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Securing Zero Liquid Discharge (ZLD) in Molasses-Based Distilleries located in Ganga Basin by Charter Action Plan

increasing industrialization trend has resulted in the generation of industrial effluent in large quantities with high organic and inorganic contents. Molasses based distllierles generate huge wastewater streams called spent wash. Spent wash is a highly organic as weli as inorganic content effluent in nature generated in the distillery industry. The spent wash from distilleries is unfit for direct discharge on land, irrigation as well as discharge into rivers or streams. To control industrial pollution by distlileries in Ganga River, a holistic action plan was prepared in consultation with concerned stakeholders.

During 19th episode of Mann Ki Baat (MKB) Hon'ble Prime Minister (PM) of india mentioned about the formulation of action plan for control of water pollution by distillery Industries in River Ganga and he also acknowledged about the attainment of Zero Liquid Discharge by Distilleries in Uttarakhand (UK) and Uttar Pradesh (UP).

Central Pollution Control Board (CPCB) discussed environmental issues pertaining to distillery sector with various stakeholders and formulated Charter Action Plan during 2017 for upgradation of manufacturing process technology, effluent treatment system to ensure adoption of best practices for effective spent wash management by distilleries. The Charter is aimed at facilitating distilleries to shift from an end-of-pipe treatment approach to an integrated water and waste management system. As a result of Charter action plan, 63 moiasses-based distilleries located in main stem of Ganga River has achieved ZLD which has resulted in reduction of specific fresh water consumption from 15 KL/KL of alcohol produced in 2016-17 to 5.59 KL/KL of alcohol produced in 2021-22, leading to a 62.7% reduction in specific fresh water consumption. Similarly, specific spent wash generation has reduced from 11.1 KL/KL of alcohol produced in 2016-17 to 6.48 KL/KL alcohol produced in 2021-22, leading to 41.6% reduction in spent wash generation.

Key words: Sugar cane molasses, Spent-wash, Pollution load, Blo-composltlng, Incineration boiler, Bare minimum technologies, CPU.

Mann Ki Baat Reference : Episode 19 aired on April 24th, 2016.

Formulation of Charter Action Plan has led to reduction in freshwater consumption and spent wash generation in molasses-based distilleries which has resulted in reduction of pollution load in river Ganga.

Introduction

Sugar industries are among the major agro-based industries and a backbone of rural economic development as well as Indian industrial development. For socio-economic development of the country the contribution of sugarcane or allied industries is quite obvious. During processing of sugarcane for production of Sugar, bagasse, press mud cake (PMC), and sugarcane molasses are produced as by-products. The molasses is an important raw material for the fermentation industry which is used in the production of alcohol and yeasts. A molasses is the mother liquor left after crystallization of sugarcane juice. It is a dark-coloured viscous liquid that contains approximately 40 to 50% fermentable sugar. In India, sugarcane molasses is predominately used for production of alcohol through fermentation. The fermentation involves enzymatic conversion of sucrose, glucose present in molasses into ethanol and carbon dioxide and subsequently ethanol is separated by distillation.

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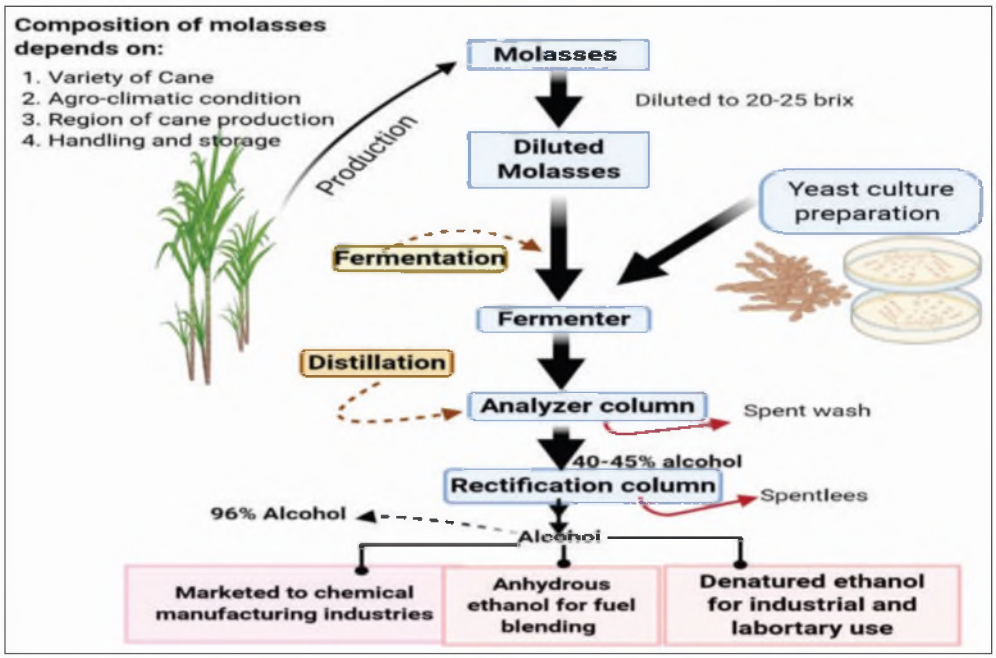

Fig. 1: Process of the ethanol manufacturing (Bhardwaj *et al.,* 2019)

Distillery spent wash (DSW), fermented sludge and spent lees are waste water streams produced during molasses- based fermentation (Fig. 1). Fermentation process generates fermented wash as the major product which can be decanted whereas the remaining sludge is called fermented sludge. The fermented wash is then further processed for separation of ethanol by distillation. The further processing of the fermented wash by distillation produces an effluent known as distillery spent wash which is released from the bottom of the analyzer column and that is the main contributor of the pollution load from the distillery. The residues from the rectifier column is known as Spent lees (Bhardwaj *et al*., 2019). The major source of pollution from the distillery is spent wash, which is also known as vinesses, stillage, and distiller spent wash (DSW) (Umair *et al*., 2021). These distilleries generate huge wastewater streams (about > 45 billion liters per year spent wash in India). These waste streams have high chemical oxygen demand (COD), biological oxygen demand (BOD), high inorganic solids content, and low pH *(*Bhardwaj *et al.,* 2019 & CPCB Charter*)*. The spent wash from distilleries is unfit for direct discharge on land, irrigation as well as discharge into rivers or streams. The Fig.1 shows process involved in the production of alcohol using molasses as feedstock and also briefed about product and waste water streams generated during alcohol processing such as spent wash, spent less etc.

Distillery sector is highly water intensive and have high pollution potential, hence in order to address these environmental concerns a holistic action plan was formulated by CPCB which led to zero liquid discharge of process and non-process effluents from distilleries.

During 19th episode of Mann Ki Baat (MKB) Hon'ble Prime Minister (PM) of India mentioned about the formulation of action plan for control of water pollution by distillery Industries in River Ganga and he also acknowledged about attainment of Zero Liquid Discharge by Distilleries in Uttarakhand (UK) and Uttar Pradesh (UP).

Pollution Potential of Distillery effluent

Considering the pollution load of distillery industry, it is categorized under 17 most polluting industries listed by the CPCB (http://) of India. The effluent discharged from distillery industries during the production of ethanol is considered as a major source of the environmental pollution. The molasses-based distilleries generate liquid waste known as spent wash, which contains a large pollution load of both organic and inorganic substances. Basically, distillery spent wash is the agro based waste effluent having high organic and inorganic compounds which are high strength based and difficult to dispose [charter_distillery.pdf (cpcb.nic.in)]. Spent wash has very high BOD (50,000-60,000 mg/L) and COD (80,000-1,20,000mg/L) (Ghosh and Ghangrekar, 2018). A typical cane molasses-based distillery generates 10-12 Liters of spent wash per Liter of alcohol produced (Bhardwaj *et al.,* 2019). Also, distillery spent wash is a good bio-source of macronutrients (nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), and Sulphur (S) and micronutrients zinc (Zn), copper (Cu), iron (Fe) and manganese (Mn). However, this dark brown spent wash is being

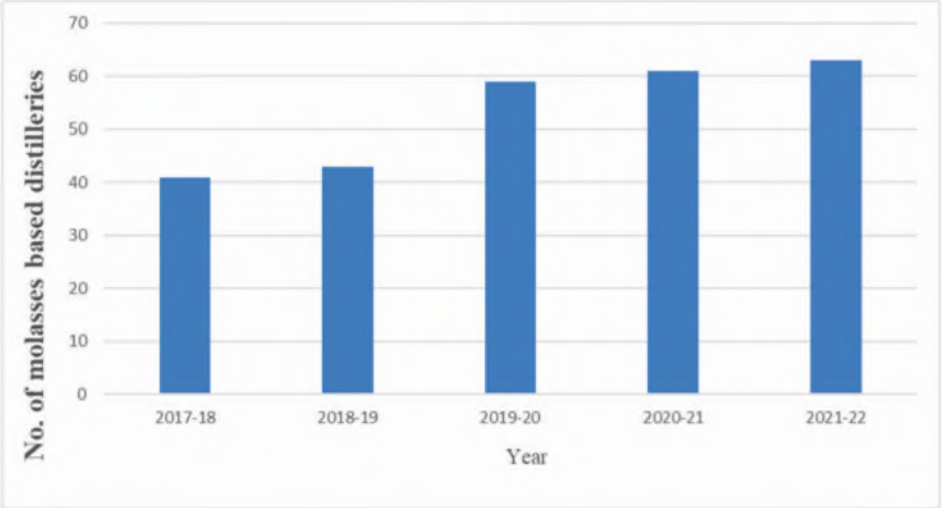

Fig. 2: Numbers of molasses-based distilleries in main stem of River Ganga during last five years

overloaded with high organic nitrogen, high organic and inorganic salts as a result having high electrical conductivity (EC) which causes depletion of oxygen and produces bad smell (Ghosh and Ghangrekar, 2018). Therefore, proper management of spent wash is crucial.

Considering the Government of India's (GoI) ambitious programme of ethanol blending in petrol the number of molasses-based distilleries has increased significantly in last few years and most probably the 20% blending will be achieved in coming few years which will further result in increase of distilleries in country (National Biofuels Policy). Subsequently, it will result in increase in spent wash generation as for every liter of alcohol produced, molasses-based distilleries generate 10-12 liter of wastewater. Fig. 2 shows the increasing numbers of molasses-based distilleries in main stem of River Ganga during last five years.

Charter Action Plan

Need for Charter

During surprise visits made by CPCB under Environment Surveillance Squad (ESS) programme, covering Distilleries spread over the entire country and in different seasons it was noted that although the standards for compliance have been notified under Environment Protection Act, 1986 and distilleries are to achieve maximum BOD load of 30mg/l for disposal of treated effluent into surface water but almost all distilleries were failing to achieving the standards thereby causing grave pollution in all water bodies including River Ganga and its tributaries. Thus, CPCB formulated the Charter Action Plan to facilitate distilleries to initiate sustainable pollution control measures (CPCB Guidelines).

Formulation of Charter Action Plan

As River Ganga is one of the sacred rivers and has immense religious as well as socio-economic significance; thus, to rejuvenate and reduce overall pollution load CPCB has prepared an action plan based on holistic and participatory approach. The Charter takes a focused 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 (Bhardwaj *et al.,* 2019*)*. Thereafter, in the mid of 2017, CPCB discussed environmental issues pertaining to distillery sector with various stakeholders and prepared phase wise action plan for the distillery industries situated in River Ganga basin and its major tributaries in the state of UK, UP, Bihar, Jharkhand and West Bengal.

CPCB took initiative to assess the effluent treatment plant performance and achievement of the prescribed norms by distilleries in the Ganga basin and convened meetings of distilleries on May 11, 2017 and May 24, 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 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 Charter took a holistic approach for

pollution prevention and control, 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. 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, which also includes evaluation/ validation of process technologies, water audit, assessment of effluent generation and its ZLD, ETP adequacy and implementation of recommendations made in adequacy reports from the expert institutes. Thereafter, ensuring effective and continuous monitoring of ZLD systems through involvement of State Pollution Control Boards (SPCBs) and Knowledge Partners. In effective of that, CPCB has facilitated annual inspection of distillery industry from 2017 onwards through expert technical institutes and SPCBs.

As per the Charter action plan, it is mandatory to achieve zero liquid discharge from Distilleries. To conform ZLD; distilleries have employed various forms of primary, secondary and tertiary effluent treatment methods and polishing treatments methodologies. The commonly adopted / suggested routes by distilleries for achieving ZLD are as follows;

Route 1 : Raw spent wash Bio-methanation followed by multiple effect evaporation followed by bio-composting using PMC as filler material.

Route 2 : Raw spent wash concentration by multiple effect evaporation followed by incineration of concentrated spent wash in specially designed incineration boiler.

Distilleries proposing to use any advance or new technology other than above mentioned shall follow defined procedure for verification and rectification of process, which should ultimately ensure that the treatment of effluent shall be strictly confirming to the prescribed standards for achieving zero liquid discharge.

Any of the Zero liquid discharge system adopted will produce process condensate during achieving desired spent wash concentration through multi effect evaporation plant. The process condensate along with other low strength effluents are treated through Condensate Polishing Unit (CPU) and treated water is recycled, reused for molasses dilution, cooling tower make-up water or for any other non-process applications which is resulted in reduction of direct fresh water consumption in the distillery operations.

Results and Discussion

The implementation of Charter action plan and establishment of environment management cell has led to achievement of zero liquid discharge by 63 molasses-based distilleries located in main stem of Ganga River, which has also resulted in overall reduction of freshwater requirement and spent wash generation. Based on the industrial data collection and its verification during annual inspections being carried out by knowledge partners it has been substantiated that the specific fresh water consumption has reduced from 15 KL/KL of alcohol produced in 2016-17 to 5.59 KL/KL of alcohol

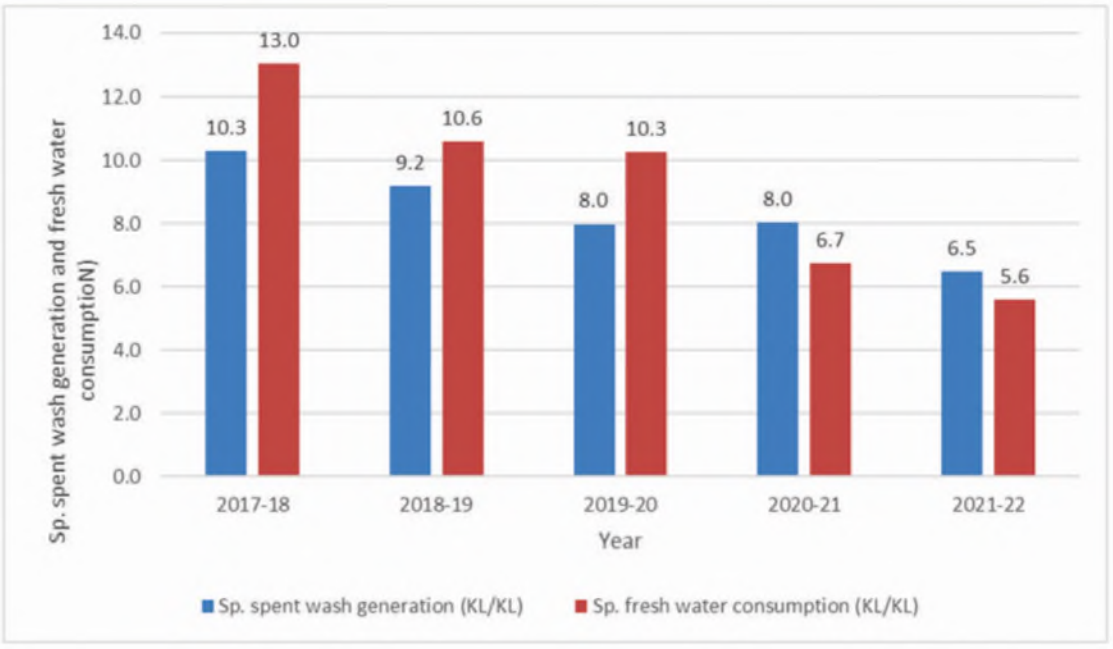

Fig. 3 : The trend of specific spent wash generation in molasses-based distilleries in main stem of River Ganga

produced in 2021-22, leading to a 62.7% reduction in specific fresh water consumption. Similarly, specific spent wash generation is reduced from 11.1 KL/KL of alcohol produced in 2016-17 to 6.48 KL/KL alcohol produced in 2021-22, leading to 41.6% reduction in spent wash generation (Fig. 3).

Following Figure 3, shows that the reduction in fresh water consumption and spent wash generation since 2017-18 to 2021- 22, respectively.

Benefits of ZLD

- installation of ZLD technology encourages water usage monitoring closely, avoid wastage and recycling of water by conventional and relatively less expensive solutions, therefore being useful for a unit's water management system.
- 90-95% recovery of water and valuable products from the wastewater justifies its high operational cost.
- Meeting most stringent regulatory norms leads the industry to a more sustainable growth.
- Using zero liquid discharge techniques, there is a possibility to recover water from waste water and recovered water can be utilized for industrial purpose and reduce fresh water consumption.
- Reduction in freshwater demand from industry results in more availability of water to meet the demands for domestic and agriculture purposes.

Adoption of ZLD system in Distilleries has benefitted not only in the management of spent wash but also in conservation of freshwater. Most of the distilleries has installed ZLD system followed by a water treatment process plant (CPU) through which wastewater is treated, purified, and further recycled in process and non-process applications and resulted in reduction in fresh water consumption. ZLD process eliminates liquid discharge as well as pollution load from distillery industry and thus eliminates possibility of pollution discharge, which may further pollute water bodies/rivers.

The state-wise specific freshwater consumption and spent wash generation during 2021-22 is shown in Fig. 4. As a result of stage-wise Charter implementation, since 2017-18 to 2021-22 specific freshwater consumption and specific spent wash generation in molasses-based distilleries has reduced from 13KL of freshwater to 5.59KL/KL of alcohol produced and 10.3KL to 6.5KL/Kl of alcohol produced, respectively.

Due to upgradatlon/change in fermentation process from batch type to Fed- batch type as well as upgradation or change in distillation process from atmospheric distillation to multi pressure distillation (MPR) and integrated approach in spent wash evaporation system has reduced average spent wash generation from 10.3 KL/KL of alcohol production to 6.5 KL/KL of alcohol production in last few recent years and same has been conformed from the above Fig. 5.

The annual monitoring programme by knowledge partners and SPCBs has resulted in technology upgradation, process standardization and adoption of best practices by industries which has helped in reduction in specific freshwater consumption and raw spent wash generation. Due to adoption of ZLD system organic or inorganic load in the receiving water bodies has drastically reduced. Moving towards zero pollution will require even more robust legislation,

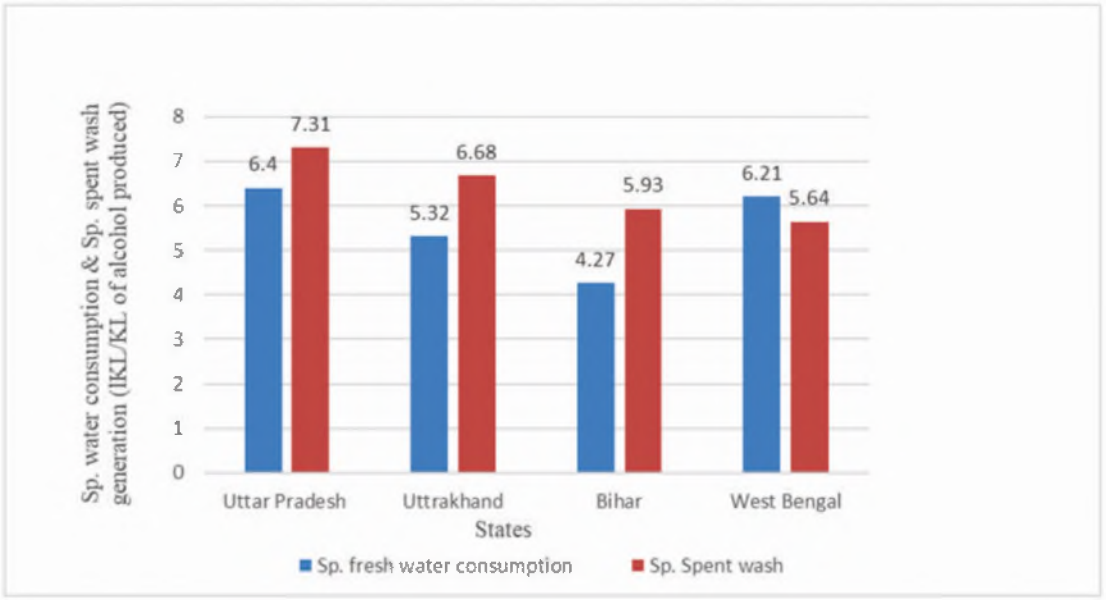

Fig. 4: State wise specific water consumption, specific spent wash generation in molasses-based distilleries

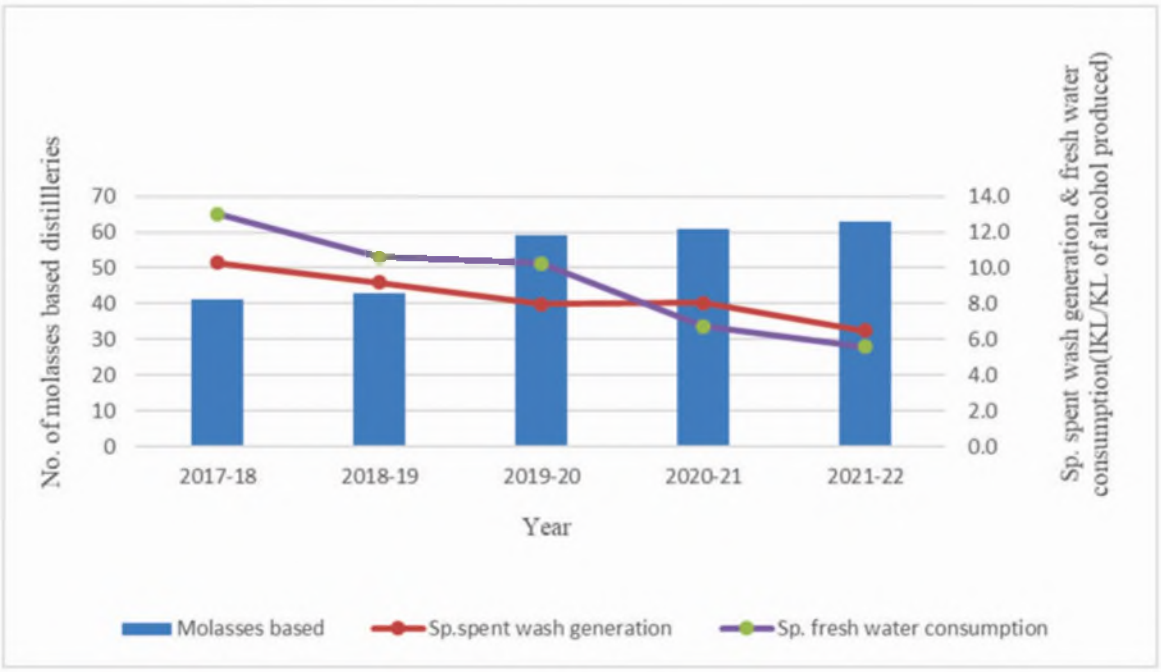

Fig. 5: Trend of specific spent wash generation and specific fresh water consumption

implementation, and monitoring to ensure that the industries of tomorrow are both clean and sustainable.

Way Forward

Fresh water consumption shall be reduced further by recycling of spent wash for molasses dilution during B-Heavy/Sugar cane syrup distliiery operation which may result in overall reduction in spent wash generation and freshwater consumption and at the same time achieving higher alcohol concentration in fermentation.

This holistic participatory approach for implementation of CPCB charter nationwide will help in saving of ground water extraction through technology upgradation and adoption of best management practices as briefed in the Charter.

Conclusion

This article focused on a wide range of biological as well as physicochemical treatments that are needed for the treatment of distliiery spent wash. The combination of different technologies can be employed for absolute treatment of distillery spent wash. There are several advantages that resulted in to the implementation of ZLD system proposed in Charter and distillery industries has been benefited due to implementation of Charter action points, reuse of treated water and securing zero liquid discharge. At the same time the implementation of the ZLD has helped distillery industries in reduction of raw spent wash generation to better extent. in addition to that, the distillery industry has adopted water recovery system from spent wash and its reuse after treatment which has helped in reduction of specific fresh water consumption. it is sure that the annual monitoring of Grossly Polluting industries (GPis) for compliance verification of ZLD has facilitated the distillery industries in River Ganga basin.

चार्टर कार्य योजना द्वारा गंगा बेसिन में शीरा-आधारित आसवनी में जीरो लिक्विड डिस्चार्ज (ZLD) सुनिश्चित करना

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सारांश

औद्योगीकरण की बढ़ती प्रवृत्ति के परिणामस्वरूप उच्च कार्बनिक और अकार्बनिक सामग्री के साथ बड़ी मात्रा में औद्योगिक बहि:स्राव उत्पन्न हुआ हैं। शीरा-आधारित आसवनी विशाल अपशिष्ट जल धाराएँ उत्पन्न करती हैं जिन्हें स्पेंटवॉश कहा जाता है। स्पेंटवॉश आसवनी उद्योग में उत्पन्न एक अत्यधिक जैविक और साथ ही अकार्बनिक सामग्री है। डिस्टिलरीज से स्पेंटवॉश जमीन पर सीधे डिस्चार्ज, सिंचाई के साथ-साथ नदियों या नालों में डिस्चार्ज के लिए अयोग्य है। गंगा नदी में आसवनी द्वारा औद्योगिक प्रदूषण को नियंत्रित करने के लिए संबंधित हितधारकों के परामर्श से एक समग्र कार्य योजना तैयार की गई थी। मन की बात (एमकेबी) की 19 वीं कड़ी के दौरान भारत के माननीय प्रधान मंत्री (पीएम) ने गंगा नदी में आसवनी उद्योगों द्वारा जल प्रदूषण के नियंत्रण के लिए कार्य योजना तैयार करने के बारे में उल्लेख किया और उन्होंने उत्तराखंड (यूके) और उत्तर प्रदेश (यूपी) में डिस्टिलरीज द्वारा जीरो लिक्विड डिस्चार्ज की उपलब्धि के बारे में भी कहा।

केंद्रीय प्रदूषण नियंत्रण बोर्ड (सीपीसीबी) ने 2017 के दौरान एक चार्टर कार्य योजना तैयार की है ताकि आसवनियों द्वारा प्रभावी स्पेंटवॉश प्रबंधन के

लिए सर्वोत्तम प्रथाओं की अपनाना सुनिश्चित किया जा सके। चार्टर का उद्देश्य डिस्टिलरी को एंड-ऑफ-पाइप उपचार दृष्टिकोण से एक एकीकृत जल और अपशिष्ट प्रबंधन प्रणाली में स्थानांतरित करने की सुविधा प्रदान करना है। चार्टर कार्य योजना के परिणामस्वरूप, गंगा नदी के मुख्य धारा में स्थित 63 शीरा आधारित आसवनियों ने ZLD हासिल कर लिया है, जिसके परिणामस्वरूप 2016-17 में विशिष्ट ताजे पानी की खपत 15 केएल/केएल (किलो लीटर /उत्पादित अल्कोहल किलो लीटर) से घट कर 2021-22 में 5.59 केएल/केएल हुई है जिससे विशिष्ट ताजे पानी की खपत में 62.7% की कमी आई है। इसी तरह, स्पेसिफिक स्पेंटवॉश जेनरेशन 2016-17 में 11.1 केएल/केएल (किलो लीटर /उत्पादित अल्कोहल किलो लीटर) से घटकर 2021-22 में 6.48 केएल/केएल हो गया है, जिससे स्पेंटवॉश जेनरेशन में 41.6% की कमी आई है।

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