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EDITORIAL

India with 18% of the World's population has only 4% of the world's water resources. In India, more than 50% of the population is facing scarcity of water, especially in view of population growth and economic development with more than 600 million population living in water shortage areas. Present conditions and future forecasting shows worsening water condition in the coming decades. Water being a basic human requirement needs appropriate planning, development, and management. The government agencies involve several action plans, policies and regulations across all levels of India's federal structure and consequently illuminating every facet of water resource management in all Indian states and sectors.

The Hon'ble Prime Minister of India in several episodes of Mann Ki Baat, spoke on the need for intensive water conservation and also combined these issues with several successful case studies. The Hon'ble Prime Minister of India exhorted every citizen of India that "every drop of rain should be conserved" further encouraging all possible solutions to conserve the water resources of India. In the purview of the above, to overcome the problem of water scarcity, efficient water management strategies and techniques (Reduce, Reuse and Recycle) have been planned and implemented. Central Pollution Control Board, played a pivotal role in the subject matter by implementing, continuous surveillance, and monitoring of industrial pollution, sewage, and water quality; technological intervention through participatory approach in industries such as Pulp & Paper, Sugar, Distillery, etc. for freshwater conservation, wastewater minimization, pollution load reduction and also reuse and recycling of treated wastewater in either industrial process or irrigation purposes. Domestic sewage, one of the major contributors of water pollution in the Indo-Gangetic basin has also been managed through capacity augmentation of sewage treatment facilities, adoption of alternative treatment technologies, action plan preparation and implementation for major drains and continuous surveillance. It also focusses on managing the water quality of river Ganga, Yamuna and its tributaries through pollution source mapping and action plan preparation and its implementation involving local administration and governmental agencies.

This special issue highlights all regulatory and technological interventions for water quality management for municipal wastewater, industrial wastewater, occasion and festivities deteriorating water quality, water sustainability and water reuse and resource recovery. Even after implementing all possible technologies and policies, we have a long way to go towards sustained utilization of water, protection and conservation of water resources, rainwater harvesting, development of surface and ground resources, the establishment of water bank, etc. These Water-management decisions covered in this special issue can have environmental, physical, social and economic impacts that are widespread and pervasive. It is, therefore, the need of an hour to disseminate the most relevant information for arriving at rational policies and decisions resulting in maximum environmental benefits.

Editor
Indian Forester

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FRONT COVER

Dipterocarpus species- a giant Gurjan tree in Little Andaman

Photo by : N. Bala
Division of Forest Ecology & Climate Change,
Forest Research Institute, Dehradun (Uttarakhand)

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Securing Zero Black Liquor Discharge in Pulp and Paper Industries of River Ganga basin through Participatory approach

The pulp and paper industry has been considered a large consumer of freshwater and one of the largest sources of surface water pollution. The Indian paper industry are highly intensive in terms of consumption of raw material, chemicals, energy, and water thereby generating high volume of wastewater with complex characteristics, black liquor with high Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD) and Total Suspended Solids (TSS). Central Pollution Control Board (CPCB), after consultation with different stakeholders prepared an action plan for black liquor management in Pulp and Paper industries. The action plan was successfully implemented and resulted into zero black liquor discharge in river Ganga basin since 2014. To ensure zero black liquor discharge, around 100 chemical pulping digesters were dismantled, and 7 Chemical Recovery Plants (CRP) were commissioned for black liquor management. The initiatives and ensurance of zero black liquor discharge from Pulp and Paper Industry in Uttarakhand and Uttar Pradesh was acknowledged by Hon'ble Prime Minister of India in Mann ki Baat, Episode-19th dated 24/04/2016. The Pulp and Paper industries located in Ganga basin are being inspected annually with technology partners for verification and to ensure no black liquor discharge into recipient water bodies. Implementation of zero black liquor discharge led to improvement in water quality of recipient water bodies such as river Dhela, Bahela, Kosiand Ramgangain terms of Dissolved Oxygen (DO) and Bio-chemical Oxygen Demand (BOD) and no incidence of coloured water discharge observed in river Ganga since 2017. Implementation of action plan and continuous surveillance through annual inspection of pulp and paper industries led to reduction in pollution load from 76.5 TPD to 1.74 TPD in 2021 as compared to 2011. The successful case of this holistic participatory approach and policy needs to be implemented nationwide for black liquor management in Pulp and Paper mills.

Key words: Pulp and paper, Black liquor, Water pollution, Chemical recovery, Mann Ki Baat, Action plan.

MKB Episode Reference: Episode 19 aired on April 24, 2016.

The impact of participatory approach, technological intervention and action plan for black liquor management in pulp and paper industries of river Ganga basin have been highlighted.

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Introduction

River Ganga is one of the main sources of livelihood for western Indo-Gangetic plane habitants. Apart from the livelihood, the river holds special place in Indian peoples' life due to its sacred belief. Two major head streams i.e. river Bhagirathi and river Alaknanda originate from glaciers located in Himalayan mountains and meet at Devprayag to form river Ganga. It is the 2525 km long river with catchment area of 1086000 km^2 (Trivedi, 2010; Ranjan *et al*., 2020 and Vidyarthi *et al*., 2020). The river Ganga flows in five states, Uttarakhand, Uttar Pradesh, Bihar, Jharkhand and West Bengal before confluence into Bay of Bengal. The major tributaries of the river Ganga are Ramganga, Kali East, Yamuna, Tons, Gomti, Sone, Ghagra, Gandak, Kosi, Mahananda and Damodar. These tributaries are also having several sub-tributaries and 2nd, 3rd, and 4th order drains, which carries the pollution load. Each state contributed significant amount of pollution load in the river by discharging untreated sewage and industrial wastewater. The industrial pollution majorly comes from the industries like; Distillery, Pulp and Paper, Sugars and others.

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In 2011, CPCB estimated that, Uttarakhand (UK) and Uttar Pradesh (UP) stretch contributed a significant pollution load in river Ganga by discharging 1,61,792 KLD and 73,470 KLD untreated/partially treated effluent, respectively. Out of the total discharge, Pulp and Paper industries were one of the major contributors with industrial discharge of 146,000KLD (90% of industrial discharge) and 39,220 KLD (53% of industrial discharge) from UK and UP respectively (Feasibility report CPCB; 2014). Paper industries of the states of UK and UP were mainly located in the cluster of Kashipur, Meerut, Muzaffarnagar, Moradabad having production varying from 30-250 TPD. Most of these industries located in these clusters had small production units which utilized agro-residue and wastepaper as raw material and were installed without Chemical Recovery Plant (CRP) (Jwala *et al*., 2017). Furthermore, high silica content, adverse thermal and flow properties of agro-residue black liquor deterred industries to install CRP and adopt alternative environmental management options. In addition, these industries needed to change their product line frequently, which lead to huge wastewater generation. Most of these industries were discharging either partially treated black liquor or untreated black liquor which resulted into deterioration of water quality of recipient water bodies (Endlay *et al*., 2022 and Vidyarthi, 2018). During 2009, the value of Dissolved Oxygen (DO) in river Dhela, Bahela was observed as Nil, whereas the value of DO in river Kosi and Ramganga were in the range of 3.5-7.8 mg/L and 5.4-9.2 mg/L, respectively. In 2009, the BOD value of river Dhela, Bahela, Kosi and Ramganga was observed as 340 mg/L, 44-179 mg/l, 10 mg/l and 4-8.4 mg/l, respectively (Rana *et al*., 2022). Pulp and paper industries specially those using agro-residue/wood as raw material and with production capacity of<100 TPD were discharging black liquor directly into recipient water bodies. The black liquor has high solid content (8-12%), and the COD varies in the range of 75000-125000 mg/L. The black liquor was the main reason behind the strange colour of these tributaries and river Ganga. In 2007, the black liquor generated from these industries was 10000KLD out of which 4000 KLD was discharged into river Ganga. The generation of black liquor steadily increased in the subsequent years due to increase in production. In 2011, the black liquor production was 17500KLD and black liquor discharge was 6000 KLD. Apart from the black liquor management most of the pulp and paper mills were having effluent treatment facilities to treat generated wastewater but that too were not up-to the satisfactory level or most of them were having inadequate facility (Endlay *et al*., 2022 and Vidyarthi, 2018).

In the above context CPCB in association with technical institutions were involved in Techno-economic feasibility study for Setting up of Common Chemical Recovery Plant (CCRP) based on conventional technology and standalone modified fluidized bed chemical recovery system for agro/ wood-based Pulp and Paper Industries operating in identified clusters of Uttar Pradesh (UP) and Uttarakhand (UK) for management of Black liquor (Endlay *et al*., 2022). In consultation with all the stakeholders and in 2012, CPCB formulated and implemented an action plan for black liquor management for pulp and paper sector, and as a result despite of 18000 KLD black liquor generation, the discharge of black liquor was found to be zero in the Ganga river basin (cGanga Report on Pulp and Paper, 2019). In the 19th Episode of Mann Ki Baat dated 24/04/2016, Hon'ble PM also acknowledged the efforts of eliminating black liquor discharge from Pulp and Paper Industry in Uttarakhand and Uttar Pradesh. This paper deals with participatory approach adopted to assure proper management of black liquor a systematic participatory and stakeholder (Regulatory bodies, Technical Institution, Industrial Association, NGO, and Locals).

Methodology

Problem Identification through Survey and Primary Data Collection

Pollution load assessment of River Ganga performed by CPCB in 2011 shows that the quality of river Ganga water was severely affected. CPCB with SPCB performed an extensive survey (physical and documentation) to map all the tributaries, drain, intensity of pollution load and sectoral specific major polluters. In the second step of the survey, pulp and paper industry were inventoried and assessed. The pulp and paper industry required a huge amount of water during various processes of paper making, which generates huge amounts of wastewater of different pollution parameters.

To identify pulp and paper sector inherent problems

For the assessment of point pollution source, industrial sector specific inherent problem identification was carried-out, Sector specific inventory (Questionnaire) was prepared for problem identification for pulp and paper sector. Inventorization of pulp and paper industries of UK and UP was carried out. Pulp and paper industries of UK and UP states mainly located in four clusters: Kashipur, Meerut, Muzaffarnagar, and Moradabad. A total 60 pulp and paper industries located in four clusters of these two states were inventoried. Out of 60 industries, 20and 40 industries were located in UK and UP respectively.

Inventorization and Status of Pulp and Paper Mill

In the preparation of inventory several aspects to identify the problem assessed; type of raw material used, raw material to pulp conversion process (Pulping), quality enhancement process (Bleaching), type of product manufactured, freshwater consumption and source, availability of generated wastewater treatment facility, treated water discharge mechanism, housekeeping, in-house technical capacity etc. Apart from inventorization, analysis of section wise wastewater parameters was also carried out.

Participatory Approach

In the preparation of pollution load abatement strategy, participatory approach was applied in which, experts from various fields were brought together and brain storming sessions were carried out. Experts from Indian Institute of Technology (IITs), Centre Pulp and Paper Research Institute (CPPRI), Indian Pulp and Paper Industrial Association (IPPIA), and Industry people were involved in the exercise (Fig. 1). A bond between all the stockholders was developed to prepare and execute the charter (Charter, 2015).

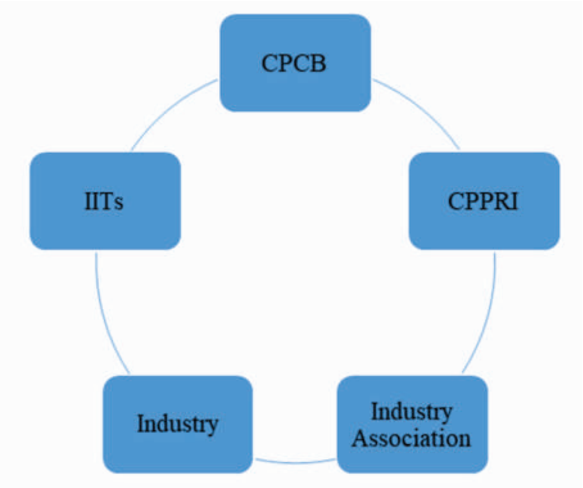

Fig. 1: Participatory approach for pollution reduction from pulp and paper sector

Action Plan for black liquor management

The action plan for black liquor management includes; Installation and commissioning of Chemical recovery Plant (CRP),Common Chemical Recovery Plant (CCRP), Flow measurement of Black Liquor, installation of Mass Flow meter (connected to PLC based logic or DCS), Recording of daily, to-date monthly and to-date yearly production of Soda Ash (in MT), installation of separate steam mass flow meter in CRP, record keeping of steam consumption in evaporators (MT/Day), recording of Steam Economy of evaporators, Consumption of power in the total CRP in Units/Day, Separate power meter (with totalizer) connected to PLC based logic or DCS for the CRP, record for consumption of Caustic in cooking digester, Declaration of total caustic purchased and total Soda Ash produced in a month, record for input raw materials utility (like steam, power, chemicals etc) effluent flow and pulp production data on daily / monthly / yearly basis, record for effluent generation and discharge, facility for transportation of block liquor to Common CRP (CCRP) through pipelines only, installation of cameras at the discharge points and restriction to run digesters for pulping by Paper Mills without having CRP facility or membership of a common CRP.

Regular monitoring of Pulp and Paper Industries

(a) Monitoring and Reporting

Under monitoring and reporting, paper industries required to submit monthly data of expected total running hours of evaporators and FBR, expected production of black liquor and Soda Ash and prior information to CPCB/ SPCB in case of shutdown or breakdown of the CRP and verification of declaration by industry for CRP operation through SPCB. Paper industries were required to submit report for physical verification of black liquor management and compliance through third party technical institute of repute.

(b) Real-time monitoring of CRP operation

Installation and connectivity of camera (facing chimney) to SPCBs/ PCCs server for online monitoring of FBR.

Connection of flow measurement and power meter to PLC based logic or DCS.

(c) Scrapping/ Dismantling of digester

The CPCB also made it mandatory to scrape the digester of the industries those who switched their raw material from agro/ wood to wastepaper or does not have facility of chemical recovery (Fig. 2).

(d) Steps taken for water conservation and improved water use efficiency

(i) Development of model Consolidated Consent and Authorization (CCA)

CPCB developed Model template for Consolidated Consent & Authorization (CCA) incorporating novel and proven technologies, norms for freshwater consumption, wastewater discharge as key performance indicators for adoption by seven State PCBs in Ganga and Yamuna main stem states.

Enforcement of model CCA in seven SPCBs/ PCCs of Ganga and Yamuna main stem states underway with three SPCBs namely UPPCB, BSPCB and UKPCB already issuing fresh CTO as per model template.

(ii) Regulatory framework for groundwater abstraction

In consultation with Central Ground Water Authority, it was made mandatory that specific freshwater consumption limit as per model CCA to be incorporated in the NOC for groundwater.

(e) Regulatory framework for ensuring zero black liquor discharge

CPCB is carrying out inspection of 100% of GPIs of Ganga basin since 2017.

Fig. 2: Dismantling of digestors at pulp and paper industries not having CRP.

The inspection includes, ensurance of zero black liquor discharge, verification of compliance w.r.t. effluent discharge norms, material balancing, water audit etc,

It also includes collection of Primary data regarding validity of Consent to Operate (CTO), black liquor management, recycle and reuse of treated effluent, verification of route of Zero Liquid Discharge (ZLD), performance assessment of Effluent Treatment Plant (ETP) system etc.

Total number of Pulp and Paper industries inspected was 90 in 2017, 85 in 2018, 93 in 2019, 100 in 2020 and 97 in 2021 in Ganga main stem states. In 2021 total paper production in Ganga main stem was estimated as11942.25tonsper day. (CPCB Report, Sept' 2022)

The BOD load in the effluent discharged by Pulp paper industries reduced significantly from 76.5 TPD to 1.74 TPD i.e. 97.7% reduction in BOD load is observed in 2021 in compared to 2011 (CPCB Report, Sept' 2022)

Impact of Action plan on black liquor management

Most of the Pulp and Paper industries located in the Kashipur, and Muzaffarnagar cluster were agro-based. These industries were discharging 2000 and 6000 m^3/day black liquor directly into water bodies without any treatment (cGanga Report on Pulp and Paper, 2019). These categories of industries used to discharge a significant amount of Black liquor before the implementation of the action plan as they were not equipped with the Chemical recovery facility (CRP).

(a) Kashipur Cluster

The Kashipur industrial cluster had 26%agro-based industries and black liquor generation grew with increase in production. Till 2004, all these industries were discharging 100% of generated black liquor into nearby water bodies. From 2005 onwards, industries started installing CRP and as a result the black liquor discharge reduced consequently and by 2012 the Kashipur cluster achieved zero black liquor discharge. From year 1983 to 2017, production in the Kashipur cluster grew 20 times and the black liquor generation grew 28 times (Fig. 3) (cGanga Report on Pulp and Paper, 2019).

(b) Muzaffarnagar Cluster

The Muzaffarnagar industrial cluster had 25% agro-based Pulp and Paper industries. The black liquor generation increased with an increase in production from year 1985 to 2009. Till 2009, all of these industries were discharging 100% of generated black liquor into nearby water bodies. From the year 2010 onwards, industries started installing CRP and CCRP leading to reduction in black liquor and achieved zero black liquor discharge by year 2014 (Fig. 4). From the year 1985 to 2017, production in the Muzaffarnagar cluster grew 18 times and the black liquor generation grew 11 times (cGanga Report on Pulp and Paper, 2019).

(c) The Ganga River Basin of Uttarakhand and Uttar Pradesh

The Paper production of the industries located in Ganga River basin of UK and UP including Kashipur and Muzaffarnagar cluster was found 3523 TPD in the year 2017 and these industries were found to be generating 18797 m^3/day of black liquor. Since 2014, zero black liquor discharge was achieved (Fig. 5) (cGanga Report on Pulp and Paper, 2019).

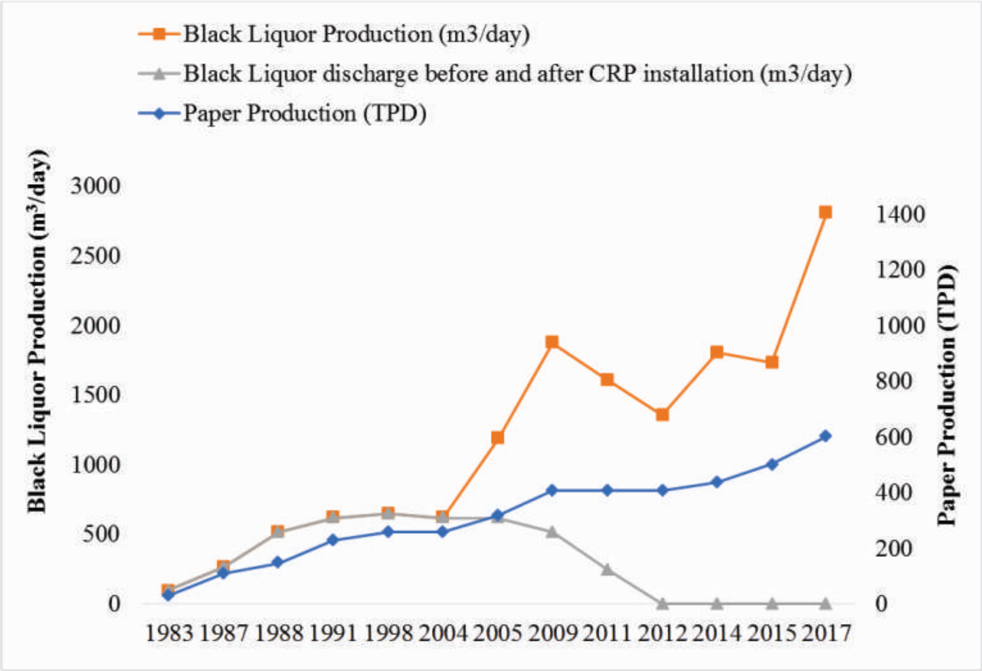

Fig. 3: Paper production, Black liquor generation and discharge of Kashipur Cluster during 1983 to 2017

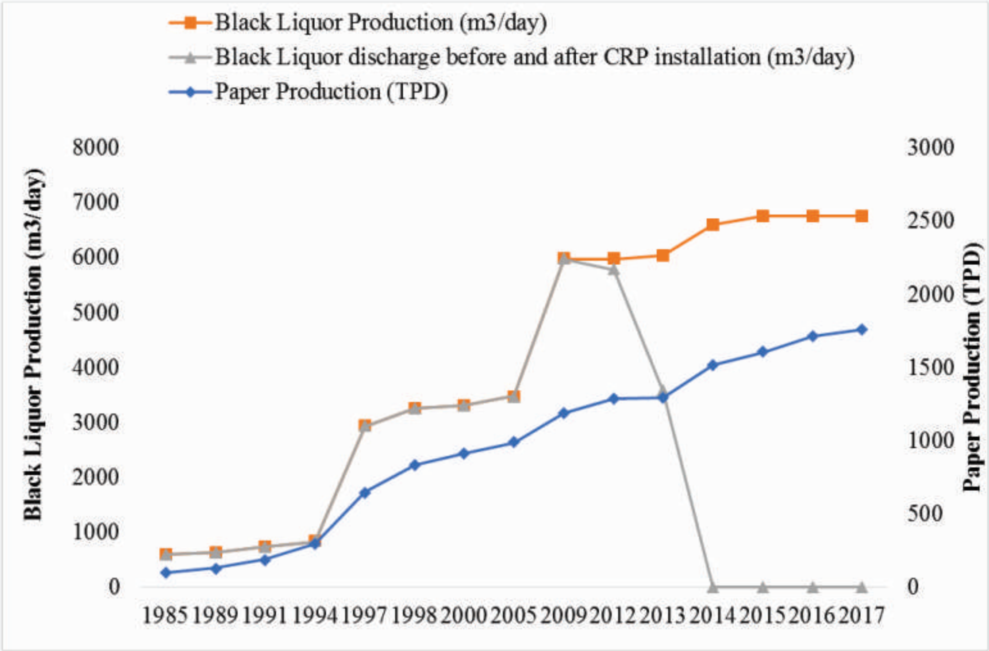

Fig. 4: Paper production, Black liquor generation and discharge of Muzaffarnagar Cluster during 1985 to 2017.

(d) Water quality of tributaries

Improvement in water quality of river Ganga and its tributaries have been observed since 2009. The DO level in 2022 as compared to 2009 improved from Nil to 8.8 mg/L in river Dhela, Nil to 7.8 mg/L in river Bahela, 3.5-7.8 to 6-7.6 mg/L in river Kosi and 5.4-9.2 mg/l to 6.6-9.3 mg/L in river Ramganga. The BOD level in 2022 as compared to 2009 reduced from 340 mg/L to 2-29 mg/L in river Dhela, 44-179

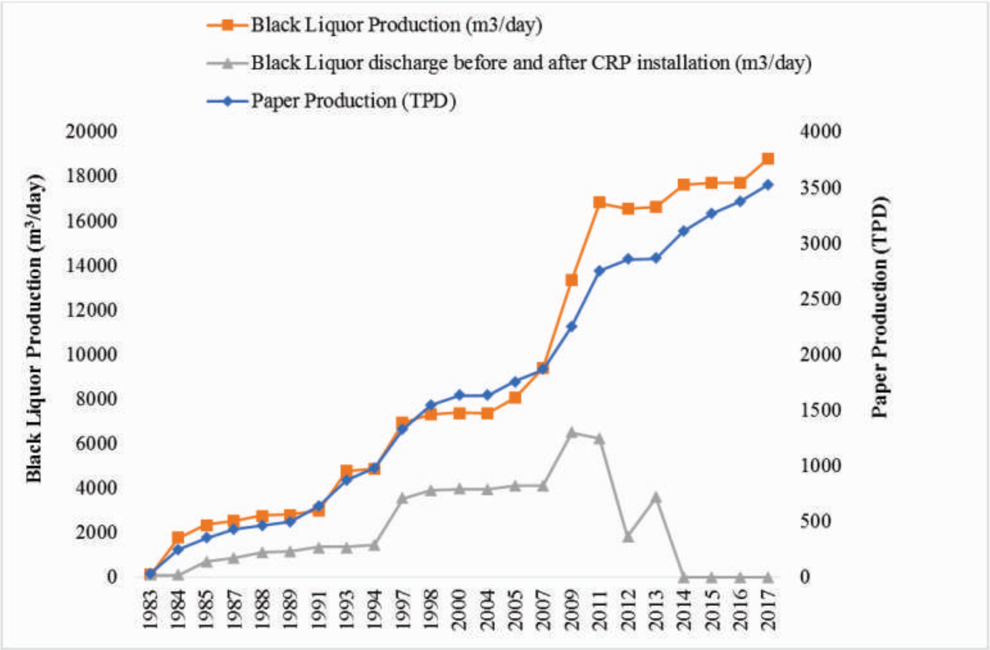

Fig. 5: Paper production, Black liquor generation and discharge into Ganga River from Uttarakhand and Uttar Pradesh from 1983 to 2017

mg/L to 2-58 mg/L in river Bahela, 10 mg/L to 3-4 mg/L in river Kosi and 4-8.4 mg/L to 3-6 mg/L in river Ramganga (Rana *et al.*, 2022).

Conclusion

The implementation of action plan for black liquor management resulted in zero black liquor discharge by dismantling of about 100 chemical pulping digesters and commissioning of 7 chemical recovery plants. Implementation of action plan and continuous surveillance through annual inspection of pulp and paper industries led to reduction in pollution load from 76.5 TPD to 1.74 TPD in 2021 as compared to 2011. As a result of zero black liquor discharge, iimprovement in water quality of rivers, Dhela, Bahela, Kosiand Ramganga was observed in terms of DO and BOD and no incidence of coloured water in river Ganga observed since 2017.

भागीदारी दृष्टिकोण के माध्यम से गंगा नदी बेसिन के लुगदी और कागज उद्योगों में शून्य ब्लैक लिकर उत्प्रवाह को सुनिश्चित करना

आर.के. सिंह, ए.के. विद्यार्थी, ए. शुक्ला, पी. रंजन, वी.कुमार और आर. कुमार

सारांश

लुगदी और कागज उद्योग को ताजे पानी का एक बड़ा उपभोक्ता और सतही जल प्रदूषण के सबसे बड़े स्रोतों में से एक माना जाता है। भारतीय कागज उद्योग कच्चे माल, रसायन, ऊर्जा और पानी की खपत के मामले में अत्यधिक सघन है, जिससे जटिल विशेषताओं के साथ उच्च मात्रा में अपशिष्ट जल उत्पन्न होता है, ब्लैक लिकर में उच्च जैव रासायनिक ऑक्सीजन मांग (बीओडी), रासायनिक ऑक्सीजन मांग (सीओडी) और कुल निलंबित ठोस (टीएसएस) की काफी मात्रा होती है। केंद्रीय प्रदूषण नियंत्रण बोर्ड (सीपीसीबी) ने विभिन्न हितधारकों के साथ परामर्श के बाद लुगदी और कागज उद्योगों में ब्लैक लिकर प्रबंधन के लिए एक कार्य योजना तैयार की। कार्य योजना को सफलतापूर्वक लागू किया गया और 2014 के बाद से गंगा नदी बेसिन में शून्य ब्लैक लिकर उत्प्रवाह हुआ। शून्य ब्लैक लिकर उत्प्रवाह सुनिश्चित करने के लिए, लगभग 100 रासायनिक पल्पिंग डाइजेस्टर को नष्ट कर दिया गया, और ब्लैक लिकर प्रबंधन के लिए 7 रासायनिक रिकवरी प्लांट (सीआरपी) चालू किए गए। उत्तराखंड और उत्तर प्रदेश में लुगदी और कागज उद्योगों से शून्य ब्लैक लिकर उत्प्रवाह सुनिश्चित करने की पहल को भारत के माननीय प्रधानमंत्री द्वारा मन की बात, एपिसोड -19 दिनांक 24/04/2016 में अभिस्वीकार किया गया था। गंगा बेसिन में स्थित लुगदी और कागज उद्योगों के सत्यापन के लिए प्रौद्योगिकी भागीदारों के साथ सालाना निरीक्षण किया जा रहा है और यह सुनिश्चित किया जा रहा है कि प्राप्तकर्ता जल निकायों में ब्लैक लिकर उत्प्रवाह नहीं हो रहा है। शून्य ब्लैक लिकर उत्प्रवाह के कार्यान्वयन से प्राप्तकर्ता जल निकायों जैसे ढेला, बहेला, कोसी और रामगंगा नदी में घुलित ऑक्सीजन (डीओ) और जैव-रासायनिक ऑक्सीजन डिमांड (बीओडी) की जल गुणवत्ता में सुधार हुआ और 2017 से गंगा नदी में रंगीन पानी के उत्प्रवाह की कोई घटना नहीं देखी गई। लुगदी और कागज उद्योगों के वार्षिक निरीक्षण के माध्यम से कार्य योजना के कार्यान्वयन और निरंतर निगरानी के कारण 2011 की तुलना में 2021 में प्रदूषण भार 76.5 टीपीडी से घटकर 1.74 टीपीडी हो गया। इस समग्र भागीदारी दृष्टिकोण और नीतिगत जरूरतों के सफल प्रकरण को देश भर के लुगदी और कागज उद्योग में ब्लैक लिकर के प्रबंधन के लिए लागू किया जाना चाहिए।

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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 distilleries generate huge wastewater streams called spent wash. Spent wash is a highly organic as well 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 distilleries 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 molasses-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, Bio-compositing, 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.

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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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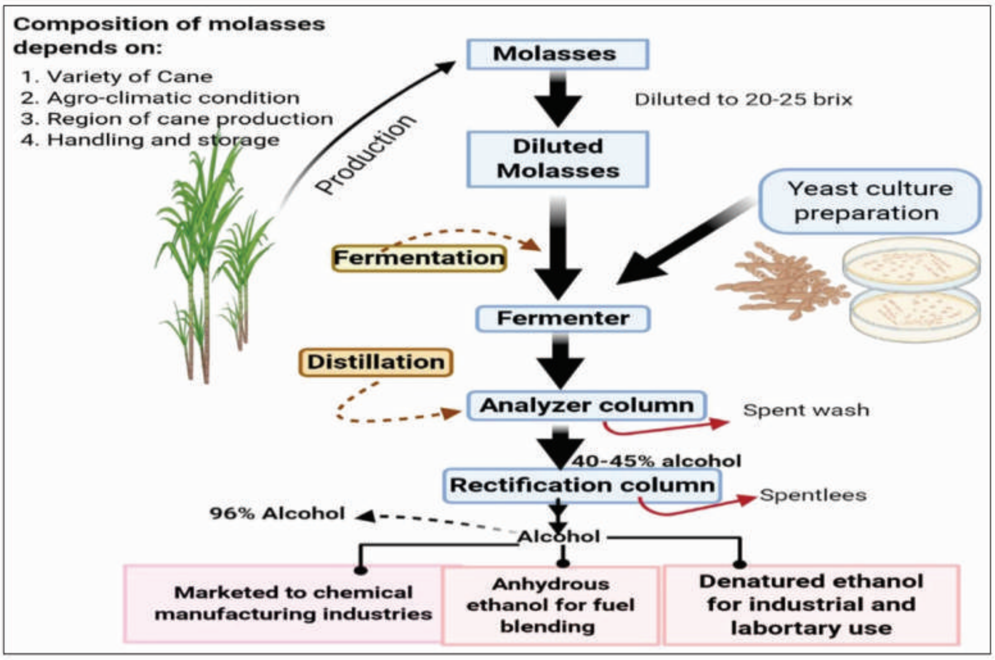

Fig. 1: Process of the ethanol manufacturing (Bhardwaj *et al.,* 2019)

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

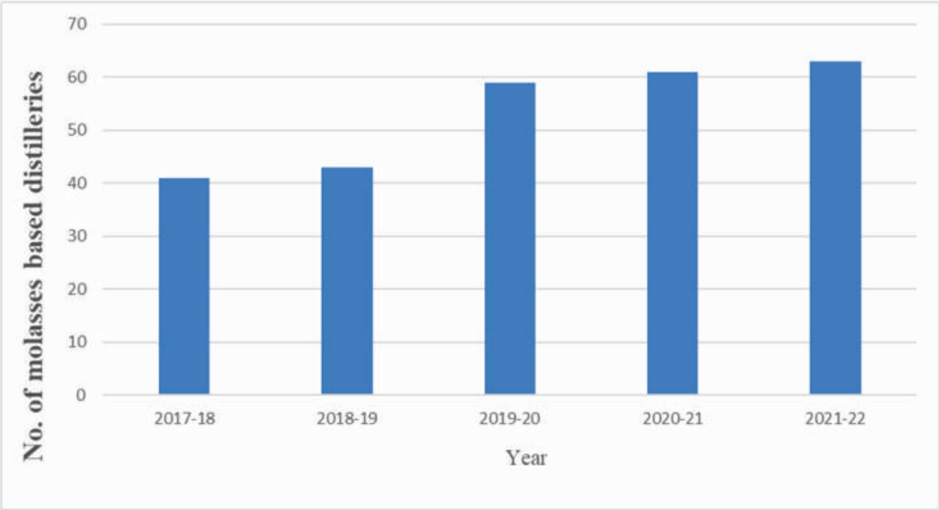

Fig. 2: Numbers of molasses-based distilleries in main stem of River Ganga during last five years

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

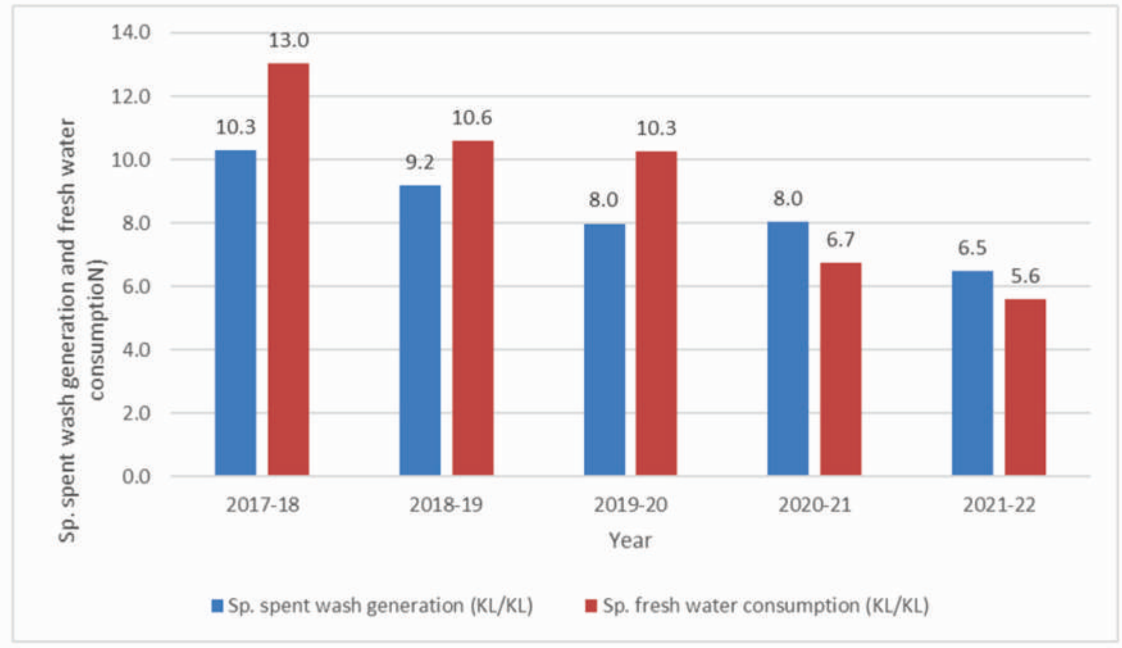

Fig. 3 : The trend of specific spent wash generation in molasses-based distilleries in main stem of River Ganga

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 upgradation/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,

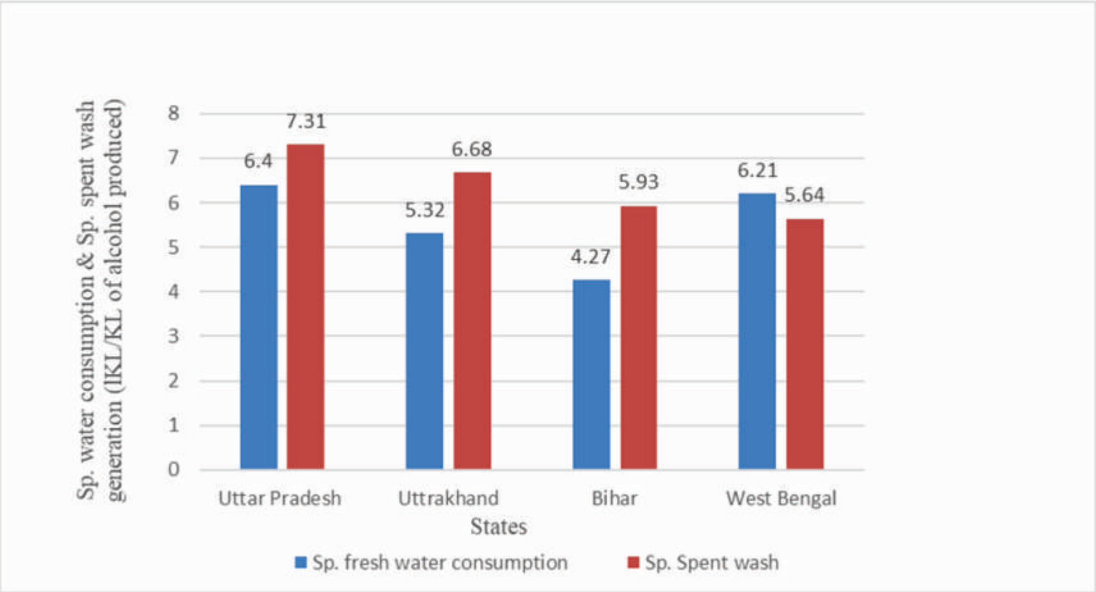

Fig. 4: State wise specific water consumption, specific spent wash generation in molasses-based distilleries

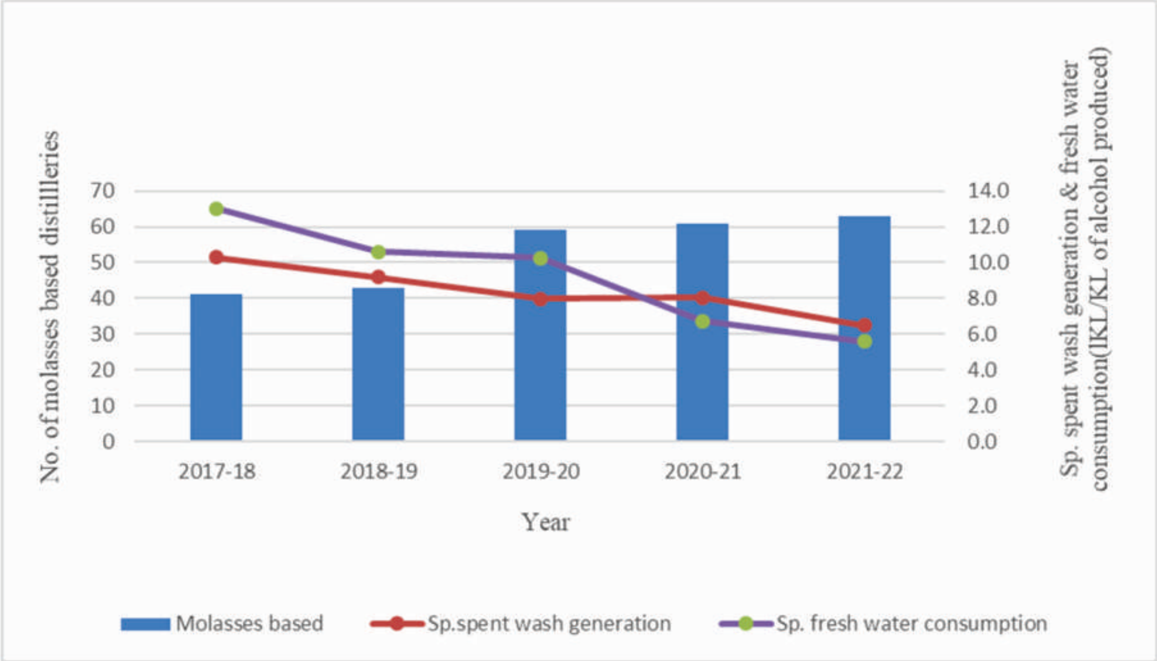

Fig. 5: Trend of specific spent wash generation and specific fresh water consumption

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 distillery 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 distillery 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

आर. सतावन, ए.के. विद्यार्थी, ए. कुमारी, एस. लोनारकर, एस. गोस्वामी, एम. चौधरी और ए. देशमुख

सारांश

औद्योगीकरण की बढ़ती प्रवृत्ति के परिणामस्वरूप उच्च कार्बनिक और अकार्बनिक सामग्री के साथ बड़ी मात्रा में औद्योगिक बहि:स्राव उत्पन्न हुआ है। 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 को 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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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.

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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

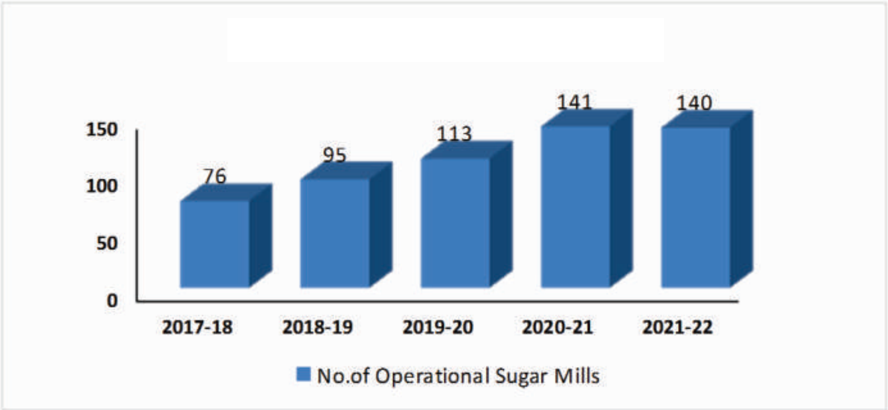

Fig. 1: Number of operational Sugar mills in Ganga Basin

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.

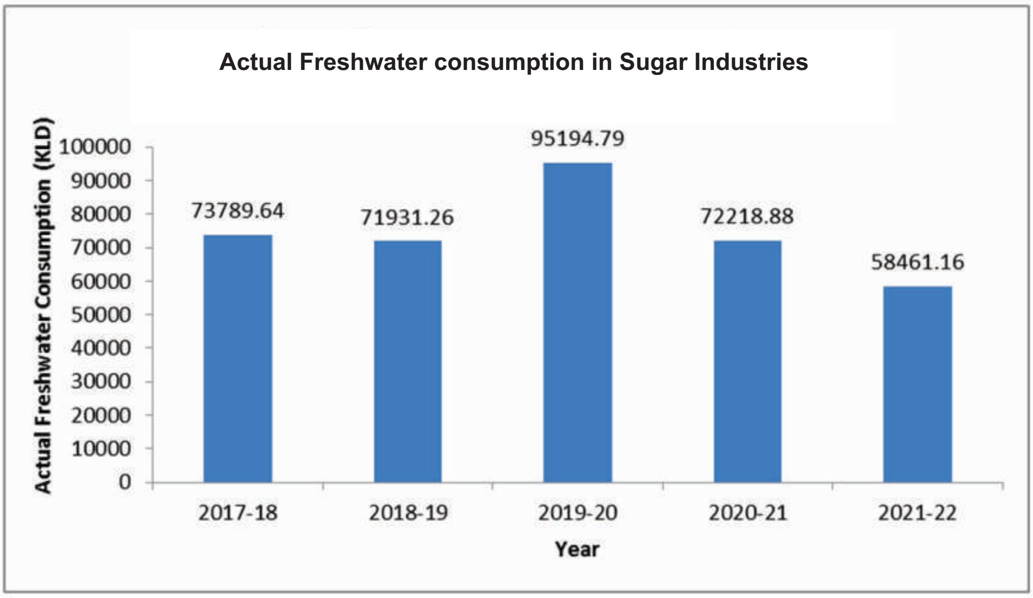

Fig. 2: Reduction in fresh water consumption

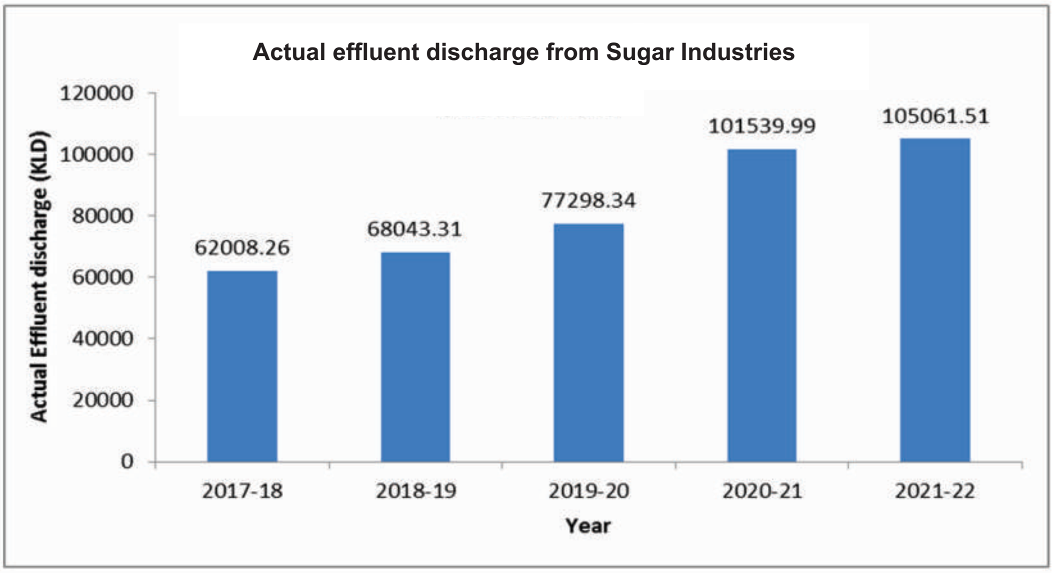

Fig. 3: Effluent discharge, KLD

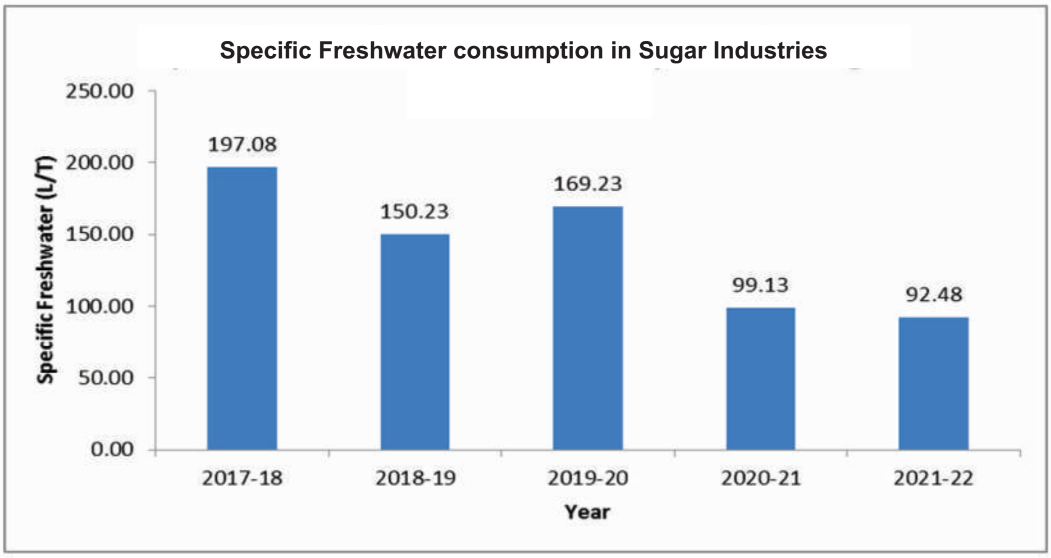

Fig. 4: Specific fresh water consumption

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

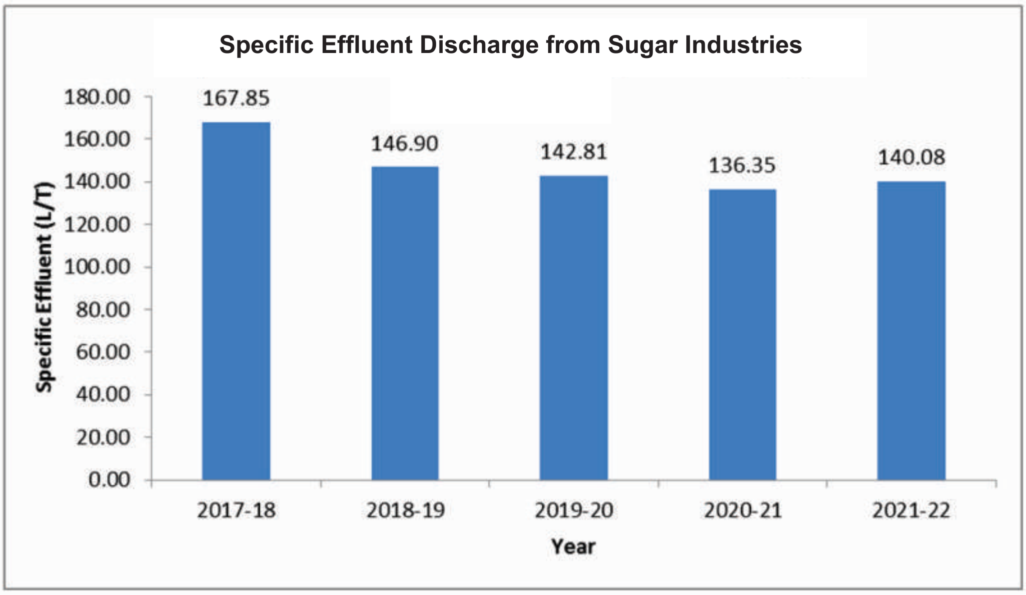

Fig. 5: Specific effluent discharge

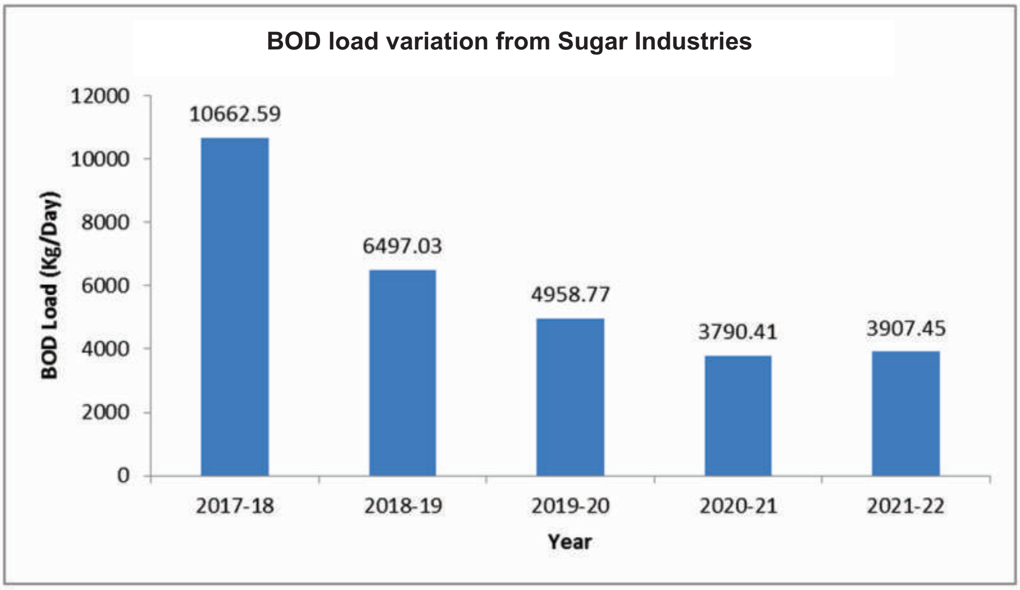

Fig. 6 : Reduction in BOD

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 प्रधाानमंत्री 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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Overview of Sugar mill

Effluent Treatment plant

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Policy Interventions towards Sewage
Management and Improvement in Water Quality of River Ganga

River Ganga is main sources of livelihood in Gangetic planes as well as holds special sacred value in Indian society. Discharge of untreated sewage in river system is one of the important causes of water pollution, which has emerged as a major socio-economic issue. In 2016, 361 TPD pollution load (in terms of BOD) was being discharged through 154 drains into the river. Till 2017-18, only 68 STP with treatment capacity of 1439 MLD were installed in Ganga front towns. By the dawn of year 2023, 139 STPs have been installed with treatment capacity of 2514 MLD, which shows an increase of 74% in treatment capacity as compared to that in 2017-18. Deployment of appropriate technologies for interception, diversion and treatment of sewage resulted in reduction of pollution load discharge to river Ganga by 252.5 TPD through 516 drains in the year 2022, which is a reduction of 30% in the load as compared to 2016. Noteworthy efforts are made for reuse of treated sewage with improved quality of treatment by adoption of stringent norms for treated sewage. In the 73rd episode of Mann ki Baat (MKB) on 31st January, 2021 Hon'ble Prime Minister (PM) of India underlined the issue of dirty water being used by the farmers for irrigation purpose and need for recycle and reuse of treated wastewater. Measures and interventions to reduce the discharge of domestic wastewater entering into the river have led to significant reduction in pollution. These efforts have ensued improvement in water quality as well as overall health of the river. There has been a significant reduction in length of polluted stretches of the river.

Key words: Wastewater discharge, Sewage management, River Ganga, Sewage treatment plants, Water quality

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

Augmentation of sewage management practices in Ganga front towns has led to improvement in water quality of river Ganga.

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Introduction

River Ganga is the main sources of livelihood in Gangetic planes as well as holds special sacred value in Indian society. The river flows through five states Uttarakhand, Uttar Pradesh, Bihar, Jharkhand and West Bengal through its journey from origin at Gaumukh, Uttarakhand to Ganga Sagar, West Bengal [Trivedi (2010) and Vidyarthi *et al*. (2020)]. India has witnessed unprecedented rate of urbanisation owing to rapid development. However, this rapid urbanization along with fast population growth has caused numerous environmental problems. Similarly, the Ganga River basin, home to 400 million people, is facing environmental challenges, with the progression of economic growth and social development. Demand for water in urban areas is ever increasing, leading to an increase in wastewater generation. Discharge of untreated sewage in water sources, surface and ground water, is one of the important causes of water pollution in India, which may pose risk to public health and environment. Hence, sewage management and sewage disposal become prime concern [Niti Ayog (2022) and MoWR (2017)]. In the 73rd episode of Mann ki Baat (MKB) on 31st January, 2021, Hon'ble Prime Minister of underlined the issue of dirty water being used by the farmers for irrigation purpose and need for recycle and reuse of treated wastewater.

This paper is aimed to assess improvement in sewage management and consequent amelioration of water quality of river Ganga. Significant policy interventions and initiatives has been made towards infrastructure development in sewage management and installation of sewage treatment plants (STPs), employing suitable technologies for interception and diversion drains to STPs. Development of infrastructure projects in tandem with implementation of stricter norms for discharge of treated sewage ensures enhanced quality of discharged treated sewage into the river [Niti Ayog (2020); Schellenberg *et al.* (2020) and CEEPHO (2013)].

Methodology

Central Pollution Control Board (CPCB) with the support from National Mission for Clean Ganga (NMCG) performs quarterly monitoring of STPs in Ganga front towns of five Ganga states, viz. Uttarakhand, Uttar Pradesh, Bihar, Jharkhand and West Bengal for their performance evaluation. Monitoring of drains discharging into Ganga and its tributaries is carried out on half early basis. Water quality monitoring of river is carried out fortnightly through network of manual monitoring stations (97) and real time water quality monitoring station (76). All analyses were carried out following the Standard Methods [APHA (2017)].

Results and Discussion

Augmentation in sewage treatment capacity from year 2017-18 to 2022- 23

In the year 2017-18 there were 68 STPs installed in the five Ganga states [Uttarakhand (UK)-10, Uttar Pradesh (UP)- 20, Bihar- 4, West Bengal (WB)- 34] with installed capacity of 1489 MLD. Fig. 1 and 2 shows year wise progressive increase in number of installed STPs (2018-19 – 82, 2019-20 – 103, 2020-21- 120, 2021-22 – 136) with corresponding treatment capacity (2018-19 – 1774 MLD, 2019-20 – 1956.68 MLD, 2020-21- 2235 MLD, 2021-22 – 2436 MLD). At advent of year 2023, 139 STPs (UK – 53, UP – 35, BH – 7, JH – 3, WB – 41) with total treatment capacity of 2514 have been installed for treatment of domestic wastewater.

The increase in treatment capacity from 1439 MLD in 2017-18 to 2514 MLD in 2022-23 suggests that an increase of 74% in treatment capacity has been achieved in past 6 years. Further, several sewage treatment infrastructures are under various stages of construction, which will be made operational in near future. This will further enhance the treatment capacity significantly.

It can be observed from the Fig. 3, that a significant improvement in utilised capacity has been achieved. Utilised capacity in year 2017-18 was 605 MLD, which amounted to be only 42% of total treatment capacity. Successive growth in utilised capacity can be seen over the years *i.e.* 1296 MLD in 2020-21, 1628 MLD in 2021-22 and 1652 MLD in 2022-23. This indicates that per cent utilization has increased from 42% in 2017-18 to 66% in 2022-23.

The increase in the utilization *i.e.* actual treatment by STPs is a resultant of employment of suitable technology for tapping of drains and diversion of waste water to STPs. In 2016, 154 drains discharging into river Ganga were monitored by CPCB through which 361.2 TPD pollution load (in terms of BOD) was estimated to be discharged. Table 1 shows progressive increase in the monitoring network on drain by CPCB, *i.e.*, from 154 drains in 2016 to 516 drains in 2022.

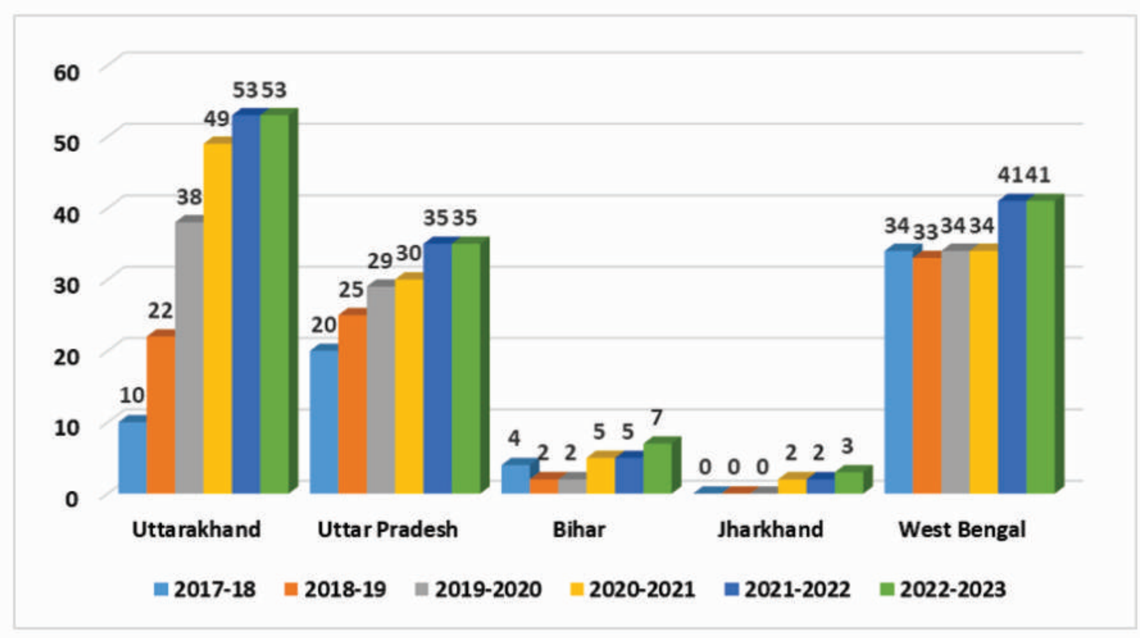

Fig. 1: Increase in number of STPs from 2017-18 to 2022-23

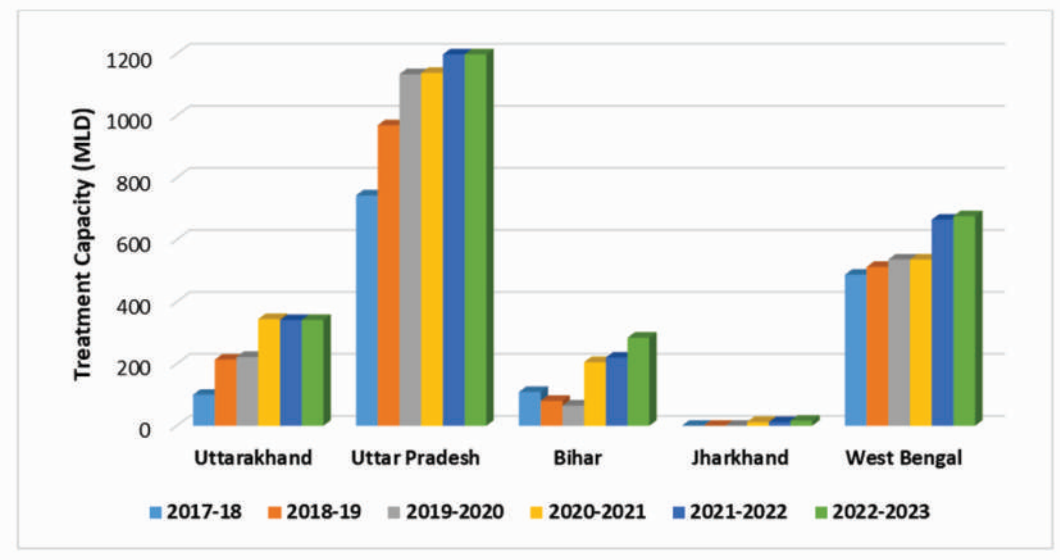

Fig. 2 : Increase in treatment capacity of STPs (2017-18 to 2022-23)

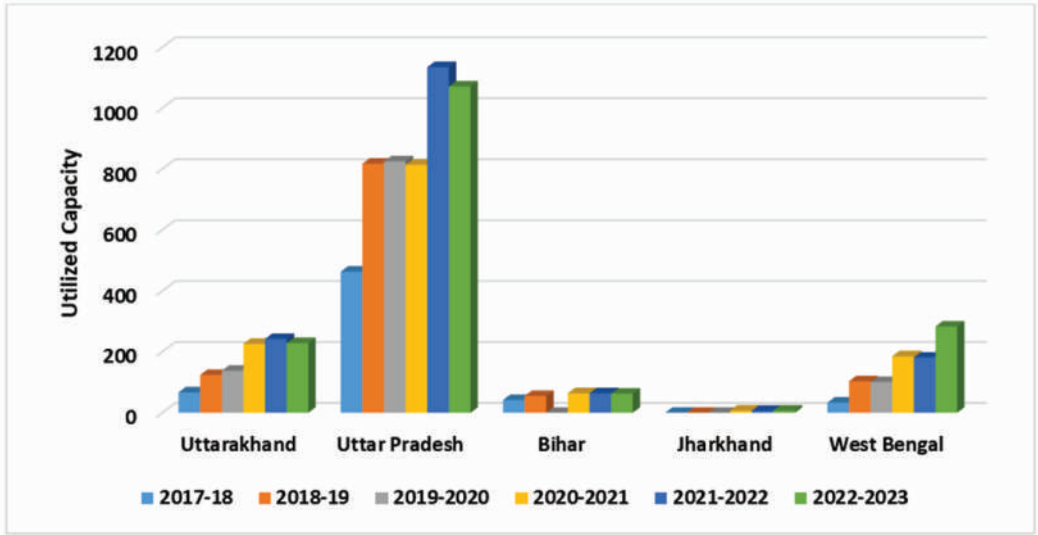

Fig. 3 : Increase in utilised capacity of STPs (2017-18 to 2022-23)

Furthermore, it can be observed that despite progressive increase in number of monitored drains, there is significant decrease in total pollution load (in terms of BOD) discharging into the river system *i.e.*, 361.2 TPD in 2016 to 252.5 TPD in 2022. This reduction in pollution load is owing to significant increase in provision of tapping through interception and diversion of wastewater to STPs. In 2016, only 6 drains were found to be tapped out of 154 monitored drains, however by 2022, through the government initiatives, substantial progress in drain tapping has been made *i.e.*, 188 out of 516 monitored drains were found to be tapped (an increase in drain tapping from 4% in 2016 to 36.4% in 2022). Monitoring of tapped drains were also continued for verification of tapping status.

Evolution in treatment technologies

In year 2017-18, employed conventional technologies such as series of waste stabilization ponds (WSPs)/ oxidation ponds (OPs) (44%) and Trickling filter (TF) (7%). Other technologies used were activated sludge process (ASP) 30%, followed by Sequential Batch reactor (SBR) (7%) and Up-flow Anaerobic Sludge Blanket (UASB) (7%) and Moving bed biofilm reactor (MMBR) (4%).

In the year 2019-20, share of (WSPs)/ (OPs) and (TF) reduced to 25.24% and 4.85% respectively. Besides these, the (ASP) was second most commonly employed technology, which accounts for 22% of installed STPs followed by (SBR) (20%), Electro-

Table 1: Year wise comparison of number of monitored drains, flow and corresponding pollution load (year 2016 to 2022)

Year	Drains Monitored	Flow (MLD)	BOD Load (TPD)	Tapped Drains
2016	154	9146.09	361.2	6
2018	151	10720.14	348.71	17
2019	151	11561.87	320.1	32
2020	260	9565.99	236.1	60
2021	503	11031.04	376.7	186
2022	516	10750.84	252.5	188

coagulation (EC) technology (10.68%), Up-flow Anaerobic Sludge Blanket (UASB) (6.8%), Moving bed biofilm reactor (MBBR) (6.8%). However, in 2022, the distribution share of SBR is highest (28%) followed WSPs/OPs + TFs (21%), ASP (17.99%), EC (12.95%), MBBR (8.63%), UASB (5.04%), (FBAS) (1.4%), and Anarobic-anoxic -oxic (A2O) (0.7%).

From this trend, it can be concluded that trend of utilization of advanced technologies for sewage treatment in 2022-23 has increased. And a substantial decline has been observed in utilization of conventional technologies (WSPs/OPs, TFs, and ASP) from 81% in 2017-18, 52% in 2019-2020 to 39.58% in 2022-23. In addition, the gradual increase in the distribution share of advanced treatment technologies (SBR, MBBR, UASB, EC, FBAS, A2O) is observed from 19% in 2017-18, 45% in 2019-20 to 57% in 2022-23.

Conventional treatments such as WSPs/OPs are the low-cost technologies for sewage treatment, however requires huge area. In addition, the performance of these methods is substantially lower in terms of their potential for meeting the stringent discharge standards. Besides, these processes are also less efficient in eliminating biological pollutants (Total Coliform/ Faecal Coliform), generates huge quantity of sludge, and require high maintenance while advanced biological treatment system such as SBR, MBBR, A2O require lesser space and are able to provide better removal efficiency with proper operation and maintenance. The SBR, MBBR based systems can work with automated controls and generally have low hourly retention time (HRT).

Technology wise distribution of STPs in Ganga front towns across the five Ganga states are represented in Table 2.

Rehabilitation of non-operational STPs

Addressing the issue of discharge of untreated sewage into river system requires multipronged strategies like installation of STPs as well as revamping and restoration of old defunct plants is vital to achieve this objective. It can be observed from the Fig. 4 that share of non-operational STPs has progressively decreased through better operation & maintenance and

Table 2: Technology wise distribution of STPs (year 2017-2018 to 2022-23)

Treatment Technology	2017-18					2019-20					2022-23					
	UK	UP	BH	WB	Total	UK	UP	BH	WB	Total	UK	UP	BH	JH	WB	Total
SBR	4	1	-	-	5	17	3		1	21	21	5	5	3	5	39
ASP	3	9	2	6	20	3	12	2	6	23	3	8	2	0	8	25
MBBR/FAB	2	1	-	-	3	4	3	-	-	7	9	3	-	-	-	12
EC	-	-	-	-	-	11	-	-	-	11	18	-	-	-	-	18
SBT	-	-	-	-	-	1	-	-	-	1	1	-	-	-	-	1
WSP/OP	1	4	2	23	30	1	4	-	21	26	0	4	-	-	22	26
UASB	-	5	-	-	5	-	7	-	-	7	0	7	-	-	-	7
A2O	-	-	-	-	-	-	-	-	-	0	0	1	-	-	-	1
CWS	-	-	-	-	-	-	-	-	-	0	-	1	-	-	-	1
FSTP	-	-	-	-	-	-	-	-	-	0	-	2	-	-	-	2
FBAS	-	-	-	-	-	-	-	-	1	1	-	-	-	-	2	2
TF	-	-	-	5	5	-	-	-	5	5	-	-	-	-	4	4
Bio-digester	-	-	-	-	-	1	-	-	-	1	1	-	-	-	-	1
Total	**10**	**20**	**4**	**34**	**68**	**38**	**29**	**2**	**34**	**103**	**53**	**35**	**7**	**3**	**41**	**139**

SBR – Sequential Batch Reactor, ASP – Activated sludge process; TF – Trickling filter; UASB – Up flow anaerobic sludge blanket; OP-Oxidation pond/WSP-waste stabilization ponds/ Aerated lagoon with or without lining; BD –Biodigester; MBBR/FAB – Moving Bed Bio Reactor/Fluidized Aerobic Bed; SBT- Soil Biotechnology; EC - Electrocoagulation; FBAS- Fixed Bed Biofilm Activated Sludge Process; FSTP- FaecalSludge Treatment Plant; A2O-Anaerobic-anoxic-aerobic; CWS- Constructed Wetland system

UK- Uttarakhand, UP- Uttar Pradesh, BH- Bihar, JH- Jharkhand, WB-West Bengal

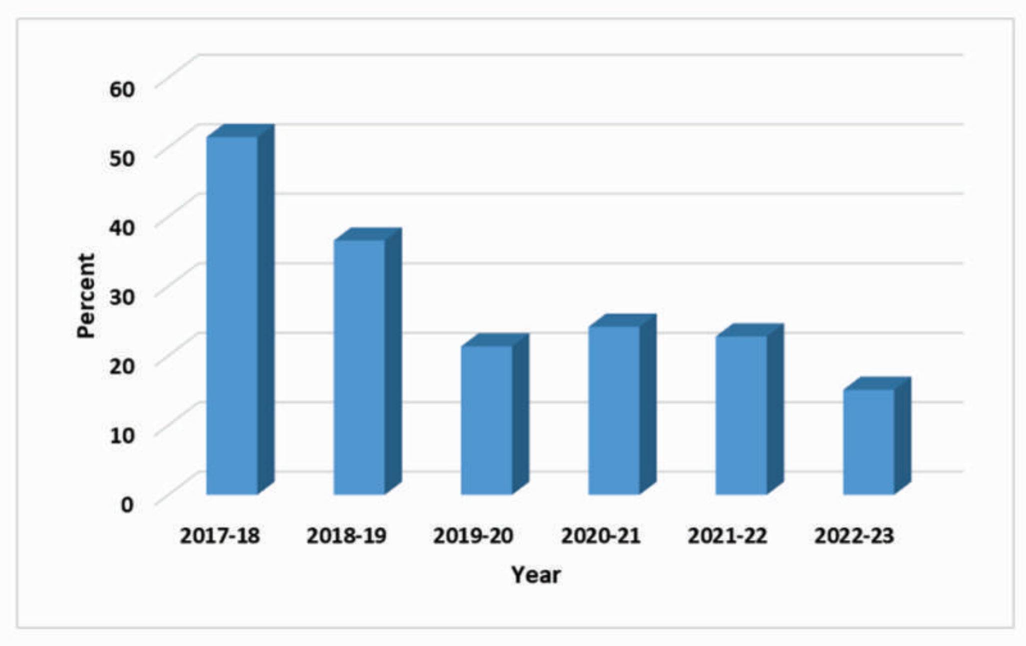

Fig. 4: Percentage decrease in share of non-operational STPs

rehabilitation of defunct STPs. For example, 7 defunct STPs in West Bengal have been rehabilitated.

Evolution of standards for treated sewage

Wastewater discharge standards are set at a national level for centralized treatment systems for salient receiving environments. The key feature of a water body from a discharge perspective is its assimilative capacity *i.e.*, maximum amount of pollution that can be diluted or degraded without affecting preliminary defined designated best uses [Schellenberg *et al*. (2020)].

In India, pollution control activities are the joint responsibility of three different institutions: the Ministry of Environment Forest and Climate Change (MoEF&CC), the Ministry of Housing and Urban Affairs (MoHUA), and the recently formed Ministry of Jal Shakti. The MoEF&CC is the nodal agency and together with the Central Pollution Control Board, these bodies are responsible for laying down policies, acts and related standards [Niti Ayog (2022)]. As discussed in section 3.2 on technological intervention, it can be emphasised that efforts are being made to achieve stringent discharge standards.

Different standards for treated sewage notified time to time by different agencies in India is provided in Table 3.

Alternative and decentralized treatment systems

Decentralized treatment system such as Faecal Sludge Treatment Plants (FSTP), phyto-remediation, bioremediation, bio-digesters etc. represents comparatively economical, affordable and ecologically sustainable choices, and also require low maintenance (Rath *et al.*, 2020). Septage treatment is a method for decentralized treatment of faecal sludge from septic tank where STPs are not constructed or no sewerage line is present. Successful implementation of projects by adopting combination of FSTP, co-treatment in STP and cluster approach has resulted in improvement in the water quality of rivers [Parkinson *et al*. (2003); Massoud *et al*. (2009); Libralato *et al*. (2011) and Larsen and Gujer (2013)].

In Uttar Pradesh, two FSTPs are commissioned at Chunar and Nandauli Village, Unnao and one FSTP is under construction at Farrukhabad. In Dehradun, septage is co-treated with sewage at Kargi STP (68MLD) and at 24 MLD STP Bijnor, co-treatment facility for septage has also been started. In West Bengal, FSTP is proposed to be installed considering cluster approach with towns/ urban local bodies (ULBs) with population less than 1 lakh for treatment of septage. Constructed wetlands for in-situ treatment of wastewater is being constructed under CPCB supervision across the length of Phuldera drain, Hapur.

Reuse of treated wastewater

Quality treatment of wastewater and its reuse policy will help to reduce the water stress in the country and also decrease the demand for freshwater (MoJS, 2020). Hon'ble Prime Minister through Mann ki Baat also emphasised on reuse of treated waste water. The extent of wastewater treatment depends on specific reuse applications and their associated characteristics/risks (CPHEEO, 2013). There are two major categories for

Table 3: Different standards notified/directed for treated sewage discharge

Parameters	CPCB direction dated 21.04.2015 to SPCBs under Sec. 18(1)(b) of E(P)A, 1986	Norms as per MoEF&CC notification dated 13.10.2017		Recommended standards of Hon'ble NGT Expert committee				Norms suggested by Hon'ble NGT order 30.04.2019
		Metro cities# & State capitals except Uttarakhand & others*	Area regions other than metros and State capitals	Mega and Metropolitan Cities	Class- I Cities	Others	Deep Marine Outfall	
pH	6.5-9.0	6.5-9.0	6.5-9.0	5.5-9.0	5.5-9.0	5.5-9.0	5.5-9.0	5.5-9.0
BOD(mg/l)	≤ 10	20	30	10	20	30	30	10
TSS (mg/l)	≤ 20	<50	<100	20	30	50	50	20
COD (mg/l)	≤ 50	-	-	50	100	150	150	50
Nitrogen- Total (mg/l)	≤**10**	-	-	10	15	_	-	10
Phosphorous- Total (for discharge in lakes& ponds) (mg/l)	-	-	-	1	1	1	-	1
Faecal Coliform(MPN/100ml)	< 100	<1000	<1000	Desirable - 100 Permissible - 230	Desirable - 230 Permissible - 1000	Desirable - 1000 Permissible - 10000	Desirable - 1000 Permissible - 10000	Desirable - 100 Permissible - 230
Ammoniacal Nitrogen (NH4-N) mg/l	≤5	-	-	-	-	-	-	-

Metro Cities are Mumbai, Delhi, Kolkata, Chennai, Bengaluru, Hyderabad, Ahmedabad and Pune.

* All State Capitals except in the State of Arunachal Pradesh, Assam, Manipur, Meghalaya Mizoram, Nagaland, Tripura Sikkim, Himachal Pradesh, Uttarakhand, Jammu and Kashmir and Union territory of Andaman and Nicobar Islands, Dadar and Nagar Haveli Daman and Diu and Lakshadweep

wastewater reuse: (a) potable uses and (b) non potable uses such as: irrigation in agriculture; industrial reuse (e.g., water cooling); aquifer recharge and other urban reuses such as toilet flushing, subway washing, coach cleaning, ground cooling, or building construction [Schellenberg *et al.* (2020)].

Reuse practices of treated sewage in Ganga front towns

Provisions for reuse of treated sewage for irrigation have been made at 36 MLD CETP, Jajmau, Kanpur, 130 MLD STP Jajmau, Kanpur, 43 MLD STP Jajmau, Kanpur, 5 MLD STP Jajmau, Kanpur, 2.25 MLD STP at NAPS Township, Narora, 4 MLD STP at Narora and 68 MLD STP at Haridwar. A Tertiary treatment plant is being installed for reuse of 40 MLD of treated sewage from 210 MLD Bingawan STP, Kanpur in Panki Thermal Power Plant.

Improvement in water quality

The main objective of the policy intervention for sewage management in tandem with initiatives for management of pollution from grossly polluting industries (GPIs) etc., is the restoration of water quality of the river Ganga and its tributaries. Treated wastewater reuse and recycling also provides the desired result in terms of sustainability and overall water quality improvement of river.

As per CPCB report on polluted river stretches 2018 in India (CPCB, 2018), 351 polluted stretches were identified under 5 priority classes with the worst water quality in Priority I stretch. The water quality data has been analysed and monitoring locations exceeding the water quality criteria are identified as polluted locations with respect to risk (Table 4).

Table 4: Priority wise polluted stretches, criteria and numbers in India.

Priority wise Number of Polluted River Stretches	Priority Number of Stretches	Criteria (BOD Level in mg/l)
Priority I	45	exceeding 30
Priority II	16	between 20-30
Priority III	43	between 10-20
Priority IV	72	between 6-10
Priority V	175	between 3-6
Total	**351**	

Due to interventions made over the period, the water quality of river Ganga has significantly restored or improved in almost all polluted stretches identified in 2018. When compared with 2022 water quality data, the polluted river stretch in Uttarakhand from Haridwar to Sultanpur has been restored.In Uttar Pradesh, the stretch from Kadaghat (Prayagraj) to Sirsa (after confluence Tamas river) and upstream Varanasi has been restored whereas stretches in Kannauj, Kanpur, Rai Bareilly, Pratapgarh, Mirzapur and Varanasi shows improvement from priority III/IV to V. In Bihar, stretch from Buxar to Bhagalpur has been restored. In West Bengal, stretch from Tribeni to Diamond Harbour has improved from priority III to V. In year 2022, major length of river Ganga is pollution free in terms of BOD (Max criteria).

Conclusion

The present study is an effort to assess the policy intervention towards augmentation in sewage management for rejuvenation of water quality of river Ganga. The incessant hard work regarding the management of sewage through the installation of sewage treatment plants, decentralized treatment of sewage and septage management, and adoption of suitable technologies for interception and diversion of sewage from drain to STPs in Ganga front towns have resulted in a significant reduction in discharge of untreated domestic wastewater into the River Ganga. Initiatives are also being taken towards reuse and treated sewage in irrigation, power plants etc which will further alleviate stress on fresh water. Implementing stringent standards through technological interventions like upgradation of sewage treatment plants and adoption of advanced treatment technologies has also helped significantly in the reduction of the pollution load from sewage. The relentless efforts made in the area of sewage management in tandem with pollution load reduction from industries has resulted in improvement in the water quality of river Ganga.

गंगा नदी की जल गुणवत्ता में मलजल प्रबंधन और सुधार की दिशा में नीतिगत हस्तक्षेप

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सारांश

गंगा नदी मैदानों में आजीविका का मुख्य स्रोत होने के साथ-साथ भारतीय समाज में विशेष पवित्र मूल्य रखती है। नदियों में अनुपचारित मलजल का निर्वहन जल प्रदूषण के महत्वपूर्ण कारणों में से एक प्रमुख सामाजिक-आर्थिक समस्या के रूप में उभरा है। वर्ष 2016 में, नदी में 154 नालों के माध्यम से 361 टीपीडी प्रदूषण भार (बीओडी के संदर्भ में) छोड़ा जा रहा था। 2017-18 तक, गंगा की मुख्य धारा वाले शहरों में 1439 एमएलडी की उपचार क्षमता वाले केवल 68 एसटीपी स्थापित किए गए थे। वर्ष 2023 की शुरुआत तक, 2514 एमएलडी की उपचार क्षमता वाले 139 एसटीपी स्थापित किए जा चुके हैं जो दर्शाता है। 2017-18 की तुलना में उपचार क्षमता में 74% की वृद्धि हुई है। मलजल के अवरोधन, मोड़ और उपचार के लिए उपयुक्त तकनीकों की तैनाती के परिणामस्वरूप वर्ष 2022 में 516 नालों के माध्यम से गंगा नदी में प्रदूषण भार निर्वहन में 252.5 टीपीडी की कमी आई, जो कि 2016 की तुलना में प्रदूषण भार में 30% की कमी है। उपचारित मलजल के लिए कड़े मानदंड अपनाकर उपचार की बेहतर गुणवत्ता के साथ उपचारित मलजल के पुनः उपयोग के लिए उल्लेखनीय प्रयास किए गए हैं। 31 जनवरी, 2021 को मन की बात (एमकेबी) की 73वीं कड़ी में भारत के माननीय प्रधान मंत्री (पीएम) ने किसानों द्वारा सिंचाई के उद्देश्य से इस्तेमाल किए जा रहे गंदे पानी के मुद्दे और उपचारित अपशिष्ट जल के पुनर्चक्रण और पुनः उपयोग की आवश्यकता को रेखांकित किया था। नदी में प्रवेश करने वाले घरेलू अपशिष्ट जल के निर्वहन को कम करने के उपायों और हस्तक्षेपों से प्रदूषण में उल्लेखनीय कमी आई है। इन प्रयासों से पानी की गुणवत्ता के साथ-साथ नदी के समग्र स्वास्थ्य में सुधार हुआ है। गंगा नदी के प्रदूषित हिस्सों की लंबाई में भी उल्लेखनीय कमी आई है।

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Assessment of Impact on Water Quality of Aquatic Resources Due to Idol Immersion

The paper encapsulates efforts made in enforcing eco-friendly idol immersion for sustainable future including dissemination of few case studies. The CPCB guidelines, if followed and acted upon, can help in bringing tremendous reduction in pollution caused by idol immersion.

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India is known for its rich culture and festivals. Festivals like Ganeshotsav and Durga Puja hold an integral place in Indian culture. The puja and celebrations are followed by the immersion of idols in water bodies. Central Pollution Control Board (CPCB) prepared guidelines for idol immersion in consultation with stakeholders to ensure safe and eco-friendly disposal of idols for conservation of natural resources. The revised guidelines are presently under implementation by respective States/ UTs. To assess the impact of idol immersion and implementation of CPCB guidelines, water quality monitoring of respective water bodies was carried out during pre and post immersion. The case study of river Yamuna in Delhi stretch indicated an increase in Dissolved Oxygen (DO) levels of 24% in 2021 and 137.7% in 2022 post immersion. Concentration of Bio-Chemical Oxygen Demand (BOD) also showed a reduction of 32.4% in 2021 and 34.9% in 2022. In 2019, at immersion sites on river Yamuna in Delhi, maximum concentration of BOD of 40 mg/L was observed which has been reduced to 22 mg/L in 2022. In terms of other physico-chemical and heavy metal parameters, significant reduction in concentration levels is observed. Similar studies were carried out in other states. Improvement in terms of creation of artificial ponds/ designated ghats for immersion of idols by local authorities, initiatives for mass awareness programmes for use of eco-friendly materials observed. In the 23rd episode of Mann Ki Baat aired on August 28th, 2016, Hon'ble Prime Minister also emphasized on the use of clay in making of Ganesh and Durga idols to prevent pollution of rivers, ponds and provide protection to aquatic life. The present paper is a compilation of case studies to assess impact of the guidelines for immersion of idols on the water bodies, in terms of various parameters including physico-chemical and heavy metal on pre and post idol immersion activities.

Key words: Eco-friendly materials, PoP, Physico-chemical parameters and Heavy metals

Mann Ki Baat Reference: Episode 23 aired on August 28, 2016.

Introduction

Idol immersion activities during some of festive occasions are causing pollution in the recipient water bodies. Non- biodegradable materials and synthetic paints used for making these idols affect aquatic life and environment. In India, many of the festivals are water centric; idols and puja materials are immersed in water bodies. The floating materials released through idol immersion in the water bodies result in eutrophication after decomposition (Das *et al.,* 2012). Careless immersion of idols in natural water bodies also blocks its flow and impedes ground for stagnation and breeding of mosquitoes (Joshi *et al.,* 2017).

The quantity and quality of these biodegradable and non-biodegradable substances deteriorates the water quality of recipient water bodies (Ujjania *et al.,* 2012). Festivals like Ganeshotsav and Durga Puja which earlier used to be limited in certain states, are now celebrated across the country. In ancient times, the idols were made using natural ingredients such as clay and/ or husk and was decorated and painted with natural colors. Paints are used for protection and providing texture to the idols (Bhattacharya *et al.,* 2014). When idols are immersed in water bodies, the paints do not dissolve easily and impact the water quality. In due course of time, people inclined towards a substitute, Plaster of Paris (PoP), which is known to be more readily available, cheaper and economically sustainable. Idols made up of PoP are painted with synthetic paints containing heavy metals like Arsenic, Cadmium, Mercury, Lead, etc. (Gupta *et al.,* 2020). Other non-biodegradable materials like plastic accessories and thermocol are also used in decorations. In 23rd episode of Mann Ki Baat, Hon'ble PM inspired promotion of eco-friendly festival celebration.

Materials and Method

Study area

To assess the impact on water quality of water bodies due to idol immersion activity, water samples were collected at different intervals by the respective State Pollution Control Boards (SPCBs)/ Pollution Control Committees (PCCs) of Andhra Pradesh, Maharashtra, Telangana and Delhi from different sites of immersion (river, pond/ lake and visarjan ghats) during the festivals of Ganeshotsav and Durga Puja in the year 2021 and 2022. Ganesh Chaturthi is celebrated in the month of September and Durga Puja during the month of October. The samples were collected during September and October 2021 and 2022 at different intervals *i.e.* pre and post idol immersion. Water samples were collected and preserved at the site of immersion. Pre-immersion samples were collected 2-3 days prior to immersion activities and post immersion samples were collected a week after the immersion. Artificial ponds/ tanks were created by the local authorities for immersion of idols in Andhra Pradesh, Delhi, Maharashtra and Telangana (Fig. 1).

The present study is focused on the impact of CPCB revised guidelines (CPCB, 2020) on water quality of recipient water bodies post immersion of idols in four states viz., Andhra Pradesh, Delhi, Maharashtra, and Telangana.

Analytical parameters

Samples collected were analyzed for physico-chemical parameters viz., Dissolved Oxygen (DO), Bio-Chemical Oxygen Demand (BOD), Total Dissolved Solids (TDS), Hardness as $CaCO_3$ and Heavy Metals such as Arsenic (As), Cadmium (Cd), Copper (Cu), Lead (Pb), Chromium (Cr), Nickel (Ni), Zinc (Zn), Iron (Fe), Cobalt (Co) and Manganese (Mn). Collected samples were analyzed based on Standard Methods for the Examination of Water and Wastewater (APHA Method) by respective SPCBs/ PCCs.

Measured data was compiled and analyzed statistically to assess the impact of idol immersion on various monitored parameters in water bodies.

Result and Discussions

The analysis results of samples collected during Pre and Post immersion of idols in year 2021 and 2022 for the states viz. Andhra Pradesh, Delhi, Maharashtra and Telangana is provided in Table 5.

Delhi

In Delhi, nine locations on river Yamuna were monitored during pre and post immersion in Ganesh and Durga festival in 2021 and 2022. The average per cent variation in concentration of various parameters was calculated and provided in Table 1. As per the analysis of data of year 2021, in Delhi, one location was found complying to the Primary Water Quality Criteria for Outdoor Bathing (PWQC) w.r.t. DO *i.e.,* 5 mg/L and at another location was found complying w.r.t. BOD *i.e.,* 3 mg/L. In year 2022, three locations were found complying w.r.t. DO. None of the locations was found complying w.r.t. BOD. The results revealed significant average increase in DO level of 24% in 2021 and 137.7% in 2022 post immersion. Concentration of BOD also showed a reduction of 32.4% in 2021 and 34.9% in 2022 post immersion activities. Additionally, a decrease in maximum concentration of BOD post immersion from 40 mg/L in 2019 to 10 mg/L and 22 mg/L in subsequent years of 2021 and 2022, respectively was observed. TDS also found decreased in concentration however, the degree of reduction was lesser during 2022 than

Fig. 1: Idol immersion in artificial ponds

2021. With respect to heavy metal parameters, drop in concentration of Cr, Cu and Pb observed in 2021 post immersion, while during 2022, Zn and Fe concentration was found reduced. The increase in DO levels may be attributed to the dilution available during monsoon season, release of water from upstream. Increase in metal concentration observed during post-immersion activity may be due to agitation in river bed during monsoon season.

Table 1: Average per cent variation in concentration of parameters in Delhi post immersion of idols in year 2021 and 2022.

Parameters	2021	2022
DO (mg/L)	24.0	137.7
Conductivity (µmhos/cm)	-19.9	-
BOD (mg/L)	-32.4	-34.9
Hardness as $CaCO_3$ (mg/L)	-21.2	-
TDS (mg/L)	-19.1	-5.6
Cd (mg/L)	-8.3	0.5
Cu (mg/L)	-6.6	475.3
Pb (mg/L)	-8.3	22.2
Cr (Total) (mg/L)	50.0	25.6
Ni (mg/L)	41.7	33.3
Zn (mg/L)	42.8	-22.2
Fe (Total) (mg/L)	372.7	-25.3
Co (mg/L)	-4.2	-
Mn (mg/L)	9.3	-

Telangana

In Telangana, one location each on five different lakes where immersion of idols was carried out, were monitored during pre and post immersion in 2021 and 2022. The average per cent variation in concentration of various parameters was calculated and provided in Table 2. In year 2021, in Telangana, none of the locations were found complying to the PWQC w.r.t. DO *i.e.* 5 mg/L and BOD *i.e.* 3 mg/L, post immersion. In year 2022, in Telangana, 2 locations were found complying w.r.t. DO and no locations were found complying w.r.t. BOD parameter. The results revealed a significant average increase in DO (26.6%), BOD (7.5%), Hardness (12.1%) and TDS (3.6%) in 2021 post immersion. However, an increase in concentration w.r.t. heavy metals viz. Cd, Cu, Pb and Zn was observed. During 2022, a deterioration in water quality w.r.t. physico-chemical parameters such as DO (0.2%), BOD (104.5%), Hardness (29.0%) and TDS (29%) and a decrease in concentration of heavy metal parameters such as Cd, Cu, Pb, Zn and Mn was observed.

Table 2: Average per cent variation in concentration of parameters in Telangana post immersion of idols in year 2021 and 2022.

Parameters*	2021	2022
DO (mg/L)	26.6	-0.2
BOD (mg/L)	-7.5	104.5
Hardness as $CaCO_3$(mg/L)	-12.1	29.0
TDS (mg/L)	-3.6	22.5

*Refer Table 5 for Heavy metals concentration

Maharashtra

In Maharashtra, five locations were monitored on three rivers, one lake and one pond where immersion of idols was carried out, during pre and post immersion in 2021 and 2022. The average per cent variation in concentration of various parameters was calculated and provided in Table 3. In year 2021, in Maharashtra, all 5 locations were found complying to the PWQC w.r.t. DO *i.e.* 5 mg/L and 3 locations were found complying w.r.t. BOD *i.e.* 3 mg/L. In year 2022, 3 locations w.r.t. DO and 2 locations w.r.t. BOD *i.e.* 3 mg/L were found complying to the criteria. The results revealed a significant improvement in DO during 2021 (11.80%) and 2022 (7.68%). BOD showed improvement during post immersion in 2021 of 46.02%. TDS increased post immersion during both 2021 (36.18%) and 2022 (47.95%) indicating a deterioration.

Table 3: Average per cent variation in concentration of parameters in Maharashtra post immersion of idols in year 2021 and 2022.

Parameters*	2021	2022
DO (mg/L)	11.80	7.68
Conductivity (µmhos/cm)	30.59	86.66
BOD (mg/L)	-46.02	3.86
TDS (mg/L)	36.18	47.95

* Data for Heavy metals not available

Andhra Pradesh

In Andhra Pradesh, five locations on four Lakes/ Ponds where immersion of idols was carried out were monitored during pre and post immersion in 2021 and 2022. The average per cent variation in concentration of various parameters was calculated and provided in Table 4. In year 2021, in Andhra Pradesh, two locations were found complying to the PWQC w.r.t. DO *i.e.* 5 mg/L and one location was found complying w.r.t. BOD *i.e.* 3 mg/L. In year 2022, 3 locations w.r.t. DO and 2 locations w.r.t. BOD were found complying to the criteria. The results revealed an increase in DO levels during both 2021 (0.83%) and 2022 (13.66%). During 2021, deterioration was observed in rest of the parameters

Table 4: Average per cent variation in concentration of parameters in Andhra Pradesh post immersion of idols in year 2021 and 2022.

Year	2021	2022
DO (mg/L)	0.83	13.66
Conductivity (µmhos/cm)	31.87	4.76
BOD (mg/L)	9.84	-4.86
Hardness as $CaCO_3$ (mg/L)	15.17	-1.51
TDS (mg/L)	30.29	-0.79
As (mg/L)	4.17	10.00
Cd (mg/L)	0.00	20.00
Cu (mg/L)	10.00	6.40
Pb (mg/L)	0.00	20.00
Cr(Total) (mg/L)	0.00	25.00
Ni (mg/L)	0.00	45.00
Zn (mg/L)	49.00	-8.01

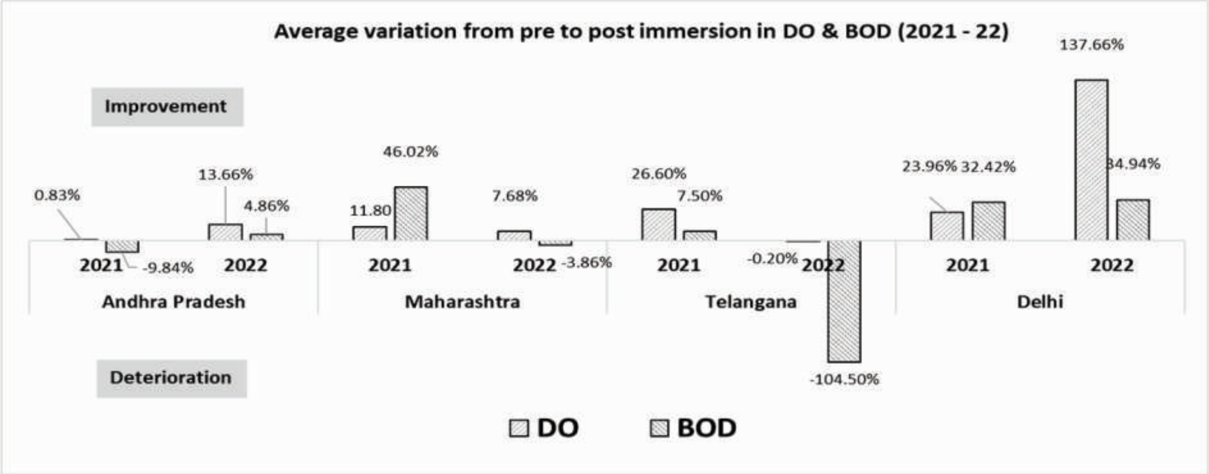

Fig. 2: Average variation in DO and BOD from pre to post idol immersion

Table 5: Range of Physico-chemical and Heavy Metal parameters Pre and Post immersion of idols during 2021 and 2022

Parameter	Phase of monitoring	Andhra Pradesh		Delhi		Telangana		Maharashtra	
		Year 2021	Year 2022	Year 2021	Year 2022	Year 2021	Year 2022	Year 2021	Year 2022
Dissolved Oxygen (mg/L)	pre post	4.1 - 6.7 4.1 - 5.8	BDL - 7.2 0.2 - 7	BDL - 6.8 BDL - 7.8	0.3 - 7.3 1.4 - 9.5	1 - 4.6 2.1 - 4.4	0.3 - 6 0.3 - 5.9	4.6 - 6 5.8 - 6.7	4.8 - 5.7 4.6 - 6.8
Conductivity (µmhos/cm)	pre post	264 - 1609 330 - 1577	322 - 1079 311 - 857	428 - 1370 320 - 1180	- -	- -	- -	474 - 690 737 - 835	280 - 610 510 - 1196
Bio-chemical Oxygen Demand (mg/L)	pre post	1.4 - 8.6 1.8 - 7.6	1.2 - 36 1.4 - 28	3 - 13 BDL - 10	18 - 32 10 - 22	4 - 22 3.2 - 22	2.6 - 10 4-14	5.5 - 15 2.8 - 6.2	4.2 - 5.2 3 - 7.6
Hardness as $CaCO_3$ (mg/L)	pre post	80 - 380 96 - 352	92 - 320 64 - 256	164 - 416 148 - 292	- -	216 - 561 180 - 380	130 - 410 192 - 458	- -	- -
Total Dissolved Solids (mg/L)	pre post	168 - 1084 220 - 1092	210 - 660 186 - 532	260 - 850 218 - 642	328 - 682 259 - 721	301 - 754 298 - 748	352 - 980 458 - 1092	347 - 571 560 - 626	174 - 782 390 - 860
Arsenic (mg/L)	pre post	0.001 - 0.004 0.001 - 0.003	0.001 - 0.006 0.001 - 0.007	BDL BDL	- -	- -	- -	- -	- -
Cadmium (mg/L)	pre post	0.001 0.001	0.001 0.001 - 0.002	BDL - 0.06 BDL	BDL - 0.81 BDL - 0.61	BDL BDL - 0.0028	BDL - 0.083 BDL - 0.019	- -	- -
Copper (mg/L)	pre post	0.001 0.001 - 0.002	0.001 - 0.011 0.001 - 0.006	BDL - 0.18 BDL - 0.02	BDL - 0.89 BDL - 0.9	BDL BDL - 0.124	BDL - 0.321 BDL - 0.004	- -	- -
Lead (mg/L)	pre post	0.001 0.001	0.001 0.001 - 0.002	BDL - 0.13 BDL - 0.02	BDL - 0 BDL - 0.3	BDL - 0.012 BDL - 0.014	BDL - 0.371 BDL - 0.078	- -	- -
Chromium (Total) (mg/L)	pre post	0.001 0.001	0.001 - 0.002 0.001 - 0.003	BDL - 0.01 BDL - 0.02	BDL - 0.66 BDL - 0.82	- -	- -	- -	- -
Nickel (mg/L)	pre post	0.001 0.001	0.001 - 0.002 0.001 - 0.004	BDL - 0.01 BDL - 0.02	BDL - 0.54 BDL - 10	- -	- -	- -	- -
Zinc (mg/L)	pre post	0.001 - 0.005 0.001 - 0.004	0.004 - 0.025 0.001 - 0.012	0.02 - 0.57 0.02 - 0.11	BDL - 0.89 BDL - 0.82	BDL BDL - 0.224	BDL - 1.149 BDL - 0.3	- -	- -
Iron (Total) (mg/L)	pre post	- -	- -	0.56 - 5.29 0.67 - 13.03	BDL - 2 BDL - 0.78	- -	- -	- -	- -
Cobalt (mg/L)	pre post	- -	- -	BDL - 0.02 BDL - 0.01	- -	- -	- -	- -	- -
Manganese (mg/L)	pre post	- -	- -	0.06 - 0.54 0.04 - 0.39	- -	BDL - 0.71 BDL	BDL - 2.525 BDL - 0.737	- -	- -

- Data not available

viz., Conductivity (31.87%), BOD (9.84%), Hardness (15.17%), TDS (30.29%), As (4.17%) and Cu (10%). During 2022, average decrease in concentration of parameters such as BOD, Hardness and TDS of 4.86%, 1.51% and 0.79%, respectively was observed. However, concentration of heavy metals viz., As (10%), Cd (20%), Cu (6%), Pb (20%), Cr (25%) and Ni (45%) increased.

From the case study of four states viz. Andhra Pradesh, Delhi, Maharashtra and Telangana, it is inferred that evident impact of idol immersion on water bodies was lesser in Andhra Pradesh, Delhi and Maharashtra after revised guidelines were made effective from 01.01.2021. Continuous and concerted efforts of State Government departments with public participation resulted into improvement in water quality of recipient water bodies (Fig. 2).

Conclusion

To celebrate the religious activities in an eco-friendly manner, the use of bio-degradable materials for idol making, puja offerings, decoration and paint shall be the viable and sustainable option. The CPCB guidelines for Idol Immersion, 2020 stipulate the use of naturally occurring clay, eco-friendly water-based bio-degradable and non-toxic natural dyes for coloring idols and no use of single use plastic and thermocol materials for making of idols. The CPCB guidelines having clear division of responsibilities amongst various stakeholders viz. artisans, puja committees and local and urban authorities, if followed and acted upon, can help in bringing tremendous reduction in pollution and maintenance of water quality of water bodies post idol immersion. Floating materials and puja offerings to be collected and processed to prevent pollution in water bodies. Artificial ponds/ tanks were created by the local authorities during 2022 for immersion of idols in Andhra Pradesh (1), Delhi (65), Maharashtra (662) and Telangana (23).

For creating awareness among the stakeholders and general public, SPCBs/PCCs have increased efforts by taking innovative and interesting actions such as:

a. Replacement of temporary idols by permanent idols through Puja Committees;
b. Poster/ banner at public places, use of biodegradable idols;
c. Idol immersion only in artificially made temporary ponds;
d. Turmeric Ganesha Campaign -2021 and Seed Ganesha Campaign -2022, "Guinness World Record" for making the largest number of Ganesha idols in one place on 28/8/2022;
e. Demonstration of making Haldi Ganesha idols in Schools;
f. Issuance of guidelines to the idol manufacturers;
g. Distribution of clay Ganesh idols and involvement of academic institution for creating awareness;
h. Idols with eco-friendly colors;
i. Radio and SMS campaign, pamphlets distribution, slogans, etc. and
j. Construction of permanent dedicated idol immersion points.

Public awareness and participation are important for effective implementation of CPCB guidelines.

मूर्ति विसर्जन के कारण जलीय संसाधनों की जल गुणवत्ता का आकलन

सुनीति पाराशर, मिताली शर्मा, दीप्ति गोयल, प्रदीप कुमार मिश्रा,
अल्पना नरूला एवं प्रशांत गार्गव

सारांश

भारत अपनी समृद्ध संस्कृति और त्योहारों के लिए जाना जाता है। भारतीय संस्कृति में गणेशोत्सव और दुर्गा पूजा जैसे त्योहारों का अभिन्न स्थान है। पूजा और उत्सव के बाद जल निकायों में मूर्तियों का विसर्जन किया जाता है। केंद्रीय प्रदूषण नियंत्रण बोर्ड (सीपीसीबी) ने मूर्तियों के सुरक्षित और पर्यावरण के अनुकूल निपटान सुनिश्चित करने और प्राकृतिक संसाधनों के संरक्षण के लिए सभी संबंधितों के परामर्श से मूर्ति विसर्जन हेतु दिशानिर्देश तैयार किए हैं। वर्तमान में परिशोधित दिशानिर्देश संबंधित राज्यों/संघ राज्य क्षेत्रों द्वारा क्रियान्वयन के अधीन हैं। मूर्ति विसर्जन के प्रभाव का आकलन करने और सीपीसीबी के दिशानिर्देशों के क्रियान्वयन के लिए, संबंधित जल निकायों की विसर्जन से पहले और बाद में जल गुणवत्ता निगरानी की गई थी। दिल्ली में यमुना नदी पर केस स्टडी ने विसर्जन के बाद घुलित ऑक्सीजन (Dissolved Oxygen) के स्तर में वर्ष 2021 में 24% और वर्ष 2022 में 137.7% की वृद्धि का संकेत दिया। जैव-रासायनिक ऑक्सीजन मांग (Bio-Chemical Oxygen Demand) की सांद्रता में भी विसर्जन के बाद की गतिविधियों में वर्ष 2021 में 32.4% और वर्ष 2022 में 34.9% की कमी देखी गई, जो दिशानिर्देशों के प्रभावी क्रियान्वयन का संकेत देती है। वर्ष 2019 में, यमुना नदी के विसर्जन स्थलों पर, 40 मिग्रा/ली की अधिकतम जैव ऑक्सीजन मांग (BOD) सांद्रता पाई गई थी, जो बाद के वर्ष 2021 (10 मिग्रा/ली) और वर्ष 2022 (22 मिग्रा/ली) में कम हो गई है। अन्य भौतिक-रासायनिक और भारी धातु मापदंडों के संदर्भ में, सांद्रता के स्तर में कमी पाई गई है। इसी प्रकार का अध्ययन कुछ अन्य राज्यों में भी किया गया है। अन्य सुधारों में स्थानीय प्राधिकारियों द्वारा मूर्तियों के विसर्जन के लिए अधिक संख्या में कृत्रिम तालाबों/निर्दिष्ट घाटों का निर्माण एवं पर्यावरण के अनुकूल सामग्रियों के उपयोग के लिए जन-जागरूकता कार्यक्रमों के लिए पहलों में वृद्धि शामिल है। माननीय प्रधान मंत्री जी ने दिनांक 28 अगस्त, 2016 को प्रसारित मन की बात के 23वें एपिसोड में नदियों, तालाबों के प्रदूषण को रोकने और जलीय जीवन को सुरक्षा प्रदान करने के लिए गणेश और दुर्गा की मूर्तियों के निर्माण में मिटी के उपयोग पर भी जोर दिया। वर्तमान पेपर विभिन्न भौतिक-रासायनिक और भारी धातु मापदंडों के संदर्भ में, जल निकायों पर मूर्तियों के विसर्जन के लिए दिशानिर्देशों के प्रभाव का आकलन करने के लिए केस स्टडीज का संकलन है।

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