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Water Quality, Heavy Metal Accumulation, and Haematological Studies in Economically Important Fishes, *Oreochromis mossambicus* and *Catla catla* at Retteri Lake, Tamil Nadu, India

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Abstract: The current study examined water quality variables, heavy metal accumulation, and haematological markers in *Oreochromis mossambicus* and *Catla catla* in Retteri Lake from July 2022 to January 2023. The study revealed that the water quality of the Lake was within acceptable limits for the majority of the criteria examined. However, heavy metal concentrations in the water surpassed acceptable limits, indicating potential toxicity hazards to fish and other aquatic organisms. The fish's haematological indices indicated a considerable drop in red blood cell count, haemoglobin, and haematocrit, indicating the potential influence of heavy metal buildup on the fish health.

Keywords: Water quality, Accumulation, Haematology, *Oreochromis mossambicus*, *Catla catla*, Retteri lake, Heavy metal, Zinc, Chromium

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Introduction

Water is necessary for all kinds of life and cannot be exaggerated in terms of ecological relevance (Millennium Ecosystem Assessment, 2005). Water is essential to the ecosystem's functioning. It works as a solvent for nutrients, minerals, and organic substances, allowing them to be transferred to where these are needed in the environment. Water also serves to govern the Earth's temperature and weather patterns, which is important for climate regulation. It also aids in air and water purification by acting as a filter, trapping pollutants and eliminating them from the environment (United Nations Environment Programme, 2016). Lakes are critical freshwater ecosystems that provide several ecological, social, and economic advantages (Dillon and Rigler, 1975). They serve as essential supplies of drinking water, recreation, and habitat for a wide range of aquatic plants and animals. Lakes are home to a diverse range of fish species that are essential for both commercial and leisure fishing. However, human activities such as land use changes, pollution, and climate change endanger the health and sustainability of these systems (Carpenter *et al*., 1998; Schindler, 2001).

Retteri Lake is a significant body of water in the northern part of Chennai, India. This lake is vital to the environment, the economy, and society. It covers an area of 230 hectares and can hold 46 million cubic metres of water. The city of Chennai relies heavily on Retteri Lake for drinking water. Retteri Lake is a major supply of freshwater for Chennai inhabitants. The lake is part of the Adyar river basin, which serves 50% of the city's water needs (Venugopal *et al*., 2009). The lake is critical in regulating groundwater recharge in the city (Shanmugam and Kalithasan, 2019). Retteri Lake acts as a buffer during heavy rains, assisting in flood management. The catchment area of the lake has been planned to prevent floods in the neighbouring communities (Mohan, 2015). Retteri Lake is an ideal place for outdoor activities such as boating, fishing, and cycling. The Chennai Corporation has created a park surrounding the lake that draws a lot of people (Salem *et al*., 2018).

The ecological significance of Retteri Lake has been highlighted in various scientific studies. It is also a haven for many species of birds. Water pollution has become a global problem nowadays and evaluation of water resource policy is needed to counter this problem. Deaths and diseases are caused worldwide due to water pollution and approximately 14,000 peoples die every day due to water pollution (Pink, 2006). Water quality is influenced by many factors like precipitation, climate, soil type, vegetation, geology, flow conditions, groundwater, and human activities, Non-point source pollution also includes nutrients, sediments, and toxic contaminants (Florscu *et al.,* 2010).

Heavy metals are one of the major, pollutants present in small quantities in the earth's crust. Heavy metals constitute an important class of toxic substances encountered in numerous occupational and environmental circumstances. The heavy metals present at <0.1% level in earth's crust. But anthropogenic geochemical factors are releasing a large number of toxic heavy metals into the aquatic ecosystem (Beddi and Engine 2005). These modified molecules lose their ability to function properly and thus result in malfunction or death of affected cells. Heavy metals are major pollutants of aquatic environment because of their persistence and ability to be accumulated in aquatic organisms (Maheswaran and Deve Paul, 2008). Heavy metals when reach the aquatic bodies deteriorate the life sustaining quality of water and cause damage to both flora and fauna (Zyadah and Abdelbaky, 2000). Toxic substances, such as heavy metals, pesticides, and organic pollutants, can accumulate in the food chain and cause adverse health effects in humans and wildlife. These heavy metals not only accumulated in fish but also in plants in the environment and cause damage to animal and plant tissues (Khaliq *et al.*, 2022, Ullah and Alqahtani, 2022; Ibrahim *et al.*, 2022). In aquatic animals, heavy metals cause sub lethal pathology of the liver, kidneys, reproductive, respiratory, and nervous systems (Engwa *et al*., 2019).

Haematological data are used routinely in the health care of humans and domestic animals Haematologic evaluations are also gradually becoming a routine practice for determining the health status in fish and crustaceans (Tavares-Dias and Moraes, 2003; Ranzaini-Paiva *et al*., 2003; Cazenave *et al*., 2005; Maharajan *et al*., 2017). Haematological parameters are often used as health status and stress indicators in fish as in mammals. Haematological parameters are recognized as secondary stress indicators. Theblood parameters that are most frequently evaluated during routine haematological

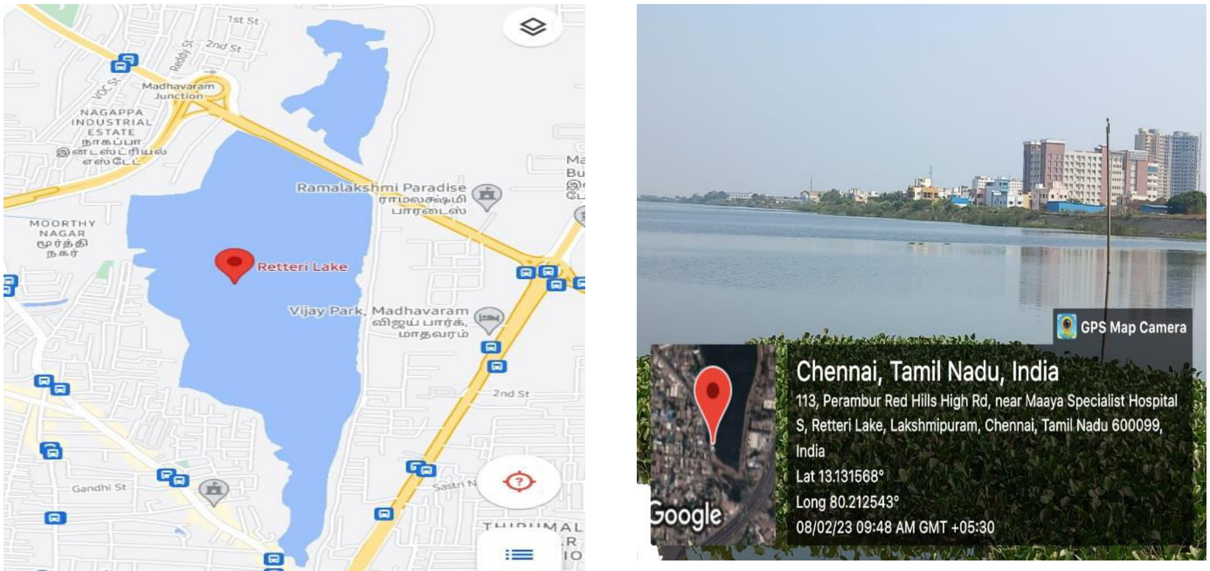

Fig. 1: Experimental site – Retteri lake (Chennai).

examinations of fish populations include the haemoglobin concentration, the haematocrit level, the red blood cell count, aspects of the morphology, and distribution of the formed cellular elements and leucocytes in the blood. The haematological indices are used to assess the functional status and oxygen-carrying capacity of the bloodstream. The haemoglobin content and erythrocyte count are directly related to environmental factors such as temperature and salinity, while immune system parameters are used to assess any alterations in the defence mechanism of fish. As such, an analysis of the normal haematological profile of a fish enables an expert to identify external and internal stress conditions and to predict the chances of disease.

The present study examined water quality variables, heavy metal accumulation, and haematological markers in *O. mossambicus* and *Catla catla* in Retteri Lake from July 2022 to January 2023.

Materials and Methods

Study area:

Retteri lake (Fig. 1) is located on the Grand Northern Trunk (GNT) Road of Chennai, India. The lake spread over 5.42 million square meters and fed by adjacent water bodies such as Red hills reservoir and Korattur lake.

Collection and Analysis of Water and Fish samples:

Water samples were collected in Jerri cans during the early hours for the current study. The closed Jerri can be dipped in the lake at a depth of 0.7 to 0.9 m, then opened inside and closed again to raise it to the surface to collect lake water samples. The samples were collected from three different locations and merged to form a single integrated sample. Many physical and chemical interactions might influence the quality of the water sample between collection and analysis; so, the sample was preserved shortly after collection to minimise this change. By adding chemical preservatives and reducing the temperature, the water samples were kept. The Merck water quality analyzer kit was used to test the following water quality characteristics in collected water samples: water colour and odour, turbidity, total solids, pH, turbidity, alkalinity, and dissolved oxygen (DO). Five Tilapia and Catla species of approximately the same weight and length were gathered, regardless of gender. The study was conducted throughout the pre-monsoon and monsoon seasons. The collected water was transported to the laboratory for furthe examination.

Metal Analysis in fish samples:

Atomic absorption spectrophotometry (AAS) was used to measure the concentration of zinc and chromium in the water sample. The procedure involves digesting the water sample with a mixture of nitric and hydrochloric acid and then analyzing the resulting solution using AAS. Muscle and liver were dissected from the fish samples and they were stored in vials. Then the samples were dried in an oven at 80 °C for 24 h before being grinded. For digestion, approximately 2 g of powdered samples were obtained. Digestion was carried out using a 2:1 mixture of strong nitric acid and hydrogen peroxide. An atomic absorption spectrophotometer (AAS) was used to measure the heavy metals such as zinc and chromium in the digested sample.

Hematological Assay:

Fish collected from the lake were least disturbed as it is reported that handling stress alters several of the blood parameters. Blood was collected by heart puncture and by the cardinal vein puncture. Blood was collected in small test tubes containing anticoagulant (ethylene diamine tetra acetic acid). Standard techniques were employed for the estimation of haematological indices (Blaxhall and Daisly, 1973).

Results

Water quality analysis:

In the present observation the pollutants concentration was high during monsoon season. The appearance, odour and turbidity of water during monsoon was high compared to that of pre-monsoon season. The pH value of monsoon water was also high in the Retteri Lake (Table 1). The heavy metals like zinc and chromium were also high in pre-monsoon season.

Accumulation of Heavy metals:

During the pre-monsoon season, heavy metals such as zinc and chromium were abundant in reservoir water. Retteri water's heavy metal concentration was matched to WHO quality norms and standards. Zinc and chromium levels were found to be higher than recommended limits. Figure 1 depicts the concentration of heavy metals (Zn and Cr) in Retteri Lake water samples. Zinc concentrations were highest in pre-monsoon water samples. The values for zinc and chromium during the pre-monsoon period were 4.21 and 0.60 mg/l, respectively, whereas the concentrations of Zn and Cr metals during the monsoon season were 3.19 and 0.32 mg/l, respectively.

Figure 2 depicts the amounts of heavy metals Zinc and Chromium in liver and muscle tissues of Tilapia and Catla during the monsoon and pre-monsoon seasons. During the pre-monsoon season, the metal zinc was found to be greatest in Catla liver (0.19 mg/g) followed by Tilapia liver (0.16 mg/g). Cr concentrations are similarly higher in Tilapia and Catla muscles and liver during the pre-monsoon season than during the monsoon season (Fig. 2).

Hematological Assay:

In the current study, pollutant concentrations in Tilapia and Catla during the pre-monsoon season resulted in a substantial decrease in RBC count, Hb%, and WBC count as compared to the monsoon season (Fig. 3). RBC counts were higher in two species of fish during the monsoon season (4.01 and 3.05 x 10 µl) than pre-monsoon (3.31 and 2.91 x 10 µl). During the monsoon season, the MCV% of the fishes was 99.72 and 92.50%, but during the pre-monsoon season, the values were lower (93.69 and 88.65%). MCH levels in fish were 40.15 and 41.15 during the monsoon season, and 37.67 and 38.70 during the monsoon season. Similarly, during monsoon fishes had MCHC values of 20.90 and 23.09%, but during pre-monsoon MCHC values were 19.76 and 19.61%. During the current study, PCV% was shown to be lower in monsoon fishes than in pre-monsoon fishes. The mean PCV% during monsoon exposure for Tilapia

Table 1: Water quality parameters in Retteri Lake

Water quality	Pre-monsoon	Monsoon
Appearance	Brownish	Slightly Brownish
Odour	Soil	Slightly
Turbidity	Moderate Turbid	Turbid
pH	6.1 ± 0.795	6.7 ± 1.279
Total Solid	671 ± 6.985	630 ± 7.905
Total Dissolve Solid	409 ± 4.472	380 ± 5.269
Total Suspended Solid	265 ± 5.789	226 ±6.188
Alkalinity (mg/l)	0.0099 ±0.002	0.0078 ±0.003
Total hardness (mg/l)	25.54 ±2.598	24.65± 3.425
Dissolved oxygen (mg/l)	5.9 ±0.701	6.8 ±0.825

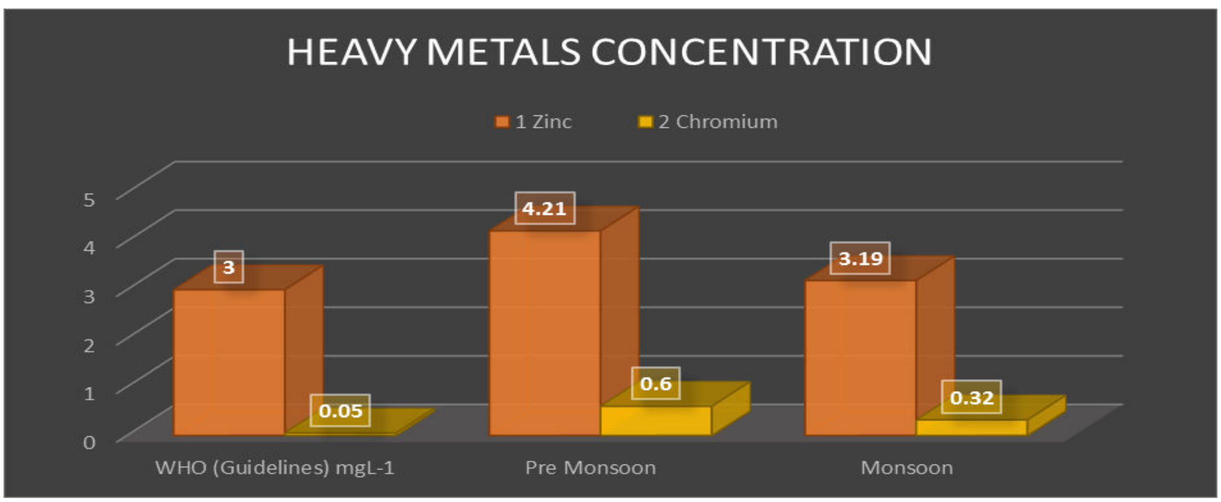

Fig. 1: Heavy metal concentration in Pre-monsoon and Monsoon Season of Retteri lake.

and Catla was 25.23 and 26.03, respectively, whereas the mean PCV% of pre-monsoon for fish species was 28.01 and 27.18, respectively.

Discussion

Heavy metals are released from many natural and anthropogenic sources, and after leaving the Earth, they eventually end up in the environment as a byproduct /pollutant (Bashir *et al.,* 2017). They interact with various environmental domains including as soil, water, sediment, and the atmosphere. Environmental contamination caused by heavy metals is on the rise, and its disastrous effects on wildlife are cause for alarm (Cimboláková *et al*., 2019). The specified values of heavy metal content have a negative impact on the health of the ecosystem and biota. Present study also evident for the heavy metal pollution affecting in economically important fishes in Retteri lake.

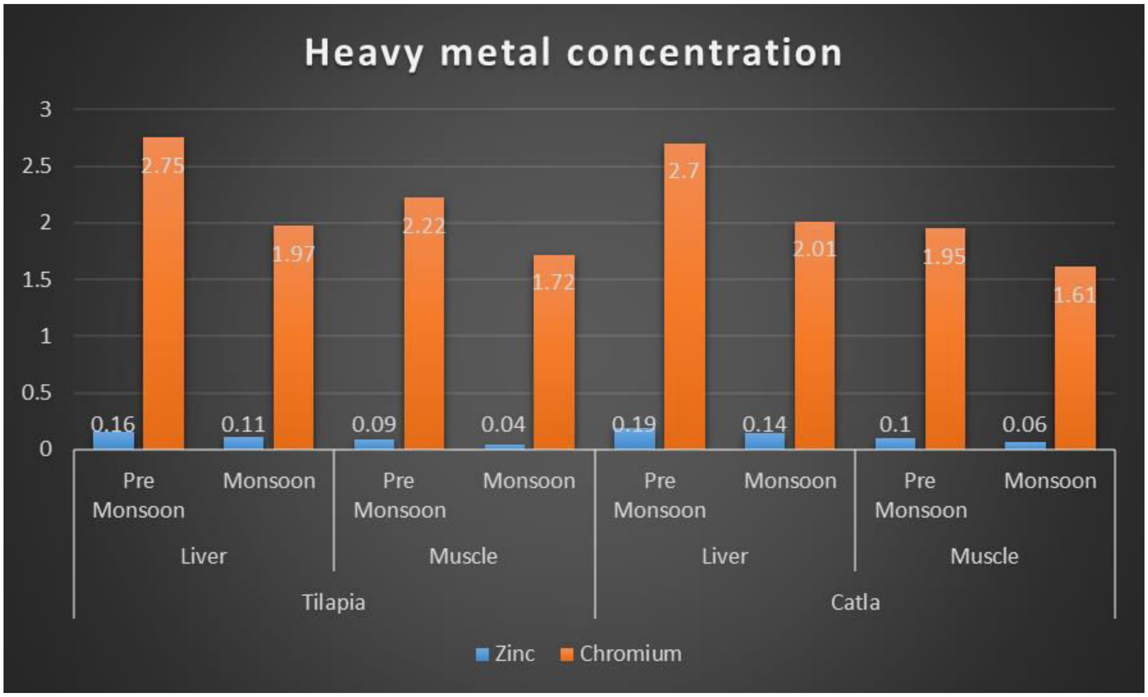

Fig. 2: Heavy metal concentration in the Liver and Muscle of *Tilapia* and *Catla* during Pre- monsoon and Monsoon seasons.

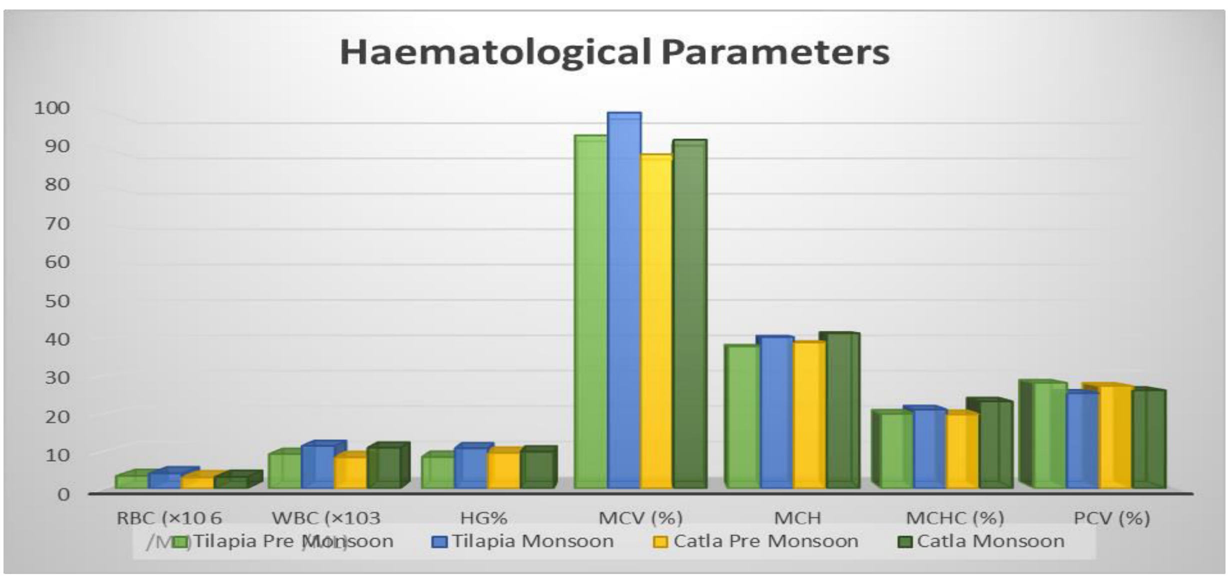

Fig. 3: Haematological Parameters of Tilapia and Catla during Pre monsoon and Monsoon of Retteri Lake.

Heavy metal movement into groundwater from toxic waste sites is a major environmental concern. Heavy metals and other inorganic contaminants degrade water quality, rendering it unsafe for human consumption (Brraich and Jangu, 2015). The main sources of heavy metal contamination, such as industry and urbanisation, contaminate the water, affecting agricultural practises as well. The usage or application of that water (carrying heavy metals) into an agricultural area, where it bio-accumulates in crops, either contaminates the crops or enters the food web through biomagnification.

The fish *Mastacembelus armatus* procured from Harduaganj Reservoir showed mean values of RBC 2.16 x 10^6 mm^{-3} and Hb 9.48 gdL^{-1}. The values mentioned above showed a significant ($P < 0.01$) decrease when compared to the control (Mehjbeen and Nazura, 2012). This study on haematological changes in fish serves as an effective tool in the diagnosis of the extent of environmental pollution and also the abiotic fish diseases. Hypoxia, anaemia, and hyperthermia are related stresses causing an osmotic imbalance and decreased capacity of the RBC to carry sufficient oxygen unless otherwise compensated by erythropoiesis or suitable physiological adjustments. Decreased RBC and Hb content in the present study during pre-monsoon may be due to destructive action of pollutants on erythrocytes and as a result of which the viability of the cells may be affected as was also reported by Karuppasamy *et al*. (2005). Multiple form of haemoglobin allows fish to adjust more efficiently to physiological stress such as varying water temperature and oxygen concentration. Haemolysis occurs in response to toxicity that leads to alteration in the selective permeability of the membrane. All these reports are in agreement with the present study of reduction in RBC count and Hb content of fish from polluted lakes due to the inhibition of aerobic glycolysis curtailing synthesis of iron and haemoglobin via the lowered energy status in fish. It has been suggested that heavy metal exposure decreases the RBC count and Hb content due to impaired intestinal absorption of iron. Exposed *Mastacembelus armatus* showed the mean value of WBC as 3.84 x 10^3 mm^3. The values mentioned above showed a significant increase when compared to the control ($P < 0.01$) (Mehjbeen and Nazura, 2012). Increase in TLC in the present study was a result of direct stimulation for its defines from diseases due to the presence of polluted substances. Progressive increased levels of TLC have been reported in *C. punctatus* exposed to lead (Hemavathi and Rao, 2000) and *Clarias batrachus* exposed to mercuric chloride. Leucocytosis is directly proportional to severity of stress condition in maturing fish and is a result of direct stimulation of immunological defence due to the presence of pollutants (heavy metals) in this reservoir. The observations made in present study for WBC are also in good agreement with those of Karuppasamy *et al*. (2005) and Hardikar and Gokhale (2000). Hence, the present investigation results confirm that stress due to various heavy metals present in the reservoir does create haematological disturbances, erythrocyte destruction (haemolysis), and leucocytosis in fish population, affecting the immune system and making the fish vulnerable to diseases. The haematological parameters in fish are reflected by the physio-chemical condition of is habitat (Bala *et al.*, 1994). In present observation the increased heavy metal concentration in Tilapia and Catla fishes during pre-monsoon season resulted into significant reduction in Hb% than monsoon. It is inferred that the decrease in Hb% in the present study may be due to anaemia caused by heavy metal mixture due monsoon season. It may be due to the decrease rate of production of erythrocytes or increased loss of these cells or compared erythropoietin due to direct effect of heavy metals.

The value of WBC increases in the Tilapia and Catla during monsoon period compared to pre-monsoon, MCV, MCH and MCHC value of pre-monsoon fishes were also decreased as compared to the monsoon fishes. Similar findings were reported by Reddy (1998) and Tawani and Fujegin (2008). Decrease in PCV% was observed in pre monsoon exposures fishes during the present investigation. Kidney and liver is the major target organs of heavy metal poisoning, as these are the hemopoietic organs (Kotnius, 1999). The effect of a model mixture of five heavy metals (copper, zinc, nickel, chromium, and iron) on *Oncorhynchus mykiss* during short-term exposure were studied, and it was discovered that the most sensitive haematological parameters, such as Hb and Hct, changed depending on the concentration of the mixture and the duration of exposure (Vosyliene, 1999). The current study supports the earlier findings.

Several changes in the hematologic indices of various fish species exposed to Cr have been widely reported. Majharul Islam *et al.* (2020) studied the effects of Cr on the haematological indexes of *Pangasianodon hypophthalmus* and discovered that Cr concentrations of 30, 40, and 60 mg/L significantly lowered Hb and Hct levels after 96 hours. Mallesh *et al.* (2015) exposed the fish Cirrhinus mrigala to sub-lethal Cr concentrations (3.4, 5.2, and 10.4 mg/L) for 1440 hours and found a significant decline in Hb and Hct levels, resulting in anaemia in fishes.

These heavy metals, like indicator species, will eventually infiltrate the food web via water and food, causing significant health effects on humans and other animals. As a result, one of the most significant techniques to dealing with heavy metal contamination in fresh water ecosystems is to prevent it from happening in the future. Uncontrolled sewage and industrial waste discharge has severely degraded the fresh water ecosystem in general, and water quality in particular, influencing the biochemical and physiological health of aquatic flora and fauna, including fish. It is therefore recommended that industrialists do not dispose of their trash unless it has been processed first in order to maintain ecological equilibrium. Finally, if pollution from these specific sources is decreased, Such methods or measures must be established in order to provide a solution to this situation. As a result, it is critical to act now to ensure that future heavy metal emissions and releases in fresh water ecosystems are minimised to the greatest extent possible in order to prevent worldwide contamination of aquatic ecosystems and dangerous effects on fish and humans.

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