLD, industry has to meet compliance with standards and the results through on-line effluent monitoring devices will be available with regulatory authorities and also in public domain.

Many industries which include Distilleries, Pulp & Paper (waste paper pulping), Textiles and Tanneries clusters operating through Common Effluent Treatment Plants (CETPs) have implemented ZLD systems.

1.2.7.2. Conclusion and Way Forward

i. The industries having high organic load and other refractory nature of pollutants will be requiring to adopt ZLD system.

ii. ZLD refers to a system which would enable and industry to recover clean water using back into industrial processes or domestic use and not subjecting to be disposed in ambient environment including use in industrial premises.

iii. Industries will have options to select technical system facilitating to achieve ZLD.

iv. Industries are liable to face closures if found violating the prescribed standards and not having installed on-line effluent monitoring devices where data will have to be available with regulatory bodies and also in public domain.

v. Sectors like Pulp & Paper will immediately adopt charter which will facilitate them to reduce pollution load and maximize reduction in water usage / consumption as well as reducing in quantity of effluent disposed. However, such industries shall be subjected to regular vigilance and followed by stern action in case of their noncompliance to the existing stipulated / notified standards.

1.2.7.3. Zero Liquid Discharge in Distillery

Distilleries generate large volume of high strength effluent called "spent wash", which is one of the recalcitrant effluent having extremely high COD (80,000-1,20,000 mg/l), BOD (40,000-60,000 mg/l), SS, inorganic solids, low pH, strong odour and dark brown colour. As per the effluent standards notified under the Environment (Protection) Rules, 1986, treated effluent from distillery shall have BOD- 30 mg/l for disposal into surface water bodies, or 100 mg/l for disposal on land for irrigation.

Most of the molasses based distilleries have installed anaerobic digesters and adopted following practices for spent wash management.

1. Ferti-irrigation
2. One time application before sowing of crop (Pre-sown irrigation)
3. Bio-composting of pre-treated spent wash

The problems associated with distilleries due to the currently used treatment methods of composting, ferti-irrigation and one time land application of spent wash vis-à-vis advanced technologies including evaporation, concentration, incineration of concentrated spent wash for power generation were discussed and made following recommendations:

A. Proposal for establishing stand alone distilleries involving comprising, fertiirrigation and one time land application of spent wash may not be considered henceforth by SPCB/MoEF/PCC.

B. Proposal for establishing distilleries attached with sugar unit may be considered if they followed one of the following options:

   - Bio-methanation followed by bio-composting; or

   - Reboiler/Evaporation/Concentration followed by incineration of concentrated spent wash in boiler (for power generation).

C. The proposals of existing stand alone distilleries for increase of production/expansion based on composting, ferti-irrigation and one time land application of spent wash may not be considered henceforth by SPCB/MoEF.

D. The proposals of existing distilleries (both stand alone and those attached with sugar units) that not complying with the required environmental standards may be asked to switch over to emerging technologies from existing technologies of composting, ferti-irrigation and one time land application of spent wash in a time bound manner.

During the last few years CPCB have made surprise visits under ESS programme in the molasses based distilleries in the Country, covering distilleries spread over the entire country and in different seasons. The outcome of this surprise monitoring of distilleries indicates abysmal environmental performance of distilleries adopting ferti-irrigation, one time land application and bio-composting with more than 60% cases of serious non-compliances. Ground water contamination, river water pollution and soil degradation due to mismanagement of spent wash with these practices have been reported across the country.

In view of these continuous non-compliances, Central Board is insisting all the existing distilleries (both stand alone and those attached with sugar units) that are not complying with the required environmental standards to switch over to emerging technologies from existing technologies of composting, ferti-irrigation and one time land application of spent wash in a time bound manner.

The following technologies have been supported for concentration of spent wash

(i) Anaerobic digestion – Biogas

(ii) Reverse osmosis RO) - Permeate/Reject

(iii) Multiple effect evaporation (MEE) – Concentrate/Process condensate

(i) Anaerobic digestion:

- Well established technology. Almost all distilleries have anaerobic digesters.
- Digesters designed for COD loading rate of 5 kg/m3/day has given best performance. CSTR and UASB based digesters are more suitable for molasses based distilleries.
- BOD removal efficiency- 85-90%, COD removal efficiency- 55-65%, Specific biogas generation (NM3/kg of COD consumed)- 0.45-0.55, Methane content of biogas- 55- 65%, H2S content of biogas- 2-4%

(ii) Reverse osmosis (RO) System:

- Spent wash volume can be reduced by 45-55% for BSW & 35-45% for RSW.
- Permeate can be used after pH correction. Hence, fresh process & non-process water requirement is reduced.
- Permeate recovery- BMSW: Average - 45 -55%, Raw SW: Average - 35 - 45%
- Permeate can be recycled after proper treatment as make- up water in CTs or for molasses dilution.
- Operational cost (about Rs.0.60 per cum) is slightly lesser than MEE plants.

(iii) Multi Effects Evaporator (MEE):

- Well established technology for concentration up to 40% solids, which can result in substantial SW volume reduction.
- Some MEE plants are susceptible to scaling above 2000 ppm SS in the feed.
- Process condensate requires polishing treatment before reuse in process and nonprocess applications.

- Integrated RSW evaporation can result in reduction of final SW volume to 3.5 to 6.5 lit./lit. without additional steam requirement depending on fermentation technology employed.
- Scaling is severe when product concentration is above 50% solids and it is extremely difficult to remove the scaling.

Drying/incineration of concentrated Spent wash can be achieved through :

(i) Spray dryer / Rotary dryer

(ii) Slop fired boiler

(i) Spray dryer/ Rotary dryer:

- Calorific value of dried powder is about 2200 Kcal/Kg, moisture content 4-5%.
- Disposal of dried power is not standardized. At some distilleries, it is used as supplementary fuel along with agro based fuel in boilers where as at some of the distilleries being sold as fertilizer.
- Distilleries with capacity of about 30 KLD to 45 KLD have been reported operating dryer system successfully and therefore viable option for small scale distilleries with capacities < 60 KLD.

(ii) Slop fired boiler:

- 55 to 60% solids concentrate or spent wash powder is fired in a specially designed boiler with or without subsidiary fuel. Steam generated runs a TG set to generate electricity. Exhaust steam is used in distillery and evaporation plant operations
- Overall system is supposed to be self-sustaining in terms of steam and power balance after initial stabilization period.
- Potash rich ash as a by-product.
- Slop fired boilers are in operation in India since 2006 and distilleries/ technology suppliers have reported addressing various bottle necks through improved design/ innovative technologies.

Spent wash can be effectively disposed off in the cement kiln system through coprocessing route to substitute coal up to 5% without adversely affecting the kiln performance and product quality. Co-processing of spent wash concentrate in cement kiln has successfully been put to trial run and can be adopted by distilleries, in lieu of captive slop fired boiler, for spent wash management to achieve zero liquid discharge, subject to the availability of adequate kiln capacity and necessary logistic arrangements. Co-processing could be a cost effective alternate option for attainment of ZLD by distilleries which have already installed evaporation-concentration facilities, depending upon their location suitability. However many cement plants are not keen in accepting the SW due to transportation/ handling/ storage/ scaling/ distance etc.

The suggested Technological Options for Achieving ZLD may include:

- Bio-methanation followed by R.O/MEE followed by incineration (slop fired).
- Bio-methanation followed by R.O/MEE followed by drying (spray/rotary).
- Concentration through MEE followed by co-processing in cement/thermalpower plant.
- Bio-methanation and RO followed by MEE followed by bio-composting.

1.2.7.4 Reproduction Of references made at the National Green Tribunal As Referred To In The Judgement Of 13-07-17 In Application No. 200 of 2014 (C.Writ Petition No. 3727/1985) (M.A. No. 594/2017 & 598/2017) in The Matter Of: M.C. Mehta Versus Union Of India.

ZERO LIQUID DISHCARGE (ZLD), CONTINUOUS EMISSION MONITORING SYSTEM (CEMS) AND ONLINE MONITORING SYSTEM:

In this judgement, the Tribunal is concerned with the identification and resolution of all sources causing contamination of river Ganga and its tributaries. The paramount source of pollution of the river is the effluent discharge from the industrial sectors. Regulation of industrial effluents introduced directly or indirectly into the river Ganga or its tributaries is a fundamental requirement for abatement of pollution. In segment-B, highly polluting industries like sugar, distillery, textile, tannery, paper mills and slaughterhouses, amongst others are located. These industries discharge treated or in majority of cases even untreated effluents into the water bodies. All industries are required to discharge their effluents strictly in accordance with the prescribed parameters. Violation thereof, leads to consequences including closure of the units in accordance with the law. Despite such serious consequences, the industrial pollution of the river has been on escalation, since past many years. There are apparent deficiencies in the effectiveness of the regulatory and supervisory regime, provided under various environmental laws in force in the country. One of the ways to improve the regulatory regime and to ensure that the industries should adhere to the relevant environmental laws was to enforce ZLD and online monitoring system. In fact, the CPCB had issued directions to the UPPCB under section 18(1)(b) of the Water Act, 1974 for seeking action plan from industries on implementation of ZLD in identifying industrial sectors in March–April, 2015. It had even issued guidelines for techno-economic feasibility of implementation of ZLD for water polluting industries in June 2015. It required that there shall be compliance with the environmental standards notified under Environment Protection Act of 1986 and to permit the industries to discharge effluents only after compliance. It was acknowledged that ZLD was a necessity and technically exigent. It was also stated that ZLD can be achieved by adopting conventional primary, secondary and tertiary effluent treatment and polishing by filtration and using clean water back into process or domestic use. It also provided an option to select the technical system facilitating achievement of ZLD. In other words, ZLD could be attained by recycling or by achieving no discharge at all by use of appropriate technology. Similarly, the CPCB on 5th February, 2014 had directed the State Boards to further direct the 17 categories of the industries which were highly/grossly polluting industries in Ganga River Basin States to install CETPs, common bio-medical waste treatment facility, common treatment storage, disposal facility of hazardous waste and to install online monitoring system covering 13 effluent parameters in relation to pH, BOD, COD, TSS, Flow, Chromium, Ammoniacal Nitrogen, Fluoride, Phenol, Cyanide, Temperature, AOx and 8 technical parameters, PM, CO, Fluoride, NOx, SO2, Cl2, HCl and NH3. In the directions, values thereof were even provided.

145. During the course of hearing, all these aspects raised serious controversies. Some of the stakeholders including the Industries Association, particularly, All India Distillery Association vehemently objected to the enforcement of these directions. Vide its order dated 17th February, 2016, the Tribunal noticed the presence of the various Associations like sugar, textile, tannery industries, etc., which were provided time to submit their written submissions in relation to attainment of ZLD and installation of online monitoring system if ordered across the board. In response to this, written submissions were filed on behalf of the various stakeholders as well as the Industries Associations. We may briefly examine the same. The challenges to ZLD on behalf of the All India Distillery Association is that the UPPCB had issued ZLD directions to member industries of the association on 4th March, 2015 stipulating Concentration and Incineration as the only option available to industries. It is stated that the CPCB and UPPCB had not considered the negative environment impacts, burden on natural resources, economic unviability, high capital cost and long term sustainability of the directions. It is stated that the directions would result in increase in the emission levels and substantially cause air pollution from pollutants such as PM 2.5, PM 10, RSPM, NOx, SOx and Hydro Carbons. The energy required for concentration system would be un-economical and at the same time would consume huge quantity of water, additional effluents generation as MEE. The concentrated distillery effluents incinerators are very inefficient in stack emission norms as Electro Static Separators are not installed due to technical feasibility and specifically high moisture in flue gases. The directions would result in substantial increase in greenhouse gases. Distillery effluent is a rich source of BOD and COD, which can be anaerobically treated to generate methane gas. Control land application is one of the most plausible

feasibility options that should be provided. It has been practiced in various countries including Brazil, South Africa, Indonesia, etc. One Time Controlled Land Application (OTCLA) should be applied instead of 'Ferti-Irrigation' as earlier directed by the Board. OTCLA would be applied in a controlled manner through tankers and shall be once in 3 to 5 years depending on the soil nutritional deficiency, rainfall patterns, groundwater levels and soil characteristics. According to the affidavit filed on behalf of the Industries Association, it is also stated that it acknowledges the cooperation of the CPCB in allowing Bio-composting as an alternative method of achieving ZLD. The bio-composting and use of spent wash for agriculture is most environmental friendly and ecologically sustainable technology as it records the waste as a source and prescribes a policy shift. The CPCB estimates that an addition of ₹ 6–8 per liter of product cost shall be escalated by installing the systems of MEE, RO+MEE with incineration. There would be different criteria for different areas in the country.

The MoEF & CC had filed an affidavit dated 4th November, 2016. It has been in compliance to the directions issued by the Tribunal. It is stated that ZLD is not insisted for those tanneries which are connected with CETPs. Any tannery unit attached with CETPs shall achieve the inlet and treated effluent quality standards as per notification dated 1st January, 2016. The stipulation of ZLD has been proposed for large scale units in environmentally sensitive/critical areas based on the approval of CPCB. Similarly, directions have been issued for large scale units of Textile Industries in relation to ZLD. It was intended to introduce self-regulation. It is also stated with regard to the concept of ZLD that there is no discharge of processed wastewater from the premises of the industries. It is to permit water resource by reuse, recycle and recovery to the extent possible. Similar stand has been taken by the MoWR. The UPPCB also filed a detailed affidavit answering the issue whether ZLD can be applied across the board in respect of all industries. It was stated that ZLD cannot be applied to all industries in segment-B. In relation to distillery units, after applying ZLD technology, the industries have become ZLD units. This seems to be factually incorrect. In relation to Sugar Industries, it is stated that notification has been issued providing the standards for discharge of treated effluent on the land. In respect of Textile Industries, the Notification dated 10th October, 2016 has been laid down and ZLD has not been insisted upon. In respect of Paper and Pulp Industries, no final notification has been issued and as per the Charter, the Paper and Pulp units which are using agro base as raw material has to treat black liquor and they could become ZLD with Chemical Recovery Plant, where black liquor is concentrated and evaporated. For tanneries, draft Notification dated 10th October, 2016 has been issued for comments and no final notification has yet been issued. The MoWR has issued a Notification dated 7th October, 2016 issued under section 24 of the Act of 1986 where it has been stated that every endeavour will be made to ensure that uninterrupted flow of water is maintained at all the times in the river and no person shall discharge anytreated or untreated sewage into river Ganga, its tributaries or on its bank, directly or indirectly. Similarly, restriction has been placed on industrial waste, biomedical waste or any hazardous substance. It needs to be noticed that there is contradiction in terms, not only between the two Notifications issued by the MOWR and MOEF&CC dated 7th October, 2016 and 10th October, 2016, respectively but also the principal statute, i.e., Water Act. The MoWR has issued a Notification dated 7th October, 2016 which requires that no person shall discharge directly or indirectly any treated or untreated sewage or sewage sludge into river Ganga, its tributaries or its bank. Similarly, it also prohibits discharge of treated or untreated trade effluent and industrial waste, bio-medical waste or other hazardous substance both directly orindirectly into river Ganga or its tributaries or their banks.

On the other hand, the Notification issued by MoEF&CC dated 10th October, 2016, provides that the treated effluent as well as sewage could be discharged into the water bodies provided it satisfies prescribed standards. The Notification, particularly, in relation to the Textile Industries prescribes the standards and states that in case of direct disposal into river or in the lake, stringent standards could be provided to the satisfied standards, as already noticed on similar lines in the draft Notification in relation to Tannery Industry. The provisions of the Water Act specifically permits discharge of trade effluents on land, drains, water bodies and other places if it specifies the prescribed norms. The Notification issued by MoWR, thus places a complete prohibition on discharge of sewage or trade effluent, which in terms is contrary to the statutory provisions of the Water Act and the Notification issued by the MoEF&CC in terms of Environmental Protection Act, 1986. The Notification issued by MoWR can thus hardly be given effect to and the ZLD concept proposed can hardly be complied across the Board. What probably was intended under the Notification of 7th October, 2016 was ZLD of the industrial units by ensuring recycle and reuse of effluents for irrigation, horticulture, industrial and cooling purposes. The other Notification provides a relaxation completely to various kinds of industries in relation to the effluent that such group of industries discharge. The Notification issued by MoWR cannot override the provisions of the Water Act, Environmental Protection Act, 1986 and other statutory Notifications. However, this Notification would have to be given its plausible meaning by holding that it suggests ZLD in the above terms but does not absolutely prohibit the discharge of the industrial trade effluent, i.e., In consonance with the prescribed standards. If the Notification is given in literal interpretation it may result in shutting down of large number of industries in the country, that certainly does not seem to be the intent of the Notification, particularly, in face of the enacted law by the Parliament. The purpose is to achieve the prescribed trade effluent and preferably means for recycle, reuse thereof, unless the conditions of the Consent to Operate order specifically provide for installation of devices like incineration or evaporation.

At this stage, we may also refer to the compliance statement filed on behalf of the MoEF&CC and CPCB, jointly, in furtherance to the Chamber meeting of 8th July, 2016. The issue afore-referred was fully clarified in its minutes of meeting, filed on 3rd August, 2016. It is stated that ZLD refers to installation of facilities and systems to enable the industrial effluents for recycling and converting solute into residue into solid by adopting method of concentration and thermal evaporation. Draft standards have also been spelled out by the Ministry, which were to be put up on the website inviting comments of the people. It was stated that in the case of ZLD there will be no discharge and upto 97% water can be recovered by reuse in the process. There would be salt generation of 4 tonnes per MLD, which can be recovered for reuse and would meet the prescribed standards. While the conventional treatment system would leave discharge into surface water bodies or use for irrigation releasing high TDS. It is also convenient to operate and maintain the treated effluents which can be used for irrigation purposes after compliance. Comments were also submitted with regard to online monitoring system with the purpose to create self regulation standards and comply with the stipulation.

In furtherance to the order of the Tribunal dated 17th February, 2016, the association of industries were also directed to make representation to the CPCB and they were to be commented upon by the Central Pollution Control Board and record was to be placed before the Tribunal. The representation from sugar sector, tannery sector and distillery sector were also received by the Board. Common argument was that and the raw distillery effluent if directly concentrated and incinerated, would not give beneficial results. It would lead to wastage of energy produced from non-renewal sources besides loss of nutrients present in the spent wash. Bio-composting, concentration or incineration had not been tested and proven to be correct and environment friendly. The cost of the technology is very high, therefore, economically not viable. It would be impossible for the industries to adhere to this technology. Probably treated effluents could easily be used for irrigation purpose. The Small Scale Industries are not capable of meeting the ZLD and therefore, CETP would be the proper remedy. Primarily, the comments of the Boards were primarily that the incinerator or bio-composting or insulation for spent wash and disposal is optional for the industries. Some industries have adopted this technology. A minimum quality specification of the finished compost is essential to ensure that the industries practice biocomposting properly following the protocol and utilization of finished compost in agriculture. The industries in any case should achieve the standards as per the Notification of 1st January, 2016 and textile units should be attached to CETPs. The remnant of treated effluent should be allowed to be discharged into river only after exhausting it upon reuse for irrigation.

From the above discussion, on advantages and disadvantages of the ZLD, it is evident that ZLD cannot be adopted across the board. It must have rationality as its sole criteria, should be unit centric and industry specific oriented. The Sugar or Distillery Industries may be of a huge capacity say discharging 100 MLD per day. They could be a Sugar Industry or Distillery Unit with 10 MLD discharge and thus a very small-scale unit. To apply same yardstick to all would not be feasible and result oriented. They should be assessed on their own performance and function, however, ensuring in all the situations that the effluents permitted to be discharged on land/drain, etc. should be strictly adhering to the prescribed norms. The Board in its advisory capacity may be able to suggest or guide as to the integral technology, which may be feasible for the industries for attaining the prescribed norms. To impose ZLD on such industries would neither be fair nor just. In fact, it will not be in consonance with the requirement of law under relevant Acts. An industry should be permitted to operate, subject to grant of Consent to Operate, by the concerned Board. The CPCB has them competency under law to issue directions under Section 18 of the Water Act. The purpose of empowering Boards with certain powers is to restrict and control pollution. It is not expected from the Boards to stop the natural growth or restrict industries from operating but compliance to the environmental laws is fundamental to exercise of their powers. The Board must take into consideration of the aspects including technology, financial viability, limitations of the unit, process adopted by the industries but in all events ensuring that the discharge of effluents from the unit has to be strictly in compliance with the prescribed standards. No industries, big or small can be permitted to pollute the groundwater, drains, water bodies and environment.

To put it simply, the ZLD directives cannot be applied across the board. On the one hand, it would be violative of the rights of the parties while on the other would not be in consonance with the provisions of the relevant environmental acts. ZLD should be applied on case to case basis. The concerned boards should exercise its technical know-how to issue appropriate directions in that behalf. The ultimate purpose is prevention and control of pollution and not an internal management of the plant. Effluent discharge must be strictly within the prescribed norms and the Board in appropriate cases could issue directions with regard to recycle, reuse of the treated effluent appropriately. The ZLD as inferred from the notification dated 7th October, 2016 is incapable of being enforced across the Board without reference to the member industries and other relevant aspects afore-stated.

Similarly, the Online Monitoring System or Continuous Emission Monitoring System should also be applied on case-to-case basis with reference to the facts and circumstances of the given unit. They must be practicable, for instance, if there is a tannery unit which has consent for processing of hides at a day to be expected to become ZLD or to install Online Monitoring System or Continuous Emission Monitoring System would be opposed to any accepted principles of technology and safeguards of economic advancement. They would be compelled to operate and discharge their effluents only and strictly as per the prescribed norms in default. They would be liable to be shutdown. Another consequential issue that arises in this context, there has to be a specialised, technically sound and dedicated mechanism with every Board including CPCB which monitors entire input of Online Monitoring System or Continuous Emission Monitoring System. This monitoring should include not only collection of data but to ensure that actions taken in default and operational deficiencies in the units are rectified within the prescribed time, failing which the unit should be ordered to be closed. The concept of selfregulation would achieve its object, only when there is an effective supervisory control. There have been serious and noticeable drawbacks, deficiencies, and omissions in regulatory regimes else, the current state of industrial clusters, drains, tributaries of the river would not have been prejudicial to such an extent. Continuous calibration by CPCB to ensure that the online monitoring system shows the correct values and it must be compared with the actual effluent analysis collected by the Board on regular intervals.

The Judgement states that

1. From the above discussion, on advantages and dis-advantages of the ZLD, it is evident that ZLD cannot be adopted across the board. It must have rationality as its sole criteria, should be unit centric and industries specific. The Sugar or Distillery Industries may be of a huge capacity say discharging 100 KL per day. They could be a Sugar Industry or Distillery Unit with 10 KLD discharge and thus a very small-scale unit. To apply same yardstick to all would not be feasible and result oriented. They should be assessed on their own performance and function, however, ensuring in all the situations that the effluents permitted to be discharged on land/drain, etc. should be strictly adhering to the prescribed norms.
2. The Board in its advisory capacity may be able to suggest or guide as to the appropriate technology,which may be feasible for the industries for attaining the prescribed norms. To impose ZLD on such industries would neither be fair nor just. In fact, it will not be in consonance with the requirement of law under relevant Acts.
3. An industry should be permitted to operate, subject to grant of Consent to Operate, by the concerned Board. The CPCB has the competency under law to issue directions under Section 18 of the Water Act. The purpose of empowering Boards with certain powers is to restrict and control pollution. It is not expected from the Boards to stop the natural growth or restrict industries from operating but compliance to the environmental laws is fundamental to exercise of their powers.
4. The Board must take into consideration of the aspects including technology, financial viability, limitations of the unit, process

adopted by the industries but in all events ensuring that the discharge of effluents from the unit has to be strictly in compliance with the prescribed standards.

5. No industries, big or small can be permitted to pollute the groundwater, drains, water bodies and environment.
6. The ZLD directives cannot be applied across the board. On the one hand, it would be violative of the rights of the parties while on the other it may not be in consonance with the provisions of the relevant environmental acts.
7. The concerned Board should utilise its technical know-how to issue appropriate directions in that behalf. The ultimate purpose is prevention and control of pollution and not an internal management of the plant. Effluent discharge must be strictly within the prescribed norms and the Board in appropriate cases could issue directions with regard to recycle, reuse of the treated effluent appropriately. The ZLD as inferred from the notification dated 7th October, 2016 is incapable of being enforced across the Board without reference to the member industries and other relevant aspects aforestated.
8. Similarly, the Online Monitoring System or Continuous Emission Monitoring System should also be applied on case-to-case basis with reference to the facts and circumstances of the given unit. They must be feasible, for instance, if there is a tannery unit which has consent for processing of say 10 hides a day, it cannot be expected to become ZLD or to install Online Monitoring System or Continuous Emission Monitoring System would be opposed to any accepted principles of technology and safeguards of economic advancement. They would be compelled to operate and discharge their effluents only and strictly as per the prescribed norms in default, they would be liable to be shutdown.
9. Another consequential issue that arises in this context is that there has to be a specialised, technically sound and dedicated mechanism with every Board including CPCB which monitors

entire input of Online Monitoring System or Continuous Emission Monitoring System. This monitoring should include not only collection of data but to ensure that actions taken in default and operational deficiencies in the units are rectified within the prescribed time, failing which the unit should be ordered to be closed. The concept of self-regulation would achieve its object, only when there is an effective supervisory control.

10. There have been serious and noticeable drawbacks, deficiencies, and omissions in regulatory regimes else, the current state of industrial clusters, drains, tributaries of the river would not have been prejudicial to such an extent. Therefore, CPCB or UPPCB should ensure continuous calibration so that the online monitoring system shows the correct values and it must be compared with the actual effluent analysis collected by the Board on regular intervals.

SECTION-2

DISTILLERY EFFLUENTS–UTILISATION IN AGRICULTURE

2.1 Abstract

2.1.1 Use of Waste Waters in Agriculture

Water security has emerged as a vital issue for India and the World. Climate change projections forecast an imbalance in water availability and a consequent adverse impact on agriculture productivity. Sugar cane a water intensive crop is expected to suffer a yield reduction of 30% in India because of water related issues. It is in this context that waste waters emerge as a potential source for meeting the water demand after essential treatment. Many industrial effluents contain variable amounts of plant nutrients. If gainfully utilized in agriculture, they have the capacity to replace the use of synthetic fertilizers which are a major environmental concern. Effluent irrigation offers a low cost alternative where both the fertilizing and irrigation aspects of the waste can be utilized and the receptors (Land, air, water etc.) and communities protected against pollution. Nitrogen, phosphorous and potassium are valuable nutrients. Waste water irrigated fields generate great employment opportunities also. Effluent reuse has been recognized as an impending reality in developing countries. Aerobic composting, vermi-culture, ferti-irrigation and one time land application have also been recognized as emerging technologies by the CPCB. Reuse in agriculture benefits nations in less pollution, avoidance or reduction of cost of treatment, savings in cost of fertilizers and reduced water management stress and costs. Sugar mill effluents increased the Electrical conductivity, Organic Carbon, Na^+, K^+, Ca^{2+}, Mg^{2+}, Fe^{2+}, TKN, PO_4^{-3}, SO_4^{2}, Zn, Cd, Cu, Mn and Cr of the soil in both the winter and summer seasons. The change in soil

characteristics improved the fertility and enhanced the nutrient status at lower concentrations of Sugar mill effluent irrigation.

Post methanated distillery effluents have a lower C:N ratio and degrade more swifty in soil as compared to untreated spent wash.

Controlled land application of spent wash helps in restoring soil fertility, enhances soil micro flora and improves the physical and chemical properties of soil. The saturated hydraulic conductivity and pore space of the spent wash leached soils have been observed to increase significantly with simultaneous reduction in bulk density and water disposable clay. The availability to N,P,K,S,Zn, Cu, Fe, and Mn in the spent wash amended soils was found to increase significantly. Conjoint application of spent wash and other organic amendments like farm yard manure, green leaf manure and bio compost has been tried and found beneficial under dry land conditions. Waste waters from different industries could cater to the irrigation needs of various crops.

2.1.2 Use of Distillery Effluents as a Liquid Fertilizer

Traditionally the spent wash was used for irrigation of crops and for composting with press mud from sugar mills, as filler material. The Central Pollution Control Board (CPCB) has prescribed protocols for use of S.W. for irrigation. Two sets of norms have been developed for irrigation, one for standing crops (ferti-irrigation) and another for once a year land application before sowing of a crop (Pre-sown irrigation) with the view to standardize procedures for utilisation of spent wash for agriculture and at the same time ensure protection of the environment. Like wise requirements for surface or aerobic composting process have also been prescribed.

Distillery spent wash is a potential source of renewable energy. It does not contain any toxic heavy metals and being of plant origin and because of its rich nutrient contents may serve as a good fertilizer for crops, more effective than inorganic or mixed fertilizers being used by farmers. Distillery effluents were once regarded as the most highly polluting effluents. The energy, fertilization and irrigation potential of distillery effluents has helped the industry to build immense social acceptability now. Distillery effluents are a rich source of Nitrogen, Phosphorous and Potassium. Potassium is the most richly represented. It also has appreciable quantities of micro nutrients. Being organic in nature, the nutrients are more rapidly taken up by plants from soil. They also contain large amounts of Ca, Mg, Na, S and Chlorides which can be used as a resource for crop production and reduce the use of inorganic fertilizers. It has been stated that alternate methods of clarification in place of “Milk of Lime” in Sugar Mills may improve the quality of molasses by reducing Potassium and Sodium, rendering the usability of bio methanated spent wash (after further treatment) for agricultural applications. Some authors have observed that spent wash irrigation may also lower the incidence of insect pests. Distillery effluents have been found to be more effective than a mixture of inorganic fertilizers and cow dung manure. The current technologies of concentration incineration and concentration need heavy expenditure and the potash and other salts present may create a fouling in the evaporators and boiler heat transfer sections. The rich organic and inorganic constituents allow it to bring remarkable changes in the physical, chemical and biological properties of soil. Distillery effluents are used as a supplement to mineral fertilizer in Brazil. Nutrient recycling through the application of vinasse and filter cake to sugar cane crops in Brazil has reduced the consumption of fertilizers as compared to other crops and in other countries. The use of Urea mixed distillery spent wash is widely prevalent in Australia as a single application. Post methanated spent wash application to growing crops is discouraged, instead land application before planting is suggested to be a better option. In Australia spent wash is blended with additional crop nutrients and sold as manure. Spent wash could also be used for composting the trash in fields. Sugar mill effluents may be used as a suitable diluent for spent wash to reduce the pollution load and subsequently used in fertigation with a 1:1 dilution ratio, the BOD has been expected to come down to 3600 mg/L from 51023 mg/L, COD to 62075 MG/L from 90179 mg/L and TDS to 32700 mg/L from 72090 mg/L.

Nutrients present in the Vinasse and those obtained from the supplements in the anaerobic treatment can be recycled by using the effluents in fertigation and sludge for plant fertilization. Although Fertigation is the most feasible option for the management of stillage but the intensity of impacts depends on the characteristics of the soil and climate of the fertigated area. Appropriate time, space and rate of application of vinasse in agriculture has added significant amount of nutrients, improved the soil quality of degraded lands and increased crop yields. However, detailed management plans have been recommended to be drawn up.

Uncontrolled continuous land application has been however cautioned against as being detrimental to soil conditions.

2.1.3 Economics

It has been claimed that the 290 odd distilleries in India produce 40 billion liters of effluents (spent wash) per annum with an annual value of Rs. 500 crores in terms of N, P, K, and S; 150 crores for micro nutrients and organics; a Rs. 100 crores saving in the annual environmental cost; Rs. 100 crores in terms of loss to fisheries; 500 crores savings in water treatment costs, 100 crores in public health and another 100 crores in landscape costs. Energy savings in respect of the secondary and tertiary systems of treatment could be as high as Rs. 1400 crores per annum. In downstream rural areas of Vadodara in Gujarat, waste water supports annual agriculture production worth Rs. 266 million.

By using spent wash at different levels some authors have observed a substitution of 40-90% of the inorganic fertilizer cost. Some have also observed that in terms of Presown land application followed by irrigation, net returns in the treatment with only potassic fertilizer was Rs. 64630/- per ha and increased to Rs. 76183 per ha due to substitution of 50% of recommended dose of Potassium with spent wash. Spent wash application above 50% level was not beneficial.

2.1.4 Effect on Crops

Distillery effluents have been observed to bring about increases in yield indicators for wheat and rice. Sugarcane has been observed to withstand the application of concentrated distillery effluent without showing reduction in yield, instead application of spent wash has been observed to bring about an increase in the yield. Long duration crops may need nutrients over a longer period of time. Spent wash meets the long term requirement for nutrients. Biomethanated spent wash application has found to enhance the yield in maize also. A need to balance nutrients by supplementing with other fertilizers has also been suggested. The application of spent wash has not only benefited the maize crop in supplying nutrients throughout its growth period but also favoured the growth of microbial biomass. It has generally been established that crop nutrition through chemical fertilizers is inferior to spent wash irrigation. Sunflower, soybean and grasses have all responded positively to spent wash irrigation. The application of digested spent wash to the soil either along with irrigation or as soil amendment has a beneficial effect on soil nutrients thereby increasing the uptake of nutrients by the crop and ultimate increase in crop productivity. Along with irrigation water, lower concentrations suitably supplemented with N and P appear to be more beneficial than higher concentrations. Positive yields in crop productivity have been observed in pulses. In oil seeds an increase in the protein and oil content has also been reported. Some countries have reported an increase of 45-100% in the yield of grasses, maize, fodder and beet using distillery effluents. The application of spent wash has also been demonstrated to be beneficial for the worms and insects that are essential for germination and nutrient availability. Distillery effluents have been reported to significantly increase the grain yield in maize. An ideal application was a conjunctive use of spent wash along with chemical fertilizer better than only spent wash or only chemical fertilizers.

2.1.5 Impact on Groundwater

In the absence of sufficient surface leaching, the use of undiluted spent wash may result in increased salinity of soil and ground water.

Some authors believe that there is no consequent nitrate pollution in ground water even after sustained use of spent wash over years. Nevertheless, utilization of spent wash for irrigation needs to be pursued with caution because of the possibilities of leaching. Ground water needs to be constantly monitored as also suggested by the CPCB Protocol.

2.1.6 Impact on Soil

2.1.6.1 Physical Properties

Diluted spent wash irrigation has been observed to improve the physical and chemical properties of the soil and also to increase the soil micro flora. When effluents are applied on soil, some contaminants get fixed in soil, others are held as exchangeable complexes where plants could utilize them, while some may leach to the water table below. An increase in the mean weight-diameter of water stable aggregates, moisture retention and available water capacity of the soil has also been reported. The soil organic carbon and potassium content along with the uptake of nutrients has registered improvements. The soluble carbon present in spent wash acts as a carbon source and also as a chelating agent supplying all required nutrient. It also binds soil particles, forms stable aggregates and improves the structure, aeration and water holding capacity. Some authors have held that tropical soils are generally deficient in organic carbon content and any addition of organic carbon is always beneficial. III effects if any are temporary and after a certain time the system gets stabilized through the degradation of organic acids. Authors have also observed that generally post harvest soils have not been recorded to exhibit any adverse impacts.

2.1.6.2 Chemical Properties

The application of spent wash has been observed to increase the pH, EC, cations, anions, Sodium Adsorption ratio, Potassium Adsorption ratio, exchangeable Na and K and exchangeable Ca and Mg. Microbial degradation of organic matter in soil has also been held responsible for increased pH and nitrogen availability in soils treated with distillery effluents. The mineralization of organic matter results in an increased availability of plant nutrients including soil nitrate availability. Spent wash not only adds to the soil but also enhances the mineralization of N from organic N pool in soil. Application of distillery effluents to alkali soils increases the available P content of soil, the acidic spent wash being responsible for solubilizing the insoluble soil 'P' in alkali soils. Available micronutrients like Fe, Mn, Zn and Cu have been observed to progressively increase with the graded application of diluted spent wash. This is due to the direct contribution from the effluent as also the solubilisation and chelation affect of organic matter supplied by the effluent. Damaging impacts on soil chemistry at doses of 300 m^3/ha or lower has generally not been observed. All observations indicate that distillery effluents are rich in plant nutrients and improve the soil nutrient status if applied on soil. Some authors have stated that in post harvest soils, pH increased by 5%, organics 48%, humic acid carbon by 16%, fulvic acid carbon by 53%, N by 48%, P by 21%, K by 320%, Ca by 221% and Mg by 90%.

2.1.6.3 Biological Properties

The biological activity of soils is positively affected by the application of distillery effluents. Bacteria, Actinomycetes, Azotobacter and fungi showed significantly higher counts than in unamended soils. The amylase, dehydrogenase, phosphatase and cellulase activities have been observed to increase but the urease activity remained unaffected. When applied to the soil the color of the effluents is amenable to microbial and photo-degradation without deteriorating the biological composition of soil. Some authors have also found the presence of appreciable amounts of growth promoters like Gibberellic acid and Indole Acetic Acid in the distillery spent wash. Application of spent wash has also been observed to reduce the incidence of some plant pests.

2.1.6.4 Nutrients and Nutrient Uptake

Spent wash application in agriculture improves the uptake of nutrients from the soil. Distillery effluents used by themselves or as supplements to other fertilizers (N and P) have resulted in the increased uptake of N, P, K, Ca and Mg from soil. Leaching of nitrate from the soil was also reduced when distillery residues were used in soil. Some authors have also observed that the application of diluted spent wash increased the uptake of Zn, Cu, Fe and Mn. Higher uptake levels have been reported at lower dilution levels. Mineralization of organic matter and nutrients in soil has been held responsible for the increased uptake.

2.1.7 Procedures, Practices and Guidelines

In spite of an overall beneficial impact of the use of distillery effluents in agriculture, the application has to be attempted with caution. The characteristic of effluents and the environmental impacts of utilizing in agriculture have to be carefully assessed. A continuous vigil on soil, water and crop quality needs to be maintained. Doses of fertilizers and effluents have to be fixed on crop and soil requirements. Utilisation of treated industrial effluents in agriculture has great potential as an alternate source of irrigation water. Proper treatment of effluents and agronomic management strategies have to be developed for use on a long term basis. Biocomposting, Presown land application and Fertigation Protocols have been developed by the Central Pollution Control Board.

2.2 Review of Literature

2.2.1 Use of Waste Water in Agriculture

Somashekhar et al., (1984) state that the effluents of a paper factory, a automobile industry, a textile industry and food and paper industry were alkaline in nature and contained variable amounts of plant nutrients such as Ca, Mg, B, Fe and Cu. The raw effluents altered physicochemical properties of treated soil and they were responsible for reduction in the rate of germination of seeds. Diluted effluents however showed a favorable effect on seedling growth.

Narasimharao and Narasimharao (1992) indicated that the Bhadhrachalam Paper Board industry effluent (Andhra Pradesh) could be safely used for irrigation of rice and cotton on alluvial soil having loamy to sandy loam texture.

Wani and Lee (1992) and Wani et al., (1995) state that one of the most conspicuous features of the modern consumerist's society is the generation of massive quantities of waste. This is both costly and difficult to dispose off through conventional methods. Environmental degradation due to the indiscriminate use of modern agricultural techniques such as the use of synthetic fertilizer is a major threat confronting the world. It leads to loss of soil fertility due to imbalanced use of fertilizers that adversely impacts agricultural productivity apart from causing degradation of soil.

Joshi et al., (1996) state that in recent years, considerable attention has been paid to industrial wastes that are usually discharged on land or into sources of water. It is anticipated that industrial activities will accelerate with the pace of development. This would have an adverse impact on our atmosphere and would cause environmental degradation. On the other hand, a huge amount of wastewater generated from distillery has an important role to play in the context of scarcity of fresh water resources for irrigating agricultural land. Industrial wastewater could be used effectively with proper precautions to increase soil productivity. The utilization of industrial wastewater for agricultural purposes could also provide a solution to the disposal problems.

Aziz et al., (1998) studied the growth, yield and quality parameters of Triticale cultivation due to the use of treated oil refinery effluent. The performance of crop was better under treated oil refinery effluent compared with that underground water. Further, they found that three irrigations with tannery effluent proved superior to four irrigation with treated oil refinery effluent for almost all the studied characteristics.

Joshi, (2002) states that agricultural utilization of wastewaters offers a low cost alternative where the manurial and irrigational potential of various types of wastewaters can be utilized. Care must however be taken to ensure that the resources are used effectively, land is protected, ground water and surface water are protected and the community is not adversely affected. When tied to irrigation, the Nitrogen and Phosphorus present in wastewater are considered valuable nutrients rather than contaminants. It has been further stated that water with a TDS of up to 700 ppm, Sulphates up to 192 ppm, Chlorides up to 142 ppm, per cent Sodium up to 50, Boron up to 0.5 and EC up to 750 dS/m are excellent for irrigation while water with a TDS of beyond 2,000 ppm, Sulphates > 780 ppm, Chlorides > 355 ppm, per cent Sodium > 75, Boron > 2.0 and EC greater than 2,250 dS/m are unfit for irrigation. In terms of SAR, waters with a SAR of > 26 are unsuitable for irrigation. It has been said that mixed with irrigation water, Post methanated effluents up to 10 per cent can be given any time after 25 days of crop emergence.

Anonymous, (2004) states that water security is emerging as increasingly important and vital issue for India and the world. Most of the river basins in India and elsewhere are closing or closed and experiencing moderate to severe water shortages, brought on by the simultaneous effects of agricultural growth, industrialization and urbanization. Wastewater or low quality water is emerging as potential source for demand management after essential treatment. Current and future fresh water demand could be met by enhancing water use efficiency and demand management. A report states that approximately 60 per cent of industrial wastewater, mostly generated from large-scale industries, is treated. Additionally, wastewater irrigated fields generate great employment opportunity for female and male agricultural laborers to cultivate crops, vegetables and flowers, fodders that can be sold in nearby markets or for use by their livestock.

Mahawar R.S. (2007) has stated that traditionally the spent wash is used for irrigation of crops and for composting with press mud from sugar mills, as filler material. The Central Pollution Control Board (CPCB) has prescribed protocols for use of S.W. for irrigation. Two sets of norms have been developed for irrigation, one for standing crops (ferti-irrigation) and another for once a year land application before sowing of a crop (Pre-sown irrigation) with the view to standardize procedures for utilisation of spent wash for agriculture and at the same time ensure protection of the environment. Like wise requirements for surface or aerobic composting process have also been prescribed. It is expected that, following the recommended procedure for land application and compositing, distilleries will not discharge spent wash, treated or untreated, into surface waters and will achieve the requirement of CREP of zero discharge into inland surface waters.

Das et al., (2008) state that the use of industrial effluent in cropping depends on several factors such as site-specific information on soil, climate, crop type, physical landform and mode of application. This multi – faceted character of the factors opens up the prospect of using effluent at different contexts. With precise information, careful planning, complex management practices and highly stringent monitoring procedures, effluent could be profitably utilized under specific circumstances / landscape. Nonetheless effluent reuse in agriculture is an impending reality and essential in developing countries particularly India, where irrigation requirement is large. Distillery spent wash could alleviate soil constraints; improve environment to the level suitable for plant growth if properly managed under a specific situation.

The guidelines for Water Quality Management (Central Pollution Control Board, 2008) prescribe that emerging technologies such as aerobic composting, vermiculture, ferti-irrigation etc. as secondary treatment should be adopted for organic wastes by the industries. Root zone technology is also being advocated. The guidelines also said that the reuse and recycling of wastes for agricultural purposes would not only help to reduce the pollution and requirement of fresh water for such use but would also supplement the much needed nutrients and organic manure to plants.

Winpenny et al., (2010) observe that recycling wastewater is an essential element of integrated water resources management. The reuse of wastewater is a means of recycling not only water but also nutrients which otherwise exert heavy environmental and economic costs to receiving bodies of water.

They have recognized that the major benefits that can be expected from the reuse of treated wastewater are –

1. The avoided cost of abstraction, transmission, treatment and distribution of fresh water.
2. Savings in the cost of fertilizer due to the nutrient content of wastewater.
3. Saving in the cost of wastewater treatment.
4. The greater reliability of reused wastewater.
5. Reduced water and land Pollution.

Banupriya and Gowrieb (2012) stated that since the production of wastewater is a continuous process, it can cater for substantial irrigation requirements, where shortage of water becomes limiting factor.

Sathish et al., (2013) state that there is an increasing interest in the agricultural use of industrial wastes because of the possibility of recycling valuable components such as organic matter, N, P and other nutrients and their suitability for land application.

Nagaraj and Kumar 2007 (IIT, Roorkee) stated that the present water, energy and nutrient crisis and the need to preserve these resources strengthen the case for utilization of wastewaters for manuring and irrigation.

Vadivel et.al 2014 have concluded that appropriate time, space and rate of application of vinasse in agriculture has added significant amounts of nutrients, improved the soil quality of degraded lands and increased crop yields. Crop yield increments vary as per soil fertility status, spent wash composition, methods of application and inherent ability of crop._However, indiscriminate and inappropriate application and storage for treatment has affected water quality. This may require detailed application management plans to be drawn up.

Kumar and Chopra 2014 have concluded that the Sugar mill effluents increased the Electrical conductivity, Organic Carbon, Na^+, K^+, Ca^{2+}, Mg^{2+}, Fe^{2+}, TKN, $PO4^{3-}$, $SO4^{2-}$, Zn, Cd, Cu, Mn and Cr of the soil in both the winter and summer season. The change in soil characteristics improved the fertility and enhanced the nutrient status at lower concentrations of Sugar mill effluent irrigation. The accumulation of heavy metals in soil and S. officinarum increased with an increase in Sugar mill effluent irrigation in both seasons. The agronomic performance (yield and growth parameters) of S. officinarum gradually increased at 10% to 25% and decreased at 50% to 100% concentration of the Sugar mill Effluents in both seasons. Raw and untreated effluents with a BOD of 1680 mg/L and a COD of 2275.89 mg/L were used at different dilutions for irrigating the test plots for fertigating twice a month with 50 gallons of Sugar mill effluents at 10, 25, 50, 75 and 100% concentration along with bore well water as control.

Ravindra *et.al.* 2016, state that in terms of Presown land application followed by irrigation, net returns in the treatment with only potassic fertilizer was Rs. 64630/- per ha and increased to Rs. 76183 per ha due to substitution of 50% of recommended dose of Potassium with spent wash. Spent wash application above 50% level was not beneficial.

Sinha *et.al.* 2014 in a study to assess the integrated effect of biomethanated distillery effluent (BMDE), bio compost and farm yard manure as a source of plant nutrients observed that the cane yield increased significantly with the application of BMDE, bio compost and FYM over control. The highest cane yield was recorded (72.13 t/ha) in treatment receiving 100% K_2O replacement through BMDE. The lowest yield (58.50 t/ha) was observed in the control. The authors have concluded that the application of BMDE and bio compost brings remarkable changes in the properties of soil and these enhance the fertility of soil and productivity of sugarcane significantly.

2.2.2 Use of Distillery Effluents as liquid fertilizer

Bajpai and Dua (1972) suggested the use of distillery effluent as a Nitrogen source by obtaining a significantly higher yield in sugarcane with 200 kg N through spent wash application.

Basu, (1975) state that the discharge of wastewaters from wineries and distilleries is becoming increasingly restricted as pressures from environmental regulations increase and as awareness of the negative impacts of seasonal discharges of water containing high nutrient and organic loadings into water courses spreads. Raw stillage discharge has a highly deleterious effect on fish life. However, stillage has been proposed for use as a fertilizer.

Dongale and Savant (1978) opined that spent wash is as good as Potassium Chloride (KCl) as a source of Potassium for sorghum.

Berton et al., (1983) found that the availability of K in spent wash was similar to that in KCl and Potassium Sulphate (K_2SO_4).

Webb and Chapman (1987) and Paula et al., (1999) found spent wash as reliable substitute for muriate of potash for sugarcane and potato. The distillery effluent can be considered as liquid manure and controlled application of the treated effluent can increase the productivity of sugarcane and sugar beet.

Kulkarni et al., (1987) classified spent wash as a dilute liquid organic fertilizer with high Potassium and add that its colloidal Nitrogen serves as a slow release fertilizer thereby proving better than most chemical Nitrogen sources. Further, availability of Phosphorus was more important due to slow mineralization besides the large amount of other important secondary elements like Ca, S and Mg as well as trace elements such as Cu, Mn and Zn. They also said that spent wash has 90 to 93 per cent K (as water) and 7 to 9 per cent solids. The 75 per cent of solids were found to be organic and remaining 25 per cent to be inorganic. The two third of P was inorganic form and availability was more than any important inorganic source.

Joshi et al., (1996) stated that the spent wash, being loaded with organic and inorganic compounds could bring remarkable changes on the physical, chemical and biological properties of soils and thus influences the fertility of soil significantly. Also, distillery effluent contained large amounts of organic matter, N, P, K, S and Ca and this was used as a resource in crop production in India as an alternative source of nutrients thereby reducing investment on inorganic fertilizers.

Sundaramurthy, (1998) reported that raw distillery effluents were found to lower the incidence of two major sap feeding insects in cotton: the plant louse and white fly. The incidence of bollworm was also significantly decreased in cotton crops treated with an insecticide in combination of spent wash. This also resulted in an increased yield in seed cotton from 851 to 1270-1360 kg ha^{-1}.

Ramana et al., (2002) state that distilleries, one of the most important agro-based industries in India, produce ethyl alcohol from molasses for potable and industrial uses. The use of distillery wastewater in agriculture is quite popular. In some water scarce areas, farmers are forced to use the effluent as a substitute for irrigation water but over the years its use has led to the realization of its fertilizer potential also. Various workers from their studies have suggested suitable application rates for distillery effluent for ferti-irrigation purposes and crop-specific nature of effluent.

Nandy et al., (2002) observed that spent wash has high BOD due to which the application of an anaerobic treatment technology with biogas recovery has been reported to be highly effective. However, anaerobically treated spent wash still contains high concentrations of organic pollutants and cannot be discharged directly. Being of plant origin, spent wash contains large quantities of soluble organic matter and plant nutrients, which if utilized for crop production could prove to be a good source of nutrients. This is expected to solve the problem of waste disposal.

Joshi, (2002) reported that one of the important ecological benefits of wastewater disposal is the utilization of distillery industrial effluent for irrigation purposes, which provides several advantages:

a) **Less sludge:** Wastewater for irrigation requires lower levels of treatment than for stream discharge, which yields another benefit-less sludge. Lagoon systems are often used to renovate wastewater before reuse. Lagoon systems have low labour requirements and no routine sludge handling requirements.
b) **Expediency and cost effectiveness:** Being a long distance from a receiving stream may motivate a community to consider irrigation. Because excavating and laying long sewer lines can be the most expensive aspect of a wastewater treatment system, irrigating wastewater on nearby land may be more affordable.
c) **Nutrient value:** When tied to irrigation, the Nitrogen and Phosphorous present in wastewater are considered valuable nutrients rather than contaminants. Because treated wastewater can be irrigated on turf, timber and field crops, farm fields may be considered as one of the irrigation sites. Additionally, irrigation adds significant polishing treatment to the effluents.
d) **Additional water source:** Treated water serves as an extra source of water available for irrigation.

Baskar et al., (2003) stated that since the distillery effluent is essentially a non-toxic plant extract with high organic matter content, K, Mg, and Ca and appreciable quantities of micronutrients it has widely been used as ferti-irrigation for crops.

Das et al., (2009) indicate that treated spent wash especially from cane sugar molasses distillery is an enriched source for plant nutrients and that it is a promising option particularly during water shortage.

Rath et al., (2011) state that due to high concentration of organic load, distillery spent wash is a potential source of renewable energy. The effluent does not contain any toxic heavy metals, as it is a waste from plant materials. Distillery spent wash at 50 per cent v/v concentration may serve as a good liquid fertilizer for crops and is more effective than that of the fertilizer used by the local farmers as well as the inorganic fertilizer plus the organic manure (cow dung).

Jain and Srivastava (2012) state that distillery effluent is more effective than that of the fertilizer used by the local farmers as well as the inorganic fertilizer plus the organic manure (cow dung).

Rath et al., (2013) stated that the wastewater produced by distillery plant continuously could cater the needs of irrigated crops.

Christofelletti C.A. *et.al.* (2013) have apprehended that the disposal of effluents over a long period of time may cause changes in the chemical and physical properties of soils, rivers and lakes and may also have adverse effects on agricultural soils and biota in general. They have suggested that new studies and green methods need to be developed aiming at sugarcane vinasse recycling and disposal. (www.ncbi.nlm.nih.gor/pubmed/24084103.)

Thamaraselvi *et.al.* 2014 diluted spent wash from distillery with Sugar Mill effluents to get Sugar wash which they used in different concentrations as Fertigant. Mixing Sugar effluents to distillery spent wash gave resultant pollutants as in table below.

	Spent Wash (SW)	**Sugar Effluents (SE)**	**Sugar Wash 1:1 SW to SE**
BOD	51023 mg/L	3089 mg/L	36300 mg/L
COD	90179 mg/L	6498 mg/L	62075 mg/L
TDS	72090 Mg/l	1650 mg/L	32200 mg/L

The authors have observed that while 100% of seed germination was observed in 5% of diluted sugar wash, seed germination percentage was reduced at higher concentrations (10 and 15% Sugar Wash Irrigation). The Chlorophyll content, root length, shoot length, fresh weight and dry weight showed high values at 5% Sugar wash irrigation. The authors have concluded that Sugar effluents may be used as a suitable diluent for spent wash to reduce the pollution load and subsequently use it in fertigation for the growth of Raphanus sativus.

Jibril and Omprakash 2014 do not favour the use of distillery waste water for crop growth.

Sundaramoorthi, K., also further states that spent wash concentration and further incineration needs heavy expenditure. The potash and other salts present create fouling in evaporators and boiler heat transfer sections. It has been advocated that distilleries should also be allowed to integrate concentration with composting systems and utilize sludges in bio-compost.

The Office of the Principal Scientific Advisor to the Government of India, 2014 observes that in molasses the presence of Potassium, Sodium etc. is carried from the cane itself but the increased levels of calcium, phosphorous and sulphur is due to the use of “Milk of Lime” during the clarification process and sulphitation process. Alternate methods of clarification in place of “Milk of Lime” may improve the quality of molasses by reducing these elements, rendering the usability of bio methanated spent wash (after further treatment) for agricultural applications. For preseason sugar crop the recommended dose of NPK by State University in Maharashtra is 340:170:170 based on nutrient contents in BMSW.

The post methanated effluents can produce more than 85000 tonnes of biomass annually by providing 245000 tonnes of potassium, 12500 Tonnes of nitrogen and 2100 Tonnes of phosphorous annually. One years effluents can be expected to meet the potassium requirements of 1.55 million hectare, nitrogen requirement of 0.13 million hectare and phosphorous requirement of 0.025 million hectare land if two crops are taken in a year.**Kamble *et.al.* 2017**

The irrigation with distillery waste water seems to be an attractive agricultural practice. One cubic meter of biomethanated effluents contains nearly 5 Kg of Potassium, 300 grams of nitrogen and 20 gms of phosphorus. If one centimeter of post methanated effluent is applied on one hectare of agricultural land annually, it will yield nearly 600 Kg of Potassium, 360 Kg of Calcium, 10 Kg of Sulphates, 28 Kg of nitrogen and 2 Kg of phosphates.**Rath *et.al.* 2011**

2.2.3 Economics

Strauss and Blumenthal (1990) estimated that in India about 73,000 ha of peri-urban agriculture is subject to wastewater irrigation.

Mahimairaja and Bolan (2000) state that wastes provide both nutrients and water and save energy in reducing the cost on effluent treatment.

Joshi, (2002) has summarized that the 290 odd distilleries in India produce 40 billion liters of effluents per annum with an annual value of Rs. 500 crores in terms of N, P, K and S, annual value of Rs 150 crores for micro nutrients and organics and an annual environmental cost of Rs 100 crores in terms of loss to fisheries, water treatment costs (500 crores), public health costs (100 crores) and landscape cost (100 crores).

Anonymous, (2004) reported that irrigation with sewage or sewage mixed with industrial effluents results in saving of 25 to 50 per cent of N and P fertilizer and leads to 15 to 27 per cent higher crop productivity, over the normal waters.

Minhas and Samra (2004) reported that in peri-urban areas, farmers usually adopt year round, intensive vegetable production systems (300 to 400 per cent cropping intensity) or other perishable commodity like fodder and earn up to 4 times more from a unit land area compared to freshwater. In downstream rural areas of Vadodara in Gujarat, wastewater supports annual agricultural production worth Rs. 266 million.

Kavitha *et.al.* (2008) noted that by using spent wash at different levels they could substitute 40-90% of the inorganic fertilizer cost.

Sarayu et al., (2009) state that the ever-increasing amount of distillery spent wash and its disposal has stimulated the need for developing new technologies to process this effluent efficiently and economically including growth and yield of different crops in agriculture.

Nagaraj and Kumar (IIT Roorkee) 2007 have recognized that the reuse and recycling of wastes for agricultural purposes would not only help to reduce the pollution and requirement of fresh water for irrigational purposes, but would also supplement the crops with the essential nutrients and organic manure required. It is also predicted that utilization of distillery effluent for irrigation of land would provide N, P and potash to the fields worth Rs. 500 crores (approximately) each year, in the organic form. This would also bring about a cost saving in the secondary and tertiary systems of treatment estimated as Rs. 1400 crores in terms of energy savings.

Baskar *et.al.* 2013 have summarized that Distillery effluent is a valuable source and must not be wasted at any cost. All agencies should work together to harness the biomass and bio-energy potential of these wates.

Ravindra *et.al.* 2016, state that in terms of Presown land application followed by irrigation, net returns in the treatment with only potassic fertilizer was Rs. 64630/- per ha and increased to Rs. 76183 per ha due to substitution of 50% of recommended dose of Potassium with spent wash. Spent wash application above 50% level was not beneficial.

Kamble *et.al.* 2017 say that in India there are 295 distilleries producing 3.20 billion liters of alcohol generating 45 billion litres of waste water annually. This has the potential to produce 1200 million cubic meters of biogas with a capacity of generating 5 Trillion kilo calories of Energy every year.

Baskar *et.al.* 2003 have concluded that Utilisation of spent wash in agriculture would save costs on fertilizer and facilitate reduction in pollution load on aquatic systems.

2.2.4 Effect on Crops

2.2.4.1 Wheat and rice

Pathak et al., (1999) state that the distillery effluent increased both wheat and rice yields grown in sequence.

Pathak et al., (1999) also stated that the rice grain yield registered an increasing trend up to BOD 2,000 mg L^{-1}.

Doddamani et al., (2010) revealed that the application of 150 per cent recommended dose of Nitrogen recorded significantly high grain and straw yield of wheat (39.4 q and119.8 q/ha respectively) than other treatments.

2.2.4.2 Sorghum

Zalawadia and Raman (1994) revealed positive influence of distillery wastewater on sorghum yield.

2.2.4.3 Sugar Cane

Bajpai and Dua (1972) reported that sugarcane has been found to withstand the application of concentrated distillery effluent without showing reduction in the yield. Significantly higher yields of sugarcane and an increase in available N content of soil were observed with 200 kg N per ha supplied through spent wash.

Rodella and Ferrari (1977) observed an increase in ash and K content of raw and clear cane juice and molasses due to application of vinasse.

Usher and Wellington (1979) stated that application of spent wash increased the cane yield of sugarcane in Australia.

Gonzales and Tianco (1982) reported that application of spent wash increased the cane yield of sugarcane in Philippines.

Vierira, (1982) reported that application of spent wash increased the cane yield of sugarcane in Cuba.

Scandaliaris et al., (1987) reported that application of spent wash increased the cane yield of sugarcane in South America.

Shinde et al., (1993) observed that spent wash solids, farmyard manure, spent wash, press mud and compost were equal in their effect.

Ghugare and Magar (1995) reported that application of 50 fold diluted 16 mg ha^{-1} lagoon stored vinasse (BOD 4,350 mg L^{-1}) to medium black soil gave 20 per cent higher cane yield than control.

Joshi, (2002) stated that the sugarcane crop receiving 9 irrigations followed by ratoon crop receiving 5 irrigations with 30 per cent concentration gave better yield as compared to normally irrigated crop. The kharif maize and rice responded well to biomethanated spent wash up to 40 per cent level. The stress symptoms were visible in case of wheat as 40 per cent biomethanated spent wash was applied for three years.

Sinha S.K. *et.al.* 2014 in a study to assess the integrated effect of biomethanated distillery effluent (BMDE), bio compost and farm yard manure as a source of plant nutrients observed that the cane yield increased significantly with the application of BMDE, bio compost and FYM over control. The highest cane yield was recorded (72.13 t/ha) in treatment receiving 100% K_2O replacement through BMDE. The lowest yield (58.50 t/ha) was observed in the control. The authors have concluded that the application of BMDE and bio compost brings remarkable changes in the properties of soil and these enhance the fertility of soil and productivity of sugarcane significantly.

2.2.4.4 Maize

Bellore and Mall (1975) stated that photosynthetic surface area and leaf chlorophyll contents are the key factors determining dry matter production. Further, chlorophyll content is considered as an index of metabolic efficiency of the plant to utilize the nutrients absorbed. The application of distillery effluents increased the leaf area and total chlorophyll content resulting in higher dry matter production in maize. This reflects the high manurial potential of the distillery effluents. The chlorophyll content and leaf area increased up to 60 days after sowing with the application of effluents.

Jagadale and Sawant (1979) reported that crops of long duration require nutrients over longer period of time and spent wash meets the long-term nutrient requirement of the crops and thus helps to reduce the fertilizer cost and nutrient losses. In sand culture studies, growth and chemical composition of sugarcane was not adversely affected by spent wash solids applied at 250 ppm but were detrimental at higher rates.

Girardin et al., (1985) stated that a positive correlation between carbon dioxide exchange rate and chlorophyll content was also reported in maize.

Ramana et al., (2002) conducted a field experiment for two years to study the effect of application of different distillery effluents, raw spent wash, biomethanated spent wash, lagoon sludge and recommended NPK+FYM (farm yard manure) and control (no fertilizer and effluent) on some physiological aspects of maize. The application of distillery effluents resulted in increased leaf area, chlorophyll content, nitrate reductase activity, total dry weight and grain yield. Biomethanated spent wash application gave the highest grain yield (36.9 qha^{-1}) followed by raw spent wash (32.2 q ha^{-1}) and lagoon sludge (28.3 q ha^{-1}). The highest yield was however observed with NPK+FYM (51.8 q ha^{-1}). They have suggested that in order to utilize the full manurial value of spent wash, some amount of fertilizer should be supplemented.

Bhukya, (2007) found that spent wash as a source of nutrients is beneficial to maize. The crop had a significantly better stand as compared to the crop, which received chemical fertilizers. The application of spent wash has not only benefited the maize crop in supplying nutrients throughout its growth period but also favoured growth of microbial biomass providing a hospitable environment for both crop growth and microorganisms. Spent wash application improved the number of leaves. The application of nitrogen through spent wash application also caused an increase in the leaf area and an increase of up to 29% in the chlorophyll content – more as compared to plots that received chemical fertilizers. Increase in chlorophyll concentration was also observed at higher nitrogen levels of spent wash application. Spent wash application also increased the cob length and diameter and the number of rows in each cob (13 to 14%). At higher applications (50% of spent wash) although the cob rows decreased, yet they were higher than those compared to chemical fertilizer application. The number of seeds also increased by 30-35%. Wherever spent wash was applied, the increase in Nitrogen content was in the order of 30 to 40%. The Phosphorous and Potassium content was also significantly influenced. An increase of nearly 15-20% of Phosphorous and nearly 70% in Potassium was observed in plants due to application of spent wash.

Bhukya, (2007) has stated that the crop nutrition through chemical fertilizers remains conclusively inferior to spent wash and that the conjunctive application of spent wash along with chemical fertilizers was inferior as a source of irrigation to the entire nutrition management through spent wash but better than only chemical fertilizers. In terms of micro nutrients Fe, Mn, Zn and Cu concentrations increased by 30 to 40% where the crop received spent wash as a source of nutrient.

A more than 40% increase in yield was possible due to contribution of nutrients from the spent wash application. For maize cultivation, a higher benefit cost ratio was observed wherever spent wash was a source of nutrients. There was a net savings of nearly 50% as a direct saving.

Rath et al., (2011) reported that in a study conducted in Kiev, Ukraine has shown increased yield of grasses, maize and fodder beet by 45-100 per cent using distillery effluent.

Kumar and Chopra (2013a) stated that distillery spent wash caused a significant increase in average height of the plants, length of leaves, breadth of leaves, leaf area index and girth of stem. Further, the application of spent wash also proved to be beneficial for the worms and insects that are essential for germination and nutrient availability; large amount of Nitrogen and other minerals were fixed in the soil.

2.2.4.5 Others

Devarajan et al., (1998) stated that higher yield in sunflower was recorded at 30 to 50 times dilutions.

Kundal et al., (2004) reported that higher yield in soybean were recorded at 30 to 50 times dilutions.

Sweeney and Graetz (1991) stated that the distillery effluent could be safely used in production of grass without any adverse effect on the growth of grass. Further, use of distillery wastes up to certain level has been found beneficial to growth and yield but indiscriminate use affects crops, soil and ground water.

2.2.5 Impact on Ground Water

Somashekhar et al., (1984) indicated that addition of undiluted spent wash would result in increased salinity of both soil and groundwater where there was not sufficient surface leaching of soil solution.

Cruz et al., (1991) studied the nitrate pollution in the groundwater due to application of spent wash in the sugarcane field over a period of 15 years. They found nitrate in the groundwater but not at levels harmful to human health.

Orland et al., (1995) observed no NO_3 pollution due to vinasse application.

Kotteeswaran et al., (1999) observed the analytical results of bore-well samples collected from spent wash irrigated fields (for more than three years), which indicated that there was no percolation of effluent to the groundwater even though it was used continuously.

Malathi, (2002) reported that no pollution on groundwater samples collected from open wells near the spent wash applied farmer's field in Theni district, Tamil Nadu as all the quality parameters were below the critical limits.

Jain et al., (2005) showed that the long-term indiscriminate use of PMDSW could lead to significant leaching of inorganic salts. Although leaching of salts has the potential to affect the quality of groundwater, the actual impact will depend on the rate of recharge of groundwater and initial status of groundwater quality.

Rajkishore and Vignesh (2012) state that though several piezometeric studies have reported that application of treated spent wash at the rate of 100 m^3 ha^{-1} did not contribute for groundwater pollution, it is not advisable to apply PMDSW continuously even at doses, 80 m^3 ha^{-1} as there is a possibility of groundwater contamination due to continuous application of PMDSW.

2.2.6 Impact on Soil

Devarajan and Oblisamy (1994); Kaushik et al., (2005); Kuntal et al., (2004) state that the diluted spent wash irrigation improved the physical and chemical properties of the soil and further increased soil micro flora thereby making conditions ideal for cultivation of variety of crops.

Sullivan, (1973) found that when effluent was applied through irrigation soil underwent a variety of physical, chemical and biological transformations. The effluent irrigations improved the physical and chemical properties of soil and increased soil micro-flora.

2.2.6.1 Physical Properties

Escolar, (1966) observed changes in hydraulic conductivity, aggregate stability and improvement in infiltration rate by addition of distillery slops to a column of soil.

Vercher et al., (1965) indicated that paper mill effluent was useful for fine sandy loam soil and did not cause any detrimental effects to soil properties.

Sullivan, (1973) found that when effluent was applied some contaminants became fixed in soil; others were held on exchangeable complex where plants could utilize them, while others might leach to the water table below.

Daniel and Bouma (1974) pointed out significant role of effluent solids (waste waters of high and low Carbon contents of simulated septic tank and simulated extended aeration) in increasing the pore clogging in less permeable clayey soils.

Rajannan and Oblisamy (1979) state that the percentage pore space in both the soils got reduced and water holding capacity of black soil increased due to effluents, whereas it decreased for red soil.

Chang and Li (1988) found that the application of vinasse to the main crop of sugarcane increased the available K content of the surface soil and remained high even after the harvest of the first ratoon. Thus the effluent had not only supplied the nutrients to the existing crop but also maintained and improved the soil fertility (for the next crop).

Mbagwu and Ekwealor (1990) studied that the progressive increase from 2.5 to 10 per cent in levels of distillery effluent increased the mean-weight diameter of water stable aggregates (1.62 mm to 2.20 mm), moisture retention (17.2 per cent to 20.2 per cent) and available water capacity of soil (14.7 per cent to 18.3 per cent).

Srivastava, (1991) reported that soils of tropical regions are low in organic carbon content. Therefore, the addition of organic matter is always beneficial for improving the soil fertility status. Any ill effects, if persist, are temporary in nature and after a certain period the system gets stabilized and adverse effects get nullified through degradation of organic acids.

Singh and Bahadur (1997) stated that effluent irrigation decreased the rate of infiltration and bulk density of soil, which are favorable traits for sandy soils. Soil fertility improved with effluent application particularly soil organic carbon and potassium status.

Pathak et al., (1999) state that saturated hydraulic conductivity, bulk density and volumetric water content improved with effluent application.

Baskar et al., (2003) suggest that soil permeability is an important parameter when planning for liquid waste disposal to agricultural land.

Bhukya, (2007) used secondary treated distillery spent wash for her studies on the effects of spent wash irrigation on the growth a yield of maize. The effluents were dark brown in color with a pH of 8.3. The conductivity was high (18 dS/m). The BOD was 5,360 mg/L and the

COD 16,000 mg/L. Spent wash was observed to be a good source of nutrients specially for Potassium (5,940 mg/L), Calcium (1,920 mg/L), Magnesium (720 mg/L), Nitrogen (0.09 per cent), Phosphorous (153 mg/L), micro nutrients and soluble organic carbon. Spent wash was used as a substitute to chemical fertilizers in Bhukya's study conducted over a continuous period. The application rates were based on the basis of nutrient requirement of the crop. The soil reaction measured as pH did not change and remained neutral. No accumulation of salts was observed. The marginal increase could not be qualified as saline soils. There was a perfect equilibrium between the addition of nutrients and removal by crops exchanged by soil and lost through leaching. Bhukya, (2007) stated that soluble carbon present in spent wash accounted for nearly 22-25% by weight. It is not only a source of carbon but also for other nutrients. It acts as a chelating agent and supplies all required nutrients to the crops throughout growth. It also binds soil particles and forms stable aggregates, improves the structure, aeration, water holding capacity etc. Bhukya, (2007) observed the carbon content of the soil to increase by 50% wherever spent wash is applied along with an increase in the available Nitrogen content. The Nitrogen is available to the crop not only at any given point but also over the period of crop growth due to a buildup of Nitrogen in soil due to spent wash application. Potassium addition is much higher than the crop requirement. This leads to an excess consumption by the plant and accumulation in soil and consequently a higher K ion exchange complex. Zn, Fe and Cu were significantly higher in treatments that received spent wash, due to mineralization of organically held, chelated and structural fractions of most of the nutrient constituents, whereas Mn remained less influenced. Soil property was not affected adversely.

Das et al., (2010) in their studies on application of distillery spent wash on paddy cultivation in red and laterite soils did not find any significant change in soil properties that could degrade soil quality or environment. Laterite soils are constrained by low pH, poor organic matter and deficiency of major nutrients. Application of spent wash improved soil properties even after harvesting.

2.2.6.2 Chemical Properties

Blosser and Owens (1964) working on pulp mill effluents found that when SAR of paper mill effluents exceeded 9.0, infiltration rate of soil was retarded. This was attributed to the Sodium replacing Calcium and Magnesium from the exchange complex of soil resulting in the dispersion of soil aggregates.

Ben et al., (1965) reported that soil properties were not affected during the eight-year period of irrigation with paper mill effluents without dilution.

Kolar and Mitiska (1965) states that Sulphite waste liquor increased the N content of the soil.

Jadhav and Sawant (1975) noticed that the application of spent wash increased pH, EC, cations, anions, SAR, PAR, exchangeable Na and K and exchangeable Ca and Mg.

Dongale and Savant (1979); Shankarappa (1993) state that an increase in exchangeable Potassium was observed when soil was treated with spent wash.

Nunes et al., (1981) applied increasing levels of spent wash and observed that total and exchangeable Na^+ values were not affected, while exchangeable K^+, Ca^{++}, Mg^{++} and pH increased. In contrast, exchangeable Al^{3+}, available P and NO^-_3 decreased.

Somashekar et al., (1984) state that mineralization of organic material as well as nutrients present in the effluents were responsible for an increased availability of plant nutrients.

Somashekar et al., (1984) opined that the mineralization of organic material as well as the nutrients present in the effluents is responsible for the increase in the availability of plant nutrients.

Orland et al., (1985) applied vinasse for 20 years and observed increased pH and higher K, Ca, Mg and CEC.

Scandaliaris et al., (1987) pointed out that application of spent wash to soil increased the soil Nitrate availability, EC and inter changeable Potassium.

Cepro and Machado (1987) stated that the cane field irrigation with sugar factory wastewater affected a tendency for the exchangeable Ca to increase.

Taluk and Medeiros (1989) observed an increase in soil pH, available N, P, K, Ca and Mg for 80 m^3 vinasse application per hectare.

Sweeney and Graetz (1991) reported that the digested distillery effluent application increased soil concentration of most elements particularly K and Na.

Devarajan et al., (1993) observed an increase of available Ca and Mg from 1,400 ppm to 2,200 ppm and 126 ppm to 470 ppm respectively due to the application of 10 times diluted distillery effluent.

They reported that the available micronutrients viz., Zn, Fe, Cu and Mn of the post harvest soil increased from 2.2 to 3.9 ppm, 22.9 to 31.6 ppm, 4.1 to 7.3 ppm and 15.5 to 25.8 ppm respectively due ferti-irrigation with 10 times diluted distillery effluent.

Joshi et al., (1996) reported an increase in organic carbon due to effluent irrigation in post harvest soil. This is attributed to the addition of organic matter through the effluents.

Zalawadia and Raman (1994) recorded higher values of electrical conductivity, organic Carbon, available N, P and K with the usage of effluent water instead of normal water at the same level of fertilizer application.

Palaniswami and Sreeramulu (1994) reported that effluents discharged from Seshasayee paper and Board Ltd., (Pallipalyan) used for irrigating sugarcane crop for 15 years showed that pH, EC, Organic Carbon, CEC, exchangeable cations, available P.K, micronutrients and enzyme activities were increased and there was practically no significant change in most of soil properties. The undiluted effluents from M/s Seshasayee paper and Board Ltd., and Venkatesh paper mills Ltd., Tamil Nadu caused an increase in pH, organic matter and contents of available nutrients in red and black soils.

Rajukkannu and Manickam (1996) reported that the high available N in the post harvest soil in the effluent treated plots might be due to the mineralization of organic matter in soil supplied through distillery effluent. Application of distillery spent wash to alkali soil significantly increased the available P content of the soil. The acidity and $HCO_3$of distillery spent wash had solubilised the native insoluble soil P and helped to increase the available P. It was also reported that the available K was increased by 4 to 5 times due to effluent irrigations, which might be due to the fact that K is the component supplied in large quantities.

Devarajan et al., (1998) and Baskar et al., (2003) state that the exchangeable Ca, Mg and Na contents of the post harvest soil were significantly increased due to the application of graded doses of distillery effluent. This might be due to Ca, Mg and Na contents of the effluent.

Mahimairaja and Bolan (2000) state that application of different levels of spent wash had remarkable impact on both NH_4-N and NO_3-N in soil. Before sowing NH_4-N content was only 72 mg/kg in the control, whereas, it ranged from 138 to 282 mg/kg under one time application of spent wash. Increase in the levels of spent wash significantly increased the NH_4-N and such increase was more due to NP fertilizer application. Soil that received 120 m^3 of spent wash plus NP fertilizers had the highest concentration of NH_4-N. Furthermore, increase in the rate of spent wash application had increased the NO_3-N significantly; however, such difference was narrow down in the post harvest soil. In general, continuous application of split doses of spent wash resulted in relatively higher amount of NO_3-N of soil.

Baskar et al., (2003) reported that the available micronutrients viz., Fe, Mn, Zn and Cu were progressively increased by the graded levels of distillery effluent and the availability being maximum with the application of distillery effluent @ 2.5 lakh litres per acre. They also stated that increased availability might be due to direct contribution from the effluent as well as solubilisation and chelation effect of organic matter supplied by the effluent.

Baskar et al., (2003) suggest that since the distillery effluent contains appreciable amounts of basic cations, organic matter and higher salt load, its application to soil may affect the chemical properties of soil.

De Souza, (2007) has indicated that the advantages of using vinasse in soil include a rise in pH, increased cation exchange capacity, availability of nutrients, improved soil structure, increased water retention and development of the soils micro flora and micro fauna. Because of a deeper root system, the vinasse introduces nutrients in depth. There do not appear to be any damaging impacts on soil at doses lower than 300 m^3/ha, while higher doses may damage the sugarcane or, in specific cases (sandy or shallow soils) contaminate underground waters.

Das et al., (2009) stated that in post harvest soil, pH increased by 5 per cent, organics by 48 per cent, humic acid carbon by 16 per cent, fulvic acid carbon by 53 per cent, N by 48 per cent, P by 21 per cent, K by 320 per cent, Ca by 221 per cent and Mg by 90 per cent. They have also indicated that apart from saving fresh water by 10 to 20 per cent through distillery effluent irrigation at different dilutions, an accrued benefit in terms of incorporating plant nutrients in soil was also evident in the pot experiment study.

Kalaiselvi and Mahimairaja (2010) undertook a study to evaluate the impact of spent wash irrigation on the Nitrogen dynamics in soil with groundnut as the test crop. They used biomethanated spent wash with a pH of 7.1, BOD of 12800 mg/L, COD of 35000 mg/L, Phosphorous 40 mg/L, Potassium 9097 mg/L, Sodium 357 mg/L, Calcium 4600 mg/L and Nitrogen 420 mg/L. One time application and continuous split dose of application was tried in separate main plots. 8 sub plots were also designed within the main plots. They applied different levels of spent wash to the field by spraying manually to each plot 15 days before sowing for the main plot designed for one time application. In the second main plot treatment, the spent wash was applied in three equal splits with irrigation water. The first split dose was applied 15 days after sowing. The crop was supplied with Nitrogen and Phosphorous fertilizers at 17 kg and 34 kg/ha. The K was entirely supplied through the spent wash. For each of the two main plots the subplot applications were as follows:-

T1 – Control

T2 – Recommended dose of Nitrogen and Phosphorous.

T3 – Spent wash @ 40 m^3/ha

T4 – Spent wash @ 40 m^3/ha + Recommended dose of N and P.

T5 – Spent wash @ 80 m^3/ha.

T6 - Spent wash @ 80 m^3/ha + Recommended dose of N and P.

T7 – Spent wash @ 120 m^3/ha.

T8 - Spent wash @ 120 m^3/ha + Recommended dose of N and P.

The transformation and the availability to plants in soil was greatly influenced by the spent wash application with both methods of application (one time and split dose) exhibiting different responses. Before sowing (15 days after one time spent wash application), both NH_4-N and NO_3-N were significantly higher in soil with one time application, whereas at the later stages (pod formation and harvest), continuous application recorded higher values. Irrespective of the methods of application, at all stages of crop growth, the amount of NH_4-N and NO_3-N were greater in soil that received spent wash at a rate of 120 m^3/ha plus the recommended dose of N and P. The lowest concentration was observed in the control followed by only N and P. The soil data indicated that the spent wash not only adds N to the soil but also enhances the mineralization of N from organic N pool in soil.

Darmalingaiah, (2011) reported that application of 1.5 N as compared to similar fertilization through spent wash recorded highest available N, P and K in soil and the highest N, P, K and S uptake were recorded with 1.5 N through spent wash. Application of 1.5 N through spent wash recorded the highest soil enzyme activity. The least were recorded in a mixture of 0.25 N through spent wash and 0.25 N through fertilizer. Here 'N' was the recommended dose for Nitrogen.

Srivastava et al., (2012) in their study on the impact of Ferti-irrigation with distillery effluents and Di-ammonium Phosphate (DAP) on the soil and growth characteristics of Egg plant, concluded that distillery effluents have a significant impact on soil properties. Among the various dilutions of distillery effluents used, irrigation with 50 per cent concentration, improved the soil nutrients and micro flora status that resulted in the maximum growth performance of Solanum melongena plants in comparison to Bore well water or DAP and was more economical than using DAP.

Kumar and Chopra (2013) used various dilutions of distillery effluents with a BOD of 3276.84 mg/L, COD of 8678.65 mg/L, Total Kjeldahl Nitrogen of 580.97 mg/L, Nitrates 1468.78 mg/L, Phosphates 642.26 mg/L, Sulphates 1286.49 mg/L and Potassium (K^+) 548.68 mg/L in their experiments on the effects of ferti-irrigation on the growth and yield of Vicia faba. L. and on soil characteristics. The contents of heavy metals viz Cd, Cr, Cu, Mn and Zn were found to be higher than the limits prescribed for irrigation. The authors have observed that at all dilutions for applications the soil texture remained unchanged. The increment in most of the other parameters like OC, Na^+, K^+, Ca^{2+}, Mg^{2+}, Fe^{2+}, TKN, PO_4^{3-}, SO_4^{2-}, Cd, Cr, Cu, Mn and Zn of the soil may be attributed to higher organic load of distillery effluents. Potassium salts were reported to be chiefly responsible for an increase in the electrical conductivity.

Kumar and Chopra (2013a) have reported that soils irrigated with Distillery effluents showed an increase in EC, Organic Carbon, Calcium, Magnesium, Sodium, Potassium, Iron, Total Kjeldahl Nitrogen, Phosphates, Sulphates, Zinc, Cadmium, Copper, Manganese and Chromium. The authors also observed a decrease in moisture content, water holding capacity, bulk density and pH. No drastic change was observed in the soil texture with the application of all concentrations of distillery effluents. These observations were in comparison to changes when irrigated with Bore Well Water irrigated soil in both the rainy and summer seasons. They concluded that Distillery effluents are rich in plant nutrients and heavy metals and that distillery effluent ferti-irrigation improved the soil nutrient status in both the cultivated seasons.

2.2.6.3 Biological Properties

Kolar and Mitiska (1965) reported that Sulphite waste liquor derived from paper mill effluent increased the general microbial activity, humus content and sorption capacity.

Vercher et al., (1965) indicated that on addition of Sulphite spent liquor, NH_4 became immobilized in the early stages due to N assimilation by microorganisms, which rapidly consumed carbohydrates and organic acids present in Sulphite spent liquor.

Neves et al., (1983) stated that application of various rates of stillage resulted in substantial but temporary increase in the population of bacteria and fungi, but, Actinomycetes were inhibited until population of other microorganism decreased. Application of stillage contributed to soluble nitrogen, which stimulated non-fixing bacteria but inhibited temporary Nitrogen fixing Bacteria. The population of bacteria increased rapidly following the decline of non-fixing bacteria Azospirillum spp. Nitrogenase activity was also stimulated by stillage application but the effect was only in the presence of applied molybdenum.

Fillip and Muller (1984) reported that application of fermentation residues @ 200 tonnes per ha positively influenced the biological activity of soil. Bacteria, Actinomycetes and fungi in amended soil sample showed significantly higher colony counts than in the unamended soils. The abundant growth of Calothrix maxchica var. intermedia was noticed in soil, which received the effluent of molasses distillery. The effluent particularly at low concentrations (1 to 10 per cent v/v) and neutral pH increased the growth of organisms.

Mattiazo and Ada Gloria (1985) found that the organic matter oxidation brought out by microbial activity was responsible for increased pH of the soil treated with distillery effluent.

Tauk et al., (1990) found that annual application of vinasse increased the amylase and cellulase activity but urease activity was unaffected in the red yellow latosol of Cerroda area in Brazil.

Lal, (1990) compared the effect of distillery spent wash and sewage on enzyme activities in different soils and concluded that the cellulase, dehydrogenase and phosphatase activities were increased in soil irrigated with distillery effluent than with sewage effluent. He also reported that an increase in enzyme activity was more marked in Palampur acid soil than in neutral soil of Indian Argriculture Research Institute (IARI), New Delhi.

Adhikary, (1989) reported that the Cyanobacterium grew photo heterotrophically and chemo heterotrophically in the medium supplemented with sucrose and lower concentrations (10 per cent v/v) of neutralized distillery effluent.

Smith, (1991) states that enzymes are the indicators of microbial activity and may provide an index of total microbial activity in soil.

Devarajan et al., (1993) reported that the soil enzyme activities were well maintained with 50 times diluted spent wash irrigation and the phosphatase enzyme activity was not suppressed by the spent wash irrigation.

Devarajan et al., (1993) also state that when applied on the soil, the colour of the effluent is amenable to microbial and photo-degradation, without deteriorating the biological composition of soil.

Brookes, (1995) reported that the soil enzymes show an immediate response to any deviation in soil health.

Goyal and Kapoor (1995) also observed an increased microbial biomass and dehydrogenase activity due to application of distillery effluent and established a close relationship between the number of microorganisms and enzyme activity in soil.

Valdes, et al., (1996) reported an increase in the soil organic matter by 1 per cent with sugar factory effluent applied to soils in Cuba.

Rajukkannu and Manickam (1996) state that the rhizosphere region could be influenced by various environmental factors and physiological conditions of the plant, which might be responsible for variations in the population dynamics of different groups of microflora in the rhizosphere of crops as influenced by effluent irrigation. The experiment conducted regarding the population dynamics of bacteria, Actinomycetes, fungi, Azospirillum and Azotobacter in the field soils grown with turmeric, paddy, ginger, cotton, banana and groundnut showed that the 50 times and 40 times diluted effluent irrigations enhanced or maintained the microbial populations in the soils. The soil enzyme activities were also maintained with 50 times diluted effluent irrigation.

Lakshmanan and Gopal (1996) also found that the population of bacteria, fungi, Actinomycetes and Acetobacter in the soils irrigated with 50 times diluted effluent was higher than the soils irrigated with other dilutions viz., 40, 30, 20 and 10 time dilutions and they reported that the population varied with period under effluent irrigation and the peak was recorded in the fifth month.

Jhosi et al., (1996) reported that the soil pH registered no significant change with effluent amendment in wheat crop.

Murugaragavan, (2002) detected the presence of appreciable amounts of growth promoters viz., Gibberillic Acids (GA) and Indole Acetic Acid (IAA) in the distillery spent wash. It was also observed that the addition of raw spent wash @ 125 m^3 ha^{-1} in dry land soils increased the activity of soil enzymes viz., phosphatase, dehydrogenase and urease.

Baskar et al., (2003) have observed that, effluent irrigation can influence the biotics and population dynamics of the microorganisms in the rhizosphere of crops.

Baskar et al., (2003) reported that pre-plant application of graded doses of distillery effluent significantly increased the pH and EC of the soil from the initial level and they stated that the high salt load of effluent might have increased the soluble salt content of the post harvest soil.

They stated that though the distillery effluent contains only small quantity of Nitrogen, its application significantly increased the available N status of post harvest soil. This might be due to its direct contribution as well as through increased microbial activity by the supply of other essential nutrients and organic matter, which in turn might have increased microbial decomposition and released the native N source.

Kaushik et al., (2005) stated that use of spent wash at lower concentration would increase the activity of dehydrogenase in pearl millet.

Bhukya, (2007) in her studies on the effects of spent wash irrigation on maize have observed that, spent wash fertilization caused an increase of about 12.6% in bacterial population, over 40% increase in fungi and 30% of Actinomycetes population.

Bhargava et al., (2008) reported that the protein content in root, shoot and leaves increased in mustard plants irrigated with 50 per cent (v/v) distillery effluent at 60 and 90 days of growth period.

Lenin and Thamizhiniyan (2009) concluded that soaking the seeds at a lower concentration of spent wash increased activity of dehydrogenase enzyme in Avare (Lablab purpurea).

2.2.6.4 Nutrients and Nutrient Uptake

Takai and Oguma (1966) state that solubility of Fe-P increased in flooded soil due to addition of Sulphite-spent liquor. Sulphonic acid from Sulphite-spent liquor was not converted into sulphide in flooded soil.

Escolar, (1966) observed an increased yield and uptake of P, K and Ca by snap bean due to spent wash application.

Bajpai and Dua (1972); Agarwal and Dua (1976) state that a significantly higher yield of sugarcane and available N was recorded with 200 kg N through spent wash application.

Dongale and Savant (1978) applied K at 1,000 ppm through spent wash and noticed that at the end of 60 days, the extractable K was higher in spent wash applied soil (320 ppm) than in control (160 ppm). Uptake of K by Jowar was also higher in treated soil (21 mg/40 plants) than in control (9 mg/40 plants).

Chatterjee et al., (1979) said that FYM or decomposed straw applied at the time of planting did not release as much available N as green leaf manure (Sesbania bispinosa and Impomea crassicaulis) or spent hop (waste from brewery factory) applied at 10 tonnes per hectare to four to five weeks before planting of rice in submerged soil. Spent hop released more N (65 ppm) than other bulky organic manures (64 ppm). Application of spent hop resulted in an increase in organic Carbon (1.01 per cent), CEC (15.15 meq/100g), P (8.7 kg/ha) and K (196 kg/ha) compared to control.

Parez Escolor and Ortiz Velez (1979) found that the application of rum distillery waste contributed to higher K in soil.

Shailendranath and Rao (1979) state that uptake of N, P, K, Ca and Mg were higher by ragi (Eleusine coracana) when urea and rock Phosphate fertilizers were treated with brewery effluent (703.5, 128.8, 467.0, 625.5 and 317.8 mg/pot respectively) than when untreated (446.0, 65.3, 396.0, 550.3 and 90.3 mg/pot respectively).

Velloso et al., (1982) reported that the application of distillery residues decreased the Nitrate loss from soil. In case of soil treated with 400 m^3 per ha of residue with addition of N and P, leaching of Nitrate was about 30 ppm less and the leaching of Ammonium and about 4 ppm more than that in case of no residue treatment.

Cruz et al., (1991) state that vinasse (distillery waste) mineralizes rapidly which releases nutrients and thus maintains soil fertility. The Ca, S, N and P contents of soil were increased.

Sweeney and Graetz (1991) reported that application of distillery waste anaerobic digester effluent to soil at any rate significantly increased K, Ca, Mg and Na concentrations than in control. Irrigation of cane field with distillery effluent increased exchangeable Calcium and Potassium. Addition of distillery effluent regardless of rate raised the soil pH, owing to an increase in soil K, Ca, Mg and Na content. Further, application of digested distillery effluent increased concentrations of most elements.

Shinde et al., (1993) observed an increased EC and available K in soil and saturation paste extract when spent wash solids were applied. Further, available N, P and extractable Fe, Mn and Zn were also found to increase at harvest of sorghum.

Korn Dorfer and Anderson (1993) stated that application of vinasse increased significantly the sugarcane, wheat, pigeon pea and maize yield as well as N, P, K, S and Ca uptake.

Goyal and Kapoor (1995) observed that application of distillery wastewater (up to 169 cubic metre per ha) increased dry matter of mung bean and increased both N and P uptake. Further increase in the level of distillery wastewater led to decrease in both dry matter production and N and P uptake.

Bhat and Doddamani (1995) found that when soils irrigated with diluted effluent for different periods had higher available N, P and K than soils irrigated with only Krishna river water and unirrigated soils; they also found higher uptake of N, P and K in less diluted treatments.

Pujar, (1995) reported that the application of diluted spent wash increased the uptake of Zinc (Zn), Copper (Cu), Iron (Fe) and Manganese (Mn) in maize and wheat as compared to control and the highest total uptake of these were found at lower dilution levels than at higher dilution levels.

Zalawadia et al., (1997) showed that application of diluted spent wash increased uptake significantly over irrigation with tube well water. They also observed an increased nutrient availability of P, K and S indicating the signs of improvement in some physical properties of soil. Similarly, an increase in available N, P and K by pre-sowing irrigation with distillery waste was reported by **Singh and Bahadur (1997)**.

Campbell, (1999) stated that Nitrate Reductase (NR) is the key enzyme for Nitrogen assimilation as Nitrate is the major N source for most of higher plants and is substrate inducible. The application of distillery effluents resulted in higher activity of the enzyme. The Nitrate reductase activity (NRA) increased up to flowering stage.

Paula et al., (1999) reported an increase in the K concentration of soil with increased rate of stillage application in potato field has been found. There was also an increase in soil Ca and pH.

Badawy and Elmatium (1999) reported that the water holding capacity, cation exchange capacity, increases the availability of Nitrogen, Phosphorus, Potassium, Copper, Zinc, Iron, Manganese; but with reduced BOD with addition of sewage sludge to a coarse textured sandy and calcareous soil.

An upsurge in nutrients uptake (N, P, K, Ca, Mg, Zn, Cu, Fe and Mn) was evident with increasing effluent concentration. Nitrogen uptake was orderly enhanced from 0 to 160 m^3/ha while P, Ca, Zn, Fe and Mn uptake was enriched up to 120 m^3/ha in 2006.

P, Ca, Mg and Fe uptakes were consistently improved with increasing effluent concentration over control but no such trend was seen in other nutrient ions. Enhancement of nutrients depends on type of element and soil type where modification occurs due to spent wash treatment. Nutrient's uptake response was significant at N, P, Ca, Mg, Zn, Cu, Fe and Mn with maximum estimate at 120 m^3/ha. Application of cane sugar molasses distillery effluent improved soil properties to enhance paddy yield significantly over normal practice without degrading soil health and environment and without using fertilizer input. Furthermore, improvement of soil properties even after harvest of paddy is additional advantage of spent wash use and could be exploited for succeeding crops.

Patil et al., (2000) observed highest uptake of N, P, and K by maize due to the addition of spent wash at the rate of 50 cubic meter per hectare, which was significantly superior to control. An increase in N, P and K uptake was due to increase in dry matter yield.

According to **Baskar et al., (2003)** the application of spent wash significantly increased the available N status of post harvest soil. The exchangeable Ca, Mg and Na contents of the post harvest soil were significantly increased due to the application of graded doses of distillery effluents.

Chandraju and Basavaraju (2007); Chandraju, et al., (2008) reported that diluted spent wash increase the uptake of nutrients of leaves vegetables.

Chandraju, et al., (2008a) stated that diluted spent wash increase the uptake of nutrients of cabbage and mint leaf.

Basavaraju and Chandraju (2008) reported that diluted spent wash increase the uptake of nutrients of root vegetable.

Basavaraju and Chandraju (2008a); Chandraju, et al., (2008b) reported that diluted spent wash increase the uptake of pulses, condiments and root vegetables.

Chandraju et al., (2011) reported that mineralization of organic material as well as nutrients present in the spent wash was responsible for increased availability of plant nutrients. Diluted spent wash increase the uptake of nutrients.

2.2.6.5 Procedures, Practices and Guidelines

Das et al., (2009) state that reuse of industrial effluent sometimes induces risk to infect soil, water and crops. Detailed guidelines are available for safe and secure use of effluents. However in effluent reuse practice, to abate adverse impacts of effluents, protecting soil health and crop quality the steps need to be followed are:

(a) Characterization of effluent:

Prior to putting into practice the effluent needs to be thoroughly analyzed and estimated for its constituents, which reveals the type and quality of effluent.

(b) Evaluation of effluent potential by comparing its characteristics with different irrigation water quality standards. After characterization, prioritization of effluent constituents as per their potential to cause damage is required in this process. This prioritization will help to eliminate the effluent, if it contains hazardous elements/compounds, such as heavy metals beyond their corresponding standards at the first instance. Heavy metal causes irreversible damage on living beings. Thus the step will help to disclose effluent's ability to be used or not-used in irrigation purpose.

(c) Match the effluent characteristics with relevant properties of dominant soil types:

Soils are of different types based on their contents and characteristics. Different soils are dominant in different regions. This could be used as a yardstick for effluent selection and improve its prospect of utilization in cropping, such as soil with acidic pH and low salinity can be used for receiving effluent of high pH and high salt content. In this way the effluent's liabilities could be conditioned and its potential can be utilized for cropping. The soil based effluent reuse option could be employed if the information of soil as per availability of fresh water resources is known in various locations / regions.

(d) Identification of effluent quality indicators:

For surveillance of effluent quality, testing of number of properties in regular interval is a major burden in effluent reuse program. Identification of salient properties of effluent will help to relieve the load while monitoring its quality in an effective manner. Choosing of appropriate mechanism to screen effluent properties and selecting the properties as indicators is vital in this process.

(e) Check the quality of crops, soil and adjacent water resources:

All steps are mandatory for effluent reuse practice. But for continued use of same kind of effluent, monitoring of indicative properties (effluent quality indicators) and a strict vigil on soil / water / crop quality are highly required to promote its safe use in crop production. There exists a growing realization that the adoption of ecological and sustainable farming practices can only reverse the declining trend in the global productivity and environment protection.

Kaur et al., (IARI, New Delhi) reported that although utilisation of wastewater is beneficial for usage in agriculture, several skills are required to be known for effective results prior to its usage:

a) Wastewater is also a rich source of plant nutrients, therefore soils irrigated with wastewater are enriched in nutrients. Hence, doses of fertilizers to be applied should be adjusted according to the nutrient contents in wastewater, amount of wastewater to be applied and crop nutrient requirement. Soil testing should also be carried on regular basis to check imbalanced nutrition or soil sickness.

b) Stopping irrigation 1 to 2 weeks before harvest can effectively reduce crop contamination. However, this is difficult to implement because many vegetables (especially leafy vegetables) need watering up to the point of harvest to increase their market value. This technique may be possible for some fodder crops that do not have to be harvested at the peak of their freshness.

c) Under the situation where land has already been contaminated and food crops are not permitted; alternate land uses like establishment of manmade forests with high economic value and having high rate transpiring trees like sal, mahogany, Eucalyptus, poplar, bamboo, neem (Azadirachta indica), shisham (Dalbergia sissoo) etc. for non-edible products like fuel and timber and developing green belts around the cities can be considered.

Suresh (2011), CPCB, has suggested that application of spent wash can be hazardous to vegetation, reduce soil alkalinity and manganese availability resulting in inhibition of seed germination. The CPCB also holds that use of bio methanated spent wash for irrigation without proper monitoring can affect ground water quality by altering its physicochemical properties due to leaching.

Rathika and Ramesh, 2013 have emphasized on the importance of waste water irrigation to offset the immense shortage of irrigation water. In their review of characterization of wastes, effect of waste water use on soil and crops and the management strategies from various industries (Distillery, Paper and Pulp, Tannery, Textile, Fertilizers and Sewage effluents) they have concluded that utilisation of treated industrial effluents in agriculture has great potential as an alternate source of water for increased demands of agriculture produce. They however suggest that a proper treatment of effluents and agronomic management strategies have to be developed for use on a long term basis._Generally it has been observed that treated waste water when used in low concentration with canal/tube well waster will have an encouraging effect on crop and yield.

SECTION-3

DISTILLERY EFFLUENTS–PRESOWN LAND APPLICATION

3.1 Abstract

The Central Pollution Control Board is of the opinion that biomethanated spent wash with a BOD of less than 7000 mg/L could be used for pre sown irrigation. Studies carried out by Agricultural Scientists have revealed that most of the food crops show good response to pre sow distillery effluent irrigation and the addition of effluents increases the soil fertility. Around 200 cubic meters per ha is required 25 to 30 days before sowing. The application is governed by the N requirement of the crop and soil type and is usually done 30 days in advance of sowing and onset of rains. Some estimates indicate that application of distillery effluents @ 50 m3/ha will supply 75 Kg. N, 40 Kg. P and 50 Kg. K which represents almost half the N and P and 100 percent of the K requirement. It will also supply 105 kg Ca, 100 Kg Mg, 200 kg S, 0.5 kg Zn, 3.25 Kg Fe, 0.2 Kg Cu and 0.25 Kg Mn. A significant increase in yield indicators of various crops (20 to 60%) subject to pre sown irrigation has been reported without associated environmental hazards. The addition of spent wash also increases the soil fertility. Ammoniacal nitrogen build up has been found to be the maximum in soils when one time soil application @120 m^3/ha and N and P supplement has been practiced. Post harvest soils have been seen to demonstrate an increase in the available micro nutrients like Fe, Zn, Cu and Mn. Pre-sown application of less than 300 m^3/ha has not been observed to adversely affect soils. Leachates from a long time application of spent wash to agricultural fields have been observed to cause an increase in the Nitrate levels but the concentrations were not beyond the levels harmful to human health. There are different observations on leachability of spent wash

constituent to ground water. It is generally felt that with a cautious application, the problem could be sufficiently managed without any damage to ground water quality.

Presowing generally involves filling post harvest fields with distillery effluents and allowing it to dry for 15-20 days after which the fields are tilled and sown. Subsequent irrigation is given with fresh water. A centimeter of post methanated effluents applied on one hectare of land could annually yield about 600 kg of Potassium, 360 kg of calcium, 100 kg of Sulphates, 28 kg of nitrogen and 2 kg of phosphates.

Application could be carried out twice in a year. Application rates of over 400 m^3/ha have been variously tried. Pre sown application is also practiced in Australia, Brazil, Cuba and Philippines where up to 240 m^3/ha spent wash has been applied in addition to chemical fertilizers and improved cane and sugar yields obtained. Paddy, maize, sugarcane, sweet sorghum, barley, low land grasses, turmeric, pulses, pineapple, tuber/root medicinal plants have all responded well to pre sown irrigation.

Utilisation of distillery effluents in agricultural fields creates organic fertilization, reduces the pH, increases the availability of nutrients, the capability to retain water and also improves the physical structure of the soil. Post harvest fields are usually filled with distillery effluents and after the surface is almost dried, the fields are tilled and the crops are sown. The ammonification, nitrification and enzyme activities of the soil have been observed to increase augmenting thereby the N availability in soil. When applied to soil, the color of effluent is amenable to microbial and photo degradation. For preseason sugar crop the recommended dose of NPK by State University in Maharashtra is 340:170:170 based on nutrient contents in BMSW. Post methanated effluent has a lower C:N ratio which facilitates it to degrade more swiftly in soil as compared to untreated spent wash. It has been said that effluent application would reduce the nutrient requirement through fertilizers. What also needs to be studied is the impact of high salt loads on sustained crop yields due to long term application of effluents. Suitable cropping patterns, agronomic practices, irrigation plans and water management practices have to be drawn up.

The CPCB in 2005 had proposed a protocol for one time controlled land application of treated post methanated spent wash as liquid manure. It specified that the BOD should be less than 7000 mg/L and pH over 7. It also specifies a system of sampling, monitoring and evaluation, storage during months of non utilization (30 days), transportation guidelines, ensuring land availability and consents and a crop wise likely volume of utilization. The Central Pollution Control Board has also felt that one time controlled land application is difficult to practice and that new stand alone distilleries may not be allowed to use this scheme for zero effluent discharge. It however does not restrict existing attached distilleries going in for expansion from adopting the practice of pre sown irrigation in some Southern States of India. The CPCB also recognizes pre sown effluent irrigation to be an emerging technology.

Post methanated effluent has a lower C:N ratio which facilitates it to degrade more swiftly in soil as compared to untreated spent wash. It has been said that effluent application would reduce the nutrient requirement through fertilizers. What also needs to be studied is the impact of high salt loads on sustained crop yields due to long term application of effluents. Suitable cropping patterns, agronomic practices, irrigation plans and water management practices have to be drawn up.

3.2 Review of Literature

3.2.1 General

Several studies were carried out by Tamil Nadu Agricultural University, Coimbatore (**Thiagarajan, 2001**) in various agricultural stations (Sakthi Sugars Ltd, Sakthinagar, 91– 92; EID parry (I) Ltd, Nellikuppam; Bannari Amman Sugars Ltd, Sinnapuliyur and Rajshree Sugars and Chemicals Ltd, Vaigaidam), which demonstrated that one time application of raw and secondary treated spent wash is effective in improving the yield in a number of crops. One time land application of treated effluent at various stages improved the yield and quality of the sugarcane. The results showed that the pH, organic Carbon and available nutrient contents of the soils were significantly increased with increasing levels of spent wash addition. Application of spent wash in soil did not have any impact in electrical conductivity of the soils. The highest cane yield of 155.8 tons/ha was recorded with the application of 125 tons/ha. The application of spent wash on Maize and Sunflower showed that the spent wash at 60 tons/acre produced higher grain yield in maize and sunflower.

Rajukkannu and Manickam (1996) state that application of distillery effluent @ 50 m^3ha^{-1} will supply 75 kg N, 40 kg P, 50 kg K which represent almost half the N and P and 100 per cent of the K requirement. It will also supply 105 kg Ca, 100 kg Mg, 200 kg S, 0.5 kg Zn, 3.25 kg Fe, 0.2 kg Cu and 0.25 kg Mn.

Phanapavudhikul, (1999) reported that the farmers used spent wash as source of fertilizer, which saved in terms of equivalent chemical fertilizer. The direct use of spent wash liquor has promise in sustainable development of agriculture in developing countries.

Ramana et al., (2002a) evaluated the manurial potential of raw spent wash (pH 4.2, Organic carbon 37.5 g/L, ammoniacal nitrogen 125.4 mg/L, Total P 240 mg/L, Total K 13 g/L), Biomethanated spent wash (pH 7.4, organic carbon 13.5 g/L, ammoniacal nitrogen 0.68 g/liter, Total P 0.13 g/L and Total K 11.5 g/Liter) and Lagoon sludge in comparison to application of recommended doses of fertilizers (NPK+FYM) and a control with no fertilizer or effluents. The characteristics of effluents provided in the paper do not appear representative for ammoniacal nitrogen in raw spent wash. The experiments were performed in clayey soils. Biomethanated Spent Wash was applied at 2.0 ha cm, RSW at 1.0 ha cm and lagoon sludge at 5 t ha^{-1}. The distillery effluents were applied 07 days before sowing. Half of N and complete P and K and FYM were applied just before sowing and the remaining half dose of N was top dressed at 45 days after sowing. The authors observed that all the three distillery effluents affected the seed yield positively. The highest seed yield of 619 kg ha^{-1} was produced by biomethanated spent wash, 557 kg/ha by raw spent wash and 472 kg ha^{-1} by lagoon sludge. An yield of 310 kg/ha was observed in the control. The distillery effluents however could not influence the protein and oil contents. All the observed increments in yield were however less than the yield of 901 kg/ha through the recommended doses of NPK+FYM (N,20; P_20_5, 60; and K, 60 kg/ha^{-1}).

Application of distillery effluents decreased both the nodule number and their fresh weight compared to control and NPK+FYM treatment. The authors relate the distillery effluents inability to produce similar results as through Fertilizer plus FYM because of the imbalance in the nutrient composition and the presence of Nitrogen and Sulphur and micronutrients in the organic from which are not readily available to crops.

The authors concluded that overall, the nutrients present in the distillery effluents played a major role in increasing the chlorophyll content, dry matter production, uptake of nutrients resulting in higher seed yield in groundnut. They have however cautioned that proper care should be taken for irrigating the lands with the effluents because of their high salt load.

Vidyarthi, (2011) has also stated in his paper that bio methanated spent wash with a BOD of less than 7,000 mg/L can be used in pre-sown irrigation. The application is governed by the N-requirement of the crop and soil type as advised by agricultural institutions. The N-requirement of the crop is to be applied in a single dose. A maximum of one third of the spent wash generation could be utilized in pre-sown irrigation and the application should be done at least 30 days in advance of sowing and onset of rains. A storage lagoon capacity of ¼th of average yearly utilization of spent wash has to be provided.

Baskar *et.al.* 2013 have advocated that the use of spent wash for presown treatment of agricultural land seems to be lucrative. Local studies are required to develop suitable application rates. Effluent application would reduce the nutrient requirement through fertilizers, however high salt load, mainly potassium and sulphur, into the soil system may hamper the sustained crop yields due to long term application of effluents. This needs to be studied. Identification of suitable cropping system, agronomic practices, irrigation scheduling and water management with distillery effluent has to be done for implementing such irrigation ensuring minimum damage caused to the soil, crop and ground water.

Controlled land application of spent wash helps in restoring soil fertility, enhances soil micro flora and improves the physical and chemical properties of soil. The saturated hydraulic conductivity and pore space of the spent wash leached soils have been observed to increase significantly with simultaneous reduction in bulk density and water disposable clay. The availability to N,P,K,S,Zn, Cu, Fe, and Mn in the spent wash amended soils was found to increase significantly. Conjoint application of spent wash and other organic amendments like farm yard manure, green leaf manure and bio compost has been tried and found beneficial under dry land conditions. Waste waters from different industries could cater to the irrigation needs of various crops.

Kamble *et.al.* 2017 have stated that Controlled application of spent wash to the land as irrigation water helps in restoring and maintaining soil fertility, increasing soil microflora and improving physical and chemical properties of soil leading to better water retaining capacity of the soil. Spent wash at the rate of 35-50 m3/ ha., was recommended as optimum dose for higher sugar cane yields in Brazil and Australia.

Kamble and Hebbara, 2015, Kamble *et.al.* 2016 a and Kamble *et.al.* 2016 b have held that land application of distillery spent wash often benefits water pollution control and utilisation for agricultural production. They have also held that waste waters from different industries produced continuously could cater to the needs of irrigated crops.

Valliapan 1999 has stated that the saturated hydraulic conductivity and pore space of the spent wash leached soils increased considerably with simultaneous reduction in bulk density and water dispersible clay. The availability of N,P,K,S,Zn,Cu, Fe and Mn in the spent wash amended soils was found to increase significantly.

Mahimairaja and Bolan 2004 have shown that, though at higher doses (>250m3/ha) spent wash application is found detrimental to crop growth and soil fertility, its use at lower doses (125 m3/ha) remarkably improves germination, growth and yield of dry land crops. It has also been revealed that conjoint application of spent wash and organic amendments (Farm yard manure, green leaf manure and bio compost) is found suitably under dry land conditions.

The Office of the Principal Scientific Advisor to the Government of India, 2014 states that One Time Controlled Land Application is allowed only after bio-methanation of spent wash. It has to be carried-out as per the protocol of CPCB under the guidance and supervision of collaborating Agricultural University. The rate of application is based on nitrogen content of SW and the nitrogen requirement of the crop. Extensive work on this aspect has been carried-out by Agricultural Universities in Tamilnadu, Karnataka, UP, Bihar and Maharashtra and most of them have reported encouraging results on crop growth and productivity. These universities have monitored continuously for last 10 to 15 years the effect of one time application of BMSW as organic liquid manure. The results have shown that there are no harmful effect on soil fertility and ground water quality. Similar type of treatment has been also extensively used in Brazil, Thailand and Australia. Due to concerns of salt salinity CPCB and some of the State Pollution Control Boards are now not encouraging this method. The Office also states that in molasses the presence of Potassium, Sodium etc. is carried from the cane itself but the increased levels of calcium, phosphorous and sulphur is due to the use of “Milk of Lime” during the clarification process and sulphitation process. Alternate methods of clarification in place of “Milk of Lime” may improve the quality of molasses by reducing these elements, rendering the usability of bio methanated spent wash (after further treatment) for agricultural applications and that for the preseason sugar crop the recommended dose of NPK by State University in Maharashtra is 340:170:170 based on nutrient contents in BMSW.

The Energy and Resources Institute (TERI) 2018 has tried its High Rate Transpiration Technology (HRTS) to reclaim the effluent loaded site of a distillery in Madhya Pradesh. The technology employs mycorrhizae and a few other useful microbes to restore greenery. HRTS is a land application system wherein effluents are used in carefully designed layouts with wide ridges and furrows and trees that are bestowed with higher-transpiration capacity grown on ridges._A selected species of mycorhizza is applied in the HRTS model, depending on the soil and waste water chemical properties. Plants were grown on solar dried beds using certain species of mycrorhizae that collect and supply essential micronutrients from the effluent loaded soils to the plant.

3.2.2 Effect on Crops

Naylor and Severson (1984) state that brewery sludge residuals on a dry basis are approximately equivalent to 3:1:10 (N: P_2O_5: K_2O). It is estimated that a single application of 5 to 20 dry tonnes per acre will increase overall hay yields over one year period by a factor of at least 5 times as compared to untreated hay fields.

Shankarappa, (1993) observed an improved growth and a significantly higher plant height, dry matter and finger millet yield at 10,000 kg per ha distillery sludge along with recommended dose of fertilizer.

Babu et al., (1996) found that application of spent wash without dilution did not result in growth deformities or any alternation in plant metabolism. A significant increase in all plant growth attributes was observed. Further total chlorophyll, phenols, pigments, proteins, amino acids, starch and Nitrogen contents were influenced by spent wash.

Devarajan et al., (1998) state that the presowing irrigations with distillery effluent had no adverse effect on the germination but improved the growth and yield.

Comezy and Rodriguez (2000) state that spent wash released from the distilleries after treatment is often referred to as "liquid fertilizer" owing to its high mineral load especially K, Mg, Ca, SO_4, Cl^-, Fe, Zn, Mn etc. All these elements are essential for the growth, development and maturation of crops. The sugar and cane yield increased following application of 50 cubic meter per hectare vinasse on plant cane and 100 cubic meter per hectare of vinasse could substitute for 5 per cent of the N, 72 per cent of P_20_5 and 100 per cent of the K_20 that has to be applied using mineral fertilization.

Joshi, (2002) state that distillery effluents can be used either in pre-sown irrigation or post sown irrigation:

a) **Pre-sown irrigation/One-time land application:** Studies carried out by Agricultural scientists have revealed that most of the food crops show good response to pre-sow distillery effluent irrigation and the addition of effluents increases the soil fertility. Around 200 cubic meters per ha of land is required 20 to 25 days before sowing. The plants can be supplemented in this manner twice in a year (approximately 9 ha is required for 1 KLPD capacity). Most of the food crops show good response to pre-sown distillery effluent irrigation.

Uppal, (2004) reported that in order to suppress the impact of BOD, biomethanation process is recommended wherein the raw spent wash is subjected to anaerobic decomposition process thereby the BOD level is brought down to 85 per cent, which is popularly referred as Post Methanated Distillery Spent wash (PMDSW). This wastewater is considered safer to use for crop production as a source of nutrients. In the past four decades, PMDSW research has been undertaken in cereals, pulses, oilseeds, cotton, sugarcane and vegetable crops. In all the cases, the data have vividly shown that one time land application of PMDSW prior to the cultivation of crops had improved the yield to the tune of 20 to 60 per cent without associated environmental hazards.

3.2.2.1 Effect on Maize

Singh and Bahadur (1998) stated that twelve pre sowing irrigations with the diluted spent wash had no adverse effect on the germination of maize but improved the growth and yield.

Mallika, (2001) in Kumar (2008) showed that the application of spent wash at a rate of 150 KL/ha produced higher gram yield in maize.

Sathish et al., (2013) used distillery effluents with a BOD of 15,300 mg/L, COD of 30,520 mg/L, Total Potassium 7,300 mg/L, Calcium of 920 mg/L, Total Phosphorous of 29.28 mg/L, and Ammoniacal Nitrogen of 636.25 mg/L. They used it in various concentrations for land application as a liquid irrigant before cultivation and solid compost after cultivation of maize. Based on their findings, they suggested that 50% and 75% concentrations of spent wash are good and result in a significant increase in average height of plants, length of leaves, breadth of leaves, leaf area index, girth of stem. The number of leaves per plant and number of tillers per plant however, did not register any significant increase.

Ravindra *et.al.* 2016 in their study on the impact of distillery Spent wash irrigation on the yield and economics of maize have suggested that the combined application of spent wash and potassic fertilizer, each at 50% level to supply recommended dose of Potassium (150:75:37.5 $N:P_2O_5:K_2O$ kg/ha) to maize crop resulted in savings of 50% cost on potassic fertilizer without reduction in crop productivity. In addition it also improved soil fertility. The required quantity of biomethanated distillery effluent and recommended FYM were applied uniformly one month before sowing on the surface and the plots were lightly irrigated. The recommended potassium dose to the maize crop was supplied through spent wash at 0, 25, 50, 75, 100, 150 and 200 percent levels.

3.2.2.2 Effect on Paddy

Das, et al., (2010) used bio methanated spent wash which had a C/N ratio of 0.84, pH of 7.7, salinity as expressed by EC of 20.7 dS/m, Nitrogen, 819.6 mg/L, Phosphorous, 673.4 mg/L, Potassium, 4690.5 mg/L, Calcium, 313.1 mg/L, Magnesium, 909.9, Sulphate, 672.4 mg/L, Zn, 3.6 mg/L, Cu, 8.1 mg/L, Fe, 87.4 mg/L and Mn 9.4 mg/L. A total dissolved solid concentration of 25.6 gm/litre was exhibited.

A field experiment was carried out growing wet season paddy in acidic red and laterite soil applied with effluents at the rate of 40, 80, 120 and 160 m^3/ha keeping zero m^3/ha as control when NPK was applied in a ratio of 100:60:60 kg/ha as Urea, Single Super Phosphate and Potassium chloride. $1/3^{rd}$ Nitrogen was applied at transplantation with P and K and the balance $2/3^{rd}$ Nitrogen was given at tillering and panicle initiation stages. Distillery spent wash was sprayed through homogenized sprayer and puddled into soil during field preparation. One-month-old paddy seedlings were transplanted 16 days after that application.

The authors observed that an application rate of 120 m^3/ha was found most favourable for growing paddy in red and laterite soil type.

They also observed that, paddy grain yield was improved by 32.61 and 78.26% with a progressive increase from 0 to 80 cubic meter per ha in the first year and decreased at application rates beyond 80 cubic meter per ha. However, as compared to the control, the yields were higher at concentration of 120 and 160 cubic meter per ha also. In the second year the improvement was 29.57 to 42% in grain. Das, et al., (2010) also observed that nearly 25 Kg additional yield per cubic meter of effluent was obtained up to 80 cubic meter per ha. An upsurge of nutrients uptake was demonstrated with increasing effluent concentration.

3.2.2.3 Effect on Sugarcane

Guimarti et al., (1968) in Kumar 2008 have recommended the optimum dose of spent wash application in sugarcane to be 419 m^3/ha with NPK supplementation.

Cooper (1975) in Kumar 2008, observed that distillery spent wash when applied at the rate of 135 m^3/ha in sugarcane was found to increase the cane yield.

Silva et al., (1981) reported that application of 80 cubic meter per hectare vinasse alone improved both cane yield and sugar per hectare.

Vierira, (1982) observed a significant increase in cane yield and recoverable sugar per hectare due to application of spent wash at the rate of 90 to 150 tonnes per hectare.

Samuel, (1986) stated that distillery effluent is of value as fertilizer when applied well before the planting of sugarcane crop.

Anonymous, (1986) reported that the application of distillery effluent at 150 and 300 t/ha increased the sugarcane yield by 53.8 and 44.0 per cent respectively when compared with untreated control. The quality parameters of sugarcane viz., POL, purity, commercial cane sugar CCS percent were not influenced due to diluted effluent irrigation. But the brix percentage in cane juice was found significantly increased in plots irrigated with 10 times diluted effluent (23.0 per cent) over river water irrigation (22.34 per cent). The studies indicated that one time application of treated undiluted effluent before planting of the crop and ploughed into the soils raised the pH slightly to the alkaline (7.87) and soil EC was not raised beyond 0.25 dSm^{-1} even at 500 t/ha of treated effluent application.

Barrocal, (1988) reported that application of vinasse at the rate of 120 m^3 per hectare accelerated cane ripening and increased cane and sugar yield per hectare. The increase in sugar yield was 2.07 tonnes per hectare over control.

Singh and Srivastava (1993) observed that juice quality parameters such as POL percent and purity coefficient remained unaffected by an addition of 500 m^3 distillery effluent.

Devarajan and Oblisamy (1994) reported that pre-plant application of distillery effluent @ 125 t ha-1 registered the highest cane yield of

155.8 t ha-1 followed by 250 and 50 t ha^{-1} which registered 148.9 and 147.7 t ha^{-1} respectively.

In Australia and Brazil the optimum dose for land application of distillery spent wash in sugarcane was found to be 35-50 m^3/ha (**Orlando et al., 1998**).

In the Philippines, spent wash application at the rate of 80-240 m^3/ha in addition to chemical fertilizers increased the cane yield by 10-12 per cent and sugar yield by 13-16 per cent than normal irrigation **(Gonzales and Tiano 1982, in Kumar 2008).**

In Cuba, spent wash application at the rate of 90-150 m^3/ha increased the potassium content in soil with increased cane yield and sugar recovery **(Vierira, 1982)**.

Increased juice quality, brix, pol percent and yield were recorded in 50 times diluted spent wash in sugar cane **(Jagdale and Savant 1979 in Kumar 2008)** and that the optimum dose for land application of distillery spent wash to get higher yield in sugarcane was 20 m^3/ha which supplied 186 kg of K per ha.

Some authors **(Devarajan 1994 in Kumar 2008)** have observed a normal yield with 50 times dilution of spent wash.

Kanimozhi and Vasudevan (2010) observed that spent wash at the rate of 35-50 m^3 ha^{-1} was recommended as optimum dose for higher sugarcane yield in Brazil and in Australia. In Sau Paulo, Brazil, the crop productivity was 2-10 times higher as compared to the untreated lands. In Cuba, spent wash application at the rate of 90-150 m^3 ha^{-1} increased the Potassium content of the soil, with increased cane yield and sugar recovery. It was found that the growth and chlorophyll content of the sugarcane in different conditions of treatment showed an increasing trend over the control. Average height of the sugarcane plant after 210 days showed an increase of 13.45 per cent in the 50 per cent DSW treated plot over the control.

The average breadth of the leaves after 210 days of plantation showed an increase of 46.96 per cent in the 50 per cent DSW plants over control. Similarly the average girth of the stem, average number of leaves per plant, average number of tillers per plant, average leaf area index and chlorophyll content of the test crop after 210 days of plantation showed an increase of 16.79 per cent, 21.18 per cent, 57.5 per cent, 62.84 per cent and 28.99 per cent respectively in 50 per cent DSW treated plants over control.

The increase in chlorophyll content in 50 per cent distillery spent wash treatment crop suggests that synthesis of chlorophyll is accelerated in low concentration.

Jain and Srivastava (2012) have studied the nutrient composition of spent wash and its impact on sugar cane growth. They have observed that the nutrient content of concentrated spent wash is much higher than the nutrient content of digested spent wash. The findings have indicated a stimulatory effect of low rate of crude spent wash (5 ml kg^{-1} soil) on root and shoot growth and inhibitory effect of higher dose (20 and 100 ml kg^{-1} soil of crude spent wash and 100 ml kg^{-1} of DSW) of both crude and digested spent wash. The crude spent wash used by them had a BOD of 40,000 mg/L whereas the digested spent wash had a BOD of 4000 mg/L. Very low rates of application of crude spent wash (5 ml kg^{-1} soil) showed improvement in bud sprouting (10.5 per cent), settling height (40 per cent), root number (9.4 per cent) and root length (13.2 per cent) while the higher rates of application (20, 100 ml kg^{-1} soil of CSW) and 100 ml kg^{-1} soil of DSW decreased these attributes. The decrease was about 17.4-50 per cent in bud sprouting, 6.7 to 33.3 per cent in settling height, 31.2-68.8 per cent in root number and 36.2-64.6 per cent in root length. The highest decreases were observed at 100 ml CSW kg^{-1} soil.

Srivastava P.C. *et.al.* 2012 carried out a field study to monitor the effect of molasses based distillery effluents on yields of sugar cane and soil properties. The treatments consisted of

a. A control plot
b. A plot with presowing irrigation with undiluted effluents

c. One plot with effluent irrigation: tubewell irrigation in the ratio of 1:3 at the tillering stage
d. One plot with two irrigations with Effluents :Tubewell water (1:4) at tillering and 30 days after tilleirng.

The subplots either received no fertilizer application (F0) or had 50% of recommended dose (50 kg N, 60 Kg P_2O_5) and 40 Kg K_2O per hectare as basal dose, F1 with a top dressing of 50 Kg N/ha at tillering and in June before the onset of monsoon. The authors have observed that use of distillery effluents, irrespective of the method of application significantly increased the yield of sugarcane over no application of effluents. Application of 50% recommended fertilizer dose increased the yield of Sugarcane over no application of effluents. Application of 50% recommended fertilizer dose increased the cumulative cane yields under different effluent treatments. Effluent supplemented irrigation (1:3 as above) resulted in a significant build up of organic carbon in surface soil as compared to tubewell irrigation. Effluent irrigation also increased the accumulation of Alkaline Potassium Permanganate in the 30-45 cm layer as compared to only tubewell irrigation. The use of distillery effluent as presowing or standing crop irrigation increased ammonium acetate extractable Potassium in surface and sub-surface layers. The authors, based on their observations have concluded that the use of distillery effluent in sugarcane crop as presown or standing crop irrigation has no adverse impact on soil reaction or electrical conductivity and could save atleast 50% of basal NPK application with significantly higher cane yields of main crop and two subsequent ratoons.

3.2.2.4 Other Crops

Dongale and Savant (1978) in Kumar 2008 observed that there was an increase in organic carbon and available N, P and K in soil with land application of distillery spent wash in sorghum.

Bucknall et al., (1979) reported that a total annual application of potale (waste product of malt whisky distillery) @ 100 cubic meter per ha increased the dry matter yield of lowland grass and grain yield of barley. Application of 220 cubic meter per ha potale gave higher grain yield (5,000 Kg./ha) over no potale applied plot (2,900 Kg./ha). Number of ears per m^2 and grain weight was also increased (554 and 42.99 g) over control (445 and 39.0 g).

Savant et al., (1980) revealed that the highest yield of grain (2.96 t ha^{-1}), cane juice (16.62 t ha^{-1}) and ethanol (2184 litres ha^{-1}) in sweet sorghum were observed for one time soil application of post-methanated distillery spent wash @ 84 m^3 ha^{-1} when compared to 100 per cent recommended fertilizer (NPK) and control.

Sweeney and Graetz (1991) stated that treated spent wash @ 50 KL ha^{-1} as basal + biosuper @ 2.5 t ha^{-1} + 75 per cent NPK significantly increased the growth and yield of turmeric.

Sweeney and Graetz (1991) stated that the highest yield of grain (2.96 t ha^{-1}), cane juice (16.62 t ha^{-1}) and ethanol (2184 litres ha^{-1}) in sweet sorghum were observed for one time land application of PMDSW @ 84 m^3 ha^{-1} when compared to 100 per cent recommended fertilizer – Nitrogen Phosphorous Potassium (NPK) and control.

Goyal and Kapoor (1995) reported that application of distillery wastewater @ 160 m^3 per ha increased dry matter production of mung bean and further increase to 640 m^3 per ha, declined the dry matter drastically and was even less than control.

The effect of this digested spent wash on the seed germination of chickpea showed that lower concentrations (2.5 to 20 per cent) of digested spent wash did not inhibit seed germination under laboratory conditions. Though 100 per cent seed germination was observed at 50 per cent spent wash concentration, it led to poor seedling growth and delayed seed germination. A higher concentration (500 m^3 ha^{-1}) of digested spent wash completely suppressed seed germination. The growth of chickpea plants was recorded as root and shoot weight in plants. Both root weight (0.895 mg) and shoot weight (0.668 mg) were maximum at the 2.5 per cent concentration of digested spent wash. As the concentration of digested spent wash increased, the root and shoot weight decreased.

Goyal and Kapoor (1995) concluded that both PMDSW @ 37.5 m^3 ha^{-1} with supplementation of 25 per cent of recommended N and 60 per cent of recommended P prior to planting improved the biomass yield, quality of Cumbu Napier hybrid fodder up to three cuttings.

Paula et al., (1999) working on a reddish yellow latosol of Brazil found that weight of pine apple fruit and yields increased with an increase in application of vinasse rate (0,100,200 or 400 m^3 vinasse/ha as K source). Addition of K increased titrable acidity and total soluble salts in fruit.

Joshi, (2002) has stated that while the yield did not respond significantly to pre sown application of spent wash, the oil percentage improved and maximum increase (0.66 per cent to 0.76 per cent) occurred at an application rate of 400 cubic meter per ha.

Chidankumar and Chandraju (2008) reported that the soil was enriched in NPK contents after application of spent wash, which results in an increase in soil fertility for the harvest of vegetables. Hence the distillery spent wash can be conveniently used repeatedly for the growth of top vegetables.

Chandraju et al., (2011) in their investigation on the influence of different concentrations of spent wash on the yields of tuber/root medicinal plants in normal and spent wash treated soils, used primary treated spent wash with a pH of 7.57, BOD of 16,100 mg/L, COD of 41,250 mg/L, Ammoniacal Nitrogen 750.8 mg/L, Total Phosphorous 40.5 mg/L, Total Potassium 7500 mg/L and Sulphur 70 mg/L. 33% diluted primary treated spent wash was used for irrigating Ginger, Radish, Turmeric, Onion and Garlic. They also pretreated one of the fields with diluted spent wash for four times with an interval of one week. Each time the land was ploughed and exposed to sunlight. The yields were very good in 33% spent wash irrigation compared to raw water in both the pretreated and non-pretreated fields. It has also been observed that the yields in the pretreated fields were higher than the yields in the non-pretreated fields for both types of irrigation (raw water and 33% diluted spent wash).

3.2.3 Impact on Soil

Dongale and Savant (1979); Shankarappa (1993) state that an increase in exchangeable Potassium was observed when soil was treated with spent wash.

Joshi et al., (1996) conducted an experiment and revealed that at surface layer the available K content of the post harvest soil (after wheat crop) was substantially increased from 87 ppm (control) to 1,075 ppm due to one-time application of distillery effluent @ 240 m^3 ha^{-1}.

Nagarajan and Kumar (IIT Roorkee) 2007 state that the utilization of distillery effluents in agricultural fields creates organic fertilization in the soil, which raises the pH, increases the availability of certain nutrients, the capability to retain water and also improves the physical structure of the soil. The effluents are mostly used for pre-sowing irrigation where the post harvest fields are filled with distillery effluents. After 12 to 15 days when the surface is almost dried, the fields are filled and the crops are sown. Subsequent irrigation is given with fresh water or diluted spent wash. One cm of post methanated effluent if applied on one-hectare land annually will yield 600 kg of Potassium, 360 kg of Calcium, 100 kg of Sulphates, 28 kg of Nitrogen and 2 kg of Phosphates.

Kamble *et.al.* 2017 have stated that Controlled application of spent wash to the land as irrigation water helps in restoring and maintaining soil fertility, increasing soil microflora and improving physical and chemical properties of soil leading to better water retaining capacity of the soil.

Influence of long term application on sugarcane and soils has been evaluated by **Kamble and Hebbara, 2015, Kamble *et.al.* 2016 a. and Kamble *et.al.* 2016 b.**

Kumari *et.al.* 2015 conducted field studies on Brassica campestris to assess the potential of the diluted post methanated distillery effluents. The results indicated that there was not much variation in pH, conductivity and nitrate of soil whereas TDS, conductivity, nitrate and COD of the well water increased but only slightly and within the permissible limits.

Valliapan 1999 has stated that the saturated hydraulic conductivity and pore space of the spent wash leached soils increased considerably with simultaneous reduction in bulk density and water dispersible clay. The availability of N,P,K,S,Zu,Cu, Fe and Mn in the spent wash amended soils was found to increase significantly.

Baskar *et.al.* 2013 say that the post methanated effluents have a lower C:N ratio and so it would degrade more swifty in soil as compared to untreated spent wash.

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Shivaraj Kumar et.al 2017 suggest that mostly the distillery waste waters are used for presowing irrigation. The post harvest fields are filled with distillery effluents. After 15-20 days when the surface is almost dried, the fields are tilled and the crops are sown and subsequent irrigation is given with fresh water. One centimeter of post methanated effluent applied to one hectare of agricultural land annually will yield nearly 600 kg of potassium, 360 kg of calcium, 100 kg of sulphates, 28 kg of nitrogen and 2 kg of phosphates.

Deshpande *et.al.* 2017 experimented on the effect of Primary biomethanated spent wash (PBSW) on soil properties, nutrient uptake and yield of wheat on sodic soils at varying doses of 100,200,300,400 and 500 cubic meter per hectare. The results have revealed that the physical properties namely bulk density and hydraulic conductivity were improved in sodic soil. The authors have also observed a significant reduction in pH, calcium carbonate and exchangeable sodium and an increase in organic carbon, cation exchange capacity (CEC) and electrical conductivity (E.C.) in the soil due to the addition of PBSW. The available soil nitrogen (N) Phosphorous (P), Potassium (K) and micro nutrients iron, manganese, copper and zinc (Fe, Mn, Cu, and Zn) content after the harvest of wheat was the highest in 500 m3/ha treatment compared with all other treatment. The exchangeable Calcium (Ca2+) Magnesium (Mg2+) increased significantly and exchangeable sodium (Na+) reduced significantly with increased dosage of PBSW. The application of PBSW (@500, 400, 300 and 200 m^3/ha) resembled the other treatments of FYM and Gypsum. The PBSW application at the rate of 500 m3/ha had recorded the highest grain (43.33 quintal/ha) and straw (72.72 quintal/ha) yield and the maximum total uptake of N, P, K, Fe, Mn, Cu and Zn by wheat which was at par with the treatment of FYM (5 t/ha)+Gypsum @ 100% GR+RDF AST (Recommended dose of Fertilizer after test)

3.2.3.1 Impacts on Soil-Nutrients/Uptake and Physiology

Devarajan and Oblisamy (1995) reported that one time application of single dose spent wash added large amount of N and increased the ammonification and nitrification, resulting in higher concentration of

NH_4-N and NO_3-N in soil. Similar results were also observed in the incubation experiment. At later stages crop removal and losses due NH_3 volatilization and NO_3 leaching reduced the contents in soil. In continuous application, nutrients were added to soil in split doses continuously, which gradually increased the concentration of NH_4-N and NO_3-N in soil. One time application or continuous application of different levels of spent wash had remarkably increased the NH_4-N and NO_3-N in soil. Devarajan and Oblisamy, (1995) also reported increase in the N availability in soil due to spent wash application.

The results of the experiments have shown that the transformation and the plant availability of N in soil were greatly influenced by the spent wash application. The levels and methods of spent wash application differed significantly in affecting the N dynamics. Continuous application of split doses of spent wash at a rate of 120 m^3/ha with or without the recommended dose of NP fertilizers was found better in improving the nutrients status of soil. The spent wash not only adds Nitrogen to soil, but also promotes the mineralization and/or solubilization of Nitrogen in soil.

Baskar et al., (2001) stated that the results of field experiment performed using biomethanated spent wash showed that the transformation and the plant availability of N in soil were greatly influenced by the spent wash application. The two methods of spent wash application differed significantly in affecting the N dynamics. Before sowing (15 days after spent wash application), both NH_4-N and NO_3-N were significantly higher in soil with one time application, whereas, at later stages (pod formation and harvest stages), continuous application recorded higher values.

Rajkishore and Vignesh (2012) in their review on distillery spent wash in the context of crop production, conclude that the past studies do demonstrate various beneficial aspects of treated spent wash application to agricultural soils. These benefits are an increased soil micro and macro nutrient status, enzyme activities and improved crop productivity. They also goes on to further say that controlled land application of post methanated distillery spent wash is an alternate and effective strategy for disposal which offers double benefit of water pollution control and utilization for agricultural production. They do caution against excessive or continuous use.

Shivaraj Kumar *et.al.* 2017 support the claim that controlled land application of the spent wash to land as irrigation water helps in restoring and maintaining soil fertility, increasing soil microflora, improving physical and chemical properties of soil which also leads to a better water retaining capacity of the soil. Bio methanated spent wash with a BOD of 7,200 mg/L and a COD of 18032 mg/L was used in the study.

3.2.4 Procedures, Guidelines and Practices

Joshi, (2002) has stated that 200 cubic meter of Post Methanated Spent Wash per hectare could be applied 20 to 25 days before sowing and that the application could be done twice a year. Most of the food crops show good response to pre sown distillery effluent irrigation. When applied to soil the colour of effluent is amenable to microbial and photo degradation.

The CPCB, (2005) proposed a protocol for “one-time controlled land application of treated post bio-methanated distillery spent wash as liquid manure”. Indian Agricultural Research Institute, Delhi and Tamil Nadu Agricultural University, Coimbatore performed several field and experimental studies, based on which the following protocols for utilization of treated post methanated spent wash for pre-sown controlled Land Application as basal manure are recommended.

I. Basic Requirements

1. Any distillery desirous of utilizing the spent wash for pre-sown controlled land application should use treated post bio-methanated spent wash only.
2. The effluent to be utilized for one time controlled application after post bio-methanation shall have a BOD_3 27 °C value not exceeding 7000 mg/L and pH should be more than 7.

3. The distillery shall engage full time expert and other required manpower for the implementation and monitoring of controlled land application of spent wash.

4. The distillery shall construct pucca and lined storage tanks with a maximum holding capacity of 30 days for storing the spent wash during the monsoon and/or non-application period.

5. The command area for spent wash application shall be preferably within a considerable distance from the distillery unit in order to facilitate easy monitoring and effective control over land application of spent wash.

6. The distillery shall either provide pipeline network or engage tanker lorries for spent wash transportation based on the location and distance of the command area meant for spent wash land application.

7. The distillery should maintain pucca records and data regarding spent wash land application. In case, tanker lorries are engaged for spent wash transportation to the field they should carry a "Transit Card" with the following details:

    (a) Tanker lorry number

    (b) Date/Time of loading and unloading

    (c) Field address

    (d) Receiving person

    (e) Distance travelled

8. Infrastructure facilities should be arranged for collection and analysis of samples drawn from the application zones.

9. The distillery after fulfilling the above basic requirements shall maintain a comprehensive "Controlled Land Application Plan" for utilization of treated bio-methanated spent wash. The plan includes the details on:

(a) Survey no./Plot no./Field name of land for controlled land application along with their extent/area.

(b) The distillery shall obtain the acceptance of the farmers in the form of “Spent wash Request Application” before the application of spent wash to their land.

(c) Agronomic plan for effective utilization of land by crop rotation.

(d) Spent wash application schedule to the fields.

10. Controlled Land Application of Treated (post bio-methanated) spent wash shall be carried out as described below:

    (i) Pre-sown Controlled Land Application as basal manure

11. Treated (post bio-methanated) spent wash should be applied uniformly on land at least 20 days prior to sowing of the crop and ploughed before raising the crops.

12. The dosage of treated (post biomethanated) spent wash for various crops is furnished in Table 6.

13. The rate of application of spent wash shall be quantified by the following techniques:

    (i) Horizontal open discharge method

    (ii) Measuring container

    (iii) V-notch

II. Safety Protocol

1. Though the crops normally cultivated in the area can be grown under the scheme the rotation of crops is preferable.

2. Post bio-methanated spent wash application during the germination and seedling growth shall be avoided.

3. Any concurrent use of fertilizers shall be done judiciously to avoid super imposed effect.

III. Monitoring Protocol

1. The unit shall form an internal monitoring cell under the supervision of an agricultural graduate to closely monitor the application of treated (post bio-methanated spent wash for controlled land application).
2. The farmers should be educated about the application of treated (post bio-methanated) spent wash for controlled land application.
3. The application of treated (post bio-methanated) spent wash on the soil should be with the farmer's acceptance and transport through tankers should not cause any environmental concern.
4. Short-term and long-term monitoring must be carried out with agricultural experts. The distillery units should have their own monitoring team with renowned agricultural experts to assess the compliance status of protocol on controlled land application protocol for treated (post bio-methanated) spent wash.
5. The physicochemical characteristics of the soil under treated (post bio-methanated) spent wash application shall be regularly monitored for pH, electrical conductivity (EC), Nitrogen, Sodium and Potassium. One representative sample per 50 ha at depths of 30 cm and 60 cm shall be collected at least twice a year for this purpose. The pH and EC of the extract of the mixture of 2 parts of soil with 5 parts of water shall not exceed 8.5 and 4 millimhos/cm respectively.
6. The ground water quality shall be monitored for BOD, Total Dissolved Solids (TDS) and Nitrate (NO_3) by collecting one representative sample from open wells/bore holes situated in every 50 ha area of land under spent wash application at least twice a year. The increase in BOD, TDS and NO_3 shall not exceed 3 mg/L, 200 mg/L and 10 mg/L over the initial results.
7. Piezometers shall be installed to study the long-term nutrient mobility in soil and its impact on ground water quality, at

minimum 5 zones in the command area for continuous monitoring.

8. In the event of first observation of any of the soil and ground water monitoring parameters exceeding the prescribed limits, the treated (post bio-methanated) spent wash application in that particular location shall be discontinued immediately and the distillery should implement corrective measures for remediation.
9. The records of soil and ground water quality monitoring data shall be properly maintained for verification by the State Pollution Control Board (SPCB)/CPCB.
10. A MoU with nearby reputed agricultural university shall be entered into (prior to application of post-methanated spent wash on land) for monitoring of required dose of spent wash, quality of spent wash used monitoring of soil, groundwater and productivity of crop.
11. The findings of minimum one-year study by the concerned agricultural universities shall be made available by distilleries to SPCB/CPCB prior to one time controlled land application of post methanated spent wash. The report on findings will be reviewed also by the sub-committee.

The Office of the Principal Scientific Advisor to the Government of India has recommended in 2014 that Controlled application of BMSW may be beneficial for reclamation of sodic soil as BMSW has large quantity of Ca & Mg compared to Na, and if the soil is well drained soluble salts of Na can easily leach out from surface soil. Pre sowing application of BMSW followed by two irrigations can leach out soluble salts from surface soil for better germination and growth of the crop. For preseason sugarcane crop the recommended dose of NPK by state university in Maharashtra is 340:170:170 based on the nutrient contents in BMSW. The calculations for BMSW quantity to be applied to fulfill the nutrient requirement are as below:-

A) BMSW application on the basis of N requirement (340 kg /ha) of sugarcane

N content in BMSW	Total BMSW to be added for 340 kg/ha N	Nutrients added through 170 m3 BMSW (kg/ha)			Other essential nutrients (Kg/ha)						Na added (kg/ha)
		N	P	K	Ca	Mg	SO4	Mn	Zn	Cu	
1 kg /m3	340 m3	340	272	3060	1360	680	1088	1.7	1.7	0.34	340
Remarks		No additional use of N – fertilizers required	Excess by 102 kg. No need to add extra P	Excess by 2890kg. No need to add							

B) BMSW application on the basis of P requirement (170 kg /ha) of sugarcane

P content in BMSW	Total BMSW to be added for 170 kg/ha P	Nutrients added through 113 m3 BMSW (kg/ha)			Other essential nutrients (Kg/ha)						Na added (kg/ ha)
		N	P	K	Ca	Mg	SO4	Mn	Zn	Cu	
1.0 kg/m3	170 m3	170	170	1700	680	340	544	0.85	0.85	0.17	170
Remarks		Addition al use of 170 kg N through Urea is required	No additiona l use of P – fertilizers required	Excess by 1530 kg							

C) BMSW application on the basis of K requirement (170 kg /ha) of sugarcane

N content in BMSW	Total BMSW to be added for 170 kg/ha K	Nutrients added through 68 m3 BMSW (kg/ha)			Other essential nutrients (Kg/ha)							Na added (kg/ha)
		N	P	K	Ca	Mg	SO4	Mn	Zn	Cu		
9 kg/ m3	19 m3	19	19	171	76	38	60.8	0.095	0.095	0.019		19
Remarks		Additional use of 306 kg N through Urea is required.	Additional use of 151 kg P through SSP is required.	No additional use of K – fertilizers required								

The Office of the Principal Scientific Advisor, Govt. of India, 2014, based on the contents of BMSW and the quantity of BMSW to be applied in sugarcane, has given recommendations to consider BMSW application rate on the basis of K content in effluent and K requirement of crop and the soil type which will be less in quantum, easy to use and fewer problems in soil. However, continuous use of BMSW will create water permeability and lead to salt accumulation in soil. Therefore, limited use of BMSW with permissible BOD is desirable for controlled land application. However, derived from the experiments conducted by Tamil Nadu Agricultural University, Coimbatore at different locations of Tamil Nadu, the Office of the Principal Scientific Advisor, Govt. Of India, 2014 has recommended the following biomethanated spent wash dosage based on the Nitrogen requirement of various crops.

Spent wash (bio-methanated) Dosage for Various Crops based on Nitrogen Requirement

Crops	Spent wash (Post bio- methanated) to be applied based on Nitrogen requirement (m3 /ha)		
	Loamy Soil	Clay Soil	Sandy Soil
Sugarcane	90-125	80-115	70-95
Paddy	80-150	70-135	60-115
Maize	100-150	90-135	75-115
Sunflower	35-90	35-80	25-70
Turmeric	30-50	30-45	25-40
Banana	125-250	115-225	100-190
Cotton	70-80	65-75	55-60
Tobacco	60-70	55-65	45-55
Sorghum	35-90	30-80	25-70
Groundnut	35-90	30-80	25-70
Ragi	60-80	55-75	45-60
Gingelly	20-30	20-30	15-25
Chillies	70-90	65-80	55-70
Brinjal	60-70	55-65	45-55
Tomato	90-100	80-90	70-75
Onion	40-60	35-55	30-45

- Derived from the experimentals conduct by Tamil Nadu Agricultural University, Coimbatore at different locations of Tamil Nadu.

They have also suggested that a long term comprehensive research project on these aspects should be undertaken to verify the above hypothesis in various types of soils in different agro-climatic zones of

India for different crops along with national agricultural institutes. To aid such effort, AIDA may collect the information regarding the use of BMSW for ferti-irrigation in countries like, Brazil and Australia and submit it to concerned authority.

Following are some suggestions based on the contents of BMSW and the quantity of BMSW to be applied in sugarcane

- The present protocol of controlled land application of BMSW is based on N content in BMSW (@1.0 kg N/m3) and RDN to be applied per ha. For application of 340 kg N /ha in Maharashtra 340 m3 BMSW is required. The quantum of BMSW is very high and can create water permeability and salt accumulation in clay soils and also ground water pollution in coarse textured soils. In Maharashtra, if RDP of sugarcane and P content in BMSW (@1.0 kg P/m3) is considered the BMSW requirement will be 170 m3 and if RDK of sugarcane and K content in BMSW (@9.0 kg K/m3) considered, quantum will be 19 m3.
- It is recommended to consider BMSW application rate on the basis of K content in effluent and K requirement of crop and the soil type which will be less in quantum, easy to use and fewer problems in soil. However, continuous use of BMSW will create water permeability and lead to salt accumulation in soil. Therefore, limited use of BMSW with permissible BOD is desirable for controlled land application.
- A long term comprehensive research project on these aspects should be undertaken to verify the above hypothesis in various types of soils in different agro-climatic zones of India for different crops along with national agricultural institutes. To aid such effort, AIDA may collect the information regarding the use of BMSW for ferti-irrigation in countries like, Brazil and Australia and submit it to concerned authority

Jadhav et al., (2011) state that one time controlled application on fallow land has been recognized by the CPCB as a method to utilize the spent wash but cautioned that one has to be very careful before application of spent wash for irrigation and should ensure that –

- Total application of the spent wash for irrigation during a crop per year is decided by the N, P and K content of the spent wash and requirement of the crop.
- Spent wash is sufficiently diluted before the application for ferti-irrigation to ensure electrical conductivity (EC), fixed dissolved solids, chloride, sulfate, sodium absorption ratio (SAR) and BOD within specified limits.
- Electrical conductivity of the saturation extract of the soil sample is not allowed to increase beyond 4 mmhos per cm. EC of the extract of a mixture, by weight, of 2 parts of soil and 5 parts of water shall be analyzed regularly.

The CPCB report of 2011 (Suresh et al.,) states that 'Controlled Land Application' appears to be one of the viable alternatives if it is practiced scientifically. The protocol developed by CPCB is based on the practices followed in other parts of the world with a great success and also studies carried out by Agricultural Universities in India. The report also goes on to say that the Regulatory Agencies feel that 'Controlled Land Application' is not practicable as monitoring and controls are very difficult, even though the task was entrusted to Agricultural Universities.

Vidyarthi, (2011) reports the Charter on Corporate Environmental Responsibility to prescribe that the:

1. Existing Molasses based Distilleries have to obtain Zero effluent discharge through:
    - Bio-composting
    - Concentration and incineration
    - Bio-methanation followed by two stage secondary treatment followed by Ferti-irrigation.
    - Bio-methanation followed by pre-sown irrigation

- Bio-methanation followed by treatment and discharge into the deep sea

2. New Distilleries and expansion of Existing distilleries (Molasses based) have to ensure zero effluent discharge in surface water/ground water.
3. He also refers to CPCB resolution of May/June 2008 and says that:
    - New stand-alone distilleries have to go in for concentration incineration systems.
    - New attached distilleries will have to –
      - Follow bio-methanation followed by bio composting
      - Concentration incineration system (Reboiler/Evaporation/Concentration followed by incineration of concentrated spent wash in boiler (for power generation)

- Existing stand-alone distilleries going in for expansion will have to adopt concentration incineration systems.
- Distilleries (both stand-alone and attached) not complying with the required environment standards to switch over to emerging technologies from existing technologies of Ferti-irrigation, one time land application and composting in a time bound manner.

4. Co-processing in cement kilns/furnaces of TPP'S/steel plants has been recommended as a technology option in 2010-11 by the CPCB.

Shivaraj Kumar et.al 2017 suggest that mostly the distillery waste waters are used for presowing irrigation. The post harvest fields are filled with distillery effluents. After 15-20 days when the surface is almost dried, the fields are tilled and the crops are sown and subsequent irrigation is given with fresh water. One centimeter of post methanated effluents applied to one hectare of agricultural land annually will yield nearly 600 kg of potassium, 360 kg of calcium, 100 kg of sulphates, 28 kg of nitrogen and 2 kg of phosphates.

Spent wash at the rate of 35-50 m3/ ha., was recommended as optimum dose for higher sugar cane yields in Brazil and Australia. **Kamble *et.al.* 2017**.

Baskar *et.al.* 2003 have concluded that the problems of high BOD, COD and electrical conductivity of distillery effluents could be overcome either by the application of distillery effluents after proper dilution (1:10 to 1:50) with irrigation water or by pre-plant operation (40 to 60 days before planting) to give sufficient time for the natural oxidation of organic matter.

Mahimairaja and Bolan 2004 have shown that, though at higher doses (>250m3/ha) spent wash application is found detrimental to crop growth and soil fertility, its use at lower doses (125 m3/ha) remarkably improves germination, growth and yield of dry land crops. It has also been revealed that conjoint application of spent wash and organic amendments (Farm yard manure, green leaf manure and bio compost) is found suitably under dry land conditions.

SECTION-4

DISTILLERY EFFLUENTS - FERTI IRRIGATION

4.1 Abstract

Fertigation is an emerging field for agricultural purposes because it applies water and fertilizer simultaneously and use of distillery water in fertigation could lead to proper management of waste water and conservation of ground water. The manure potential of distillery effluents can profitably be used as a supplement to fertilizer along with irrigation water. Most of the authors are of the opinion that spent wash at lower concentrations can be safely used for irrigation and fertilization. Because of a very high concentration of K, the distillery effluents have to be supplemented with other nutrients, notably N, P and S to give it a balanced nutritional value. Some authors have observed that delaying the application of urea supplemented spent wash until the crop has grown to 0.5 meters in height produced the best results. Direct application of post methanated spent wash to growing crops is discouraged because of the excessive BOD, COD and EC. Sugar mill effluents may be used as a suitable diluent for spent wash to reduce the pollution load and subsequently used in fertigation with a 1:1 dilution ratio, the BOD has been expected to come down to 3600 mg/L from 51023 mg/L, COD to 62075 MG/L from 90179 mg/L and TDS to 32700 mg/L from 72090 mg/L.

Diluted spent wash irrigation has been tried without any adverse affect on soil fertility, seed germination and crop productivity. The physical and chemical properties of the soil have improved and so has the soil micro flora. The CPCB has held that emerging technologies such as ferti-irrigation should be opted by the industries for secondary treatment of wastes and has added that this may not only control

pollution at source but also act as an alternative for energy savings for treatment of distillery waste water. It is important that ferti-irrigation and irrigation be differentiated in terms of utility to crops and separate procedures for ferti-irrigation and irrigation evolved. Applying the existing standards of 100 mg/L (on land for irrigation) to ferti irrigation would need reconsideration.

Grasses, barley, wheat, sugarcane, maize, sorghum pulses, gram, pea, paddy, ground nut, flowering plants, vegetables, beans, have all responded positively to various dilutions of spent wash irrigation and registered significant increase in the yield parameters. Distillery waste water irrigation has been observed to have significantly increased the nutrients in the soil. The agronomical performance (V. Mungo) was found to have been significantly increased at lower concentrations (20 to 40%) decreasing as the concentration increases (60 to 100%)

Application of lower doses of digested spent wash to the soil, either along with irrigation or as a soil amendment has a beneficial effect on soil nutrients and their uptake resulting in increased crop productivity. Spent wash application at higher doses could cause a buildup of salts, particularly Potassium in the soil. Most of the authors however, do not report any negative impact of spent wash on soil. Nutrient uptake was generally observed to be enhanced. Some authors attribute the higher uptakes of N and Mn to the presence of readily decomposable sugars in the liquor and the P and Mg uptakes due to the lignin and tannin contents. Ferti-irrigation as described by the CPCB involves achieving a BOD of less than 800 mg/L, storing treated effluents and diluting them prior to irrigation to suit the soil and crop type. It also says that it could be restricted to one or more irrigations within the command area. Application of spent wash could be done in alternate years and further irrigations to be done using fresh water. More research may be required on the risks of infiltration of vinasse into soil, into groundwater and on the impacts on human health due to use as a ferti-irrigant. Fertigation may have to be practiced under strict control.

4.2 Review of Literature

4.2.1 General

Jadhav and Savant (1975) state the manurial value of distillery effluent can profitably be used as supplement to the fertilizer along with irrigation water. The use of effluent water has indicated that 25 per cent of the recommended dose of fertilizer nutrients can be saved in this way, which not only solves disposal problem but also substitutes some quantity of inorganic fertilizers.

Samuel, (1986) reported that the spent wash contained N, P, K, Ca, Mg and S and thus valued as a fertilizer when applied to soil through irrigation with water.

Rajendran, (1990) stated that the spent wash could be safely used for irrigation purpose at lower concentration.

Manickam, (1996) reported that the distillery effluent contains fairly high amounts of N, P, K, Ca, Mg and S besides appreciable amounts of micronutrients. Distillery spent wash at 20 per cent v/v concentration may serve as a good liquid fertilizer for germination and growth of crops and has been proved to be more effective than that of the fertilizers used by the local farmers.

According to **Babu et al., (1996)** spent wash does not have any heavy metals and can be used as a source of irrigation by going for higher dilutions with normal water.

Rajukkannu and Manickam (1996) reported that the primary treated distillery effluent is found to contain all major and micronutrients in considerable amount to sustain growth and yield of crops. Technology has been developed to use this effluent as ferti irrigation source to crops like sugarcane, sunflower, soybean etc., after diluting it with irrigation water to reduce the BOD level in the ratios of 1:10 to 1:50.

Raverkar et al., (2000) stated that the higher dilution could be used for irrigation purpose without adversely affecting soil fertility and crop productivity.

Ramana et al., (2001) stated that diluted spent wash could be used for irrigation purpose without adversely affecting soil fertility, seed germination and crop productivity.

Baskar et al., (2003) said that the fertilizer potential can suitably be harnessed in agriculture as pre-plant application or ferti-irrigation with proper dilution. Effluent based liquid fertilizer because of a very high concentration of K in the distillery effluents, has to be supplemented with N and S to give it a balanced nutritional value. The use of urea mixed distillery spent wash is widely prevalent in Australia as a single application. Delaying the application of urea supplemented spent wash until the crop has grown to 0.5 meters in height produces the best results. Using overhead irrigation to wash urea into the soil within 05 days of applying urea mixed spent wash can minimize ammonia volatilization losses. Flood irrigation is not recommended where urea based spent wash is placed on the inter row as water will dissolve urea as it moves down the furrow, leading to an uneven distribution of N. Urea and sulphuric acid mixed spent wash should be used in sulphur deficient soils (< 3 mgs/kg soil). Adding sulfuric acid to urea mixed bio dunder to enrich it with sulphur (15 kg/ha) had no significant short effect on soil acidity.

They have suggested that the undiluted spent wash/post methanated effluents should not be directly applied to growing crops because of their excessive BOD, COD and EC. It should be applied to the field well before the planting of the crop to give sufficient time for the natural oxidation of organic matter or diluted with normal water before applying to growing crops. The distillery effluents can be transported through pipelines or tanker lorries. Distilleries are giving full/half of the transport cost to the farmers. However they also go on to say that technology has been developed to use the primary treated effluents as a ferti-irrigation source to growing crops like sugarcane, sunflower, soybean etc. after proper dilution with irrigation water, but looking into management problems associated with transporting effluents to the fields (specially situated in the interior) during the cropping season, farmers, in spite of the high yields, preferred application of undiluted effluents to fallow lands during summers.

Kuntal et al., (2004); Kaushik et al., (2005) reported that diluted spent wash could be used for irrigation purpose without adversely affecting soil fertility, seed germination and crop productivity. The diluted spent wash irrigation improved the physical and chemical properties of the soil and further increased soil microflora.

CPCB document titled 'Guidelines for Water Quality Management' (2008) states that emerging technologies such as ferti-irrigation should be opted by the industries for secondary treatment of wastes. This not only control pollution at source but also acts as an alternative for energy savings for treatment of distillery wastewater.

Kumar and Chopra (2013) have referred to the BIS Standards for irrigation water as follows:

Table 7: BIS Standards for irrigation water.

T.D.S.	1900 mg/L
pH	5.5-9.0
BOD	100 mg/L
COD	250 mg/L
Cl	500 mg/L
Ca	200 mg/L
TKN	100 mg/L
NO_3^{2-}	100 mg/L
SO_4^{2-}	1000 mg/L
Fe	1.0 mg/L
Zn	15 mg/L
Cd	2.00 mg/L
Cu	3.00 mg/L
Mn	1.00 mg/L

Cr	2.00 mg/L
SPC	10000 mg/L
MPN (PER 100 ml)	5000 mg/L

Kumari *et.al.* 2015 conducted field studies on Brassica campestris to assess the potential of the diluted post methanated distillery effluents. The results indicated that there was not much variation in pH, conductivity and nitrate of soil whereas TDS, conductivity, nitrate and COD of the well water increased but only slightly and within the permissible limits. However there was a significant increase in the plant biomass, diameter of shoot, area of leaf as well as number and length of pods and root hairs. The hydrophilic colloids of the seeds increased significantly (P<0.01) and the yield of mustard seeds was increased by 30% as compared to the conventional fertilizer.

Thamaraselvi *et.al.* 2014 diluted spent wash from distillery with Sugar Mill effluents to get Sugar wash which they used in different concentrations as Fertigant. Mixing Sugar effluents to distillery spent wash gave resultant pollutants as in table below.

	Spent Wash (SW)	**Sugar Effluents (SE)**	**Sugar Wash 1:1 SW to SE**
BOD	51023 mg/L	3089 mg/L	36300 mg/L
COD	90179 mg/L	6498 mg/L	62075 mg/L
TDS	72090 Mg/l	1650 mg/L	32200 mg/L

The authors have observed that while 100% of seed germination was observed in 5% of diluted sugar wash, seed germination percentage was reduced at higher concentrations (10 and 15% Sugar Wash Irrigation). The Chlorophyll content, root length, shoot length, fresh weight and dry weight showed high values at 5% Sugar wash irrigation. The authors have concluded that Sugar effluents may be used as a suitable diluent for spent wash to reduce the pollution load and subsequently use it in fertigation for the growth of Raphanus sativus.

Verma and Kumar 2014 have concluded that Fertigation is an emerging field for agricultural purposes because it applies water and fertilizer simultaneously and use of distillery water in fertigation could lead to proper management of waste water and conservation of ground water. Fertigation is also helpful in controlling the attack of Pathogens by preventing the wetting of crop foliage. Highly soluble nutrients can be supplied directly to the root through root zone technology thereby maximizing nutrient efficiency and minimizing excess fertilizer and leakage to underground water.

The studies of **Singh *et.al.* 2014** have supported the utility of Distillery Effluents for crop production but after proper dilution. The undiluted distillery effluent used by them was of low concentration (BOD 567.66 mg/L) and COD (2156.33 mg/L)

The **Office of the Principal Scientific Advisor to the Government of India, 2014** states that Fertigation is allowed only after primary biomethanation followed by secondary aerobic biological treatment. The BOD of the secondary treated effluent should not exceed 500 mg/L. The treated effluent is diluted prior to irrigation such that the concentrations of BOD may not exceed 100 mg/L. The application rate of the diluted effluent is decided on the basis of the nitrogen content of the diluted effluent, the nitrogen requirement of the crop and the type of soil of the field. The nitrogen requirement of the crop may be met in one or more irrigations. Once the nitrogen requirement is met and if further irrigations are required, these will be done using fresh water. The proper monitoring and supervision of ferti-irrigation system is very difficult. It requires large land area and water for dilution. It has to be carried-out as per the protocol of CPCB under the guidance and supervision of collaborating Agricultural University. However many state pollution control boards are now not allowing this method of spentwash disposal.

They also add that in molasses the presence of Potassium, Sodium etc. is carried from the cane itself but the increased levels of calcium, phosphorous and sulphur is due to the use of “Milk of Lime” during the clarification process and sulphitation process. Alternate methods of clarification in place of “Milk of Lime” may improve the quality of molasses by reducing these elements, rendering the usability of bio methanated spent wash (after further treatment) for agricultural applications and that for the preseason sugar crop the recommended dose of NPK by State University in Maharashtra is 340:170:170 based on nutrient contents in BMSW.

Fuess *et.al.* 2015 have emphasized on the need for pretreating effluents before reuse of stillage in fertigation. They have stated that different processes such as anaerobic digestion and coagulation flocculation may be satisfactorily applied to the treatment of stillage, which may maintain its fertilizing potential for further reuse in agriculture. They have however cautioned that although Fertigation is the most feasible option (in economical and technical aspects) for the management of stillage but the intensity/occurrence of impacts depend on the characteristics of the Soil and climate of the Fertigated area. They also feel that the continuous land application of stillage in nature will certainly result in adverse conditions for the environment in the long run.

Gomes de Barros *et.al.* 2016 state that the nutrients present in the Vinasse and those obtained from the supplements in the anaerobic treatment can be recycled by using the effluent in fertigation and the sludge for plant fertilization.

4.2.2 Effect on Crops

Goel and Mandavekar (1983) state that distillery waste could be safely used as fertilizer along with irrigation water. Cymopsis tetragonoloba irrigated with 10 per cent distillery waste induced nodulation; higher concentration resulted in suppression of nodulation and growth.

Guruswamy, (1986) advocated dilution of effluent from lagoon, after which it can be used successfully in sugarcane, wheat, barley and elephant grass.

Pujar, (1995) studied the distillery effluent as a source of irrigation at higher dilutions. For wheat, 50 times dilution proved better but for maize and sugarcane, a lower dilution (10 times) proved superior. However, 10 times dilution produced unfilled nature of grains in wheat crop due to excessive nutrients particularly Nitrogen. Pujar, (1995) recorded higher grain yield in wheat and maize with 50 times and 10 times dilution of effluent, respectively.

Singh et al., (1995) stated that the irrigation with distillery effluent had no adverse effect on the germination of wheat, maize, sorghum and cowpea. In fact, it had beneficial effects as compared to irrigation with fresh well water.

Nagappan et al., (1996) reported that application of distillery effluent @ 0.30 lakh litres per acre per month along with irrigation water for wet land and garden land crops and 0.90 lakh litres per acre for rain fed crops increased the yield of crops viz., wet land sugarcane, wet land paddy, garden land sugarcane, garden land paddy, garden land cotton, rainfed maize, rainfed sorghum, rainfed bajra and rainfed red gram to the tune of 39.01, 0.070, 28.85, 0.79, 0.50, 0.17, 0.23, 0.26 and 0.43 tonnes per ha respectively over control.

Singh and Bahadur (1997) found positive effect of spent wash on maize growth and soil productivity. In the areas wherever distillery effluent is available, 50 or more than 50 times dilution with irrigation water could increase rice yield without any detrimental effect on soil health.

Annadurai et al., (1999) found positive effect of spent wash on maize growth and soil productivity. In the areas wherever distillery effluent is available, 50 or more than 50 times dilution with irrigation water could increase rice yield without any detrimental effect on soil health.

Ramana et al., (2001) stated that the spent wash could be safely used for irrigation purpose at lower concentration. Most of the field crops, viz., sugar cane, rice, wheat and mustard showed positive response to biomethanated spent wash application along with irrigation water. Even after 20th irrigation with spent wash on specific fields, none of the crops showed any toxicity symptoms even up to 30 per cent concentration.

Nagaraj and Kumar 2007 (IIT, Roorkee) stated that Post-methanated distillery effluents used in various concentrations have demonstrated increase in yield and biomass with no injuries to crops in post sown irrigation. Different crops have been observed to respond differently.

Kamble and Hebbara, 2015, Kamble *et.al.* 2016 a and Kamble *et.al.* 2016 b have evaluated the influence of long term application on sugarcane .

Kumari *et.al.* 2015 conducted field studies on Brassica campestris to assess the potential of the diluted post methanated distillery effluents. The results indicated that there was a significant increase in the plant biomass, diameter of shoot, area of leaf as well as number and length of pods and root hairs. The hydrophilic colloids of the seeds increased significantly (P<0.01) and the yield of mustard seeds was increased by 30% as compared to the conventional fertilizer.

Baskar *et.al.* 2003 have concluded that Distillery effluent application was observed to increase the yield of sorghum, wheat, maize, sugar cane, cotton, ground nut, sunflower, soybean, sugar beet, potatoes and other vegetables, forage crops and tree crops but had adverse effect on legumes and no effects on rice.

Mahimairaja and Bolan 2004 have shown that, though at higher doses (>250m3/ha) spent wash application is found detrimental to crop growth and soil fertility, its use at lower doses (125 m3/ha) remarkably improves germination, growth and yield of dry land crops. It has also been revealed that conjoint application of spent wash and organic amendments (Farm yard manure, green leaf manure and bio compost) is found suitably under dry land conditions.

4.2.2.1 Effect on Crops- Sugar Cane

Agarwal and Dua (1976) in Kumar (2008) recommended the application of 20 times diluted spent wash to sugarcane to get yield of 12.5 tonnes/ha. The application of diluted spent wash having a BOD of 1,000 mg/L in sugarcane increased the yield on an average by 5.1 MT per area.

Agarwal and Dua (1976) observed 5 times yield increase in sugarcane due to the application of 20 times diluted spent wash; it was also found that the cane yield was higher at 1:10 dilution of distillery effluent in sugarcane.

Pawar et al., (1992) reported that 50 times diluted spent wash was beneficial which recorded higher juice purity, brix, pol and yield of sugarcane C0740.

Devarajan et al., (1993) observed significantly higher sugarcane (CO.771) yield in diluted effluent irrigations than when irrigated with normal water. Devarajan et al., (1993) concluded that distillery spent wash at 40 to 50 times dilutions increased the yield of sugarcane. It was also found that the cane yield was higher at 1:10 dilution of distillery effluent in sugarcane.

Devarajan and Oblisamy (1995) recorded highest cane yield (182.8 tonnes) when irrigated with distillery effluent diluted 50 times. It was also found that sugarcane variety CO. 853 registered significantly higher cane yield by 14.6 and 8.3 per cent at 50 and 40 times dilution, respectively than with irrigation purely by water. However, cane yields and juice quality decreased with an increase in concentration of the effluent in irrigation water. Thus, they recommended 50 times diluted effluent as suitable for irrigating the crop. Juice quality was also better than control.

Ghugare and Magar (1995) reported that the response was significant when 50 times diluted vinasse was applied. Cane (188.1 tonnes per ha) and commercial cane sugar yield (25.96t/ha) were 20 percent higher than control values (155.9 and 20.94 t/ha).

Pujar and Manjunathaiah (1996) conducted an experiment that revealed that distillery effluent at 1: 10 dilutions showed significantly higher yields in sugarcane.

Zalawadia et al., (1997) showed that application of diluted spent wash increased cane yield and nutrient uptake significantly over tube well water. They also observed increased P, K and S thereby indicating improvement in soil properties.

Solomon et al., (1997) observed that as the ripening of the cane gets underway and sugar accumulation becomes apparent in the internodes, growth process comes to stand still. The enzymatic machinery governing sucrose metabolism becomes operative leading to a gradual increase in "sucrose content" and maintaining reducing sugars in well coordination with the source and sink. Application of distillery spent wash in moderate quantity (@ 25 per cent concentration) perhaps impacts on the quality profile of plant crop of early maturing variety (CoS 95255) as compared to mid-late (CoS 767) or late maturing variety (BO 91). This is due to the fact that in early maturing varieties suppression of internodal soluble acid invertase (SAI) became evident during October end, whereas in late varieties the activity of SAI gets suppressed at a later stage due to their prolonged growth requirement.

In a field experiment **(Thiagarajan, 2001**) conducted in EID Parry (I) Ltd, Nellikuppam, spent wash was applied at different levels diluted with irrigation water and the studies conducted at four different locations. The studies revealed an increase in cane yields. 1:10 dilutions for sandy loam and 1:20 for clay and clay loam soils was the best dilution and gave highest cane yield. Results from several field experiments have shown that the treated distillery spent wash could be advantageously used for irrigation to the standing crops particularly sugarcane by making suitable dilution without any adverse effect on soil and crops.

Gopal, (2001) recorded higher cane yield in 1:20 dilution of distillery effluent in sandy soils and higher cane yield under 1:30 dilutions in clay loam soils. The experiment conducted by Gopal, (2001) revealed that diluted (3:1 - water + effluent) effluent application after tillering phase (from 110 DAP to harvest) registered significantly more number of millable cane (98.6 t ha-1), lengthier cane (135.9 cm), higher cane (105.6 t ha-1) and sugar yield (12.6 t ha-1) than irrigations commencing from germination and grand growth phase.

Baskar et al., (2003) reported that application of pre-treated distillery effluent at graded doses (0, 0.5, 1.0, 1.5, 2.0, and 2.5 lakh litres per acre) progressively increased the cane yield of sugarcane when it was applied well before (40 days) the planting.

Singh et al., (2007) undertook a study to examine the use of distillery spent wash for irrigation and evaluate its potential to improve sucrose content in plants and ratoon crops. The crops were grown in research farms at Gorakhpur, India with alluvium-derived soil. The three bud cane sets were planted in the month of March. Distillery spent wash at 25, 50 and 100 per cent concentration was applied at the early stages of growth (60 and 90 days after planting). Normal irrigation was given in control plants. (The paper, however, fails to indicate the characteristics or the status of treatment given to spent wash before discharge from the factory).

The authors observed that all the three cane varieties used by them showed improvement in total soluble solids (TSS) per cent by addition of 25 per cent Distillery spent wash but showed a negative response at higher doses. Application of vinasse @ 25 per cent concentration showed marked improvement in sucrose accumulation in all three varieties and this trend was recorded till harvest in March. The ratoon crop exhibited an almost similar trend. Out of the three varieties examined, CoS 95255 (early maturing) and CoS 767 (mid-late and medium sugar) and Bo91 (late maturing and medium sugar), var. CoS 95255 was found to be best suited for the application of distillery spent wash @ 25 per cent concentration.

Mohana et al., (2009) and **Madrod et al., (1986)** reported similar findings. At lower concentration, effluent application enhanced both peak value of germination and mean daily germination, when they used distillery effluent to irrigate sugarcane crop.

Rath et al., (2010) evaluated the impact of raw spent wash on the growth of sugarcane. They used spent wash with a pH of 7.23, BOD of 15,300 mg/L, COD of 30,520 mg/L, total Phosphorous 28.36 mg/L, total Potassium 6,500 mg/L, Calcium 920 mg/L, Sodium 420mg/L, Sulphur 75.6 mg/L and 636.25 mg/L of Ammoniacal Nitrogen. Sugar cane test crop was planted and the plants allowed to grow for three months with regular watering once a week. After three months the fields were treated with different doses of distillery spent wash (25, 50, 75 and 100 per cent concentration) once a month. One set was kept as a control with no application of spent wash. Fields were irrigated with water every week. Growth attributes like plant height, leaf length, leaf breadth, stem girth, number of leaves per plant, number of tillers/plant and leaf area index were also evaluated. It was found that different growth parameters showed an increasing tendency from the control up to the concentration of 75 per cent of distillery spent wash but at 100 per cent all the parameters declined. The authors concluded that raw spent wash at a concentration of 75 per cent could be conveniently used for cultivation of sugarcane without external (either organic or inorganic) fertilizer.

Rath et al., (2011) studied the effect of different concentrations of distillery spent wash, inorganic fertilizer and farmyard manure on the growth and chlorophyll content of sugarcane. They used spent wash with a COD of 30,520 mg/L, BOD of 15,300 mg/L, pH 7.23, Ammoniacal Nitrogen of the order of 636.25 mg/L, Total Phosphorous 29.28 mg/L, Total Potassium 7,300 mg/L and Sulphur 75.6 mg/L. These effluents were used at 50% and 100% concentrations to study the impact on the growth and chlorophyll content of sugarcane. Fertilizer used by farmers and fertilizer plus cow dung was also assessed. Fields were treated 3 months after plantation with regular watering. Growth parameters were observed to be adversely affected at higher concentrations. Spent wash application was found to be more effective than the fertilizers being currently used by the farmers

(NPK @ 25 kg/ha before planting the sets, urea @ 125 kg/ha in two doses at 30 days and 90 days after plantation and urea @ 60kg/ha + potash @ 62 kg/ha after 150 days of plantation). All the growth parameters showed an increasing trend from the control except 100% distillery spent wash where a declining trend over the control in all parameters was observed. Maximum growth and chlorophyll content was observed in 50% distillery spent wash as compared with two different types of fertilizers.

Rath, et al., (2011) concluded that the spent wash treated soil is enriched with the plant nutrients such as Nitrogen, Phosphorous and Potassium. Subsequent use of spent wash for irrigation was found to have enriched soil fertility without any adverse effect. 50% spent wash can be conveniently used for irrigation of sugarcane crop without any external (either organic or inorganic) fertilizer application.

4.2.2.2 Effect on Crops - Maize

Joshi et al., (1996) reported that effluent treatment at 20 per cent dilution with 50 per cent NP application had shown the best yield (5.3 t ha^{-1}) in case of maize, saving 50 per cent N and P and 100 per cent K.

Pujar and Manjunathaiah (1996) revealed that distillery effluent at 1: 10 dilutions showed significantly higher yields in maize. Distillery effluents significantly increased the grain yield of maize compared to control. BSW produced the highest grain yield (43 per cent higher) over control (21.0 quintals) ha^{-1}. The higher grain yield was associated with larger size of the cobs, higher number of seeds per cob coupled with high 100-grain weight.

Joshi, (2002) reported a maximum increase in the yield of maize (70 per cent) when irrigated with 20 per cent post methanated effluents and that high yields were also observed (42 per cent) when irrigated with 30 per cent and 40 per cent Post Methanated Effluents. No injuries were recorded at any concentration (10 to 40 per cent) examined.

Sukanya and Meli (2004) observed a significant difference among the dilutions with respect to grain yield. A grain yield of 76.8 quintal per ha was recorded when irrigated with lower dilution (1:5) as compared to remaining dilution levels and an increase of 14.7 per cent over grain yield on irrigation with good water. A similar effect was observed in terms of number of rows per cob and the weight and maize yield as a result were significantly higher as compared to farmers practice. This was as good as the application of chemical fertilizer on an equivalent basis.

4.2.2.3 Effect on Crops - Groundnut

Juwarkar and Dutta (1983) reported that irrigation of groundnut with raw distillery wastewater resulted in the reduction of nodulation and absence of fruit formation of the plant. This inhibitory effect was reduced when raw wastewater was diluted to 50 per cent by tap water.

Pathmanabhan et al., (1988) state that the dry matter and yield of groundnut enhanced considerably due to application of Fe or Zn under effluent irrigation. The uptake of Na and Mg were reduced on addition of amendments under effluent irrigation while no significant increase was obtained with K and P.

Baskar et al., (2001) reported that higher seed and oil yield were recorded with 40 and 50 times diluted irrigations. Higher yield were recorded at 30 to 50 times dilutions.

Murugaragavan, (2002) reported that seed hardening with spent wash (10 per cent and 20 per cent) significantly improved the germination and growth parameters of crops like groundnut and gingelly.

Ramana et al., (2002a) state that application of raw spent wash, bio methanated spent wash and lagoon sludge increase total chlorophyll content, crop growth rate, total dry matter and final seed yield. Biomethanated spent wash was observed to give the greatest seed yield. The distillery effluents did not influence protein and oil contents

Das et al., (2009) observed that in their pot experiments on spent wash irrigation, the biomass yield of groundnut was decreased at 0 to 50 per cent dilutions of spent wash with water while with higher dilutions (80 to 90 per cent) the yield was equivalent with the yield observed with 100 per cent water.

Kalaiselvi and Mahimairaja (2010) reported that the percentage of germination and the seedling growth of groundnut increased for one to ten per cent concentrations of the fertilizer factory effluent. Continuous application of split doses of spent wash produced more number of gynophores per plant than one time application of spent wash. Application of different levels of spent wash markedly increased the number of matured pods and such effect was more pronounced when spent wash was applied in split doses continuously. Plants that didn't receive spent wash (control) had lesser number of matured pods; whereas, plants with the application of spent wash at the rate of 120 m^3 ha^{-1} plus recommended dose of NP fertilizers had greater number of matured pods. The results of the yield attributes revealed that the number of gynophores, number of matured and immatured pods, 100 kernel weight, shelling percentage and number of nodules, were enhanced significantly due to the application of spent wash over the control. The addition of spent wash resulted in a substantial increase in Protein and oil content of groundnut seeds. Similar to yield, increase in the rate of application increased the Protein and oil content significantly. The crop applied with 120 m^3 of spent wash with NP fertilizers had higher amount of Protein and oil content, however, it was not statistically different from the crop that received spent wash alone. There was only a small increase in seed Protein and oil content due to the application of NP fertilizers alone. This shows that the improvement in Protein and oil content was mainly due to the application of spent wash. The nutrients, particularly, N and S present in the spent wash and higher rate of mineralization in soil would have resulted in greater amounts of N and S uptake by groundnut crops. The continuous application of split doses of spent wash was found better in improving the yield attributes, which was reflected on groundnut yield. The Protein and oil content of groundnut seeds were also improved markedly.

Darmalingaiah, (2011) performed a field experiment on the utilization of treated spent wash as a source of nutrients and irrigation water in agriculture. They used treated effluents with a pH of 8.3, conductivity of 18 dS/m, BOD 5,360 mg/L and a COD of 16,000 mg/L for use as a fertigant for ground nut. 40 per cent spent wash was applied before sowing and remaining 60 per cent applied in three split doses at 30, 45 and 60 days after sowing. 7 different treatment concentrations based on the recommended doses of nitrogen (RDN) were decided as follows with their replications.

T1	100 per cent RDN Through Fertilizer
T2	100 per cent RDN Through Spent wash
T3	1.5 times RDN through fertilizer
T4	1.5 times RDN through Spent wash
T5	0.5 RDN Through Fertilizer and 0.5 RDN through Spent wash
T6	0.25 RDN through Spent wash+0.75 N through fertilizer
T7	0.75 N through Spent wash +0.25 N through fertilizer

Darmalingaiah observed that the application of 1.5 times the required dosage of nitrogen applied through spent wash (40 per cent pre-sowing; balance in three split doses at 30, 45 and 60 days after sowing) significantly increased the plant height, number of leaves per plant, total dry matter, leaf area index, maximum CGR, significantly higher SLW, leaf area duration, biomass duration, chlorophyll concentration, nitrate reductase activity, relative water content, oil and protein content, yield. Lowest yield attributes were observed in a mixture of 0.25 N through Spent wash and 0.75 N through fertilizers.

Kalaiselvi and Mahimairaja (2011) conducted a field experiment using groundnut (Arachis hypogea. L.) as a test crop to examine the effect of spent wash on nutrient dynamics. The experimental soil was sandy loam in texture. The experiment was laid out in a split plot design with two main plots and eight sub plot treatments and 3 replicates. The treatment details were as follows:

M1- One time application sprayed manually 15 days before sowing.

M2- Continuous split doses application. Applied in 03 equal splits along with irrigation water. The first split dose of spent wash was applied 15 days after sowing. The crop was supplied with N and P fertilizers as per the recommended dose of 17 and 34 kg/ha in the form of urea and single superphosphate. Potassium was entirely supplied through spent wash. The sub plots were treated as follows:

T1- Control

T2- Required dose of Nitrogen and Phosphorous.

T3- Spent wash @ 40 m^3 ha^{-1}

T4- Spent wash @ 40 m^3 ha^{-1} + required dose of Nitrogen and Phosphorous.

T5- Spent wash @ 80 m^3 ha^{-1}

T6- Spent wash @ 80 m^3 ha^{-1} + required dose of Nitrogen and Phosphorous.

T7- Spent wash @ 120 m^3 ha^{-1}.

T8- Spent wash @ 120 m^3 ha^{-1} + required dose of Nitrogen and Phosphorous.

The authors observed that among the spent wash applied plots, the plot which received 120 m^3ha^{-1} along with N and P recorded the maximum values of yield attributes viz. number of gynophores, 100 kernel weight, shelling percentage and number of nodules over the control. The protein and oil contents also increased significantly. The split application gave better results than one time land application.

4.2.2.4 Effect on Crops – Pulses, Gram and Pea

Sahai et al., (1985); Srivastava and Sahai (1987); Sahai and Neelam (1987); Mukherjee and Sahai (1988) state that effluent concentration up to 5 per cent was beneficial for growth of mung (Phaseolus radiatus), pigeonpea (Cajanus cajan) and chick pea (Cicer arietinum); growth, however was retarded at higher concentrations.

Rajaram and Janaradhanan (1988) reported that cow pea, black gram and mung bean responded well up to 2.5 per cent concentration of spent wash but soybean was sensitive even at lower level to distillery effluents.

Kannan and Upreti (2008) studied the impact of untreated (raw) distillery effluents and distillery effluents after conventional anaerobic treatment from a molasses based distillery on mung bean (Vigna radiata). Mung bean seeds were presoaked for 6 hours and 30 hours respectively in different concentration of 5, 10 and 20 per cent v/v of each effluent with distilled water and the germination, growth characters and seedling membrane enzymes and constituents were investigated. The untreated distillery effluents used by them exhibited a pH of 4.5, a BOD of 7,752 and a COD of 13,824 while the treated effluents had a pH of 7.15, a BOD of 28.7 and a COD of 73.4. The studies conclude that untreated distillery effluents are highly toxic for mung bean seed germination and plant growth even at low concentration of 5 per cent (v/v) and may not be suitable for irrigation. Treated effluent up to 10 per cent (v/v) concentration reflected low observed adverse effect levels. The authors concluded that treated distillery effluents if used for irrigation of legume crops need to be diluted over 10 times. (Since very high quality treated effluent has been used in the experiment, this finding may require more extensive evaluations).

Rani and Srivastava (1990), while studying the impact of various concentrations (10, 25, 50, 75 or 100 per cent v/v) of distillery effluent on growth of peas, found that shoot length, leaf number per plant, leaf area, chlorophyll content and phytomass exhibited a gradual increase up to 25 per cent but inhibited root growth. The number of pods per plant, seeds per pod and seeds per plant in peas increased up to 25 per cent concentration but seed chlorophyll content was highest (15.7 per cent) at 10 per cent concentration. They also reported that diluted spent wash increases the growth of shoot length, leaf number per plant, leaf area and chlorophyll content of peas.

Narain et al., (2012) conducted a study on the effect of distillery effluents on germination and seedling growth of Pisum sativum. They used distillery effluents with a pH of 8.25 ± 0.05, BOD of 5,980.83 ± 1.97 mg/L, COD of 21,999.47 ± 1.99 mg/L at concentrations of 10, 25, 50, 75 and 100 per cent. Distillery effluent did not show any inhibitory effect on seed germination, vigor index, root length, shoot length and dry weight at lower concentrations. Maximum germination percentage and vigor index were observed at 25 per cent concentration, which they concluded could be used as a suitable liquid fertilizer.

Gahlot et al., (2011) investigated the effect of digested spent wash on soil properties and growth parameters of chick pea (Cicer arietinum). They used digested effluents with a pH of 7.92 and a COD of 20,800 mg/L in various concentrations. The total Nitrogen and Phosphorous concentrations were reported as 1210 mg/L and 760 mg/L respectively (Potassium, Calcium and Sodium have not been estimated).

The authors used different concentrations (0, 2.5, 5.0, 10, 20, 50 and 100 per cent) of digested spent wash for studying the effect on seed germination. In order to assess the impact on nodulation, nutrient uptake and plant growth of chick pea, the recommended dose of fertilizers (RDF) was varied to (the 100 per cent RDF was equivalent to 20 kg nitrogen + 40 kg P_2O_5 per hectare) reveal the beneficial effect of supplementation with digested spent wash at levels ranging from 2.5 per cent to 50 per cent along with irrigation. Similarly the soil was amended with different levels (10, 25, 50, 100, 250 and 500 m^3/ha) of digested spent wash before sowing. The study revealed that irrigation with 20 per cent concentration of digested spent wash had no adverse effect on seed germination under pot culture conditions. Similarly as a pre-sown soil amendment, up to 250 m^3ha^{-1} of digested spent wash had no adverse impact. However at higher concentration of 50 per cent and 500 m^3 ha^{-1} it was inhibitory. In terms of nodulation, an increased concentration as irrigation water affected the nodulation even at low concentration of 5 per cent whereas the application of digested spent wash in soil at a rate of 100 m^3 ha^{-1} had no adverse effect on nodulation. Lower doses of digested spent wash (5 per cent or 50 m^3 ha^{-1}) were found to have no adverse effect on the root and shoot growth of chick pea and even proved to be stimulatory which has been attributed to its maturing effect. Higher nutrient uptake has been recorded at lower concentrations of spent wash irrigation. With an increase in concentration there was a decrease in the N and P uptake. In the case of pre-sowing application, the nutrient uptake increased up to 50 m^3 ha^{-1}, but at higher doses it decreased. Although there has been no appreciable change in the soil pH, soil EC, percentage organic carbon and total N and P content increased with increasing doses of spent wash in both the application (pre-sown ferti irrigation).

The authors have concluded that the application of lower doses of digested spent wash to the soil, either along with irrigation or as a soil amendment, has a beneficial effect on soil nutrients thereby increasing the uptake of nutrients by the crop and ultimately resulting in increased crop productivity.

Kumar *et.al.* 2014 concluded that distillery waste water irrigation significantly increased the nutrients in the soil and the agronomical performance of V. mungo was radically increased at lower concentrations from 20% to 40%_concentration of distillery waste water and decreased at higher concentrations (60% to 100% of distillery waste water). It has been suggested that the waste water can be used after dilution for maximum yield of V. mungo.

Kumar *et.al.* 2014 also found out that the enrichment factor of heavy metals was in the order of Cd>Cr>Zn>Cu>Mn for soil and Cu>Mn>Zn>Cr>Cd in V. Mungo after irrigation with distillery waste water. The accumulation of various heavy metals in different part of V. Mungo were in order of Leaves>shoot>root>fruits for Cu, Mn and Zn and root>shoot>leaves>fruits for Cd and Cr after distillery waste water irrigation. They have suggested that distillery effluent with proper dilution can be used as a bio fertigant for V. Mungo. The effluents used in the study possessed a BOD of 1150.68+-5.51 mg/L and a COD of 1640+-6.30 Mg/L.

4.2.2.5 Effect on Crops - Vegetables

Rani and Srivastava (1990) reported that in Citrus maxima the shoot length, leaf number/plant, leaf area, chlorophyll content and phytomass exhibited a gradual increase up to 10 per cent effluent concentration application.

Sharma, (2001) reported that vinasse (2.5-3.5 t ha-1) increased the yield of sugarbeet, potatoes and other vegetables by 20 per cent. Okra germination percentages increased from 75 per cent with tap water to 90 per cent with 25 per cent effluent. Both shoot and root length and fruit weight together with biomass and root dry weight were greatest with 25 per cent effluent.

Ramana et al., (2002) in their study on the effect of different concentrations of raw distillery spent wash (0 per cent, 5 per cent, 10 per cent, 15 per cent, 20 per cent, 25 per cent, 50 per cent, 75 per cent and 100 per cent) on seed germination in some vegetable crops like tomato, chilly, bottle gourd, cucumber and onion observed that the effect of distillery effluent is crop specific and due care should be taken before using the distillery effluents for pre-sowing irrigation purposes. The distillery effluents used in this experiment were highly acidic (pH 4.0-4.1) and saline (EC 25.30 dSm^{-1}) and contained 2020 mg/L total Nitrogen, 125.4 mg/L Ammoniacal nitrogen, 240 mg/L total Phosphorus, 139 mg/L organic Phosphorous, 13,000 mg/L of total Potassium and 2,820 mg/L of total Sulphur.

Chandraju et al., (2008); Chandraju and Basvaraju (2007) reported that diluted spent wash increases, the height, germination and growth of flowering plants for vegetables.

Chidankumar and Chandraju (2008) selected Brinjal, Beans, Cauliflower, Cucumber, Chillies, Cluster beans, Cabbage and Ladyfinger for their investigations on effects of primary treated spent wash at different dilutions on growth and yield. They used primary treated spent wash with a COD of 40,530 mg/L, BOD of 16,200 mg/L, Ammoniacal Nitrogen 743.66 mg/L, Total Phosphorous 30.26 mg/L, Total Potassium 7200 mg/L and Sulphur 74.8 mg/L. The seeds were sown and irrigated with raw water, 50% and 33% of pretreated spent wash, twice a week and rest of the period with raw water. The 50 per cent and 33 per cent concentrations exhibited a BOD of 7,818 and 4,800 mg/L; COD of 18,316 and 10,228 mg/L; total Phosphorous of 12.20 and 6.79 mg/L; total Potassium of 3,700 and 2,400 mg/L; Calcium of 600 and 380 mg/L; Sulphur of 35.0 and 22.6 mg/L and Sodium of 260 and 240 mg/L, respectively. The Ammoniacal Nitrogen concentration was 345.24 mg/L and 276.64 mg/L, respectively. Very high yields in the case of 33% spent wash irrigation for all the vegetables as compared to 50% were observed. The yields with raw water were minimum. Post harvest soil demonstrated an enrichment of N, P and K. No adverse effect on soil was observed. The authors concluded that distillery spent wash can be conveniently used repeatedly for the growth of top vegetables.

Chidankumar and Chandraju (2009) reported diluted spent wash to increase yields of top vegetables (creepers).

Chidankumar et al., (2009) also observed that diluted spent wash increased yields of some root vegetables in spent wash treated soils.

Chidankumar et al., (2009) studied the impact of spent wash irrigation on Bottle Gourd, Ash Gourd, Pumpkin, Snake Gourd, Ridge Gourd and Bitter Gourd. The primary treated spent wash used by them was characterized by 40,530 mg/L of COD, 16,200 mg/L BOD, 743.68 mg/L of Ammoniacal Nitrogen, 30.26 mg/L Total Phosphorous, 7,200 mg/L Total Potassium and 74.80 mg/L Sulphur. The seeds were sown and irrigated with raw water, 50% and 33% primary treated spent wash twice a week and rest of the period with raw water as required. They observed that the yields were highest in 33% spent wash irrigation, moderate in 50% and low with raw water irrigation. Soil tests after harvest indicated that there is an increment in the plant nutrients (N, P and K) and no adverse impact on any other parameters.

Different Fertigant doses of distillery effluents were used by **Kumar and Chopra 2010** for fertigation of Trigonella foenum-graecum along with control bore well water. (Upto 90 days of harvesting). The agronomical parameters such as shoot length, root length, number of roots, root nodules, number of leaves, flowers, pods, pod length, dry weight, chlorophyll content, leaf area index, crop yield and harvest index (HI) of T. foenum-graecum were recorded to be in the increasing order at low concentrations of Distillery Effluents (5 to 50%) and in decreasing order at high concentration of distillery effluents (75 to 100% as compared to control).

Chandraju et al., (2011) reported that diluted spent wash increases yields of tuber/root medicinal plants, yields of leafy medicinal plants and also increases the germination growth and yields of flowering plants.

Gandhar et al., (2011) states that the application of distillery effluent was more economical than that of DAP treatment in the cultivation of Solanum melongena plants. It acts as ferti-irrigant in the form of plant nutrients, which provide agro potentiality to the plant. Thus, 50 per cent dilution of distillery effluent can be conveniently used for the effective cultivation without using any other external fertilizers and water for enhancing the crop productivity.

Srivastava et al., (2012) in their study on the impact of ferti-irrigation with distillery effluents and DAP on the soil and growth characteristics of Egg plant, used acidic effluents (pH 6.71 ± 0.3) with a BOD of 1734 ± 5.89 mg/L, COD of 2527.02 ± 19.19 mg/L. They have not reported the Potassium content but have observed Total Kjeldahl Nitrogen (TKN) of 477.85 ± 6.90 mg/L and Phosphate of 177.72 ± 5.99 mg/L. The above effluents were collected from the outlet of secondary settling tanks and were used in dilutions of 10, 25, 50, 75 and 100 per cent made up with bore well water. The effluents in concentrations as above were applied to the soil and left to mineralize for two weeks. Pre sown seedlings were then transferred to this soil (in poly bags) and irrigated with diluted distillery effluents (500 ml) twice a week as per the requirement of crop plant and no drainage was allowed. Srivastava, et al., (2012) noted the highest chlorophyll concentration at 25 per cent concentration of distillery effluent as compared to bore well water or DAP application. Higher concentrations were found detrimental. The flowering and fruiting parameters in terms of flowers per plant, fruits per plant and fruit weight per plant were highest at 50 per cent concentration of distillery effluents as compared to bore well water or DAP. The research recommended rate for application of DAP on egg plant has been reported as 220 kg/hectare.

Chandraju et al., (2012) reported that the diluted spent wash increases yields of condiments.

4.2.2.6 Effect on Crops - Wheat and Rice

Madrod et al., (1986) reported that the protein percent in wheat grains showed an increased trend at lower dilutions of effluent irrigation. The authors suggested that 50 per cent concentration of distillery effluent has positive correlation with root length, shoot length, chlorophyll a, chlorophyll b and total chlorophyll content in wheat (Triticum aestivum).

Joshi, (2002) observed an increase in grain yield (t/ha) in the case of wheat crop irrigated with post methanated effluents. The maximum yield (5.64 and 5.82 tons/ha) was observed at the 10 and 20 per cent post methanated effluent irrigated levels in comparison to the control (3.65 t/ha). 30 per cent and 40 per cent levels of irrigation brought down the yield (4.73 and 4.24 t/ha) but it was still more than the controls.

Sukanya and Meli (2004) state that in two years of experiment conducted at Dharwad (Karnataka) in red soil, highest wheat grain yield was recorded when irrigated with 1:50 diluted spent wash compared to lower dilutions, where significantly lower yield (10.6 q/ha) was recorded.

Sukanya and Meli (2004) conducted studies to observe the response of wheat to the graded dilution of distillery effluent irrigation during the Rabi seasons of 1999-2000 and 2000-2001. They utilized distillery effluents and raw water dilutions of 1:5, 1:10, 1:25 and 1:50 apart from only bore well water and only undiluted effluents. Wheat was sown in the second week of November. A fertilizer dose of 100:75:50 kg N: P_2O_5: K_20 per ha was applied to the crop of which 50 percent of N and the full dose of P and K were applied at the time of sowing and remaining 50 percent N was top dressed at 30 days after sowing. The crop received 8 irrigations at 10 days interval.

The authors observed that dilution levels significantly influenced the gram yield. A grain yield of 52.59 quintal per ha was recorded with irrigation by higher dilution levels of 1:50 as compared to other dilution levels but was found at par with yields recorded with only bore well water irrigation (51.29 q/ha). The lowest grain yield of 10.56 quintal per ha was recorded under irrigation by undiluted effluents.

Availability of N, P, K, Zn, Cu, Fe and Mn content in soils was significantly higher in plots irrigated with undiluted effluents. However the total nutrient uptake by crop was significantly higher in plots irrigated at 1:50 dilution levels as it produced maximum biomass and economic yield.

The authors concluded that the dilution treatment of 1:50 was found better for highest crop yields but there was lesser residual nutrient availability due to higher nutrient uptake. The lesser dilution result in higher residual nutrient availability.

Kumar, (2008) reported that fresh application of post-methanation distillery effluent to wheat resulted in significant improvement in grain yield over that grown on residual fertility.

Joshi, (2002) has stated that irrigation with 30 per cent post methanated effluents (PME) produced the maximum increase in yield of rice (22 per cent) and that no injury was observed up to 40 per cent of PME irrigation when an almost identical yield increase was observed.

Rath et al., (2013) in their in vitro study on the impact of spent wash on germination, seedling growth, pigment content and different biochemical parameters of rice used various dilutions of spent wash. The spent wash was characterized by a BOD of 15,300 mg/L, COD of 30,520 mg/L, a pH of 7.23 and a nutrient component characterized by 636.25 mg/L Ammoniacal Nitrogen, 29.28 mg/L Total Phosphorous and 7,300 mg/L Total Potassium. They used dilutions of 5%, 10%, 15% 20%, 25% and 50% of post methanated spent wash and found the highest germination percentage at 15% concentration of distillery spent wash. At higher concentration the germination percentage gradually decreased. They attribute it to a low water absorption capacity of seeds due to osmotic imbalance and lesser oxygen due to the high organic matter content. The study also demonstrated the highest seedling root length at 15%, maximum shoot length at 20%, highest chlorophyll content at 15% and the maximum carotenoid, phaeophytin and total protein content at 20%. Higher concentrations generally impacted the study parameters adversely. 20% v/v concentration was good for germination and growth of rice, which is more effective than that of fertilizers used by local farmers.

4.2.2.7 Effect on Crops - Beans

Escolar, (1966) observed an increased yield in snap bean when subjected to effluent irrigation.

Tharkeshwari and Shobha (2006) observed significant improvement in growth of seedlings in 25 per cent concentration, which may be due to enhancing effect of nutrients present in spent wash. The germination percentage root and shoot length of Vigna radiata was significantly higher in 25 per cent concentration as compared to control. However, 50 and 30 percent germination was observed in 75 and 100 per cent concentrations, respectively.

Kumar and Chopra (2013) used distillery effluents with a BOD of 3276.84 mg/L, COD of 8678.65 mg/L, Total Kjeldahl Nitrogen of 580.97 mg/L, Nitrates 1468.78 mg/L, Phosphates 642.26 mg/L, Sulphates 1286.49 mg/L and Potassium (K^+) 548.68 mg/L in their experiments on the effects of ferti-irrigation on the growth and yield of Vicia faba. L. and on soil characteristics. They used 100 per cent, 75 per cent, 50 per cent, 25 per cent and 10 per cent dilutions of the aforesaid samples. The results revealed that the seed germination of V. faba L is negativity correlated to distillery spent wash irrigation and they attributed it to the toxicity effects of the effluents. The uptake of Ca, Mg, Na, and K also, according to them, decreases due to leaching as the pH decreases. They had applied 50 gallons of distillery effluents at 10, 25, 50, 75, and 100 per cent concentrations twice a week on the plots with a blank for bore well water. The agronomical parameters at vegetative growth stage showed insignificant positive correlation with distillery effluents. Vegetative growth was found to increase from 10 per cent to 25 per cent concentration of distillery effluents and decreased when the effluent concentrations increased from 50 to 100 per cent. Higher EC and related high salt concentrations are found as limiting factors for seed germination and vegetative growth. The chlorophyll content of V. faba was found higher when fertigated with 25 per cent distillery effluents.

The number of flowers (60 days after planting) in V. faba was affected insignificantly with the maximum number of flowers being observed at 25 per cent concentration and decreasing at higher concentrations. At the maturity stages the maximum number of pods were observed at 25 per cent concentration. The yield and harvest increased significantly with distillery effluent ferti-irrigation. They finally suggested that distillery effluents diluted to 25 per cent could be used for maximum yield of V. faba.

Kumar and Chopra 2013 have supported the use of appropriately diluted distillery effluents as a bio fertigant for Vicia faba. The agronomical properties like dry weight, shoot length, root length, number of flowers, number of pods etc. increased at 10 to 25% concentrations but decreased at 50 to 100% concentrations. The translocation of various heavy metals in different plant parts of V. faba were in the order of leaves>shoot>root>fruits for Cu, Mn and Zn; root>shoot>leaves>fruits for Cd and shoot>root>leaves> fruit for Cr.

Kumar and Chopra (2013) in their studies on the impact of distillery effluent irrigation on the agronomic behavior of Vigna radiata, L. used a 5%, 10%, 25%, 50%, 75% and 100% concentration of spent wash with a pH of 5.67, an EC of 12.68 dS/m, BOD of 3,265 mg/L, COD of 8,653 mg/L, Na^+ of 277.02 mg/L, K^+ of 536.56 mg/L, Ca^{2+} of 1855.05 mg/L, Nitrates 1455.36 mg/L. and Total Kjeldahl Nitrogen of 572 mg/L.

They have observed the maximum seed germination with control irrigation and the minimum with 100% concentration of distillery effluents. Seed germination was also recorded to be negatively correlated with different concentrations of distillery effluents in both the growing seasons. At the vegetative growth stage (at 45 days) the maximum shoot length, root length, dry weight, chlorophyll content and LAI per plant were recorded with 50% concentration of distillery effluents in rainy season and 25 per cent in the summers. The authors have also observed that at the flowering stage (60 days) the maximum flowers and pods per plant were recorded with 50% concentration of Distillery Effluents in the rainy season and 25% in the summer season.

Nitrogen and Phosphorous have been indicated to be essential for flowering, too much Nitrogen can delay or prevent flowering while Phosphorous deficiency is sometimes associated with poor flower production and flower abortion. At the maturity stage (90 days) all concentrations of distillery effluents showed a considerable effect on crop yield and Harvest Index.

Kumar and Chopra (2013) concluded that the agronomical performance of V. radiata L. gradually increased from 5 to 50 per cent concentrations of distillery effluents in the rainy season and 5 to 25% concentration in the summers. It decreases at higher concentration of 75 and 100% in the rainy season and 50 to 100% in the summers. Distillery effluents can be used for irrigation purposes after appropriate dilution. This may save the dual purpose of fighting pollution and meeting the challenges of water scarcity.

4.2.2.8 Effect on Crops - Others

Zalawadia and Raman (1994) have observed that the irrigation of diluted distillery water supplied with 75 per cent of the recommended NPK fertilizer gave a similar yield as irrigation with well water and supplemented with the recommended NPK fertilizer rate.

Rajendran, (1990) studied the effect of distillery effluent on seed germination, seedling growth and chlorophyll content in sunflower (Helianthus annus L.) var EC 68414 and revealed decreased seed germination, seedling growth and chlorophyll content with increased effluent concentration which remained safe at low concentration of up to 25 per cent.

Machado-De-Armas et al., (1994); **Pandey and Soni (1994)** observed that at lower concentration, effluent application enhanced both peak value of germination and mean daily germination of Albizia procera but which was inhibited at higher concentration of effluents.

Pandey and Soni (1994) noted that at a lower concentration (10 per cent) effluent enhanced the PV (peak value) of germination) and MDG (mean daily germination) in Acasia catechu and Dalbergia sissoo but there was no effect on time required for germination compared with control values for the two species.

Pandey et al., (2008) evaluated effect of different concentrations on germination of Acacia catechu, Dalbergia sissoo and Morussl and reported that the low effluent concentration (10 per cent) enhanced the germination of all species relative to control values.

Chandraju et al., (2012a) in their study on the effects of distillery effluents on Asters and Daisies used various dilutions of primary treated spent wash having a COD of 41,250 mg/L, BOD of 16,100 mg/L and other nutrients like Nitrogen (Ammoniacal 750.8 mg/L), Total Phosphorous (40.5 mg/L), Total Potassium (7500 mg/L) and Sulphur (70 gm/L). Seeds of Aster and Daisies were sown in different pots (50 cm high and 30 cm dia.) and irrigated with raw water, 1:1 primary treated spent wash (PTSW), 1:2 PTSW and 1:3 PTSW twice a week and the remaining period with raw water. They observed that the germination, growth and yields of both plants were very good in both 1:3 and 1:2 dilutions as compared to 1:1 PTSW and raw water. They attributed it to the better uptake of N, P and K. The studies could not demonstrate any negative impacts of heavy metals like Lead, Cadmium and Nickel on the leaves of Aster and Daisies. Post harvest soil characteristics were not observed to be adversely affected.

Chandraju et al., (2012b) studied the impact of distillery spent wash irrigation on the germination of Himalayan Balsam and Crossandra in pots. Irrigation was done with raw water and at concentration of 1:1, 1:2 and 1:3 of primary spent wash. Primary treated spent wash with a ph of 7.56, BOD of 16,100 mg/L, COD of 41,250 mg/L, total Phosphorous 40.5 mg/L, total Potassium 7500 mg/L, Calcium 900 mg/L, Magnesium 1244.16 mg/L and Ammoniacal Nitrogen of 750.8 mg/L was used. The authors observed that in both the plants studied, germination was best at 1:3 concentrations of spent wash as compared to raw water and higher concentration. The growth of plants was also noticed to be highest at 1: 3 primary treated spent wash irrigation. Post harvest soil analysis did not exhibit any adverse impact on soil. The authors concluded that spent wash could be conveniently used as irrigation medium with required dilution without affecting the environment and soil without external fertilizers.

Gothwal et al., (2012) observed that distillery spent wash and dairy wastewaters could be suitably used as an amendment of bagasse at low concentrations (5 per cent for DSW and 10 per cent for DWW) for enhancing the Pleurotus mushroom productivity. They concluded that on the basis of higher yields, improved biological efficiency and richer protein content, both these wastewaters appear suitable options for substrate amendment of bagasse for Pleurotus species cultivation.

4.2.3 Impacts on Soil

Devarajan et al., (1993) registered significantly higher sugar cane yield in CO. 771 irrigated with 50, 40, 30 and 20 times diluted effluent than with normal water. The effluent irrigations improved the physical, chemical and soil micro-flora during cane cultivation

Devarajan and Oblisamy (1994) reported that the diluted spent wash irrigation improved the physical and chemical properties of the soil and further increased soil micro flora.

Joshi, (2002) has observed that mixed with irrigation water (up to 10 per cent) spent wash can be given any time after 25 days of crop emergence. Post sown irrigation in which plants are directly exposed to effluents, particularly at higher doses may cause indirect injury to the plant due to its high BOD and salt loads. Effluent application at higher doses causes accumulation of salts, particularly K in the soil profile.

A study carried out by **Lewis, (2007)** on effluents from DCM Shriram Industries Limited indicates the effluents were being utilized for their nutrient values. The Irrigation Management Plan submitted by the industry to the CPCB has concluded that "if regulated properly, diluted distillery effluent can be profitably used for ferti irrigation - significant changes in soil and ground water quality are not likely visible based on two years monitoring but continued application has the potential to cause accumulation of salts in the soil and their leaching in ground water and has to be monitored on a long term basis. At the Daurala Distillery Complex, the entire spent wash generated from the distilleries is sent to the anaerobic digester for bio methanation. 40 to 50% of bio methanated spent wash is added to press mud for production of compost whereas the remainder after secondary treatment, is diluted with distillery process water, temporarily stored and finally piped to local farms as liquid fertilizer as per the protocol prescribed by the CPCB.

Chidankumar and Chandraju (2008) found that the soil was enriched in NPK contents after application of spent wash, which results in an increase in soil fertility for the harvest of vegetables. Hence the distillery spent wash can be conveniently used repeatedly for the growth of top vegetables.

Chandraju et al., (2011) in their investigation on the influence of different concentrations of spent wash on the yields of tuber/root medicinal plants in normal and spent wash treated soils, used primary treated spent wash with a pH of 7.57, BOD of 16,100 mg/L, COD of 41,250 mg/L, Ammoniacal Nitrogen 750.8 mg/L, Total Phosphorous 40.5 mg/L, Total Potassium 7500 mg/L and Sulphur 70 mg/L. 33% diluted primary treated spent wash was used for irrigating Ginger, Radish, Turmeric, Onion and Garlic. They found that there was no negative impact of spent wash on soil. The study concluded that the spent wash treated soil is enriched with the plant nutrients such as NPK and further use of diluted spent wash for irrigation enriches soil fertility.

Deshpande *et.al.* 2017 experimented on the effect of Primary biomethanated spent wash (PBSW) on soil properties, nutrient uptake and yield of wheat on sodic soils at varying doses of 100,200,300,400 and 500 cubic meter per hectare. The results have revealed that the physical properties namely bulk density and hydraulic conductivity were improved in sodic soil. The authors have also observed a significant reduction in pH, calcium carbonate and exchangeable sodium and an increase in organic carbon, cation exchange capacity (CEC) and electrical conductivity (E.C.) in the soil due to the addition of PBSW. The available soil nitrogen (N) Phosphorous (P), Potassium (K) and micro nutrients iron, manganese, copper and zinc (Fe, Mn, Cu, and Zn) content after the harvest of wheat was the highest in 500 m3/ha treatment compared with all other treatment. The exchangeable Calcium (Ca2+) Magnesium (Mg2+) increased significantly and exchangeable sodium (Na+) reduced significantly with increased dosage of PBSW. The application of PBSW (@500, 400, 300 and 200 m^3/ha) resembled the other treatments of FYM and Gypsum. The PBSW application at the rate of 500 m3/ha had recorded the highest grain (43.33 quintal/ha) and straw (72.72 quintal/ha) yield and the maximum total uptake of N, P, K, Fe, Mn, Cu and Zn by wheat which was at par with the treatment of FYM (5 t/ha)+Gypsum @ 100% GR+RDF AST (Recommended dose of Fertilizer after test)

4.2.3.1 Impact on Soil-Nutrient uptake and Physiology

Hashmoto and Yokota (1965) found significant increase in the uptake of total Mn, P, K and Mg by oats with increasing rates of application of paper mill effluent. They attributed it to the presence of readily decomposable sugars in the liquor, which enhanced N and Mn uptake. Increased P and Mg uptake was ascribed to lignin and tannin contents.

Bhat (1994) reported that the EC, SAR and available nutrient status of soil receiving diluted effluent were higher compared to soils irrigated with water only.

Corazza and Sales Filho, 2014 have observed that failure to maintain the optional doses of vinasse, which varies according to soil type and sugarcane varieties, leads to risk of salinisation and degradation of the quality of sugarcane produced. More research may be required on the risks of infiltration of vinasse into soil, risks to and maintenance of ground water quality and human health. With no control over fertigation, soil salinisation and under ground aquifers contamination were controversial.

4.2.3.2 Procedures, Guidelines and Practices

Devarajan and Oblisamy (1994) recommended higher dilution of spent wash for irrigation to reduce adverse effects on soil and crop productivity. The higher dilution could be used for irrigation purpose without adversely affecting soil fertility and crop productivity.

Vidyarthi, (2011) states that the ferti-irrigation practice has been described to consist of –

- Bio-methanation followed by two stage biological treatment to achieve a BOD < 800 mg/L.
- Storing treated effluents in lined lagoons as prescribed. Providing a storage capacity of 25 per cent of average yearly utilization of spent wash.

- Dilution of treated effluents prior to irrigation to meet critical water quality parameters such as N-requirement of crop, soil type.
- One or more spent wash irrigation.
- Further irrigations to be done using fresh water.
- Application of spent wash each alternate year.
- Command area extends to a radial distance of 20 Km.

The Office of the Principal Scientific Advisor, Government of India, 2014 refers to the following protocol for utilization of distillery effluents for irrigation of agricultural crops, as agreed by the Central Pollution Control Board.

Based on the field and experimental studies carried out by the Indian Agricultural Research Institute (IARI), Delhi nd the experience of the Central Pollution Control Board for application of industrial effluents on land using it as a treatment medium, the following protocols are recommended for the utilization of treated distillery effluents (BOD 100 mg/1) for irrigation of agricultural crops.

1. **Basic Requirements**

   (i) Any distillery desirous of utilization the effluent for irrigation should have completed the construction and commissioning for bio- methanation plant for primary treatment of spent wash followed by secondary biological treatment (aerobic) with two stage aeration before utilization on land for irrigation.

   The BOD value of the finally treated effluent before storage in the lined storage tank small not exceed 500 mg/1

   The BOD value of the effluent in the storage lagoon shall not exceed 100 mg/1

   It shall not be transported to the filed for irrigation through tanker.

(ii) The distillery shall construct concrete and lined storage tank with a minimum retention time of 1 month for storing the final treated and diluted effluent during the monsoon and /or non-irrigation period.

(iii) The command area requirement for irrigation shall be calculated at the rate of not less than 9 ha/kilolitre of daily alcohol production capacity. For 30 kld installed alcohol production capacity, the distillery will require minimum 270 ha of land for irrigation under the scheme.

(iv) The distillery shall construct distillery channel network for transporting effluent, preferably of closed conduits or of pucca construction, to cover the area irrigated under the scheme.

(v) The distillery after fulfilling the above basic requirements shall prepare a comprehensive 'Irrigation Management Plan' (IMP) for utilization of it's effluent and got it approved by the State Pollution Control Board at the time of grant of consent. The IMP include the details on:

a. Survey/plot (khasra) numbers of land for irrigation under the scheme along with their area.

b. Written agreement with the owners (farmers) of the land mentioned in (i) above, to bring their land for use under the scheme.

c. The treated spent wash from the storage lagoon with a BOD value of 100 mg/1 and TDS (inorganic) as 2100 mg/1, maximum shall be utilized for irrigation.

d. The depth of one irrigation shall not be more than 10 cm or as per the crop requirement, whichever is less. The total number of irrigation shall not exceed six for any crop.

e. Agronomic plan for effective utilization of land by crop rotation.

f. Effluent distribution schedule to the fields.

g. Infrastructure facilities available/planned for collection and analysis of samples collected as per item 3 i.e. Monitoring Protocol.

h. Full-time expert and other manpower employed for the purpose of managing the IMP and;

i. The fresh water may not be allowed for dilution of spent wash treated or partially treated.

2. Safety Protocol

vi. Though the crops normally cultivated in the area can be grown under the scheme the rotation of wheat, rice and sugarcane crops is preferable.

vii. Effluent application during the germination and seeding growth shall be avoided.

viii. Any concurrent use of fertilizers and pesticides shall be done judiciously to avoid super-imposed effect.

3. Monitoring Protocol

ix. The physic-chemical characteristics of the soil under irrigation by distillery effluent shall be regularly monitored for pH and Electrical Conductivity (EC). One representative sample per 10 ha at depths of 30 cm and 60 cm shall be collected at least twice a year, for this purpose. The pH and EC of the extract of the mixture of 2 parts of soil with 5 parts of water shall exceed 8.5 and 4 milliohms/cm respectively.

x. The ground water quality shall be monitored by installing one hand pump for covering 10 ha area of land and one bore well for 20 ha area of land. Groundwater for BOD, Nitrates and TDS. The net addition to the groundwater quality in terms of (i) BOD shall not exceed 3 mg/1, (ii) Nitrates, expressed as 'N' shall not exceed 10 mg/1, and (iii) TDS shall not exceed by 10% or 200 mg/1 whichever is less.

xi. The records of soil and groundwater quality monitoring data so collected shall be properly maintained for verification by the State Pollution Control Board, at least once after every cropping season.

xii. In the event of first observation of any of the soil and groundwater monitoring parameters exceeding the prescribed limits, effluent application shall be stopped immediately and the distillery shall communicate the matter to the State Pollution Control Board about such observation. The industry would be solely responsible for reclamation of soil and groundwater quality at their own cost and expense, in case of damage.

SECTION-5

DISTILLERY EFFLUENTS TREATMENT - BIOCOMPOSTING

5.1 Abstract

The biocomposting system helps distilleries to utilize the sludge materials segregated from the distillery processes, incineration, spent wash and R.O. plant rejects to convert it to valuable bio compost using sugar unit press mud. Sugar press mud is produced at a rate of 7-9% of total weight of sugar cane in carbonation industries and 3-5 % in sulfitation industries. The falling population of livestock has brought down the availability of Farm Yard manure. Bio-compost is now filling up this gap as an organo-mineral supplement. Bio-compost prepared from distillery spent wash was reported to contain higher Organic Carbon (15.5%), N (2.0%), P (2.5%) and K (3.0%). The pH of the compost was found ideal (7 to 7.5) with a C: N ratio of 15: 1. Application of bio-compost and 50% NPK application was found to have enhanced the available N, P and K status of soil and recorded maximum yields of cane over the yield when 100% NPK was used. Spent wash-press mud compost has been observed to improve the stability of aggregates and porosity. Composting also assists in the degradation of colored organics in the distillery effluents which also enrich the compost with nutrients specially potassium. In order to provide a balanced nutritional value and enrich it more, the compost could be enriched with the use of rock phosphate, gypsum, yeast sludge, bagasse, sugarcane trash, boiler ash, coir pith and water hyacinth. Both Aerobic and Anaerobic composting techniques have been suggested requiring about 30 days for active reactions and another 30 days for maturing. Spent wash utilization in aerobic composting is more than spent wash consumptions in anaerobic composting. The Central Pollution Control Board has issued directions

to distilleries to use press mud and concentrated Spent wash in a ratio of 1:1.6. The earlier protocol had allowed a Press mud to unconcentrated spent wash ratio of 1:2.5 for a 45 days cycle and 1:3.5 for a 60 days cycle. The Ministry of Agriculture, Cooperation and Farmers welfare has added specifications for organic fertilizers in 2015 under the Fertilizer control order.

Shortage of filler materials, large land requirements and the distribution network of compost appear to be major problems associated with bio composting. The Central Pollution Control Board has also found that, within some of the distilleries studied by it, the composting process has not been up to the standards with problems of press mud availability, unlined areas and problems of leachate etc. It has been suggested that distilleries, which are facing a shortage of press mud, can use alternative agro by-products such as bagasse, sugar cane trash, coconut coir in combination with press mud. A 20:80 ratio of alternative agro products to filter cake has been recommended. Some authors suggest that since the production of press mud is seasonal, arrangement of alternate sources of filler material or alternative treatment for spent may be made.

The Central Pollution Control Board has evolved a protocol for sustainable bio-composting. Distilleries with covered shed bio composting may be allowed to operate throughout the year and those without covered shed shall be operated 270 days (excluding the monsoon season). It has prescribed procedures for laying of press mud, moisture content, interludes between laying and initial turning, seeding, application of spent wash and other process and environmental details including specification of Bio-compost yard for Distillery operating 270 days.

5.2 Review of Literature - Biocomposting

Sundaramoorthi 2011 states that bio composting is providing organo-mineral supplement to Agro sector. The traditional cow-dung manure utilised in the farmland is becoming a non-available commodity due to dwindling population of cattle caused by the invasion of farm machineries and labour shortage. At a critical juncture of land productivity that is reducing year by year due to the non availability of organic matter with essential nutrients in the soil, there is a need to consider and take action to recharge the soil with nutrient rich spent wash for maintaining its continued productivity. The distilleries that are establishing with spent wash concentration and incineration as fuel in boiler scheme should also be allowed to integrate the bio-composting system. The bio-composting system helps the distillery to utilize the sludge materials segregated from distillery process, spent wash tanks and reject streams from R.O. plants (handling evaporator condensate water treatment) and convert it into valuable bio-compost manure using sugar unit press mud. The bio composting of segregated sludge materials prevents the entry of salt containing sludge into the spent wash evaporation section and ultimately to the boiler furnace as fuel. This will certainly help to reduce the impact of scale deposits in the heat transfer sections and thereby avoid frequent stoppage of evaporators and boiler for cleaning. Further, the bio composting would help the distillery to utilize the potash rich ash resulted from spent wash burning.

Shinde et al., (1993) noticed improvement in stability of aggregates and porosity due to application of spent wash solids and spent wash press mud compost.

Devarajan et al., (1993) state that since the effluent contains organic materials and many plant nutrient elements, there is scope for using it advantageously in composting. The composting enables the degradation of coloured organics in the distillery effluent and evaporation of water rapidly and also reduction in BOD. Distillery effluent will also enrich the compost with plant nutrients especially Potassium. Devarajan et al., (1993) stated that the distillery effluent based compost can be prepared by using press mud and the compost could be enriched with the use of rock Phosphate, gypsum, yeast sludge, bagasse, sugarcane trash, boiler ash, coir pith and water hyacinth.

The CPCB document titled 'Management of Distillery Wastewater' (2001) states that the composting process consists of converting the spent wash in to useful manure. This may be done with the help of specialized microbial culture or using fresh compost as seed for the microorganisms. The raw materials required for composting are spent wash, bacterial culture and a filler material. The most common filler material is press mud obtained from sugar factories. Other options are agricultural residues, such as bagasse, segregated municipal solid waste and ash. The document also states two types of composting processes, aerobic or anaerobic can be used.

Aerobic composting

A typical aerobic composting process involves arranging the press mud (filler material) in 300 to 400 m long windrows of triangular section of about 1.5 m height on impervious ground. The windrows are sprayed with a measured quantity of spent wash, usually in the ratio of 2.5 to 3.0:1, spent wash to press mud (w/w). The ratio will change depending upon the moisture content of the press mud. Other filler materials may have different liquid holding capacity. The windrows are inoculated with the seed material after the first spray. Specialized mixing machines traveling along the length of the windrows are used to mix and aerate the decomposing mass, about once in 3 days. This results in increased spent wash absorption, oxygen supply for proper growth of microorganisms and dissipation of heat, which is liberated due to metabolic activity of microorganisms. The moisture content during composting is maintained at 50 to 60 per cent by periodic spraying of spent wash.

Anaerobic composting

The process is similar to aerobic composting but anaerobic microorganisms predominate in the anaerobic composting. It is carried out in 5 to 6m. wide , 50 to 100 m long and 1 to 1.5 m. deep pits. The contents of the pit are periodically mixed, but not aerated as in the aerobic process.

Both the above processes require about 30 days for active reactions and another 30 days of maturation period to produce stable compost. However, spent wash utilisation in anaerobic process is lesser compared to aerobic process. When spent wash after biomethanation is used, the time requirement may be more. The final compost has a moisture content of 30 to 40 per cent (w/w) and Carbon to Nitrogen ratio of 15 to 17 (w/w).

The composting process requires careful management. Composting should be carried out on an impervious floor and in lined pits. The total composting and storage area should be raised or protected by bunds so that the surface runoff during rainy season does not wash off any spent wash and Lead to contamination of groundwater and surface drains. Further, during the rainy season, when there is no demand for compost, there should be adequate arrangement for holding the spent wash in lined lagoons.

Success of composting process is dependent on the availability of press mud from sugar industry or any other suitable filler material. Since the operation of sugar mills is seasonal, arrangements for alternate source of filler material or an alternate spent wash treatment should be made. Composting process, either as the sole treatment method or in combination with other methods, has been adopted with success mostly in the distilleries in Maharashtra and some southern states.

Ravi, (2003) has stated that the bio-composting process is a biochemical process in which the micro organisms or earthworm break down organic matter into humus like material which is easily absorbed by the plants. The process has the potential to convert organic wastes into stabilized bio product like bio compost, which enriches the soil biota and sustainability in agriculture. This bio composting process makes it possible to recycle organic waste back to the soil without causing pollution of land and water resources. Technologies have been identified and developed to upgrade the nutrient level of compost and to reduce the period of composting by 10 to 15 per cent. The mesophilic microflora (25–45 °C) is initially responsible for the bio process resulting in decomposition of water soluble and readily decomposable materials like sugar and proteins and release of exothermic energy. This initial conversion makes the compost hot and increases the temperature up to 50 – 65 °C replacing the mesophilic by thermophilic species of microorganisms. The rise in temperature is influenced by the nature of organic matter and to a great extent of aeration. Composting organic residues usually have a wide range of active micro flora including Nitrogen fixing bacteria like Azotobacter chroococcum and Phosphate solubilizing fungi: Aspergillus awamori and bacterial species of Bacillus polymyxa. Some specific earthworms also activate the composting process. A study was conducted to evaluate the role of efficient cellulolytic fungi in composting of crop residues rich in cellulose, hemicelluloses and lignin. Enrichment of compost with Nitrogen fixing bacteria (Azotobacter chroococcum) and Phosphate solubilizing fungi improved the nutrient content of the final product. Inoculation with microbial cultures in presence of 1 per cent rock Phosphate is beneficial input to obtain a good quality compost rich in N and available P_2O_5 and the humus content is also higher.

Baskar et al., (2003) concluded that, the presence of plant nutrients and organic materials enables the distillery effluents to be used advantageously for composting with bagasse or press mud. The composting enables the degradation of coloured organics in the distillery effluents and evaporation of water along with a reduction in BOD. The distillery effluents also enrich the compost with plant nutrients especially potassium.

Saliha et al., (2011) state that composting is an ecofriendly method of solid waste management, which helps to recycle valuable nutrients in the soil and plant systems. The manurial value of different composts prepared from various sugar industry wastes were analysed for their nutrient potentials. The composts prepared from sugarcane trash, press mud, bio-earth prepared from press mud and distillery spent wash were evaluated for their efficiencies in terms of organic Carbon, primary, secondary and micronutrients. Among the different composts, bio-compost prepared from press mud and distillery spent wash was found to contain higher organic Carbon (15.5 per cent), N (2.0 per cent), P (2.5 per cent) and K (3.0 per cent). The pH of the compost was found to be ideal (7 to 7.5) with a C: N ratio of 15: 1. The results of the field experiments conducted to evaluate the efficiencies of the composts indicated that the application of bio-earth /bio-compost @ 5t.ha^{-1} and 50 per cent NPK enhanced the available N, P and K status of the soil from 210, 12 and 190 kg. ha^{-1} to 290, 24 and 410 kg ha^{-1} respectively and the maximum cane yield of 115 t ha^{-1} was recorded in this treatment which was an additional yield of 25 kg ha^{-1} over 100 per cent NPK alone (90 t ha^{-1}). The application of composted sugar industry wastes in the form of bio-compost not only enhances the soil nutrient status and cane yield but also serves as a means for eco-friendly management of industrial by-products.

Suresh, (2011) suggests the following drawbacks to anaerobic digestion followed by evaporation and composting –

- The filler material press mud is not available in required quality.
- The ratio of press mud to spent wash 1:2.5 appears to be impracticable.
- Needs revision depending on the moisture content of press mud.
- The disposal of compost as manure also appears to be difficult in some parts of the country.
- The land requirement is around 0.25 hectares/KL of spirit production, which is a huge area.
- Due to large requirements of press mud, the technology may not be suitable for large capacity distilleries.
- Composting process is not allowed for stand-alone distilleries as per the present guidelines.
- Composting is not allowed for raw spent wash due to the fear that leachate concentrations may be very high when raw spent wash is used.
- Whenever “composting” process is adopted, the distillery should not be operated during rainy season.
- 270 days operation in a year is only permitted.

It has been observed that within the distilleries studied by **Vidyarthi, (2011)** the composting process has not been up to the standards with problems of press mud availability, unlined areas and problems of leachate etc.

Rengraj and Sultana 2014, describe press mud as a soft, spongy, amorphous and dark brown or white material containing sugar, fiber, and coagulated colloids including cane wax, albuminoids, inorganic salts and soil particles. It consists of 80% water and contains 0.9% to 1.5% of sugar, organic matter, nitrogen, phosphorous, potassium, calcium, sulphur, coagulated colloids and other materials in varying amounts. It is acidic having a high BOD and COD and cannot be disposal directly into water bodies like other organic materials. It affects the physical, chemical and biological properties of the soil. In many areas press mud is directly transported to the fields from Sugar Mills as an organic enhancement to fields. Sugar Press mud is produced at a rate of 7-9% of total weight of sugar cane in carbonation industries and 3-5% in sulfitation industries. The authors observed that ecofriendly, good quantity with stabilized nutrient range of press mud compost can be obtained with 1:3.5 ratio of press mud to spent wash. They used spent wash with a BOD of 80000 mg/L to 100000 mg/L and a COD of 180000 to 200000 mg/L.

The Ministry of Agriculture, Cooperation and Farmers Welfare, 2015 has at a new serial no. 5, added the specifications for organic fertilizers after schedule IV, part A of the fertilizer control order.

5. Bio enriched organic manure

I	Moisture percent by weight maximum	30 to 40%
II	Particle Size	Minimum 90% material should pass through 4.0 mm 1.S seive.
III	Bulk density (g/cm^3)	<1.0
IV	Total viable count (NPK and Zn bacteria) or N and P bacteria or (N and K Bacteria.	$5x10^6$ (within 03 months from date of manufacture

V	Total organic carbon, percent by weight minimum	14.0
VI	Total nitrogen (as N) percent by weight	0.8
VII	Total phosphates (as P_2O_5) percent by weight	0.8
VIII	Total Potash (as K_2O) percent by weight minimum.	0.5
IX	NPK nutrient –Total of N, P_2O_5, and K_2O nutrient.	Not less than 3%
X	C:N ratio	<18
XI	pH	6.5 to 8.0
XII	Conductivity (as dSm-1) not more than	4.0
XIII	Heavy metal content (as mg/kg) maximum	
	Arsenic (as As_2O_3)	10.0
	Cadmium (as Cd)	5.00
	Chromium (as Cr)	50.0
	Copper (as Cu)	300.00
	Mercury (as Hg)	0.15
	Nickel (as Ni)	50.00
	Lead (as Pb)	100.00
	Zinc (as Zn)	100.00
		(This needs to be verified from the Hindi version of the notification.)

The Central Pollution Control Board, August 2018, has prescribed a procedure/protocol for Bio Composting which provides that:

1. Distilleries with covered shed bio-composting may be allowed to operate throughout the year and those without covered shed shall be operated 270 days (excluding monsoon season)

2. Press mud may be directly laid in the bio-compost yard or properly stored for consumption the rest of the year.
3. Feed stock is received as combination of press mud, yeast sludge and boiler ash in press mud yard or plant as per requirement from sugar industries. Average Moisture content after testing : 70±5%
4. Areas for Press mud storage, Bio-compost operation and finished goods storage must be properly demarcated.
5. Windrows laid shall be as per the machine size and the length as per the Bio-compost yard
6. On completion of laying & dressing of windrows, initial turning should be started, between the 4^{th} to eighth day to reduce moisture content from 70±5 % to 50±5 %. Time required for achieving desired moisture level, in summers is 3 to 5 days and in winters 4 to 7 days.
7. On achieving 50± 5 % moisture , bio culture (as a seed is added) in windrows and turning of windrow started for proper mixing of culture seed and allow to increase windrow's temperature at around 70^{O} C.
8. Prepared windrows left idle from the eighth to the tenth day for 2-3 days for proper growth of microbes.
9. Growth/ development of microbes in windrows is observed by measuring its temperature. In normal condition temperature of windrows is between 60-70°. This temperature gain is result of microbial activity.
10. When desired temperature is achieved (within 2-3 days), start turning of press mud through aero tiller machines without any major deviation in shape & size of windrows.
11. Measure temperature manually with the help of thermo-meter.

12. Receive concentrated effluent from plant or lagoon at the bio compost yard through flow meter.

13. Spray concentrated spent wash not more than 10% of press mud weight on alternate days using the aero tiller or on suitable interval based on windrow temperature & moisture content. (The overall consumption of concentrated spent wash shall be 1.6 m3/MT of Press Mud). Alternatively spent wash can be sprayed on the basis of moisture content i.e. spraying can take place when moisture content has come down to 45 to 50% so as to increase moisture content to about 65 to 70%. During active Bio composting process the moisture will tend to go down because of heat generation.

14. During turning & spraying of effluent, monitor the windrow's temperature on daily basis and note in the log book. The quantity of sprayed effluent must be noted down in the log book.

15. Concentrated spent wash and turning of windrows continues for 50-60 days from the 10^{th} to 50^{th} day or till the windrows temperature up to 55+ 5°C maintained.

16. If no temperature rise is observed, then stop the concentrated spent wash spray on windrows and continue the turning of bio-compost till moisture content reaches 35±5 %. Generally from the 50^{th} to 60^{th} day.

17. Store the prepared bio-compost under covered condition during rainy season

18. Bio-compost shall be analyzed for parameters as per the Fertilizer Control order with latest amendments and shall be packed as per the customer requirement.

19. Personal Protective Equipment (PPE) as per job requirement shall be used by personnel working in the bio -compost yard.

20. Check the top level of concentrated spent wash storage lagoon on daily basis so as to maintain below Red mark.

NB: Requirement of Pressmud depends on the size of aerotilling machines which are available in different sizes and also with side mounted turner and top mounted turning equipment. Further, the windrows require dressing with JCB machine after every turning for which a spacing of about 3.0 meters is required between each windrow.

This Standard Operating Procedure also provides specifications for covered Bio-compost yard for Distilleries operating throughout the year and those operating 270 days (excluding rainy season) along with Biocompost area calculations. It includes details for yard length, windrow markers, bays, Down comers for rain water, protection against cross wind rain, leachate collection pits, leachate collection drains, Truss members, roofing, floor lining, ground water monitoring facilities, location of piezometers and hand pumps, data recording, approach roads, storage for ready compost and camera locations.

SECTION-6

UTILISATION IN AGRICULTURE – INTERNATIONAL PRACTICES

6.1 Abstract

Australia, Brazil, Mexico and some other countries have demonstrated some notable practices towards the utilization of spent wash in Agriculture. In Australia spent wash is blended with additional crop nutrients and sold as manure. Spent wash has also been used to compost trash in the field. The fields are generally sprayed with spent wash to facilitate the accelerated composting. Aspirator guns used in Brazil draw spent wash from lorry tankers and spray spent wash to cover a radius of 200 feet. In Brazil, the application of vinasse and filter cake to sugarcane crops has reduced the consumption of fertilizers as composed to other crops and in other countries. The Sao Paulo Secretariat for Environment has developed a technical standard. It specifies permitted places, doses, protection of master channels and storage etc. There are mills that have applied vinasse to 70 percent of their crop areas.

In Mexico, a Ferti-irrigation programme was put in place in 1996 with a financial cost sharing of 35% federal Government funds, 15% state government funds and 50% beneficiary contribution. 87% of the farmers in the project area reported increased yields and 90% reported better use of irrigation water. The program also achieved water saving of 40% and an energy reduction of 32%. The Harvested area increased 18% and the yield by 30% giving an internal rate of return of 16% to the Farmers.

In Australia, the Agriculture and Resource Management Council of Australia and New Zealand and the Australian and New Zealand Environment and Conservation Council have recommended the storage and use of liquid effluents to be subsequently used in land

application with the solids to be used as compost. Land application has been prescribed to be one of the most efficient methods of recycling valuable water along with the effluents nutrient and organic components. Effluents have been advised to be applied at rates that do not cause the development of anaerobic conditions. The guidelines also prescribe a number of other safeguards including instruments that could be used to spray effluents. Low trajectory large droplet irrigation is preferred.

An efficient land application system can be assessed by evaluating whether the basic objectives of irrigating crops is being achieved, there is no polluted runoff, recommended levels of sustainable down ward environmental values is maintained and there is no physical, chemical or biological degradation of soils.

Australia markets spent wash blended with nitrogen, sulphur and phosphorous as Bio dunder an organic fertilizer and also as Liquid one shot for application to sugarcane and other crops. A Polluting substance this way, has been turned into a saleable, import replacing product and improved the business position and community acceptance of the generator. Bio dunder has been accepted by cane farmers in Australia as a valuable Potassium rich fertilizer and 100% of the Bio dunder product at the Sarina Distillery is now recycled into this market.

In Romania, the application of vinasse to permanent grasslands at the rate of 4 to 7 t/ha in 1:5 water dilution increased yield by 50 to 81% over control. In Ireland, slops are concentrated and processed to form Pot Ale which can be used for agriculture use. Several major crops are being irrigated successfully with waste waters in India.

6.2 Review of Literature

6.2.1 General

Sundaramoorthi, 2011 has emphasized upon the need of utilizing the nutrient capacity of spent wash to recharge the soil in order to maintain its continued productivity. He states that in Australia spent wash is blended with additional crop nutrients and sold as manure. Spent wash could also be utilized for composting the trash in the field. In Brazil, the accumulated trash material in the sugarcane harvested field is sprayed with spent wash to facilitate the accelerated composting of the trash in the field itself.

Spent wash at the rate of 35-50 m^3/ha was recommended as optimum dose for higher sugarcane yield in Brazil and in Australia. In Phillipines, spent wash application at the rate of 80-240 m3/ha in addition to chemical fertilizers increased the cane yield by 10-12% and sugar yield by 13-16 percent compared to normal irrigation.

Patil S.V. 2014 suggests alternative agro by products such as bagasse, sugarcane trash, coconut coir etc. can also be used in combination with filter cake (about 20:80 ratio of alternative agro byproducts to filter cake)._This can be practiced in distilleries having shortage of press mud so as to meet the material balance. It is, however, important to pulverize the alternative agro by product to the required particle size before bio-composting.

Patil S.V., 2014 estimates the cost of covering compost yard at about USD 225000 per HA.

T**he Office of the Principal Scientific Advisor to the Government of India, 2014** concludes that scientifically operated bio-composting can result in Zero Liquid discharge (ZLD). It is used either as a primary treatment, secondary treatment after anaerobic digestion or tertiary treatment after concentration of SW. The mixing of SW and press mud (PMC) (50-70% moisture) has to be carried out (2.5:1 proportion for 45 days cycle and 3.5:1 proportion for 60 days cycle) in surface windrows with the help of an aerotiller machine (Self-propelling) for spraying, mixing, turning and aeration of compost material. Addition of special blend of cultures or cow dung provides microbial inoculum required for composting.

The CPCB (2018b) has issued directions to distilleries to use press mud and concentrated spent wash in a ratio of 1:1.6. This is against the earlier protocol which had allowed a Press mud to spent wash ratio of 1:2.5 for a 45 days cycle and 1:3.5 for a 60 days cycle.

Patil S.V. 2014 also states that bio composting of concentrated spent wash (30% solids) requires a longer cycle time (60 days).

In a study conducted in Kiev, Ukraine increased yield of grasses, maize ad fodder by 45 to 100% using distillery spent wash has been reported. **Kamble et. al. 2017.**

Kanimozhi and Vasudevan, 2010 have observed that in Sao Paulo, Brazil, the crop productivity was 2 to 10 times higher on treated lands (This may need to be confirmed). The yields registered an increase in Trinidad and Tobago due to spent wash application on Soils. In Philippines, spent wash application at the rate of 80-240 m3 ha-1 in addition to chemical fertilizer increased the cane yield by 10 to 12 percent and the Sugar yield by 13 to 16% compared to normal irrigation. In Cuba, the application of 90 to 150 m3 h-1 of spent wash increased the Potassium content of the soil with increased cane yield and sugar recovery.

6.2.2 Brazil

Chares (1985) and Samuel (1986) reported that the distillery effluent is used as a supplement to mineral fertilizer in Brazil as the distillery effluent contained N, P, K, Ca, Mg and S and is thus valued as fertilizer when applied to soil through irrigation water. Further it had been observed that the stand of leguminous intercrop was reduced by vinasse when applied at the early stages of plant growth.

Joshi, (2002) reported that in Brazil spent wash flows in High Density Poly Ethylene (HDPE) Lined Channel for Spray Application on farmlands through aspirator. A temporary channel is formed during application to supply spent wash for spray application by aspirator. Whenever spent wash channel is not present, spent wash is transported through twin tankers. Spent wash aspirator draws spent wash from lorry tankers for spraying. Aspirator spray gun sprays spent wash to cover 200 feet radius. Spent wash spray wets the sugarcane trash and topsoil and accelerates in-situ trash composting in addition to nutrients supply to ratoon crop of sugarcane.

De Souza, (2007) describes the systems currently being used in Brazil for ferti-irrigation with liquid residue. Transportation is by standard tanker trucks and application by sprinkling. For sprinkling, the direct mounting system (pump and engine set and canon sprinkle on a wheel base) and the self-propelled, winding reel system (currently the most popular) one are used. This can be fed directly by channels or trucks. It is a semi mechanical system using less manual labour than direct mounting but fuel costs may be high. The surface area and infiltration furrow systems have been eliminated for failing to promote the full use of vinasse and involving underground contamination risks. Direct ferti irrigation with tanker trucks is not being preferred because of greater soil compacting, impossibility to apply in planted sugar cane areas, difficulties on rainy days, low distribution uniformity and costs. Studies aiming at the development of vinasse application procedures have included center pivot and subsurface dropping systems.

Macedo, (2007) has concluded that nutrient recycling through the application of vinasse and filter cake to sugarcane crops in Brazil has reduced the consumption of fertilizers as compared to other crops and in other countries.

De Souza, (2007) has informed that the Sao Paulo Secretariat for Environment has developed a technical standard in order to regulate the application of vinasse in Sao Paulo State. It specifies permitted places, doses, protection of master channels and storage etc.

De Souza, (2007) states that vinasse is now fully recycled to the field for ferti irrigation in Brazil. There are mills that have applied vinasse to 70 percent of their crop areas.

Shivajirao, (2012) states that in Brazil waste generated from sugarcane juice fermentation is mainly used as a fertilizer due to its high Nitrogen, Phosphorus and organic content. It is use to increase sugarcane productivity and also under controlled conditions the effluent is capable of replacing application of inorganic fertilizers.

6.2.3 Mexico

Gonzalez and Contijoch (1994) state that in 1996, the Ferti-irrigation Program, within the framework of the Agricultural Alliance, was put into effect. It was considered that even the nation's most advanced agriculture—the segment under irrigation—needed a technological transformation to improve its profitability and productivity. The Ferti-irrigation Program under the Agricultural Alliance had a financial cost sharing of 35 per cent federal government funds. State governments usually covered 15 per cent, and the project beneficiaries finance the remaining 50 per cent. This program encompassed the following types of investment:

- High and low pressurized systems
- Ferti-irrigation equipment, pipes, pumping equipment, filters, gauges and gauging structures
- Designs and executive projects
- Specialized technical assistance

The producers were in charge of the projects and contracted directly for the work. In 1995, Mexico had 6.2 million of ha of irrigated land of which, 380,000 ha were pressurized systems. From 1996 to 2000, improved areas with high- and low-pressurized systems reached 5,71,889 ha, benefiting 1,03,174 producers. With these implementation results, the improved area had nearly doubled under the program. More than 400 small and medium enterprises supplied goods and services for the program. In the process, they increased their capacity, installed new plants and committed themselves to delivering on time goods and services of the requisite quality. Services supplied included design, installation, maintenance and system servicing. In the areas covered by this program, 87 per cent of the farmers reported increased yields, and 90 per cent reported better use of irrigation water. The internal rate of return calculated for this project in 2000 was 27.9 per cent.

Contijoch, (2003) describes a World Bank document providing several illustrative examples of diversity in drainage solutions and integrated water management. It presented a mosaic of practical solutions to drainage, which included vegetable cultivation with modern techniques such as ferti-irrigation in the Valley of Mexico. Most important of all, Mexico is an example of how, by building the participation of farmers in the administration of irrigation and drainage systems, the water sector can contribute to the reduction of poverty and can sustain a more democratic society with less direct government intervention in day-to-day irrigation and drainage operations.

Contijoch, (2003) also describes the ferti-irrigation programme launched in 1996 in Mexico. This programme has a financial cost sharing of 35 per cent federal government funds, 15 per cent state government funds and the project beneficiaries finance the remaining 50 per cent. It covers investments in high and low pressurized systems, ferti-irrigation equipment, pipes, pumping equipment, filters, gauges and gauging structures, designs and executive projects and specialized technical assistance. The producers are in charge of the projects and contract directly for their work. Several funding options were later evolved to support the participation of small farmers. The irrigation systems under this programme included pivots, hydrants, piped canals, sub-surface drainage, sprinkler, micro sprinkler, grated pipes, drip and others.

Contijoch, (2003) further said that the ferti irrigation programme in Mexico resulted in an estimated water saving of 40 per cent and an energy reduction of 32 per cent. It increased the harvested area by 18 per cent and the production by 30 per cent giving an I.R.R. of 16 per cent, including all costs representing a 25 per cent return on farmers' investments.

6.2.4 Australia

As per the Agriculture and Resource Management Council of Australia and New Zealand and the Australian and New Zealand Environment and Conservation Council, (1998) the guidelines for a Distillery Effluent Management System in Australia recommend storage of liquid effluents to be used subsequently in land application for wood lots, pasture and grapes and the solids to be used as compost. The Australian guidelines stipulate that the treatment systems should permit safe, effective and sustainable land application of liquids and separated solids and that the treatment systems should be able to reduce or deal with Total Suspended Solids, BOD, nutrients, odour and pH. After treatment the effluent can be applied to the land at a managed rate, which ensures long-term sustainable application.

Land application has been prescribed to be one of the most efficient means of recycling valuable water along with the effluents nutrient and organic components. Land requirements and nature of soils are important criteria. Soils generally considered unsuitable for irrigation include poorly structured clays, shallow soils with rock, gravel or impeding clay close to the surface, swamps that cannot be drained, soils with poor drainage, soils with a high salt content and low permeability and coarse silica sand soils (without Iron or Aluminium rich fines). Application rates for land treatment of effluents will be limited by the hydraulic loading, nutrient loading/balance (N.P.K.), salt loading and BOD of effluents. Land application of effluent needs to be suspended during wet periods or seasons. The guidelines also stipulate that in order to minimize surface run off and soil erosion, effluent should not be used on land that is immediately adjacent to streams and watercourses, subject to flooding, water logged or saline, sloping with inadequate ground cover, rocky, slaking and highly erodible or of a high impermeable type.

Effluents have also been advised to be applied at rates that do not cause the development of anaerobic conditions. Resting period between applications may be required to permit re-aeration of the soil. Acidic effluents, highly saline effluent (sites should not be irrigated with effluents if sub surface drainage is likely to cause rising ground water tables and threats to land salinisation in the direction of groundwater flow; also salinity due to sodium chloride should be distinguished from that due to other dissolved solids. Some of which may be beneficial to the soil), whenever possible, application of distillery effluent with a SAR greater than 10 should be avoided to minimize the risk of soil water logging and destabilizing soil structure. Alternating low salinity water after using high salinity water is suggested to be monitored to avoid crushing and sealing, which can lead to an appreciably reduced infiltration rate.

The guidelines further go on to prescribe that equipment which sprays effluents, more than 1.5 meter into the air and/or produces fine droplets, which can be readily, carried off-site must not be used. Low trajectory, large droplet irrigation may be preferred. Tail water discharges should be managed properly.

An efficient land application system can be assessed by evaluating whether the basic objectives of irrigating crops is being achieved, there is no polluted runoff, recommended levels of sustainable downstream environmental values is maintained, there is no physical, chemical or biological degradation of soils.

International CSR Ethanol **(CSR Sugars, 2009)** is the second largest Australian producer of fuel ethanol. CSR Sugar produces 40 % of Australia's sugar. Ethanol products and fertilizer products are the two main product streams at the Sarina Distillery in Mackay near North Queensland. The distillery is marketing Bio-dunder™, a process co-product which is value added into a complete liquid fertilizer. Bio-dunder (or concentrated spent wash) from the Sarina Distillery is blended with Nitrogen, H_2SO_4 and Phosphorous and converted into Liquid One Shot for application as fertilizer in sugarcane and other crops. Bio-dunder™ is certified as organic and has been granted "Beneficial Use" status by the E.P.A. The key advantages of using Bio-dunder are the recycling of nutrients back into the soil. Nitrogen volatilization is reduced in Liquid One shot products, uptake by plants is more rapid and the product is cost competitive. In Australia Bio-dunder fertilizer is now precision applied using variable rate application technology. The fertilizer returns are positively supported by projections in agriculture outputs. The Department of

Environment, Australian Government (2001), has recognized that CSR's Sarina Distillery has changed from being an environmental pariah in the local community into a welcome industry. Apart from process innovations, they have turned a pollutant into a saleable, import replacing product and improved its business position through an increased community acceptance. The community's complaints have also ended.

At the Sarina Distillery, disposal of Dunder (Spent wash) was a major environmental concern, which was weighing heavily on the company's performance and societal acceptability. The Sarina Distillery considered various options including-

1. Improvements in the existing spray irrigation system
2. Installation of an incinerator to evaporate and burn the dunder, to generate steam and produce a granular fertilizer.
3. Installation of an ocean outfall pipeline.
4. Installation of an anaerobic digester to generate methane and reduce the BOD of dunder.
5. Constructing a new distillery using new technology.
6. Cessation of distillery operations.

The company examined all the options and finally decided to go in for a new plant, which could save water and concentrate the dunder into an economic by-product. In the semi continuous mode the plant produced Dunder at three times the original concentration. CSR finally constructed a new distillery at Sarina using a two tank, semi-continuous Bio still fermentation system. This was a world's first for Sarina and achieved.

1. Conversion of dunder to a by-product called Bio dunder, which was sufficiently concentrated to be used as a cane field potassium fertilizer.
2. Elimination of odour and contamination of water bodies.
3. Increased plant productively.
4. Improved quality of ethanol production.
5. Reduction in steam usage within the plant by 30 %.

6. Reduction in water consumption by 70 %.

The Sarina plant is fully automated and one person using computer-controlled application runs the distillery.

Bio-dunder has been accepted by cane and other farmers as a valuable potassium-rich fertilizer and 100 % of the Bio-dunder product at the Sarina Distillery is now recycled into this market. Previously only imported fertilizers were used.

In 1992, the Australian Chemical Industry Council awarded its annual Environment Award to CSR employees who had been instrumental in developing the Bio dunder concept. Liquid one shot is a new Liquid fertilizer based on dunder by adding Nitrogen and Sulphur and has the right balance of nutrients to be used as a fertilizer.

Liquid one shot is a byproduct of sugar cane milling and contains vegetable matter with traces of Potassium, Phosphorous and Sodium and compounds like nitrogen, calcium, magnesium and sulphur. Sulphuric acid is added to increase the sulphur content and breaks down into water, sulphur and may form sulphates in the final product. It is a brown black liquid with a mild molasses odor and a pH of 3.3 to 4.5. Liquid one shot has no significant ecotoxicity and is biodegradable. Liquid one shot has been recommended to be used as a complete fertilizer for all crops, but mainly sugar cane, applied as a liquid. Liquid one shot is classified as a non-dangerous good fertilizer product for sugarcane in Australia.

I. Liquid One Shot

LOS is a versatile nitrogen/bio dunder mix for ratoon sugarcane in soils that do not require phosphorous. LOS is a popular blend that has proven results in all growing regions with typical NKS requirements.

II. Liquid one Shot + PTM

Liquid one shot plus phosphorous is a popular mix for ratoon sugarcane in Australia where soils require phosphorous. As a complete NPKS fertilizer it is suited to the main soil types in the

Mackay and Sarina growing regions. Some grocers have used this as a plant cane top dress wherein sufficient phosphorous has been applied by liquid planting products.

III. Mid N

Mid N has higher nitrogen to potassium ratio than LOS and is used in ratoon sugarcane on soils with good potassium reserves.

IV. High N

High N has high nitrogen to potassium ratio. It is generally suited to areas where the irrigation waters have high potassium levels.

- **Bio-dunder**

Standard Bio-dunder is for use in a broad range of crop and fallow saturations. Bio-dunder can be sprayed to fallows prior to planting as a potassium reserve. It is a good source of immediately available potassium to sugar cane crops.

- **Econo LOS**

Econo Liquid one shot is a nitrogen/bio-dunder mix to better suit sugarcane soils that have lower potassium reserves.

There are a number of other spent wash based products like being used in Australia. They are Econo Los + P, Liquid 50/50, H_L N+P, Los + P Liquid preplant, LTDP, MKY 170, MKY 160 + MKY 150, MKY 110 and MKY 100, MKY 60, MKY 70 and MKY 80, MKY 200P MIDN + P, LOP Ratooner, Springton, Spring 1, MKY 170 P, MKY 180 P and MKY 190 P, Prosperine Mill Ratooner PMR 1, Prosperine Mill Ratooner PMR 2, Spring 2, MKY 160 P, Q preplant, Comet 3, MKY 140 P, MKY 150 P, PMR 3, MKY 130 P, HiK Ratooner, MKY 120 P, Comet 1, Lucerne, Pumpkin 1, Companion 2, LoN Planter, Soy starter, LoP Planter.

6.2.5 Romania, Ireland and India

Vintu et al., (2001) states that application of vinasse to permanent grassland in **Romania** at the rate of 4 to 7 t/ha in 1:5 water dilution increased yield by 50 to 81 per cent over control. This application also improved the nutritive value of fodder by enhancing Crude Protein and Calcium contents but decreased the contents of crude cellulose, Phosphorous and Magnesium.

The Best Available Technologies prescribed by the **E.P.A. Ireland**, (2008) suggest using multi effect vacuum evaporators to concentrate slops from the mash column and then process to form Pot Ale, which can be sold for agricultural use.

Kaur et al., IARI, New Delhi state that several major crops are being irrigated successfully with wastewater in **India**:

(a) **Cereals:** Along 10 km stretch of the Musi River (Hyderabad, Andhra Pradesh) where waste water from Hyderabad is disposed-off, 2,100 ha land is irrigated with waste water to cultivate paddy. Wheat is irrigated with waste water in Ahmedabad and Kanpur.

(b) **Vegetables:** In New Delhi, various vegetables are cultivated on 1,700 ha land irrigated with waste water in area around Keshopur and Okhla STPs. Vegetables like Cucurbits, eggplant, okra, and coriander in the summers; spinach, mustard, cauliflower, and cabbage in the winters are grown at these place. In Hyderabad, vegetables are grown in Musi river basin all year round, which includes spinach, amaranths, mint, coriander, etc.

(c) **Flowers:** Farmers in Kanpur grow roses and marigold with wastewater. In Hyderabad, the farmers cultivate Jasmine through waste water. Avenue trees and parks: In Hyderabad, secondary treated wastewater is used to irrigate public parks and avenue trees.

(d) **Fodder crops:** In Hyderabad, along the Musi River about 10,000 ha of land is irrigated with waste water to cultivate para grass, a kind of fodder grass.

(e) **Aquaculture:** The East Kolkata sewage fisheries are the largest single wastewater use system in aquaculture in the world.

(f) **Agroforestry:** In the villages near Hubli-Dharwad in Karnataka, plantation trees viz., sapota, guava, coconut, mango, arecanut, teak, neem, banana, ramphal, curry leaf, pomegranate, lemon, galimara, mulberry, etc. are irrigated with wastewater.

SECTION -7

DISTILLERY EFFLUENTS AND SOIL RECLAMATION

7.1 Abstract

Soil sodicity is characterised by high pH and water soluble and exchangeable sodium. The basic principle in the reclamation of sodic soils is to replace the Na^+ ions from soil exchange sites by cations like H^+, Ca^{++} and Mg^{++} ions.

It is accepted that the acidic nature of raw spent wash and the fairly good amount of Ca^{++} and Mg^{++} in it can be exploited for the reclamation of sodic soils by replacing the sodium ions from sodic soil. Application of distillery waste water to sodic soils has been observed to improve the physical properties namely bulk density and hydraulic conductivity in sodic soils. Exchangeable sodium percentages have been reported to come down from 100 to 2 in the top 15 cm soils. Among the available amendment, gypsum is the cheapest. Iron pyrites, Sulphur and Ferrous sulphate are also used. Spent wash can replace these, particularly round sugar mills and distilleries in the reclamation of sodic soils. Some authors have held that application of spent wash followed by irrigation rather than the dilution of spent wash at the time of its application work very effectively in the reclamation of sodic soils. An improvement in saturated hydraulic conductivity, soil permeability and reduction in bulk density of the soils has been noticed over these attributes in the control. Untreated spent wash should generally be used for soils having a pH of 8.5 to 10. Experiments have revealed a tremendous increase in the availability of N, P, K, S, Zn, Cu, Fe and Mn in spent wash amended soils. By serving as a source of food for many soil bacteria, spent wash amendment helps in the rapid buildup of soil microorganisms and consequently increases the acidity of many enzymes. It may also assist

in the conversion of unavailable native soil nutrients into available nutrients particularly P and micro nutrients and in the formation of relatively stable chelates with organic ligands. Application should generally be exercised with caution and areas in the vicinity of open/bore well/lakes which are used for purposes of drinking avoided. Continuous application on the same plot of land has to be minutely evaluated.

7.2 Soil Reclamation - Review of Literature

Dhar, (1939) reported that due to oxidation of carbohydrates (60-70 per cent in molasses), organic acids are formed which solubilise the native Calcium Carbonate and helps in reclamation of alkali soils.

Singh, (1961) used neutralized raw spent wash because of its acidic nature and observed a marginal decrease in soil pH, although values regarding total N, available P and K contents of soil were found higher in treated plots with spent wash than in control.

Jagadale, (1976) conducted a pot culture experiment with calcareous soil at Rahuri (Maharashtra) for its reclamation. He reported that, use of 50 times diluted spent wash did not influence sugarcane growth and chemical composition of cane juice during 4 to 12 months growth period. However, at the beginning of experiment adverse effects of spent wash on soil EC were observed.

Singh et al., (1980) reported that addition of raw spent wash without dilution is very effective in increasing the water intake rate of sodic calcareous soil in Ludhiana (Punjab). The pH and salt contents decreased to safe limits but the extent of decrease was less in lower depths. Exchangeable Sodium Percentage (ESP) reduced from 100 to 2 in the top 15 cm soil. Application of spent wash followed by irrigation rather than the dilution of spent wash at the time of its application was very effective in the reclamation of sodic soils.

Singh et al., (1980) stated that soil sodicity is characterized by high pH, water soluble and exchangeable Sodium. The basic principle in the reclamation of sodic soils is to replace the Na+ ion from soil exchange sites by cations like H+, Ca++ and Mg++' ions.

Brinkman and Sing (1984) stated that about 2.5 million ha in India have been affected solely by sodicity.

Mbagwu and Ekwealor (1991) analysed spent wash for its chemical characteristics. They reported that besides containing plant nutrients, it also possesses some of the growth promoters and the acidic nature of raw spent wash can be exploited for reclamation of sodic soils.

Pawar et al., (1992) reported and concluded that, application of spent wash followed by irrigation rather than its dilution at the time of application was very effective in reclaiming sodic soil by reducing significantly exchangeable Sodium content of an alkali soil of Rahuri (Maharshtra).

Gupta et al., (1995) stated that the salt affected soils occurring in arid and semi-arid zones occupy 12 m. ha. spread over in 15 states of the country. These salt affected soils comprise of 4.12 m ha of alkali soil, 3.26 m ha of saline soil and 4.62 m ha of saline alkali soils. Among these salt affected soils, alkali soils are found to be highly problematic for crop production because of very poor physical and chemical environment particularly in irrigated areas. Sodicity problem in irrigated agriculture is becoming more and more serious because of faulty methods of irrigation, intensive cultivation of high water requirement crops, use of poor quality water, lack of adequate knowledge about soils and poor management practices. The amelioration of these alkali soils is not only expensive but also time consuming and laborious.

Rajukkannu and Manickam (1996) reported that since the distillery spent wash is highly acidic and contains fairly good amount of Ca and Mg, this could be utilised as an organic amendment for the reclamation of sodic soils.

Joshi et al., (1996) found that there was an improvement in saturated hydraulic conductivity, soil permeability and reduction in bulk density of the soils with effluent amendment over the control.

Rajukannu and Manickam (1996) studied alkali soils of Tamil Nadu and observed that application of 5 lakh litres of raw spent wash was found to be optimum for the soil having pH range of 8.5 to 10. For soil having a pH less than 8.5, the untreated distillery spent wash should not be used. Hence, a dose of 5 lakh litres per hectare can be considered to be optimum. The use of filter cake and stillage (vinasse) as amendments for the reclamation of a saline-sodic soil were studied in a greenhouse experiment using a eutrophic alluvial sandy loam soil from an irrigated site. The treatments consisted of combined application of gypsum and filter cake and leaching with rainwater or stillage. The required amounts of amendments (gypsum equivalent to 50 per cent requirement and filter cake in proportion of 30 g/kg) were incorporated in 6.1 dm^3 soil, which was subjected to continuous leaching for 20 days. The soil solution volume, electrical conductivity, pH, concentration and quantity of Sodium leached were observed as a function of time. Soils samples from 0-10 and 10-19 cm depths were analyzed for exchangeable Sodium and Potassium contents. The best results of reclamation as well as rice growth were obtained in gypsum + filter cake treatment whereas gypsum alone was better than filter cake alone.

Ruiz et al., (1997) stated that leaching with stillage showed better results in comparison to rainwater in all the treatments including control, indicating the possibility of reclamation of saline-sodic soils with stillage without the incorporation of conventional amendments. The untreated distillery spent wash at 0.15 million litres per ha can be used as an amendment for the reclamation of non-saline calcareous sodic soil in Tiruchirapalli (Tamil Nadu). It should be applied during summer and a time lag of 40 days should be allowed to overcome the depletion of oxygen. The distillery spent wash alone or in combination with gypsum is effective in spot reclamation of alkali soils.

Valliappan, (1998) highlighted ecofriendly utilization of distillery spent wash in crop production. He further stated that, distillery effluent is a rich source of nutrient particularly Potassium. It can be used as a liquid fertilizer provided it is pre-treated in the plant before discharging into lands. Raw spent wash can also be used as an amendment for the reclamation of sodic soils provided the soils are calcareous. The pH decreased highly acidic and contains fairly good amount of Ca and Mg and other essential plant nutrients, this could be used as an organic amendment to improve the soil properties particularly in reclamation of non-saline sodic soils. The potential of distillery spent wash to supply H^+ (since DSW is highly acidic), Ca^{++} and Mg^{++} has been used as a basic principle to reclaim the sodic soil (i.e. to replace Na^+ ions in the soil exchange complex).

Valliappan, (1998) reported that one time application of spent wash at 150 ml kg^{-1} soil followed by two leaching and transplanting rice on 40th day of its application had proved to be more effective than lower dose of spent wash and gypsum @ 50 per cent GR in reducing the soil pH, ESP and SAR of sodic soil to the level of < 8, < 10.9 and < 3.0 respectively. The EC of the spent wash treated soils was brought down to < 1.0 dSm-1 after two leaching **(Valliappan, 1998).**

The detailed study **(Valliappan, 1998)** of reclamation of sodic soil using distillery spent wash revealed that the saturated hydraulic conductivity and pore space of the spent wash treated leached soils had been considerably increased from 0.44 to 2.57 x 10^{-6} ms^{-1} and 44.67 per cent to 47.67 per cent respectively with simultaneous reduction in the bulk density and water dispersible clay from 1.6210, 1.36 mg/m^3 and 7.29 to 2.26 per cent indicating the unique feature of distillery, spent wash on the reclamation of sodic soils. The availability of N, P, K, S, Zn, Cu, Fe and Mn in the spent wash amended sodic soils was found tremendously increased to the level of 244 kg ha^{-1}, 25.13 kg ha^{-1}, 1654 kg ha^{-1}, 106 mg kg^{-1}, 3.03 mg kg^{-1}, 1.82 mg kg^{-1}, 51.2 mg kg^{-1}, 17.97 mg kg^{-1}, as against 116 kg ha^{-1}, 6.13 kg ha^{-1}, 193 kg ha^{-1}, 16 mg kg^{-1}, 0.48 mg kg^{-1}, 1.02 mg kg^{-1}, 11.85 mg kg^{-1} and 10.7 mg kg^{-1} in the control respectively. He also mentioned the reasons for such remarkable effect of spent wash application on greater nutrient availability of sodic soils. They are as follows:

(i) Contribution of huge amounts of K and organic matter, considerable quantities of N, P and S and traces of micronutrients through added spent wash.

(ii) By serving as a source of food for soil fungi, bacteria and actinomycetes, it helps in rapid multiplication and build up and consequently increases the acidity of many enzymes.

(iii) Conversion of the unavailable native soil nutrients into available nutrients particularly P and micronutrients due to the action of acidic spent wash.

(iv) Formation of relatively stable chelates with organic ligands.

Valliappan, (1998) stated that sugarcane could be successfully grown in soils treated with vinasse and that these soils were not particularly suitable before vinasse application. The field experiment conducted by **Valliappan (1998)** showed that application of spent wash (150 ml kg-1 soil) without NPK fertilization to sodic soil had recorded the rice grain and straw yields of 5,720 kg ha^{-1} and 10,480 kg ha^{-1} respectively which accounted an additional grain yield of 2,755 kg ha^{-1} (93 per cent) and straw yield of 6,305 kg ha^{-1} (151 per cent) over the absolute control.

Mahimairaja and Bolan (2000) reported that any acid former applied to a calcareous soil resulted in solubilization of Ca and Mg bearing minerals with consequent release of alkaline earth metals. The released metals further take part in exchange reactions.

Similar observations with respect to release of Ca and Mg by soil minerals rich in Ca + Mg were also reported by **Taluk and Medeiros (1989)**.

Thiagarajan 2001 also claims that soil reclamation is another method of disposal technology for the spent wash in the distillery in sodic soil belt. It is an alternative to gypsum for reclamation of sodic soil. Several field experiments were conducted by Tamil Nadu Agricultural University, Trichy in Manikandam block in Trichy district with 5 lakh litre/ha to the non-saline sodic soil followed by 2 to 3 leaching with water. After 60 days, effective reclamation had been achieved and rice had been cultivated. The results indicated that there was a reduction in soil pH due to the spent wash application. There was considerable increase in organic Carbon content, available nutrient, microbial activities. This has reflected the yield of rice after cultivation. Certain limitations are there in the sodic soil reclamation by spent wash application.

i. It cannot be used in the vicinity of open / bore well / lakes which are used for purpose of drinking.
ii. Over dose of spent wash application may affect the crop yields due to high plant vegetative growth.
iii. Continuous application of spent wash in the soils may lead to nutrients toxicity.

Chinnusamy et al., (2001) reported that the highest grain yield was recorded in rice variety ADT-42 due to 75 times diluted distillery spent wash application, which was on par with 100 times diluted spent wash applied plot.

Thiagarajan, (2001) reported that distillery effluent can be conveniently used as source of irrigation in crop production. But, it has to be used judiciously because of high organic and chemical load. Continuous usage of the effluent on the same land may result in development of sodicity if the soils are ill drained.

Joshi, (2002) held that the effluents help in the reclamation of sodic soils.

Saliha, (2003) reported that the raw spent wash significantly reduces ESP of calcareous sodic soils to a safer limit.

Baskar et al., (2003) were of the opinion that soil sodicity is characterized by high pH, water soluble and exchangeable sodium. The basic principle in the reclamation of sodic soils is to replace the Na^+ ions from soil exchange sites by cations like H^+, Ca^{++} and Mg^{++} ions. The distillery effluents is highly acidic and contains a good amount of Ca^{++} and Mg^{++} ions and other plant nutrients and could be used as an organic amendment to improve the soil properties particularly the non-saline sodic soils.

Bhakiyathu et al., (2004) stated that in a study conducted on calcareous sodic soil of Madurai (Tamil Nadu) it was reported that application of raw spent wash at 1.25 lakh litres/ha helped in reducing the pH and ESP of the soil to safer limits besides enhancing soil nutrient status. They found that, higher contents of Ca, Mg and S in spent wash might have helped in reducing the sodicity by replacing Na from exchange complex. They also found that, integrated application of distillery spent wash (1.25 lakh litres/ha) with FYM @ 12.5 t/ha or biocompost at 3 t/ha is cost effective and ecofriendly technology to reclaim and enhance the fertility status of sodic soil.

Mahendra, (2007) reported that reclamation of alkali soils is essential as not only do these soils occupy significant areas, but also these lands are potentially and inherently fertile. Information generated so far on reclamation and management of sodic soils showed that these alkali lands could be put to crop production provided they are ameliorated through amendments. The reclamation of sodic soils basically requires the removal of excess Sodium on the exchange complex with Calcium and the replaced Sodium leached out of root zone. Among the amendments, gypsum is the cheapest and most convenient one for reclamation of sodic soils. But, now-a-days due to its non-timely availability, there is a need to search for alternate source of amendment particularly for calcareous sodic soils. The acidic nature of raw spent wash can be exploited in the reclamation of calcareous sodic soils. Thus, it can replace the conventional chemical amendments like Gypsum, Iron pyrites, Sulphur and Ferrous Sulphate particularly around sugar mills/distilleries for the reclamation of sodic soils. The scarcity of organic manures like FYM or compost and the problem of transporting such bulky manures have limited the scope of using such organic manures for reclamation. So, it is necessary to develop cheap and locally available highly efficient sources for reclamation. One such possibility is the addition of an acidic by-product of distillery industry i.e., raw spent wash.

The Office of the Principal Scientific Advisor to the Government of India, 2014 has stated that Controlled land application of BMSW may be beneficial for reclamation of sodic soil as BMSW has large quantity of Ca and Mg compared to Na, and if the Soil is well drained soluble salts of Na can easily leach out from surface soil. Presowing application of BMSW followed by two irrigations can leach out soluble salts from the surface soil for better germination and growth of crop.

Deshpande *et.al.* 2017 experimented on the effect of Primary biomethanated spent wash (PBSW) on soil properties, nutrient uptake and yield of wheat on sodic soils at varying doses of 100,200,300,400 and 500 cubic meter per hectare. The results have revealed that the physical properties namely bulk density and hydraulic conductivity were improved in sodic soil. The authors have also observed a significant reduction in pH, calcium carbonate and exchangeable sodium and an increase in organic carbon, cation exchange capacity (CEC) and electrical conductivity (E.C.) in the soil due to the addition of PBSW. The available soil nitrogen (N) Phosphorous (P), Potassium (K) and micro nutrients iron, manganese, copper and zinc (Fe, Mn, Cu, and Zn) content after the harvest of wheat was the highest in 500 m3/ha treatment compared with all other treatment. The exchangeable Calcium (Ca2+) Magnesium (Mg2+) increased significantly and exchangeable sodium (Na+) reduced significantly with increased dosage of PBSW. The application of PBSW (@500, 400, 300 and 200 m^3/ha) resembled the other treatments of FYM and Gypsum. The PBSW application at the rate of 500 m3/ha had recorded the highest grain (43.33 quintal/ha) and straw (72.72 quintal/ha) yield and the maximum total uptake of N, P, K, Fe, Mn, Cu and Zn by wheat which was at par with the treatment of FYM (5 t/ha)+Gypsum @ 100% GR+RDF AST (Recommended dose of Fertilizer after test)

Naorem *et.al.* 2017 have stated that the basic principle of sodic soil reclamation is to provide a source of Calcium to replace excess Sodium from the carbon exchange sites. Under the chemical amelioration techniques several amendments such as green manure, gypsum, farm yard manure, goat manure, compost etc. can be used to either change the insoluble calcium to the soluble form or supply calcium directly which replaces the adsorbed sodium from the sodic soils. Distillery spent wash is normally of high acidity and contains fair amounts of Ca and Mg and can therefore be used as an organic amendment improving the physical and chemical properties of the soil. The authors have established that the treatment of Raw distillery spent wash in sodic soil has reduced the exchangeable sodium by 9.61% electrical conductivity by 16.36% and pH by 17.24% over a 4 week application. Reduction in soil Ph from 8.24 to 7.20, Soil E.C. (DSM^{-1}) from 0.55 to 0.45, exchangeable sodium {Cmol $(p+)kg^{-1}$} from 3.12 to 2.82 and ESP (%) from 18.5 to 9.3 in four weeks of treatment showed that continuous application of distillery spent wash may further reduce these values and spent wash can be used as a potential amendment in the reclamation of sodic soils.

Baskar *et.al.* 2003 have concluded that because of the acidic nature (pH 3.5 to 4.0) untreated spent wash could be used in the reclamation of non saline sodic soil and that the potential of distillery spent wash to supply H^+ (Since it is highly acidic), Ca^{++} and Mg^{++} have been used as a basic principle to reclaim the sodic soil (i.e. to replace the Na^+ ions in the soil exchange complex.

A step wise sodic soil reclamation procedure has been attributed to the Agricultural Research Communication Center. This includes-

a. Dividing the land into compartments of convenient size.
b. Ploughing the land
c. Applying distillery spent wash evenly at 500 KL per Ha.
d. Impound water to a depth of 10-15 cm after 7 days.
e. Draining after 24 hours
f. Repeating of impounding water and draining two to three times.
g. Ploughing at optimal moisture level
h. Application of well decomposed FYM or composted press mud @ 5 T per Ha.
i. Sowing/Transplanting after 60 days of spent wash application.

Mahimairaja and Bolan 2004 have shown that large amounts of soluble salts have been found to be leached from calcareous and high pH Sodic soils amended with spent wash. Application of spent wash has also been observed to result in the leaching of high amounts of sodium (Na) from high pH sodic soils. It has been however cautioned that exceptionally high loading of the leachate with organic and inorganic contaminants may pose potential risk for ground water contamination

SECTION-8

ENVIRONMENT AND POLLUTION CONTROL LAWS-SOME IMPORTANT PROVISIONS

A regime for pollution control could be established in India only with the promulgation of the Water (Prevention and Control of Pollution) Act 1974. Prior to this, public health, safety, convenience, decency and morals were covered under the Indian Penal code of 1860 and the term "Public Nuisance" defined under section 268 to include all acts and omissions likely to adversely impact public welfare . Fouling water of public springs or reservoirs was a punishable offence under section 277 and making the atmosphere noxious to health was covered as a punishable offence under section 228. (Indian Penal Code,1860). Section 133 and 144 of the code of Criminal Procedure, India, 1973 as amended had provided for powers to the district Administration to order the removal of the nuisance including danger to public health and property. (Criminal Procedure Code, 1973)

India currently has a number of enactments aimed at promoting a clean and healthy environment. Some of these being the:

8.1 The Water (Prevention and Control of Pollution) Act 1974

The Water (Prevention and Control of Pollution) Act 1974, a Central Act of Parliament, initiated the establishment of a regime for control of Pollution in India in the form of the Central and the State Pollution Control Boards and Committees. The Act, the objective of which was to control Pollution and maintain the wholesomeness of water also established a system of restraining pollutants from being discharged into rivers, lakes, wells or land, obtaining consents to establish and operate and fixing standards. It also gave powers to the Boards and Committees (U.T. Administration) to issue directions which could include directions for closure of any activity, operation or process and/or the suspension of water and power supply and punitive provisions. In the early days of implementation of the Water Act 1974 and the Air Act 1981, or immediately before the promulgation of the said Acts, many new development projects and industries had come up without adequate pollution control measures and the major problem before them was that they were not aware of the environmental implications and responsibilities while planning for the project. It was also generally observed that most financial viability assessments were undertaken without including the costs for pollution control. This was a severe impediment in Industrial growth and an administrative blockage. Industry wanted to run the plant, recover funds and then invest in pollution control – the Board could not permit this. It was then that the concept of availing a No Objection Certificate was introduced by the Boards – primarily to advise industries on their responsibilities for pollution control, make them provide for it before commissioning and assess the financial viability of their projects accordingly. The N.O.C. was also meant to enable the regulators, facilitators, bankers, etc understand the project in its complete perspective and minimise the risks involved in clearing environmentally unsound proposals. While the Air Act had already prescribed for a consent to establish, it was through the amendment of 1988 that specific legal provisions were made in the Water Act to legalize Consents to establish under section 25 of the Water Act.

8.1.1 Functions of Pollution Control Boards with respect to the Water Act 1974

8.1.1.1 Central Board generally advisory in Nature with powers to make standards for water quality and Ambient Air Quality. See also section 16 of the Water Act, 1974 as below

Section16. Functions of Central Board.

(1) Subject to the provisions of this Act, the main function of the Central Board shall be to promote cleanliness of streams and wells in different areas of the States.

(2) In particular and without prejudice to the generality of the foregoing function, the Central Board may perform all or any of the following functions, namely: -

(a) advise the Central Government on any matter concerning the prevention and control of water pollution;

(b) co-ordinate the activities of the State Boards and resolve disputes among them;

(c) provide technical assistance and guidance to the State Boards, carrying out and sponsor investigations and research relating to problems of water pollution and prevention, control or abatement of water pollution;

(d) plan and organise the training of persons engaged or to be engaged in programmes for the prevention, control or abatement of water pollution on such terms, and conditions as the Central Board may specify;

(e) organise through mass media a comprehensive programme regarding the prevention and control of water pollution; .

[(ee) perform such of the functions of any State Board as may be specified in an order made under sub-section (2) of Sec. 18;]

(f) collect, compile and publish technical and. statistical data relating to water pollution and the measures devised for its effective prevention and control and prepare manuals, codes or guides relating to treatment and disposal of sewage and trade effluents and disseminate information connected therewith;

(g) lay down, modify or annul, in consultation with the State Government concerned, the standards for a stream or well: Provided that different standards may be laid down for the same stream or well or for different streams or wells, having regard to the quality of water, flow characteristics of the stream or well and the nature of the use of the water in such stream or well or streams or wells;

(h) plan and cause to be executed a nation-wide programme for the prevention, control or abatement of water pollution;

(i) perform such other functions as may be prescribed.

(3) The Board may establish or recognise a laboratory or laboratories to enable the Board to perform its functions under this section efficiently, including the analysis of samples of water from any stream or well or of samples of any sewage or trade effluents.

8.1.1.2 State Pollution Control Boards to lay down standards, prevent pollution, issue consents, evove technology, direct closures advise the State Government etc. as prescribed under section 17 of the Act.

Section 17. Functions of State Board.

(1) Subject to the provisions of this Act, the functions of a State Board shall be.

(a) to plan a comprehensive programme for the prevention, control or abatement of pollution of streams and wells in the State and to secure the execution thereof;

(b) to advise the State Government on any matter concerning the prevention, control or abatement of water pollution;

(c) to collect and disseminate information relating to water pollution and the prevention, control or abatement thereof;

(d) to encourage, conduct and participate in investigations and research relating to problems of water pollution and prevention, control or abatement of water pollution;

(e) to collaborate with the Central Board in organising the training of persons engaged or to be engaged in programmes relating to prevention, control or abatement of water pollution and to organise mass education programmes relating thereto;

(f) to inspect sewage or trade effluents, works and plants for the treatment of sewage and trade effluents and to review plans, specifications or other data relating to plants set up for the treatment of water, works for the purification thereof and the system for the disposal of sewage or trade effluents or in connection with the grant of any consent as required by this Act;

(g) lay down, modify or annul effluent standards for the sewage and trade effluents and for the quality of receiving waters (not being water in an interState stream) resulting from the discharge of effluents and to classify waters of the State;

(h) to evolve economical and reliable methods of treatment of sewage and trade effluents, having regard to the peculiar conditions of soils, climate and water resources of different regions and more especially the prevailing flow. The Water (Prevention and Control of Pollution) Act, 1974 characteristics of water in streams and wells which render it impossible to attain even the minimum degree of dilution;

(i) to evolve methods of utilisation of sewage and suitable trade effluents in agriculture;

(j) to evolve efficient methods of disposal of sewage and trade effluents on land, as are necessary on account of the predominant conditions of scant stream flows that do not provide for major part of the year the minimum degree of dilution;

(k) to lay down standards of treatment of sewage and trade effluents to be discharged into any particular stream taking into account the minimum fair weather dilution available in that stream and the tolerance limits of pollution permissible in the water of the stream, after the discharge of such effluents;

(l) to make, vary or revoke any order –

  (i) for the prevention, control or abatement of discharge of waste into streams or wells;

  (ii) requiring any person concerned to construct new systems for the disposal of sewage and trade effluents or to modify, alter or extend any such existing system or to adopt such remedial measures as are necessary to prevent control or abate water pollution;

(m) to lay down effluent standards to be complied with by persons while causing discharge of sewage or sullage or both and to lay down, modify or annul effluent standards for the sewage and trade effluents;

(n) to advise the State Government with respect to the location of any industry the carrying on of which is likely to pollute a stream or well;

(o) to perform such other functions as may be prescribed or as may, from time to time be entrusted to it by the Central Board or the State Government.

(2) The Board may establish or recognise a laboratory or laboratories to enable the Board to perform its functions under this section efficiently, including the analysis of samples of water from any stream or well or of samples of any sewage or trade effluents.

8.1.1.3 Central Pollution Control Board empowered to give directions to the State Pollution Control Board, which are binding on the State Boards.

Section18. Powers to give Directions.

1. In the performance of its functions under this Act -- (a) the Central Board shall be bound by such directions in writing as the Central Government may give to it and every State Board shall be bound by such directions in writing as the Central Board or the State Government may give to it: Provided that where a direction given by the State Government is inconsistent with the direction given by the Central Board, the matter shall be referred to the Central Government for its decision.

2. Where the Central Government is of the opinion that the State Board has defaulted in complying with any directions given by the Central Board under sub-section (1) and as a result of such default a grave emergency has arisen and it is necessary or expedient so to do in the public interest, it may, by order, direct the Central Board to perform any of the functions of the State

Board in relation to such area for such period and for such purposes, as may be specified in the order.

3. Where the Central Board performs any of the functions of the State Board in pursuance of a direction under sub-section (2), the expenses, if any, incurred by the Central Board with respect to performance of such functions may, if the State Board is empowered to recover such expenses, be recovered by the Central Board with interest (at such reasonable rate as the Central Government may, by order, fix) from the date when a demand for such expenses is made until it is paid from the person or persons concerned as arrears of land revenue or of public demand.

4. For the removal of doubts, it is hereby declared that any directions to perform the functions of any State Board given under sub-section (2) in respect of any area would not preclude the State Board from performing such functions in any other area in the State or any of its other functions in that area].

8.1.1.4 Samples to be collected by the Boards according to the procedures for sampling as provided. Samples not to be admitted as Legal evidence unless procedures followed.

Section 21. Power to Take Samples of Effluents and Procedure to be Followed in Connection Therewith.

(1) A State Board or any officer empowered by it in this behalf shall have power to take for the purpose of analysis samples of water from any stream or well or samples of any sewage or trade effluent which is passing from any plant or vessel or from or over any place into any such stream or well.

(2) The result of any analysis of a sample of any sewage or trade effluent taken under sub-section (1) shall not be admissible in evidence in a legal proceeding unless the provisions of sub-sections (3), (4) and (5) are complied with.

(3) Subject to the provisions of sub-sections (4) and (5), when a sample (composite or otherwise as may be warranted by the

process used) of any sewage or trade effluent is taken for analysis under sub-section (1), the person taking the sample shall--

(a) serve on the person in charge of, or having control over, the plant or vessel or in occupation of the place (which person is hereinafter referred to as the occupier) or any agent of such occupier, a notice, then and there in such form as may be prescribed of his intention to have it so analysed;

(b) in the presence of the occupier or his agent, divide the sample into two parts;

(c) cause each part to be placed in a container which shall be marked and sealed and shall also be signed both by the person taking the sample and the occupier or his agent;

(d) send one container forthwith,--

(i) in a case where such sample is taken from any area situated in a Union territory, to the laboratory established or recognised by the Central Board under section 16; and

(ii) in any other case, to the laboratory established or recognised by the State Board under section 17;

(e) on the request of the occupier or his agent, send the second container.-

(i) in a case where such sample is taken from any area situated in a Union territory, to the laboratory established or specified under sub-section (1) of section 51; and

(ii) in another case, to the laboratory established or specified under sub-section (1) of section 52.

(4) when a sample of any sewage or trade effluent is taken for analysis under sub-section (1) and the person taking the sample serves on the occupier or his agent, a notice under clause (a) of sub-section (3) and the occupier or his agent wilfully absents himself, then, -

(a) the sample so taken shall be placed in a container which shall be marked and sealed and shall also be signed by the person taking the sample and the same shall be sent forthwith by such person for analysis to the laboratory referred to in sub-clause (i) or sub-clause (ii), as the case may be, of clause (e) of sub-section (3) and such person shall inform the Government analyst appointed under sub-section (1) or sub-section (2), as the case may be, of section 53, in writing about the wilful absence of the occupier or his agent; and

(b) the cost incurred in getting such sample analysed shall be payable by the occupier or his agent and in case of default of such payment, the same shall be recoverable from the occupier or his agent, as the case may be, as an arrear of land revenue or of public demand:

Provided that no such recovery shall be made unless the occupier or, as the case may be, his agent has been given a reasonable opportunity of being heard in the matter.

(5) When a sample of any sewage or trade effluent is taken for analysis under sub-section (1) and the person taking the sample serves on the occupier or his agent a notice under clause (a) of sub-section (3) and the occupier or his agent who is present at the time of taking the sample does not make a request for dividing the sample into two parts as provided in clause (b) of sub-section (3), then, the sample so taken shall be placed in a container which shall be marked and sealed and shall also be signed by the person taking the sample and the same shall be sent forthwith by such person for analysis to the laboratory referred to in sub-clause (i) or sub-clause (ii), as the case may be, of clause (d) of sub-section (3).

8.1.1.5 No person shall knowingly cause or permit any poisonous, noxious or polluting matter to enter into any stream or well or sewer or on land

Section 24. Prohibition on Use of Stream or Well for Disposal of Polluting Matter, Etc.

(1) Subject to the provisions of this section, -

(a) no person shall knowingly cause or permit any poisonous, noxious or polluting matter determined in accordance with such standards as may be laid down by the State Board to enter (whether directly or indirectly) into any [stream or well or sewer or on land]; or

(b) no person shall knowingly cause or permit to enter into any stream any other matter which may tend, either directly or in combination with similar matters, to impede the proper flow of the water of the stream in a manner leading or likely to lead to a substantial aggravation of pollution due to other causes or of its consequences.

(2) A person shall not be guilty of an offence under sub-section (1), by reason only of having done or caused to be done any of the following acts, namely;-

(a) constructing, improving or maintaining in or across or on the bank or bed of any stream any building, bridge, weir, dam, sluice, dock, pier, drain or sewer or other permanent works which he has a right to construct, improve or maintain;

(b) depositing any materials on the bank or in the bed of any stream for the purpose of reclaiming land or for supporting, repairing or protecting the bank or bed of such stream provided such materials are not capable of polluting such stream;

(c) putting into an stream any sand or gravel or other natural deposit which has flowed from or been deposited by the current of such stream;

(d) causing or permitting, with the consent of the State Board, the deposit accumulated in a well, pond or reservoir to enter into any stream.

(3) The State Government may, after consultation with, or on the recommendation of, the State Board, exempt, by notification in

the Official Gazette, any person from the operation of sub-section (1) subject to such conditions, if any, as may be specified in the notification and any condition so specified may by a like notification and be altered, varied or amended.

8.1.1.6 Provisions of Consent to establish and Consent to operate

Section 25. Restrictions on New Outlets And New Discharges.

(1) Subject to the provisions of this section, no person shall, without the previous consent of the State Board,--

(a) establish or take any steps to establish any industry, operation or process, or any treatment and disposal system or an extension or addition thereto, which is likely to discharge sewage or trade effluent into a stream or well or sewer or on land (such discharge being hereafter in this section referred to as discharge of sewage); or

(b) bring into use any new or altered outlets for the discharge of sewage; or

(c) begin to make any new discharge of sewage;

Provided that a person in the process of taking any steps to establish any industry, operation or process immediately before the commencement of the Water (Prevention and Control of Pollution) Amendment Act, 1988, for which no consent was necessary prior to such commencement, may continue to do so for a period of three months from such commencement or, if he has made an application for such consent, within the said period of three months, till the disposal of such application.

(2) An applications for consent of the State Board under sub-section (1) shall be made in such form, contain such particulars and shall be accompanied by such fees as may be prescribed.

(3) The State Board may make such inquiry as it may deem fit in respect of the application for consent referred to in sub-section (1) and in making any such inquiry shall follow such procedure as may be prescribed.

(4) The State Board may –

(a) grant its consent referred to in sub-section (1), subject to such conditions as it may impose, being--

(i) in cases referred to in clauses (a) and (b) of sub-section (1) of section 25, conditions as to the point of discharge of sewage or as to the use of that outlet or any other outlet for discharge of sewage;

(ii) in the case of a new discharge, conditions as to the nature and composition, temperature, volume or rate of discharge of the effluent from the land or premises from which the discharge or new discharge is to be made; and

(iii) that the consent will be valid only for such period as may be specified in the order,

and any such conditions imposed shall be binding on any person establishing or taking any steps to establish any industry, operation or process, or treatment and disposal system or extension or addition thereto, or using the new or altered outlet, or discharging the effluent from the land or premises aforesaid; or

(b) refuse such consent for reasons to be recorded in writing.

(5) Where, without the consent of the State Board, any industry operation or process, or any treatment and disposal system or any extension or addition thereto, is established, or any steps for such establishment have been taken or a new or altered outlet is brought into use for the discharge of sewage or a new discharge of sewage is made, the State Board may serve on the person who has established or taken steps to establish any industry, operation or process, or any treatment and disposal system or any extension or addition thereto, or using the outlet, or making the discharge, as the case may be, a notice imposing any such conditions as it might have imposed on an application for its

consent in respect of such establishment, such outlet or discharge.

(6) Every State Board shall maintain a register containing particulars or conditions imposed under this section and so much of the register as relates to any outlet, or to any effluent, from any land or premises shall be open to inspection at all reasonable hours by any person interested in, or affected by such outlet, land or premises, as the case may be, or by any person authorised by him in this behalf and the conditions so contained in such register shall be conclusive proof that the consent was granted subject to such conditions.]

(7) The consent referred to in sub-section (1) shall, unless given or refused earlier, be deemed to have been given unconditionally on the expiry of a period of four months of the making of an application in this behalf complete in all respects to the State Board.

(8) For the purposes of this section and sections 27 and 30,-

(a) the expression "new or altered outlet" means any outlet which is wholly or partly constructed on or after the commencement of this Act or which (whether so constructed or not) is substantially altered after such commencement;

(b) the expression "new discharge" means a discharge which is not, as respects the nature and composition, temperature, volume, and rate of discharge of the effluent substantially a continuation of a discharge made within the preceding twelve months (whether by the same or different outlet), so however that a discharge which is in other respects a continuation of previous discharge made as aforesaid shall not be deemed to be a new discharge by reason of any reduction of the temperature or volume or rate of discharge of the effluent as compared with the previous discharge.

Section 26. Provision Regarding Existing Discharge of Sewage or Trade Effluent.

Where immediately before the commencement of this Act any person was discharging any sewage or trade effluent into a stream or well or sewer or on land, the provisions of section 25 shall, so far as may be, apply in relation to such person as they apply in relation to the person referred to in that section subject to the modification that the application for consent to be made under sub-section (2) of that section shall be made on or before such date as may be specified by the State Government by notification in this behalf in the Official Gazette.

Section 27. Refusal or Withdrawal of Consent By State Board.

(1) A State Board shall not grant its consent under sub-section (4) of section 25 for the establishment of any industry, operation or process, or treatment and disposal system or extension or addition thereto, or to the bringing into use of a new or altered outlet unless the industry, operation or process, or treatment and disposal system or extension or addition thereto, or the outlet is so established as to comply with an conditions imposed by the Board to enable it to exercise its right to take samples of the effluent.

(2) A State Board may from time to time review --

(a) any condition imposed under section 25 or section 26 and may serve on the person to whom a consent under section 25 or section 26 is granted a notice making any reasonable variation of or revoking any such condition.

(b) the refusal of any consent referred to in sub-section (1) of section 25 or section 26 or the grant of such consent without any condition, and may make such orders as it deemed fit.]

(3) Any conditions imposed under section 25 or section 26 shall be subject to any variation made under sub-section (2) and shall continue in force until revoked under that sub-section.

Section 28 Provision of Appeals

(1) Any person aggrieved by an order made by the State Board under Section 25, section 26 or section 27 may within thirty days from the date on which the order is communicated to him, prefer an appeal to such authority (hereinafter referred to as the appellate authority) as the State Government may think fit to constitute:

Provided that the appellate authority may entertain the appeal after the expiry of the said period of thirty days if such authority is satisfied that the appellant was prevented by sufficient cause from filing the appeal in time.

(2) An appellate authority shall consist of a single person or three persons as the State Government may think fit, to be appointed by that Government.

(3) The form and manner in which an appeal may be preferred under sub-section (1), the fees payable for such appeal and the procedure to be followed by the appellate authority shall be such as may be prescribed

(4) On receipt of an appeal preferred under sub-section (1), the appellate authority shall, after giving the appellants and the State Board an opportunity of being heard, dispose of the appeal as expeditiously as possible.

(5) If the appellate authority determines that any condition imposed, or the variation of any condition, as the case may be, was unreasonable, then,--

(a) where the appeal is in respect of the unreasonableness of any condition imposed, such authority may direct either that the condition shall be treated as annulled or that there shall be substituted for it such condition as appears to it to be reasonable;

(b) where the appeal is in respect of the unreasonableness of any variation of a condition, such authority may direct either that the condition shall be treated as continuing in force unvaried or that it shall be varied in such manner as appears to it to be reasonable.

8.1.1.7 Section 32 of the Water Act 1974 and the use of emergency provisions by the Boards

Section 32 of the Water (Prevention and Control of Pollution) Act 1974 makes provisions for emergency actions to be taken by the State Pollution Control Boards in the event of the presence of poisonous, noxious or polluting matter into a stream, well or on land. Section 32 specifies as follows.

1. Where it appears to the State Board that any poisonous, noxious or polluting matter is present in any stream or well or on land by reason of the discharge of such matter in such stream or well or on such land or has entered into that stream or well due to an accident or other unforeseen act or event and if the Board is of opinion that it is necessary or expedient to take immediate action, it may for reasons to be recorded in writing, carry out such operations as it may consider necessary for all or any of the following purposes, that is to say.
    a. Removing that matter from the stream or well or on land and disposing it of in such manner as the Board considers appropriate.
    b. Remedying or mitigating any pollution caused by its presence in the stream or well
    c. Issuing orders, immediately restraining or prohibiting the persons concerned from discharging any poisonous, noxious or polluting matter into the stream or well or on land in from making in sanitary use of the stream or well.
2. The power conferred by subsection (i) does not include the power to construct any works other than works of a

temporary character which are removed on or before the completion of the operations.

A couple of issues are important in so far as the implementation of this provision is concerned. A closer scrutiny reveals that the proviso would apply when

a. A polluting, noxious or poisonous matter is present as a result of discharge of such matter into a stream, well or on land.

b. A polluting, noxious or poisonous matter has entered a stream or well due to an accident or other unforeseen circumstances.

Some State Boards are issuing closure orders under their powers under section 32 for routine non compliances also. This does not appear to be just. Section 32 is an emergency provision and in so far as issuing orders is concerned, the orders could be restricted to only restraining discharge of the poisonous, noxious or polluting matter. Closure of manufacturing operations is not indicated in section 32. It can only be used in section 33(A).

There is also no provision of appeal for action taken under provisions of section 32 of the Act. Section 28 of the Water (Prevention and Control of Pollution) Act 1974 provides for appeals against orders passed under section 25, 26 and 27 of the Water Act which are provisions related to the Consent from the State Board and the refusal or withdrawal of such consent. The National Green Tribunal Act of 2010 makes provisions of an Appeal only in orders passed by the Appellate authority under section 28 of the Water Act 1974 and by the State Government (in matters related to revision of consent) under section 29 of the Water Act or on the directions issued by the Boards under section 33A of the Water Act.

Boards may make application to Courts

Section 33. Power of Board to make Application to Courts for Restraining Apprehended Pollution of Water in Streams or Wells.

(1) Where it is apprehended by a Board that the water in any stream or well is likely to be polluted by reason of the disposal or likely disposal of any matter in such stream or well or in any sewer, or on any land, or otherwise, the Board may make an application to a court, not inferior to that of a Metropolitan Magistrate or a Judicial Magistrate of the first class, for restraining the persons who is likely to cause such pollution from so causing.

(2) On receipt of an application under sub-section (I) the court make such order as it deems fit.

(3) Where under sub-section (2) the court makes an order restraining any person from polluting the water in any stream or well, it may in that order-

(i) direct the person who is likely to cause or has caused the pollution of the water in the stream or well, to desist from taking such action as is likely to cause pollution or, as the case may be, to remove such stream or well, such matter, and

(ii) authorise the Board, if the direction under clause (i) (being a direction for the removal of any matter from such stream or well) is not complied with by the person to whom such direction is issued, to undertake the removal and disposal of the matter in such manner as may be specified by the court.

(4) All expenses incurred by the Board in removing any matter in pursuance of the authorisation under clause (ii) of sub-section (3) or in the disposal of any such matter may be defrayed out of any money obtained by the Board from such disposal and any balance outstanding shall be recoverable from the person concerned as arrears of land revenue or of public demand.

8.1.1.8 Power of Boards to issue Directions for Closure

Section 33A. Power to give Directions.

Notwithstanding anything contained in any other law, but subject to the provisions of this Act, and to any directions that the Central

Government may give in this behalf, a Board may, in the exercise of its powers and performance of its functions under this Act, issue any directions in writing to any person, officer or authority, and such person, officer or authority shall be bound to comply with such directions.

Explanation - For the avoidance of doubts, it is hereby declared that the power to issue directions under this section includes the power to direct-

(a) the closure, prohibition or regulation of any industry, operation or process; or

(b) the stoppage or regulation of supply of electricity, water or any other service.

8.1.1.9 Penalties and Procedure

Section 41. Failure To Comply With Directions Under Sub-Section (2) Or Sub-Section (3) Of Section 20, Or Orders Issued Under Clause (C) Of Sub-Section (1) Of 32 Or Directions Issued Under Subsection (2) Of Section 33 Or Section 33A.

(1) Whoever fails to comply with any direction given under sub-section (2) or sub-section (3) of section 20 within such time as may be specified in the direction shall, or conviction, be punishable with imprisonment for a term which may extend to three months or with fine which may extend to ten thousand rupees or with both and in case the failure continues, with an additional fine which may extend to five thousand rupees for every day during which such failure continues after the conviction for the first such failure.

(2) Whoever fails to comply with any order issued under clause (c) of sub-section (1) of section 32 or any direction issued by a court under sub-section (2) of section 33 or any direction issued under section 33A shall, in respect of each such failure and on conviction, be punishable with imprisonment for a term which shall not be less than one year and six months but which may extend to six years and with fine, and case the failure continues,

with an additional fine which may extend to five thousand rupees for every day during which such failure continues after the conviction for the first such failure.

(3) If the failure referred to in sub-section (2) continues beyond a period of one year after the date of conviction, the offender shall, on conviction, be punishable with imprisonment for a term which shall not be less than two years but which may extend to seven years and with fine.

Section 42. Penalty For Certain Acts

(1) Whoever –

(a) destroys, pulls down, removes, injures or defaces any pillar, post or stake fixed in the ground or any notice or other matter put up, inscribed or placed, by or under the authority of the Board, or

(b) obstructs any person acting under the orders or directions of the Board from exercising his powers and performing his functions under this Act, or

(c) damages any works or property belonging to the Board, or

(d) fails to furnish to any officer or other employee of the Board any information required by him for the purpose of this Act, or

(e) fails to intimate the occurrence of an accident or other unforeseen act or even under section 31 to the Board and other authorities or agencies as required by that section, or

(f) in giving any information which he is required to give under this Act, knowingly or willfully makes a statement which is false in any material particular, or

(g) for the purpose of obtaining any consent under section 25 or section 26, knowingly or willfully makes a statement which is false in any material particular, shall be punishable with imprisonment for a term which may extend to three months or with fine which may extend to ten thousand rupees or with both.

(2) Where for the grant of a consent in pursuance of the provisions of section 25 or section 26 the use of a meter or gauge or other measure or monitoring device is required and such device is used for the purposes of those provision, any person who knowingly or willfully alters or interferes with that device so as to prevent it from monitoring or measuring correctly shall be punishable with imprisonment for a term which may extend to three months or with fine which may extend to ten thousand rupees or with both.

Section 43 Penalty For Contravention Of Provisions Of Section 24.

Whoever contravenes the provisions of section 24 shall be punishable with imprisonment for a term which shall not be less than one year and six months but which may extend to six years and with fine.

Section 44. Penalty For Contravention Of Section 25 Or Section 26

Whoever contravenes the provision of section 25 or section 26 shall be punishable with imprisonment for a term which shall not be less than one year and six months but which may extend to six years and with fine.

Section 45. Enhanced Penalty After Previous Conviction

If any person who has been convicted of any offence under section 24 or 25 or section 26 is again found guilty of an offence involving a contravention of the same provision, he shall, on the second and on every subsequent conviction, be punishable with imprisonment for a term which shall not be less than 2 [two years] but which may extend to seven years and with fine: Provided that for the purpose of this section no cognizance shall be taken of any conviction made more than two years before the commission of the offence which is being punished.

Section 45A. Penalty for Contravention of Certain Provisions of the Act

Whoever contravenes any of the provisions of this Act or fails to comply with any order or direction given under this Act, for which no penalty has been elsewhere provided in this Act, shall be punishable with imprisonment which may extend to three months or with fine which may extend to ten thousand rupees or with both and in the case of a continuing contravention or failure, with an additional fine which may extend to five thousand rupees for every day during which such contravention or failure continues after conviction for the first such contravention or failure.

8.2 THE WATER (PREVENTION AND CONTROL OF POLLUTION) CESS ACT, 1977

The Water (Prevention and Control of Pollution) Cess Act, 1977 was an act of Parliament to provide for the levy and collection of a cess on water consumed by persons carrying on certain industries and by local authorities with a view to argument the resources of the Central Board and the State Boards for the prevention and control of water pollution constituted under the Water (Prevention and Control of Pollution) Act. 1974.The Water (Prevention and Control of Pollution) Cess Act 1977 provided that the State Pollution Control Boards and Committees shall levy and collect a Cess on water consumed by persons carrying on any Industry and from all Local authorities. This enactment, earlier made with the objective of augmenting the resources of the Pollution Control Boards, has been totally repealed through provisions of Section 18 of the Taxation Laws (Amendment Act) 2017.No Fresh Cess returns have to be submitted for periods beyond 01-07-2017 and no fresh assessments have to be made by the Pollution Control Boards/Committees for consumption beyond 01-07-2017. However Cess not collected by the Pollution Control Board for periods prior to 01-07-2017 shall be collected and paid by the Pollution Control Boards/Committees (the designated collection Authorities) to the Consolidated Fund of India and All persons liable to pay cess before 1st July, 2017 shall continue to be assessed and cess collected from the date of acquisition of such liability.

8.3 THE AIR (PREVENTION AND CONTROL OF POLLUTION) ACT, 1981

The Air (Prevention and Control of Pollution) Act 1981 which introduced procedures for control of Air Pollution and prescribed ambient air quality and emission standards was also a Central Act of Parliament. The Boards and the Committees constituted to implement the Water (Prevention and Control of Pollution) Act 1974 were also empowered to administer the provisions of the Air (Prevention and Control of Pollution) Act 1981. Provisions for preventing discharge of emissions beyond the prescribed standards (Section 22) and for availing of consent to establish and operate were introduced (Section 21). The Boards were given powers to issue directions which could include directions for closure, suspension of water and power supplies (Section 31) and punitive provisions were prescribed as similar to those in the Water(Prevention and Control of Pollution) Act 1974.

8.3.1 Functions of Pollution Control Boards with respect to the Air Act 1981

8.3.1.1 Central Board generally advisory in Nature with powers to make standards for water quality and Ambient Air Quality

Section 16. Functions of the Central Board

(1) Subject to the provisions of this Act, and without prejudice to the performance, of its functions under the Water (Prevention and Control of Pollution) Act, I974 (6 of 1974), the main functions of the Central Board shall be to improve the quality of air and to prevent, control or abate air pollution in the country.

(2) In particular and without prejudice to the generality of the foregoing functions, the Central Board may-

(a) advise the Central Government on any matter concerning the improvement of the quality of air and the prevention, control or abatement of air pollution;

(b) plan and cause to be executed a nation-wide programme for the prevention, control or abatement of air pollution;

(c) co-ordinate the activities of the State and resolve disputes among them;

(d) provide technical assistance and guidance to the State Boards, carry out and sponsor investigations and research relating to problems of air pollution and prevention, control or abatement of air pollution;

(dd) perform such of the function of any State Board as may, be specified in and order made under sub-section (2) of section 18

(e) plan and organise the training of persons engaged or to be engaged in programmes for the prevention, control or abatement of air pollution on such terms and conditions as the Central Board may specify;

(f) organise through mass media a comprehensive programme regarding the prevention, control or abatement of air pollution;

(g) collect, compile and publish technical and statistical data relating to air pollution and the measures devised for its effective prevention, control or abatement and prepare manuals, codes or guides relating to prevention, control or abatement of air pollution;

(h) lay down standards for the quality of air.,

(i) collect and disseminate information in respect of matters relating to air pollution;

(j) perform such other functions as may be prescribed.

(3) The Central Board may establish or recognise a laboratory or laboratories to enable the Central Board to perform its functions under this section efficiently.

(4) The Central Board may-

(a) delegate any of its functions under this Act generally or specially to any of the committees appointed by it;

(b) do such other things and perform such other acts as it may think necessary for the proper discharge of its functions and generally for the purpose of carrying into effect the purposes of this Act.

8.3.1.2 State Pollution Control Boards to lay down standards, prevent pollution, issue consents, evove technology, direct closures advise the State Government etc. as prescribed under section 17 of the Act.

Section 17. Functions of State Boards.

(1) subject to the provisions of this Act, and without prejudice to the performance of its functions, if any, under the Water (Prevention and Control of Pollution) Act, 1974 (Act 6 of 1974), the functions of a State Board shall be-

(a) to plan a comprehensive programme for the prevention, control or abatement of air pollution and to secure the execution thereof-,

(b) to advise the State Government on any matter concerning the prevention, control or abatement of air pollution;

(c) to collect and disseminate information relating to air pollution;

(d) to collaborate with the Central Board in organising the training of persons engaged or to be engaged in programmes relating to prevention, control or abatement of air pollution and to organise mass-education programme relating thereto;

(e) to inspect, at all reasonable times, any control equipment, industrial plant or manufacturing process and to give, by order, such directions to such persons as it may consider necessary to take steps for the prevention, control or abatement of air pollution;

(f) to inspect air pollution control areas at such intervals as it may think necessary, assess the quality of air therein and take steps for the prevention, control or abatement of air pollution in such areas;

(g) to lay down, in consultation with the Central Board and having regard to the standards for the quality of air laid down by the Central Board, standards for emission of air pollutants into the atmosphere from industrial plants and automobiles or for the discharge of any air pollutant into the atmosphere from any other source whatsoever not being a ship or an aircraft:

Provided that different standards for emission may be laid down under this clause for different industrial plants having regard to the quantity and composition of emission of air pollutants into the atmosphere from such industrial plants;

(h) to advise the State Government with respect to the suitability of any premises or location for carrying on any industry which is likely to cause air pollution;

(i) to Perform such other functions as may be prescribed or as may, from time to time, be entrusted to it by the Central Board or the State Government;

(j) to do such other things and to perform such other acts as it may think necessary for the proper discharge of its functions and generally for the purpose of carrying into effect the purposes of this Act.

(2) A State Board may establish or recognise a laboratory or laboratories to enable the State Board to perform its functions under this section efficiently.

8.3.2 Central Pollution Control Board empowered to give directions to the State Pollution Control Board which are binding on the State Boards.

Section 18. Power to give Directions.

(1) In the performance of its functions under this Act –

(a) the Central Board shall be bound by such directions in writing as the Central Government may give to it; and

(b) every State Board shall be bound by such directions in writing as the Central Board or the State Government may give to it :

Provided that where a direction given by the State Government is inconsistent with the direction given by the Central Board, the matter shall be referred to the Central Government for its decision.

(2) Where the Central Government is of the opinion that any State Board has defaulted in complying with any directions given by the Central Board under sub-section (1) and as a result of such default a grave emergency has arisen and it is necessary or expedient so to do in the public interest, it may, by order, direct the Central Board to perform any of the functions of the State Board in relation to such area, for such period and for such purposes, as may be specified in the order.

(3) Where the Central Board performs any of the functions of the State Board in pursuance of a direction under sub-section (2), the expresses, if any, incurred by the Central Board with respect to the performance of such functions may, if the State Board is empowered to recover such expenses, be recovered by the Central Board with interest (at such reasonable rate as the Central Government may, by order, fix) from the date when a demand for such expenses is made until it is paid from the person or persons concerned as arrears of land revenue or of public demand.

8.3.3 Restrictions on Use of Certain Industrial Plants, Provision of Consents

Section 21. Provisions of Consents to establish and operate

(1) Subject to the provisions of this section, no person shall, without the previous consent of the State Board, establish or operate any industrial plant in an air pollution control area :

Provided that a person operating any industrial plant in any air pollution control area immediately before the commencement of Section 9 of the Air (Prevention and Control of Pollution) Amendment Act, 1987, for which no consent was necessary prior to such commencement, may continue to do so for a period of three months from such commencement or, if he has made an application for such consent within the said period of three months, till the disposal of such application.

(2) An application for consent of the State Board under sub-section (1) shall be accompanied by such fees as may be prescribed and shall be made in the prescribed form and shall contain the particulars of the industrial plant and such other particulars as may be prescribed :

Provided that where any person, immediately before the declaration of any area as an air pollution control area, operates in such area any industrial plant such person shall make the application under this sub-section within such period (being not less than three months from the date of such declaration) as may be prescribed and where such person makes such application, he shall be deemed to be operating such industrial plant with the consent of the State Board until the consent applied for has been refused.

(3) The State Board may make such inquiry as it may deem fit in respect of the application for consent referred to in sub-section (1) and in making any such inquiry, shall follow such procedure as may be prescribed.

(4) Within a period of four months after the receipt of the application for consent referred to in sub-section (1), the State Board shall, by order in writing, and for reasons to be recorded in the order, grant the consent applied for subject to such conditions and for such period as may be specified in the order, or refuse such consent :

Provided that it shall be open to the State Board to cancel such consent before the expiry of the period for which it is granted or refuse further consent after such expiry if the conditions subject to which such consent has been granted are not fulfilled :

Provided further that before canceling a consent or refusing a further consent under the first proviso, a reasonable opportunity of being heard shall be given to the person concerned.

(5) Every person to whom consent has been granted by the State Board under sub-section (4), shall comply with the following conditions, namely :-

(i) the control equipment of such specifications as the State Board may approved in this behalf shall be installed and operated in the premises where the industry is carried on or proposed to be carried on :

(ii) the existing control equipment, if any, shall be altered or replaced in accordance with the directions of the State Board;

(iii) the control equipment referred to in clause (i) or clause (ii) shall be kept at all times in good running condition;

(iv) chimney, wherever necessary, of such specifications as the State Board may approve in this behalf shall be erected or re-erected in such premises;

(v) such other conditions as the State Board may specify in this behalf; and

(vi) the conditions referred to in clauses (i), (ii) and (iv) shall be complied with within such period as the State Board may specify in this behalf :

Provided that in the case of a person operating any industrial plant in an air pollution control area immediately before the date of declaration of such area as an air pollution control area, the period so specified shall not be less than six months :

Provided further that –

(a) after the installation of any control equipment in accordance with the specifications under clause (i), or

(b) after the alteration or replacement of any control equipment in accordance with the directions of the State Board under clause (ii), or

(c) after the erection or re-erection of any chimney under clause (iv), no control equipment or chimney shall be altered or replaced or, as case may be, erected or re-erected except with the previous approval of the State Board.

(6) If due to any technological improvement or otherwise the State Board is of opinion that all or any of the conditions referred to in sub-section (5) require or requires variation (including the change of any control equipment, either in whole or in part), the State Board shall, after giving the person to whom consent has been granted an opportunity of being heard, vary all or any of such conditions and thereupon such person shall be bound to comply with the conditions as so varied.

(7) Where a person to whom consent has been granted by the State Board under sub-section (4) transfers his interest in the industry to any other person, such consent shall be deemed to have been granted to such other person and he shall be bound to comply with all the conditions subject to which it was granted as if the consent was granted to him originally.

8.3.4 Persons Carrying on Industry, Etc., not to Allow Emission of Air Pollutants in Excess of the Standards Laid Down by State Board

Section 22 Emissions to be within prescribed standards

No person operating any industrial plant, in any air pollution control area shall discharge or cause or permit to be discharged the emission of any air pollutant in excess of the standards laid down by the State Board under clause (9) of sub-section (1) of Section 17.

8.3.5 Power of Board to make Application to Court for Restraining Persons from Causing Air Pollution

Section 22A Boards can make application to Courts

(1) Where it is apprehended by a Board that emission of any air pollutant, in excess of the standards laid down by the State Board under clause (g) of sub-section (1) of Section 17, is likely to occur by reason of any person operating an industrial plant or otherwise in any air pollution control area, the Board may make an application to a court, not inferior to that of a Metropolitan Magistrate or a Judicial Magistrate of the first class for restraining such person from emitting such air pollutant.

(2) On receipt of the application under sub-section (1), the court may make such order as it deems fit.

(3) Where under sub-section (2), the court makes an order restraining any person from discharging or causing or permitting to be discharged the emission of any air pollutant, it may, in that order, -

   (a) direct such person to desist from taking such action as is likely to cause emission;

   (b) authorize the Board, if the direction under clause (a) is not complied with by the person to whom such direction is issued, to implement the direction in such manner as may be specified by the court.

(4) All expenses incurred by the Board in implementing the directions of the court under clause (b) of sub-section (3) shall be recoverable from the person concerned as arrears of land revenue or of public demand.

8.3.6 Violation of Standard due to accidents

Section 23 of the Air (Prevention and Control of Pollution) Act 1981 makes provisions for actions to be taken by the State Board in the event of discharge of any air pollutant in excess of the prescribed standards as a result of an accident or unforeseen event. The Air Act provides as follows in this context.

23. Furnishing of information to State Board and other agencies in certain cases

(1) Where in any 1 *** area the emission of any air pollutant into the atmosphere in excess of the standards laid down by the State Board occurs or is apprehended to occur due to accident or other unforeseen act or event, the person in charge of the premises from where which emission occurs or is apprehended to occur shall forthwith intimate the fact of such occurrence or the apprehension of such occurrence to the State Board and to such authorities or agencies as may be prescribed. (2) On receipt of information with respect to the fact or the apprehension of any occurrence of the nature referred to in sub-section (1), whether through intimation under that sub-section or otherwise, the State Board and the authorities or agencies shall, as early as practicable, cause such remedial measure to be taken as are necessary to mitigate the emission of such air pollutants. (3) Expenses, if any, incurred by the State Board, authority or agency with respect to the remedial measures referred to in sub-section (2) together with interest (at such reasonable rate, as the State Government may, by order, fix) from the date when a demand for the expenses is made until it is paid, may be recovered by that Board, authority or agency from the person concerned, as arrears of land revenue, or of public demand. This provision therefore restricts its applicability only to infringements

being reported/observed as a result of accident/unforeseen circumstances. Unlike provisions in the Water Act, 1974, an appeal against orders issued under section 23 can be filed before the Appellate constituted under section 31 of the Air act 1981.

The National Green Tribunal Act 2010, is the Appellate authority for orders passed by the Appellate authority constituted under section 31 of the Air Act 1981.

8.3.7 Power to take Samples of Air or Emission and Procedure to be followed in Connection Therewith.

Section 26. Sampling Procedures

(1) A State Board or any officer empowered by it in this behalf shall have power to take, for the purpose of analysis, samples of air or emission from any chimney, flue or duct or any other outlet in such manner as may be prescribed.

(2) The result of any analysis of a sample of emission taken under sub-section (1) shall be admissible in evidence in any legal proceeding unless the provisions of sub-sections (3) and (4) are complied with.

(3) Subject to the provisions of sub-section (4), when a sample of emission is taken for analysis under sub-section (1), the person taking the sample shall –

   (a) serve on the occupier or his agent, a notice, then and there, in such form as may be prescribed, of his intention to have it so analyzed;

   (b) in the presence of the occupier or his agent, collect a sample of emission for analysis;

   (c) cause the sample to be placed in a container or containers which shall be marked and sealed and shall also be singed both by the person taking the sample and the occupier or his agent;

(d) send, without delay, the container or containers to the laboratory established or recognized by the State Board under Section 17 or, if a request in that behalf is made by the occupier or his agent when the notice is served on him under clause (a), to the laboratory established or specified under sub-section (1) of Section 28.

(4) When a sample of emission is taken for analysis under sub-section (1) and the person taking the sample serves on the occupier or his agent, a notice under clause (a) of sub-section (3), then –

(a) in a case where the occupier or his agent willfully absents himself, the person taking the sample shall collect the sample of emission for analysis to be placed in a container or containers which shall be marked and sealed and shall also be signed by the person taking the sample, and

(b) in a case where the occupier or his agent is present at the time of taking the sample but refuses to sign the marked and sealed container or containers of the sample of emission as required under clause (c) of sub-section (3), the marked and sealed container or containers shall be signed by the person taking the sample, and the container or containers shall be sent without delay by the person taking the sample for analysis to the laboratory established or specified under sub-section (1) of Section 28 and such person shall inform the Government analyst appointed under sub-section (1) of Section 29, in writing, about the wilful absence of the occupier or his agent, or, as the case may be, his refusal to sign the container or containers.

8.3.8 Appeals

Section 31 Right to Appeal

(1) Any person aggrieved by an order made by the State Board under this Act may, within thirty days from the date on which the order is communicated to him, prefer an appeal to such authority

(hereinafter referred to as the Appellate Authority) as the State Government may think fit to constitute :

Provided that the Appellate Authority may entertain the appeal after the expiry of the said period of thirty days if such authority is satisfied that the appellant was prevented by sufficient cause from filling the appeal in time.

(2) The Appellate Authority shall consist of a single person or three persons as the State Government may think fit to be appointed by the State Government.

(3) The form and the manner in which an appeal may be preferred under sub-section (1), the fees payable for such appeal and the procedure to be followed by the Appellate Authority shall be such as may be prescribed.

(4) On receipt of an appeal preferred under sub-section (1), the Appellate Authority shall, after giving the appellant and the State Board an opportunity of being heard, dispose of the appeal as expeditiously as possible.

8.3.9 Power to give Directions

Section 31A. Boards to have powers to close industries, operations or processes

Notwithstanding anything contained in any other law, but subject to the provisions of this Act and to any directions that the Central Government may give in this behalf a Board may, in the exercise of its powers and performance of its functions under this Act, issue any directions in writing to any person, officer or authority, and such person, officer or authority shall be bound to comply with such directions.

Explanation : For the avoidance of doubts, it is hereby declared that the power to issue directions under this section includes the power to direct–

(a) the closure, prohibition or regulation of any industry, operation or process; or

(b) the stoppage or regulation of supply of electricity, water or any other service.

8.3.10 Penalties and Procedures

Section 37. Failure to Comply with the Provisions of Section 21 or Section 22 or With the Directions Issued Under Section 31-A.

(1) Whoever fails to comply with the provisions of Section 21 or Section 22 or directions issued under Section 31-A, shall, in respect of each such failure, be punishable with imprisonment for a term which shall not be less than one year and six months but which may extend to six years and with fine, and in case the failure continues, with an additional fine which may extend to five thousand rupees for every day during which such failure continues after the conviction for the first such failure.

(2) If the failure referred to in sub-section (1) continues beyond a period of one year after the date of conviction, the offender shall be punishable with imprisonment for a term which shall not be less than two years but which may extend to seven years and with fine.

Section 38. Penalties for Certain Acts.

Whoever –

(a) destroys, pulls down, removes, injures or defaces any pillar, post or stake fixed in the ground or any notice or other matter put up, inscribed or placed, by or under the authority of the Board, or

(b) obstructs any person acting under the orders or directions of the Board from exercising his powers and performing his functions under this Act, or

(c) damages any works or property belonging to the Board, or

(d) fails to furnish to the Board or any officer or other employee of the Board any information required by the Board or such officer or other employee for the purpose of this Act, or

(e) fails to intimate the occurrence of the emission of air pollutants into the atmosphere in excess of the standards laid down by the State Board or the apprehension of such occurrence, to the State Board and other prescribed authorities or agencies as required under sub-section (1) of Section 23, or

(f) in giving any information which he is required to give under this Act, makes a statement which is false in any material particular, or

(g) for the purpose of obtaining any consent under Section 21, makes a statement which is false in any material particular.

shall be punishable with imprisonment for a term which may extend to three months or with fine which may extend to ten thousand rupees or with both.

Section 39. Penalty for Contravention of Certain Provisions of the Act.

Whoever contravenes any of the provisions of this Act or any order or direction issued there under, for which no penalty has been elsewhere provided in this Act, shall be punishable with imprisonment for a term which may extend to three months or with fine which may extend to ten thousand rupees or with both, and in the case of continuing contravention, with an additional fine which may extend to five thousand rupees for every day during which such contravention continues after conviction for the first such contravention.

8.4 The Environment Protection Act, 1986

The Environment Protection Act 1986 was also a Central Acts of Parliament and the Central Government was given the responsibility of administering the Environment Protection Act 1986. The Central Government could delegate certain functions under the E.P. Act 1986 to the State Pollution Control Boards, the State Government or any other agency as prescribed.The Environmental (Protection) Act 1986 was an umbrella act of Parliament to be executed by the Central

Government. The act covers a range of polluting and environmentally significant activities and prescribes standards and procedures to be followed. The standards for effluents and emission as prescribed under the Environment (Protection) Act 1986 cannot be relaxed by any State Boards or Committees. They can only be made stringent on a case to case basis. It also provides for annual submission of Environmental Statements (Audits). Some important sections of the E.P. Act are as follows:

Section 3. Power of Central Government to take Measures to Protect and Improve Environment

(1) Subject to the provisions of this Act, the Central Government shall have the power to take all such measures as it deems necessary or expedient for the purpose of protecting and improving the quality of the environment and preventing, controlling and abating environmental pollution.

(2) In particular, and without prejudice to the generality of the provisions of sub-section (1), such measures may include measures with respect to all or any of the following matters, namely :

   (i) co-ordination of actions by the State Governments, officers and other authorities –

      (a) under this Act, or the rules made thereunder; or

      (b) under any other law for the time being in force which is relatable to the objects of this Act;

   (ii) planning and execution of a nation-wide programme for the prevention, control and abatement of environmental pollution;

   (iii) laying down standards for the quality of environment in its various aspects;

   (iv) laying down standards for emission or discharge of environmental pollutants from various sources whatsoever :

Provided that different standards for emission or discharge may be laid down under this clause from different sources having regard to the quality or composition of the emission or discharge of environmental pollutants from such sources;

(v) restriction of areas in which any industries, operations or processes, or class of industries, operations or processes shall not be carried out or shall be carried out subject to certain safeguards;

(vi) laying down procedures and safeguards for the prevention of accidents which may cause environmental pollution and remedial measures for such accidents;

(vii) laying down procedures and safeguards for the handling of hazardous substances;

(viii) examination of such manufacturing processes, materials and substances as are likely to cause environmental pollution;

(ix) carrying out and sponsoring investigations and research relating to problems of environmental pollution;

(x) inspection of any premises, plant, equipment, machinery, manufacturing or other processes, materials or substances and giving, by order, of such directions to such authorities, officers or persons as it may consider necessary to take steps for the prevention, control and abatement of environmental pollution;

(xi) establishment or recognition of environmental laboratories and institutes to carry out the functions entrusted to such environmental laboratories and institutes under this Act;

(xii) collection and dissemination of information in respect of matters relating to environmental pollution;

(xiii) preparation of manuals, codes or guides relating to the prevention, control and abatement of environmental pollution;

(xiv) such other matters as the Central Government deems necessary or expedient for the purpose of securing the effective implementation of the provisions of this Act.

(3) The Central Government may, if it considers it necessary or expedient so to do for the purposes of this Act, by order, published in the Official Gazette, constitute an authority or authorities by such name or names as may be specified in the order for the purpose of exercising and performing such of the powers and functions (including the power to issue directions under section 5) of the Central Government under this Act and for taking measures with respect to such of the matters referred to in sub-section (2) as may be mentioned in the order and subject to the supervision and control of the Central Government and the provisions of such order, such authority or authorities may exercise the powers or perform the functions or take the measures so mentioned in the order as if such authority or authorities had been empowered by this Act to exercise those powers or perform those functions or take such

Section 5. Power to give Directions

Notwithstanding anything contained in any other law but subject to the provisions of this Act, the Central Government may, in the exercise of its powers and performance of its functions under this Act, issue directions in writing to any person, officer or any authority and such person, officer or authority shall be bound to comply with such directions.

Explanation **:** For the avoidance of doubts, it is hereby declared that the power to issue directions under this section includes the power to direct–

(a) the closure, prohibition or regulation of any industry, operation or process; or

(b) stoppage or regulation of the supply of electricity or water or any other service.

The powers to issue directions as above have also been vested with the Chairmen of the Central and State Pollution Control Boards and also the Central Ground Water Authority for their specific areas of operation and for violation of notified standards.

Section 7. Persons Carrying on Industry, Operation, etc., not to Allow Emission or Discharge of Environmental Pollutants in Excess of the Standards

No person carrying on any industry, operation or process shall discharge or emit or permit to be discharged or emitted any environmental pollutant in excess of such standards as may be prescribed.

Section 8. Persons Handling Hazardous Substances to Comply with Procedural Safeguards

No person shall handle or cause to be handled any hazardous substance except in accordance with such procedure and after complying with such safeguards as may be prescribed.

Section 11. Power to take Sample and Procedure to be followed in Connection there with

(1) The Central Government or any officer empowered by it in this behalf, shall have power to take, for the purpose of analysis, samples of air, water, soil or other substance from any factory, premises or other place in such manner as may be prescribed.

(2) The result of any analysis of a sample taken under sub-section (1) shall not be admissible in evidence in any legal proceeding unless the provisions of sub-sections (3) and (4) are complied with.

(3) Subject to the provisions of sub-section (4), the person taking the sample under sub-section (1) shall –

(a) serve on the occupier or his agent or person in charge of the place, a notice, then and there, in such form as may be prescribed, of his intention to have it so analyzed;

(b) in the presence of the occupier or his agent or person, collect a sample for analysis;

(c) cause the sample to be placed in a container or containers which shall be marked and sealed and shall also be signed both by the person taking the sample and the occupier or his agent or person;

(d) send without delay, the container or the containers to the laboratory established or recognized by the Central Government under section 12.

(4) When a sample is taken for analysis under sub-section (1) and the person taking the sample serves on the occupier or his agent or person, a notice under clause (a) of sub-section (3), then, -

(a) in a case where the occupier, his agent or person willfully absents himself, the person taking the sample shall collect the sample for analysis to be placed in a container or containers which shall be marked and sealed and shall also be signed by the person taking the sample, and

(b) in a case where the occupier or his agent or person present at the time of taking the sample refuses to sign the marked and sealed container or containers of the sample as required under clause (c) of sub-section (3), the marked and sealed container or containers shall be signed by the person taking the samples, and the container or containers shall be sent without delay by the person taking the sample for analysis to the laboratory established or recognized under section 12 and such person shall inform the Government Analyst appointed or recognized under section 13 in writing, about the willful absence of the occupier or his agent or person, or, as the case may be, his refusal to sign the container or containers.

Section 15. Penalty for Contravention of the Provisions of the Act and the Rules, Orders and Directions

(1) Whoever fails to comply with or contravenes any of the provisions of this Act, or the rules made or orders or directions issued thereunder, shall, in respect of each such failure or contravention, be punishable with imprisonment for a term which may extend to five years or with fine which may extend to one lakh rupees, or with both, and in case the failure or contravention continues, with additional fine which may extend to five thousand rupees for every day during which such failure or contravention continues after the conviction for the first such failure or contravention.

(2) If the failure or contravention referred to in sub-section (1) continues beyond a period of one year after the date of conviction, the offender shall be punishable with imprisonment for a term which may extend to seven years.

Section 19. Cognizance of Offences

No Court shall take cognizance of any offence under this Act except on a complaint made by –

(a) the Central Government or any authority or officer authorized in this behalf by that Government; or

(b) any person who has given notice of not less than sixty days, in the manner prescribed, of the alleged offence and of his intention to make a complaint, to the Central Government or the authority or officer authorized as aforesaid.

8.4.1 Other Provisions under the Environment Protection Act 1986

8.4.1.1 The E. Waste (Management) Rules 2016.

The E. Waste (Management) Rules 2016 (GSR 338E:23.3.2016) apply to every manufacturer, producer, bulk consumer, other consumer, collection centre, refurbisher, dismantler, recycler or to any dealer and e-retailer involved in the manufacture, sale, transfer, purchase, collection, storage and processing of e-waste or electrical and electronic equipment (EEE) as detailed in schedule 1 to the E-waste Rules. The rules establish responsibilities for the manufacturer, producer, collection centre, dealers, refurbishers, consumers, bulk consumers, dismantlers, recyclers and the state Government and prescribe a procedure for obtaining of authorization for the Manufacturer (From SPCB), Producer (Extended Producer responsibility authorization from the CPCB), Refurbisher (One Time authorization from the CPCB), dismantler (SPCB) and Recycler (SPCB). Specific authorizations are required to be obtained by the occupiers (defined as the person, who in relation to any factory or premises has control over the affairs of the factory or the premises, and includes in relation to a hazardous substance the person in possession of the substance or waste).

The manufacturer, producer, importer, transporter, refurbisher, dismantler, recycler shall liable for all damages caused to the environment or third party due to improper handling and management of E-Waste and shall also be liable to pay all financial penalties as levied for any violation of the provisions under the rules by the State Pollution Control Board with the prior approval of the Central Pollution Control Board.

8.4.1.2 The Bio Medical Waste Management Rules, 2016

The Bio Medical Waste Management Rules 2016 have superseded the earlier rules of 1998 and now apply to all persons who generate, collect, receive, store, transport, treat, dispose or handle bio medical waste in any form including hospitals, nursing homes, clinics, dispensaries, veterinary institution, animal houses, pathological laboratories, blood banks, ayush hospitals, clinical establishments, research or educational institutions, health camps, medical or surgical camps, vaccination camps, blood donation camps, first aid rooms of schools, forensic labs and research labs.

The rules have established procedures for handling of biomedical wastes (Rule 4, 5, 8 and schedule I), the operation of bio medical waste treatment and disposal facilities (Rule 7), the standards (as prescribed under Schedule II) and requirements of an authorization from the State Pollution Control Boards or Committee (Rule 10).

8.4.1.3 The Construction and Demolition Waste Management Rules, 2016

The Construction and Demolition Waste Management Rules 2016 were published by the MoEF and CC on 29-03-2016 vide G.S.R. 317 (E). These rules apply to every waste resulting from construction, remodeling, repair and demolition of any civil structure of individual or organization or authority which generates construction and demolition waste such as building materials, debris, rubble. A waste generator could be any person or association of persons or institutional, residential and commercial establishments including Indian Railways, Airport, Port and Harbors and defense establishments who undertake construction or demolition of any civil structure which generate construction and demolition waste. The rules establish procedures for segregation, storage and disposal, of preparing waste management plans, seeking approvals from Municipal Authorities and payment of charges for processing and disposal of such wastes. (Rule 4) The rules also prescribe duties of service providers and contractors (Rule 5), duties of local authorities, who shall also examine and sanction the Waste Management plans (Rule 6), State Pollution Control Boards (Rule 8) who would grant authorization to the construction and demolition waste processing facilities and the duties of the State Governments/UT, (Rule 9), the CPCB (Rule 10), the BIS, the Indian Road Congress (Rule 11) and the Central Government (Rule 12).

8.4.1.4 Solid Waste (Management and Handling) Rules 2016

Handling of disposable products and use of Refuse derived fuel

The MoEF and CC has notified the Solid Waste (Management and Handling) Rules 2016 under the E.P. Act which regulates the disposal of solid or semi solid domestic solid wastes, also from non-residential waste generators. These rules do not cover Industrial solid wastes, Hazardous Chemicals, Bio medical wastes, E-Wastes , lead acid batteries and radioactive wastes. They provide a system of seeking an authorization from the Pollution Control Board for the processing and disposal of such wastes.

An important feature of the Rules, of interest to distilleries, is that all manufacturers or brand owners of disposable products like tin, glass, plastic packaging etc. shall provide necessary financial assistance to the local bodies for establishing the waste management systems. A ‘Collect back system” is also expected to be put in place by all brand owners who sell or market their products in a non biodegradable packaging material. Manufacturers brand owners or marketing companies are also required to educate the masses for wrapping and disposal of products.

It has also been provided that Industrial units within 10 kms. from RDF and Waste to Energy plants, based on solid wastes shall make arrangements to replace at least 0.5% of their fuel requirements by the RDF so produced

8.4.1.5 The Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016

The Hazardous and other Wastes (Management and Transboundary Movement) Rules 2016 have been notified by the MoEF and CC and apply to wastes which by reason of their characteristic properties, (Physical, Chemical, Biological, Reactive, Toxic, Flammable, Explosive or Corrosive) causes danger or is likely to cause danger to health or environment whether alone or in contact with other waste or substances. Such waste has been indicated to also include wastes covered in the Schedule I, II and III of these rules. The notification also makes a mention of “other wastes” needing regulation. “Other Wastes” are those wastes which are included in Part B and Part D of Schedule III to the notification.

The rules provide for authorisations, granted normally for a period of 5 years and procedures for handling Hazardous and other wastes including Temporary storage of wastes, utilisation of Hazardous waste as a resource and the import and export of Hazardous wastes.

8.4.1.6 The Manufacture, Storage and Import of Hazardous Chemical Rules, 1989

The Manufacture, Storage and Import of Hazardous Chemical Rules, 1989 were notified under the Environment Protection Act and deal with industrial accidents involving Hazardous chemicals. The rules apply to industrial activities involving the use of Hazardous chemicals as identified through Part I of Schedule I and column II of part 2 of the rules and to isolated storages involving the storage of hazardous chemicals beyond the threshold quantities as prescribed (Schedule 2, Column 2 and 3). Ethyl Alcohol is regarded as a Hazardous Chemical.

Occupiers having control over industrial activities involving the handling of hazardous chemicals will have to identify the major hazards and take adequate steps to prevent major accidents and provide information training equipment including antidotes necessary to ensure safety. The rules also provide procedures for notifying accidents (Rule 5), Preparation of safety reports (Rule 10), notification of sites (Rule 7) and the preparation of onsite emergency plan by the occupier (Rule 13) and an offsite emergency plan by the authorities (Rules 14). Import of Hazardous chemicals is covered under Rule 18.

8.4.1.7 Environmental Statement

The Ministry of Environment, Forest and Climate Change has provided at Rule 14 of the Environmental Protection Rules 1986 that every person carrying on an industry, operation or process requiring consent under section 25 of the Water Act (1974) or under section 21 of the, Air Act 1981 or both or an authorization under the Hazardous Waste (Management and Handling) Rules 1989 issued under the Environment (Protection) Act, 1986 shall submit an environmental statement for the financial year ending the 31st March in Form V to the concerned State Pollution Control Board on or before the thus thirteenth day of September every year, beginning 1993.

8.4.1.8 The Environment Impact Assessment notification of 2006

The EIA Notification of 1994

Recognizing the importance of Environmental Impact Assessments in locating development activities in an environmentally sustainable manner, the Ministry of Environment and Forest, Government of India, in 1994, had prescribed a procedure for imposing restrictions and prohibitions on the expansion and modernization of scheduled activities, being undertaken in any part in India, unless environmental clearance has been accorded by the Moef, Government of India or in certain cases by the State Government.

The EIA Notification of 2006

The E.I.A. notification of 1994 as above was superseded and replaced by notification no S.O. 1533 dated 14-09-2006 issued by the Government of India. This notification provided for the establishment of the State Environmental Impact Assessment Authorities, the Central and State Expert Appraisal Committees and laid down the procedures for granting environmental clearances. It is under this notification that clearances are issued by the MoEF after 2006.

The Environment Impact Assessment notification of 2006 identifies 37 activities in 8 categories of projects and activities (New projects and expansion or modernization of existing projects) where prior Environmental clearance must be obtained by the project proponents (Schedule 1). The activities are classified into two categories A and B. Category A projects are considered through an Expert Appraisal Committee constituted at the level of the Central Government and granted/refused a clearance by the MoEF and CC, GOI on the recommendation of this Committee. Category B projects are considered through the State Expert Appraisal Committees and granted /refused clearances by the State Environmental Impact Assessment Authority. In the absence of a duly constituted authority/committee at the State Level, a category ‘B’ project automatically becomes a category ‘A’ project.

Screening, Scoping, public consultation (with exceptions) and appraisal constitute the various stages of project evaluation and time frames for each stage prescribed. Environmental Impact Assessments have been provided as an essential management tool (with exceptions) for the clearance mechanism. Quality Council of India, accredited consultants have been authorized to make presentations on the EIA and EMP before the respective Appraisal Committees.

A six monthly monitoring schedule is also prescribed. Monitoring is done by the Ministry of Environment, Forest and Climate Change. This is essentially a clearance granted by the Ministry of Environment and Forests and the SEIAA/SEAC represent constituent entity of the Ministry at the State Level.

Validity of Environmental Clearances is generally limited to 10 years and the Environmental Clearance is transferable. This clearance is different from the consents to establish issued by the State Boards and Committees and the conditions of the Environmental Clearance are generally included as condition of consent aforementioned.

8.4.1.9 The Central Ground Water Authority

The Central Ground Water Authority has been constituted under section 3 (3) of the Environment Protection Act, 1986 to regulate and control development and management of ground water resources in India and to issue necessary regulatory directions for the purpose. The National Green Tribunal has directed that no person shall with draw ground water without the permission of the CGWA. (NGT)

8.5 The Public Liability Insurance Act, 1991

The Public Liability Insurance Act is an act of Parliament of India to provide for immediate relief to the persons affected by accidents occurring while handling any hazardous substances. This act is related to immediate relief, not compensation and is specific to relief on death or injury to any person other than a workman (as defined in the workman compensation Act 1923) or damage to any property as a result of a major accident. The victims also have a right to claim compensation under any other law in force.

Every owner handling any hazardous substance (as defined and categorized in the Act) has to take out one or more insurances policies against liability to give relief. The insurance policy shall not be less than the amount of paid up capital (defined as the amount of the market value of all assets and stocks of the undertaking on the date of contract of insurance) and not more than 50 crore rupees. Every owner is also supposed to pay to the insurance, together with the premium, a sum equal to the amount of the premium for a relief fund.

The maximum aggregate liability on the insurer has been limited to Rs. 5 Crores in the case of a single accident and Rs. 15 Crores in case of more than one accidents during the currency of the policy or one year whichever is less. Any award for relief beyond the amount shall be met from the relief fund and in case the award is for an amount greater than the sum of the insurers liability and the relief fund then the extra sum will be paid by the owner. The owner is supposed to reimburse the Collector for the Money which is paid from the relief fund.

The right to claim relief under the PLI Act is in addition to any right to compensation as under any other law in force. However, in case compensation is also sought, the amount of relief will be deducted from this compensation.

Section 12 of the Act empowers the Central Governments and State Government to issue directions on prohibition or regulation of the handling of any hazardous substance or for stoppage or regulation of the supply or electricity, water or any other service. Failure to comply with the directions issued under section 12 as above or not taking an insurance policy or not contributing to the relief fund will invite imprisonment which shall extend from 18 month to 72 months (24 months to 84 months in case of repeated offence). A maximum imprisonment of 3 months and a fine of Rs. 10000 is prescribed for other offences.

8.6 The National Green Tribunal Act, 2010

The National Green Tribunal constituted through the National Green Tribunal Act of 2010 deals with the effective and expeditious disposal of cases relating to environmental protection and conservation of forests and other natural resources and also adjudicates on legal rights and compensation for damages. It specifically address to questions arising out of the implementation of the Water (Prevention and Control of Pollution) Act 1974, the Air (Prevention and Control of Pollution) Act 1981, the Water (Prevention and Control of Pollution) Cess Act 1977, The Environment Protection Act of 1986, the Forest conservation Act of 1980, the Wild Life Protection Act 1972, the Public Liability Insurance Act of 1991 and the Biodiversity Act of 2002. This includes adjudication of disputes arising out of decisions taken by the appellate authorities constituted under the aforesaid acts and disputes arising out of orders passed by the Pollution Control Boards, Forest and Environment Departments, National and State Biodiversity Boards, Central and State Environmental Impact Assessment Authorities. The procedure for filing application prescribes that an application or appeal to the tribunal can be made by the applicant or appellant either in person or through an authorised agent or by a duly authorised legal practitioner. The highlight of this Act has been the appointment of expert Members and the inclusion of provisions for the use of scientific knowledge in the settlement of disputes.

Appeals against orders passed by the Tribunal are only maintainable at the Supreme Court of India. Section 26 (i) of the National Green Tribunal Act States that a person who fails to comply with an order or award or decision of the Tribunal is punishable with imprisonment for a term up to 3 years or with a fine up to I.N.R. 10 Crores or both. If the failure or contravention continues, an additional fine of Rs. 25000 would apply to every day of the failure after connection for the first failure.

In case of noncompliance of orders or decisions by companies, Section 26(2) provides a fine of upto Rs. 25 crores. If the failure or contravention continues, an additional fine upto Rs. 100000 per day applies.

8.7 Corporate Social Responsibility-The Company Act, 2013

The Company's Act of 2013 has made provisions for Corporate Social Responsibility with a provision to spend 2% of the average profits over the past 3 years and made CSR and the reporting of C.S.R. activities mandatory. (Section 135, Company Act 2013) The Environmental Impact assessment notification of 2006 enables the government to prescribe compulsory incorporation and implementation of C.S.R. initiatives. Noncompliance has been regarded as a punishable offence.

Section 135. Corporate Social Responsibility

(1) Every company having net worth of rupees five hundred crore or more, or turnover of rupees one thousand crore or more or a net profit of rupees five crore or more during any financial year shall constitute a Corporate Social Responsibility Committee of the Board consisting of three or more directors, out of which at least one director shall be an independent director.

(2) The Board's report under sub-section (3) of section 134 shall disclose the composition of the Corporate Social Responsibility Committee.

(3) The Corporate Social Responsibility Committee shall,—

(a) formulate and recommend to the Board, a Corporate Social Responsibility Policy which shall indicate the activities to be undertaken by the company as specified in Schedule VII;

(b) recommend the amount of expenditure to be incurred on the activities referred to in clause (a); and

(c) monitor the Corporate Social Responsibility Policy of the company from time to time.

(4) The Board of every company referred to in sub-section (1) shall,—

(a) after taking into account the recommendations made by the Corporate Social Responsibility Committee, approve the

Corporate Social Responsibility Policy for the company and disclose contents of such Policy in its report and also place it on the company's website, if any, in such manner as may be prescribed; and

(b) ensure that the activities as are included in Corporate Social Responsibility Policy of the company are undertaken by the company.

(5) The Board of every company referred to in sub-section (1), shall ensure that the company spends, in every financial year, at least two per cent. of the average net profits of the company made during the three immediately preceding financial years, in pursuance of its Corporate Social Responsibility Policy:

Provided that the company shall give preference to the local area and areas around it where it operates, for spending the amount earmarked for Corporate Social Responsibility activities:

Provided further that if the company fails to spend such amount, the Board shall, in its report made under clause (o) of sub-section (3) of section 134, specify the reasons for not spending the amount.

Explanation.—For the purposes of this section "average net profit" shall be calculated in accordance with the provisions of section 198.

8.8 The Forest Conservation Act, 1980

The Forest Conservation Act, 1980 is a Central Act of Parliament providing for the conservation of forests and for matters connected therewith or ancillary or incidental there to. Section 2 of the Act makes provisions of a prior approval of the Central Government being necessary before a State Government or any other Authority issues directions for dereservation of reserved forests (which have been reserved under the Forest Act 1927), use of forest land for non forest purposes, assigning forest land by way of lease or otherwise to any private person or to any authority, corporation agency, or any other organization not owned, managed or controlled by the government and clear felling of naturally grown trees. The term forest land mentioned in section 2 refers to any reserved forest, protected forest, or any area recorded as forest in the Government records. Land notified under section 4 of the Indian Forest Act would also come under the purview of the Forest conservation Act 1980. The Supreme Court of India has held that Forests as understood in the dictionary term would be regarded as forest land. The term 'Forest' would not be applicable to plantation raised on private lands except notified private forests. Procedures for making application have been prescribed. Appeals lie with the National Green Tribunal.

8.9 The Wild Life Protection Act of 1972

The Wild Life Protection Act of 1972 provides for the protection of wild animals, birds and plants with a view to ensuring the ecological and environmental securities of the country and for matters ancillary and incidental thereto. The act provides for the constitution of the National Board for Wild life and the State Board for Wild Life and regulates the hunting of wild animals and protection of specified plants. It also empowers State Governments to notify Sanctuaries, National Parks and game reserves and regulate development in the fringe area through delineation and notification of Eco sensitive zones. If also provides for a system of clearances from the National Board for wild life. Any project which is proposed within 10 Kms of the boundaries of a protected area shall also require a NBWL clearance if an eco sensitive area has not already been notified for the protected area.

8.10 Public Interest Litigation

Somewhere during the evolution of these tools, public interest litigation was also recognised as a cooperative effort in which the petitioner, the state or the public authority and the court endeavoured to secure legal rights, benefits and privileges conferred upon the weaker sections of society and to reach social justice to them. It was also recognised that the state or public authority which is arrayed as a respondent in public interest litigation should in fact welcome it as it would give an opportunity to right a wrong or to redress an injustice done to the poor and weaker section of the community whose welfare is and must be the prime concern of the State or the Public authority. It was this period that witnessed the emergence of the courts as courts for the poor and struggling masses of the country and of public interest litigation as a tool to solve problems of the poor and the vulnerable sections of society. (S.P.Gupta and others vs. President of India and others, AIR 1982, S.C.149; Peoples Union for Democratic Rights and others vs Union of India and others, AIR 1982, S.C. 1973)

Of special importance to enviro-legal action is writ Petition no. 8209 and 8821/83, which was the first public interest Litigation in the country, involving issues related to environmental and ecological balance. It brought into sharp focus the conflict between development and conservation and emphasised the need for reconciling the two in the large interests of the country. Against an imbalance to ecology and hazard to healthy environment due to working of lime stone quarries in the Mussoorie ranges, the Supreme court ordered the closure of lime stone quarries.

The ball had been set rolling for a dynamic movement in the country. Coupled with increasing environmental awareness and an imperative need to conserve environment, individuals and groups started looking to the courts for a judicial redressal to social problems. The Supreme court stated that it would respond even to a letter addressed by any individual in matters of public interest. A number of issues were thrown up. It was recognised that non compliance of pollution control laws was a serious offence. Non conformity to standards stipulated by the Pollution Control Board elicited decisions involving immediate closure. Episodal pollution and hazards thereof brought to the fore the importance of industrial siting and absolute liability. Industries were asked to shift from non conforming land use areas. Forest rights were restored, workers rights protected, health compensations awarded. A number of important directions were given by the courts from time to time which have served as indicators of judicial thought and the seriousness with which they view environmental inaction. Some of these are:

a. Where an enterprise is engaged in a hazardous or inherently dangerous activity and harm results to any one on account of an accident in the operation of such hazardous or inherently dangerous activity resulting in the escape of toxic gas, the enterprise is strictly and absolutely liable to compensate all those who are affected in the accident and such liability is not subject to any of the exceptions which operate vis a vis the tortuous principle of strict liability. In such a case, the measure of compensation must be correlated to the magnitude and capacity of the enterprise because such compensation must have a deterrent effect. The larger and more prosperous the enterprise, the greater must be the amount of compensation.

b. Where in a public interest litigation owners of some of the tanneries did not care, in spite of notice to them, even to enter appearance in the Supreme Court to express their willingness to take appropriate steps to establish the pre-treatment plants, it was held that so far as they were concerned an order directing them to stop working their tanneries should be passed. It was further observed that the financial capacity of the tanneries should be considered as irrelevant while requiring them to install PETPs.

c. Where a person though not a riparian owner is a person interested in protecting the lives of the people who make use of the water flowing in the river Ganga his right to maintain the petition connot be disputed. Stay by High courts should not normally be granted and if granted the matter should be disposed off within a short period, say about two months.

d. Where remedial measures are required, the Supreme Court directed the Central Government to assess the amount which the respondents are liable to pay to improve and restore the environment in the area, damaged by their action. In case of failure of the respondents to pay the amount, the same could be recovered by the Central Government in accordance with Law.

e. The Supreme Court ordered the closure of 168 hazardous industries in Delhi and also ordered them to shift outside the capital. The court has given protection to the workers by directing that they shall be treated as continuing in their employment, with a shifting allowance. Those who want to quit their jobs or cannot shift could claim retrenchment benefits plus the shifting allowance.

f. Similarly on 19 Dec 1996, the Supreme Court directed 550 tanneries to a new site by April 1997. They were asked to deposit 25% of the price of the new land. All units which deposit the money were directed to be permitted to operate till they are relocated. Directions were also issued that workmen will not be retrenched but allowed to continue at the same site. They should be considered as actively employed between the closure and relocation. The tanneries opting for closure will have to pay 6 years (Six) wages to the retrenched workers. (Jan. 1997)
g. The Supreme Court to save the Taj Mahal from pollution being caused by polluting industries at Agra ordered for the shifting/ relocation of industries and directed some to adopt gas based technologies.
h. The Supreme court has ordered that compensation be paid to the heirs of the deceased workers, suspected to have succumbed to silicosis; ailing workers and even to those who have succumbed to the disease because of living in the neighbourhood of quartzite crushing units in Jhargram, West Bengal
i. The Supreme court has ordered the polluting tanneries in Tamil Nadu to compensate the affected persons and to pay the cost of restoring the damaged ecology
j. The Gujrat High Court has ordered the closure of dyeing and printing units, holding them responsible for polluting the drinking water. The dyeing units were also required to pay 1% of their 3 years turn over as penalty to the people affected by the polluted water

Please also see Singh Yashpal, Editorial and Laws and Procedures in www. wealthywaste.com.

SECTION-9

ENVIRONMENTAL PERFORMANCE RATING OF DISTILLERIES IN UP

Edited from Singh Yashpal, wealthywaste.com/success stories, 16-05-11 updated 16-03-17

9.1 Introduction

It is time tested by now that the future, of Pollution Control and Environmental Management in any country, does not rest solely on regulatory mechanisms. Voluntary and participatory mechanisms have to play bigger roles. Wastage have to be minimized, resources consumed more prudently and the urge to conserve embedded in our cultures in order to achieve the desired levels of environmental sustainability. Looking into the mirror always helps to improve and so does emulating better performers. With the regulatory mechanism severely crunched for human resources, voluntary approaches will need to pick up. The traditional regulatory approach to Pollution control, the first wave of regulatory procedures was followed by the second wave of market based economic instruments like pollution charges, product charges, user fees, performance bonds, liability payments, non compliance fees, deposit refund schemes and tradable permits. The Water (Prevention and Control of Pollution) Cess Act , 1977 has been a very effective economic instrument in regulating the use of water. Public disclosure systems have followed as the third wave. This promised creation of better market opportunities, improvements in environmental performance, increased confidence of investors, insurers and financial institutions, improved relationships with local communities, regulators and non-governmental organizations. Public disclosures also help build societies confidence and protect corporates from the fear of loosing significant economic values of good reputation.

The provision for Environmental Audit (Statement) as prescribed under the Environmental Protection Act for 1986 has great promise but has not been able to deliver. It was designed to be a tool through which corporates analyze their environmental performance in time and take suitable measures for improvement in resource consumption and waste management. Being linked to regulations, it made industry apprehensive, apprehensive of the fact that non compliance could be used to their legal disadvantage by the regulator. This introduced some amount of misreporting in order to make the report acceptable to regulatory agencies rather than helping the industry to introspect and improve. Voluntary approaches, delinked to regulation, therefore, are assumed to play a more important role. Public disclosures of performance indicators provide powerful financial, social and reputational incentives for reducing negative externalities. It can also induce improvements from bad performers (which may otherwise require costly litigation) and introduce a system where corporate internalize reputation effects and perform better. The PROPER PROKASIH, Indonesia's public disclosure program has been very successful in awarding good performers and calling public attention to polluters who are not in compliance with the regulations (Shakeb Afsah et.al. 1997). Philippines, Colombia, Mexico and Brazil have also undertaken identical programmes.

Here at home the Centre for Science and Environment has attempted a green rating of the Paper, Automobile and Chloralkali sector **(Chandra Bhushan, 1999; CSE 2004, and Chandra Bhushan and Sunita Narain, 2002)** and ranked the major players on environmental performance. Another study done by the same organization for the cement industry pointed out that where economic logic met environmental objectives, the industry did well like in energy use and utilization of wastes but where investments did not yield short terms results the industry failed to meet expectations like in mine management, emission control and regulating livelihoods. Socially the industry was found to be dismal. Centre for Science and Environment, 2005. Most of these studies point out that the major factors wrong with these industries is an inefficient use of resources and a poor technology base. **(Chandra Bhushan 1999)**

A pilot programme for environmental performance rating and public disclosure for industries was also initiated as part of a World Bank Programme and implemented collectively through the C.I.I., World Bank and the Uttar Pradesh Pollution Control Board. The author to the present study was a part of the study initiated in May 2001 which was coordinated from the World Bank by Mr. Carter Brandon, Dr. Smita Misra, Dr. Sushmita Dasgupta. (Also covered in **Singh Yashpal, 2004**) The programme covered 33 industries of different sizes and sectors at Ghaziabad and Noida. Industries were classified as Black and Red (implying lack of compliance) and Blue, Green and Gold (different levels of achieving compliance). Out of the 33 participating industries 6 were rated as Gold and Green, 16 rated Blue and 11 rated Black. This was a location specific compliance rating programme including small and medium enterprise also. It was not designed to be an environmental performance rating.

The Charter on Corporate Responsibility for Environmental Protection,(MoEF. 2003) introduced through the efforts of the MoEF, the Pollution Control Boards and Industry Associations has seen a major breakthrough in voluntary environmental performance.

In spite of the immense advantages that voluntary disclosure systems have, environmental performance rating exercises have been attempted but at a few places in India.

A pilot programme was commissioned by the U.P. Pollution Control Board in 2000 to evaluate and rate the environmental performance of the units in the Alcohol Industry. **(Singh Yashpal 2004)** The study involved identification of the environmental indicators associated with the various activities in Alcohol production, understanding their environmental impacts and rating the environmental performance for intra industry comparisons by working out appropriate weightage systems for these indicators. The highlight of the study was the analysis of resource utilization efficiency of the units and its impact on environmental performance as well as profitability. The results of the study along with the names of the top 5 and bottom five performers were presented in an ‘open house’ where representatives from most of the participating distilleries were present. The report had concluded that in the case of Uttar Pradesh, the environmental performance of distilleries in western and Central Uttar Pradesh is better. Semi urban distilleries have a better performance as compared to rural based ones. Remarkably the study also revealed that improved environmental performance leads to better profitability. The industry was however observed to exhibit insensitiveness to the use of raw materials, water, fuel, and power which results in enormous cost escalations. It was estimated that the sector could save more than Rs 100 crores per year if only the bad performers could come to the level of the best performers. The recommendations of the study were circulated and discussed in another open house. The participating distilleries had assured that they would take necessary action and improve their environmental performance.

The then Principal Secretary, Environment, Government of Uttar Pradesh, Dr. Pradeep Kumar, I.A.S, the prime mover behind this programme had hoped that the study would lead to better control of industrial Pollution besides improving the efficiency of units. The report was also presented by Dr. Yashpal Singh before representatives from all over the world at an International Conference on Economic Instruments held at the OECD, Paris in 2004.The World Bank recognized this report as an important study and published a poster acknowledging the utility of the study. The poster also recommended that the exercise should be repeated so as to assess benefits.

It is in this context that the Distillery sector had been revisited to evaluate the impacts of the previous study. It also intended to tell the industry where it could still improve in order to earn better profits and reputation. While the earlier study looked into the performance indicators for the years 1998-99 to 2000-2001, the later study covered the year 2004-05 to 2006-07.

The present report presents a comparative study of both the assessments. The Distillery sector with an installed capacity to convert over 3 million tonnes of molasses annually in U.P. is one of the major industrial sectors with a constantly growing contribution to the state exchequer by way of excise duty (Rs. 2912.90 Crores in 2004-2005, Rs. 3114.3 Crores in 2005-2006 and Rs 3518.3 Crores in 2006-2007). It also provides employment to more than 10,000 persons in the state. The industry has grown considerably over years. While there were 37 operational distilleries in U.P. (35 molasses based and 2 broken grains and malt based) out of a total of 43 distilleries in 2000-2001, 59 distilleries have been reported for 2006-2007 (56 Molasses based and 3 grain based). All these distilleries were requested to participate in the study. Out of these, 36 distilleries participated. 24 distilleries have participated in both the 2000-2001 and 2006-2007 evaluations.

The high BOD from distilleries has been a cause of major environmental concern over the years. They have also been covered under the Corporate Responsibility for Environmental Protection 2003 (MoEF 2003) wherein it has been provided that a system of bank guarantees and an action plan be put in place to implement the following options/ recommendations mutually accepted by the regulators and industry.

1. Spent wash to be utilized for compost making with press mud/Agriculture residue/Municipal wastes.
2. Spent wash to be concentrated and dried/incinerated.
3. Effluent to be used for irrigation only after Biomethanation, two stage secondary treatment and dilution with process water.
4. Effluents (BOD<2500 mg/L) to be discharged in a controlled manner into the sea only after Biomethanation and secondary treatment so that D.O. does not fall below 4 mg/L in the mixing zone.
5. To be used in fertiirrigation and for one time controlled application on land after detailed study.

6. Achieve zero effluents discharge in inland surface waters by December 2005.

It was also decided that new stand alone distilleries and expansion of existing distilleries will not be given environmental clearance unless they achieve zero effluent discharge in surface/ground water.

The AIDA has compiled data from 233 Distilleries across the country in 2006. Based on this data,101 distilleries had achieved 100% utilization of spent wash,17 gave incomplete information, 34 achieved 50 to 75% utilization and 22 distilleries were closed. **(aidaindia.org/its08 and cpcb.nic.in).**

Like in any other business the technologies here are need based and resource intensive with an orientation towards maximizing production rather than optimizing production. The present study aims to bring about a paradigm change in the industrial understanding of pollution control and environmental balance. The issue being addressed as an end product of resource optimized, cost-effective, quality led regulatory compliant and competitive process with an added bonus of public good will.

9.2 Terms of References for the Assessments

1. To monitor the environmental performance of distilleries in terms of capacity utilization, molasses consumption MT per KL production of alcohol, recovery of alcohol in liters per M.T. of Total reducing sugar in molasses, water consumption in KL per KL Alcohol produced, total energy consumption in GJ per KL Alcohol produced, total renewable energy consumption and net external energy consumption.

2. To monitor the environmental performance of distillery in terms of regulatory compliance status including consent under the Water (Prevention and control of Pollution) Act 1974, status of default as compared to compliance norms set by the U.P. Pollution Control Board, status of ISO 140001 systems, completion of effluent treatment plants, final disposal of effluents (stream/land/ biomanure), spent wash generation per

unit production and dilution ratio. For the second phase of the study the compliance status to the Charter on Corporate Responsibility to Environmental Protection was also taken into account.

3. To compare the performance from both the assessments.

9.3 The First Phase

The first phase of the study carried out by the Pollution Control Board covered data from all the existing distilleries in the state including U.P. collected for the years 1998-99, 1999-2000 and 2000-2001. The study under the overall guidance of Dr. Pradeep Kumar, Principal Secretary Environment was coordinated by Dr. C.S. Bhatt, Member Secretary U.P. Pollution Control Board, Dr. Yashpal Singh, Chief Environment Officer, U.P. Pollution Control Board .M/s ENV Development Assistance Systems (India) Pvt. Ltd., Lucknow were engaged as consultants and assisted in the execution of the study. The rating was based on overall performance for the year 2000-2001.

Forty three distilleries (including 03 in present Uttaranchal) participated, 37 (including 03 in Uttaranchal) were operational of which 35 were molasses based and 02 grain based. One distillery which had started production in 2000-2001 was not considered along with another which remained out of production in 2000-2001. Thus the first study was based on an evaluation of 33 molasses based distilleries.

The second phase of the study was initiated by the Directorate of Environment, Government of U.P., Dr. Yashpal Singh, Director, Environment, Government of U.P. and Dr. C.S. Bhatt, Member, Secretary, U.P. Pollution Control Board were the principal investigators. During this study the performance of individual distillery units has been analyzed for the years 2004-2005, 2005-2006 and 2006-2007. The ratings have been based on the performance for the years 2006-2007. There were 59 distilleries in U.P. during the period 2006-2007, 2 distilleries were closed and 13 could not participate. 45 distilleries participated in the exercise. 08 distilleries had just started production in the year of evaluation and hence were not considered because of short term data but data collected from them shall help in later exercises. 36 distilleries were considered for evaluation. 03 of these were grain based. Distilleries in Uttaranchal were not considered for the second evaluation.

9.4 Methodology

1. Performance indicators were identified
2. Questionnaires were developed by the project coordinators and consultants and sent to various distilleries
3. Weightages for different environmental performance indicators were assigned and finalized after discussions with the officers of the Directorate of Environment, the Pollution Control Board and the distilleries.
4. The filled in questionnaires received from industry were analyzed and compared to data available with the Pollution Control Board. They were revised accordingly. Revised datasheets were sent back to the distilleries for authentication.
5. Eight distilleries selected randomly on a geographical basis (West, East and Central U.P.), capacity criteria (large/medium/small) were visited to verify the credibility of the reported data.
6. Data with respect to alcohol production, molasses consumption, total sugars and BOD of spent wash was also obtained through the excise department for the first assessment.
7. A series of presentations made at the Pollution Control Board and before distillery representatives and useful suggestions incorporated..
8. Final Report presented at an open house.

For the second phase of the study although discussions were held with the industry representatives and officers from the Directorate of Environment and the Pollution Control Board yet no formal interactive open house was organized. Industry enthusiasm in participation was encouraging. M/s ENV Development Assistance Systems (India) Pvt. Ltd., Lucknow were engaged as consultants and assisted in the execution of the study.

Assignment of Weightage

1. Maximum 100 marks were assigned for evaluation and are presented indicator wise in Table 1.
2. Marks were given on the basis of performance for the year 2000-01 for the first phase and 2006-2007 for the second phase. Trends were analyzed over all the three years of study for both the phases.
3. No marks were given for incomplete, improbable, vague data or for cases where data was not supplied by the industry.
4. Marks were based on performance in relation to pollution control norms. Where PCB norms were not available they were based on the best of industry or with the industry average.
5. The criteria for evaluation for 2006-2007 were slightly revised over those for 2000-2001.(Table 1) e.g the 2000-2001 phase had estimated that there was a good possibility of the best performers to improve further and hence had assigned only 80% marks to the best performers. During the second phase better practices were introduced leaving a lower possibility for further improvement hence 90% marks were allocated to the best performers. Similar assumptions were made with respect to criteria where Modal values were the benchmarks.

Table 1

A. Plant Level Performance (Total Marks: 33)

S No.	Performance Indicators	Max. Marks Assigned	Norms	Criteria for evaluation
1.	Capacity Utilisation	2	No Norm	Marking shall be based on proportionate performance, with full

				marks to 100% Utilization. For a utilization of more than 100%, marks shall be reduced on percentile basis for the utilization in excess of 100%. This was done away with for 2006-2007
2.	Molasses Consumption:	5	Norm- 4.87 MT/KL (Based on TRS in Molasses as 43.42% , 2000-01 avg., FS in TRS as 90% & Recovery Rate 52.5 litre/Qtl FS.)	Marking done on proportionate basis, awarding 50% marks to the 'Norm Figure' & 80% (90% in 2006-2007) marks to 'Best of Industry', minimum marks being zero.
3.	Recovery of Alcohol:	3	Norm- 472.50 litre/MT of TRS (Based on Excise Norm, taking FS 90% of TRS)	Marking done on proportionate basis, giving 50% marks to the 'Norm Figure' & 80% (90% in 2006-2007) marks to 'Best of Industry', minimum marks being zero.
4.	Water Consumption	10	Norm- 15 KL/KL of Production (Modal Value – 94.75 KL/KL) (Based on	Marking done on proportionate basis, giving 80% marks to the 'Norm Figure' & 10% (20% in 2006-2007) marks to 'Modal Value',

			Water Prevention & Control of Pollution - Cess Rule 1978)	minimum marks being zero.
5.	Total Energy Consumption	4	No Norm (Modal Value – 18.32 GJ/KL)	Marking done on proportionate basis, giving 80% (90% in 2006-2007) marks to 'Best of Industry' & 30% (25% in 2006-2007) marks to 'Modal Value', minimum marks being zero.
6.	Total Renewable Energy Consumption	4	No Norm (Modal Value – 93.42 GJ/KL)	Marking done on proportionate basis, giving 100% marks to 'Best of Industry' & 70% marks to 'Modal Value', minimum marks being zero. 70% to Modal Criteria removed for 2006-2007
7.	Net External Energy Consumption	5	No Norm (Modal Value – 9.44 GJ/KL)	Marking done on proportionate basis, giving 100% marks to 'Best of Industry' & 40% marks to 'Modal Value', minimum marks being zero. 40% to Modal Criteria removed for 2006-2007

Trend (Total Marks: 7)

(1 mark for each parameter)

a. Marking done by comparing the performance for the year 2000-01 with the average of the unit under consideration, for the respective parameter.

b. If the performance for the year 2000-01 is within $\pm$ 5% of average, trend has been taken as constant.

c. Trend has been taken as positive, when the performance for the year 2000-01, (removed for 2006-2007) is more than 95% of the Installed Capacity.

d. For the year 2006-2007 the trend has been taken as positive if the performance for the year 2006-2007 is equal to or better than average over the years under study .

B. Regulatory Compliance Status (Total Marks: 5, 15 for 2006-2007)

S No.	Performance Indicators	Max. Marks	Norms	Criteria for Evaluation		
1.	Consent under the Water Act 1974.	5	-	Marks allotted on the basis of the status for the Years 2000 and 2006 i.e. full marks if consent is granted and zero marks if consent is not granted.		
2.	Marginal/Heavy Default without dilution {Negative Marking: }	- 5	Norms: (BOD Level – mg/l)	<u>Standard</u>	<u>Marginal</u>	<u>Heavy</u>
			Inland Surface Water	30	< 200	> 200
			On land (Based on UPPCB Norms)	100	< 500	> 500
				No negative marking done for the effluent discharged within the standard levels		

				prescribed for BOD.

Note: Marks for regulatory compliance for 2006-2007 have been increased to 15 with 10 marks being allotted to compliance with the CREP.

C. Corporate & Environmental Aspect (Total Marks: 55 for 2000-2001, 45 for 2006-2007)

S No.	Performance Indicators	Marks	Norms	Criteria for Evaluation
1.	ISO 14001-EMS	10	-	Industry with ISO 14001-EMS allotted full marks otherwise zero marks.
2.	Completeness of ETP	10 5 for 2006-2007	-	Marks are added for each stage of treatment installed and operative. No marks given for the stage, which is not functional. For lagoons being used for treatment, only 25% marks (in lieu of that stage) given. Deleted for 2006-2007 The distilleries, which are producing bio-manure from the effluent discharge, are also given the benefit of marks for Secondary first stage & second stage treatment, as the case may be, giving consideration to the approximate quantity of the effluent used in bio-composting.
3.	Effluent Discharge	10	-	Distilleries disposing off effluent in all the three categories viz. Stream, Land and Bio- composting or any

				two of the above categories, given the marks on proportional / average basis for each category. In 2006-2007 distilleries discharging into stream or land have been given 2 & 5 marks respectively. Any units disposing entire effluent through bio-composting have been assigned 10 marks.
4.	Spent Wash Generation	10	As per Environment (Protection) Rules 1986, Waste Water Generation Standards Part-B, Sl.4(c), allowable waste water generation is 12 KL /KL of production. (Modal Value – 14.92 KL/KL)	Marking done on proportionate basis, giving 80% (90% in 2006-2007) marks to 'Best of Industry' & 40% marks to 'Modal Value', minimum marks being zero.
5.	Biogas Generation	15 10 for 2006-2007	No Norm (Modal Value – 29.95 Nm^3/KL)	Marking done on proportionate basis, giving 80% marks to 'Best of Industry' & 40% (50% in 2006-2007) marks to

				'Modal Value', minimum marks being zero. For the 2006-2007 study where biogas is generated but not utilized or not generated before composting negative marks (-5) have been given
6.	Dilution of Effluent {Negative Marking:}	-10	No Norm	No negative marking done for the dilution ratio up to 0.33; thereafter 1 mark deducted for each increase in ratio by 1 or fraction thereof.

In 2006-2007 units based on the new technology (utilizing multi effect evaporators to concentrate spent wash and use it as fuel to generate energy have been assigned 25 marks including maximum marks for biogas generation (10), Zero discharge (10) and completeness of ETP (5) decided for 2000-2001.

Note: for the year 2006-2007, 10 additional marks have been assigned against regulatory compliance for compliance with provisions of CREP. These have been taken from completeness of ETP (5 marks) and Biogas generation (5 marks) as these are important parts of CREP. The overall criteria for norms is generally uniform for both years of study.

Grain Based Distilleries

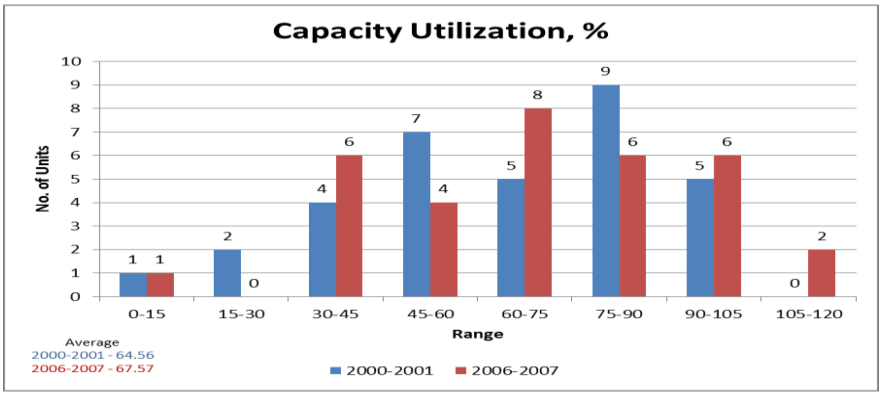
Industry norms for grain based distilleries are not available. Norms for raw material consumption and recovery of alcohol are also not prescribed. Further, the two distilleries utilize different raw materials – broken Vs malted grain. Their environmental performance has, therefore, been evaluated on the basis of performance values for various identified parameters.

9.5 The Evaluation

9.5.1 Plant level performance

9.5.1.1 Capacity Utilization

A higher capacity utilization has been regarded as a positive indicator. The capacity utilization of the 33 molasses based units under evaluation in the first phase varies from 2.9% to 105.15% with 3 units achieving a capacity utilization of more than 100%. The average capacity utilization is 64.56 with 18 distilleries crossing the average. Twenty three distilleries have exhibited an improving trend in capacity utilization over years of study.



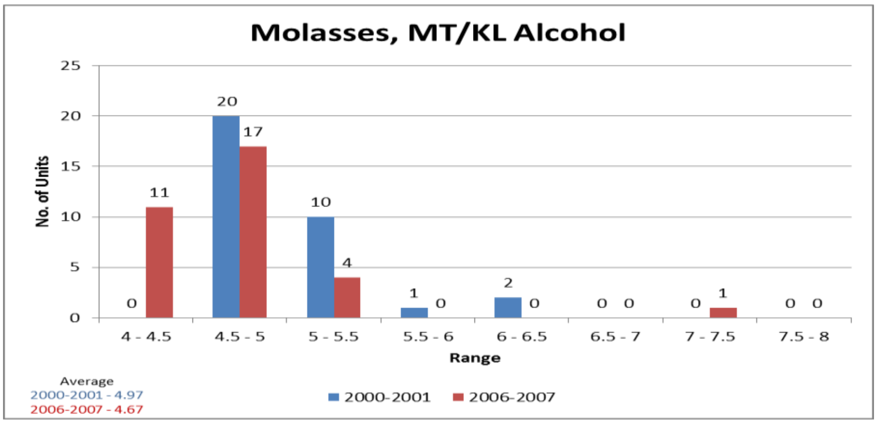
Of the two grain based distilleries, one unit has achieved a capacity utilization of 97.53% and the other unit could attain only 24.93% capacity utilization.

During 2006-2007, the capacity utilization ranged from 4.27% to 111.44% with 03 units recording more than 100%. The average capacity utilization was 67.57% which was an improvement over the 2000-2001 figures of 64.56%. While 18 industries crossed the average capacity utilization of 64.46% in 2000-2001, only 16 could cross this benchmark in 2006-2007.An interesting observation is that the low performers have improved in capacity utilization. In terms of averages there has been an improvement in capacity utilization during the second phase.

9.5.1.2 Molasses Consumed

Lower molasses consumption per KL alcohol produced has been regarded as a positive indicator. The industry norm has been taken as 4.87 MT/KL (See Table 1). During the first phase of the study the 33 molasses based distilleries exhibited a range of 4.53-6.28 MT per KL alcohol. Eighteen distilleries were found to be using below this norm of 4.87MT per KL.. The average consumption was 4.97 MT/KL which was higher than the norms. Nineteen distilleries were using below the average leaving 14 distilleries with a scope for improvement at least to average performance.

It has also been estimated for 2000-2001, that the worst performing unit on improving to the best performance is likely to save Rs. 14.00 lacs per annum. An annual saving of Rs. 26.95 crores is estimated if all the units achieve this performance value.



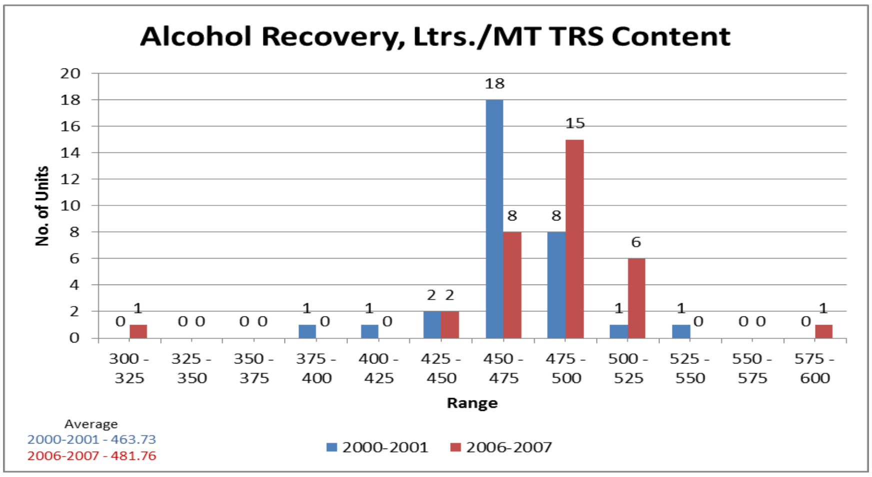
For the year 2006-2007 the consumption of molasses in the 33 molasses based distilleries show a range of 4.02 to 7.12 MT/KL alcohol with an average of 4.67 which is an improvement over the 4.97 MT/KL values for 2000-2001. 19 distilleries in 2000-2001 were using less than 4.97 MT/KL while for the same quantities (4.97) in 2006-2007, 27 industries were below, this an improved performance by 08 industries.

In the two grain based distilleries studied the grain consumption was 3.27 and 2.75 MT/KL of alcohol.

9.5.1.3 Recovery of Alcohol

The Excise department had laid down a norm of 472.50 liter per MT of TRS for recovery of Alcohol per MT of total reducing sugar in molasses during 2000-2001. The evaluation exercise indicates a wide variation in the actual recovery which ranges from 379.40 to 536.78 Liters/MT of TRS. A lower alcohol recovery has been considered as a negative indicator. The average recovery is 463.73 Liters which is lower than the norms and leaves scope for improvement. Only 14 distilleries perform better than the norms while 21 distilleries are better than the average performance.

The average recoveries for 2006-2007 were 481.76 liters/MT TRS content. Better than the norm of 472.50 and better than the average recovery of 463.73 liters in 2000-2001. In 2006-2007, 24 distilleries were recovering more than the norm as against 14 in 2000-2001 and in terms of improvements over the 2000-2001 average of 463.73, 27 distilleries were recovering more as against 21 earlier.

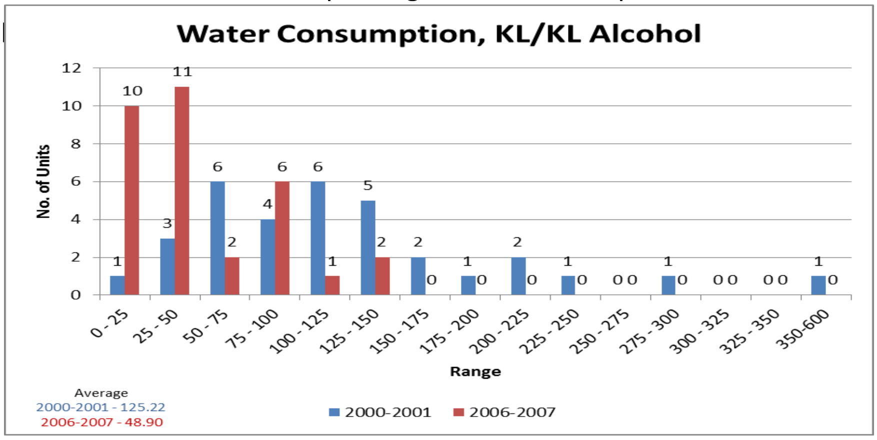


9.5.1.4 Water Consumption

Water is an important resource for the industry. The Water (Prevention and Control of Pollution) Cess Act and rules lay down a consumption limit of 15 KL of water per KL of alcohol produced beyond which increased rates of Cess apply. This has been regarded as a norm for the purpose of this exercise. Ironically only one industry performed better than this norm although proving that it is achievable. It is alarming to note that the average water consumption is as high as 125.22 KL/KL of alcohol. 20 distilleries were consuming less than the average. While one of the grain based distilleries was using 71.85 KL/KL of alcohol, the other was using 1665.66 KL/KL alcohol. A most shocking revelation.

In terms of water consumption in 2000-2001 it is proved beyond doubt that this is one area where the sector will have to work very hard. It is estimated that the performance improvement by the worst performer by emulating the best would make saving of Rs. 57.50 lacs per annum in its favor. Improvement in water consumption to levels of the best performer is likely to generate an overall saving of Rs. 12.04 crores for the entire sector.

There has been a tremendous improvement in the water consumption per KL alcohol in the year 2006-2007. The average water consumption has come down to 48.9 KL/KL alcohol from the 125.2 KL/KL alcohol in the year 2000-2001. While only 20 industries were equal to or better than the average of 125.2 KL/KL alcohol in 2000-2001, 31 industries achieved these values in 2006-2007. 04 industries were either meeting or almost meeting the norms of 15 KL and 22 industries exhibited an improving trend over the period of the second

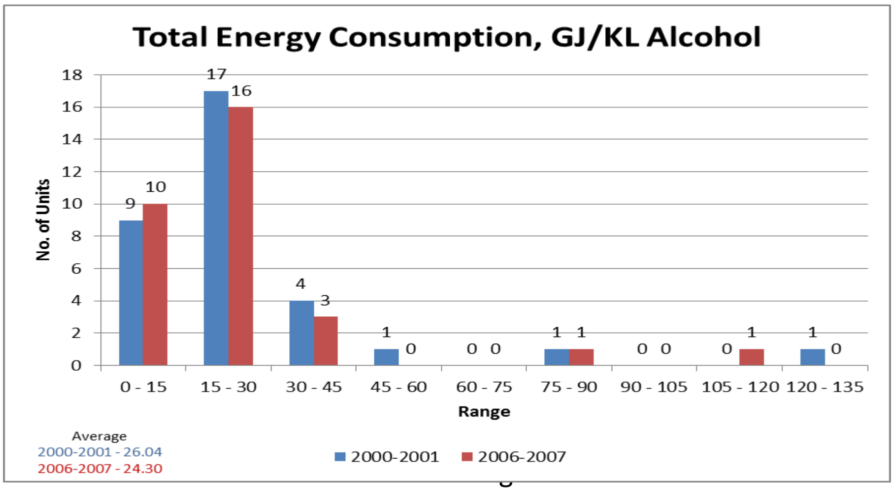


9.5.1.5 Total Energy Consumption

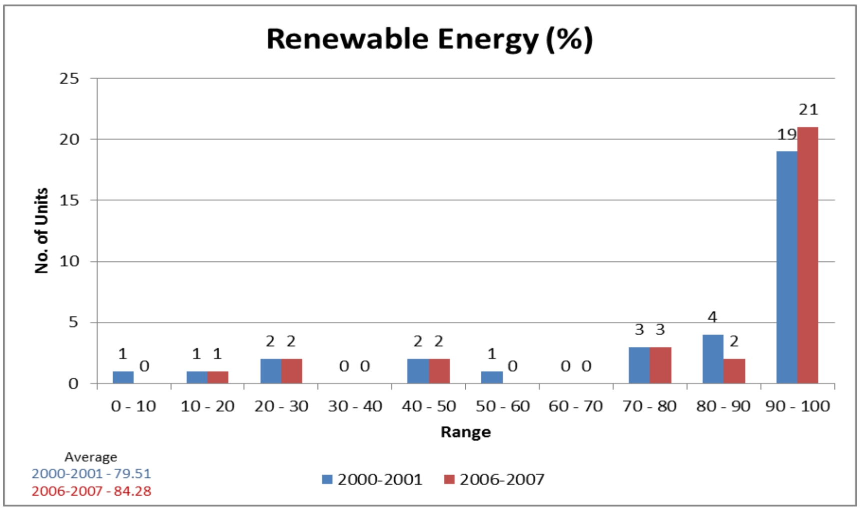
A lower per unit total energy consumption has been regarded as a positive indicator. In 2000-2001 the average energy consumption was 26.04 GJ/KL of alcohol with a range from 10.17 to 123.56 GJ/KL alcohol. Twenty four units were consuming less than the average and at least 09 were found in the economy range of 10 to 15 GJ/KL alcohol. The worst performer is consuming 123.56 Gj/Kl. If this industry improves to the level of the best performer it will result in a saving of Rs. 3.19 crores per year on 2001 estimates and if the entire industry reduces its consumption to the best level, it would result in a saving of Rs. 45.32 crores.

During the assessment carried out for the years 2004-2005, 2005-2006 and 2006-2007 the average total energy consumption has come down to 24.30 GJ/KL alcohol as against 26.04 for the previous study. Twenty one industries out of 31 assessed for this parameter were better than this average. 10 industries as against 9 earlier were in the economy range of 10 to 15 GJ/KL alcohol . The range has also narrowed down to 5.7 to 114.20 GJ as against 10.17 to 123.56 GJ for 2000-2001.

There has been considerable improvement. With an average production of 430895 KL in 2000-2001 and energy consumption of 11220505 GJ the energy consumption for the same production levels in 2006-2007 has been 10470748.5 GJ, a reduction of 749757 GJ or almost 7%. Both the grain based distilleries have also improved on this account.



grain based distilleries range from 91 to 96%

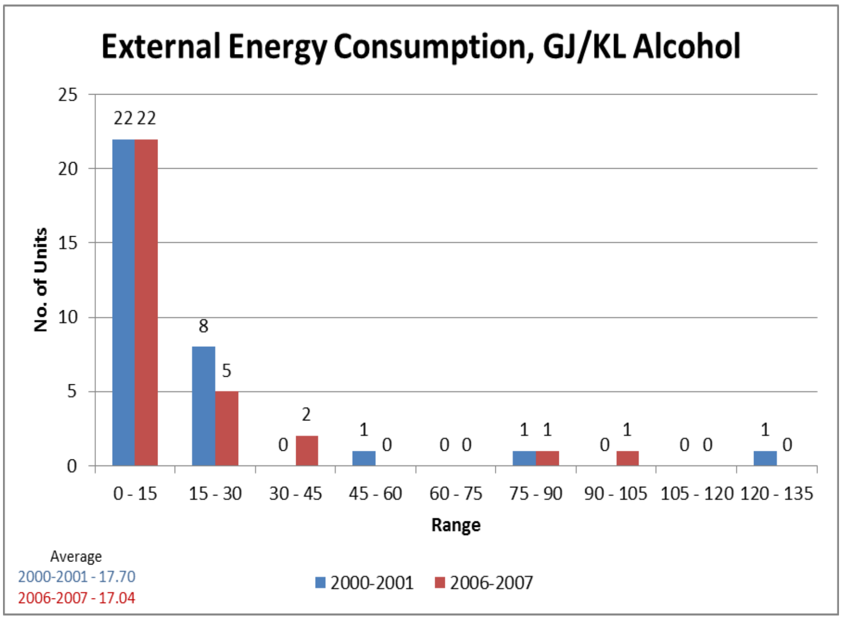


The 2006-2007 evaluation for 31 distilleries as against 33 earlier also shows that the renewable energy component has improved with an average of 84.28% as against 79.51% in 2000-2001 and 19 industries achieving near 93.42% or higher as against 16 earlier.

The grain based distilleries ranges from 90.69 to 99.63 an improvement over previous values.

9.5.1.7 External Energy Consumption

The net external energy consumption or the quantity of external fuel used per unit product has also been regarded as an important indicator. It ranges from zero to 123.56 GJ in the 33 molasses based units under evaluation for the year 2000-2001. The average net external energy consumption was 17.70 GJ (against average Total Energy 26.04 GJ) and 26 distilleries were performing better than this average. 12 industries were performing below 9.44 GJ/KL. The consumption in grain based distilleries is high ranging from 60.64 to 79.75 GJ/KL with an average 70.20 GJ/KL.



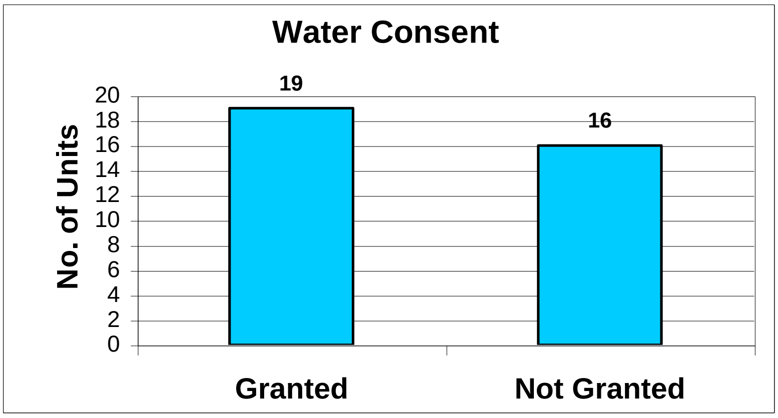
The 2006-2007 evaluation reveals that the average net external energy consumption has come down very slightly from 17.70 GJ to 17.04 GJ with 23 units performing equal to or better than this average and 12 being near 9.44 as earlier.

The net external energy consumption in 03 grain based distilleries range from 24.57 to 106.76 with an average of 58 GJ/KL. This has also registered a decrease from 70.20 GJ/KL in 2000-2001 to 58 GJ/KL in 2006-2007.

9.5.1.8 Consent Status

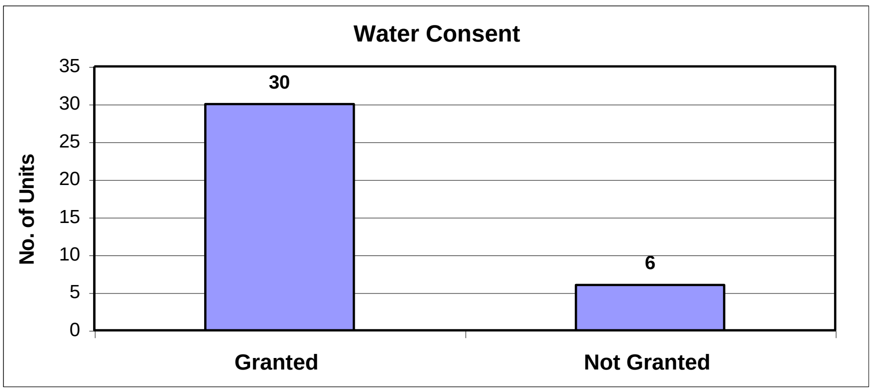
The 2000-2001 assessments reveal that out of a total of 35 distilleries evaluated , 17 molasses based and 2 grain based industries had a valid consent under the Water (Prevention and Control of Pollution) Act 1974 and 16 distilleries did not have a valid consent.

2000



The situation improves in 2006-2007 when 27 molasses based and 03 grain based industries had valid consent and only 06 distilleries were without a valid consent.

2006

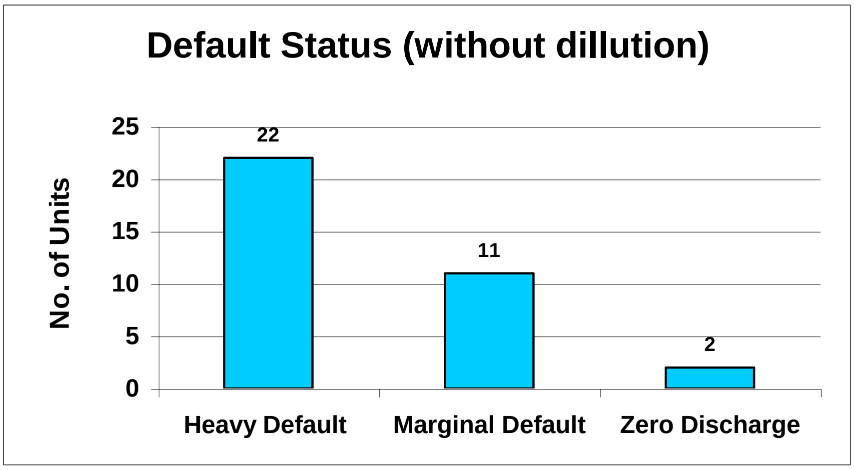


This establishes that the voluntary participation in the earlier exercise has achieved significantly more compliance to regulations.

9.5.1.9 Marginally/Heavily Polluted Effluents

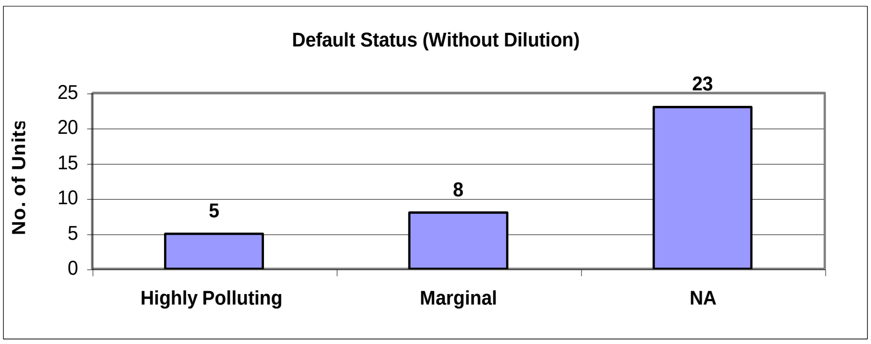
For the 2000-2001 assessment, the U.P. Pollution Control Board had agreed upon internal benchmarks for prioritising action against defaulting industries. Under this system a BOD of <200 mg/lt for inland surface water and <500 mg. /lt. for discharge on land classifies as a marginal default while values beyond these classify has major default. The 2000-2001 study identified 22 heavily defaulting units, and 11 marginally defaulting units. 02 industries had achieved zero discharge.

2000-2001



Within the same evaluation criteria, the study results for 2006-2007 indicate only 05 heavy defaulters and 08 marginal defaulters. 23 industries had achieved zero effluent discharge (Biocomposting)

2006-2007

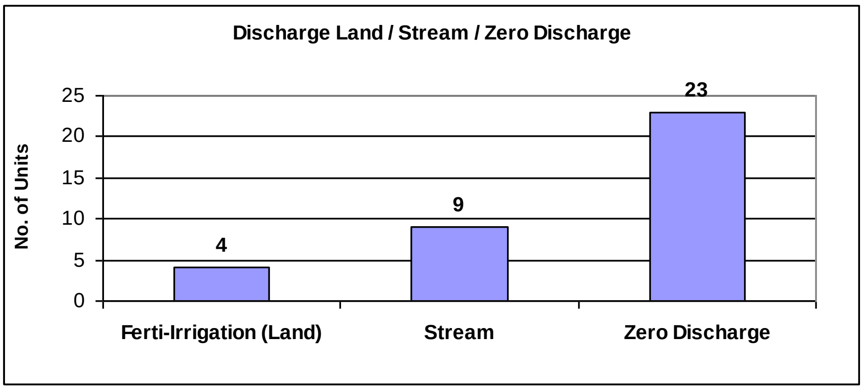


9.5.1.10 Final disposal of effluents into Stream/Land or conversion into bio-manure

Out of 33 molasses based distilleries under evaluation in 2000-2001, 2 were completely using effluents in bio-manure, 08 were partially using for bio-manure, 03 were discharging on land for ferti-irrigation and 20 units were discharging their treated effluents in streams. The grain based distilleries were using the stillage for conversion into cattle feed. Only non process effluents were discharge into stream or land or used for horticulture.

The 2006-2007 study results indicate that 4 units are using treated effluents for ferti-irrigation. 9 are discharging into stream as against 20 earlier and 23 units have achieved zero effluent discharge as against only 02 earlier. This has a potential to considerably reduce pressures on water bodies and land and is a commendable achievement.

2006-2007

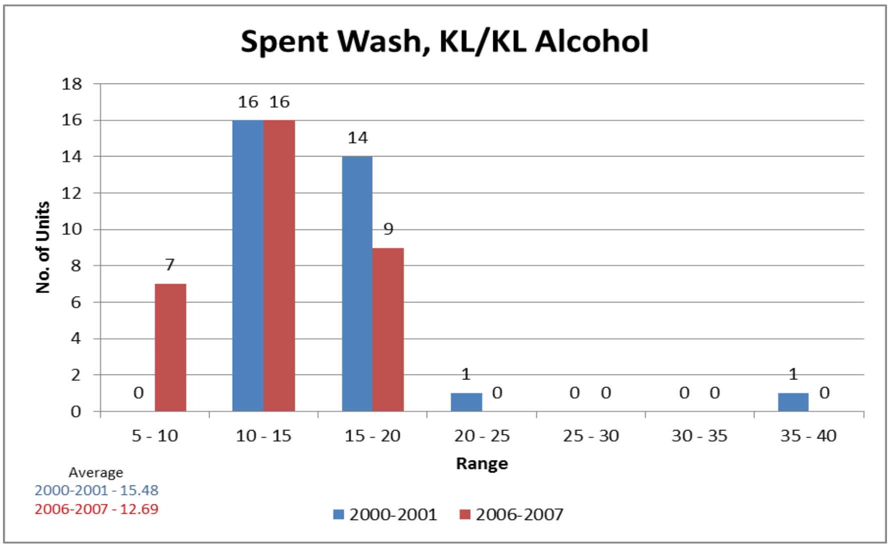


9.5.1.11 Spent Wash Generated per KL alcohol

The Environment Protection Act 1986 prescribes a standard of 12 KL of Spent wash discharge /KL of alcohol produced. A lower spent wash generated per unit production is an indicator of environmentally sound practices. During the period 2000-2001 the spent wash ranged from 10.87 to 38.34 KL per KL of alcohol produced. The average was

15.48, more than the prescribed norms. 19 industries were observed to be below this average and only 03 with in the norms of 12 KL.

The spent wash generation had reduced considerably during the year 2006-2007 and ranged from 7.89 to 19.56 KL. The average came down to 12.69 KL/KL as against 15.48 earlier. In terms of the average for 2000-2001 where 19 industries were below this average, the number in 2006-2007 has increased to 24,a very positive sign with almost 12 achieving the norms of 12 KL/KL.



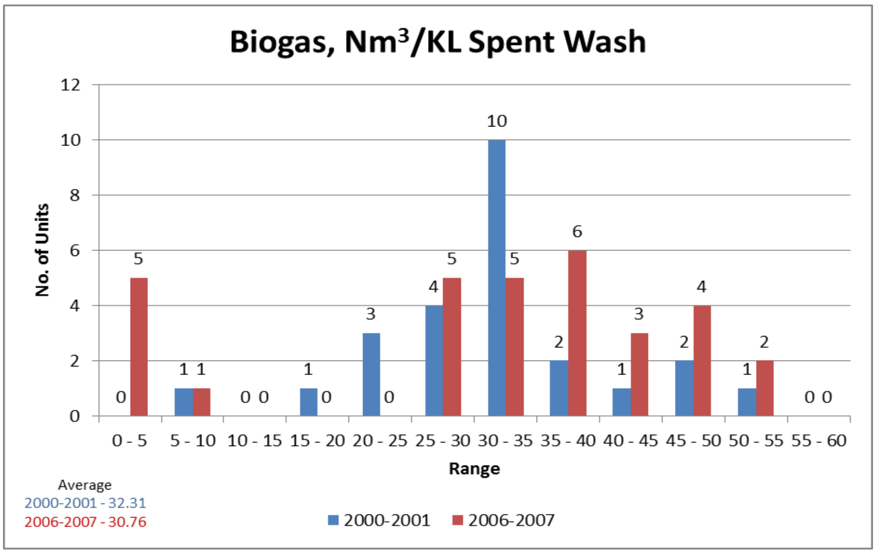
The average stillage generated from the two grain based industries in 2000-2001 is 13.4 KL/KL (range 10.99 to 15.75) while for 2006-2007 the same is observed as 12.26 KL/KL. This also exhibits an improvement.

9.5.1.12 Biogas Generation

Production of biogas in primary treatment is an important indicator as more of biogas would mean less of BOD in effluents. Out of the 33 participating industries in 2000-2001, data from 02 was doubtful, biogas plant installed in the distilleries was not found to be functional and biogas from 03 units is discharged into the atmosphere unmonitored and hence the generation could not be measured. Of the remaining 26 industries, the biogas generation ranges from 7.26

to 54.30 Nm^3/KL spent wash with an average of 32.31 Nm^3/KL. 10 distilleries were producing equal to or more than the average value.

Generation of biogas in grain based distilleries was not observed to be feasible.



33 distilleries were evaluated in 2006-2007. 02 units were concentrating the spent wash and utilizing it to generate steam and power while achieving zero discharge, 05 units are not utilizing the biogas to meet their energy requirements. They either do not generate biogas or do not utilize it. In the remaining 26 industries the generation of biogas ranges from 9.33 to 54.32 Nm^3/KL with an average of 36.67 Nm^3/KL, an improvement over 32.31 Nm^3/KL recorded earlier.In terms of the earlier average of 32.31 Nm^3/KL, 12 distilleries are now beyond this as against 10 earlier.

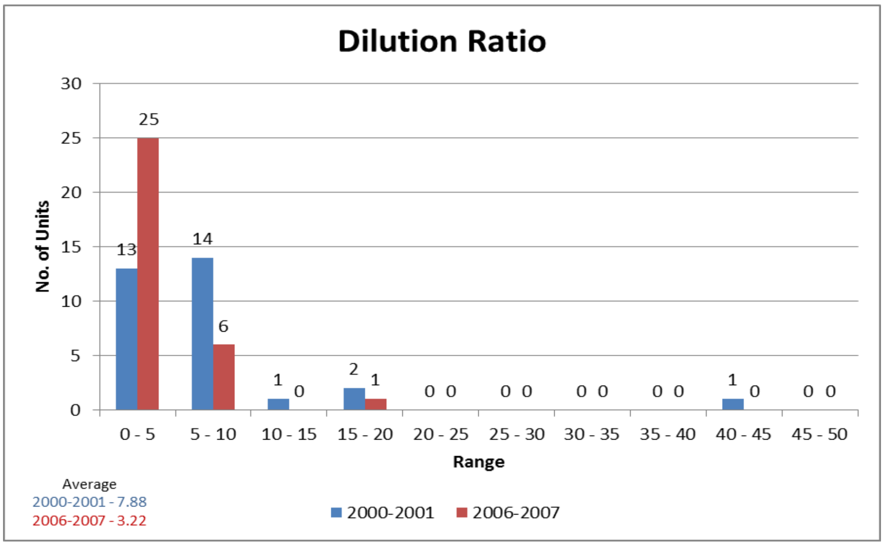
Out of the three grain based distilleries only 01 distillery is generating biogas. The stillage is converted into cattle feed.

9.5.1.13 Dilution Ratio

Dilution of effluents by fresh water or less polluting effluents impacts the effluent discharge from the industry. The lower the dilution ratio, the higher is the pressure on industry to operate the plant more efficiently.

A higher dilution ratio resulting in high water consumption is due mainly to the lower recycling/reuse of effluents in the process and has been considered as a negative indicator. The dilution ratio for 32 distilleries in 2000-2001 ranges from 0.31 to 44.81 with an average of 7.88. 22 distilleries were below the average.

During the year 2006-2007 the exhibited range for the ratio was 0.09 to 15.29 with an average of 3.22, a considerable improvement over the average of 7.88 observed in 2000-2001. Benchmarking with the average of 7.88 in 2000-2001, the study for 2006-2007 revealed that 30 distilleries were below this figure and have improved in terms of using less dilution water.



In terms of grain based distilleries, one industry has a dilution ratio of more than 100 which indicated that the industry was producing abnormally high quantity of effluents and wasting water. In 2006-2007 while two grain based distilleries were having low ratios (1.38 and 3.6) the third was very high (79.3) indicating a wastage of water.

9.5.1.14 ISO 14001 Environmental Management System

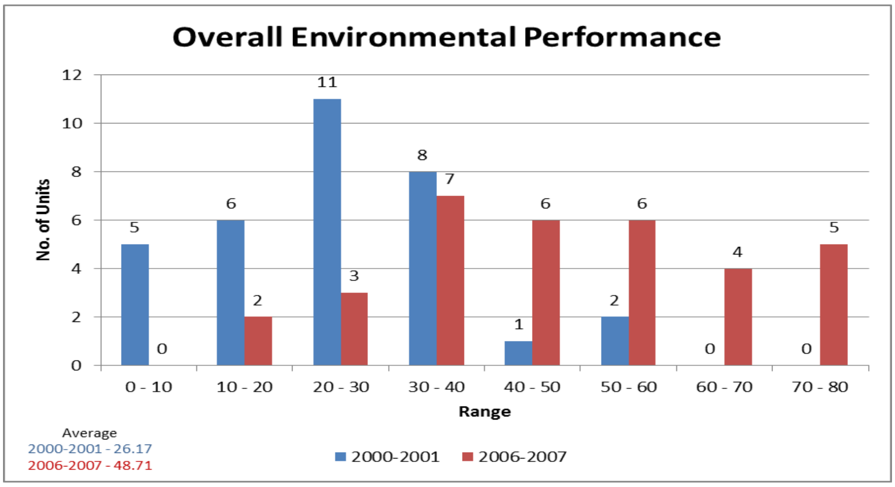
No unit was observed to be holding an ISO 14001 certification in 2000-2001. In 2006-2007, although a few distilleries were in the process of obtaining the ISO certification, there is no distillery having the certificate.

9.5.1.15 Overall performance

In terms of the overall performance score based on all the parameters, the 2000-2001 study revealed a range of 1.82 to 54.15 and an average score of 26.27. 15 distilleries were equaling to or better than this average.

The range for overall environmental performance for the study in 2006-2007 indicates a range of 14 to 78 with an average performance of 48.71. This is a considerable improvement over the past performance of 2000-2001.

Comparing to the 2000-2001 average marks of 26.27 when 15 distilleries were equal to or better than the score, the study for 2006-2007 has revealed that 30 distilleries have improved on this performance benchmark.



The average for 2006-2007 (48.71) is almost close to the best performer of 2000-2001 (54.15) and 12 distilleries have performed better than the best performer of 2000-2001. This is good achievement.

The grain based distilleries have also improved (42 and 54 in 2000-2001 to 42, 43 and 75 in 2006-2007)

9.5.1.16 Conclusions

The study for the period 2000-2001 had indicated the following:

1. Distilleries in central and western U.P. are marginally better performers.
2. The semi urban distilleries were observed to perform better than the urban and rural based units.
3. 57% distilleries are located in the Ganga catchment followed by Ghagra and Yamuna. 86% of the distilleries discharge their effluents into the rivers (Ghagra-5, Gomti-1, Ganga-18 and Yamuna-6)
4. An improved environmental performance leads to better profitability.
5. The sector is not sensitive to the efficient use of raw materials, water, fuel and power. Optimization in raw material consumption and judicious use of water and energy shall reduce the production cost and increase profitability. This will make the product more competitive in the Global market and help the industry to maximize the capacity utilization.
6. If the bad performers evaluate the best performers, the sector is likely to save Rs. 105.81 Crores by optimizing resource utilization (Molasses Rs. 26.95 Crores, Water Rs. 12.04 Crores, Biogas Rs. 22.50 Crores, Total Energy Rs. 45.32 Crores)

The following recommendations were made and presented before an open house session with Industry representatives and the Pollution Control Board.

1. Eighteen out of the 33 units studied have a very poor environmental performance.

2. All plants should have facilities to monitor the amount of biogas generated. They must also ensure to utilize the gas in boilers to meet the energy requirements. Where the biogas generation is poor, industries should retrofit the inefficient plants.

3. Those units which have not installed the second aerobic stage should do it at the earliest.

4. There is immense scope for reducing water consumption. This should be implemented.

5. Metering systems should be installed to monitor consumption of biogas, water and electricity.

6. Wherever feasible effluents should be utilized in production of bio-manure or in the case of grain based distilleries as cattle feed. Use of treated effluents for irrigation should be encouraged.

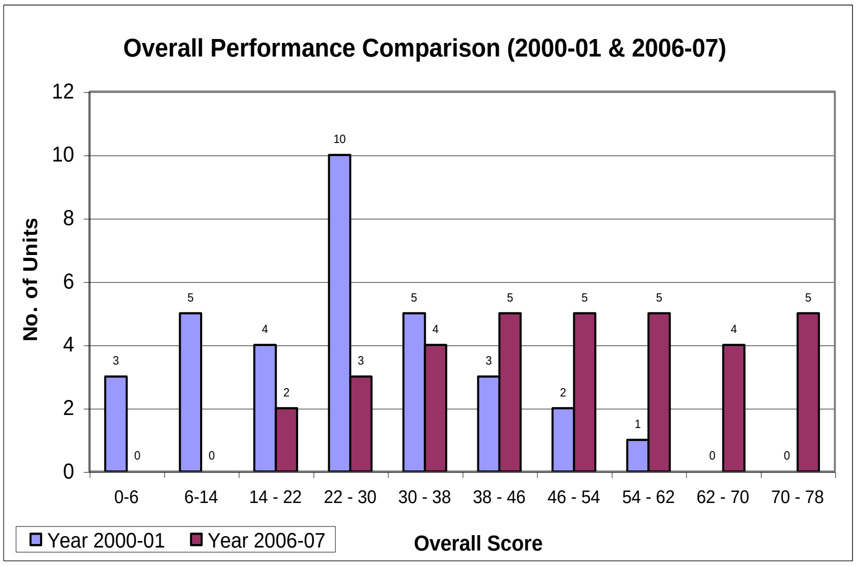
7. Energy audit and trainings should be utilized

8. Best available technologies should be utilized.

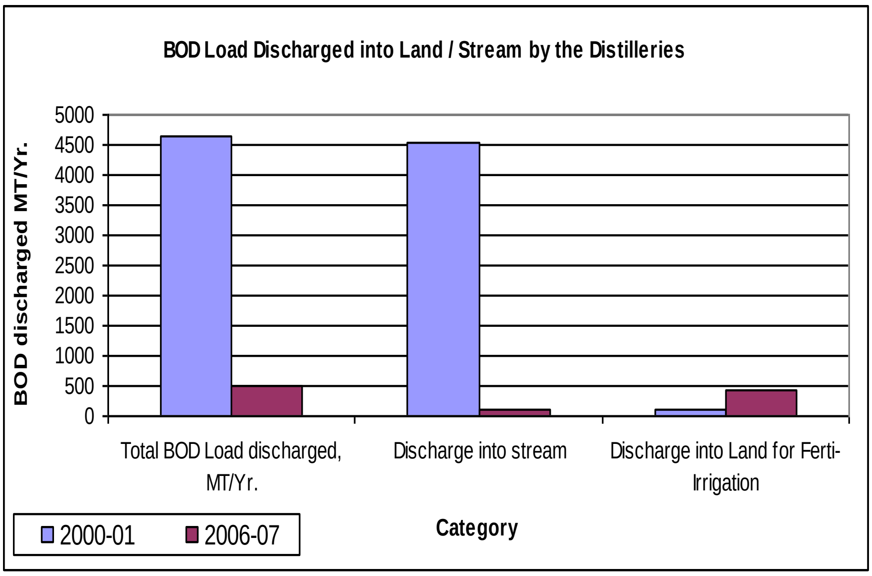
9. Distilleries should be encouraged to implement ISO 14001.

Against these findings and recommendations there has been a considerable improvement in environmental performance in 2006-2007. 24 distilleries were common to both the phases of the study, 22 of these have improved by way of total environmental performance, 12 in terms of capacity utilization, 18 in terms of molasses consumption, 17 in terms of average recovery of alcohol, 18 in terms of water consumption, 10 (out of 22) in terms of total energy consumption, 14 (out of 22) in terms of total renewable energy consumption, 17 (out of 22) in terms of spent wash generation, 13 (out of 19) in terms of biogas generation, 18 (out of 22) in terms of dilution ratio.

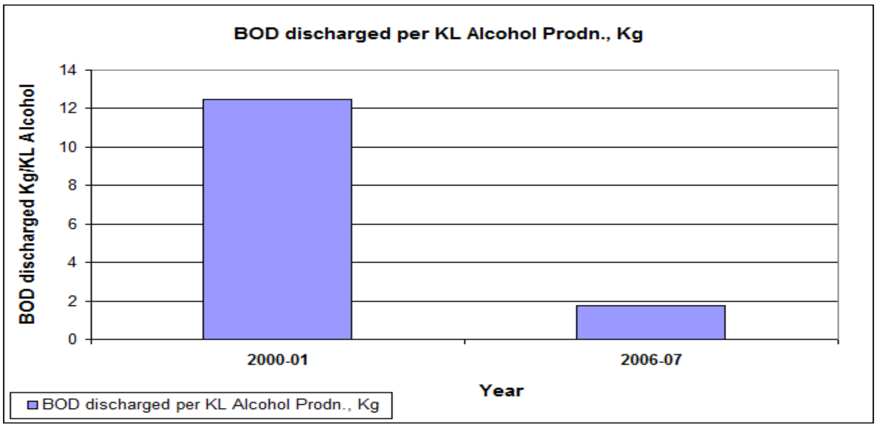
The repeat study has also reiterated the findings of the earlier study that an improved environmental performance leads to better profitability. There has been a considerable improvement in per capita use of resources although there is still scope for improvement. Two industries have adopted technologies based on concentration of spent wash and burning the same in boiler to generate steam and power for the process. These units show improved performance on all the energy indicators and have no effluent issues. Some new units installed in 2006-2007 or later are based on this technology.



The overall performance of distilleries has shown substantial improvement. There has also been a 89% reduction in the discharge of BOD from the distilleries (4637.86 MT per year in 2000-2001 to 517.70 MT per year in 2006-2007).



Significantly also disposal of B.O.D into streams has come down by 97.75 %(4526.55 Mt/year in 2000-01 to 102.02 MT/year in 2006-07). Land disposal has slightly increased from 111.31 MT/Year to 415.68 MT/year. In terms of BOD discharged per KL alcohol production the values have come down from 12.45 KG/KL alcohol to 1.72 KG/KL alcohol. A reduction of about 86%.



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READER'S NOTE

Although all care has been executed in the research, documentation and presentation yet there may be mistakes. The author would request the reader to make a note of and convey errors, omissions and suggestion which may help him to update the book in future.