# Charter
# for
# Zero Liquid Discharge (ZLD) in
# Molasses Based Distilleries

cpcb

## Central Pollution Control Board

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# 1.0 Introduction

India is the largest sugar consumer and second largest producer of sugar and molasses. It is also the fourth largest producer of alcohol in the world while being the leading producer of alcohol in the South-East Asian region with about 65% of the total share. The major raw material for distilleries is molasses, a waste byproduct of sugar mills and grains. Sugarcane, the raw material for sugar mills, is one of the major crops of the country. Consequently, agricultural and rural economy is significantly dependent on sugarcane farming and associated industries. Besides, sugar mills, distilleries and associated industries also provide large employment potential and contribute substantially to economic development of the country. As per Indian Sugar Mills Association (ISMA), in 2018-19, the total estimated revenue realization from sugar and byproducts was 1 lakh crore of which 81% was contributed by Sugar Industry while distilleries contributed 13% and other byproducts contributed remaining 6%. It is apparently the 2$^{nd}$ largest revenue contributor per annum for the government.

Molasses, a byproduct of sugar industries is the major raw material for distilleries in India while a few distilleries also use grains such as sorghum, corn, rice, wheat, millet etc., as raw material. Since sugar season 2019-20, Government of India (GOI) has allowed use of either sugarcane juice, sugarcane syrup, B Heavy molasses or sugar as feedstock for ethanol production, apart from the conventional C heavy molasses. As compared to ethanol derived from C- heavy molasses route, diversion of B heavy molasses reduces the sugar availability by 15-20 % and increases ethanol availability by about 90-100%. On the other hand, diversion of sugarcane juice for ethanol production reduces sugar availability by 100% and increases ethanol availability by about 580-600%. Due to consistent surplus in sugar production and resulting depression in sugar price, diversion of sugar cane juice and B heavy molasses in ethanol production can boost both the ethanol economy as well as revive the sugar industry.

As per All India Distillers Association (AIDA), in 2019-20, there were 392 molasses based distilleries and 113 grain based distilleries in the country with total installed capacity of 6.93 billion litres per annum and 2.58 billion litres per annum respectively. In India, distilleries are classified as "Red Category" since molasses based distilleries consume significant quantities of fresh water and produce spent wash (vinasse) having very high pollution load.

In India alcohol is produced in the form of either i) Rectified Spirit (95 to 96 % v/v ethanol) that is mainly utilized for industrial purposes in the form of ordinary and special denatured spirit (ODS or SDS), ii) Extra Neutral Alcohol or Neutral Spirit (96 % v/v ethanol that is used for manufacture of potable liquors and iii) Fuel Ethanol or Anhydrous Alcohol thatis mainly used for blending with petrol.

The average capacities of Indian molasses baseddistilleries ranges between 30 to 60 KLPD. There are very few distilleries above 100 KLPD capacities as well. However, with aggressive implementation of Ethanol Blending Programme (EBP) by GOI, the capacities of Indian distilleries are now gradually increasing.

## 2.0 Quality of Molasses in North India

Molasses, a byproduct of sugar manufacturing from sugar-cane, is the main raw material for distilleries. The molasses (final or C molasses) produced from sugar mills in Uttar Pradesh and its neighboring states ranges between 4.0 to 5.25 % of the sugar-cane crushed. The B Heavy molasses is ranging in between 6.0 to 7.0 % of sugar-cane crushed. The typical characteristics of C heavy molasses, sugarcane juice and B heavy molasses available in Uttar Pradesh and its neighbouring states is given in Table 1.

The quality of Indian C heavy molasses is inferior as compared to the molasses available in countries such as Brazil and Australia and also varies widely within the country. The reason for inferior quality of molasses is manufacture of sugar by double sulphitation method that involves three and half boiling and use of SO2 for sulphitation. However, the quality of B Heavy molasses is superior as compared to C molasses in terms of its fermentability. Yield of ethanol from final/ C heavy molasses is 235 litres/Ton while it is 310 litres/Ton from B heavy molasses.

***Table 1: Characteristics of sugarcane juice, B heavy molasses and C heavy molasses***

| S. N. | Parameters | C Molasses | BH Molasses | Cane syrup |
|---|---|---|---|---|
| 1 | pH | 5.01 | 5.41 | 4.74 |
| 2 | °Brix | 88.0 | 86.0 | 57.00 |
| 3 | Total Reducing Sugars % | 50.08 | 61.00 | 52.58 |
| 4 | Unfermentable Sugars % | 5.01 | 2.60 | 0.67 |
| 5 | Fermentable Sugars % | 45.07 | 58.40 | 51.91 |
| 6 | Carbonated ash % | 10.0 | 9.8 | 1.0 |
| 7 | Sulphated ash % | 13.0 | 11.5 | 2.5 |
| 8 | F/N | 1.05 | 2.2 | 6.4 |
| 9 | Volatiles acidity (ppm) | 5000 | 2000 | 1000 |
| 10 | Sp. Gravity | 1.40 | 1.35 | 1.19 |
| 11 | Total microbial count (CFU/gram) | $5.6 \times 10^3$ | $8.8 \times 10^1$ | $7.5 \times 10^1$ |
| 12 | Shelf life | 1-2 years | 1-2 years | Perishable |

## 3.0 Quality of Indian molasses

As far as Indian molasses is concerned the quality of molasses is usually judged on the basis of following:

i. **Fermentable to Non-fermentable (F/NF) ratio:** This should be as high as possible but not less than 1

ii. **Level of contaminants in molasses:** The average contamination level in molasses is about $10^3$ CFU/g of molasses. Higher level than this results in poor fermentation of molasses. (here, CFU/g- Colony Forming Unit per gm)

iii. **Total Organic Volatile Acidity (TOVA) of molasses:** For good quality molasses the TOVA should be in the range of 3000-3500 ppm. Higher volatile acidity is an indication of contamination of the molasses and the volatile acids generated retards the fermentation rates.

iv. **Sludge content of molasses:** The normal range of sludge content of molasses is 8.0-12.0% (v/v). Higher sludge content results in lowering the effective volume of fermenters and scaling problems in equipment and distillation columns.

## 4.0 Manufacturing Process of Alcohol

Production of alcohol comprises broadly of three sections, viz. (i) Fermentation (ii) Distillation and (iii) Effluent treatment and disposal.

(i) **Fermentation:** Alcoholic fermentation is the process in which sucrose and reducing sugars (i.e. glucose and fructose) present in molasses/sugarcane syrup are converted into ethyl alcohol and carbon dioxide by the action of several enzymes present in yeast.

(ii) **Distillation:** It is a purification step wherein the fermentation wash generated in the fermentation section, is subjected to heat in the analyzer column to separate alcohol from the wash on the basis of difference in boiling points. The alcohol is further subjected to purification in the pre rectifier and rectifier columns to obtain rectified spirit (95% v/v).

(iii) **Effluent treatment:** The effluent generated from analyzer column after distillation of alcohol is known as spent wash while further purification of alcohol in pre rectifier and rectifier columns results in generation of weak effluent known as spent lees. Treatment of spent wash and spent lees is the last step in the production of alcohol.

Typical alcohol manufacturing process from molasses is illustrated in Fig 1 while manufacturing process from sugarcane juice is illustrated in process flow diagram given in Fig 2.

***Figure 1: Typical process flow diagram for alcohol production from molasses***

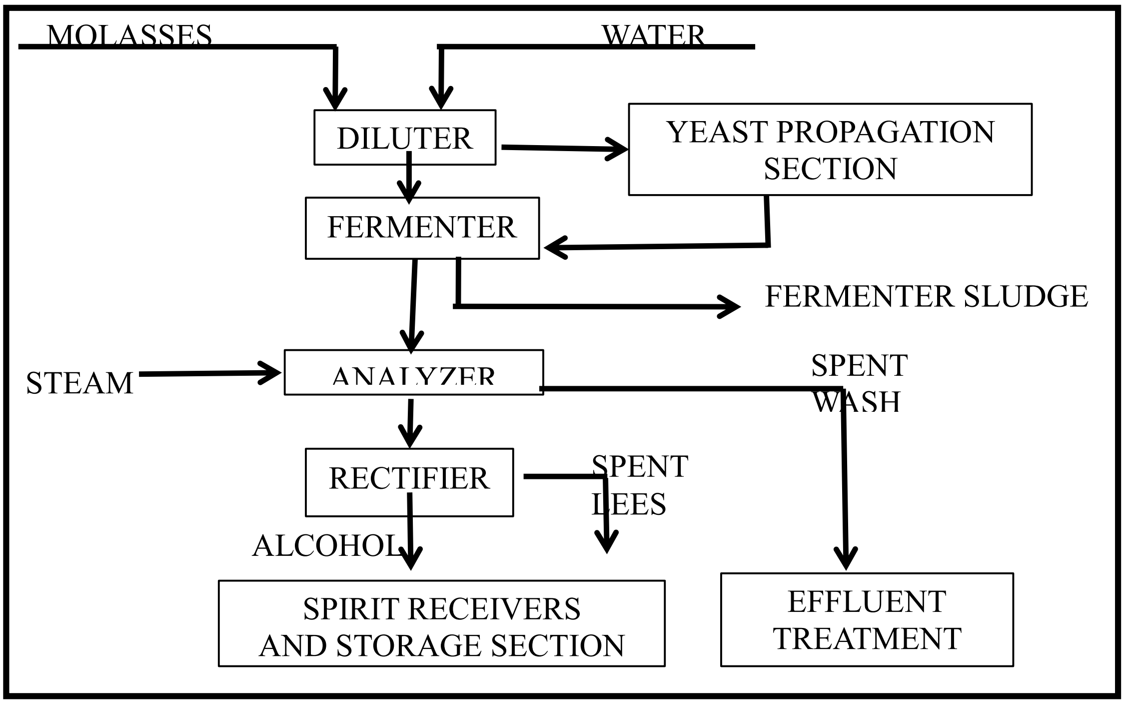
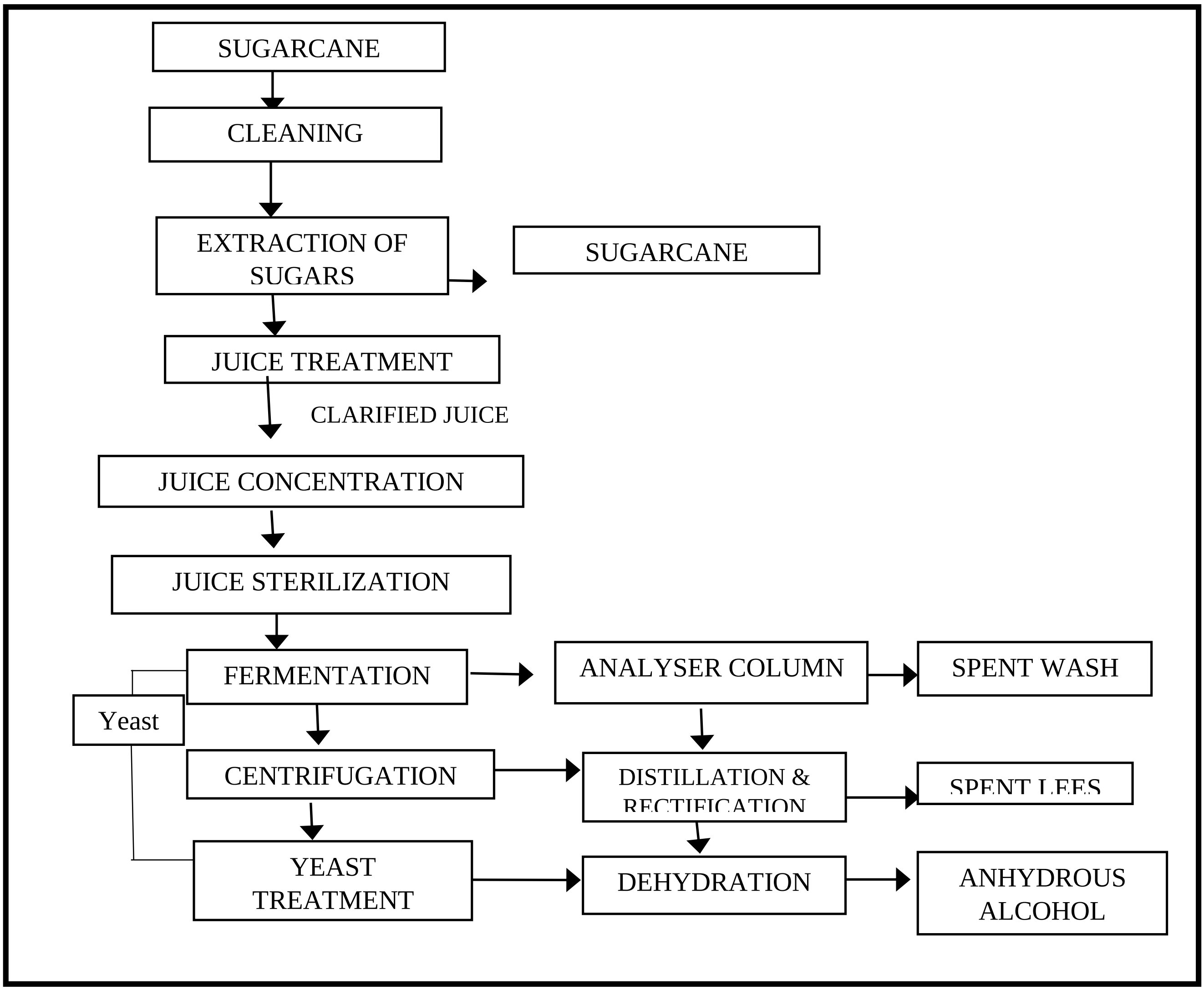



***Figure 2: Process flow diagram for alcohol production from sugarcane juice***



## 5.0 Problem analysis and Spent wash characteristics

Depending on the quality of molasses used, technology adopted for fermentation and distillation system employed, the raw spent wash generation (before concentration) can vary between 8.0 liters to 16.0 liters for every liter of alcohol produced. The general characteristics of spent wash generated by different fermentation techniques is given in Table 2. Comparative characteristics of spent wash generated from different feedstock in fed-batch fermentation is given in Table 3.

Spent wash management is a challenge as disposal of the large volume of bio-methanated spent wash and /or raw spent wash (on average 10-12 KL/KL of alcohol in case of C heavy molasses) having high Chemical Oxygen Demand (COD) & Biochemical Oxygen Demand (BOD) and salt load is a serious concern for the distilleries. Pollution control authorities in the country have stipulated stringent norms for proper disposal of spent wash as its uncontrolled discharge may affect the land surfaces and water bodies, particularly the physical, chemical and biological properties of soil and water.

The enforcement of norms for effluent treatment and discharge in Indian distilleries is to achieve fresh water conservation and prevention of pollution while taking into consideration the limited availability of land for disposal as compared to the norms followed in other countries.

Distillery spent wash has very high BOD, COD and high BOD/COD ratio. The amount of inorganic substances such as chlorides, sulphates, phosphates, potassium and calcium are also very high. Its recalcitrant nature is due to the presence of melanoidins, caramel, polyphenols and variety of sugar decomposition products such as anthocyanins, tannins and different xenobiotics compounds. The unpleasant 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. High COD, total nitrogen and phosphate content of spent wash can result in eutrophication of natural water bodies. The highly coloured compounds of the spent wash reduces sunlight penetration in water bodies, which in turn decreases both photosynthetic activity and dissolved oxygen concentration thereby affecting aquatic life.

Uncontrolled or random application of distillery spent wash on land is hazardous to the vegetation. It is reported to reduce soil alkalinity and manganese availability, thus inhibiting seed germination. Use of bio-methanated spent wash for irrigation without proper monitoring can affect the groundwater quality by altering its physicochemical properties such as colour, pH, electrical conductivity etc. due to leaching of the organic and inorganic ions.

The huge mass of effluent with highly objectionable organic matter renders the spent wash from distilleries unfit for direct discharge on land, irrigation as well as discharge into rivers or streams. Decomposition of spent wash emits very bad smell causing atmospheric pollution. Therefore, proper treatment of this effluent is necessary.

***Table 2: Raw spent wash characteristics from C heavy molasses***

| **Sr.No.** | **Parameter** | **Batch process** | **Cascade process** | **Biostil process** |
|---|---|---|---|---|
| 1 | Volume, L/L Alcohol | 14-16 | 10-12 | 8-10 |
| 2 | Colour | Dark brown | Dark brown | Dark brown |
| 3 | pH | 3.7-4.5 | 4.0-4.3 | 4.0-4.2 |
| 4 | COD | 80,000-1,10,000 | 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 | Total Solids<br>Total Volatile<br>Inorganic dissolved | 90,000-1,20,000<br>60,000-70,000<br>30,000-40,000 | 1,30,000-1,60,000<br>60,000-75,000<br>35,000-45,000 | 1,60,000-2,10,000<br>80,000-90,000<br>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 -13 are in mg/l.*

***Table 3: Raw spent wash characteristics generated from different feedstock***

| S. N. | Parameters | C Molasses | BH Molasses | Cane syrup | Cane syrup After recycle |
|---|---|---|---|---|---|
| **1** | **pH** | **4.0** | **4.2** | **4.5** | **4.5** |
| **2** | **Color** | **Dark Brown** | **Yellowish brown** | **Pale Yellow** | **Pale Yellow** |
| **3** | **Quantity (L/L alcohol)** | **10** | **8** | **6** | **3** |
| **4** | **°Brix** | **12** | **8** | **2.5** | **4.5** |
| **5** | **COD (mg/L)** | **120000** | **80000** | **25000** | **45000** |
| **6** | **BOD (mg/L)** | **60000** | **40000** | **12000** | **22000** |
| **7** | **Dissolved solids (mg/L)** | **60000** | **50000** | **18000** | **24000** |
| **8** | **Suspended solids (mg/L)** | **30000** | **20000** | **3000** | **6000** |
| **9** | **Total solids (mg/L)** | **90000** | **70000** | **21000** | **30000** |
| **10** | **Nitrogen (mg/L)** | **1000** | **700** | **400** | **600** |
| **11** | **Phosphorus (mg/L)** | **300** | **200** | **100** | **150** |
| **12** | **Potassium (mg/L)** | **10000** | **4000** | **1000** | **1500** |

Although several technologies have been introduced for treatment of raw spent wash generated by distilleries, these include various biological treatments (anaerobic and aerobic), controlled land application, physicochemical and thermal treatments among others; the capital and recurring cost involved in the treatment of huge quantity of distillery spent wash to comply with stipulated standards is often equal to or higher than the cost of the distillery plant itself. Therefore, there has been a shift from end of pipe treatment to an integrated waste management comprising of control of manufacturing process, solid waste management and recovery from waste.

Anaerobic digestion/bio-methanation is a commonly used primary treatment method for spent wash generated from molasses based distilleries in India. The characteristics of bio-methanated spent wash in case of C heavy molasses are given in Table 4. However, even after bio-methanation, the COD and BOD levels are quite high and the colour is dark brown/blackish thereby indicating that it is not possible to dispose this primary treated spent wash though drains or through uncontrolled or indiscriminate land application. The bio-methanated spent wash generated from use of B-Heavy molasses or sugarcane syrup will have relatively lower COD, BOD and total solids as compared to spent wash generated from use of C heavy molasses. Irrespective of the type of raw material used, it is necessary to adopt an all-encompassing, environment friendly and economically viable treatment system/s for bio-methanated/raw spent wash.

***Table 4: Typical Characteristics of Bio-methanated spent wash from C heavy molasses***

| Sr. No. | Parameters | Bio-methanated spent wash |
|---|---|---|
| 1 | pH | 7.0-7.5 |
| 2 | COD | 25000-35000 |
| 3 | BOD | 5000-8000 |
| 4 | Total solids | 35000-40000 |
| 5 | Total volatile solids | 6000-7500 |
| 6 | Inorganic dissolved | 25000-35000 |
| 7 | Chlorides | 5000-6000 |
| 8 | Sulfates | 2000-5000 |
| 9 | Total nitrogen | 1000-1200(1.0 kg/$m^3$) |
| 10 | Potassium | 8000-10000 (9 kg/$m^3$) |
| 11 | Phosphorus | 800-1200 (0.8 kg/$m^3$) |
| 12 | Sodium | 600-1200(1.0 kg/$m^3$) |
| 13 | Calcium | 4000-5000(4.5 kg/$m^3$) |

*Note: All the values in mg/l except for volume and pH.*

## 6.0 Review of practices of ferti-irrigation and pre-sown irrigation (one-time land application):

In 2003, CPCB issued charter on Corporate Responsibility for Environmental Protection (CREP) for the existing molasses based distilleries wherein five technologies, namely ferti-irrigation, one time land application (pre-sown irrigation application), bio-composting practices, concentration-incineration system and controlled discharge of pre-treated spent wash into deep sea, were identified for spent wash management so as to minimize the impacts on recipient environment and distillery units were asked to comply with any one or any combination of the five technologies within a period of three years.

Performance of distilleries practicing ferti-irrigation, one-time land application (pre-sown irrigation), and bio-composting was assessed by CPCB on the basis of inspections undertaken for a period of five years from 2006-2011 under the ESS programme and major findings are summarized as follows:

- Of 111 distilleries inspected during the period 2006-2011, significant/serious violations were observed in 70 distilleries (63% non-compliance).
- General treatment practice recommended for distilleries adopting ferti-irrigation or one-time land application was bio-methanation followed by primary clarifier, two-stage extended aeration system, secondary clarifier, sludge drying beds followed by storage of partially treated effluent in lined/ unlined lagoons for ferti-irrigation/one-time land application. However, most distilleries were found to undertake only biomethanation.
- As per guidelines, for ferti-irrigation and pre-sown irrigation, the recommended BOD level in treated spent wash was 800 mg/l and 7000 mg/l respectively. However, inspection reports indicated use of spent wash with BOD > 20000 mg/l, COD ≥ 80000 mg/l for land application. In case of pre sown irrigation, often raw spent wash was found to be used.
- Due to the high organic load of spent wash, dilution of up to 12-20 times was required to meet the critical water quality parameters thereby resulting in huge consumption of fresh water.
- Based on the quantity of spent wash generated and dilution to meet the nutrient requirements of the crops, land area of 20-25 ha/KL alcohol production was required to match the spent wash disposal.
- Recommended command area for ferti-irrigation was radial distance of 20km but most distilleries were found to have only few hectares of land and the available land was scattered over large distances making monitoring and effective control over the practice almost impossible.
- As per guidelines, nitrogen level in spent wash has to be adjusted before application

in accordance to the nitrogen requirement of the crop and soil type. Also, spent wash to be applied on alternate years. However, this resulted in practical problems such has high dilution levels, huge land requirement, one to two irrigations to achieve desired nitrogen level, huge accumulation of spent wash in lagoons ultimately leading to indiscriminate discharge on land and surface water.

- There was found to be zero compliance to the requirement of distribution networks of impervious conduits, impervious liner system etc., thereby leading to leaching and ground water contamination.
- Effluent flow through earthen channels was not permitted but all distilleries were foundto distribute spent wash only through earthen channels.
- The incidences of spent wash disposal along with storm water into nearby water bodies through bypass pipelines/drains were also reported.
- Ground water samples were found contaminated having colour, high TDS, nitrate and conductivity.
- As per guidelines, distilleries were permitted to have lagoon capacity equivalent to one fourth of average yearly utilization of spent wash, but almost all distilleries were found to store huge quantity of spent wash in lined and unlined lagoons. The main reason for accumulation of spent wash was the high dilution factor required to meet the nutrient requirements.
- For pre sown irrigation practice, it was recommended that maximum of one third of the spent wash generated per year would be utilised for pre-sown irrigation, instead, in practice, 50-60% of the total generated spent wash was disposed through irrigation.
- Distilleries adopting pre sown irrigation practice for spent wash management were to undertake monitoring of physico-chemical parameters of irrigated land two times in a year but none of the distilleries were found complying with the same. Instead inspectionteams reported ground water contamination as well as increase in EC values of the soil after application of spent wash and subsequent reduction with crop growth whichimplied leaching.
- Report indicated that there was little or no compliance to the guidelines issued in CREPfor distilleries adopting pre sown irrigation practice.
- There was no compliance w.r.t submission of application by distilleries to SPCB and record keeping of the transit by vehicles used for transporting spent wash for irrigation. This resulted in indiscriminate disposal of raw spent wash on land and surface water.

As per the guidelines for pre sown irrigation practice, application of spent wash should be on the basis of nitrogen requirement of crops, soil type as per the advice of experts from agricultural institutions. Also, application to be done at least 30 days in advance ofsowing and onset of rains and nitrogen requirement of the crop to be applied in a single dose. However, compliance to these guidelines required huge land area to match the disposal of spent wash and led to accumulation of huge quantity of spent wash in lined and unlined lagoons. Also, one irrigation required to achieve the nitrogen requirement hence further irrigations carried out with only fresh water.

- Studies carried out by various agriculture universities found that pre sown irrigation ledto a. accumulation of salts in the soil and subsequent leaching over time; b. decrease in soil alkalinity over a long period of time.
- Guidelines w.r.t monitoring of irrigation practices, included analysis of spent wash stored in lagoons every 15 days; monitoring of physico-chemical characteristics of soil two times in a year with one representative sample to be collected per 50 ha, at 30 and 60 cm depths; EC of saturation extract of the soil sample not to be allowed to increase beyond 4.0 mmhos/cm and 20% increase in EC above the background level should be a matter of concern; pH of the extract should be less than 8.5 and exchangeable sodium percentage should not exceed 15. However, in practice there was zero compliance to theaforementioned guidelines. No monitoring was carried out due to practical constraints such as for soil samples ≥10000 samples were required to be analysed per year.
- As per guidelines, ground water quality was to be monitored two times in a year (pre &post monsoon) at one station per 50 ha in the command area. No monitoring carried out since more than 2500 sampling locations were needed. Moreover, even scientific studies undertaken by agriculture institutes did not cover ground water quality.
- Guidelines suggested that values of BOD and Nitrate-N in ground water should not exceed 3 mg/L and 10 mg/L, respectively. Value of TDS should not increase by 20% ofthe background value subject to a maximum increase of 150 mg/L. In practice, CPCB inspection teams reported wide scale ground water contamination with colour, high nitrate, high TDS and conductivity.

Additionally, guidelines suggested setting up of at least five soil and water quality monitoring control stations in areas where spent wash irrigation was not practiced and sampling from these stations would be carried out every six months. In the event of firstobservation of contamination, the effluent application to be stopped immediately andthe distillery would inform the SPCB accordingly. The concerned distillery shall be solely responsible for reclaiming the soil and water quality at their cost and make good any damage. Alternate drinking water supply to be provided in the affected area by the distillery. Again in reality there was zero compliance and although environmentalcontamination was reported from many places. Distilleries did not have resources for remediation programme.

- Distilleries adopting irrigation practices were directed to install five hand pumps, about 50 m from the storage tanks, encircling the entire area of the tanks, for collection of samples, every six months. None of the distilleries were found complying.
- As per the irrigation management plan, spent wash shall not be utilized for irrigation during rainy season and sowing period. Also, in areas where the rainfall is between 100 and 200 cm/year, irrigation may be required only during the dry spells of the rainy season while ferti-irrigation may be carried out in rainy season in areas where the rainfall is less than 100 cm/year. Thus, spent wash irrigation could be carried out only for six months per year.
- For distilleries operating throughout the year, spent wash management through ferti-irrigation and pre sown irrigation, were found inadequate to match with the spent wash generation.

In the 147th meeting of the Central Board held on 23rd May,2008, the following observations were made:

1. Composting, ferti-irrigation and one-time land application cannot be performed during rainy season. Thus, in rainy season, distilleries had to stop these spent wash management options as well as alcohol production in rainy season. However, in practice distilleries continued with production and land application even during rainy season leading to large scale surface runoff.
2. The distilleries extract huge volume of ground water for dilution of the treated effluent to meet the requirements of prescribed standards for ferti-irrigation and one- time land application, which is not an environmentally sound practice and against policy of water conservation.
3. For ferti-irrigation, large amount of land (9 Ha per KL of alcohol) is required. Since industries themselves don’t have access to such large area, they partner with local farmers. However, it is practically impossible to monitor and control such large land area scattered in the radial area of ≥20 km.
4. The practices of ferti-irrigation and one-time land application resulted in accumulation of huge quantity of spent wash in lined and unlined lagoons.
5. Indiscriminate disposal of untreated SW on land/ frequent discharge into surface water bodies.
6. Instances of environmental damage have been reported from Uttar Pradesh, Punjab, Tamil Nadu and Karnataka due to violation relating to these practices.
7. Studies by the agriculture universities were unable to establish that the decrease in available organic/ inorganic soil contents with time is due to uptake by crop only.
8. Most of the studies were aimed to assess manorial value and lacked proper ground water quality impact assessment/leachability study of the soil mixed with spent

wash.

- Based on these observations, the Board considered and approved the following recommendations which were forwarded to MoEF&CC vide letter dated 04.06.2008:
  a. Although it is likely that these effluents due to their nutrient composition may facilitate better yields in the beginning but continued and indiscriminate use can lead to salt accumulation in the soil, endangering its productivity and sustainability. Subsequent leaching with time leads to groundwater contamination.
  b. Chloride and sulphide concentration is high is spent wash and these compounds pose serious threat to soil environment under long term use. Therefore, it becomesessential to undertake detailed investigation into the dynamics of high salt load in the soil, groundwater and atmosphere continuum system.
  c. According to recent research, distillery effluent released on soil surface, contaminate ground water. Due to high salt contents, spent wash retard seed germination and plant growth.
- Thus, under these circumstances, in 2008, the Central Board resolved that distilleries not complying with the required environmental standards may be asked to switch over to emerging technologies from existing practices of composting, ferti-irrigation and one time land application of spent wash in a time bound manner and shall achieve zero liquid discharge.
- Zero Liquid Discharge was implemented in the distilleries operating in Ganga main stem vide CPCB direction dated 07.12.2015 issued under Section (18) (1)(b).

## 7.0 Objectives of the Charter implementation programme

The implementation of a validated action plan by industrial units discharging their effluent into River Ganga and its tributaries is considered an effective measure for prevention and control of industrial pollution. Industrial effluent discharge is a major contributor to pollution in River Ganga and in this regard, distilleries have been identified as one of the main sectors contributing to industrial pollution in River Ganga.
The generation of large volume of spent wash with high pollution load by the distilleries has led the pollution control authorities in India to initiate the implementation of strict environmental norms including zero liquid discharge of process and non-process effluents from distilleries.

CPCB has taken initiative to assess the effluent treatment plant performance and achievement of the prescribed norms by distilleries in the Ganga basin. CPCB convened meetings of distilleries on 11-05-2017 and 24-05-2017 in Lucknow. In these meetings it was decided that all concerned units will submit Effluent Treatment Plant (ETP) adequacy reports and upgradation plan duly validated by reputed institutions like IITs or Vasantdada Sugar Institute (VSI) or National Sugar Institute (NSI). Subsequently, CPCB issued Direction during January to June, 2017 under Section 5 of the Environment (Protection) Act, 1986, to 40 operating molasses based distillery units

CPCB has also constituted an expert committee to formulate Action Plan/ Charter for upgradation of manufacturing process technology, effluent treatment system to ensure adoption of best practices for effective spent wash management by distilleries identified to be discharging effluent into river Ganga main stem and its tributaries.

The terms of references of this expert committee were as follows,

1) To identify and assess issues related to environmental pollution from Distilleries.
2) To assess availability and efficacy of cleaner/advance technology, state of the art technology and to formulate an Action Plan/Charter for upgradation of manufacturing process technology, effluent treatment system and adoption of best practices for implementation of spent wash management by distilleries identified as discharging effluent into river Ganga main stem and its tributaries and to prepare a time bound road map for it.
3) To assess and validate reports related to manufacturing process technology, effluent treatment system adequacy, augmentation/upgradation action plan, water audit &mass balance, assessment of spent wash and other effluent generation and action plans for implementation of the spent wash management, prepared by individual distilleries identified to be discharging effluent into river Ganga main stem and its tributaries.

The Expert Committee consisted of representatives from IIT, VSI, NSI, All India Distillers' Association (AIDA), Indian Sugar Mills Association and industry representatives. The Charter has been developed based on the deliberations that took place during the several meetings of the Expert Committee.

The main objective of formulating the Charter is to encourage the distilleries operating in the Ganga basin to comply with the prescribed environmental norms, accomplish desired level of environmental protection and achieve the objectives of the National Mission for Clean Ganga. The objectives can be achieved through upgradation of process and downstream effluent treatment technologies, along with upgradation of practices and environmental performance, besides substantial reduction of freshwater consumption as well as wastewater generation.

The Charter takes a holistic approach for pollution prevention, adoption of best practices, improvement/upgradation options in process and effluent treatment technologies including reduction of freshwater requirement through water recycling and implementation of on-line monitoring system. However, it is mandatory for the distillery industries to comply with the prescribed norms. The Charter will facilitate distilleries to achieve prescribed norms as well as initiate sustainable pollution control measures.

## 8.0 Proposed Strategy with holistic approach

Distillery sector poses two main problems - one, it has extremely high pollution potential and two, it is extremely water intensive.

- Pollution caused by distillery spent wash is one of the most critical environmental problem. Therefore, strict effluent discharge standards were notified by Ministry of Environment and Forest (MoEF), Government of India vide GSR 176(E), April 2, 1996, the effluent from distillery industry should have pH between 5.5-9.0, suspended solids 100 mg/l, and maximum BOD level of 30 mg/l for disposal into surface water and 100 mg/l for disposal on land. It also suggested that all efforts must be done to remove colour and unpleasant odour, as far as possible. The discharge standards for fermentation industries as per amendment are presented in Table 5. Despite standards imposed on effluent quality, untreated or partially treated effluent very often finds access to watercourses. Therefore, distillery waste management through exploitation of its nutritive potential for production of various high value compounds is a sustainable holistic waste management approach.

***Table 5: Standards notified by MoEF vide GSR 176(E), April 02, 1996 for fermentation industry***

| Industry | Parameters | Standard |
|---|---|---|
| **Fermentation industry (Distilleries, Maltries & Breweries)** | | **Concentration in the effluent not to exceed mg/l (except for pH and colour & odour)** |
| | pH | 5.5-9.0 |
| | Colour & Odour | All efforts should be made to remove colour & unpleasant odour as far as practicable |
| | Suspended solids | 100 mg/l |
| | BOD (3 days at 27°C) | 30 mg/l for disposal into inland surface water/river/stream<br><br>100 mg/l for disposal on land or for irrigation |

- Management of water in the distilleries needs a two pronged action plan. First is to reduce water consumption through process improvements along with reduction in fresh water consumption through recycle and reuse of water. Several technological and process improvement options are available to reduce net freshwater consumption, thereby reducing the amount of effluent generated. Second is to have quantum improvement in the individual Effluent Treatment Plants (ETPs) by adding effective and additional treatment units. This would result in achieving necessary material balance as well as producing industry grade water reusable for molasses dilution or as make-up water in cooling towers.

The Charter is aimed at facilitating distilleries to shift from an end-of-pipe treatment approach to an integrated water and waste management system based on green chemistry concept.

Other suggested strategies include:

a. A strict metering of the water used and spent wash generated is recommended.
b. Extensive and regular monitoring protocol is to be followed by regulatory authorities for improved environmental performance of the distilleries.
c. Third party involvement is recommended for planning, assessment, design and monitoring of implementation measures as prescribed in the Charter. In this regard, IITs, VSI and NSI as well as Distillers' Associations can play a pivotal role in facilitating the individual distilleries, concerned SPCBs as well as CPCB in implementing the Charter in a time bound and efficient manner.

Various important factors viz. present capacity of each distillery in Ganga River Basin, raw material being used (whether sugarcane juice, BH molasses or C heavy molasses), quality of molasses available (in case if molasses is used), fermentation & distillation technologies adopted, number of working days, generation of spent wash per liter of alcohol production, present treatment scheme adopted for treatment and disposal of distillery effluent, availability of filler material/press mud for scientific un-leachable bio-composting and availability of utilities such as steam, power, water etc. for proposed spent wash management scheme can be taken into consideration while preparing the action plan for each distillery.

## 9.0 Benchmarking of process technology vis-a-vis spent wash generation norms

**The manufacture of ethanol involves two main processes-fermentation and distillation.**

a. **Fermentation:** Alcoholic fermentation is the process in which sucrose and reducing sugars (i.e. glucose and fructose) present in molasses are converted into ethyl alcohol and carbon dioxide by the action of several enzymes present in yeast. However, all the sugars cannot be converted into alcohol. Some sugars get converted to products other than ethyl alcohol such as yeast cell biomass, glycerol, succinic acid and other minor by-products leading to decrease in ethanol yield. Typically, based on the quality of molasses available in UP and neighbouring states, 1 MT of C heavy molasses containing 38-40 % Fermentable Sugars (FS) (sucrose + glucose + fructose) can yield about 225 to 235 liters of Rectified Spirit (RS). As mentioned earlier, the fermentable sugar content of the molasses plays an important role in alcohol yield. The spent wash generation in distillery also depends on fermentation process technology and alcohol concentration achieved in fermented wash (Table 6). There are three major types of fermentation process technology, namely, batch fermentation, fed batch fermentation and continuous fermentation which are elaborated in Section 12.0. The higher the alcohol concentration achieved in fermentation, lower will be (i) fresh water requirements for molasses dilution, (ii) spent wash generation, and (iii) steam requirement for distillation.

***Table 6: Comparison of different fermentation systems using C heavy molasses***

| Sr No | Parameters | Batch Fermentation | Fed-batch fermentation | Cascade continuous Fermentation | Biostil Continuous fermentation |
|---|---|---|---|---|---|
| 1 | Fermentation efficiency | 87-88 | 88-90 | 89-91 | 90-91 |
| 2 | Alcohol % in wash (v/v) | 8.0-8.5 | 9.0-10.0 | 8.5-9.5 | 8.0-8.5 |
| 3 | Molasses quality | Can work with poor quality of molasses | Can work with poor quality of molasses | Requires good quality molasses | Requires good quality molasses |
| 4 | Retention time, hr | 28-30 | 28-30 | 22-24 | 8-9 |
| 5 | Spent wash generation, L/L of alcohol | 14-15 | 8-9 | 9-10 | 6-7 (with weak beer recycle) |
| 6 | Susceptibility to contamination | Not highly susceptible | Not highly susceptible | Highly susceptible | Not susceptible |

**b. Distillation:** It is a purification step wherein the fermentation wash generated in the fermentation section, is subjected to heat in the analyser column to separate alcohol from the wash on the basis of difference in boiling points. The alcohol is further subjected to purification in the pre rectifier and rectifier columns to obtain rectified spirit (95% v/v). Distillation is the most energy consuming process and hence is provided with utmost automation and is designed for maximum energy conservation. There are two types of distillation: conventional atmospheric distillation and multipressure distillation systems. Multipressure distillation systems offer several advantages such as reduced steam consumption, improved alcohol quality because of improved separation of impurities, reduced scale formation, reduced spent wash generation, PLC based automatic operations, reduced formation of impure alcohol etc.

The comparison between atmospheric and MPR distillation systems is given in the following Table 7.

***Table 7: Comparison between atmospheric and MPR distillation systems***

| S. No. | Particulars | Atmospheric Distillation | Multi Pressure Distillation |
|---|---|---|---|
| 1 | Distillation Efficiency | 97-98% | 98.50% |
| 2 | Steam Consumption | 3.5 Kg/Lit. of R.S. production | 2.2 Kg/Lit. of R.S. production |
| 3 | Impure spirit production | 10-15% | 5-6% |
| 4 | Down Time | Very frequent due to scaling problems in wash boiling column | Rare shutdown are required for very short duration |
| 5 | Plant operation | Manual | PLC/SCADA based control |
| 6 | Spent wash generation | 12-15 Lit/Lit of alcohol production | 9-10 Lit/Lit of alcohol production |
| 7 | Reuse of steam condensate | Nil | 80 % condensate can be used as boiler feed water |
| 8 | Finished products | Configured to produce one at a time | Two products can be produced depending on requirement |
| 9 | Quality of R.S./ENA | As per I.S. specifications | Better resolution of impurities. Matches with international specifications |
| 10 | Selling price | Lower than same alcohol produced in MPR distillation plants | Higher than same alcohol produced in atmospheric distillation plants |

It is difficult to benchmark the process technology with spent wash generation as the spent wash generation largely depends on the alcohol concentration achieved in fermentation which in turn depends on the quality of raw material/molasses available, strain of yeast used and other parameters maintained during the fermentation.
Depending upon the technologies used for fermentation, distillation and downstream effluent treatment as well quality of molasses used, the spent wash generation can vary from 1.5 to 15.0 liters per liter of alcohol produced in case of C heavy molasses.

As mentioned previously, GOI has allowed use of BH molasses or sugarcane juice/ syrup from the sugar season 2019-20 for production of ethanol. With these type of cleaner substrates, the quantity of spent wash generation is reduced and at the same time the characteristics in terms of COD and BOD are also reduced ultimately resulting in reduced pollution load on downstream effluent treatment system as well as reduction in fresh water consumption in distilleries.

In addition, it may be noted that distilleries are now achieving 12-13 % alcohol in wash with BH molasses and 12-14 % with Syrup and therefore the volume of SW generation is reduced with consequent decrease in fresh water consumption. Fermentation efficiencies has also increased by at least 1 to 2 units with use of such cleaner substrates.

## 10.0 Water Consumption in Molasses based Distilleries

Distillery is a water intensive sector. Water is required for dilution of molasses during fermentation, dilution of spirit during distillation (extractive distillation), for generation of steam, as make-up water in cooling towers as well as for non-process application such as for pump gland cooling, vacuum pump, floor and fermenter washing etc. Due to variations in the process as well as quality of raw material (molasses), the total fresh water consumption range from 10 to 20 liters per liter of alcohol production. As per the norms, total fresh water consumption allowed in molasses based distilleries is 15.0 liters for every liter of alcohol production. Higher the water consumption, higher is the volume of spent wash generation having high pollution load. However, advancements in process technologies has lowered fresh water consumption. Table 8 shows the specific fresh water consumption corresponding to different process technologies in case of C heavy molasses.

***Table 8: Process technology and corresponding specific fresh water consumption and specific spent wash generation***

| **Sr. No.** | **Process technology** | **Fresh water consumption (KL/KL)** | **Spent wash generation** |
|---|---|---|---|
| 1. | Typical batch fermentation+ atmospheric distillation | 20 | 15 |
| 2. | Cascade continuous fermentation+ atmospheric distillation | 18 | 12 |
| 3. | Biostill continuous fermentation+ atmospheric distillation | 14.5 | 9 |
| 4. | Biostill continuous fermentation+ MPR distillation | 12 | 8.0 |
| 5. | Fed batch fermentation+ MPR distillation | 12 | 8.5 |

## 11.0 Guidelines for Molasses based Distilleries

1. Molasses based distilleries in India are now classified under the "Red Category".
2. Ministry of Environment and Forest (MoEF), Government of India vide GSR 176(E), April 2, 1996, notified the discharge standards for fermentation industries including molasses based distilleries. As per the standard, the effluent from distillery industry should have pH between 5.5-9.0; suspended solids 100 mg/l, and maximum BOD level of 30 mg/l for disposal into surface water and 100 mg/l for disposal on land. It also suggested that all efforts must be done to remove colour and unpleasant odour, as far as possible.
3. The traditional aerobic and anaerobic methods were incapable of treating spent wash to meet the environmental standards. Biomethanation of raw spent wash is one of the prominent primary treatment methods used in Indian molasses based distilleries. However, even after bio-methanation, the COD and BOD levels are quite high and the colour parameter is extremely high thereby indicating that it is not possible to dispose this primary treated spent wash though drains or through uncontrolled or indiscriminate land application.
4. In 2003, CPCB issued charter on Corporate Responsibility for Environmental Protection (CREP) for the existing molasses based distilleries wherein five technologies, namely ferti-irrigation, one time controlled land application (pre-sown irrigation application), bio-composting practices, concentration-incineration system and controlled discharge of pre-treated spent wash into deep sea, were identified for spent wash management so as to minimize the impacts on recipient environment and asked distillery units to comply with any one or any combination of the five technologies within a period of three years.
5. Between 2006-2010, performance assessment of CREP guidelines was carried out by CPCB officials through surprise inspection of molasses based distilleries. As per the assessment report, there was more than 60% cases of serious non-compliances. Thus, it was resolved that all non-complying distilleries shall 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 and shall achieve zero liquid discharge.
6. In the 147$^{th}$ meeting of the Central Board held on 23$^{rd}$ May, 2008, the following decisions were made:
   a. Proposals for establishing stand-alone distilleries involving composting, ferti-irrigation and one-time land application of spent wash may not be considered by SPCBs/PCC and MoEF.
   b. Proposals for establishing distilleries attached with sugar unit may be considered if they follow any one of the following options:

- Biomethanation 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 SPCBs/PCC/MoEF.

d. The existing distilleries (both stand alone and attached with sugar units) that are not complying will be required to switch over to emerging technologies from the existing technologies (composting/ferti-irrigation, one-time land application) in a time bound manner.

7. In 2015, CPCB issued a direction dated 07.12.2015 under Section 18(1)(b) to all SPCBs to ensure implementation of zero liquid discharge in all the molasses based distilleries including yeast manufacturing units by following either of the two routes as specified below;

   a. Installing systems for solid separation for reduction in volume of spent wash and evaporation – concentration or only evaporation – concentration so as to reduce the volume to min. 40% with 30% solid conc. and water conservation by using appropriate technology such as RO & MEE or only MEE followed by bio composting with press mud from sugar industry.

      Installing system for Evaporation – concentration by using appropriate technology such as M.E.E. and Incineration boiler (Slope fired / mixed with aux. fuel, etc.), using appropriate technology.

      New standalone distilleries/expansion of existing standalone distilleries shall achieve ZLD by concentration and incineration alone.

   b. Installing advance process technologies (continuous fermentation, multi pressure distillation, integrated evaporation, etc.) for reduction of spent wash generation to 6-8 KL/KL of alcohol produced followed by evaporation – concentration and incineration, using appropriate technology such as M.E.E. and incineration boiler.

In addition, industries opting for bio composting shall be directed 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.O. 2776 (E) dated 10.10.2015 under the Fertilizer (Control) Fourth Amendment Order, 2015 issued by Ministry of Agriculture and Farmers Welfare (Dept. 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) –by 31.03.2016.
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 – by 31.03.2016.

Industries opting for concentration-incineration system shall restrict the impermeable storage of spent wash at any stage, to 07 days equivalent of production and excess storage facilities beyond this shall be levelled/dismantled by 31.03.2016 or 30.09.2016 as applicable.

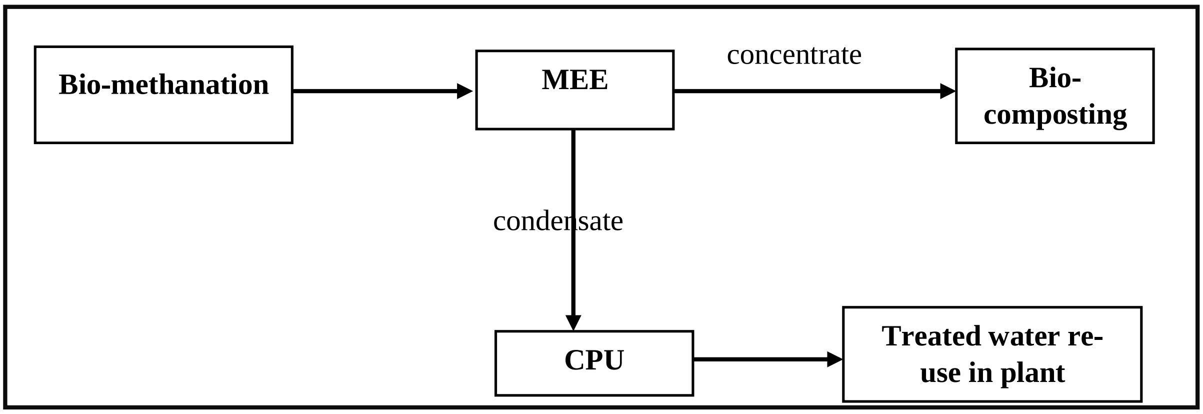
## 12.0 Available Effluent Treatment routes for achieving ZLD

The adoption of zero liquid discharge by molasses based distilleries led to reduction in BOD load from 5.41 TPD in 2017 to 0.026 TPD in 2019 while compliance of distilleries increased from 31% in 2017 to 87% in 2019. In addition, average fresh water consumption for every litre of alcohol produced by distilleries has been reduced from 15 KL per KL of alcohol in 2017 to 10.25 KL per KL of alcohol in 2019; while spent wash generated for every litre of alcohol produced, reduced from 11.1 KL per KL of alcohol production in 2017 to 8 KL per KL of alcohol production in 2019.

The various combinations of effluent treatment technologies which have been adopted by the distillery sector to achieve ZLD are briefly described below.

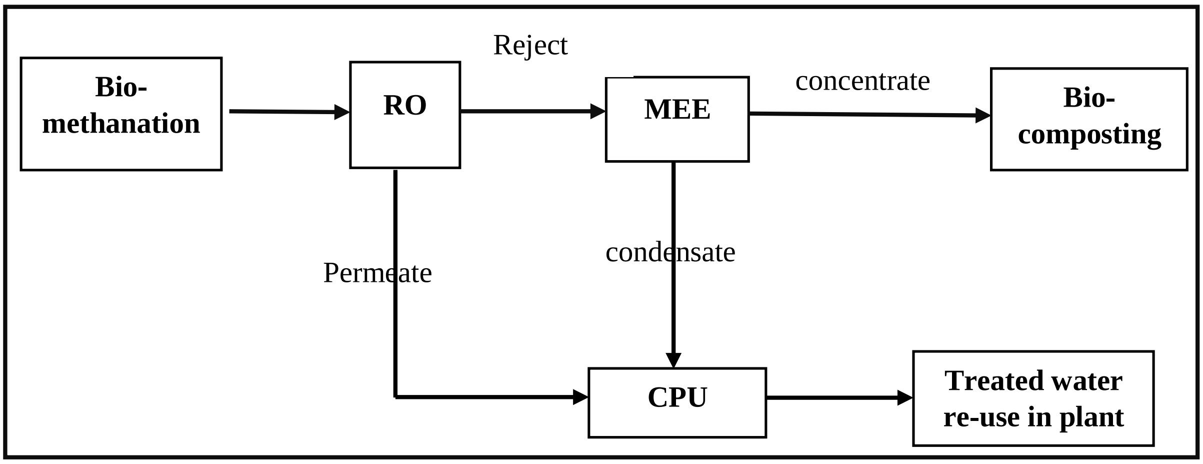
**CPCB does not prescribe or suggest any specific technology to meet the prescribed norms as a policy matter. It is the responsibility of the industry to adopt suitable technologies to achieve ZLD.**

**1.**



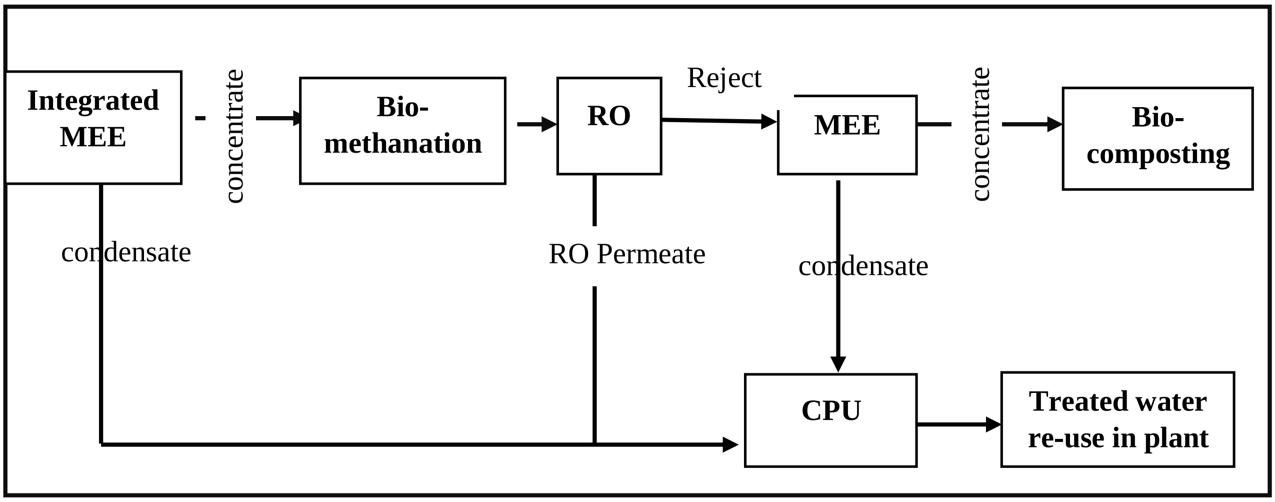

In this route raw spent wash is fed to bio-methanation plant after cooling and bio-methanated spent wash is further concentrated to about 30 % solids through a multiple effect evaporator. The concentrated spent wash is further bio-composted with filler material such as press mud cake. The evaporation plant process condensate and other low strength effluents are then treated in a Condensate polishing Unit (CPU) of suitable technology and treated water is recycled back for molasses dilution or as make-up water for cooling towers.

**2.**



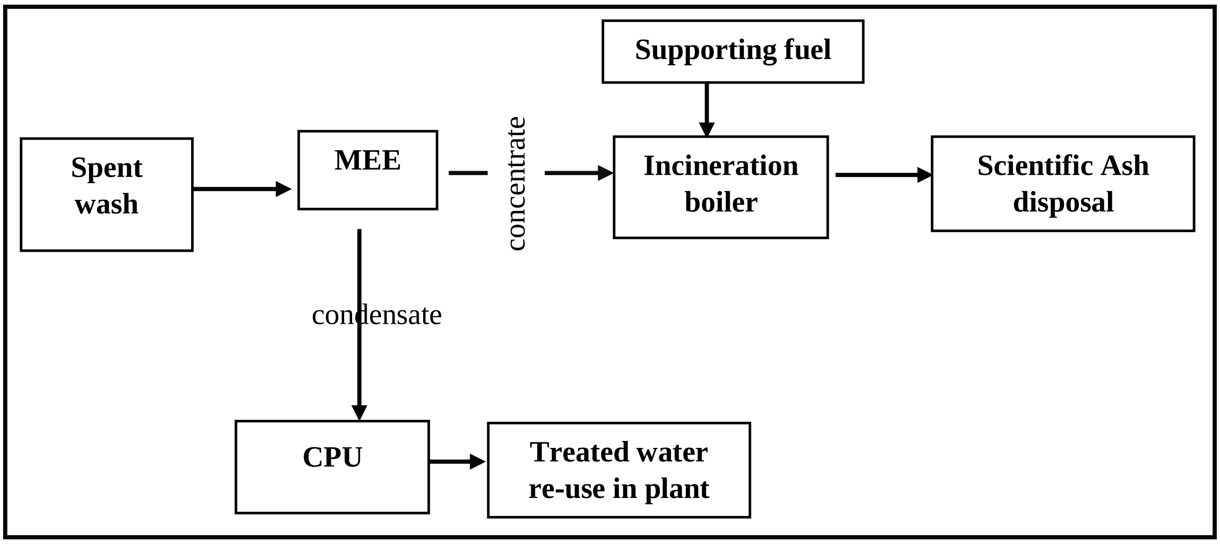

In this route raw spent wash is fed to bio-methanation plant after cooling and bio-methanated spent wash is first concentrated in a Reverse Osmosis (RO) membrane plant. The reject from RO plant is further concentrated to about 30 % solids through a multiple effect evaporator. The concentrated spent wash is further bio-composted with filler material such as press mud cake. The evaporation plant process condensate, RO permeate and other low strength effluents are then treated in a Condensate polishing Unit (CPU) of suitable technology and treated water is recycled back for molasses dilution or as make-up water for cooling towers.

**3.**



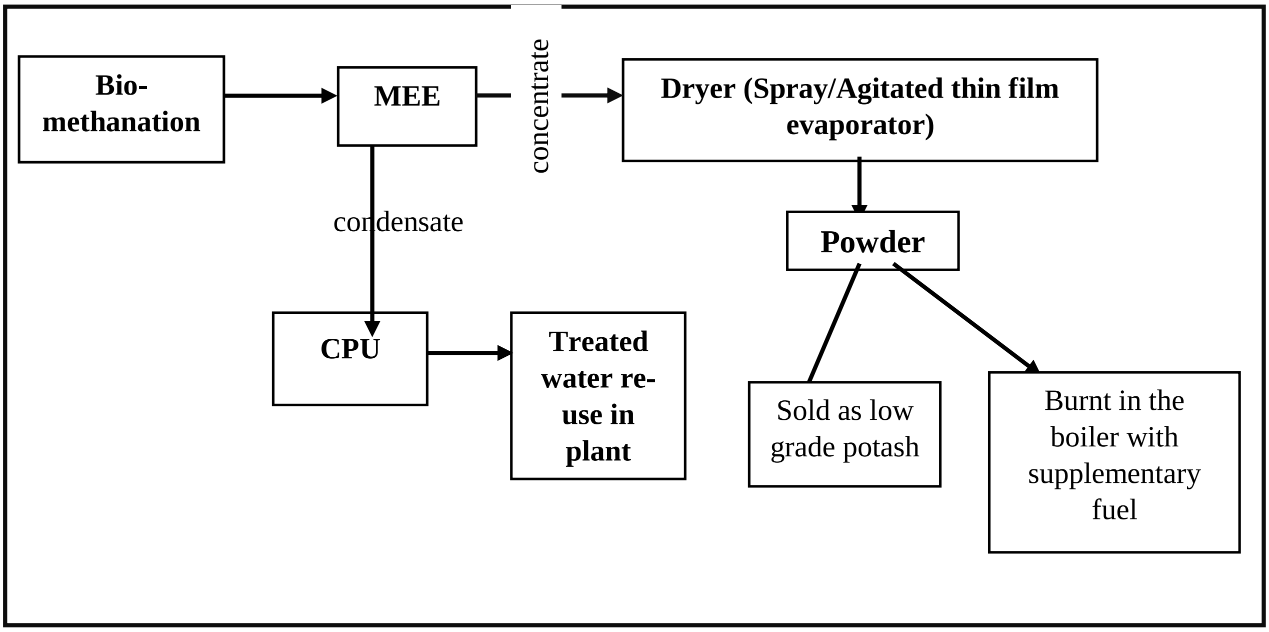

In this route raw spent wash is first concentrated though integrated multiple effect evaporator. The MEE concentrated spent wash is then fed to biomethanation plant after cooling and bio-methanated spent wash is then concentrated in a Reverse Osmosis (RO) membrane plant. The reject from RO plant is further concentrated into MEE before bio-composting with filler material such as press mud cake. The evaporation plant process condensate, RO permeate and other low strength effluents are then treated in Condensate polishing Unit (CPU) and treated water is recycled back for molasses dilution or as make-up water for cooling towers.

**4.**




In this route the raw spent wash is first concentrated though a combination of MEE plants and concentrated spent wash at about 55-60 % solids is fired along with subsidiary fuel (coal or bagasse or rice husk) in specially designed incineration boiler. The high pressure steam produced in the incineration boiler after passing through a turbine is used as process steam in the distillery and MEE plant. The turbine generates electricity necessary for distillery plant operation. The evaporation plant process condensate and other low strength effluents are then treated in Condensate polishing Unit (CPU) and treated water is recycled back for molasses dilution or as make-up water for cooling towers.

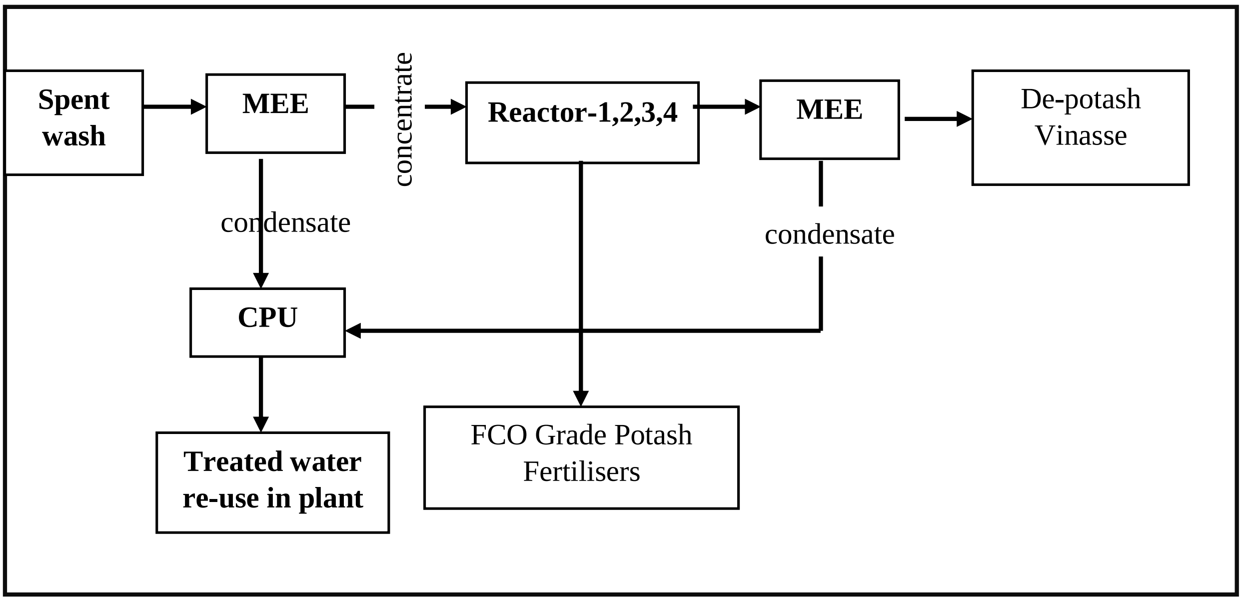
**5.**




In this route raw spent wash is fed to bio-methanation plant after cooling and bio-methanated spent wash is further concentrated to about 40-45 % solids through a multiple effect evaporator. The concentrated spent wash is further dried to powder form through a specially designed dryer system (spray or twin flash or Agitated Thin Film Evaporator (ATFE)). The spent wash powder produced can be sold as low grade potash or can be burnt along with some subsidiary fuel in a boiler. The evaporation plant process condensate and other low strength effluents are then treated in Condensate polishing Unit (CPU) and treated water is recycled back for molasses dilution or as make-up water for cooling towers.

**6.** A new ZLD route for recovery of FCO grade Potash Fertilizer and potash free organics/de-potash vinasse (DPV) from spent wash.

In this patented technology raw spent wash is concentrated to about 25% solids through a multiple effect evaporator (MEE). The concentrated spent wash is then subjected to pre-treatment steps, involving coagulation & clarification / filtration operations, to remove suspended & colloidal particulates and undesired inorganic contaminants.




Subsequently the treated & concentrated spent wash is reacted & filtered for recovery of insoluble potassium salt (as residue) & lean spent wash (as filtrate). The potassium salt is further processed for production of FCO grade potash fertilizer (KCl / $K_2SO_4$ / $KNO_3$ / $KH_2PO_4$ etc.) through reaction, filtration, evaporation & drying steps. Lean spent wash is further treated & concentrated to produce De-potash Vinasse (DPV) [TS: 50-60%]. Condensate streams from evaporation operations (MEE) are treated in Condensate polishing Unit (CPU) and treated water is recycled back for molasses dilution or as make-up water for cooling towers. The process works in similar fashion with bio-methanated spent wash also.

**CPCB is open to other advanced technologies which have been evaluated for their techno-economic viability and operational performance through reputed institutions and which can lead to prevention, control and abatement of pollution in distilleries.**

# 13.0 Best Available Technologies

## 13.1 Yeast Propagation

Most of the distilleries have yeast propagation system where pure yeast culture is developed from laboratory shake flask level to the pre-fermenter scale. High alcohol tolerant and fast fermenting yeast is required for achieving high fermentation efficiency (FE) and high alcohol concentration in fermentation. Propagation of yeast in pure form is the central and most critical aspect in molasses based distilleries. Propagation has to be carried out under totally aerobic conditions with least alcohol generation and at the same time, keeping contaminants at the lowest level. Molasses sterilization/pasteurization has to be carried-out properly during the different stages of yeast propagation. Proper precautions have to be taken to avoid contamination at all stages and for maximizing the yeast count.

New readymade yeast cultures with high alcohol tolerance and high FE in the form of active dry yeast will be available in the future which will be more expensive but will reduce the efforts required and cost of propagation.

## 13.2 Fermentation

In molasses based distilleries fermentation is generally carried out either in batch, fed-batch or continuous fermentation mode. The scientific information on these modes of operations with pros and cons of the processes are given below.

It may be noted that batch fermentation has been a traditional method of fermentation that ends up with lowest fermentation efficiency (FE) and has been replaced either by continuous fermentation or fed-batch fermentation systems.

Continuous fermentation systems provide steady state conditions with respect to time, results in maximum FE and easy to operate. However, continuous fermentation is susceptible to contamination and poor quality of molasses. Cascade continuous fermentation consisting of four fermenters has been most successful under Indian condition.

Cascade continuous fermentation with cell recycle has also been tested in India but suffered with severe contamination problems and thus was not very successful because of inferior quality of C heavy molasses produced by Indian sugar mills.

Biostill continuous fermentation with cell and weak beer recycle has been used by many distilleries and theoretically can result in maximum FE, lowest molasses dilution, lowest water requirement as well as lower spent wash generation. However, there have been some issues with fermentation of poor quality molasses and quality of spirit produced particularly from viewpoint of its potable use. Therefore, most of the Biostill fermentation plants in UP and neighbouring states have been modified to cascade continuous or fed-batch fermentation systems.

Fed-batch fermentation has been adopted recently in Indian molasses based distilleries particularly to cope-up with poor quality of molasses and to achieve higher concentration of alcohol in fermentation broth. Though the FE achieved is slightly less than continuous fermentation systems, the advantage is substantial reduction in spent wash (SW) generation because of higher alcohol concentration achieved in fermentation. Capital investment for fed-batch fermentation system is also higher than other fermentation systems. A four fermenter fed-batch system is commonly used in Indian molasses based distilleries.

From the viewpoint of best available technology (BAT) for upgradation, it can be said that depending on quality of molasses available, continuous or fed-batch fermentation system are most suitable for Indian distilleries.

### 13.3 Fermentation with spent wash recycle

With stringent norms being implemented by pollution control authorities, scarcity of water and the realization of the waste to wealth concept with regard to effluent generated, has resulted in distilleries working towards better effluent treatment and disposal strategies. For example, adoption of continuous fermentation process which involves recycling of spent wash, has led to reduction in water requirement for molasses dilution as well as reduction in volume of effluent generation. However, it may be noted that recycling of spent wash can affect the final product quality, particularly in the case of potable alcohol. Therefore, manufacturers of potable alcohol will have to show caution while utilization of fermentation processes involving spent wash recycling.

### 13.4 Distillation

Traditional method of distillation has been the atmospheric distillation system. However, it has been replaced by multipressure (MPR) distillation systems in many distilleries. MPR distillation systems are based on heat integration concept and incorporate some columns that run under vacuum, some under pressure and some under atmospheric conditions. Reboilers are also incorporated for most of the columns that avoid direct sparging of steam in the columns. Though the capital investment in MPR distillation systems is higher, it offers several advantages such as reduced steam consumption, improved alcohol quality because of improved separation of impurities, reduced scale formation, reduced spent wash generation, PLC based automatic operations, reduced formation of impure alcohol etc. as compared to atmospheric distillation systems.

From the viewpoint of BAT for upgradation, it may be stated that MPR distillation systems are advantageous with respect to reduction in spent wash quantity. Fed-batch fermentation coupled to MPR distillation can result in lowest SW generation, depending on quality of molasses available. It may also be noted that though the volumetric generation of SW will be reduced, the total BOD/COD load (MT/day) will remain the same.

## 14.0 Distillery Effluent Treatment Technologies

There are many technologies available to treat the spent wash generated by distilleries. Various biological treatments (anaerobic and aerobic), controlled land application, physicochemical and thermal treatments have been used in the past. Often the capital cost involved in the treatment of this huge quantity of distillery spent wash to the stipulated standards is equal to or higher than the cost of distillery plant itself. Hence, there has been a shift from end of pipe treatment to an integrated waste management comprising of plant control, solid waste management and recovery from waste for achieving Zero Liquid Discharge.

For treatment of spent wash, various technologies are now available such as reboilers, integrated evaporation systems, bio-methanation, multiple effect evaporation (of raw or bio-methanated spent wash), reverse osmosis (of bio-methanated spent wash), bio-composting, incineration of concentrated spent wash, spent wash drying. Each of these methods have certain advantages and limitations which are briefly described below.

### 14.1 Bio-methanation

Biomethanation of distillery spent is now a well-established effluent treatment system in Indian distilleries with attractive returns in terms of generation of biogas as an energy source (Biogas: 4500–5000 Kcal/$m^3$) with substantial reduction in pollution load. It is also characterized with low production of waste biological solids, low process energy requirement, low nutrient requirement and improving the pH of acidic spent wash. High loading rates can be achieved and active-anaerobic sludge can be preserved for many months. Ideally, distilleries with bio-methanation should run throughout the year. Therefore, bio-methanation is not suitable for seasonal distilleries. CSTR, UASB and thermophilic type digesters are more suitable for molasses based distilleries. Biogas based power generation or CNG (CBG) production can offer higher returns.

## 14.2 Reverse osmosis (RO)

Reverse osmosis is a membrane based separation technique. The feed stream is physically split into permeate and reject. 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. An RO membrane typically rejects 99 % of most ions and most organics over 150 MWCO (molecular weight cut off). About 100 RO plants have been installed in distillery industry in the country. Disc and tube configuration is well established with average 50 % recovery of permeate from BMSW. In operation of RO plants, suspended solids is the most critical factor and needs to be maintained below 2000-3000 ppm. Frequent choking of RO membrane is a common problem faced by distilleries. Permeate can be recycled after proper treatment as make-up water in cooling towers or for molasses dilution. Operational cost is slightly less than MEE plants.

## 14.3 Multiple Effects Evaporators (MEE)

Falling film or forced circulation or fluidized bed evaporators or combination of these are now being used to concentrate raw or bio-methanated spent wash in distilleries. MEEs are highly responsive to alterations of parameters such as energy supply, vacuum, feed rate, concentrations, etc. When equipped with a well-designed automatic control system, they can produce very consistent concentrated product. The fact that falling film evaporators can be operated with small temperature differences makes it possible to use them for concentration up to 30 % solids with low power consumption and short retention time. MEE plants can be operated at much lower $\Delta T$ (difference between jacket and liquid boiling temperature) that is favorable to vapour recompression and consequently, the energy consumption can be reduced.

More than 200 MEE plants have been installed so far in the distillery sector of the country. Scaling can be a severe problem when product concentration above 40 % solids is attempted to be concentrated and it is difficult to remove the scaling. Process condensate requires polishing treatment before reuse in process and non-process applications. Therefore, additional treatment cost is involved. However, integrated raw spent wash 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.

It may be noted that evaporation of bio-methanated spent wash through MEE system is not an easy task. The pH and dissolved gases in bio-methanated spent wash can affect the performance of such type of evaporators.

## 14.4 Bio-composting

Bio-composting of distillery spent wash (concentrated 40% by volume of spent wash generated and 30% solid concentration) with filler material such as press mud cake is a well-established solid phase fermentation technology that can result in ZLD with negligible power requirement. This technology is suitable to the distilleries attached with sugar mills. Bio-compost produced is rich in organic and inorganic micronutrients, which can be sold to farmers and substantial amount of income can be generated. Availability of sufficient quantity of filler material and operation during rainy season are the bottle-necks in operation of bio-composting system.

## 14.5 Incineration of distillery spent wash

Concentrated spent wash can be combusted along with supplementary fuel and entire effluent can be converted into potash rich ash. The thermal energy generated during incineration can be converted in to steam and power and the unit can become self-sufficient in captive consumption of steam and power. There are about 40 spent wash incineration units established in Indian distilleries. Early units have faced serious problems of scaling in evaporators and inherent challenges of ash deposits and clogging in the heat transfer areas of the incinerator. Boiler cleaning frequency is ranging between 15 to 45 days. Due to frequent stoppages and the cleaning process, the incinerator undergoes a cyclic thermal shock resulting in reduced life of the equipment. Desired emissions norms can be achieved by installing multi-cyclone separators or bag filters or electrostatic precipitator. Process Condensate streams can be treated and recycled back for process and non-process applications leading to Zero Liquid Discharge.

### 14.6 Drying of Spent wash

In effluent treatment system, drying is usually the last stage of the system and involves final removal of effluent from the material to convert it in a solid material. Drying is defined as removal of small amount of water from a material by application of heat. Drying commonly involves removal of all or most of the liquid by supplying latent heat to cause thermal vaporization.

Drying makes material (or effluent) more convenient in storage, packaging, transportation, preserving and at the same time improves the quality of final product.

Different types of dryers have been used for spent wash drying such as spray dryer, double drum dryer, spin flash dryer, agitated thin film dryer/evaporator etc.

Other technologies such as aerobic treatment, one time controlled land application of bio-methanated spent wash, ferti-irrigation, mist evaporation etc have been used in past but are now not allowed/encouraged.

## 14.7 Condensate Polishing Unit (CPU) Technologies

In molasses based distilleries there are two types of effluent, one is high strength effluent i.e. spent wash and the second is usually a mixture of low strength effluents i.e. process condensate (from evaporation of BMSW as well as from evaporation of RSW), reverse osmosis (RO) permeate, spent lees, cooling tower blow down, floor washing, laboratory water etc. The low strength effluents in distillery can be recycled back for process and non-process applications after proper treatment. The technology which is used for treatment of low strength effluents is generally called as Condensate Polishing Units (CPU). By using CPU, the low strength effluent quality can be transformed into suitable water quality for process and non-process applications.

Treatment of MEE condensate and RO permeate is necessary before utilization in process activities such as dilution water in fermentation process and as cooling tower make up because MEE condensate and RO permeate contain high COD and volatile fatty acids which contribute to low pH and chemical impurity. Condensate with low pH can lead to retardation of yeast activities and subsequent yield reduction if it is utilized for fermenter dilution. Also, utilization of condensate with low pH as cooling tower makeup water can lead to corrosive damage to the pipelines. Therefore, utilization/recycling of MEE condensate and RO permeate along with other low strength effluents is not feasible unless it is treated in Condensate Polishing Unit to alkalize the treated condensate to a desirable range of pH (6 - 6.5).

A CPU enables the treatment of all low strength effluents generated during treatment of spent wash. This CPU treated water can be recycled back in process/ non-process activities within the distillery premise and hence no liquid will have to be discharged outside by the distillery. Therefore, the role of CPU has become very important in achieving ZLD.

There are several CPU technologies introduced during last 5 years in the distilleries. The following CPU technologies are generally used in distillery industry:

1. Conventional (anaerobic followed by aerobic followed clarification followed by polishing) technology with or without ozonation.
2. Aerobic treatment (such as diffused aeration) followed by clarification system followed by Ultra Filtration (UF) or Reverse Osmosis (RO)
3. Membrane (RO) Technology-Pretreatment followed by RO technology
4. CPU Technology based on Stripping with steam, followed by Ozonation followed by RO

There are different merits and demerits of these technologies and properly selected technology has to be adopted depending on fresh water requirements in the distillery. Conventional technology seems to be well established providing desired results in terms of treated water quality and percentage recovery. However, other cost-effective technologies are also being developed and will be used by distilleries in future. There is a need to evaluate such technologies and therefore, sufficient time should be given to molasses based distilleries to implement them. Distilleries that are proposing to any other advanced technology than what is mentioned above shall follow a defined procedure for verification and ratification of the process which should ultimately ensure that the low strength effluents are treated as per the prescribed standards and recycled back for process and non-process applications to achieve Zero Liquid Discharge (ZLD).

Distilleries consume significant quantities of fresh water and it would be appropriate if distilleries voluntarily to take measures of fresh water conservation.

# 15.0 Performance Norms and Output Conditions for Effluent Treatment Technologies

## 15.1 Biomethanation

About 70 to 80 % distilleries in the country have adopted bio-methanation of distillery spent wash as the primary treatment method. It is one of the well-established technologies for distillery effluent treatment with excellent returns in terms of valuable biogas generation.

***Table 9: Biomethanation performance efficiencies***

| Parameters | Values |
|---|---|
| pH | Slightly alkaline |
| BOD removal efficiency | 85-90% |
| COD removal efficiency | 60-65% |
| Specific biogas generation ($NM^3$/kg of COD destroyed) | 0.45 – 0.55 |
| % of Methane in biogas | 55-65 % |

**Output Conditions:**

1. Characteristics depends on above mentioned performance efficiencies.
2. Temperature- 36-38$^0$C for mesophilic reactors.
3. Volume remains the same.

## 15.2 Reverse osmosis

Reverse osmosis is a membrane based separation technique. A membrane is a selective barrier that permits the separation of certain species in a fluid by a combination of sieving & sorption mechanisms. The feed stream is physically split into permeate (or filtrate) comprising molecules that pass through the membrane and reject (or retentate or concentrate) that is composed of the molecules retained by the membrane.

***Table 10: Reverse Osmosis Performance Parameters***

| Sr. No. | Particulars (Permeate characteristics) | Type of spent wash used | |
|---|---|---|---|
| | | From Raw spent wash | From Bio-methanated spent wash |
| 1. | Permeate recovery, % | 35-40 | 45-50 |
| 2. | pH | 2.9-3.5 | 6.8 - 7.2 |
| 3. | COD, mg/l. | 620.0 | 119.5- 235.0 |
| 4. | TDS, mg/l. | 400.0 | 200.0-350.0 |
| 5. | TSS, mg/l. | 220.0 | NIL |

**Output Conditions:**

1. Characteristic of treated effluent (reject) will depend on the input characteristic of feed spent wash.
2. General characteristic of permeate will typically be as given in above table and can vary depending on the input characteristic of feed spent wash. Permeate should be treated in CPU and recycled back for process and/or non -process applications.
3. Treated effluent volume will depend on percentage recovery of permeate.

## 15.3 Multiple-effect evaporation (MEE) of distillery spent wash

The function of a MEE is to concentrate a non-volatile solute from a solvent, usually water. Depending on the number of effects used in an evaporator the quantity of water evaporated per kilogram of steam increases.

**Performance Measures**

Main measures of evaporator performance:

1. Capacity (kg vaporized/time)
2. Economy (kg vaporized/kg steam input)
3. Steam Consumption (kg/hr)
4. Characteristics of process condensate (COD, BOD, TDS, pH etc.)
5. Characteristics of concentrate (COD, BOD, TDS, pH etc.)
6. Cleaning frequency and cleaning duration.

**Output Conditions:**

1. Characteristic of concentrate will depend on the input characteristic of feed spent wash.
2. General characteristic of process condensate can vary depending on the input characteristic of feed spent wash. Condensate should be treated in CPU and recycled back for process and/or non -process applications.
3. Concentrate volume will depend on evaporation duty of the MEE plant.

## 15.4 Bio-composting

Composting has come to be accepted as one of the good solution to the problem of distillery effluent treatment. Properly operated bio-composting can result in to zero effluent discharge. It can be used either as a secondary treatment after anaerobic digestion or as a tertiary treatment after concentration of spent wash.

**Performance norms:**

1. It should result in Zero Discharge.
2. There should be no odour or fly nuisance.
3. The finished product should be free from any repulsive odour.
4. The finished product should be baggable product, easy to handle and transport.
5. Bio-compost characteristic should be as per FCO.
6. Bio-compost yard should be made impervious.
7. The spent wash (concentrated) should be stored in impervious tank
8. For 5 to 12 % solids containing spent wash, the filler material (PMC) to spent wash ratio prescribed is 1: 2.5 for 45 days cycle and 1:3.5 for 60 days cycle.
9. For concentrated spent wash (25 to 30 % solids), the filler material (PMC) to spent wash ratio prescribed is 1: 1.6 for 60 days cycle.
10. Impervious compost yard area based on material balance (plus ready compost storage area) should be made available.
11. During rainy season, bio-composting process has to be stopped.
12. However, bio-composting can continue provided covered compost yard of required area is available.
13. Record of filler material used (PMC) and bio-compost produced/sold should be maintained.
14. The quality of bio-compost produced should be certified by Ministry of Agriculture

**Output conditions:**

1. Bio-composting process should result in Zero discharge.
2. The resultant bio-compost of above mentioned quality should be stored on impervious yard.
3. The bio-compost produced should be should be stored on impervious compost yard.

**(Note: Please refer to Annexure-I for Standard Operating Procedure (SOP) for Bio-composting operations for molasses based distilleries.)**

## 15.5 Incineration of spent wash

Incineration of concentrated spent wash along with some subsidiary fuel in a specially designed boiler is one of the potential technologies for achieving Zero Discharge. Concentrated spent wash at about 60 % solids is fired in boiler along with subsidiary fuel such as coal or bagasse or other biomass. Either fluidized bed or travelling grate type of incineration boilers are in use. They can run for 300 or more days in a year.

**Performance norms:**

1. It should result in Zero Discharge.
2. The boiler should run at the rated capacity and at rated ratio of concentrated spent wash to subsidiary fuel.
3. The incineration boiler should have installed necessary emission control system such as ESP or bag filters and should achieve the prevailing norms of boiler emissions.
4. The boiler should have installed on-line stack monitoring system.
5. The boiler cleaning frequency and cleaning duration should be minimum.

**Output conditions:**

1. Steam should be generated at rated capacity and pressure consistently.
2. The ratio of concentrated spent wash to subsidiary fuel should remain constant. However, it may be noted that the ratio will change with change in raw material i.e. in case of B heavy molasses or sugarcane juice or syrup.
3. The ash generated should be disposed of properly.

## 15.6 Dryers for spent wash drying

Different types of dryers have been used for spent wash drying such as spray dryer, double drum dryer, spin flash dryer, agitated thin film dryer/evaporator etc.

**Performance norms:**

1. It should result in Zero Discharge.
2. The dryer should run at the rated capacity producing dry powder without caramelization and with specified moisture content.
3. The vapour coming out of the dryer should be condensed and the uncondensed gases/fraction should be properly scrubbed before letting out them to the atmosphere.
4. The dryer cleaning frequency and cleaning duration should be minimum.

**Output conditions:**

1. It should produce dry bagable product.
2. Dried product should be stable and not hygroscopic.
3. Condensate collected should be treated in CPU and recycled back for process or non-process applications.

## 15.7 Technology for Recovery of FCO grade Potash Fertilizer and potash free organics/de-potash vinasse (DPV) from Molasses-based Distillery Spent Wash

In this process, potassium is selectively precipitated as insoluble salt from pre-treated & clarified spent wash. Subsequently, the potassium salt is converted to FCO grade potash fertilizer & lean spent wash is further processed & concentrated to produce De-potash Vinasse. Water recovered from MEE is processed through CPU for reuse in distillery operations. This process involves general unit operations practiced in the Industry & can operate round the year (nominally 330 days). The process works in similar fashion with bio-methanated spent wash also.

**Performance norms:**

1. The process would comply with Zero Discharge / Waste concept.
2. Potash recovery efficiency (as $K^+$) would be more than 80%
3. Equipment cleaning & maintenance to be schedule driven (preventive) to eliminate downtime
4. Plant to be operational round the year (nominally 330 days)

**Output conditions:**

1. Potassic salts produced should comply with FCO specifications.
2. DPV produced should comply with requirements of cattle feed industries
3. Condensate collected should be treated in CPU and reused in distillery operations.

## 15.8 Condensate polishing unit

Of the various available technologies available, the conventional technology (anaerobic followed by aerobic followed by polishing) is well established with desired results. The typical characteristics of input feed and treated water generated in a conventional CPU are given below in Table 11.

***Table 11: Combined raw spent wash process condensate plus spent lees and treated water characteristics***

| Parameters | Test values | | | |
|---|---|---|---|---|
| | **Feed** | **Outlet of sand filter** | **Outlet of UF** | **Outlet of RO** |
| pH | 3-4 | 6.5-7.5 | 6.5-7.5 | 6.5-7.5 |
| COD, mg/l | 6000 | 100 | < 60 | < 10 |
| BOD, mg/l | 3000 | 30 | < 20 | < 5 |
| TDS, mg/l | < 1000 | < 1000 | < 1000 | < 100 |
| Temperature, °C | 34-35 | --- | --- | --- |

**Output conditions:**

1. It should produce treated water quality with TDS of less than 2100 ppm
2. Treated water should be suitable for recycle for process (including fermentation) and non-process applications with pH 6.5-7.5, COD< 100 mg/l, BOD <30 mg/l.
3. Losses should be minimum with yield of treated water in the range 80-98 %.
4. The reject of CPU system (from UF or RO) if any, should be recycled back to effluent treatment system.

   It may please be noted that apart from the conventional technology for treatment of low strength effluents there are other potential technologies also available as mentioned previously. Irrespective of CPU technology adopted, the charter prescribes that distilleries should treat the low strength effluents and recycle them for process and non-process applications.

## 16.0 Prescribed Standards to be adopted by Molasses based Distilleries

**CPCB does not prescribe or suggest any specific technology to meet the prescribed norms as a policy matter. It is the responsibility of the industry to adopt suitable technologies to achieve ZLD as well as to comply with the following:**

1. Distilleries shall ensure reduction of spent wash generation to 6-8 liters for every liter of alcohol produced.
2. Distilleries shall minimize fresh water consumption to 8-10 liters for every liter of alcohol produced.
3. Distillery sector is a water intensive sector. Therefore, distilleries shall maximize water conservation and water recycling thereby ensuring ~80% water recovery.
4. Industries opting for bio composting shall ensure the following:
    a. For concentrated bio-methanated spent wash (30 % solids), the filler material (PMC) to spent wash ratio prescribed is 1: 1.6 for 60 days' cycle.
    b. Strict compliance to 'Standard operating procedure (SOP) for Bio-composting operation for Molasses based distilleries'.
    c. The final storage capacity of concentrated spent wash utilized in bio-composting shall be properly lined and made impermeable and shall strictly be restricted to thirty days equivalent of 40% by volume of spent wash generated and 30% solid concentration. Excess storage facilities beyond this shall be levelled and dismantled.
    d. The distilleries shall obtain valid registration/certification for the production and quality of bio-enriched organic manure (bio compost) as per Gazette Notification S.O. 2776 (E) dated 10.10.2015 under the Fertilizer (Control) Fourth Amendment Order, 2015 issued by Ministry of Agriculture and Farmers Welfare (Dept. of Agriculture, Cooperation and Farmers Welfare) from the Ministry of Agriculture/ concerned agency – within a time period of four months.
    e. Bio-composting yard has to be impervious with leachate/run away collection sump well. The impervious bio-compost yard and ready bio-compost storage area has to be prepared as per the CREP norms with HDPE lining.
    f. Refer Annexure I (Standard Operating Procedure for bio-composting operation in molasses based distilleries) for more details.

5. Industries opting for incineration shall
    a. Restrict the impermeable storage of spent wash at any stage to seven days equivalent of production and excess storage facilities beyond this shall be levelled and dismantled.
    b. Scientific ash handling, disposal and record keeping.
    c. Refer Annexure II (Standard Operating Procedure for incineration operation in molasses based distilleries) for more details.
6. Industries opting for potash recovery shall ensure
    a. potash recovery efficiency of ≥80%.
    b. potash rich salts produced should comply with FCO / other regulatory specifications.
    c. proper pre-treatment and treatment of mixture of cleaning agents and contaminants generated following each CIP routine. Recycling of cleaning agents/solutions used for CIP following proper treatment should be such that reuse rate of CIP cleaning agent is more than 95%.
7. All non-process effluents/weak strength effluents should be treated through adequate Condensate Polishing Unit (CPU) and recycled back. Recovery of reusable water should vary between 80-98%. The reject of CPU, if any, should be recycled back to effluent treatment system. Treated water from CPU should meet the following criteria
    a. TDS of less than 2100 ppm
    b. Water quality suitable for recycle in process (including fermentation) and non-process activities with pH 6.5-7.5, COD< 100 mg/l, BOD <30 mg/l.
8. Online Continuous Effluent and Emission Monitoring Services (OCEMS) requirement:
    a. Stand-alone distilleries or distilleries having independent boiler should install on-line emission monitoring system (PM or depending on fuel being used) as per the CPCB guidelines.
    b. PTZ Cameras with night vision to be installed.
    c. In case of bio-composting, one PTZ camera with night vision to be installed in bio-composting yard and one at impervious spent wash storage lagoon.
9. It would be necessary for all distilleries to identify recipient drains/ rivulets and their u/s & d/s locations in consultation with respective SPCBs, for monthly monitoring by industry to ensure ZLD from distilleries. The distilleries will have to get the samples collected from upstream and downstream locations, analysed from EPA/NABL approved laboratories and the essential parameters to be included are DO, Colour, BOD, COD, pH, and TSS.
10. Distilleries shall submit monthly report on alcohol production, spent wash generation and stepwise spent wash treatment.

11. In case of installation of any new spent wash management system or change in route for adoption of ZLD, the concerned distillery shall submit an adequacy report duly validated by recognized technical institutions like VSI, NSI or IITs.

## 17.0 Annexure-I: Standard Operating Procedure (SOP) for Bio-composting operation for Molasses based distilleries

| Sr. No. | Particulars | Time Range |
|---|---|---|
| 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 received as combination of press mud, yeast sludge and boiler ash in press mud yard or plant as per requirement from sugar industries.<br>Average Moisture content after testing : 70±5% | |
| 4. | Areas for Press mud storage, Bio-compost operation, Finished goods storage must be properly demarcated. | |
| 5. | Windrows laid shall be as per the machine size and length as per the Bio-compost yard (Windows size- 3.5 M width X 1.5 M Height). Distance between two windows 1 M min. (for top mounted aerotiller m/c.) | |
| 6. | On completion of laying & dressing of windrows, initial turning started to reduce moisture content from 70±5 % to 50±5 %. Time required for achieving desired moisture level, in summers 3 to 5 days, winters 4 to 7 days. | $4^{th}$ – $8^{th}$ day |
| 7. | On achieving 50± 5 % moisture , bio culture (as a seed) in windrows added 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 for 2-3 days to proper growth of microbes. | $8^{th}$ – $10^{th}$ day |
| 9. | Growth/ development of microbes in windrows is observed by measuring its temperature. In normal condition temperature of windrows are between 60- 70°. This temperature gain is result of microbial activity. | |
| 10. | When desired temperature 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 thermometer. | |
| 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).<br>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 or till the windrows temperature up to 55$\pm$ 5°C maintained. | 10th-50th day |
| 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 %, Heap the bio-compost about 2 M height to have aerobic condition. | 50th-60th 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. | |
| 21. | Bio-compost yard should be cleaned before start of every monsoon season | |
| 22. | Monthly report has to be submitted to respective SPCB and CPCB which includes quantity of raw spent wash produced, Quantity of Concentrated spent wash produced, Quality of press mud consumed, quantity of other filler material used in bio-compost if any along with bio-compost analysis report | Once in month during distillery operation |
| 23. | Green belt should be developed at bio-compost site as per CREP norms. | |

**NB**: Requirement of Press mud 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.

## 17.1 Specification of covered Bio-compost yard for Distillery operating throughout year

1. **Yard Length:** depending upon plot size available covered yard shall be made after leaving proper circulation area for movement of machinery; on an average 15-20% area may be allocated depending on the shape of the yard, e.g., square or rectangular yard may need the minimum circulation area where as stepped yard have the different windrow length need more circulation area.
2. **Windrow markers** indicating windrow number, date of formation, date of inoculation and date of the last application of spent wash. Marker shall be made of MS sheet with rod support, grouted in concrete. Marker shall be painted with white background and letters in black paint. The windrow marker should be located in front of windrow after leaving the distance of movement of machines.
3. **Bays:** Approximately 12.0 meter span, having spacing between vertical columns 5-6 meters, rain water gutter height 6.2 meter, gutter slope of minimum 1 in 200. Gutter MOC HDPE / PE/ GI sheet, discharging into RCC / Cement Plastered Brick masonry channels connected to leachate collection pits. In case of multiple down-comers slope is not mandatory. Ridge height will vary upon truss design. Truss design may have provision of ventilation at the top (North light pattern) or semi elliptical.
4. **Down comers for rain water:** Compost shed shall be provided with Rain gutters and the rain gutters shall be connected to the storm water drain using HDPE/PE pipe of at least 150 mm ID down-comers discharging into channel. Channel MOC RCC (M20)/brick masonry cement mortar plastered (1:6) discharging to either rainwater harvesting pit or to natural stream.
5. **Protection against cross wind rain:** Rain water entry into the shed shall be prevented by either providing protection along the sides or by providing Louvers.
6. **Leachate collection pits:** MOC- RCC (M20) / brick work cement mortar plastered (1:6). Size: not less than 1.5 meter X 1.5 meter having top level / free board 300 mm above the ground level.
7. **Leachate collection drain:** MOC- RCC (M20)/brick work cement mortar plastered (1:6). Size: 0.3 meter (width) X 0.25 (depth). The depth will increase along the length towards collection pit. Bed slope: 1 in 200 approx. with smooth finishing to prevent sludge (press mud) deposition on the base.
8. **Truss members:** Members size (Diameter, wall thickness) depending on the safe structural design capable to with stand against design wind load and rainfall. Material of construction shall be preferably GI pipes/ Galvanized angles /channel sections / RCC columns. Pre-engineered profiles may also be used.

The GI pipes/ channels should be grouted in concrete in the bio compost yard floor and should be protected by providing concrete cover of at least 150 mm all-round, at least 300mm height to prevent corrosion due to direct contact on the base.

9. **Roofing:** Poly film minimum 200 micron film with qualities of UV stability, anti-drip, anti-dust, Light Diffusion minimum 50% film fixing only on roof and gables and up to hockey purlin/GI sheet/Precoated laminated sheet
10. **Floor lining:** The floor lining shall be impervious, strong enough to prevent settlements due to machine load. Minimum thickness 100 mm. The underlining sheet shall be minimum 150 micron HDPE film below the floor. Clay layer cushion of 300 mm below the liner and 50 mm above the liner should be provided. In case of RCC flooring, the construction joint should be sealed using the water bar/hot bitumen.
11. **Ground water monitoring facilities.**
    a. **Location of piezometer wells:** Minimum at 4 places along the periphery of the bio-compost yard such that one is in the upstream of the Ground water flow direction and one in the downstream direction. For Bio-compost yard of more than 5 acres area, one additional Piezowells shall be constructed for every 5 acres and shall be in the downstream direction placed sufficient away from each other to assess any seepage /ground water contamination tested quarterly. (Example: for 20 acre Bio-compost yard the total number of Piezowells shall be 4+3 =7nos. One upstream and 6 down steam uniformly distributed). Piezo-wells shall be constructed as per the standard procedure and specifications.
    b. **Hand pump:** at least 30 meters depth, located within 500 meters to 1 Km from yards. Water quality of hand pump should be tested quarterly.
12. **Data recording:** Log book at yard should be maintained mentioning the date of formation of windrow, quantity of press mud, feed stock, date of last aero-trilling, date of last spent wash spray, quantity of spent wash spray, temperature date-wise, date of maturity, moisture content etc. Data should also be entered into the computer for record and computation. The press mud and ready compost must be weighed and records of the same shall be maintained.
13. **Approach Road to bio-compost yard**: The entrance of the Bio-compost yard should be paved all-weather road for approach of vehicles.
14. **Storage facilities for ready compost**: Covered shed having platform.
15. **Camera** as per OCEMS guidelines shall be installed in the bio-compost yard to monitor the bio- compost operations inside the shed.

## 17.2 Specification of Bio-compost yard for Distillery operating 270 days (excluding rainy season)

1. **Yard Length:** depending upon plot size available yard shall be made after leaving proper circulation area for movement of machinery; on an average 15-20% area may be allocated depending on the shape of the yard, e.g., square or rectangular yard may need the minimum circulation area where as stepped yard have the different windrow length need more circulation area.
2. **Windrow markers** indicating windrow number, date of formation, date of inoculation and date of the last application of spent wash. Marker shall be made of MS sheet with rod support, grouted in concrete. Marker shall be painted with white background and letters in black paint. The windrow marker should be located in front of windrow after leaving the distance of movement of machines.
3. **Leachate collection pits:** MOC- RCC (M20) / brick work cement mortar plastered (1:6). Size: not less than 1.5 meter X 1.5 meter having top level / free board 300 mm above the ground level.
4. **Leachate collection drain:** MOC- RCC (M20)/brick work cement mortar plastered (1:6). Size: 0.3 meter (width) X 0.25 (depth). The depth will increase along the length towards collection pit. Bed slope: 1 in 200 approx. with smooth finishing to prevent sludge (press mud) deposition on the base.
5. **Floor lining:** The floor lining shall be impervious, strong enough to prevent settlements due to machine load. Minimum thickness 100 mm. The underlining sheet shall be minimum 150 micron HDPE film below the floor. Clay layer cushion of 300 mm below the liner and 50 mm above the liner should be provided. In case of RCC flooring, the construction joint should be sealed using the water bar/hot bitumen.
6. **Ground water monitoring facilities.**

   a. **Location of piezometer wells:** Minimum at 4 places along the periphery of the bio-compost yard such that one is in the upstream of the Ground water flow direction and one in the downstream direction. For Bio-compost yard of more than 5 acres area, one additional Piezowells shall be constructed for every 5 acres and shall be in the downstream direction placed sufficient away from each other to assess any seepage /ground water contamination tested quarterly. (Example: for 20 acre Bio-compost yard the total number of Piezowells shall be 4+3 =7nos. One upstream and 6 down steam uniformly distributed). Piezo-wells shall be constructed as per the standard procedure and specifications.

   b. **Hand pump:** at least 30 meters depth, located within 500 meters to 1 Km from yards. Water quality of hand pump should be tested quarter.

7. **Data recording:** Log book at yard should be maintained mentioning the date of formation of windrow, quantity of press mud, feed stock, date of last aero-trilling, date of last spent wash spray,quantity of spent wash spray, temperature date-wise, date of maturity, moisture content etc. Data should also be entered into the computer for record and computation. The press mud and ready compost must be weighed and records of the same shall be maintained.
8. **Approach Road to bio-compost yard**: The entrance of the Bio-compost yard should be paved all-weather road for approach of vehicles.
9. **Storage facilities for ready compost**: Covered shed having platform.
10. **Camera** as per OCEMS guidelines shall be installed in the bio-compost yard to monitor the bio- compost operations inside the shed.

## 18.0 Bio-compost area calculation:

The requirement of Press mud depends on the size of the aerotilling machine that comes in varying dimensions. Also, aerotilling machines comeswith side mounted turner and top mounted turning machine. Further, the windrows require dressing with JCB machine after every turning for which a spacing of 3 meters is required between each windrow.

The area of biocompost area required shall be calculated based on the followingsample basis of calculation:

| | |
|---|---|
| License capacity of distillery | = 36,000 KL/Annum |
| Spent Wash generation | = 9 KL/KL |
| Total Spent Wash generation | = 36,000*9<br>= 3,24,000 KL |
| Concentrated Spent Wash@60% volume reduction | = 1,29,600 KL/Annum |
| | |
| 1.6 KL concentrated spent wash (CSW) is applied per MT of Press mud i.e., Press mud: CSW = 1:1.6 | |
| Press mud requirement @ 1/1.6 MT/KL | = 1,29,600/1.6<br>= 81,000 MT |
| The land requirement for press mud should therefore be designed based on the windrow size following the sample calculation as below based on 850 MT/Acre/cycle of press mud | |
| No. of Cycle | = 4 |
| Press mud/Cycle | = 81,000/4 = 20,250 MT |
| Land Area Required | = 20,250/850<br>= 23.8 Acres |
| No. of Cycle | = 5 |
| Press mud/Cycle | = 81,000/5 = 16,200 MT |
| Land Area Required | = 16,200 /850<br>= 19.0 Acres |

In case of specially designed aerotiller machine, bio-compost yard area will becalculated as per the windrow size specification mentioned by the machine manufacturer.

Land requirement for press mud storage: Equivalent to one cycle

Land requirement for storage of ready compost: 15% of additional area (that of area calculated for biocomposting process on the basis of material balance).

## 19.0 Standard Operating Procedure (SOP) for Incineration boiler operation for Molasses based distilleries

**Incineration of Spent wash**

Incineration of concentrated spent wash (55-60 °Brix) along with some subsidiary fuel in a specially designed boiler is one of the potential technology for achieving Zero Discharge of molasses based distillery effluent. Concentrated spent wash at about 55-60 % solids is fired in boiler along with subsidiary fuel such as coal or bagasse or other biomass. Either fluidized bed or travelling grate type of incineration boilers are in use. They can run throughout year.

1. Distilleries with Incineration boiler shall be in operation throughout the year.
2. Boiler should have online continuous stack emission monitoring system
3. Online Continuous Mass flow meters for measurement of spent wash at the inlet and outlet of the MEE should be installed with connectivity to SPCB and CPCB server.
4. The slope carrying pipe line from MEE plant to Boiler feed tank should have On line flow meters with data recording facility which should be transmitted online to CPCB and SPCB shall be installed at the raw spent wash/whole stillage generation line and the concentrated spent wash/whole stillage / thick syrup line connecting to incineration boiler.
5. The supporting fuel i.e. bagasse, rice husk, coal, biomass etc. are to be stored under a suitable covered area in order to avoid mixing of rain water.
6. The firefighting arrangement should be in operation in the area of fuel storage area and boiler area.
7. Slop carrying pipeline should have proper heating element arrangement to avoid spent wash choking in pipeline.
8. Concentration of spent wash in the range of 55-65% solids and then slop along with supporting fuel may be burn in incineration boiler.
9. Moisture content of different types of supporting fuel should be minimum approximately in the range as mentioned below:

| | |
|---|---|
| Coal | : 10 - 12 % |
| Rice Husk | : 10 - 12 % |
| Bagasse | : 48 - 50 % |
| Other Biomass | : 10 - 15 % |

10. When boiler is in operation and before put in operation the safety measures to be taken are as follows,
    a. Electrical supply to all prime mores such as ID & FD fans, water feed pump, spent wash feed pump, ESP/Bag filter, coal feeder & Conveyor etc.

b. Generate & storage DM water as per requirement of makeup water.

c. Start the DCS system of boiler with all calibrated parameters.

d. Start DM water feed in the boiler as per the drum design level.

e. Keep ESP/Bag filter in operation.

f. Keep FBC/travelling grate/Reciprocating bed in operation.

g. Keep Fuel and ash conveyor in operation

h. Keep optimum staff for boiler operations, such as boiler attendant, water attendant, fire man, DCS operator etc.

11. The operator must read all the instruction manual/operational manual of the concern manufacturer of the boiler before start up and during operation of boiler.

12. Boiler warm up should be initiated by using coal/bagasse/fire wood/rice husk/diesel.

13. Maintain the water level in the boiler drum.

14. The appropriate draught system should be maintained and monitored.

15. Maintain appropriate temperature of live steam, feed water, air, flue gas.

16. Maintain live steam pressure.

17. Following parameters to be maintained,

a. Bed temperature – 750 to 800 °C (as per instruction manual)

b. Draught at FBC/travelling grate as per design.

c. Hot air temperature as per design.

d. Boiler feed water temperature after de-aerator about 150 °C or as per design.

e. Slope brix, quantity, temperature as per design.

f. Ensure stack temperature should be in the range of 180 °C to 190 °C.

g. Ensure the Coal or other supporting fuel quantity and feed rate as per design before cold start of the boiler

18. Initially the boiler will be started on supporting fuel such as coal/bagasse/rice husk.
19. Switch on the slope feeding on bed using spray guns/atomizers.
20. Stabilize the operation & check the ratio of coal to slope or bagasse to slope. (for coal base it can range between 25-30:70-75 (coal: slope) and for bagasse base it can range between 35-45: 55-65 (Bagasses: slope))
21. Flue gas SPM should not more than 50 mg/m$^3$ which should be monitored by

stack analyzer (real time/online continuous monitoring system connected to SPCB & CPCB servers).

22. Ash collection will be through screw/belt conveyor from common silo and should be disposed of as fertilizer or for any other use.
23. Proper record/log book of following consumption/generation should be kept
    a. Feed water consumption, $m^3/h$
    b. Feed water analysis once in months
    c. Chemical consumption if any MT/h for WTP or Boiler.
    d. Slope consumption, MT/h
    e. Live steam Flow, Pressure and Temperature.
    f. Draft system Flow, Pressure and Temperature
    g. Solid content of the slope (% Solid of the slope)
    h. Supporting fuel consumption, MT/h
    i. Steam generation, MT/h
    j. Ash generation, MT/h
    k. Boiler blow down generation, $m^3/h$
    l. Boiler working hours, h/day.
    m. Boiler stoppage hours, h/day.
    n. Cleaning time required, h/month. (Time duration between two cleaning)
    o. Analysis of slope and supporting fuel being used in boiler (once in month)
24. Proper record of Ash generation & disposal should be kept;

| Date | Ash generated (MT) | Ash disposed off | Purpose of using Ash |
|---|---|---|---|
| | | | |
| | | | |
| | | | |