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Wastewater Reuse - A prospective towards

efficient reuse of treated wastewater from sugar industries of River Ganga Basin for irrigation

The sugar industry consumes a higher volume of freshwater, generating around 1000 liters of wastewater per tonne of cane crushed. The wastewater generated from Sugar industry is complex with high Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD) and Total Suspended Solids (TSS). As per latest data of CPCB, 2021-22, total number of operational sugar industry in Ganga River basin is 140, crushing around 739274.95 tonne of sugarcane per day, consuming 58461.16 KLD of freshwater and discharging 105061.51 KLD of effluent having 3.9 TPD of BOD load.

During 73rd episode of 'Mann Ki Baat' (MKB) (31/01/2021) Hon'ble Prime Minister of India emphasised on utilization of wastewater for irrigation purpose by farmers. To facilitate Sugar mills for adoption of best management practices and best available technologies, charter for water recycling and pollution prevention in sugar industries has been formulated and implemented by Central Pollution Control Board (CPCB) with objective of reduction in freshwater consumption, wastewater discharge, pollution load and reuse of Treated Wastewater for irrigation purpose. This paper mainly focuses on groundwater conservation by reusing treated waste water from sugar mills for irrigation purpose. The successful implementation of sugar charter reduced specific fresh water consumption by 53% and specific waste water discharge by 17% in 2021-22 compared to 2017-18. This resulted in saving of 2452.55 million liters of fresh water in spite of increase in total production in 2021-22 with respect to 2017-18.

Key words: Sugar mills, Charter, Irrigation management protocol, Treated wastewater, Freshwater consumption

Mann Ki Baat Reference: Episode 73, aired on 31st January, 2021.

The impact of initiatives taken by CPCB for the implementation of charter and irrigation management protocol in sugar industries, ensuring reuse of treated wastewater in irrigation, reduction in freshwater consumption, wastewater discharge, and pollution load.

Introduction

Sugarcane contains about 70% water (w/w) and with this high quantity of water available, there appears to be little need for drawing water from outside *i.e.* from natural resources. However, most of the Sugar mills abstract substantial amount of fresh water from natural resources to meet their requirement. Although, the sugar factories have realized the importance of the subject matter *i.e.* high volume of freshwater consumption, wastewater discharge and pollution load for which there is long road of improvement. During the manufacturing process, it produces significant quantum of effluent of high organic load (Wood, 1995). BOD load is not a big problem/challenge due to its organic/ nutrient rich content but the management of such a quantum of effluent is an environmental issue/concern for Sugar industries (Solomon 2005 and 2016). Sugar effluent contains high BOD, COD, TSS, TDS, Sulphate in the range of 500-1000, 1500-2500, 100-400, 1000-2500, and 750-800 mg/l, respectively, which is treated through biological treatment system for achieving discharge norms. Various stakeholders, governments and researchers across the world are involved in finding the solution for their environmental concern (Akhtar *et al.*, 2020 and 2021).

Most of the sugar industries are established in rural area, with sufficient availability of land for irrigation purposes. CPCB took an

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initiative to prepare a charter to adopt best practices for effluent treatment and reuse of treated wastewater. Ministry of Environment, Forests and Climate Change vide Notification dated 14th January, 2016 G.S.R. 35(E) released a charter for utilization of treated effluent in irrigation and waste water conservation in Sugar industries. The charter also includes best management practices and technological suggestions to manage the wastewater effluent from sugar industries.

As per the latest data of CPCB, during crushing season of 2021-22, total 140 Sugar mills were operational in Ganga Basin against the 76 operational sugar mills during the year 2017-18 **(Fig. 1).**

In Sugar Crushing Season (Oct-Sep) of 2021-22, more than 700 million metric tons (MMT) sugarcane was produced in the country out of which about 357.4 MMT of sugarcane was crushed by sugar mills to produce about 39.4 MMT of sugar. Out of this, 3.5 MMT sugar was diverted to ethanol production and 35.9 MMT sugar was produced by sugar mills. Thus, it is reported that India has emerged as the world's largest producer and consumer of sugar as well as the world's 2nd largest exporter of sugar(GoI, 2016; Sheetal and Kumar, 2019).

Excess Condensate Generation by Sugar Industry

Sugarcane itself contains ample quantity of water required for manufacturing of Sugar during whole crushing season as the water available in the form of condensate is re-circulated in the process however; still excess condensate water is generated. The generated excess condensate contains organic compounds, which could result in water pollution in case of direct discharge on land or water. This excess condensate can substitute fresh water requirements and conserve natural resources; if it is cooled down to 30°C and treated through a proper treatment system and can also help in the reduction of effluent generation. Excess condensate generation varies from 150 to 280 L/Ton of cane, which depends on boiler pressure, steam consumption in process, type of sugar production, type of co-generation unit and diversion of feed stock (syrup/B-H) similar to distillery for ethanol production (Kushwaha, 2015; Solomon, 2016 and Sahu, 2018).

Condenser cooling water

The condensate water mostly requires for the pans and multiple evaporators in sugar factory. An open re-circulation cooling system uses the same water repeatedly to cool process equipment. Heat absorbed from the process dissipated to allow reuse of this water. Cooling towers or spray ponds are used for this purpose. Reuse of condensate water leads to reduction of fresh water and effluent generation. Fresh water required only at the time of start-up as a make-up to maintain the quality of water. Effluent generation is mostly overflow, which varies from 60 to 100 L/Ton of cane crushed depending on quantity of vapours to be condensed.

Machinery cooling water

Cold water is being used as a cooling water for power turbines, mills prime movers, mills bearing, sulphur burners, crystallizers, air compressors, vacuum pumps, hot liquor pumps etc. In order to reduce fresh water consumption, all machinery cooling water is cooled down through separate cooling tower and re-used through underground reservoir (UGR)/ service water tank. Fresh water is required only to compensate the evaporation loss, gland cooling water and leakages. Fresh water requirement varies from 30 to 43 L/Ton of cane.

Regulatory Standards for Sugar Industry

The Ministry of Environment, Forest and Climate Change, Government of India vide Gazette Notification dated January 14, 2016, has implemented stricter environment regulatory standards for sugar industries with primary aim to minimise water pollution.

Specific wastewater discharge standards have been made stricter, by limiting to 200 L/Ton of cane crushed, as against the earlier limit of 400 L/Ton of cane crushed. This resulted in less consumption of raw water at operational level. The final treated effluent discharge

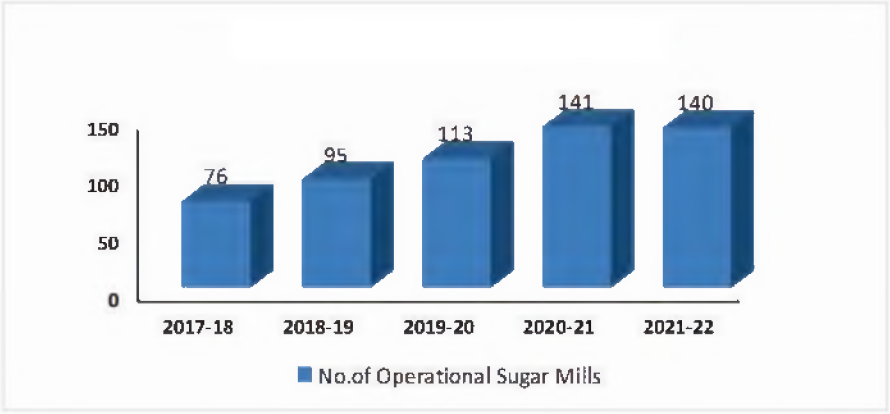

Fig. 1: Number of operational Sugar mills in Ganga Basin

has been restricted to 100 L/Ton of cane crushed and wastewater from spray pond overflow or cooling tower blow down to be restricted to 100 L/Ton of cane crushed. Only single outlet point from unit has been allowed to encourage operational efficiency, treated effluent recycling practices with a '24x7 online monitoring' protocol.

The number of compliance parameters for effluent quality has been increased from two to six (6), *i.e.* pH, Bio-chemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solids (TSS), Total Dissolved Solids (TDS) and Oil & Grease (O&G). The emission limits for particulate matter (PM) from stack has been limited to 150 mg/m^3. The notified standards also contain a protocol for 'Treated effluent irrigation' and 'Wastewater conservation and pollution control management', wherein treated effluent loading rates (in cubic meter per hectare per day) have been mentioned for different soil textures (Table 1).

Table 1: Effluent loading rate for different soil texture.

S.N.	Soil texture	Loading rate in m^3 /Ha/Day
1	Sandy	225 to 280
2	Sandy loam	170 to 225
3	Loam	110 to 170
4	Clay loam	55 to 110
5	Clay	35 to 55

The waste water conservation and pollution control management mandates that, individual units will establish cooling arrangement and polishing tank for recycling excess condensate water to process sections, or utilities, or allied units.

The Effluent Treatment Plant (ETP) will also be stabilised one month prior to the start of crushing season and will continue to operate up to one month after the end of crushing season. The protocol has also made it obligatory for the industry to install flow-meters at all water abstraction points so that fresh water usage can be minimised. Further, the industrial units have been permitted to store treated effluent in a seepage proof impermeable pond, having 15 days holding capacity.

The revised standards lead to improved operational performance of sugar industries through implementation of wastewater discharge standards and waste water conservation and pollution control management protocol. It also helped the CPCB and State Pollution Control Boards (SPCBs) / Pollution Control Committees (PCCs) in implementing specific measures in sugar industries for reducing consumption of fresh water usage, checking operational efficiency and enhancing compliance.

The revised standards are implemented from the date of notification. The standards had been recommended by the Central Pollution Control Board (CPCB), after consultations with industries and other stakeholders.

Charter for reuse of treated wastewater for irrigation purpose

As a part of Charter implementation in the year 2018 all sugar mills were required to prepare an Irrigation management plan for implementation of the irrigation management protocol. For verification of the implementation of the irrigation plan, sugar charter and compliance status, CPCB carried out annual audits of sugar mills by involving State Pollution Control Boards (SPCBs) and knowledge partners with support from National Mission for Clean Ganga (NMCG). During the 73rd episode of Mann Ki Baat, Hon'ble Prime Minister of India emphasised on the reuse of treated wastewater for irrigation purposes by farmers. The charter for water reduction/ recycling and pollution prevention was formulated with the intention to facilitate the sugar industries to adopt best practices, appropriate technologies, and policy regulations for effluent treatment. The purpose of formulating this charter is to enforce appropriate technologies for effluent treatment in sugar factories in the Ganga basin and to motivate them to comply with the prescribed environmental norms and to accomplish the desired level of environmental protection, implementation of irrigation management protocol and achieve prescribed norms of discharge so as to meet objectives of the National Mission for Clean Ganga. This is possible through the adoption of well-established efficient process technologies for sugar production, downstream effluent treatment technologies & practices, and environmental performance, besides substantial reduction of freshwater consumption as well as wastewater generation. Charter suggests proper record keeping along with strict metering at freshwater abstraction, fresh water consumption, hot and cold-water recycling system, effluent generation, and discharge points (Ranjan *et al.*, 2021).

In addition to this, other technological interventions include upgradation of ETP up-to tertiary treatment level, condensate polishing unit where high-pressure boiler is more than 45kg/cm^2 pressure, hydro jet cleaning of tubular heat exchanger over conventional cleaning, 2 stage membrane-based brine recovery system, closed loop hot and cold-water circulation systems and Installation of separate Sulphate Removal system (SRS). After charter implementation, sugar industries located in Ganga basin prepared irrigation management plan and carried out adequacy of effluent treatment plant in consultation with technical institutes.

The impact of charter was assessed in terms of fresh water consumption, effluent generation and BOD load in the sugar industries. Water management practices by sugar industries saved fresh water abstraction in the process through reuse and recycling as well as by the availability of treated wastewater for irrigation purpose (Ranjan *et al.*, 2021).

Results and Discussion

The efficacy of the irrigation management plan and charter in year 2021-22 is compared with year 2017-18 in order to understand the impact of irrigation management plan and charter in terms of reduction in fresh water consumption, effluent discharge and BOD load in Ganga basin. From data it is observed that implementation of irrigation management plan and charter improved the overall compliance status in sugar mills.

As per the latest data, the specific fresh water consumption reduced by 53% from 197.08 L/Ton of cane crushed to 92.48 L/Ton of cane crushed and specific wastewater discharge reduced by 17% from 168 L/Ton of cane crushed to 140 lit/tonne of cane crushed in 2021-22 as compared to 2017-18, respectively; although the quantum of discharge per day increased by 69.5%. This resulted in a saving of 105.60 MLD of fresh water in spite of increase in total production by ~97.5%.

Fresh water consumption

The fresh water consumption and reuse of treated wastewater was analysed during year 2017-18 and 2021-22. Irrigation management plan has been implemented through sugar charter in 2018. Before implementation of charter, treated effluent was not utilized for irrigation, while it was directly or indirectly disposed in River Ganga and its tributaries.

Based on annual inspection data freshwater water consumption has been reduced from 73,789.64 KLD to 58,461.16 KLD as a result of implementation of charter in spite of increase in production from 37,4419.24 TCD to 7,39,274.95 TCD due to increase in number of sugar units (Fig. 2).

Actual Effluent discharge

The Effluent discharge was analysed during year 2017-18 and 2021-22 and it was increased from 62,008.26 KLD to 1,05,061.51 KLD due to increase in number of sugar industries (Fig. 3).

Specific Fresh water consumption

The analysis of specific fresh water consumption during the year 2017-18 and 2021-22 shows reduction from 197.08 L/T of cane to 92.48 L/T of cane (Fig. 4)

Specific Effluent discharge

The analysis of specific effluent discharge during the year 2017-18 and 2021-22 shows reduction from 168 L/Ton of cane to 140 L/Ton of cane (Fig. 5)

Total quantity of treated waste water is being utilized in irrigation resulted in conservation of ground water and also saved river water pollution.

As per the data received from sugar mills during annual inspection in the year 2021-22, total 16090.73 Ha. land is available for irrigation by reusing treated wastewater.

BOD load

ETP adequacy reports were prepared by the sugar industry during year 2017-18 and ETP has been up-graded upto tertiary level as per the recommendations given by the sugar expert in the adequacy reports. The implementation status of ETP adequacy reports was also verified by the technical expert in the year 2018-19. Up-graded ETP's are performing satisfactorily and achieving treated water results as per notified standards.

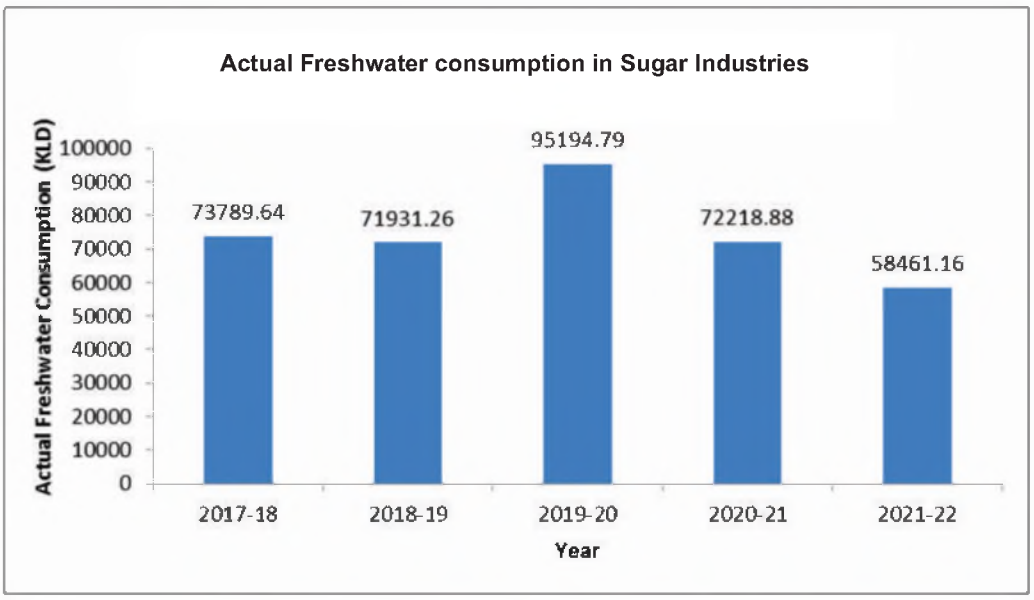

Fig. 2: Reduction in fresh water consumption

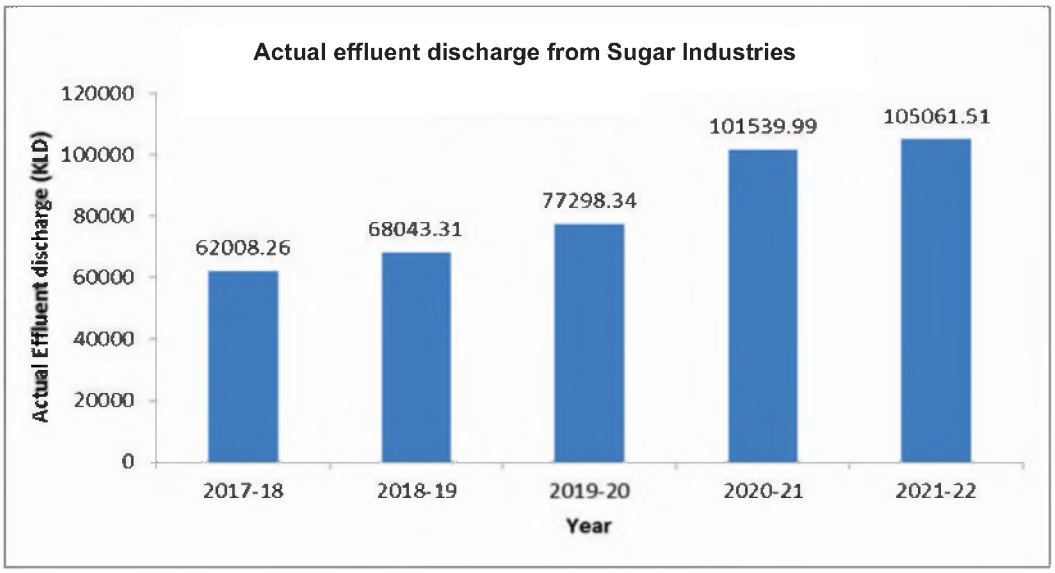

Fig. 3: Effluent discharge, KLD

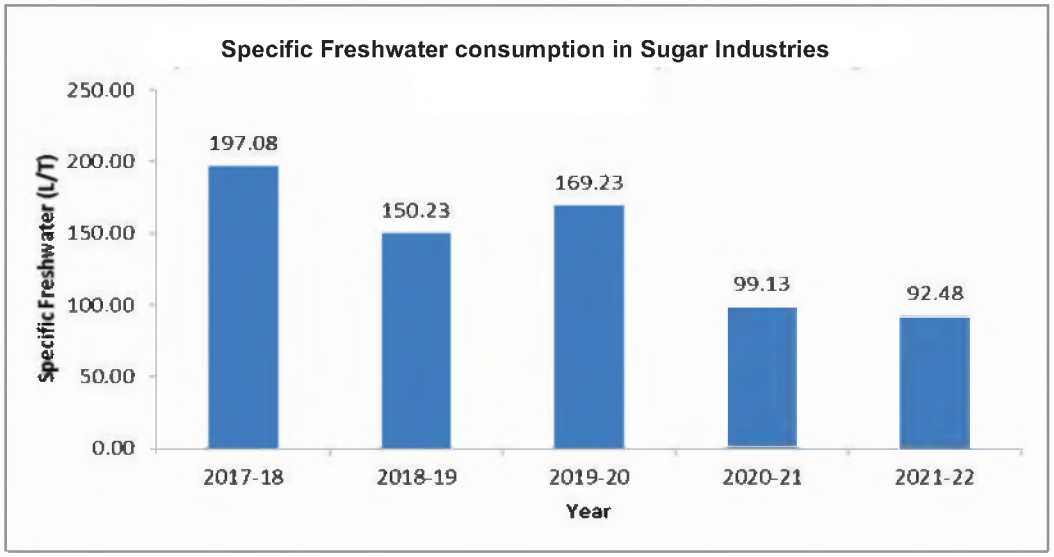

Fig. 4: Specific fresh water consumption

The comparative assessment of BOD load in the year 2017-18 and 2021-22 before and after implementation of irrigation management plan through sugar charter has been made and it is inferred that overall BOD load reduction from 10662.59 kg/day to 3907.45 kg/day (Fig. 6)

Benefit to environment in terms of reduction in BOD load

Discharge of high BOD load in river is very dangerous to the aquatic life and natural ecosystem. The assessment of the irrigation plan reveals that reduction in BOD load and reuse of treated wastewater in irrigation maintains the natural form of river water and groundwater.

Benefit to the industry

Power consumption and operation & maintenance cost has been reduced for fresh water abstraction. Disposal problem of treated water is solved by utilization for irrigation. Public image of the industry has been improved. Treatment cost of ETP is reduced due to reduction in effluent generation and BOD load.

Benefit to the farmers

Implementation of irrigation management plan has

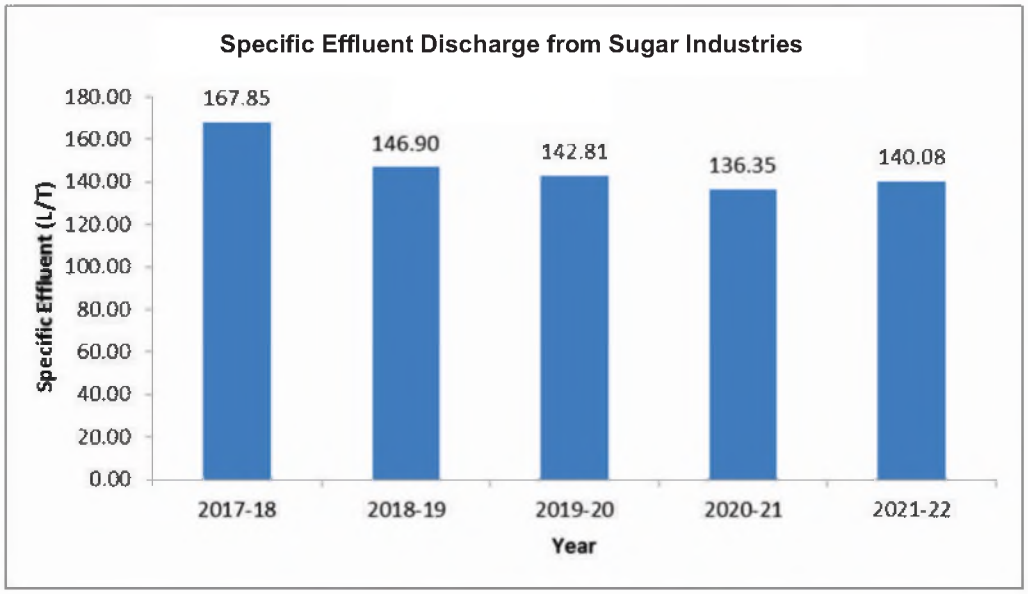

Fig. 5: Specific effluent discharge

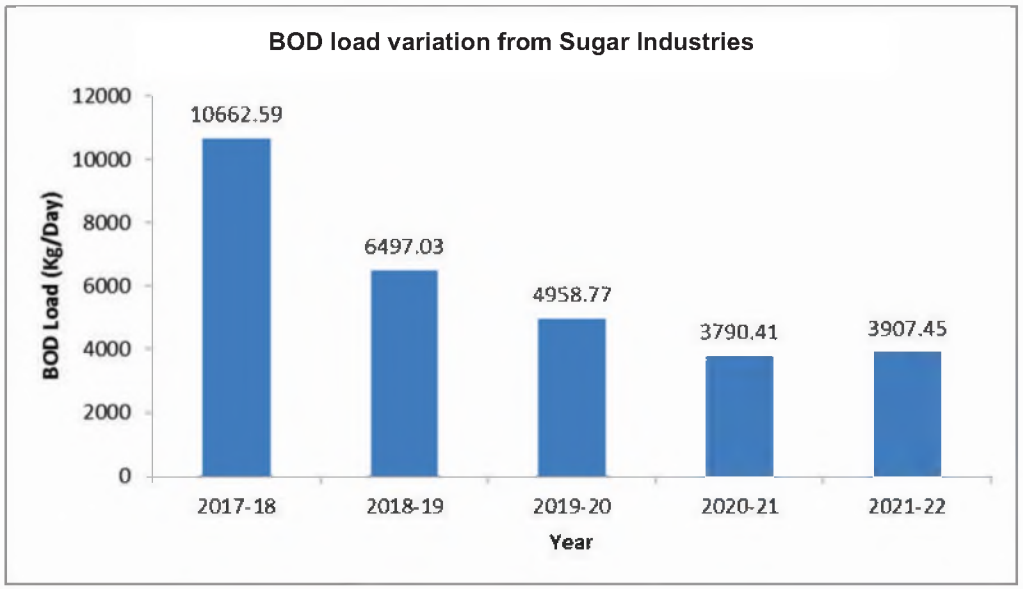

Fig. 6 : Reduction in BOD

also an economic aspect in the agricultural sector, as the farmers are using treated wastewater from sugar industries for the irrigation purpose, which also has a positive impact on the crop yield. In this way, the farmers are the direct beneficiary of implementation of irrigation management plan.

Conclusion

Central Pollution Control Board introduced charter for sugar industry in the year 2018. Charter suggested Bare Minimum Technologies (BMT) for reduction in fresh water consumption, effluent generation and ETP up-gradation. CPCB, also, prepared irrigation management plan to utilize treated effluent for land application. Sugar industries also adopted irrigation management plan, which is assessed in the annual inspection. The outcome of these initiatives proved to be very effective in treated wastewater and in conserving the ground water resources. Therefore, such type of water management programme can be implemented in Sugar industries located in other states of the country to conserve fresh water and reduce discharges in river and as well as to promote environmental sustainability.

अपशिष्ट जल का पुनः उपयोग - सिंचाई के लिए गंगा नदी बेसिन के चीनी उद्योगों से उपचारित अपशिष्ट जल के कुशल पुनः उपयोग की संभावना

प्रभात रंजन, अजीत कुमार विद्यार्थी, रीना सतावन, अश्वनी सिंह, सोनम लाली और डी.बी. सपकाल

सारांश

चीनी उद्योग ताजे पानी की अधिक मात्रा का उपभोग करता है, प्रति टन गन्ना पेराई लगभग 1000 लीटर अपशिष्ट जल पैदा करते है। चीनी उद्योग से उत्पन्न अपशिष्ट जल उच्च बायोकेमिकल ऑक्सीजन डिमांड (बीओडी), केमिकल ऑक्सीजन डिमांड (सीओडी) और टोटल सस्पेंडेड सॉलिड्स (टीएसएस) के साथ जटिल है। सीपीसीबी, 2021-22 के नवीनतम आंकड़ों के अनुसार, गंगा नदी बेसिन में परिचालन चीनी उद्योग की कुल संख्या 140 है, जो प्रतिदिन लगभग 739274.95 टन गन्ने की पेराई करती है, 58461.16 केएलडी ताजे पानी की खपत करती है और 105061.51 केएलडी प्रवाह का निर्वहन करती है जिसमें 3.9 टीपीडी बीओडी लोड होता है। मन की बात-#39; (31/01/2021) के 73वें एपिसोड के दौरान भारत के माननीय प्रधानमंत्री ने किसानों द्वारा सिंचाई के लिए अपशिष्ट जल के उपयोग पर जोर दिया। सर्वोत्तम प्रबंधन प्रथाओं और सर्वोत्तम उपलब्ध तकनीकों को अपनाने के लिए चीनी मिलों की सुविधा के लिए, चीनी उद्योगों में जल पुनर्चक्रण और प्रदूषण की रोकथाम के लिए चार्टर तैयार किया गया है और ताजे पानी की खपत, अपशिष्ट जल निर्वहन में कमी के उद्देश्य से केंद्रीय प्रदूषण नियंत्रण बोर्ड (सीपीसीबी) द्वारा लागू किया गया है, प्रदूषण भार और सिंचाई उद्देश्य के लिए उपचारित अपशिष्ट जल का पुनः उपयोग किया गया। यह शोध पत्र मुख्य रूप से सिंचाई के उद्देश्य से चीनी मिलों से उपचारित अपशिष्ट जल का पुनः उपयोग करके भूजल संरक्षण पर केंद्रित है। चीनी चार्टर के सफल कार्यान्वयन ने 2017-18 की तुलना में 2021-22 में विशिष्ट ताजे पानी की खपत में 53% और विशिष्ट अपशिष्ट जल निर्वहन में 17% की कमी की। इसके परिणामस्वरूप 2017-18 की तुलना में 2021-22 में कुल उत्पादन में वृद्धि के बावजूद 2452.55 मिलियन लीटर ताजे पानी की बचत हुई।

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