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Impact of Idol Immersion on Mumbai's Aquatic Ecosystems: Comparative Analysis of Juhu Beach, Marve Beach, and Dingeshwar Lake, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

In Maharashtra, Ganesh Chaturthi is one of the major festivals celebrated, and many idols are immersed throughout the festival. Traditionally, idols were made of biodegradable materials like clay, but in recent times, various other harmful materials like POP (Plaster of Paris), oils and paints are used which tend to bioaccumulate in organisms. The present study analysed various physicochemical parameters of water which included temperature, turbidity, total solids (TS), total

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dissolved solids (TDS), total suspended solids (TSS), conductivity, density, salinity, dissolved oxygen (DO), pH, hardness, nitrates, and phosphates, conducted before and after idol immersion at three sites in Mumbai: Juhu Beach, Marve Beach, and Dingeshwar Lake. The research observed changes in these parameters before and after the immersion of the idols which signified an increase in the level of pollution which may negatively affect the aquatic organisms' health and lifestyle. The number of idols immersed in water bodies has increased over the years, and hence there is an urgent need to control water pollution. By adopting more sustainable measures for idol immersion, we can minimize the detrimental impacts on aquatic ecosystems.

Keywords: Idol immersion; water quality analysis; mumbai; sustainable measures.

1. INTRODUCTION

Water is an indispensable resource and plays an essential role in sustaining all forms of life on Earth. Ganesh Chaturthi, one of Mumbai's most popular and widely celebrated festivals, involves a significant number of idol immersions, making it ideal for studying the impact on water quality. Festivals like Durga Puja in Bengal also see similar practices, where the idols are immersed in water bodies at the end of the celebrations. Such practices are common across various regions in India, each with its unique cultural and religious significance. The Brihan Mumbai Municipal Corporation (BMMC) released official data stating that in 2022, 43,385 idols were immersed while in 2023, 81,570 idols were immersed on the 5th day of Ganesh Chaturthi. This accounted for an increase within one year, to spike by 88% [1]. Traditional idols are often made from non-biodegradable materials like Plaster of Paris and adorned with toxic paints, chemicals, and floral waste leading to water pollution.

These pollutants have the potential to harm the aquatic ecosystem, drastically hinder the water quality in that area as well as disturb the ecological balance which adversely affects the aquatic organisms [2,3]. The floating materials released through the immersion of idols in rivers, seas, and lakes after decomposition may result in eutrophication of the water body. Long-term toxic effects are seen when non-degradable materials like metals as well as organic pollutants tend to accumulate in various vital organs of animals like fish [4-6].

The harmful effects of Plaster of Paris (PoP) idols on marine life are well-documented. PoP is derived from gypsum made of calcium sulphate, which increases the hardness of water and sulphate levels which in turn plays a crucial role in the disruption of aquatic ecosystems. The paints on these idols often contain heavy metals such as lead, mercury, and cadmium, which leach into the water, causing bioaccumulation and severe health issues in marine organisms. [7-9] The decomposition of organic materials used in idol decorations depletes dissolved oxygen, leading to hypoxic conditions harmful to aquatic life [10-13]. Physical fragments of PoP can injure marine creatures and damage habitats like coral reefs. Continuous annual immersions result in persistent pollution and ecological imbalance in water bodies, underscoring the need for sustainable practices [14,15].

Juhu Beach is one of the most popular beaches in Mumbai and a hotspot for the annual Ganesh Chaturthi celebration, where devotees immerse idols of various sizes. Marve Beach, located in Malad, is a prime location for people who travel by ferry and also serves as an immersion site. Dingeshwar Lake, in Kandivali's Charkop Village, is another site for idol immersion. As a closed body of water, Dingeshwar Lake allows for a comparative analysis of pollution levels among the three sites. These three water bodies are some of the prominent idol immersion sites in Mumbai.

The current study aimed to analyse the effect of idol immersion and its subsequent effects on the aquatic ecosystem.

2. MATERIALS AND METHODS

The levels of pollution can be monitored by comparative analysis of the physicochemical water parameters before and after idol immersion in the water body. The parameters selected for this study include dissolved oxygen (DO), salinity, hardness of water, pH, nitrates, phosphates, total solids (TS), total suspended solids (TSS), total dissolved solids (TDS), turbidity, conductivity, density. Samples from the water bodies before Ganpati immersion were taken from Juhu Beach (19°05'43.5"N

72°49'35.4"E), Marve Beach (19°11'55.8"N 72°47'47.2"E), and Dingeshwar Lake (19°12'20.3"N 72°49'07.6"E) on the 15th of September, 17th of September, and 17th of September with an ambient temperature of 32°C & 31° respectively. The Post idol immersion samples were taken on the 29th of September (Juhu Beach), the 1st of October (Marve Beach), and the 1st of October (Dingeshwar Lake). The samples were collected before and after immersion from the surface of each water body in pre-rinsed glass bottles with rubber caps. Three bottles of samples were collected during each visit and the weather and ambient temperature were recorded for better analysis of water quality. Formaldehyde was added to the first bottle from each water body to suspend biological processes since it is toxic to microbes. Thereafter, a second bottle from each of the water bodies was treated with Winkler's A and Winkler's B to fix and measure the dissolved oxygen (DO) accurately in the future. Respective precautions were taken at the time of collection. The temperature was noted using a thermometer at the time of sample collection. The third bottle collected from each water body was untreated.

The water samples were analysed using the standard methods outlined by Trivedy and Goel (1986). For pH measurement, the pH meter was used. To measure hardness, the EDTA Method was used. Winkler's Method was used to measure dissolved oxygen (DO). To measure Nitrates, the Sulphanilamide method was used. The Phosphomolybdenum method was used to measure phosphates. A Nephelometer was used to measure the turbidity. To measure the total solids (TS), total dissolved solids (TDS), and total suspended solids (TSS), we used the oven method. To measure the conductivity, we used an Electrical Conductivity Meter. A Refractometer was used to measure the density and salinity was estimated by the Argentometric method [16].

3. RESULTS

The results of the physicochemical parameters of the collected water samples were analysed for the deviation between the values before immersion and after immersion.

Temperature: The temperature of the samples in Juhu, Marve, and Dingeshwar before immersion were 28°C, 26°C, 25°C and after immersion were 31°C, 28°C, and 28°C respectively.

Turbidity: The turbidity of the Juhu sample before immersion was 7 NTU, and after immersion was 10 NTU. The turbidity for the Marve sample before immersion was 11 NTU and after immersion was 20 NTU. The turbidity of the Dingeshwar sample before immersion was 0 NTU and after immersion was 1 NTU (Fig 2).

Total Solids (TS): The values for TS from the Juhu sample before immersion was 29300 mg/L and after immersion was 39700 mg/L. The values for TS from the Marve sample before immersion was 37200 mg/L and after immersion was 47900 mg/L. The values for TS from the Dingeshwar sample before immersion was 1900 mg/L and after immersion was 1700 mg/L (Fig 3).

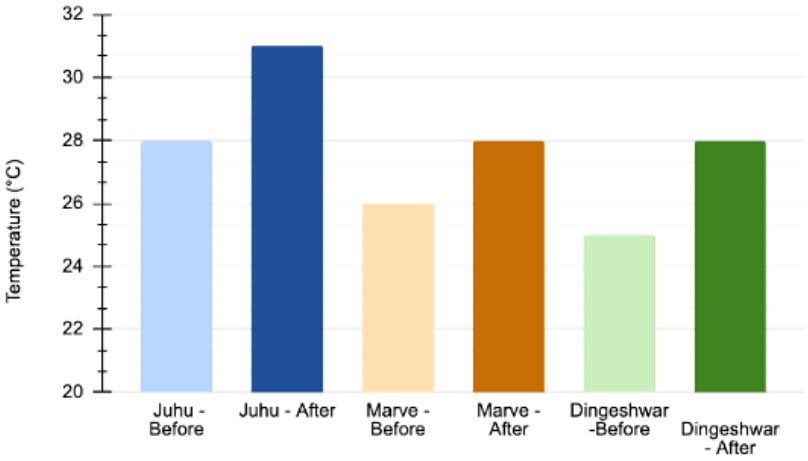

Fig. 1. Graphical representation of Temperature

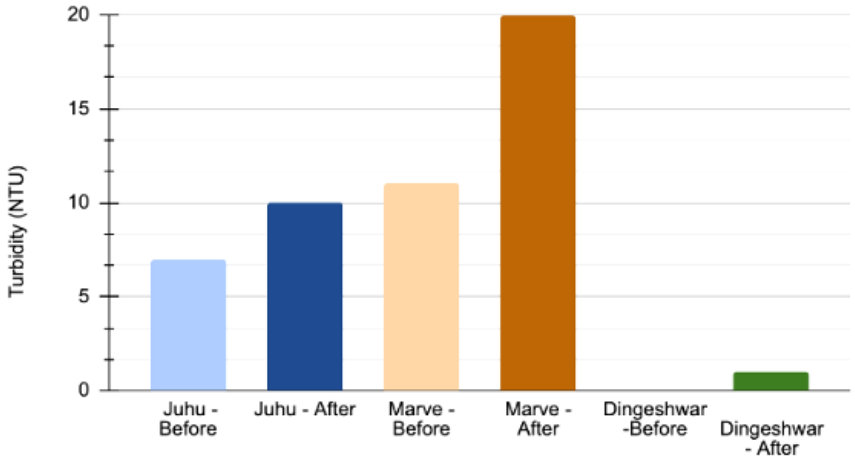

Fig. 2. Graphical representation of Turbidity

Total Dissolved Solids (TDS): The values for TDS from the Juhu sample before immersion is 28000 mg/L while after immersion, it was 38400 mg/L. The values for TDS from the Marve sample before immersion was 35700 mg/L, after immersion, it was 40000 mg/L. The values for TDS from the Dingeshwar sample before immersion was 400 mg/L and after immersion, it was 100 mg/L (Fig 3).

Total Suspended Solids (TSS): The value of Total suspended solids from the Juhu sample before Ganpati immersion and after Ganpati immersion was observed to be the same which was 1300 mg/L. The value of Total suspended solids from the Marve sample before Ganpati immersion was 1500 mg/L, after Ganpati immersion it was 7900 mg/L. The value of Total suspended solids from the Dingeshwar sample before Ganpati immersion was 1500 mg/L and after Ganpati immersion it was 1600 mg/L (Fig. 3).

Conductivity: The value of conductivity for the Juhu sample before immersion was 1.982 mS, after immersion, it was 2.971 mS. The value of conductivity for the Marve sample before immersion was 2.399 mS, after immersion, it was 2.699 mS. The value of conductivity for the Dingeshwar sample before immersion was 0.135 mS, after immersion, it was 0.137 mS (Fig. 4).

Density: The values of Density from the Juhu sample before immersion were 1.018 g/100mL, and after immersion, it was 1.024 g/100mL. The value of density from the Marve sample before immersion was 1.021 g/100mL after immersion it was 1.024 g/100mL. The values of density from the Dingeshwar sample before immersion were 1.001g/100mL, and after immersion, it was 1.001 g/100mL (Fig.5].

Salinity: The value of Salinity from the Juhu sample before immersion was 26 ‰, after immersion, it was 34 ‰. The value of salinity from the Marve sample before immersion was 30 ‰, after immersion, it was 34 ‰. The value of salinity from the Dingeshwar sample before immersion was 1 ‰, after immersion, it was 1 ‰ (Fig. 6).

Dissolved Oxygen: The value of DO from the Juhu sample before immersion was 7.528 mg/L, after immersion, it was 4.432 mg/L. The value of DO from the Marve sample before immersion was 8.865 mg/L, after immersion, it was 6.05mg/L. The value of DO from the Dingeshwar sample before immersion was 13.368 mg/l, after immersion, it was 3.729 mg/L (Fig.7).

pH: The pH values from the Juhu sample before immersion were 8.17, after immersion, it was 7.88. The pH value from the Marve sample before immersion was 7.92, after immersion, it was 7.88. The pH values from the Dingeshwar sample before immersion were 6.8, after immersion, it was 7.05 (Fig. 8).

Hardness: The value of hardness from the Juhu sample before immersion was 4300 mg/L, after immersion, it was 5900 mg/L. The value of hardness from the Marve sample before immersion was 5130 mg/L, after Ganpati immersion it was 6100 mg/L. The value of hardness from the Dingeshwar sample before Ganpati immersion was 430 mg/L, after Ganpati immersion it was 430 mg/L (Fig. 9).

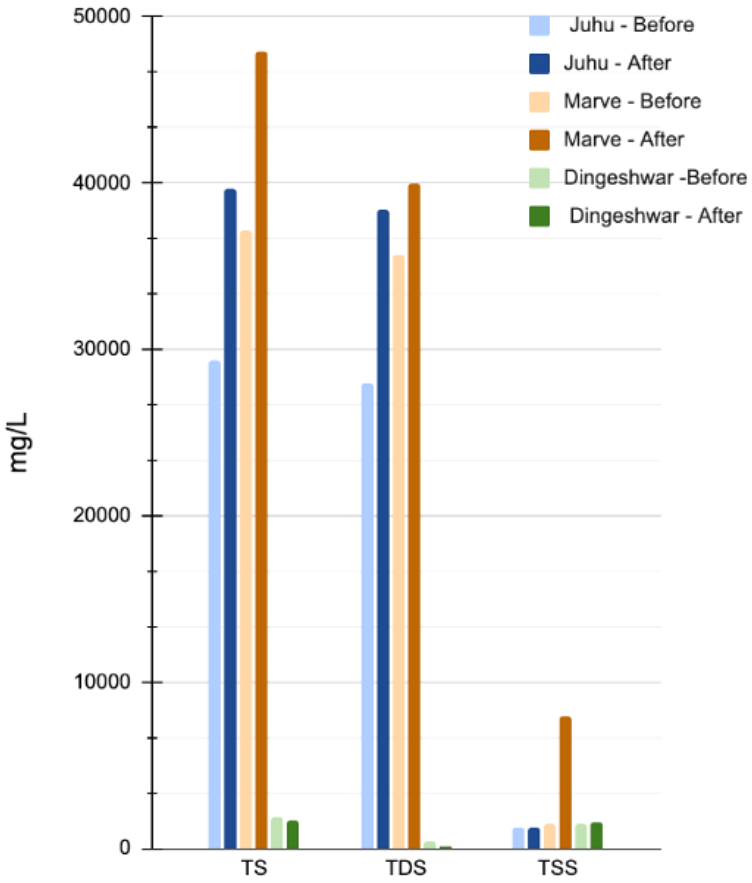

Fig. 3. Graphical representation of TS, TDS, and TSS

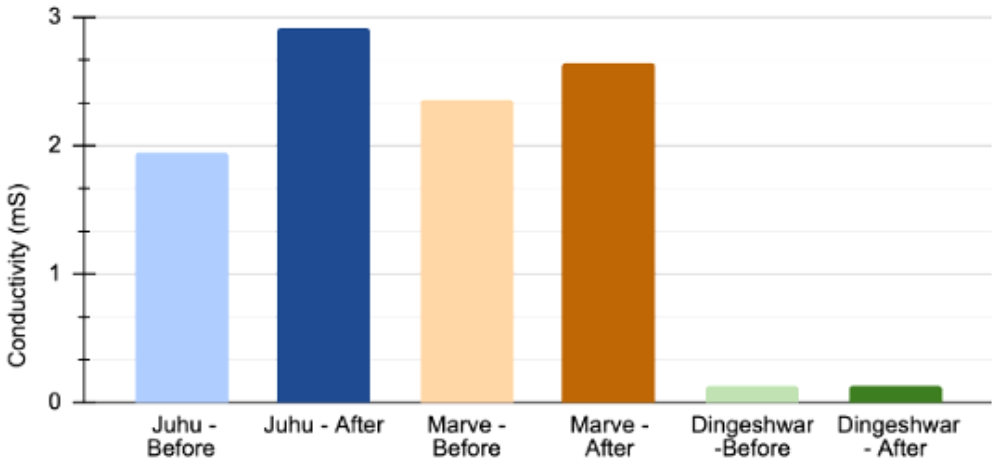

Fig. 4. Graphical representation of conductivity

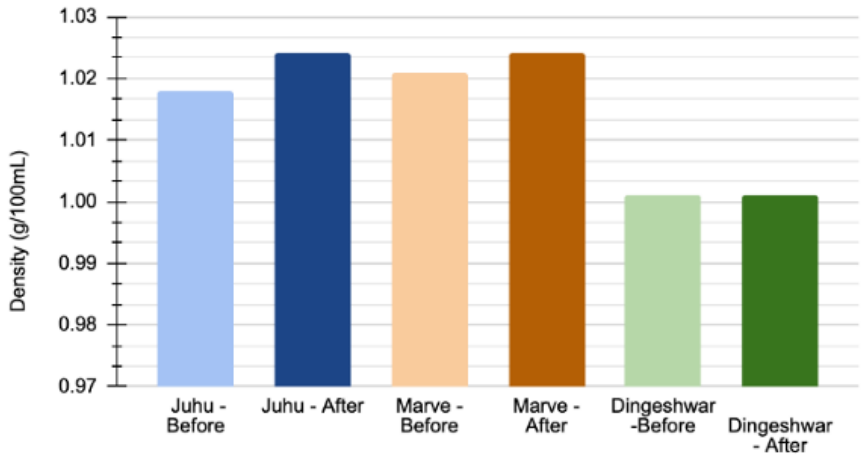

Fig. 5. Graphical representation of Density

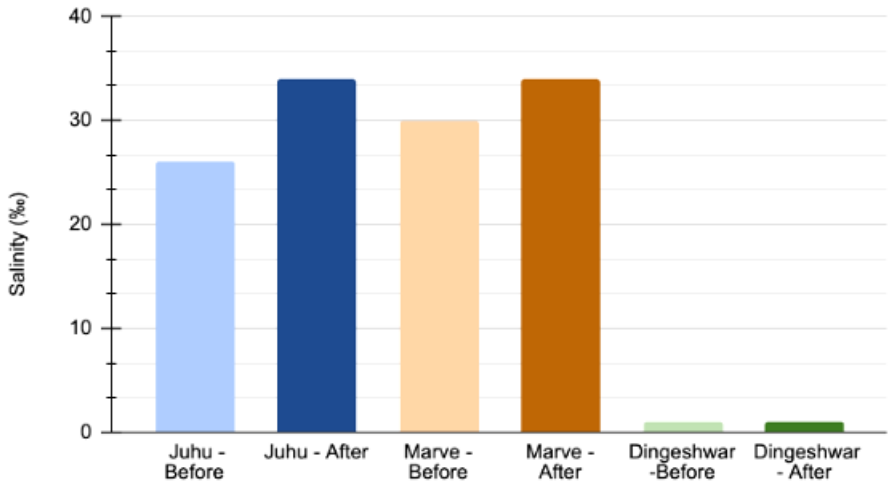

Fig. 6. Graphical representation of Salinity

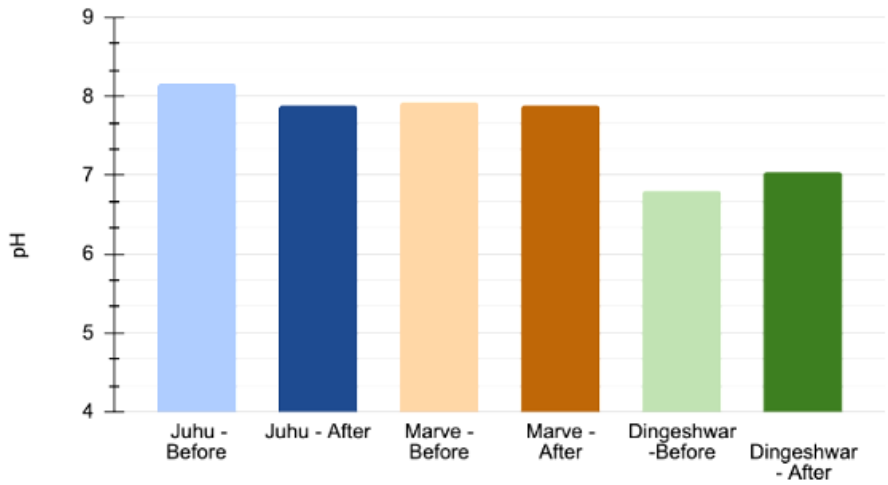

Fig. 7. Graphical representation of pH

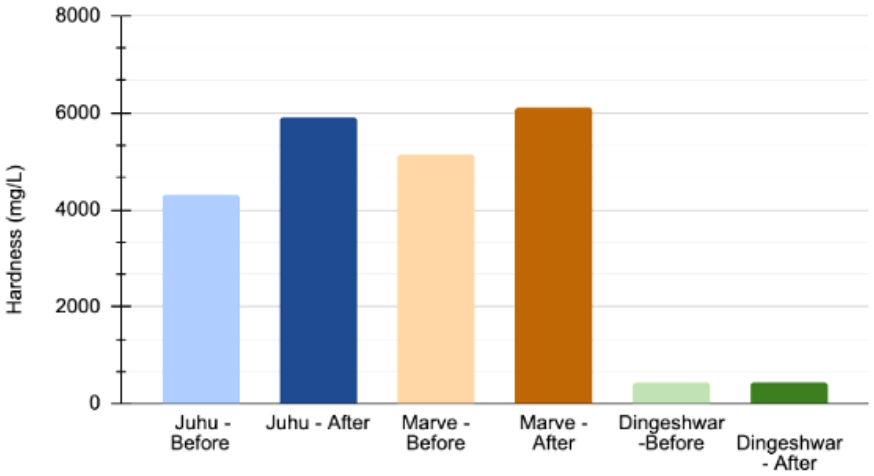

Fig. 8. Graphical representation of Hardness

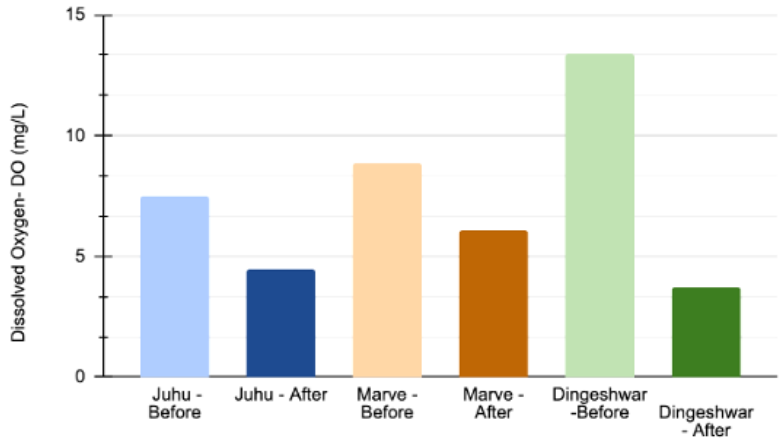

Fig. 9. Graphical representation of DO

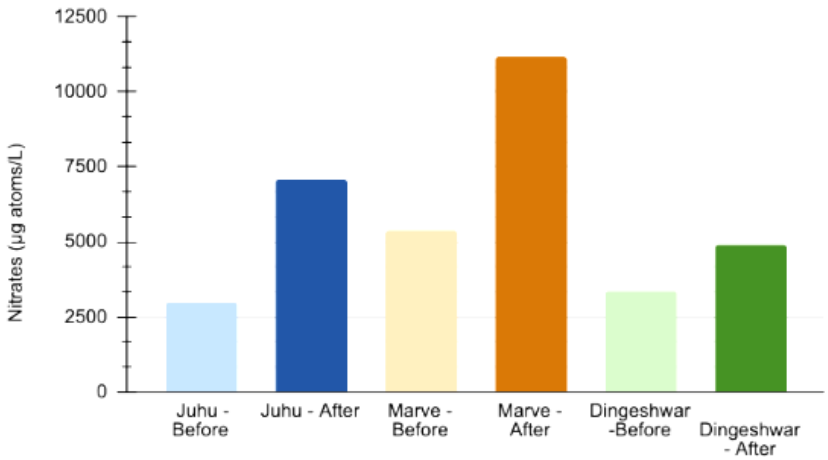

Fig. 10. Graphical representation of Nitrates

Table 1. Standard values of the Physicochemical parameters

Parameters	Standard		References
	Marine	Freshwater	
Temperature	-2 to 30 °C	2-28 °C	NOAA [17] Alternative-Energy.net, 2017 [18]
Turbidity	30 NTU	< 5 NTU	CPCB, 2019 [19] WHO, 2017 [20]
Total Solids	--	1500 mg/L	MPCB [21]
Total Dissolved Solids	10000-100000 mg/L	0-1000 mg/L	Caroll, 1962 [22]
Total Suspended Solids	100 mg/L	25 mg/L	GSA, 2001 [23] MPCB [21]
Conductivity	55000 µS/cm	100-2,000 µS/cm	Atlas Scientific, 2022 [24]
Density	1030 kg/m^3	At 4 °C is 1000 kg/m^3	CSIR-NIO [25] USGS, 2018 [26]
Salinity	35 ‰	1 ‰	UH Manoa [27]
pH	6.5-8.5	6.5-9	CPCB, 2019 [19] US EPA, 2024 [28]
Hardness	5800-7500 mg/L	300 mg/L	GSA, 2020 [29] PCB Assam [30]
Dissolved Oxygen	4.0 mg/L	8.24 - 9.08 mg/L at 25 to 20 °C	CPCB, 2019 [19] GSA, 2020 [31]
Nitrates	<0.1 ppm	< 3 ppm	Reef Central, 2010 [32] MNDH, 2015 [33]
Phosphates	0.02-0.04 mg/l	0.005-0.05 mg/L	Fauna Marin, 2020 [34] OSSE [35]

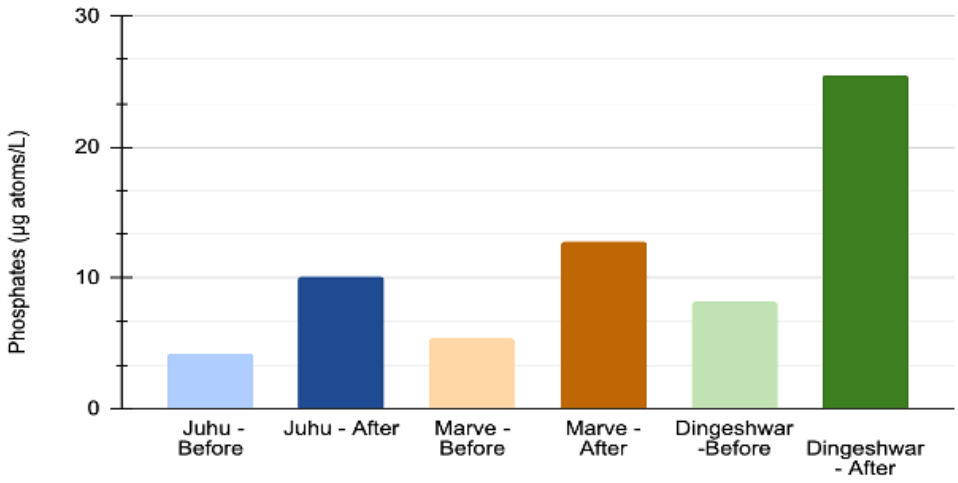

Fig. 11. Graphical representation of Phosphates

Nitrates: The values of nitrates for the Juhu sample before immersion were 3000 µg atoms/L and after immersion 7047.62 µg atom/L. The value of nitrates for the Marve sample before immersion was 5380.95 µg atoms/L; after immersion, it was 11142.86 µg atom/L. The value of nitrates for the Dingeshwar sample before immersion was 3333.33 µg atoms/L; after immersion, it was 4907.76 µg atoms/L (Fig.10).

Phosphates: The value of phosphates for the Juhu sample before immersion was 4.26 µg atoms/L, after immersion, it was 10.07 µg atom/L. The value of phosphates for the Marve sample before immersion was 5.35 µg atoms/L, after immersion, it was 12.77µg atom/L. The values of phosphates for the Dingeshwar sample before immersion were 8.19 µg atoms/L, after immersion it was 25.53 µg atoms/L (Fig.11).

4. DISCUSSION

There is a slight increase in the temperatures between before and after immersion. The temperature usually rises slightly after immersion due to chemical reactions, however after immersion the change in values could be attributed to the rainfall and/or changes in weather as reported by Gupta et al (2020) [36]. Warm water holds less dissolved oxygen than cool water, and may not contain enough dissolved oxygen for the survival of different species of aquatic life. Some compounds are also more toxic to aquatic life at higher temperatures [37].

The increase in turbidity may be owing to the disturbance in water due to idol immersion [38]. The increase in turbidity was also observed by Bhattacharya et al from the water bodies in Bangalore (2014) [39]. In some cases where the fish species survive in turbid water habitat, suspended solids can clog/harm gills aperture and reduced the resistance towards various disease and parasites (EPA, 2012).

In Juhu and Marve there was a notable increase in TS while in Dingeshwar a decrease in TS was observed. This could indicate deterioration of water quality [40]. Similar findings were observed by Jain et al in Mindhola river in Surat (2018).

In Juhu and Marve, there is a significant increase in TDS, which may be due to the material added while immersion of idols which are soluble in water like clay, paints, floral offerings etc. [41]. Whereas in Dingeshwar, a decrease in TDS was observed that could be attributed to the stagnancy of lentic habitat.

In Juhu water sample the TSS readings observed to be the same before and after idol immersion probably due to less navigational activities causing less churning of water. In Marve, there is a significant increase in TSS after immersion. In Dingeshwar there is a slight increase in TSS after immersion. This high value of suspended solids can be due to the increased run-off into the sea during monsoon and idol immersion [42]. Total suspended sediment adversely impacts the algae and aquatic macrophytes over limiting the quantity of light penetrating over the water column, which afterward limits the frequency of photosynthesis [43].

Conductivity is helpful in the determination of minerals in water [44]. Specific conductance is a measure of the electric current in the water sample carried by the ionized substances; therefore, the dissolved solids are related to this measure, which is also influenced by the good conductivity of inorganic acids, bases, and salts, the poor conductivity is characteristic of an organic compound [39]. When conductivity increases in the water, so does the salinity. As salinity affects the solubility of dissolved oxygen (DO) it is critical to measure conductivity alongside salinity when determining the water quality. The higher the salinity and conductivity levels, the lower the DO levels in the water, which can cause issues for some aquatic plants and animals. Some aquatic life can tolerate salinity changes, however, most cannot, and will either die or become seriously sick [45].

Density increases with an increase in mass. The density of water increases with an increase in salinity since there is an increase in mass i.e., salt. The increase in total solids, total dissolved solids, and total suspended solids in marine water can also point toward an increase in density [46]. Similarly decrease in total solids and total dissolved solids observed in current investigation justifies the stability in density observed in Dingeshwar sample. The density of water also affects its temperature regulation, which is vital for aquatic life [47].

The increase in the values of salinity after immersion at Juhu and Marve Beach could be due to wave action, evaporation, and the impact of idol immersion. However, for Dingeshwar, the salinity remains unchanged as it is a freshwater body. Salinity may get affected due to the weather. Salinities at the margins or outside the tolerance range of particular species will prevent their occurrence, change their behaviour, or limit reproduction and germination, reducing their fitness for survival in that environment [48].

There was a drastic decrease in the DO content in samples from all three water bodies. Water pollutants can diminish the egg, embryo by reducing DO [49]. The heavy input of wastewater and organic matter resulted in an anoxic environment due to the consumption of DO [17]. For living organisms, about 4 mg/L of minimum DO should be in water [17]. This decrease indicates that the adequate dissolved oxygen content depleted, a prerequisite for the aquatic life [18].

For Juhu and Marve Beach, a marginal decrease in the pH was observed whereas for Dingeshwar Lake a marginal increase in pH was observed. Fish and other aquatic organisms are particularly sensitive to changes in pH because they rely on dissolved oxygen for respiration. Maintaining a neutral pH range is essential for promoting the growth and survival of freshwater fish [50]. A low concentration of dissolved oxygen may result in a high pH whereas a high concentration of dissolved oxygen may result in a low pH [19]. This change in pH can be due to the chemicals or materials like Plaster of Paris, paints, etc. used in the idols. These chemicals and materials affect the pH of water [8].

For Juhu and Marve Beach, there is an increase in hardness while it remains constant for Dingeshwar Lake [51]. It can increase due to the mixing of organic and inorganic wastes [20]. Water hardness affects fish health owing to osmoregulation factor. Some common fish disease treatments are affected by water hardness and hence needs to be considered while calculating dosages. It should be noted that the water hardness affects the pH scale of the aquarium water. Hard water has comparatively higher pH and this will be alkaline [21].

Nitrate values increased after idol immersion because of the organic matter immersed along with the idol. Similar findings were shown by Dhote and Dixit (2011) [22]. Under extremely high exposure levels, aquatic invertebrates and fish may die. Early life stages of aquatic animals are more sensitive to nitrate than are juvenile and adult animals. Larval stages of amphibians appear to be particularly sensitive to subtle effects from nitrate exposure [23].

The concentration of phosphates was drastically increased after idol immersion for all water bodies. This may be due to the deposition of POP and chemicals during idol immersion as well as the decomposition of organic matter in the water sediments [24]. The increased nutrient (phosphorus) leads to an increased growth of aquatic plants and organic production of the water body. Enriched phosphorus levels can accelerate the growth of algae and other plants that impair the suitability of the water for municipal, recreational, and fishery use (CRJ, 2019) [25].

5. CONCLUSION

From our study, it can be concluded that idols are usually composed of non-biodegradable and toxic materials, which adversely affect the flora and fauna of both marine and freshwater ecosystems and their water quality.

By performing various physicochemical tests, the observed changes in the parameters of the samples collected before and after immersion were notable. It was also observed that idols were not immersed alone but also with flowers and decorative items. This explains the increase in chemicals, organic and inorganic matter as well as toxicity levels. This points to the pressing need to use idols made up of eco-friendly materials such as clay, mud, and paper mache for more sustainable and cost-effective celebrations. This can be a great alternative to idols made of POP (Plaster of Paris). Immersion of idols in artificial wells and water bodies, along with little to no water usage during immersion can help immensely in reducing pollution of water. Hence, adopting these measures can help endorse low-impact and ecologically sound practices in the festival.

CONFERENCE DISCLAIMER

Some part of this manuscript was previously presented and published in the conference: An International Conference on Coastal and Marine Conservation CMC-2024 dated from 1st and 2nd March, 2024 in Mumbai, India. Web Link of the proceeding: https://mithibai.ac.in/wp-content/uploads/2024/02/CMC2024-CONFERENCE-brochure.pdf

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of manuscripts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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