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Validation of eco-enzyme for improved water quality effect during large public gathering at river bank

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ABSTRACT

In contrast to existing trends and expected deteriorating water quality in the river Yamuna in Delhi which carries potential cultural economical and health importance, March 2016 water data showing improvement despite large public gathering at river bank during Cultural Festival. The reasons and factors were investigated. The paper presents the test reports of eco- enzyme which was found to be used during the event of World Culture Festival at the river bank in March 2016. The eco- enzyme is found to positively affect pH (from 6.7 to 7.2) reducing solids (from 884 to 745) suspended solids-(from 121 to 47) hardness and chlorides in a stable water body- Pond. The eco- enzyme testing in drain water showed optimum water cleaning effect on 0.5% concentration by showing the reduction of Biological Oxygen Demand from 690 to 231, Chemical oxygen demand from 537 to 384, nitrates (from 5.54 to 3.39) Coliform count by 10%. Considering cost-effectiveness of the enzyme it is considered feasible technique to mitigate polluted water bodies.

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INTRODUCTION

Yamuna river of India originates from the Yamunotri Glacier at a height of 6,387 meters in lower Himalaya. It travels 1,376 kilometers, covers drainage area of 366,223 square kilometers. From Yamunotri to Wazirabad onwards in Delhi (Fig. 1), its physical appearance changes drastically majorly due to waste water discharge in to the river. Presence of cadmium, mercury and arsenic found increased and high level of heavy metals and pesticides is major health concern since vegetables grown in these flood plains are consumed by large populations (NaithaniandPande, 2015).Delhi generates 1,900 million liter per day (mld) of sewage, against an installed wastewater treatment capacity of1,270 mld. Thus, 630 mld of untreated and a significant amount of partially treated sewage enters the river every day. While developed nations adopt stringent water quality requirements to control river pollution from point and non-point sources, the situation is different in most developing countries.

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More than 70% of drinking water supply of Delhi is abstracted from river Yamuna. An estimated 57 million people are dependent on the water of the Yamuna River. In India Rivers like Vishwamitri, Yamuna carries a very high cultural, economic and geographical importance hence quality of water is subject of research (Bhangaonkar and Patel, 2017). Practice of travelling to bath and pray at Yamuna bank is common ritual during festivals like Melas, Kumbh in India. Many studies have done evaluation of such cultural activities at the river bank on the quality of water during such festivals/ occasions and defined factors affecting quality of water. A study (Pathak *et al.,* 2016) and many others (Shukla and Gupta,2015; Singh; Bhatia, 2016) showed deterioration of physiochemical and biological parameters like dissolved oxygen (DO) Biological Oxygen demand(BOD), pH, Chloride, conductivity, turbidity, hardness etc. Normal pure water BOD is ≤3 mg/ L of water. Apart from major pollutants to the river (industrial waste, urbanization, improper agricultural practices, and sewage water disposal without treatment) religious, cultural and social activities are also considered as source of pollution to river water. The prescribed Standards for BOD, DO, TDS and TC (list of abbreviations for full form) are laid by Central Pollution control Board (CPCB)– an Indian standard lab authority for monitoring pollution, which describe quality of water for bathing i.e. BOD <= 3 mg/L, DO >= 5 mg/L, TDS 500 mg/L, TC 500 MPN/100 ml,Free ammonia is to be less than 1.2 mg/L (WQCBW, 1986) and shows deterioration of water quality in Delhi mostly at Nizamuddin and Shahadradrain site in periodic test reports. Apart from bathing, festivals and many cultural activities involving large population gathering happen at the bank of the river. Similar mass gathering happened in the year 2016 in the month of March at Yamuna bank and the event is widely known as World Culture Festival (WCF). The festival was held on the Yamuna flood plains in New Delhi from 11 to13 March 2016 (Sowmiya, 2018).It was organized by the Art of Living Foundation's 35th year of service. It was reported to have been attended by 3.5 million people in audience and 37,000 artists over 3 days (Echeverri-Gent, 2017).There were assumptions about the event affecting quality of water. Hence review of chronological water quality assessment by researchers (Naithani and Pande, 2015) and routine CPCB test reports (independent referral agency) is done and in this pursuit, it was observed that quality of water was found improved, when compared with previous year's same months data of water pollution levels. Table 1 is showing chronological order of water quality data for March 2014 to 16. These reports led to exploration of factors playing role behind such effects and explore what measures were undertaken to clean up the river so that despite large conglomeration of more than million persons during March 2016, Yamuna water quality did not deteriorated.

In this CPCB report submitted to the Honorable National Green Tribunal about the quality of water in the river showed most parameters stable during March 2016. A pre and post comparison (Table 2) of the WCF month's data further showing stable/improved water quality post WCF when compared March month of 2016 (pre-WCF) and April 2016 (post-WCF).

The dates of water sampling by CPCB are generally 3-4 March and 1-2 April every year and by chance WCF happened between these dates. Despite over all deterioration of water quality in past successive year's report from Aleem, and Malik, (2005) showing constantly increasing deterioration as much as DO has fallen below 1 in last 20 years. The reasons behind the

Table1: Comparative figures showing quality of water during March 2014-15-16 (WQSRY, 2016)

Locations	Monitoring date	pH	Dissolved Oxygen (mg/L)	Chemical Oxygen Demand (mg/L)	Bio-chemical Oxygen Demand (mg/L)	ammonia	Total coliform (MPN/100 ml)
Yamuna river at	March 14	7.8	11.0	8	2		450
Palla	March 15	7.4	5.5	35	3		17000
	March 16	7.8	9.2	9	2		1400
Yamuna river at	March 14	7.5	1.2	42	13	6.8	35000000
Nizammudin	March 15	7.8	not done	83	29	12.3	3500000
	March 16	7.1	0.9	92	45	16.4	3500000
Yamuna river at	March 14	7.7	0.9	117	29	12.5	4600000
Agra canal	March 15	7.8	not done	75	27	14.1	5400000
	March 16	7.1	0.6	82	21	11.8	9200000

Table 2: Water status just pre (March) and post WCF (April) at Yamuna

	pH	Dissolved oxygen (mg/ml)	Coli form (MPN/100 ml)
Yamuna At Palla- pre WCF site			
Before 11 March 2016, Pre WCF		5.5	17000
During April 2016- post WCF	7.2	8.8	400
Yamuna at Nizamuddin- WCF site			
Before 11 March 2016, Pre WCF	7.4	0.9	35[5]
During April 2016- post WCF	7.3	0.4	35[5]
Yamuna at Agra Canal- post WCF site			
Before 11 March 2016, Pre WCF	7.1	0.6	92[5]
During April 2016- post WCF	7.5	0.4	11[5]

quality found stable/ better in some parameters during March 2016 may be the measures undertaken to keep Yamuna clean during WCF. When explored, it was found that some low cost, feasible measures were undertaken by the organizers and administration during this mass conglomeration with more than a million participants from 155 countries for three consecutive days. Those measures were 1) Maintaining the good flow of the river water to avoid usual stinking smell from water.2) the wetland was cleared of municipal and civil debris, which was occupying the river bank and releasing leaches to river water constantly. 3) Before the WCF event, Eco-enzyme was added at the junction where the Barapula drain joins Yamuna and a major mild contributor to Yamuna and situated around the WCF venue**.** Besides measures number 1 and 2, the interest of the study was to see the effectiveness of measure number 3, to see if adding eco-enzyme has any widely acclaimed effect in cleaning water or not, for which very few publications are available (Bihar Watch, 2016; Miracle of Enzymes–Yamuna, 2016). Under this study, samples of water were lifted from two sites at Yamuna bank, one from drain discharging in Yamuna and one from a dirty water pond at Yamuna bank. Objective of the study was to validate the eco-enzyme effectiveness and its role in cleaning River's polluted water during WCF. This study reports comparison of river water quality parameters during 2014-16 and retesting done during 2017 to validate eco-enzyme effect on pollution source to the river water.

MATERIALS AND METHODS

The purposes was to repeat and test the same act of adding enzyme and see water quality in similar/real field conditions pre and post adding of enzyme; hence the samples of waters were lifted from one drain to Yamuna and a pond at Yamuna bank. In the drain water Eco-enzyme was added in different concentration to find effect of dilution on effectiveness and efficacy of different concentrations on defined biochemical markers of water quality. In pond water samples were lifted from water body pre and post adding of enzyme. The tests were conducted in the similar CPCB, National Accreditation Board for Testing and Calibration Laboratories NABL (NABL) accredited labs –which are conducting the Yamuna water quality assessments periodically as a routine.

Eco- enzyme

Eco- enzyme was prepared following prescribed and tested methods (Dhiman, 2017). Wide use of this eco-enzyme is being done in Thailand and published literature shows its effectiveness in treating waste water (Ho *et al*., 2014). However in Indian field conditions like in river, pond and, drain its effectiveness is not widely tested and this gap of information is filled with this study. The enzyme was prepared by using ingredient– jaggery, fruit peels and water in 1:3:10 ratios in closed container, fermented for 3 months' time. Supernatants were poured in clean container and stored in cool dried place for about one month till its use in different concentrations in water samples at test sites.

Site for water samples

- For testing's of eco-enzyme-The drain water was lifted from Gautamnagar drain- a tributary to Barapula drain to river Yamuna. The time of collection of sample from the drain was at 9 am. Five liter of container was used to collect and one liter containers were used to distribute water equally at five places and add four different quantity of eco-enzyme in each pre-labeled container.

- A pond from Goverdhan village was the site at Yamuna banks to see effectiveness of eco-enzyme on such dead water body, since surface of the pond was fully covered with green algae.

After collecting water, samples were immediately transferred in ice container to labs for processing on the same day within 2 hours. Decoding and interpretation was done by separate independent team to ensure blinding (to avoid bias) in sampling, testing and reporting. Label codes were not disclosed to lab person so that blinding can be ensured in testing and reporting.

Sampling procedure for pond water

Location of sampling was Goverdhan, at Yamuna river bank (Fig. 1). The water of pond which was covered by green planktons due to nitrification of water was considered to be dead water and treated by enzyme after lifting pond water samples. The samples were handed over to the team of Uttar Pradesh Pollution Control board on 4-10-2017. Table 3 shows pre and post enzyme treatment, water quality parameters, 45 days post treatment. The time of post intervention sampling after adding enzyme to pond was 45 days and that happened due to logistic

Table 3. Water quality parameters Pre and Post eco- enzyme to pond water

Parameters tested	Pre enzyme treatment on 04.10.17	Post enzyme treatment, on 30.11.17
Color	colorless	colorless
Odor	odorless	odorless
Temperature	20	14
Ph.	6.7	7.2
Total Solids-TS	884	745
Total Suspended solids-TSS	121	47
Dissolved solids	763	698
BOD (after 3 days incubation at 29o C (mg/L)	0.4	1.0
COD (Dichromate reflux methods, mg/L)	256	176
Alkalinity as CaCO3 (mg/L)	248	226
Total Hardness as CaCO3 (mg/L)	380	272
Calcium hardness as CO3 mg/L	196	134
Mg hardness as CaCO3 (mg/L)	184	188
Chloride - Cl	2445	2307

Testing Lab: Uttar Pradesh Pollution Control Board

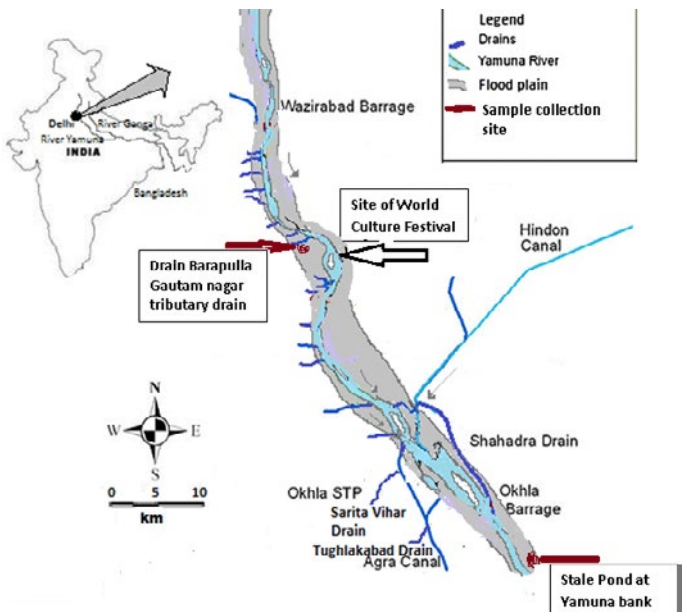

Fig. 1: Geographic locations of the study area at river bank, showing sites of event and water sample collection for eco-enzyme testing

issues (festival season and staff's non availability before that).Thousand times dilution of enzyme has been reported to give best activity of enzyme for cleaning water (Dhiman, 2017).To achieve 1000 times dilution calculation of estimates of volume of pond water was done. The pond was of 80X60X10 ft. hence 48000 sq. ft. volume required 480 liter enzyme to treat water. One liter of water sample was lifted prior adding the enzyme in to pond water. Water samples were collected from midpoint of pond to test biochemical and physical parameters as per established parameters and methods (Singh*etal.,* 2008) and presented in Table 3.

Sampling procedure for drain water

For collection of water, sterilized bottles were used. Bottles were washed thoroughly and rinsed with distilled water for microbial analysis. Each dry bottle was rinsed with 0.5ml sodium thiosulphate (10% solution). Samples of water were collected by lowering the bottle in mid-stream of drain and pond, transported to lab on same day. Containers were labeled as A B C D E. No enzyme was added to bottle labeled as "A" and for other bottles, eco-enzyme was added in different concentration Table 4. The codes and concentration of enzyme applied in each bottle is as follows:

- Code E: 0.5% (5 ml enzyme in one liter of drain water bottle)
- Code D: 1% (10 ml of enzyme in one liter drain water)
- Code C 2.5% (25 ml of enzyme in one liter drain water)
- Code B 5% (50 ml of enzyme in one liter drain water)
- Code A: No enzyme in drain water sample of one liter

RESULTS AND DISSCUSSION

The Eco-enzyme also known as garbage enzyme was tested in this study to find validity of its capacity in treating waste water. Though it is researched and published for efficiency (Fazna and Meera, 2013; Fu, 2011; Arun and Sivashanmugam, 2015) and it is practically in use for purpose of waste water treatment in the countries like Thailand. To see its effectiveness in Indian field conditions and to see what concentration of the enzyme will be more effective, the samples were collected and treated as described above with aseptic precautions and bottling as per standard norms. Tests were conducted as per published standards (Clair *et al*., 2003) at NABL accredited Government recognized labs and results are shown in Table 3.

It was observed that drain water (treated by 4 different concentrations) showed maximum purification with the least amount of enzyme at 0.5% concentration of bottle labeled as E. In view of the social, economic, religious and cultural significance of the Yamuna River and progressive degradation of its water quality, numerous conservation campaigns and the major cleaning up projects like the (Yamuna Action Plan, 2003) were undertaken for its restoration and conservation. Comparative analysis of the trends in river water quality parameters of the Yamuna River illustrates that despite of all the efforts the water is not fit for designated best uses in the Delhi and afterwards segments. Investigation shows that pollution in river Yamuna is largely due to direct injection of untreated drains and industrial effluents and cost effective sewage treatment technology is highly required (Dubey, 2016).The quality restoration of any river, especially of the Yamuna at different

Table 4: Water quality parameters with different concentration of eco- enzyme in drain water

Locations	Monitoring date	pH	Dissolved Oxygen (mg/L)	Chemical Oxygen Demand (mg/L)	Bio-chemical Oxygen Demand (mg/L)	ammonia	Total coliform (MPN/100 ml)
Yamuna river at	March 14	7.8	11.0	8	2		450
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Yamuna river at	March 14	7.7	0.9	117	29	12.5	4600000
Agra canal	March 15	7.8	not done	75	27	14.1	5400000
	March 16	7.1	0.6	82	21	11.8	9200000

locations, is a very complex and interdisciplinary endeavor (Singh, 2007).Regular water quality studies of River Yamuna are being undertaken by Central Pollution Control Board since 1977. The findings of these studies are available in various reports (Katyal and Qader, 2012; Sharma and Kansal, 2011). Besides these reports, year-wise water quality status of National Water Quality Monitoring Programme (NWQMP) locations data is also collated in Water quality statistics of India, published regularly by CPCB and technologies by researchers (Bhargava, 1985).

Eco- enzyme: low cost waste water management

In response to a question in Indian Parliament (LokSabha), unstarred question no. 736, answered on 21.07.2016 on pollution in Yamuna by member Badrudd in Ajmal, the minister of water resources, river development and Ganga rejuvenation answered that the organic pollution load measured as BOD ranges between 1 mg/L to 97 mg/L against the safe water quality criteria as <3 mg/L. The water quality data collected during 2015 indicates fluctuating trends in terms of DO, BOD and Nitrates. Under Yamuna action plan, the old sewage treatment plants proposed to be rehabilitated at a cost of Rs.1656 crores (Loksabha, 2014).The cost of eco-enzyme is approximately Indian Rs.30-50/- per liter and its constant mixing with drain water also does not require high budget. Simple installation of mixing of enzyme at confluence of drain and river meeting point may be enough. CPCB reports show the worst quality of water at Nizamuddin site (WCF site) (Sharma and Kansal, 2003).Steps was definitely required for cleaning the most polluted sites of Yamuna. A Sewage Master Plan has been finalized by the Delhi Jai Board and is being implemented in phases to provide sewage facilities in non-sewer areas at an estimated cost of Indian Rs.20.000 Crore (Shukla and Gupta, 2015). While, comparing the cost involved in the measures undertaken to treat waste water, then it is observed that resources were managed judiciously during WCF, to avoid huge expenditure incurred in mitigation of water pollution, hence despite numerous studies (Shukla and Gupta, 2015; The Art of living, 2016) stating deteriorating effect of large gathering, it is not reflected in Yamuna waters during WCF gatherings. Though bathing was not undertaken during WCF gathering, but human waste and excreta was expected to cause damage, which however was found absent. Almost all studies have shown decreasing quality of water (decreasing pH and BOD) with cultural activities that do not include bathing on river like Murtivisarjan (holy statue submersion ceremony) Chat-Puja Etc. where the Ghat (River bank) are used for non-bathing purposes by pilgrimages. Confluence of mass gathering during WCF for 3 days at river bank with generation of bio-waste was also expected to affect water quality while observations of the serial CPCB reports are not showing deterioration. The reason may be either discharge were not released in Yamuna or treated before releasing. Despite huge flux of waste and organic matter during WCF the improved quality parameters shows the effectiveness of measures undertaken to mitigate pollution. Several water treatment technologies available but are not fully implemented in view of cost and logistics constraints. Besides that, the conventional water treatment processes are based on chemical coagulation and filtration or biological slow sand filtration etc. which have little capacity. Therefore emphasis is given to the feasible and economical techniques. The present study's test reports have come up with validation of one such product-available and able in water pollution mitigation. Similar validations from outside India indicate that higher dilutions of eco-enzyme resulted in a more active efficiency (Fu, 2011). The results also indicated that ammonia, nitrogen and phosphorus had been removed by eco-enzyme. However, due to the high amount of organic material in the eco-(garbage) enzyme, an increase in BOD may be observed. Similar is the Pond water report (Table 4) indicated that the garbage enzyme is effective in reducing ammonia, nitrogen and phosphorus, but not BOD. A study by (Arunand Sivashanmugam, 2015) showed that eco (garbage) enzyme possesses protease, amylase and lipase activity and reduces 37.2% of total solids, 38.6% of suspended solids and 99% of pathogens in dairy waste, activated sludge. However further tests are required to understand the detailed mechanism of such observations and actions of eco- enzyme.

CONCLUSION

Either improved or stable river water quality (despite large public gathering) is observed during March 2016 as DO is observed rising from 5.5 in March 2015 to 9.2 in March 2016, COD decreasing from 35 to 9 mg/L and significant decrease in coliform

count around WCF site. Polluting water bodies adjacent to Yamuna river when tested by adding same eco-enzyme showed improved water quality parameters i.e. Ph. rising from 6.7 to 7.2, total solids reducing from 884 to 745, SS from 121 to 47, DS from 763 to 698, BOD from 0.4 to 1.0 mg/L. Reduction of total hardness i.e. 380 to 272 mg/L in pond water and ammonia, nitrogen, chlorides, coliforms in drain water. Maximum effectiveness observed at 0.5% concentration of enzyme showing pH rising from 6.8 to 7.1 despite enzyme itself having low Ph. Hence apart from other measures, use of eco-enzyme in the drains had role in cleaning water of Yamuna. It is also concluded that the measures undertaken during WCF are doable, feasible, and economical and may be replicated to maintain good quality of water in Yamuna. The present study observes that measures undertaken during mass conglomeration at Yamuna banks can be made part of Yamuna action plan for Cleaner River.

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CONFLICT OF INTEREST

The author declares that there is no conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies have been completely observed by the authors.

ABBREVIATIONS

BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
CaCO3	Calcium carbonate
Cl_2	Chlorine
CPCB	Central Pollution Control Board
DO	Dissolved oxygen
E. coli	Escherichia coli
FCC	Fecal Coliform count
NABL	National Accreditation Board
NH3+N	Ammonia + nitroge
NO3-N	Nitrate nitrogen
Mg/L	Milligrams per liter
ml	Milliliter
MPN	Most probable number
PO4-P	Phosphate
SS	Suspended solids
Sq.ft.	Square feet
TSS	Total suspended solids
TDS	Total dissolved solids
TC	Total Coliform
TSS	Total suspended solids
WCF	World Culture Festival

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