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DETERMINATION OF WATER QUALITY PARAMETERS AFTER ARTIFICIAL IDOL IMMERSION ON A LAKE IN MUMBAI, INDIA

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ABSTRACT: Immersion of deity idols during religious festivals is a source of contamination of lakes. This paper discusses the impact of idol immersion on water quality of a lake in Mumbai. The water sampling and analysis was done according to international standard procedures. A total of thirteen physico-chemical parameters were assessed. Variations in these parameters were prominently seen in after immersion samples. pH declined after immersion period, thereby increasing acidity values. Phosphate phosphorous (PO_4-P) concentration was found to increase significantly indicating plankton formation and eutrophication. BOD (mean from 12mg/L- 26mg/L) did not show much rise, COD predominantly increased (from 27.4mg/L - 76.4mg/L). This indicated higher synthetic organic load coming from the probable sources like POP idols, paints, oils, etc. Though the post- immersion organic carbon (1.88 ppm avg.) did not alter much, the inorganic carbon content showed an increase (40.94 ppm avg.). Turbidity and conductivity also increased indicating higher content of colloidal and free ions. The increase in values needs to be considered as a warning sign. Number and size of synthetic idols is increasing every year due to commercialization of festival. Religious activities cannot be stopped but we can certainly reduce pollution and save the lake by creating awareness in society.
Key words: Water pollution, Idol immersion, Water quality, Physico-chemical parameters, Lake.

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INTRODUCTION

'Water' - a valuable resource. It is a critical requirement of all life forms starting from micro-organisms to huge sized mammals. From a range of water reservoirs supplying drinking water to man, lakes are a crucial component. Lakes are called wide-ranging, productive and interactive ecosystems in the world. [1] Unfortunately, lakes today have reached a point of crisis due to unplanned industrialization and urbanization. [2].

Water pollution is an undesirable change in the natural quality of water caused by physical, chemical and biological factors leading to effects on living organisms and environment. Water pollution thus causes an effect on the health, normal functioning and properties of a water body. Lake is defined as a lentic water system, which means steady water. The pollutants in such water thus remain locked inside the water thereby causing profound disastrous effects through eutrophication, bioaccumulation, bio-magnification, toxicity, etc.

Metropolitan cities like Mumbai are facing a number of serious problems of ever increasing population, land scarcity, resource crunch, environmental pollution, improper natural resource management and many more. Mumbai, once composed of seven different islands has transformed drastically over the years. The fresh water bodies in Mumbai are thus under stress due to above stated glitches. In addition to industries, urbanization and slum sprawl; the transforming customs and traditions of people are also polluting water bodies.

India is a multi-cultural country with a range of festivals and Indians celebrate them with ever increasing enthusiasm to pay homage to various deities round the year.[3] One such festival is "Navratri" – a nine day long festival in which idol immersion in water bodies is a celebration finale. In olden days the idols were composed of clay. But recently the idols are made of non-biodegradable materials like plastic, cement and plaster of paris (POP). So also the idols are painted with synthetic paints and dyes that contain toxic chemical materials. Paints contain heavy metals like lead, mercury, etc. which are harmful. Acidic materials like gypsum, sulphur, phosphorous and magnesium are used in making POP. On immersion of these idols, the water gets highly contaminated thereby hampering the entire aquatic ecosystem. Specially those materials which do not dissolve in water, deplete the dissolved oxygen level and increase water acidity.[4]The aim of the current study was to evaluate the alterations in the physico-chemical properties of lake water before and after the idol immersion.

MATERIALS AND METHODS

Study area: The metropolitan city of Mumbai is the capital of Maharashtra and economic capital of India. The city contains all the geographical features like hills, rivers, plains, mud flats, beaches and so also the lakes. The study was carried out on one such lake called Sion Lake (19°2'50" N 72°51'57" E) situated in town Sion. Once it was a small pond dirty throughout the year which used to be cleaned during festivals. Clean up actions fell short. Due to the efforts of vigilant locals, the devotees staying around the temple and Brihanmumbai Municipal Corporation (BMC) – the local governing authority; the beautification, clean up and maintenance work took place. The lake is still utilised as idol immersion centre. [5].

Water sample collection and analysis

Sample collection was done at 5 sites in the roughly rectangular lake, four around the corner and one at the centre, named accordingly as sampling sites A, B, C, D and E. The surface water samples were collected before and after idol immersion activity. Water samples were collected in new, well rinsed and pre-cleaned plastic bottles, properly labelled and preserved as per the American Public Health Association Standard Method for Water and Wastewater Analysis. [6] The internationally practiced standard procedures for sample processing, solution preparation and analysis were followed. The physico-chemical parameters namely water temperature, pH, total acidity, total alkalinity, phosphate-phosphorous, conductivity, DO, COD, BOD, total carbon, total organic carbon, total inorganic carbon and turbidity ware assessed. Temperature was noted on site. The samples were then brought in laboratory. Turbidity and pH were immediately determined followed by analysis of remaining parameters. Samples were analysed based on standard procedures of water analysis. Titrimetric and colorimetric methods were preferred. [6], [7].

RESULTS AND DISCUSSION

The physico-chemical parameters of lake water before and after idol immersion have been reported in the following table-1

Water Temperature: Temperature may not be a governing parameter in fresh water systems because most aquatic life can tolerate a wide range of changes in ambient temperature. But in polluted water, temperature causes profound effect on DO and BOD levels thereby hampering aquatic ecology. [1] Rise in temperature speeds up the chemical reactions and reduces the solubility of gases in water. In the current study, the surface water temperature increased by 1°C from 33°C before immersion to 34°C in post-immersion samples. [8] Indian standards for discharge of environmental pollutants describes that resultant temperature should not exceed 5°C above the receiving water temperature. Hence there was no significant increase in temperature of lake water.

pH

pH is an indicator that determines suitability of water for various purposes like drinking, domestic use, industrial purpose, sustenance of aquatic life, etc. It has an effect on solubility of nutrients in water. [9] Organisms are extremely sensitive to pH and its higher variations may lead to their death. In the present study, the water pH was found to be slightly acidic in range. Although there was no major variation in pH values of pre-immersion (mean pH 6.61) and post-immersion samples (mean pH 6.43), the pH marginally moved towards acidity in all the five samples. This might have happened as a result of more number of idols, organic matter content and decorative materials immersed in the lake water. IS: 15000 gives the limiting range of pH for drinking water to be 6.5 to 8.5. Hence pH values were more or less within the same range. Fortunately, BMC has a practice of idol immersion in a limited area of the lake and removing immersed idols immediately. This helped in making water faintly acidic.

Turbidity

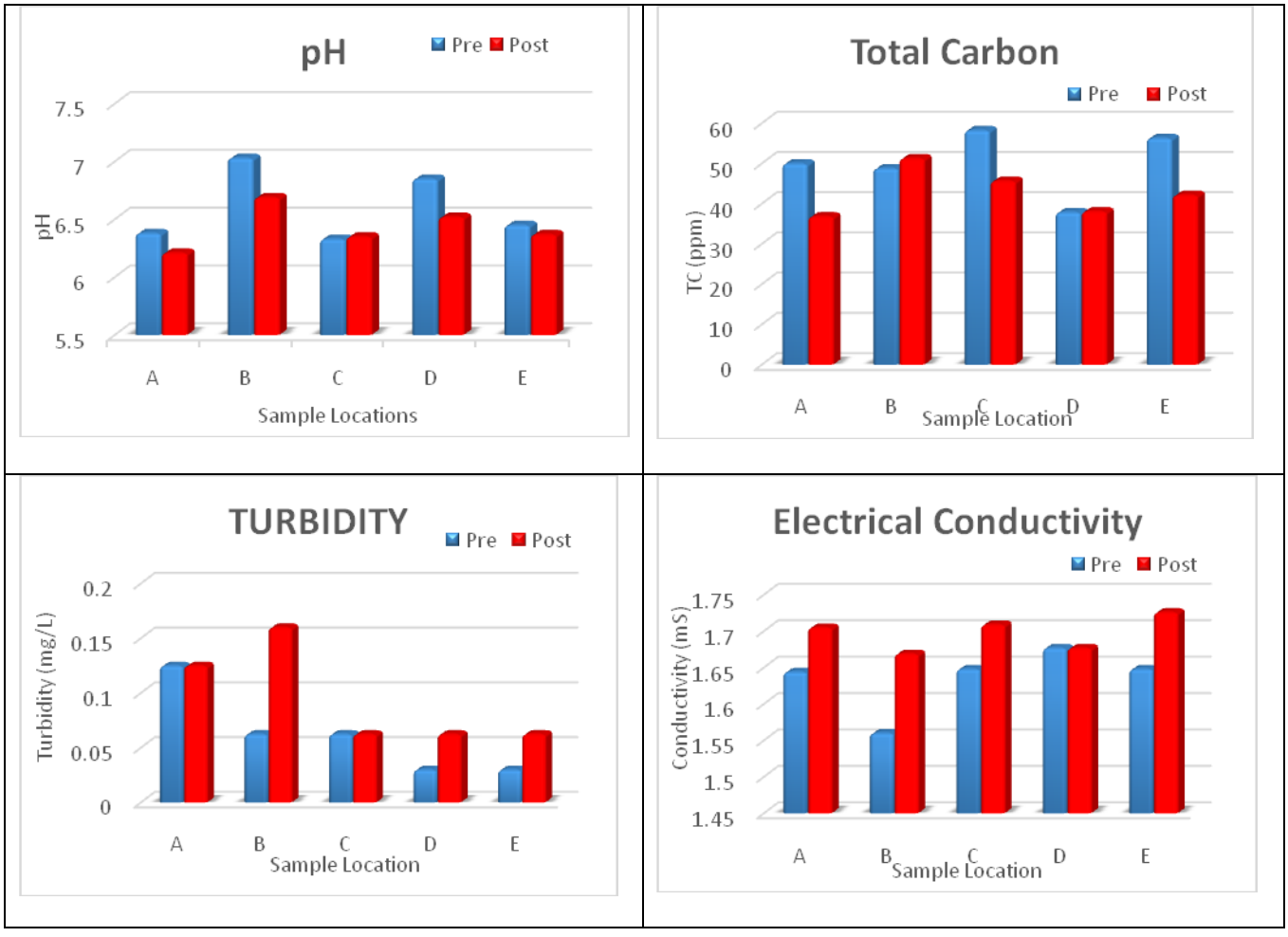
The productivity of natural water bodies is due to its unique property of transparency. The transparency of natural water bodies is an important determinant of its condition and productivity. In transparent water, the sunlight can penetrate at considerable depth thereby increasing photosynthesis and primary productivity. Turbidity in water is caused by suspended and colloidal matter like clay, silt, fine organics, micro-organisms, etc. In the present study there was no major change in turbidity values even after idol immersion.

The average turbidity before immersion was 0.06 mg/L which increased to 0.09 mg/L in after immersion samples. [10] in their study of comparison between immersion pattern of clay and POP idols have shown that clay idols provide greater turbidity than POP idols. The same situation occurred in the current study. POP idols do not disintegrate in to fine particles thereby reporting no major changes in surface water turbidity.

Table 1: Physico-chemical parameters of lake water before and after idol immersion

	Samples	Temp (°C)	pH	Total Acidity	Total Alkalinity	PO_4-P	EC (mS)	DO	BOD	COD	Turbidity	TOC (ppm)	TIC (ppm)	TC (ppm)
Pre-immersion samples	A	33.00	6.38	25.00	140.00	0.35	1.64	9.00	10.00	19.00	0.13	11.00	38.99	49.99
	B	33.00	7.03	37.50	120.00	0.70	1.56	9.30	12.00	40.00	0.06	0.00	48.79	48.79
	C	33.00	6.33	25.00	112.00	0.35	1.65	8.10	20.00	5.00	0.06	9.68	48.59	58.27
	D	33.00	6.85	50.00	124.00	0.35	1.68	9.40	4.00	53.00	0.03	0.00	37.89	37.89
	E	33.00	6.45	25.00	124.00	0.35	1.65	9.70	14.00	20.00	0.03	12.28	44.03	56.31
	Avg.	33.00	6.61	32.50	124.00	0.42	1.64	9.10	12.00	27.40	0.06	6.59	43.66	50.25
Post-immersion samples	A	34.00	6.21	25.00	160.00	0.70	1.71	9.30	6.00	89.00	0.13	1.17	35.68	36.85
	B	34.00	6.69	37.50	180.00	0.71	1.67	8.50	20.00	70.00	0.16	6.35	44.93	51.28
	C	34.00	6.35	37.50	104.00	0.70	1.71	10.00	48.00	58.00	0.06	0.90	44.79	45.69
	D	34.00	6.52	25.00	120.00	0.70	1.68	8.00	26.00	85.00	0.06	0.21	37.89	38.10
	E	34.00	6.37	37.50	124.00	0.70	1.73	8.00	30.00	80.00	0.06	0.76	41.41	42.17
	Avg.	34.00	6.43	32.50	137.60	0.70	1.70	8.76	26.00	76.40	0.09	1.88	40.94	42.82

(Note: Units of measurement: Total acidity – mg/L, Total alkalinity – mg/L, PO_4-P - µg atoms/mL, DO – mg/L, BOD – mg/L, COD – mg/L, Turbidity – mg/L)



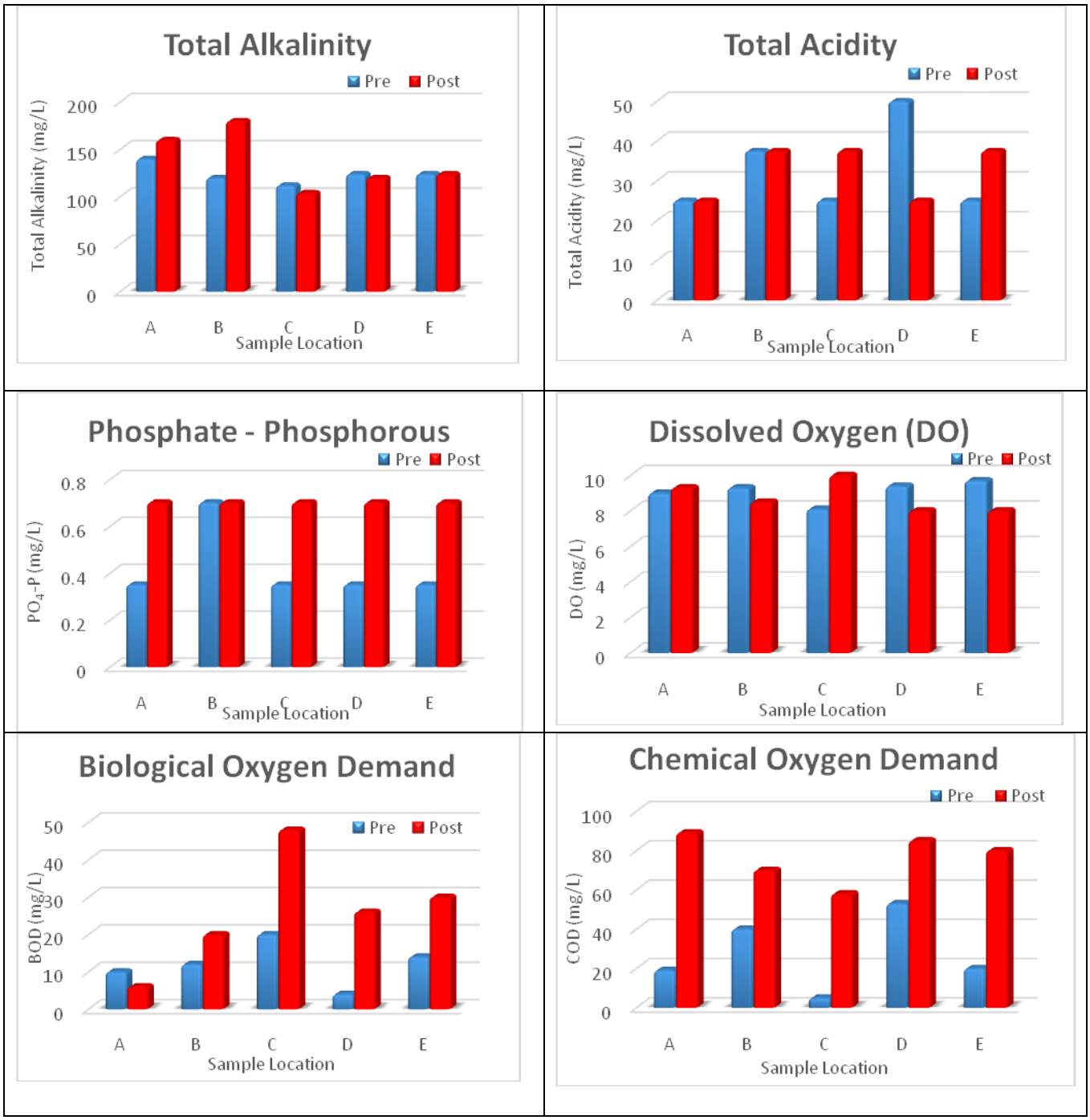


Figure 1: A graphical representation of physico-chemical paramaters in pre-immersion and post-immersion water samples

Electrical Conductivity (EC)

It is a numerical expression of sample to carry electric current. It depends on total concentration of ionic substance dissolved in water. Most of the salts in water are present in ionic forms which can carry electric current. Hence, conductivity is a good and rapid measure of total solids. Before immersion, the EC values ranged between 1.56 – 1.68 mS and after immersion the EC values varied between 1.67– 1.73 mS.

Total Alkalinity

Alkalinity in natural water bodies is mainly due to salts of weak acids. In natural waters, there are many salts of weak acids such as silicates, phosphates, borates, etc. that cause alkalinity in addition to carbonates and bicarbonates, together called as total alkalinity. In this investigation, the alkalinity values were found to be increasing except at location C as shown in the table.

The average total alkalinity value in pre-immersion samples was recorded to be 124 mg/L which increased to 137.6 mg/L in post-immersion samples. Jadhav et al [11] have stated that alkalinity is due to basic salts of Na, K, Ca, Mg and these are the components of artificial idols. It is this reason that alkalinity value has increased. IS: 15000, 1992 [12] state the maximum alkalinity value to be 200 mg/L for drinking water. All the values determined in the current study were thus within given limits.

Total Acidity

The total acidity in a solution is the amount of all the hydrogen ions (H^+) present in the solution. It is a more accurate representation of the acid concentration. Total acidity is caused by strong mineral acids, weak acids and hydrolysing strong acids. However, in natural unpolluted fresh water, the acidity is mainly due to presence of free CO_2 in the form of carbonic acids. Lakes generally have lower lime stone deposits. Acidification of fresh water in a lake depends upon presence of lime stone rocks which create buffering action and lowering acidity. Much of the damage to aquatic life in sensitive areas with this little buffering capacity is a result of acidic shock. This is caused by the sudden addition of large amounts of highly acidic materials, in this case POP idols. [13] In the current study, the acidity values were found to be relatively unchanged. It indirectly means the presence of sufficient buffering action and presence of salts occurring within the water.

Phosphate Phosphorous

The biochemical processes in natural waters requires an array of inorganic substances but the role of phosphorous in this is considerably vital. [14]It is an essential macronutrient for algal growth and is a governing factor behind eutrophication. In the present study, the mean phosphate value before immersion was found to be 0.42 µg atoms/mL which increased to 0.70 µg atoms/mL in post-immersion samples. The probable source of this phosphate has been POP. Hence this needs to be considered as an alarming sign. IS: 15000 Indian general standards describe maximum phosphate levels to be 5 mg/L. Hence the values stated here are far within the limiting value. [12].

Dissolved Oxygen (DO)

DO content of water is immensely significant to all aquatic organisms and is considered to be the factor that indicates the biochemical processes occurring in a water body as it determines the biological changes. On account of disturbance in the water column, DO increases at surface layer due to mixing of atmospheric oxygen.[15] The DO levels in the current study were recorded to be 9.1 m/L on an average in pre-immersion samples. The same in post immersion samples reduced to an average value of 8.76 mg/L. The marginal reduction has been attributed to increased decomposition of organic matter added due to idol immersion. For drinking water, the DO limit has been decided to be 6.0mg/L. [15]The current study samples thus did not go lower than the limiting value indicating sufficient infiltration of atmospheric oxygen. There is no need of aerators to maintain the DO levels of water body.

Biological Oxygen Demand (BOD)

BOD is a parameter to assess the quality of water. It is the most reliable characteristic and may serve as a useful pollution index of water body. It is one of the pollution indicating factor and its value increases due to decomposition of organic materials.[16] Except, the sampling station A, the BOD values were found to increase in post-immersion samples. The BOD values before immersion ranged from 4 to 20 mg/L (mean 12 mg/L) which increased to the range of 6 – 48 mg/L (mean 26 mg/L) in after immersion samples. Although none of the samples exceeded the standard limiting value, the increase has been due to load of organics in post-immersion samples attributed to immersion activity. Indian standards state maximum BOD value (3 day) to be 30 mg/L. Hence other than a single post-immersion sample of location C (48 mg/L) other samples showed BOD value within given limits. [17].

Chemical Oxygen Demand (COD)

COD is an important parameter to know the water quality because the COD value increases by addition of synthetic pollutants. COD value in the current study was found to have increased in post-immersion samples at all the sampling stations. The average COD value in pre-immersion samples was determined to be 27.4 mg/L that raised to 76.4 mg/L in post-immersion water samples. None of the water samples crossed standard limiting value, but this needs to be considered as a warning signal. In the scenario of ever increasing number of idols, the value may increase substantially. IS: 15000 suggests maximum COD value to be 250 mg/L. All samples were thus within the given limits. [12]

Total Organic Carbon (TOC)

Organic matter in water consists of number of materials such as macroscopic particles, colloids, dissolved macromolecules and specific compounds, to name a few. Organic matter content is measured as total organic carbon (TOC) which are fundamental components of the carbon cycle. Measurements of BOD and COD reveal the content of organic substances being susceptible to decomposition under specific conditions. TOC measurement provides information on all organic substance content in water or sediments. [18]. In present study, TOC values decreased over time from pre-immersion samples (mean 6.59 ppm) to post immersion samples (1.88 ppm). This shows that organic carbon generated as a part of idol immersion activity does not form a part of sediment but gets decomposed in water. This has further been confirmed through BOD results.

Total Inorganic Carbon (TIC)

The total inorganic carbon or dissolved inorganic carbon (DIC) is a total of inorganic carbon species in a solution such as CO_2, carbonic acid, carbonate and bicarbonate ions. Studies of inorganic carbon analysis in natural waters provide information on the biological productivity and buffer capacity. Determination of total inorganic carbon, alkalinity and dissolved carbon dioxide gives an indication of the balance between photosynthesis and respiration by biota, both within the water column and sediments and carbon dioxide transfers from the water column to the atmosphere.[19] TIC is necessary for phytoplankton built up and maintenance of primary productivity. In the current study, there was a marginal decrease in TIC values after idol immersion. The average TIC value reduced from 43.66ppm in pre-immersion samples to 40.94ppm in post-immersion samples. This showed that idol immersion does not affect the inorganic carbon content of fresh water body.

Total Carbon (TC)

Summation of TOC and TIC values gives an idea of total carbon content of water bodies. The average TC value in before immersion samples was found to be 50.25ppm which got reduced to 42.82ppm in post-immersion samples. The said reduction was mainly due to reduction in TIC values.

CONCLUSION

Effect of synthetic idols immersion is rise in physico-chemical parameters of lake water. Present study concluded that lake water quality deteriorated after idol immersion. The clean-up activities of BMC, awareness campaigns by environmentalists and initiatives by vigilant citizen have helped to maintain pollution levels minimal.

Maharashtra Pollution Control Board along with local administration is running awareness programmes among students, idol manufacturers, devotees and locals regarding adverse effects of idol immersion. This is achieving a lot to change. The same needs to be continued to attain significant transformation. As the time passes more people may show concern and celebrate the festival in an eco-friendly manner.

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