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Short Communication

Evaluation of heavy metal toxicity in water using the fishes of Vaigai River, Tamil Nadu, India

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Abstract

The Vaigai River was highly polluted by various chemicals and heavy metals due to industrial and domestic discharge. These pollutants cause serious damage to the fishes. In the fishes these pollutants gets accumulated in their liver, bone, muscles and kidney. The heavy metal toxicity of the river were analyzed by collecting the fish from various sites of the river and estimation of heavy metals like chromium, cadmium, lead and nickel were done by isolating these organs. Various physico chemical parameters and heavy metal concentration of the Vaigai River water were also analyzed. From the result it was found out that concentration of nickel, lead and chromium were higher than the permissible limit.

Keywords: Fish, nickel, zinc, lead, chromium.

Introduction

Rivers and lakes are very important part of our natural heritage but these were getting contaminated in recent times by various chemicals and pollutants from domestic and industrial sector. The use of heavy metals has been increased in the recent past and this result in an increased load of heavy metals in the aquatic ecosystem[1] and it causes damage to the aquatic life[2].

These heavy metals mostly stimulate to produce more reactive oxygen species (ROS) which causes toxic effect to the Aquatic organisms by oxidative stress. Heavy metals cause adverse effect to the human health because mostly they are carcinogenic[3].

The most important contributor in the food chain of the aquatic ecosystem were fishes and these fishes can accumulate the heavy metals[4,5] through ingestion of heavy metal contaminated food materials, certain dissolved heavy metals can penetrate the gills through liphophilic membrane and some of the heavy metals can be deposited on the tissues.

Various studies revealed that fishes are bioaccumulative in nature so that fishes can accumulate heavy metals from the aquatic environment and it is depend upon the exposure time and concentration and it also depends upon various factors like salinity, alkalinity, temperature, metabolism rate of the fish[6-9].

The increased usage of heavy metals which causes pollution in the aquatic environment and this makes the fishes to deplete and it leads to the reduced nutrient flow[10], due to this most of the endemic fish communities were threatened to be extinct.

Certain heavy metals like Mercury (Hg) and Lead (Pb) are toxic and they are dangerous even when they are present in low concentrations and these can cause certain dreadful diseases like cancer.

Materials and methods

Study site: The River Vaigai which is present in Madurai, Tamil Nadu of southern India. It originates from the Periyar Plateau of the Western Ghats and flows northeast through the Kambam Valley, which lies between the Palani Hills to the north and the Varushanad Hills to the south. Vaigai river water is highly polluted by different industrial discharge and domestic discharging near Thiruppovanam region that is in Madurai city region.

Collection of samples: Water sample were collected in 4 sites of the Vaigai River during the whole study period. Various Physico-chemical parameters of River water were analyzed through the methods described by APHA[11]. Iron (Fe), from Zinc (Zn), Lead (Pb), Nickel (Ni) and Chromium (Cr) concentration in water were estimated through Atomic Absorption Spectrophotometer.

Collection and Estimation heavy metals in fish sample: Fishes like *Catla (Catla catla)* and Tilapia (*Oreochromis mossambicus)* were collected from the study sites on monthly basis. Various organs of fish like muscles, liver, gills and kidney were taken from the sampled fish and metal toxicity was analyzed. Heavy metals estimation was done in atomic absorption spectrophotometer (AAS) Model Elico SL-173.

Statistical analysis of Data: Data will be statistically analyzed by following the software PAST[12].

Results and discussion

Heavy metals analysis in Vaigai water: Tables 1-5 shows mean concentrations of Iron, Zinc, Lead, Nickel and Chromium in the water collected from four sites of sampling stations.

Iron: Mean concentration of iron in Vaigai River water varies between a maximum 11.50 ± 10.04mg/l and minimum 5.63 ± 3.31mg/l at site I and site IV respectively (Table-1). Toxic doses of iron may cause depression, coma, respiratory failure and cardiac arrest. In comparison with World Health Organisation (WHO) guidelines iron concentration is very high in our study.

Table-1: Mean Iron concentration in water in various sampling stations

Site	Mean Iron concentration (mg/l)
I	11.5±0 ± 10.04
II	8.11 ± 6.55
III	7.22 ± 3.12
IV	5.63 ± 3.31

Zinc: Zinc concentration of Vaigai River water varies between a maximum 2.66 ± 0.86mg/l and minimum 2.52 ± 0.53mg/l at site I and site II respectively (Table-2). The values Zn in all the sites were slightly lesser than the acceptable limit of 5mg/l by WHO, 2004.

Table-2: Mean Zinc concentration in water in various sampling stations.

Site	Mean Zinc concentration (mg/l)
I	2.66 ± 0.86
II	2.52 ± 0.53
III	2.32 ± 0.81
IV	2.01 ± 0.63

Lead: Lead and their compound are toxic in nature. Lead salts which come under water hazard class 2 so they are considered as harmful. Lead concentration of Vaigai river water varies between a maximum 2.06 ± 0.52mg/l and minimum 0.31 mg/l from site I and site IV respectively (Table-3). Lead concentration was very high in Site I and Site II, lower in Sites III and IV than the permissible limit range (0.01mg/l) given by WHO, 2004.

Table-3: Mean Lead concentration in water in various sampling stations.

Site	Mean Lead concentration (mg/l)
I	2.06 ± 0.52
II	1.23 ± 0.55
III	0.42 ± 0.10
IV	0.31 ± 0.11

Nickel: Mean nickel concentration in the River water was higher of about 2.23 ± 0.63 at site I, followed by that of 2.11 ± 0.52, 2.04 ± 0.51, 1.57 ± 0.321mg/l at site II, site III and site IV respectively. Site IV had the lowest nickel concentration. Among the four stations, site I exhibited significantly higher nickel contamination than rest of the three sampling stations (Table-4) even though in all sites the nickel concentration is below the permissible limit (3mg/l).

Table-4: Mean Nickel concentration in water in various sampling stations.

Site	Mean Nickel concentration (mg/l)
I	2.23 ± 0.63
II	2.11 ± 0.52
III	2.04 ± 0.51
IV	1.57 ± 0.32

Chromium: Chromium concentration in all four sampling sites showed significantly fluctuated with the mean highest chromium contamination level of 0.67 ±0.07mg/l at site I and mean lowest concentration were found from the Site II (0.031 ±0.04) (Table-5). The permissible limit range for chromium is 0.05mg/l. All the sites except Site III show high concentration of chromium.

Table-5: Mean Chromium concentration in water in various sampling stations.

Site	Mean Cr concentration (mg/l)
I	0.67 ± 0.07
II	0.37 ± 0.05
III	0.031 ± 0.04
IV	0.28 ± 0.03

Table-6: Physicochemical parameters measured in sampling sites.

Site	Dissolved oxygen (mg/l)	pH	Electric conductivity (S/m)	Total hardness (mg/l)	Magnesium (mg/l)
I	0.61 ± 1.02	6.35 ±0.22	11.50 ± 10.04	1173.42 ±22.35	264.73 ± 56.85
II	5.56 ± 2.32	7.42 ± 0.17	8.11 ± 6.55	150.72 ±33.62	113.53±142.31
III	1.73 ± 3.30	7.32 ± 0.55	7.22 ± 3.12	472.32 ±44.32	75.61 ±64.55
IV	2.05 ± 1.67	7.11 ± 1.67	8.32 ± 3.22	975.32 ± 545.32	253.45±56.85

Physiochemical parameters measured in sampling sites: Dissolved oxygen: Physico-chemical parameters observed in study sites were listed in Table-6. River showed significant variations in dissolved oxygen content with the mean highest content of 5.56 ± 2.32 at site II and lowest value (0.61± 1.02 mg/l) observed at site I. Dissolved oxygen concentrations between 6.5-8mg/l are normally considered to be healthy. In the present result all sites except Site II have low DO.

pH: The pH value of the River Vaigai is between 6.35 ± 0.22 and 7.42 ± 0.17. Highest pH values 7.42 ±0.17 was recorded from site II whereas lowest pH value 6.35 ±0.22 was recorded from sampling site I. low pH may occur due to the acidic contaminants from the domestic sewage water, electroplating units, industrial effluents, and agricultural wastes.

Electric conductivity: The electric conductivity of River water varies between a maximum of 11.50 ± 10.04S/m at site I and minimum of 7.22 ± 3.12S/m in site III. Healthy water normally ranges from 0.001 to 0.1S/m. So these values show that all the study sites were polluted.

Total Hardness: In our study, total hardness of the River water ranges from 150.72 ± 33.62mg/l to 1173.42 ± 22.35mg/l at site II and site I respectively. Presence of increased amount of calcium and magnesium salts which leads to high hardness value. The increase in water hardness can causes decreased water volume and it makes increased evaporation rate at high temperature. Normally more than 180mg/l of calcium carbonate when present in the water it is considered to be very hard. As per this guideline all the sites except site II were very hard.

Magnesium: The Magnesium level was lowest in Site III (75.61 ±64.55mg/l) and highest in Site I (264.73±56.85mg/l). Natural magnesium arises from the rocks and artificially some industries add magnesium to various materials like plastics and it is also present in the cattle feed and chemical fertilizers. The drinking water magnesium range is 30mg/l and permissible limit range is 100mg/l. The higher values of magnesium were observed at sites I, II and IV.

Heavy metal contamination in fishes: Results of heavy metals present in different parts of *Catla catla* and Tilapia were presented in Figures 1-16.

Heavy metals in muscle: The result shows that in all four sites Lead concentration was found to be high (Figure-1, 5, 9, 13). In sites I, II and IV Tilapia shows high concentration of Pb, Cr, Cd and Ni in muscles than *Catla catla*. Next to Lead, Cadmium shows high level in three sites (Sites I, II and IV). Chromium comes third in position in three sites (Sites I, II and IV). Nickel concentration is comparatively lesser than other metals. In Site III *Catla catla* shows higher concentration of Pb and Cr.

Heavy metals in Gills: As per the results of present study, heavy metal concentration in fish gills shows Cadmium accumulation was high (Figure-2, 6, 10, 14) in maximum sites (Sites I, II and III). It was followed by Lead (in all sites) and its concentration was high in *Catla catla* than Tilapia. Chromium got third position and Nickel occupied last place. Tilapia had high concentration of Chromium in gills. In all the sites *Catla catla* accumulates more Nickel than Tilapia.

Heavy metals in Kidney: Lead (Sites I and III) and Nickel (Sites II and IV) concentration was found to be high (Figure-3, 7, 11, 15) in the study sites followed by lead, Cadmium and Chromium. *Catla catla* had high concentration of heavy metals in kidney than Tilapia.

Heavy metals in Liver: In Liver, Cadmium concentration was found to be high (Figure-4, 8, 12, 16) in three sites followed by lead, Nickel and Chromium. *Catla* catla had more concentration of metals than Tilapia.

The Order of heavy metal concentration in the Muscles were found to be Pb>Cd >Cr>Ni, in gills it was found as Cd>Pb>Cr >Ni, in kidney it is in the order of Pb>Ni>Cd>Cr and in the liver it is found to be Cd>Pb>Ni>Cr. *Catla catla*, accumulates metals more in kidney and liver region whereas Tilapia accumulates heavy metals in muscle and gills.

Conclusion

Due to anthropogenic activities more amount of threatful nondegaradable bioaccumulative heavy metal pollutants were produced. These metals pass to the humans from the bio accumulative fishes through the food chain and it causes severe adverse health hazards to both humans and fishes. Regular monitoring of heavy metals has to be done in both water and from the fishes to ensure safety among the people.

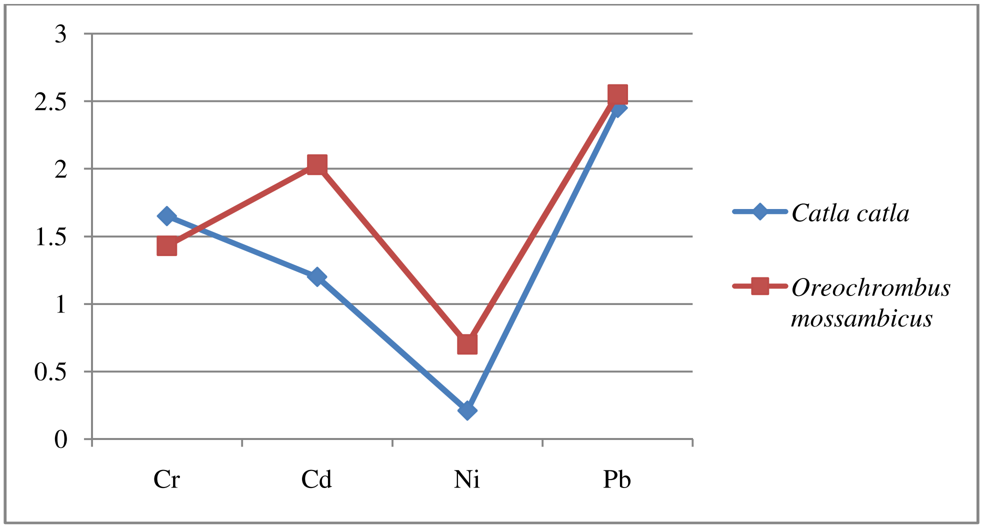

Figure-1: Heavy metal level in fish muscle mg/kg in sampling site I.

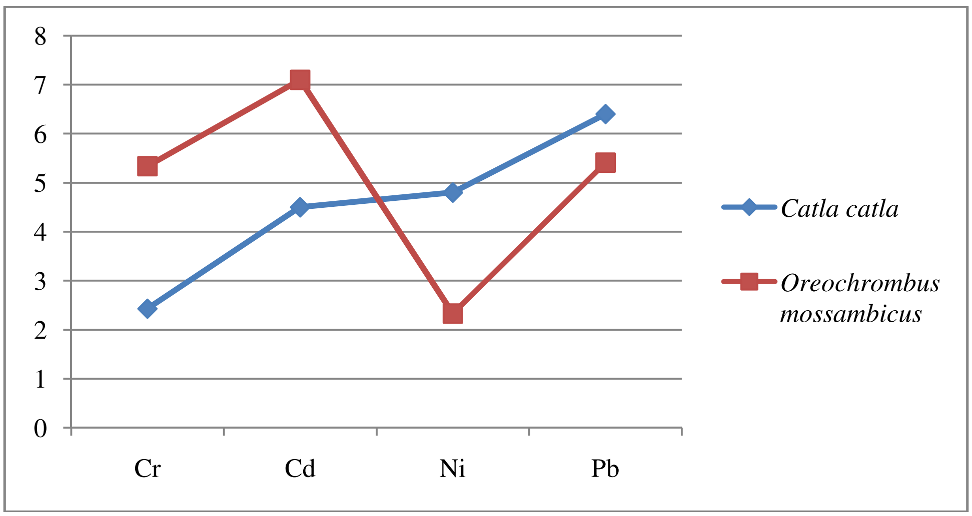

Figure-2: Heavy metal level in fish Gill mg/kg in sampling site I.

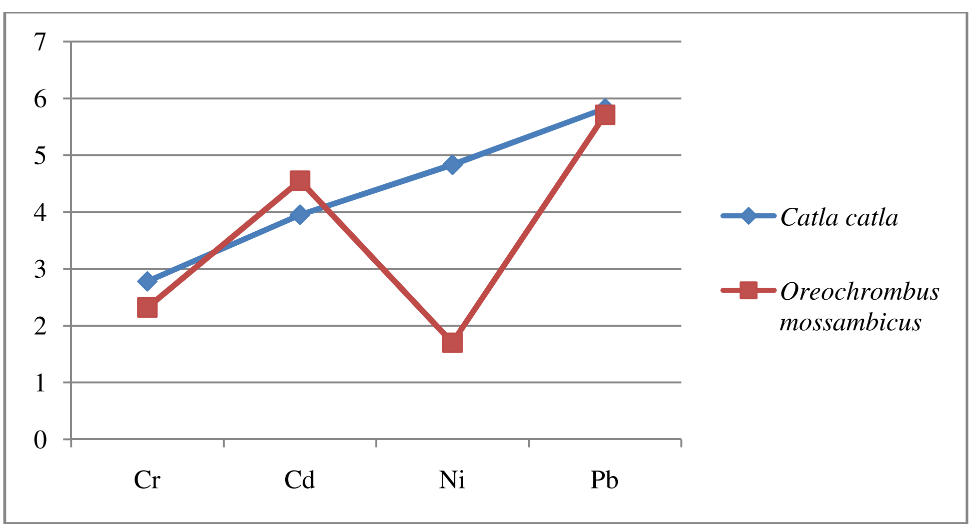

Figure-3: Heavy metal level in fish Kidney mg/kg in sampling site I.

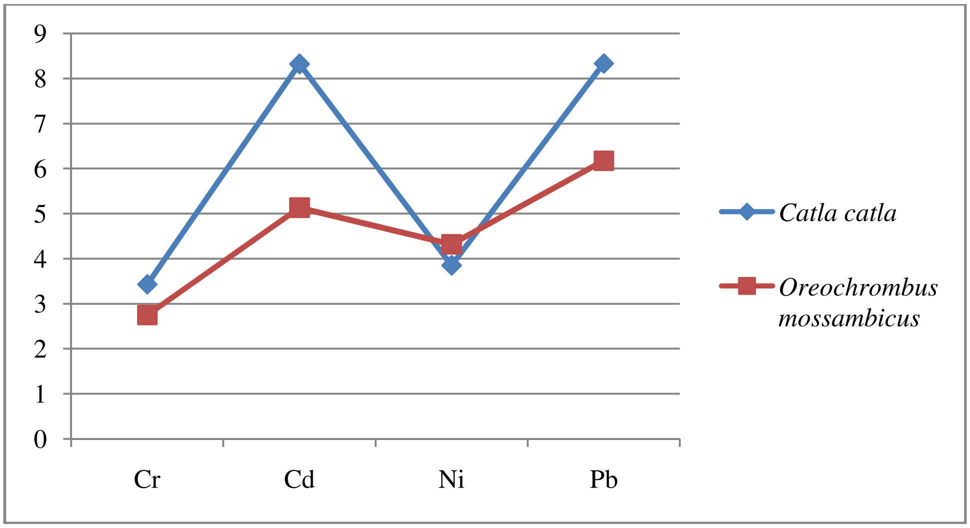

Figure-4: Heavy metal level in fish liver mg//kg in sampling site I.

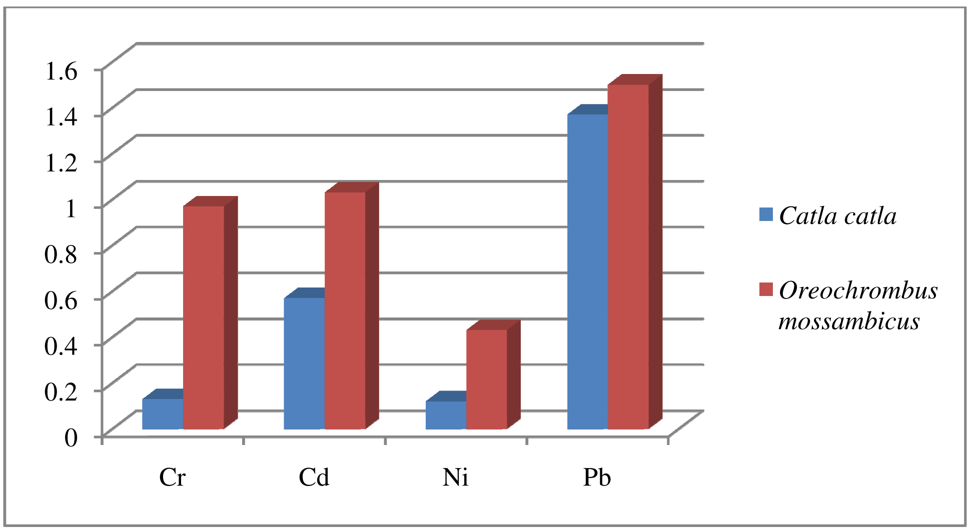

Figure-5: Heavy metal level in fish muscle mg/kg in sampling site II.

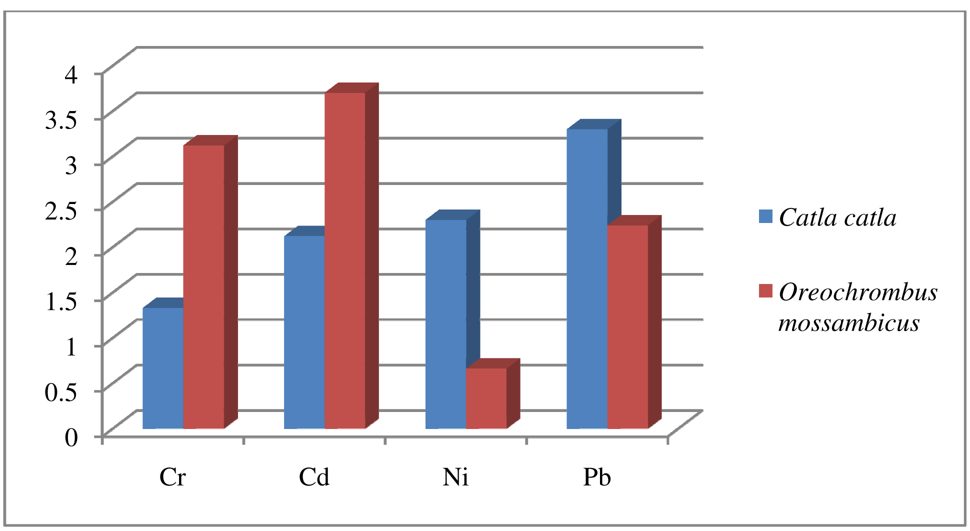

Figure-6: Heavy metal level in fish gill mg/kg in sampling site II.

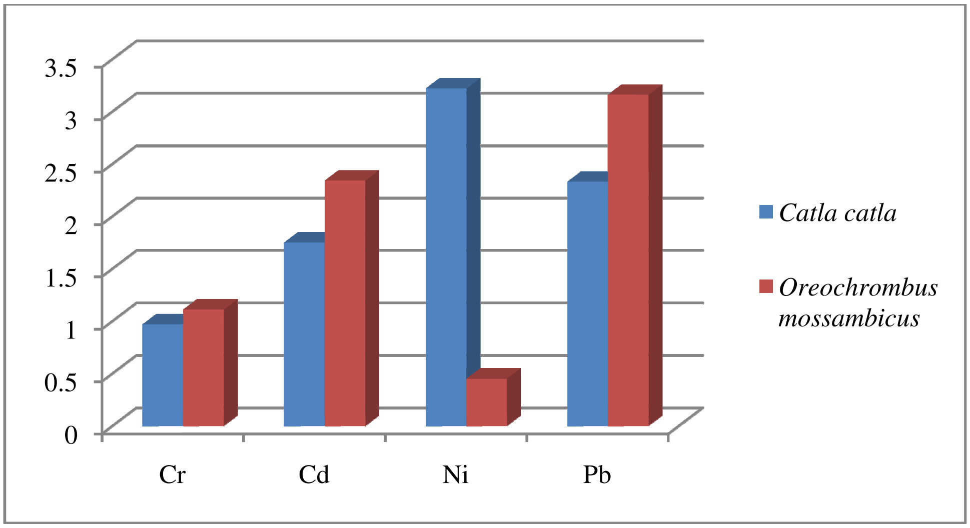

Figure-7: Heavy metal level in fish kidney mg/kg in sampling site II.

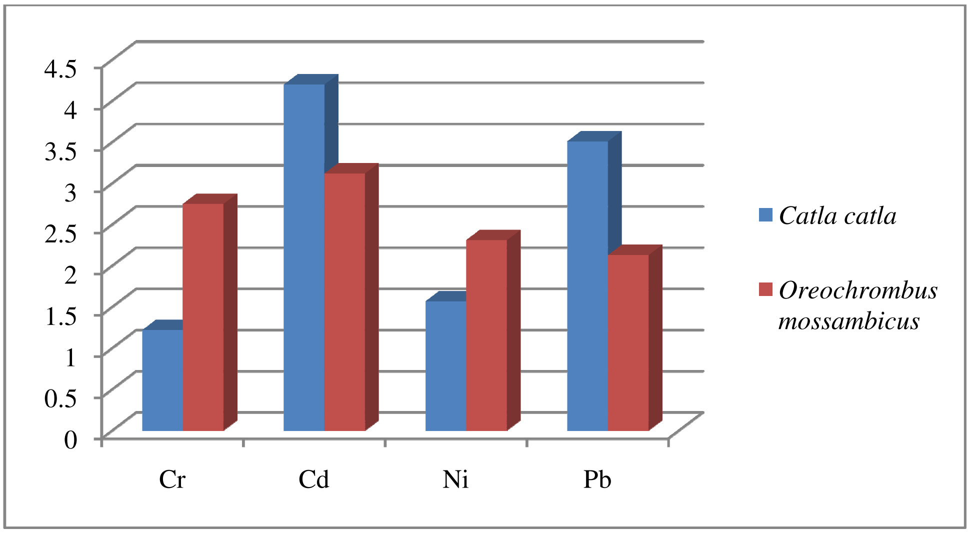

Figure-8: Heavy metal level in fish liver mg/kg in sampling site II.

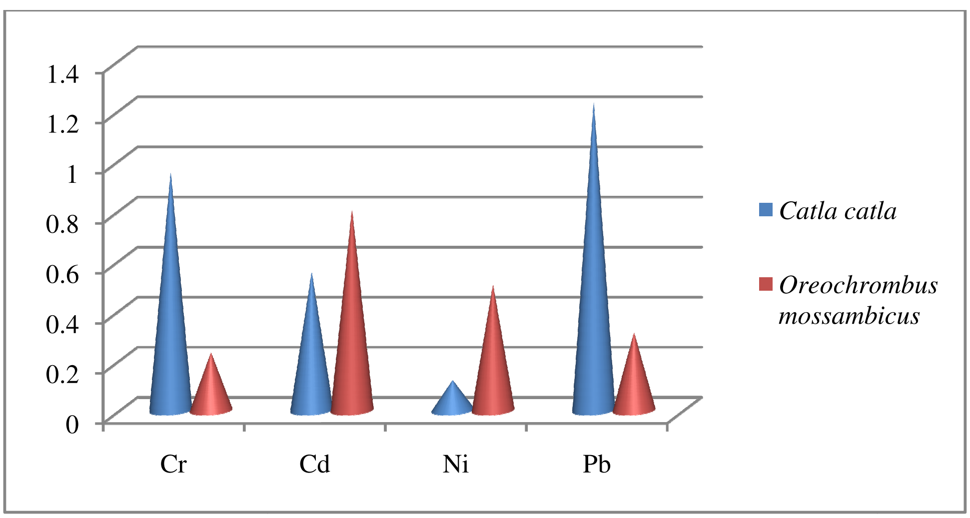

Figure-9: Heavy metal level in fish muscle mg/kg in sampling site III.

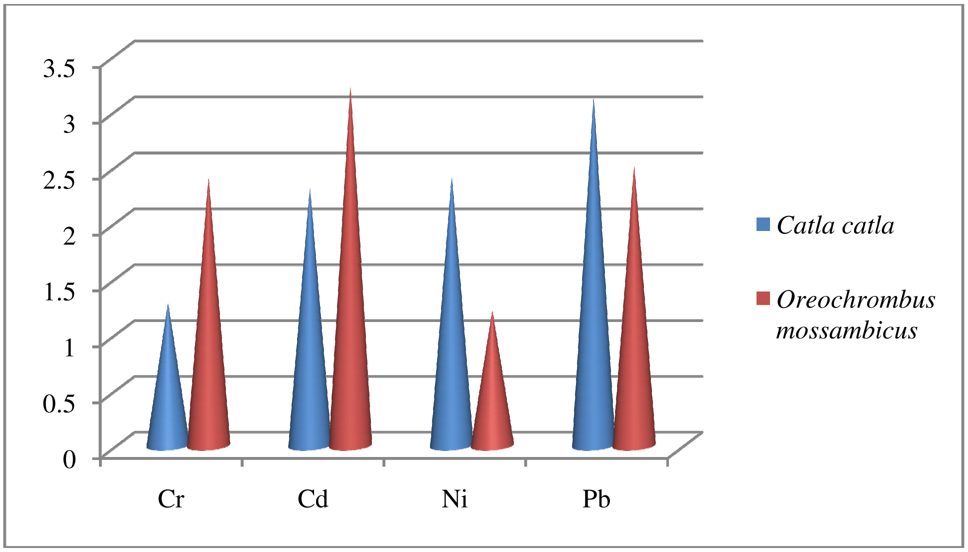

Figure-10: Heavy metal level in fish gill mg/kg in sampling site III.

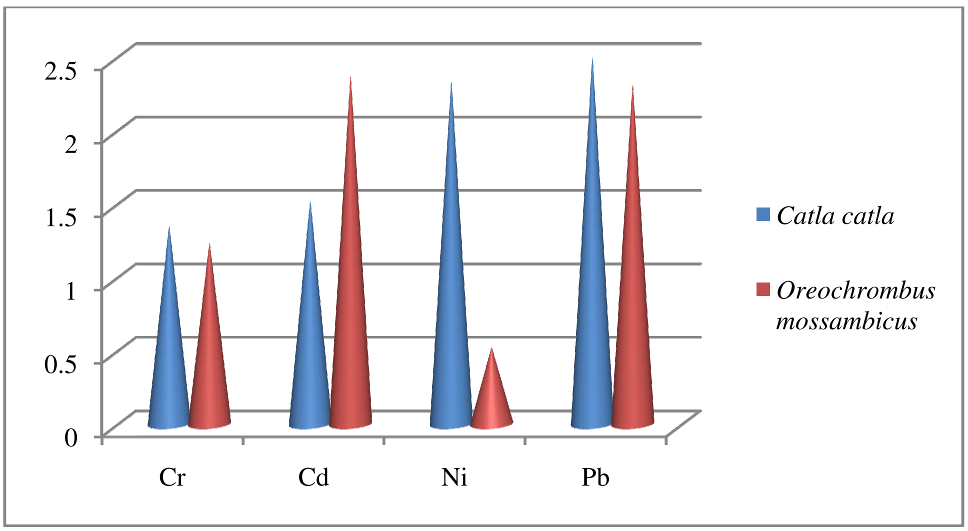

Figure-11: Heavy metal level in fish kidney mg/kg in sampling site III.

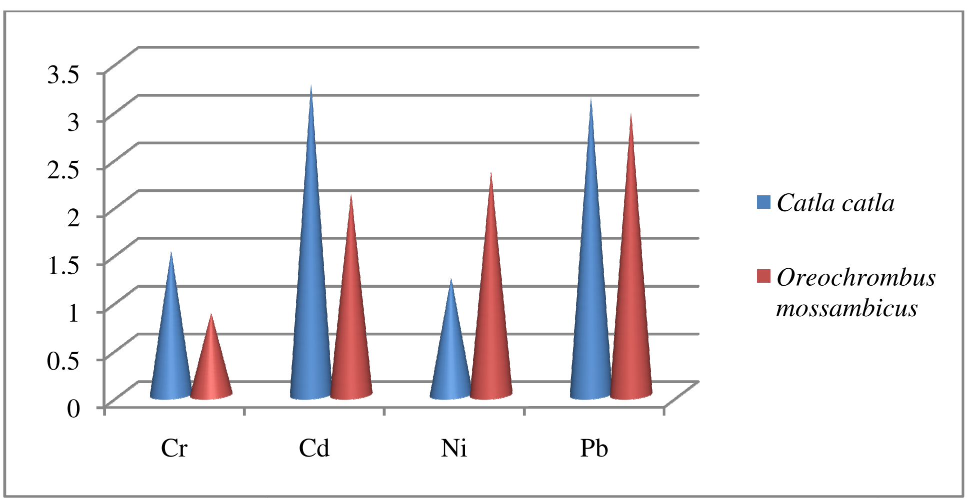

Figure-12: Heavy metal level in fish liver mg/kg in sampling site III.

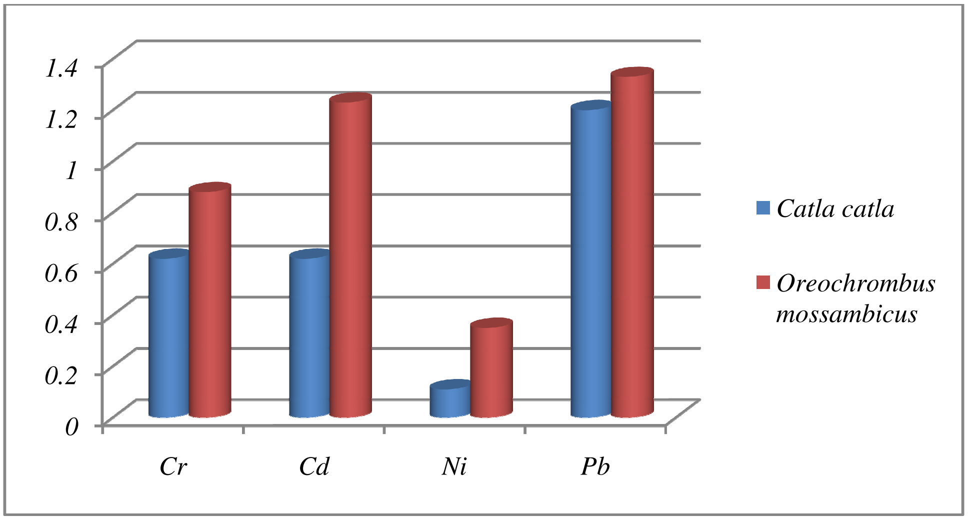

Figure-13: Heavy metal level in fish muscle mg/kg in sampling site IV.

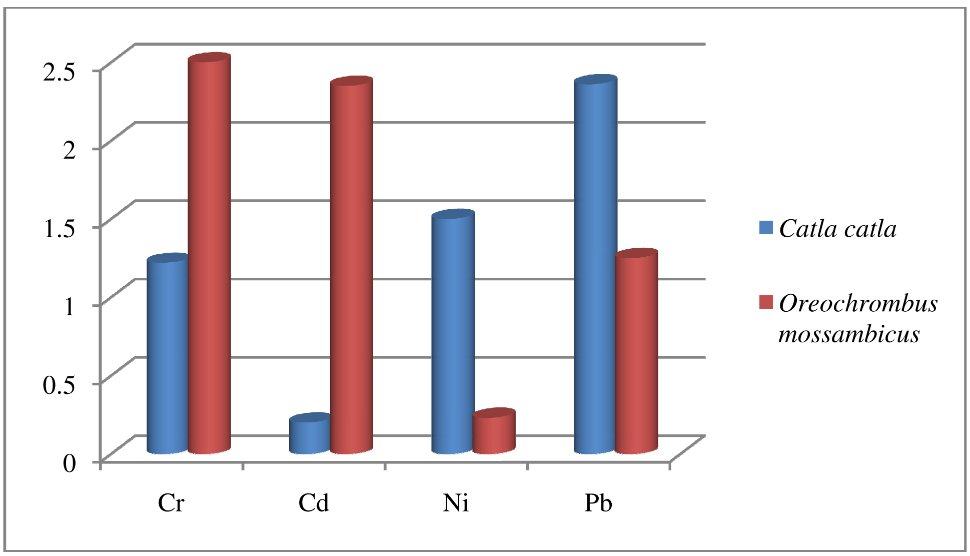

Figure-14: Heavy metal level in fish gill mg/kg in sampling site IV.

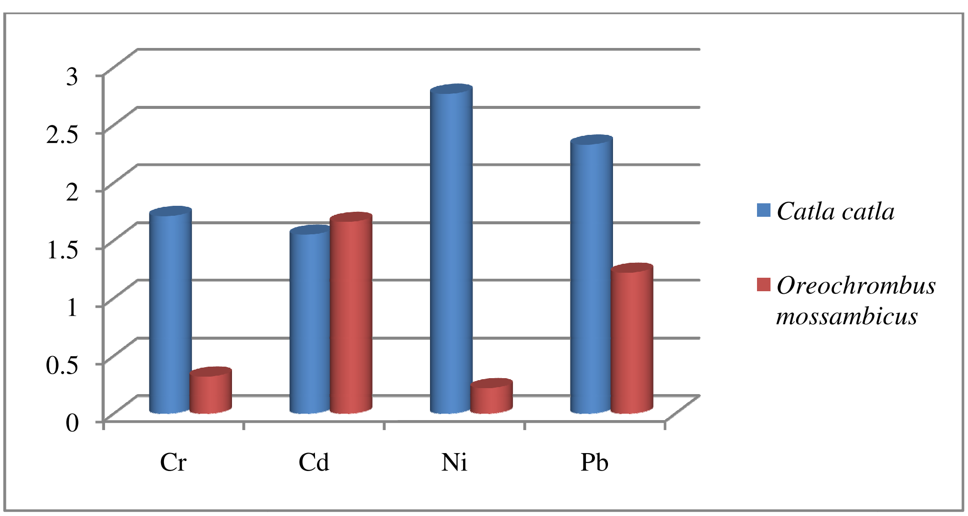

Figure-15: Heavy metal level in fish kidney mg/kg in sampling site IV.

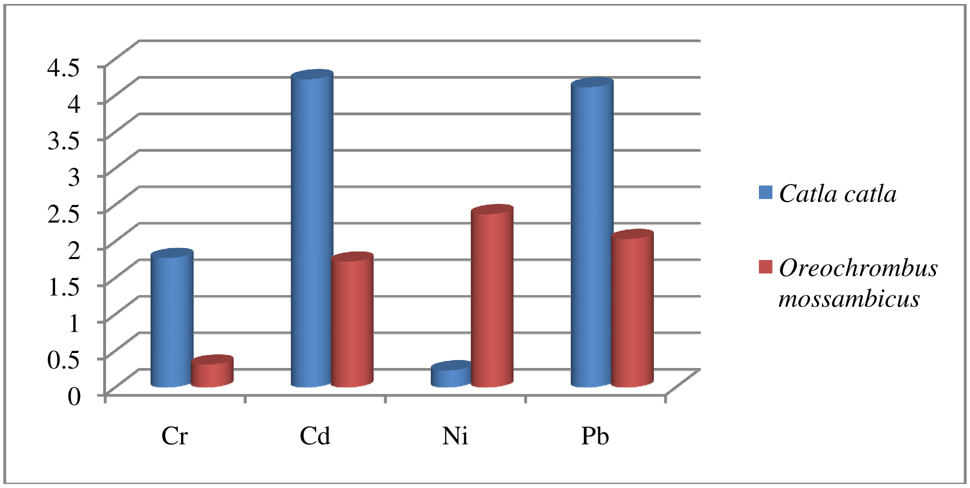

Figure-16: Heavy metal level in fish liver mg/kg in sampling site IV.

The domestic wastes and industrial effluents should be disposed safely by various bioremediation processes and also possible recycling methods were adopted and made the river and lake ecosystem healthy. In order to conserve our fish communities we have to adopt certain strategies to eliminate and prevent the heavy metal contaminants mixing with the River or any other aquatic habitat.

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