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Mitigating industrial pollution in urban water bodies using African Sharptooth catfishes

Jaydev Misra[a] and Priyadarshini Mallick[b]*

[a]Department of Economics, Dhruba Chand Halder College, Dakshin Barasat-743 372, South 24-Parganas, West Bengal, India

E-mail: jaydevmisra@gmail.com

[b]Department of Microbiology, Asutosh College, Kolkata-700 026, India

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Clarias gariepinus or African Sharptooth catfish survives in minimal amount of dissolved oxygen (DO) levels in stable water aquatic systems. *Clarias gariepinus* has a gill structure which can trap oversized pollutants molecules, hold them for long and excretes out for organic wastes. The main objective of the present study was to investigate the impacts on urban water pollution before and after the application of *Clarias gariepinus* in water bodies by measuring metal concentrations in water and sediment. Results shows that concentration of more than recommended level of Cr, Cu, Zn, Fe, Pb, Cd and Ni in urban water bodies can be reduced by recruiting *Clarias gariepinus* in those water bodies.

Keywords: *Clarias gariepinus*, pollutants, metal concentration, toxic wastes, fractional distillation process, Mann-Whitney *U*-test.

Introduction

In different parts of the India, many river systems are contaminated with domestic, industrial, mining and agricultural effluents[1]. Aquatic systems, especially in West Bengal, are considered as suitable sites for disposal of and recycling the sewage and toxic wastes and the drains of the excess to the nearby larger water body. Anthropogenic enrichment of trace metals in aquatic environments has been frequently observed in urban and semi-urban areas of the state. Major sources of metals domestic effluent and urban storm water runoff are also major sources of contamination[2]. However, the increasing pollutant load and the over exploitation of the water resources for portable supplies, irrigation, industries and the thermal power plants to meet the requirements of the ever increasing population, considerably reduces their assimilative capacity. And increases the cost of treating water for human consumption.

Haldia, as our case study area, is a developing industrial township situated at the junction of rivers Hooghly and Haldi. The river Hooghly carries industrial and anthropogenic wastes from the city of Kolkata and Howrah other than that of the head water constituents. The river Haldi is relatively free from anthropogenic pollutants. Haldia is fast growing into a major industrial center of eastern India and industries like Haldia Petrochemicals; Pteriphthalic acid project of Mitsubishi Chemical Corporation; Haldia Dock Complex under Calcutta Port Trust (handles > 20 million ton of traffic including petroleum products, LPG, liquid ammonia, chemicals, coal, fertilizers, edible oils, molasses and general cargo); Exide Industries Ltd. producing automotive batteries; Shaw Wallace & Co. producing organophosphate pesticides, are doing business since long in the area. In addition, it has 118 small scale and cottage industries. These industries are releasing effluents mainly through a common canal, which joins at two points with the river Hooghly. The main junction, situated at Patikhali, is operated by a sluice gate, which partially prevents entry of tidal water. Another junction is about 2 km downstream of Patikhali and has a provision of a sluice gate but is kept closed. Other than the common canal, industrial effluents are also released partly at different locations of the river. In both the rivers Hooghly and Haldi, the existing high pH (>7.5) is precipitating the metals and protecting the water phase and secondly, the huge tidal water dilution is reducing the anthropogenic effects in the zone. In many studies, it has been found that the probable source of Pb was both the head-water constituent of rivers Hooghly-Haldi and industrial effluents of Haldia (Samanta *et al*., 2004; Choudhury *et al.*, 1999). From those studies, it appears that the alarming concentrations of Cd, Cu and Pb may be responsible for tissue manifestations due to their persistent sub lethal concentrations, which is detrimental to fish health and therby to human health though consumption of those fishes. Sediment-associated pollutants can also influence the concentrations of metals in both water column and biota if they are desorbed[3]. Sediments in Hugli and Haldi rivers, flowing adjacent to Haldia township, were reported to be important sinks for metals and organochlorine pesticides. Contaminated sediments can threaten organisms in the benthic environment[4,5] and also fish that consume them[6,7]. Mitigating those metal concentrations in water bodies and securing human health is a big question for scientists and policy planners. Against these background, present study has tried to focus, whether *Clarias gariepinus* or African Sharptooth catfish can able to absorp the present climatic conditions of Haldia township and reduce the amount of metal concentration by absorbing them.

Clarias gariepinus or African Sharptooth catfish is a species of catfish of the family clariidae (the air breathing catfishes). The native range of the African catfish covers most of the continent, it can be found in almost any habitat, but thrives in slow-flowing rivers, as well as ponds, or dams. Catfish have also been recorded in the upper reaches of estuaries. The presence of an accessory breathing organ enables this species to breath air when very active or under very dry conditions. They remain in the muddy substrates of dams and ponds and occasionally gulp air through the mouth. The African sharptooth catfish is a dominant freshwater fish that can grow up to 1.7 m long and weigh up to 60 kg, with an estimated maximum lifespan of 8 years. The sharptooth catfish is thus considered to have a rapid growth rate and,

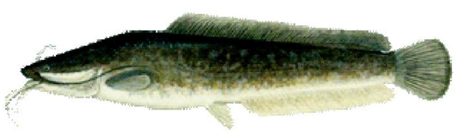

Fig. 1. *Clarias gariepinus* or African Sharptooth catfish.

depending on the ambient conditions, reach a standard length of 200 mm in just one year. This fish has four pairs of long trailing sensory organs, known as 'barbels', around its mouth which resemble a cat's whiskers, hence the name 'catfish'. These whisker-like tactile organs house the taste buds of the catfish and are used to search for food in murky water. The body of the Sharptooth catfish is elongated, with long, low dorsal and anal fins and a smoothly rounded tail fin, and the body has no scales. Care should be taken when handling the catfish as it possess a strong, hollow, bonified leading spine-like ray on its dorsal and pectoral fins. As a defence, these spines may be locked into place so that they stick outwards, which can inflict severe wounds. Colour varies dorsally from dark to light brown and is often mottled with shades of olive and grey while the underside is a pale cream to white. The small eyes of the catfish are set far forward in the flat and bony head, while at the back of the head there is a subsidiary breathing organ above the gills that allows it to take in oxygen directly from the air.

The uniqueness of this species is that it survives in minimal amount of dissolved oxygen (DO) levels in stable water aquatic systems. The presence of this particular variety in water has an adverse effect of pollutants presence since *Clarias gariepinus* has a gill structure which can trap oversized pollutants molecules, hold them for long and excreates out for organic wastes. Mostly industrial pollutants are of oversized structures which are emitted and diluted in water bodies like local ponds, rivers and its respective tributaries. According to theory, when the levels of essential metals exceed the normal metabolic requirements, they become potentially toxic to the fish itself and to organisms that consume the fish. Studies elsewhere have shown that fish accumulate and retain metals from the aquatic environment through a process dependent on exposure concentrations, duration of exposure, species, salinity and temperature.

Hence, objective of the present study was to investigate the levels of concentration of heavy metals on urban water bodies and how far *Clarias gariepinus* can reduce such concentration by their biosynthesis. Initial hypothesis of the study was that if adequate amount of *Clarias gariepinus* can be grown in still water bodies adjacent to industries, a pollution check can be set on an organic and bio compatible level.

Materials and methods:

Study area:

The industries in Haldia are releasing effluents into the water bodies mainly through a common canal, which joins at two points with the river Hooghly. The main junction, situated at Patikhali, is operated by a sluice gate, which partially prevents entry of tidal water. Another junction is about 2 km downstream of Patikhali and has a provision of a sluice gate but is kept closed. Other than the common canal, industrial effluents are also released partly at different locations of the river. To understand the present metal pollution in the zone, an experimental protocol has been performed with ten different sources of pollutants in Haldia industrial area.

Three sites were at Patikhali, Haldia, which is on the river Hooghly. One was the industrial effluent out fall (OF) point; another was 50 meter above out fall (AOF) and rest was 50 meter downstream of out fall orbelow out fall (BOF). One sampling site was about 3.5 km upstream off Patikhali, named Hooghly above industrial area (HAIA). Other three sampling sites were 12 km downstream of Patikhali: one is on the river Hooghly, one is at the confluence of rivers Hooghly and Haldi and the other one is at 1 km upstream of the confluence on the river Haldi. A total of 42 samples were collected during the sampling period of pre monsoon seasons. From HAIA and river Hooghly, 10 and 12 samples were collected respectively during October, 2017 to April, 2018. At Patikhali OF, 20 samples were collected since it was closed during other two sampling periods.

Water quality analysis and metals in water:

Water was sampled at selected sites in the wet and dry seasons on four occasions (October, December, February and April) over seven months in 2017-2018. Sampling occurred between 12:00 and 16:00 on all occasions to minimize variation due to climate factors. Water for metal analysis was collected in sterilized 250 ml polyethylene bottles, filtered through 0.45 μm Whatman GF filters and acidified with nitric acid to pH < 2. The purpose of the acidification was to reduce adsorption of metal ions onto container surfaces. Temperature, pH, conductivity and dissolved oxygen (DO) were measured in the field. Water temperature and DO were measured using a HACH oxygen 330i meter, and pH and conductivity were measured using a HACH pH meter and WTW 330i conductivity meter, respectively. Water samples were analyzed in the laboratory for total and reactive phosphorus (orthophosphate), total nitrogen, nitrate and ammonia.

Metal estimation in water was performed in the laboratory using flame atomic absorption spectrophotometry (FAAS). The acid digestion process used for both the water and sediments is a strong digestion method and was chosen so that the total metal content could be estimated. The water sample was aspirated into a flame and atomized. Quality control was assured by the use of procedural blanks and standards. In each case a known concentration of the standard solution was assayed after every 10 samples to verify the analytical quality of the result because there was no standard reference material available.

Fish sample and metal concentration in Clarias gariepinus:

African Sharptooth catfish *Clarias gariepinus* occur in the freshwater systems of Africa and India and are commonly consumed by local communities. Given the fact that many waterways are polluted, it is possible that *C. gariepinus* may accumulate metals, with subsequent deleterious effects on human health (Cooper 2008). Fish sample, for the present analysis, were collected from upper Manyame River in Zimbabwe, which has been imported by Mohunpur campus of University of Animal and Fishery Sciences (UAFS).

Fish length (standard/total), body weight (wet) and organ/tissue weight (wet and dry) were recorded. In the laboratory, fish were dissected with clean autoclaved stainless steel instruments. One gram (wet weight) of gill, liver, kidney and muscle tissue of *C. gariepinus* was measured using an electronic balance. The tissues were placed into Petri dishes to dry at 120^{o}C until they reached a constant weight. Dry gill, liver, kidney and muscle tissue were placed in digestion flasks to which 5 ml perchloric acid and 10 ml nitric acid were added. All acids used were of analytical grade quality. The digestion flasks were placed in an oven at 130^{o}C until all materials dissolved.

The principal aim of the current investigation was to determine accumulation levels of chromium (Cr), copper (Cu), lead (Pb), zinc (Zn), iron (Fe), nickel (Ni) and cadmium (Cd) in the tissues of *C. gariepinus* in relation to their concentrations in water and sediment, to facilitate the formulation of effective environmental management strategies to mitigate the industrial effluents in water bodies in Haldia.

Results and discussion

The order of concentration of metals in sample water bodies in West Bengal was Zn > Pb > Cu > Fe > Cr > Ni > Cd. There was a significant difference ($p < 0.05$; Mann-Whitney *U*-test) in the concentration of Cu and Pb in water between different water bodies. However, only the concentrations of Fe and Pb in sediments at sample water bodies had a significant difference ($p < 0.05$), with concentrations of Fe and Pb being abnormally high at Haldia.

Table 1. Actual concentration of metals in sample water bodies

Metals	Mean	SD
Cr	39	22
Cu	44	03
Zn	629	345
Fe	22	11
Pb	84	39
Cd	1.76	1.3
Ni	3.65	3.01

In the gills, Zn and Fe concentrations were higher than all the other heavy metals found in the water bodies. The highest Fe and Zn concentrations were recorded in liver tissues. As was the case with liver and gill tissues, Fe and Zn concentrations were highest in kidney tissues.

Table 2. Actual concentration of metals in *Clarias gariepinus*

Metals	Gill	Liver	Kidney	Muscels
Cr	0.41±1.3	0.39±0.89	0.51± 0.23	0.29± 0.17
Cu	0.07±0.05	0.13±0.07	0.14±0.08	0.10±0.08
Zn	2.41±0.8	5.35±2.37	2.01±0.4	2.0±0.67
Fe	2.03±0.27	1.10±0.25	1.30±0.15	1.0±0.3
Pb	0.19±0.12	0.05±0.04	0.03±0.10	0.02±0.10
Cd	0.08±0.07	0.11±0.09	0.3±0.09	0.09±0.08
Ni	0.94±0.12	0.81±0.09	0.52±0.31	0.71±0.19

It was also observed that the concentration of pollutants present in some chosen targeted organs of the fish, had ample amounts of heavy metals such as Cr, Cu, Zn, Fe, Pb, Cd and Ni.

Conclusions

It was concluded that the fish, *Clarias gariepinus* or African Sharptooth catfish, has the capability to absorb and trap considerable amount of pollution causing heavy metals in its respective organs. Thus, incorporating its growth in urban pollution affected water bodies responsible for carrying industrial affluents, would yield us the desirable benefit of reducing the amount of pollutants in the form of heavy metals in such bodies.

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