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Research Article

Water quality and the fate of aquatic life in Torsa river, North Bengal, India: an analytical study

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ABSTRACT

Objective: Rivers that play an important role in sustenance of aquatic lifeline are getting polluted by rapid urbanisation and industrialization, impacting the state of health in fishes. Heavy metal, like lead (Pb) contamination from industrial effluent and pesticides may have distressing effects on the ecological balance. Though water has some self-purification capacity, the toxic load is simply too high for it. Torsa river in North Bengal is an International river flowing through China, Bhutan, India and Bangladesh. It is very important to check the health of it's aquatic life, from the perspective of knowledge about biodiversity, because this river traverses a vast territory through different countries, and is home to various types of Boroli fish consumed by locals.

Methods: Water samples collected from 6 different sites, in acid washed sterile polythene bottles, in the early morning hours, were tested en-site for pH, turbidity and electrical conductivity by respective instruments. Pb was measured in both water and Boroli fish found in Torsa river through Atomic Absorption Spectrophotometry in flame photometer; water sample in triplicate and fish sample in duplicate through 4 step microwave dry digestion process using nitric acid.

Results: The concentration of Pb in Torsa river water samples at different sites was found to be significantly high than the highest desirable limits. Temperature, electrical conductivity & turbidity of the water was found to be significantly high as well, along with decreased pH. The concentration of Pb absorbed by liver and kidney of Boroli fish was found to be very high, though that in the flesh was found to be below detection limits.

Conclusions: The state of health of water and fish found in Torsa are in need of improvement before it can be totally safe for human consumption and usage. The very high heavy metal load is not only harmful for humans, but also poses a serious threat to the ecological balance of the aquatic life.

Keywords: Lead, pH, Turbidity, Elcetrical conductivity, Atomic absorption spectrophotometry

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Introduction

River plays an important role in the development of a country and sustenance of lifeline for all living organisms. In present times, however, they are getting polluted by rapid urbanisation and industrialisation. Mostly river water is used for drinking water supply and agriculture purposes. According to United Nation reports India is expected to face critical levels of water crisis by 2025 and there will be serious water shortages.[1] The aquatic environment is considered one of the main factors controlling the state of health and disease in fishes. Heavy metal, like lead (Pb) contamination particularly the non-essential elements may have distressing effects on the ecological balance of the recipient aquatic environment with a diverse of organisms including fish.[2] River water though has some self purification capacity, but for most industrial effluent from dye, pigments, paper and pulp, pharmaceuticals, food processing, leather, battery industries, etc. and also pesticides residue from agriculture discharged, are beyond that purifying capacity. The combined effect of all these might be the reason of frequent fish death and depletion of aquatic ecosystems. Also, this can enter the human system, through food chain and bio accumulate and bio magnify. Fish makes up a major source of non vegetarian protein in Indian, specially Bengali diet.[2] This is an organism of high tropic level which is a significant indicator of Pb content of the aquatic system.[3]

The river Torsa in Cooch Behar district, India is notorious for flooding and unpredictable behaviour. However, the problem starts only when it enters the sub Himalayan region. The Torsa river originates from the Chumbi Vally in Tibet, China, known as Machu; it flows into Bhutan, named Amo Chu. After crossing Bhutan it enters into India at Jaigaon, Alipurduar district, West Bengal, India known as Torsa river. In Terai, West Bengal, India after crossing numbers of tea gardens, Jaldapara National Park and plains of Cooch Behar, Tufangunj it enters into Bangladesh at Balabhut region, which is the junction point of West Bengal and Assam in India and Bangladesh. Torsa river is an International river and it has total length of 358 km, out of which 113 km in China, 145 km in Bhutan, 45.06 km of rivers flows in India and rest in Bangladesh. It is very important to check its aquatic life's health from the perspective of knowledge about biodiversity, because this river crosses various types of topographical regions.

The river channel is this region is wide and shallow and the slope is flat, making the river a major route for drainage system in the sub Himalayan areas. Because of this fact, there might have been a decline in abundance and distribution of Boroli fish (*Aspidoparia jaya and Cabdio morar).*[4]

The objectives of this study are

- The interpretation of the impact of pollution on surface water quality of Torsa river in Cooch Behar, India.
- Find out the suitability of Torsa river water for fisheries.
- To evaluate the health risk of Boroli fish collected from the Torsa river on people consuming them.

Materials and Methods

For this study, a total of 46 samples of Boroli fish were collected randomly from the sampling site between November 2017 to April 2018. The water samples too were collected from below 10 – 20 cm of surface layer during that time in six different location. Location of the water collection spots of Torsa river were depicted in Table 1; along with satellite photograph of water collection spot location in Figure 1.

Study site and sample collection

The six sampling sites were selected according to the flow of water and discharge of industrial and domestic waste in Torsa river. Site 1 is a random freshwater site, site 2 has a farmers' market and watermelon plantation site, site 3 is an agricultural land where chemical pesticides are used, site 4 has the Tufanganj town waste dumping site, site 5 is a major waste dumping site with industrial, municipal and agricultural waste load, and site 6 is at the junction point with Assam and Bangladesh. Water samples were taken in sterilised acid washed polyethylene sample bottles, below 10–20 cm of the surface of water from sites during early morning hours for the 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^{0}C until they could be prepared for digestion and analysis.

Table 1: Location of the water collection spots of Torsa river flowing through Cooch Behar, West Bengal, India.

S No.	Name of the Spot	GPS Readings	AMSL (ft)	Location of Survey Spot		
				Block	**Gram panchayat**	**Village**
1	Shiltorsa	26°30'05"N & 89°19'33"E	184	Alipurduar I	Patlakhawa	Sahebpota
2	Pundibari	26°25'04"N & 89°20'05"E	164	Cooch Behar II	Pundibari	Sajer Par Ghoramara
3	Takagach	26°19'58"N & 89°24'55"E	143	Cooch Behar II	Pundibari	Kamini Ghat
4	Ghugumari	26°17'16"N & 89°27'42"E	122	Cooch Behar I	Ghugumari	Ghugumari
5	Balarampur	26°15'05"N & 89°36'38"E	107	Tufanganj I	Balarampur	Balarampur
6	Balabhut	26°12'22"N & 89°42'02"E	94	Tufanganj II	Balabhut	Balabhut

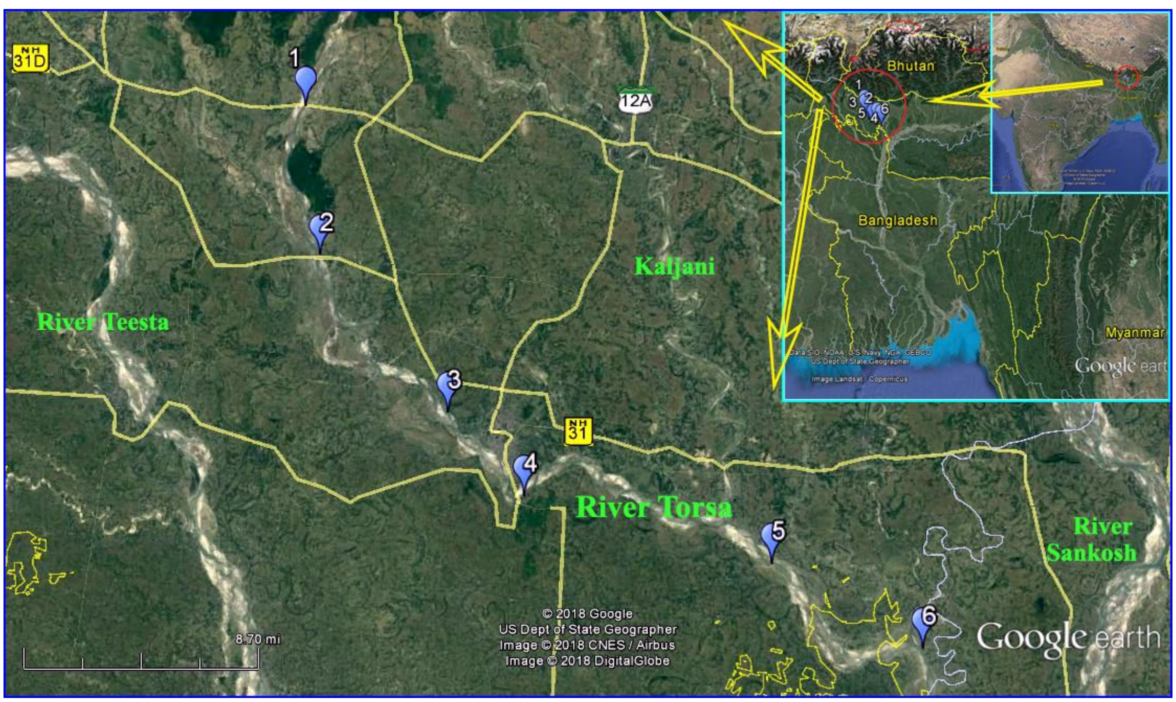

Figure 1: Location of the water collection spots of Torsa river flowing through Cooch Behar, West Bengal of India (Courtesy: Google earth surfed on 01/04/2018 at 9:50 am).

Table 2: Microwave digestion programme used for Boroli fish.

Steps	Temperature (in ^{0}C)	Time (in minute)	Power (in Watt)
1	25^{0}C – 96^{0}C	20 min	1000 W
2	96^{0}C (Hold)	30 min	1000 W
3	180^{0}C	10 min	1000 W
4	180^{0}C (Hold)	10 min	1000 W

Table 3: Instrumental conditions for Perkin Elmer 2130 AAS for Pb analysis.

Element	Current (in mA)	Slit width (in nm)	λ_{Max} (in nm)	Flame colour	Flame type	AAS technique
Lead (Pb)	10 mA	1 nm	217 nm	Blue	Air / C_2H_2	Flame

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 EC 304**.**

Pb analysis for of water and fish samples

The water samples collected were analysed for Pb using a flame atomic absorption spectrophotometer (Perkin Elmer 2130 AAS). All samples were collected and analysed in triplicate. The water samples were analysed according to the standard methods prescribe by American Public Health Association (APHA).[5]

The dissected Boroli fish samples were thawed, cleaned and washed with de-ionised water. They were oven dried at 80^{0}C in acid wash petridish up to a consistent weight. Boroli fish samples were kept in desiccators for cooling and then homogenised 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 programme.[6] The programme is shown in Table 2.

After digestion 2 ml of 30% hydrogen peroxide (H_2O_2) were added to the digest to reduce the vapours of HNO_3 and to accelerate the organic substance assimilation by increasing the temperature.[7] The samples were diluted with 50 ml de-ionised water in acid washed standard flasks and each sample was filtered through a 0.45 µm Whatmann paper. After filtration digested samples were analysed by AAS in a Flame photometer. The operational parameter settings of Perkin Elmer 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 control, standards and calibration curves were prepared: samples tested in duplicate and read in triplicate. The samples were blank corrected and concentration of Pb exposed as mg/kg dry weight for fish and mg/L for water.

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 analysing a certified standard reference material SRM 1634 B for trace elements in water and SRM 1577 B for trace elements in fish from National Institute of Standard 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.[8]

Statistical analysis

The statistical analysis was done using SAS software.[9] All the samples were measured in triplicate and the mean and standard deviation determined. They were compared against WHO, ICMR and BIS standard for maximum permissible limits for the specific parameters of physical and chemical properties of water. The fish sample was also studied in triplicate and lead levels in different organs were compared with the WHO maximum permissible unit.

Ethical issues

The study was in accordance with Declaration of Helsinki and guidelines on good clinical practice locally available.[10] It was also approved by institutional review board and ethics committee.

Results and Discussion

The observation was focussed an assessment of physico-chemical characteristics of the flowing Torsa river water. The results of the analysis are shown in Table 4.

The fluctuation in temperature of river water depends on the season, geographical location, sampling time and temperature of effluents entering the system.[11] Temperature in Torsa river water was seen to be varying for about 6^0C in between different location, and subside to normal before and after the town drainage area. The Tufanganj town waste site showed the highest temperature in our study. This rise in temperature in town area might be due to the aerobic and anaerobic biological reactions produced by the chemical and domestic sewages influence. The fishes fail to reproduce probably at higher temperature artificially created by manmade effluents.[12] This increase in temperature also reduces the solubility of gases in water. If water is two warm, there may not be enough oxygen in it for aquatic life.

The pH is an important factor that determines the suitability of water for domestic and agriculture purposes and any alteration of such may be toxic for flora and fauna.[13] 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 precipitating more easily than at higher pH values. Due to the waste disposal in Torsa river water turned slightly acidic, with ranges varying from 5.87 to 7.64, mostly in the Tufanganj area due to an entire town’s waste disposal, resulting in faster the 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.[14]

In the present study, electrical conductivity value of three different locations were found to be higher as compared to the permissible limits, with the agricultural land using chemical pesticcides having the highest conductivity, closely followed by the watermelon plantation site and the Tufanganj drainage site. There might be indications that chemical pesticides produce some effect on the salinity of freshwater. 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. Ions in water conduct electrical current. Conductivity increases as salinity increases. Aquatic flora and fauna are adapted to a certain range of salinity, subside which they may perish. Apart from its biological effects salinity can also affect water chemistry and density.[15]

The presence of suspended solids in water transparency is an important index of eutrophication. Turbidity ranges are determined in few collection sites. It has been observed that 5 NTU increase in turbidity in a clear steam 0.5 m deep may reduce photosynthesis by aquatic plants by 13% or more.[16] The present study found highest turbidity in the water draining the Tufanganj area, as it is a major dumping site for all kinds of waste products. This was closely followed by the industrial and agricultural waste dumping site.

Table 4: Physico-chemical results of surface water samples of Torsa river water in different study areas.

Locations	Parameters with units				
	Temperature (in ^{0}C)	pH	Electrical conductivity (in µs/cm at 25^{0}C)	Turbidity (in NTU)	Lead (Pb) (in mg/L)
Shiltorsa	25.5±0.3	7.41±0.02	502±6.9	7.6±0.2	0.49±0.14
Pundibari	27.6±0.2	6.73±0.13	939±4.8	12.5±0.5	0.96±0.05
Takagach	28.9±0.4	6.49±0.03	1105±1.8	14.8±0.4	1.01±0.32
Ghugumari	30.5±0.3	5.87±0.12	1059±8.2	19.7±0.8	2.69±0.82
Balarampur	26.8±0.4	7.64±0.41	702±9.1	16.7±0.3	1.90±0.31
Balabhut	24.6±0.3	7.52±0.32	592±5.6	11.3±0.7	1.82±0.42
WHO, ICMR and BIS standard for maximum permissible limit as per ISO 10500: 1991		7.0 – 8.5	250 - 750	5 - 10	Less than 0.05

Values represent Mean±SD.

Table 5: Concentration of Pb in µg/gm of dry weight of Boroli fish organs.

Time period	Liver	Kidney	Gills	Muscle/ flesh	FAO/ WHO
November 2017 to April 2018	1.98±0.03	1.63±0.14	1.32±0.04	BDL	0.2

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

The concentration of Pb in Torsa river water samples at different sites was found to be in the range of 0.5 to 2.7 mg/L, which are significantly high when compare to the highest desirable limits set by ICMR, BIS and WHO standard. Again, the Tufanganj drainage area showed the highest amount of Pb in the river water, followed closely by the major waste dumping site. Lead arsenate is used as a pesticide and lead borate finds in industrial waste from printing dyeing and oil refineries, etc. The Torsa river water may be polluted by Pb due to the direct discharge of municipal effluents into the river. Non-biodegradable substance, like Pb accumulate and get biomagnified along the food chain and are neuro- and nephrotoxic, as well as carcinogenic and its affect the metabolism of the fresh water fauna.[2]

Pb toxicity in human, from all these sources mention, has quite a few clinical manifestation. It causes irritability, neurological symptoms, insomnia, attention-deficit disorder and cognitive problems.[2]

Boroli fish samples were analysed for the concentration of Pb. It was seen to have increased noticeably in these stretch of Torsa river and were seen to exceed the standard prescribed by FAO and WHO.[17] The extracted Pb from various organs of Boroli fish are presented in Table 5.

The concentration of Pb absorbed by liver and kidney of Boroli fish is very high and 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.

Conclusions

The Pb levels detected in the Torsa river are higher than acceptable limit as per local and international standards. The Pb enter the environment through aquatic life systems and animals surrounding the river. The danger of bioaccumulation and biomagnifications of the Pb make them a big threat to human health and welfare. Hence, it is mandatory that steps be taken to reduce the biological and Pb based effluent load deposited into the Torsa river, before making it a suitable place for development of fisheries industry.

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