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Short Communication

The ritual of idol immersion and the aquatic environment surrounding us: a study of water quality and it's inhabitants of the Ganga River and Immersion Pond in Kolkata, India

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Abstract

The aquatic environment, controlling the state of health of fishes, is severely affected by common toxic pollutants like Lead (Pb) in surface water. During certain festivals, idols are immersed in Ganga or nearby ponds and lakes, with a rough estimation of around 950 idols in the Ganga from Babughat alone and about 200 in the New Town Immersion pond in Kolkata, India. Chemical paints used on the idols contain high amount of Lead, leading to alteration in the water quality, pH, temperature and total dissolved solid (TDS) load. Yellow, red, orange and white pigments contain the most amount of Pb, and are toxic even in very small quantity, entering the human system through food chain, and bioaccumulate and biomagnify. In this study, the water quality of Ganga river and Immersion pond in New Town, Kolkata are measured during Pre-immersion, Immersion and Post-immersion phases, and the risk assessment of the health effects on fish consumption from these areas are attempted. Water and fish samples are measured, from the immersion pond of New Town, Kolkata, and Babughat, Ganga river bank, for Pb content, and water temperature, turbidity and conductivity, during pre-immersion, immersion and post-immersion phases. Pb content in the water, which was high to begin with, raised severely beyond permissible limits during immersion phase and continued to remain so during post immersion phase. The Pb content in the organs of Tilapia fish from the Immersion pond showed Pb content beyond permissible limits in post immersion phase. A significant increase in temperature is noted in both sites during immersion, affecting the aquatic life. The pH becomes acidic during immersion phase, resulting in faster heavy metal release rate and producing leaching. Electrical conductivity shoots up way beyond permissible limits, producing harmful gases. Turbidity too was severely increased during immersion phase, reducing photosynthesis by aquatic plants.

Keywords: Lead poisoning, pH, Conductivity, Turbidity, Atomic Absorption Spectrophotometry.

Introduction

Water is one of the most essential requirements of life. The aquatic environment is considered one of the main factors controlling the state of health and disease in fishes. Also, heavy metals, like lead (Pb), is one of the major types of common toxic pollutants in surface water. Religious festivals like Durga Puja, Ganesha Festivals are traditionally celebrated in Kolkata, India, as a social and community activity. After the festivals are over, the idols are immersed in the Ganga or nearby water bodies like ponds and lakes. In this period, it has been roughly estimated that around 950 idols are immersed in the Ganga from Babughat alone and about 200 are immersed in the New Town Immersion pond in Kolkata, India.

During immersion, along with the biodegradable materials used in construction of the idols, several heavy metals enter the aquatic system as well and increase their concentration above permissible limits, thereby altering pH, temperature and total dissolved solid (TDS) load. The chemical paints used on the idols contain high amount of Pb giving rise to alteration in the water quality. Immersion caused the noxious dyes to contaminate the river and other water bodies. In its most basic form, the paint consists of pigments and the solvents in which they are suspended. Almost all the paints used for idol painting contain Pb, as shown by Table-1.

Table-1: Chemical composition of Pb based pigments.

Pigments	Metals and Compounds with Lead
Yellow	Naples Yellow, Lead-Tin-Yellow, Chrome Yellow: Natural pigment of plumbous chromate, $PbCrO_4$
Red	Red Lead, Lead tetra oxide, Pb_3O_4
Orange	Chrome Orange is a naturally occurring pigment mixture composed of lead (II) chromate and lead(II) oxide, $PbCrO_4 + PbO$
White	Cremnitz white, basic plumbous carbonate, $(PbCO_3)_2\,Pb(OH)_2$

Yellow, red, orange and white pigments contain the most amount of Pb and are very toxic even in very small quantity in humans. This can enter the human system, through food chain, and bioaccumulate and biomagnify. Fish makes up a major source of non-vegetarian protein in the Indian, specially Bengali diet. This is an organism of high tropic level which is a significant indicator of Pb content of the aquatic system[1]. Significant positive correlations have been observed by Farkas et al, between levels of heavy metals in aquatic systems and its accumulation in different organisms[2].

In the present investigation, the water quality of Ganga river and Immersion pond in New Town, Kolkata was measured during Pre-immersion, Immersion and Post-immersion phases. Also an attempt has been made to focus on the risk assessment of the health effects on fish consumption from these areas.

Materials and methods

For this study, a total of 78 samples of Tilapia fish (*Oreochromis mossambicus*) were collected randomly from the sampling site between July 2016 to November 2016. The water samples too were collected from surface layer during that time.

Study site: It was conducted in immersion pond of New Town, Kolkata, India. The catchment area is about 0.40 sq Km. It is used for irrigation purposes and commercialized fishing. Also, water samples were collected from Babughat, Ganga river bank, which is an important idol immersion site in Kolkata, India.

Sample collection: Water samples and fish samples were collected from the New Town pond. The samples were collected one month prior to immersion activities (Pre-immersion samples), during idol immersion (Immersion phase samples) and one month after the activities were over (Post-immersion samples). Water samples were taken in sterilized, acid washed polyethylene sample bottles, below 10-20 cm of the surface of water from the study site during early morning hours for analysis. Fishes were taken using a drag net. Their total length and weight were measured, dissected to separate the organs and were placed on ice immediately for transportation to the laboratory. In the laboratory they were kept at -20^{o}C until they could be prepared for digestion and analysis.

The water samples collected were preserved by adding 5 ml of 1N HNO_3 and adjusting pH to 4.0. The samples were analysed at the site itself for pH using Systronics digital pH meter No 335 and for turbidity using Turbidity meter and Electrical conductivity by Conductivity meter no EC304.

Pb analysis of water and fish samples: The water samples collected were preserved by adding 5 ml of 1N HNO_3 and adjusting the pH to 4.0 and were analysed for Pb using a Flame Atomic Absorption Spectrophotometer (Perkin Elmar; 2130 AAS). All samples were collected and analysed in triplicate. The water samples were analysed according to the standard methods prescribed by American Public health Association (APHA)[3].

The dissected fish samples were thawed, cleaned and washed with de-ionised water. They were oven dried at 80^{o}C in acid wash petridishes up to a constant weight. Fish samples were kept in desiccators for cooling and then homogenized by grinding to a fine powder with mortar and pestle. Moisture content of individual fish samples were calculated, 0.5 gm of the powder sample was processed in duplicate and then digested using close vessel microwave digestion. Fish samples were digested in HNO_3 and are subjected to 4 steps of microwave digestion program[4]. The program is described in Table-2.

Table-2: Microwave digestion program used for Fish.

Steps	Temperature	Time	Power
1	25-96^{o}C	20 min	1000W
2	96^{o}C (Hold)	30 min	1000W
3	180^{o}C	10 min	1000W
4	180^{o}C (Hold)	10min	1000W

After digestion, 2 ml of 30% hydrogen peroxide (H_2O_2) were added to the digest to reduce the vapors of HNO_3 and to accelerate the organic substance assimilation by increasing the temperature[5]. The samples were diluted with 50ml de-ionised water in acid washed standard flasks and each sample was filtered through a 0.45µm Whatmann paper. After filtration, digested samples were analysed by AAS in a Flame Photometer. The operational parameter settings of Perkin Elmar 2130 AAS are shown in Table-3.

The Pb concentrations of the samples were read against appropriate blank and standard solutions with an oxy-acetylene N_2O acetylene flame. Nitrogen is used as a carrier gas and the hollow cathode tube of Pb was employed as a radiation source. Appropriate controls, standards and calibration curves were prepared; samples tested in duplicate and read in triplicate. The samples were blank corrected and concentration of Pb expressed as mg/Kg dry weight for fish and mg/L for water.

Table-3: Instrumental conditions for Perkin Elmar 2130 AAS for Pb Analysis.

Element	Current (mA)	Slit width (nm)	γ Max (nm)	Flame color	Flame type	AAS technique
Lead	10	1	217	Blue	Air/C_2H_2	Flame

Quality control: The analytical quality control included analysis of standard and triplicate analysis of samples and blanks. The accuracy of the analytical techniques were evaluated by analyzing a certified standard reference material SRM 1634B for trace element in water and SRM 1577B for trace elements in fish, from National Institute of Standard and Technology (NIST, USA). All tests were done using Inter laboratory quality control materials of Centre of Disease control and Prevention (CDC, USA). The observed levels of Pb were compared with WHO, BIS, ICMR, and ISO 15000:1991 desirable limits, for getting actual contamination impact on desired area[6].

Statistical analysis: Statistical significance was assayed with student's t test and results were deemed significant when $p<0.005$. The analysis was done using SAS software[7].

Ethical issues: The study was in accordance with Declaration of Helsinki[8] and guidelines on good clinical practice locally available. It was also approved by institutional review board and ethics committee.

Results and discussion

The observation was focused on assessment of physic-chemical characteristics of the flowing Ganga river water and artificial immersion pond. The results of the analysis are shown in Table-4. The study reveals the negative impact of idol immersion activity on quality of water, and it shows that the static artificial pond is more affected by such than the flowing Ganga river.

The fluctuation in temperature of river water usually depends on the season, geographic location, sampling time and temperature of effluents entering the stream[9]. Temperature in Ganga water was seen to be rising suddenly for about 3°C during immersion time, and subside to normal after a period of time. But that of the immersion pond was seen to rise about 5.7°C during the same activity, which is higher when compared to the Ganga river. This rise in temperature might be due to the aerobic and anaerobic biological reactions produced by the chemical paints. This enhances solubility of other chemical products and act as a vicious cycle[10]. This significant increase in temperature during the immersion period affects the aquatic life. The fishes fail to reproduce properly at higher temperature artificially created by manmade chemical activities[11]. This increase in temperature also reduces the solubility of gases in water. If water is too warm, there may not be enough oxygen in it for aquatic life.

Among chemical properties of water, pH is an important factor that determines the suitability of water for domestic purposes, and any alteration of such may be toxic for flora and fauna[12]. Ecosystems are sensitive to changes in pH and most heavy metals become more soluble in water as the pH decreases. H^+ or H_3O^+ ions occupy more adsorption sites at lower pH values, which result in soluble and carbonate bound heavy metals precipitated more easily than at higher pH values. During the immersion activities the pH of both Ganga river and immersion pond turned slightly acidic, with ranges varying from 8.45 to 6.81 in Ganga and 8.31 to 5.91 in the immersion pond. This results in faster heavy metal release rate.

When temperature increases along with decreased pH, as found in the present study, leaching effect of water increases and also aquatic life gets adversely affected[13].

Conductivity increases with the increase of cation or anion in water. In the present study, electrical conductivity value was found to be higher in the immersion pond as compared to the Ganga. Electrical conductivity has direct correlation with increase in microbial metabolic activities in the stagnant water condition, with more toxic effects than the flowing water conditions and more production of harmful gases. Common ions in water that conduct electrical current include sodium, calcium, magnesium and chloride. Since dissolved salts and other organic chemicals conduct electrical current, conductivity increases as salinity increases. Aquatic flora and fauna are adapted to a certain range of salinity, outside which they may perish. Apart from its biological effects salinity can also affect water chemistry and density[14].

Table-4: Physio-chemical results of surface water samples in Immersion sites of Ganga river and immersion pond.

Parameters (with units)	Results						ICMR and BIS standard for maximum permissible limit ISO 10500:1991	WHO permissible limit
	Pre immersion		Immersion		Post immersion			
	Ganga	Pond	Ganga	Pond	Ganga	Pond		
Temperature (°C)	25.6 ± 0.3	24.9 ± 0.4	28.7 ± 0.2	30.6 ± 0.4	26.8 ± 0.3	26.9 ± 0.5		
pH	8.45 ± 0.12	8.31 ± 0.16	6.81 ± 0.13	5.91 ± 0.19	8.21 ± 0.16	7.10 ± 0.32	6.5 – 8.5	7.0 – 8.5
Electrical conductivity (µs/cm at 25°C)	502 ± 7.0	516 ± 9.0	936 ± 5.0	1106 ± 9.0	496 ± 5.0	556 ± 4.0	250 – 750	<=750
Turbidity (NTU)	9.2 ± 0.2	9.9 ± 0.3	13.2 ± 0.5	20.6 ± 0.3	10.4 ± 0.1	15.2 ± 0.4	5 – 10	5 – 10
Lead (Pb) (mg/L)	0.49 ± 0.12	0.92 ± 0.06	1.85 ± 0.07	1.92 ± 0.32	0.82 ± 0.21	0.91 ± 0.09	0.05	0.05

Values represent Mean ± SD.

The presence of suspended solids in water transparency is an important index of eutrophication. Turbidity ranges within permissible limits in pre-immersion phase, but deteriorates during both immersion and post-immersion phases. The maximum turbidity was observed in surface water in both the study sites during immersion phase, when huge quantity of both inorganic and organic material was added to both the sites. It has been observed that 5 NTU increase in turbidity in a clear stream 0.5m deep may reduce photosynthesis by aquatic plants by 13% or more[15].

It was observed that the surface turbidity of the immersion pond in New Town, Kolkata are turned the water almost mud grey during and after a few days of idol immersion. Similar impacts have been seen in the twin lakes of Bhopal during festivals[16].

The concentration of Pb in water samples of Ganga river and immersion pond were significantly raised during the Immersion phase to the level of 1.85±0.07 mg/L and 1.92±0.32 mg/L respectively from 0.49±0.12 mg/L and 0.92±0.06 mg/L in the Pre-immersion period. They are significantly high when compared to the highest desirable limits set by ICMR and BIS standard. This is due to the Pb present in the chemical paints in the idols. Also, solvents are used in most paints including many water based paints as well, which dissolve in water and settle down to form sediments and contaminate the water body over a long period of time. These non biodegradable substances accumulate and get biomagnified along the food chain and are neuro and nephrotoxic, as well as carcinogenic[17].

The color pigments which get dissolved in water affect the metabolism of the freshwater fauna[18]. The effects of Pb carrying paints is less pronounced in the Ganga than the immersion pond because of the constant flow of water across the river, but still the toxicity levels are well above the permissible limit. Through the food chain these toxic metals enter human bodies and also contaminate ground water through percolation, particularly noticeable along the Ganga riverbanks due to the sand content in its soil. This causes a lot of adverse effect on underground water quality as well.

Pb toxicity in humans, from all these sources mentioned, has quite a few clinical manifestations. It causes irritability, neurological symptoms, insomnia, attention-deficit disorder and cognitive problems[19].

Tilapia fish (*Oreochromis mosambicus*) samples of immersion pond were analysed for the concentration of Pb. It was seen to have increased noticeably in the post-immersion phase. The biometrics of Tilapia fish are described in Table-5.

The extracted Pb from various organs of fish are presented in Table-6.

The amount of Pb in the organs of Tilapia fish were seen to exceed the standard prescribed by FAO[20]. Concentration of Pb in flesh was compared with permissible levels of FAO/WHO[21]. However, they were found to be below detection limits in all the stages.

Table-5: Biometrics of Tilapia fish (*Oreochromis mosambicus)* present in Immersion pond of New Town, Kolkata, India.

Measurement	Pre-immersion	Immersion	Post-immersion
Colour	Light pink	Blue black	Grayish black
Wet weight (in Gm)	339 ± 21	372 ± 34	310 ± 19
Length (in mm)	249 ± 16	232 ± 19	228 ± 12

Values represent Mean ± SD.

Table-6: Concentration of Pb in µg/gm of dry weight of fish organs.

Time period	Liver	Kidney	Gills	Muscle/ Flesh	FAO
Pre-immersion	1.46 ± 0.02	1.51 ± 0.03	1.01 ± 0.01	BDL	0.2
Immersion	1.49 ± 0.10	1.49 ± 0.12	1.10 ± 0.02	BDL	
Post-immersion	2.16 ± 0.02	1.92 ± 0.13	1.39 ± 0.02	BDL	

BDL- below detection limit; Values represent Mean ± SD.

The concentration of Pb absorbed by liver and kidney is very high during immersion and post-immersion activities. The order of absorption of Pb by fish organs is as follows: Liver>Kidney>Gills.

Since liver plays an important role in detoxification processes, the elimination of Pb through it might be the cause of its high concentrations in the organ. Similar mechanisms may explain the high amount of Pb in kidney. These elevated levels reflect the elevated level of Pb in water. Gill covers more than 50% surface area of fish, and its external locations render it most vulnerable to direct contact with polluted water. The mucus layer covering the organs absorb Pb from the surrounding water.

Conclusion

The change of water quality due to immersion of idols was identified in both the Ganga river and the immersion pond in New Town, Kolkata, in the present study. Also, this study indicates that the pollution load in the immersion pond has increased significantly after idol immersion, contaminating the Tilapia fish (*Oreochromis mosambicus*) population, disturbing the aquatic ecosystem and contaminating the food chain which carries the toxic heavy metal from lower to higher tropic levels. Proper education and motivation seems to be the order of the day, as far as possible, regarding limiting the Ganga river and New Town pond in Kolkata, India for use of immersion purposes.

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