TOXIC EFFECT OF HEAVY METALS CONCENTRATION ON GILLS AND MUSCLES IN THE SELECTED FISH SPECIES

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ABSTRACT

The high density of heavy metals makes them dangerous even in small doses. Various household effluents, industrial waste, atmospheric sources, other metal-based companies, and E-Waste are all potential entry points for these metals into aquatic environments. The degeneration of aquatic species, the development of deformities in aquatic organisms, and the contamination of the aquatic environment are all attributable to heavy metal pollution. These toxic heavy metals are responsible for a wide range of fish diseases, including reduced hatching rates, teratogenesis, bioaccumulation in the tissues, etc. The pollution of water sources and habitats with heavy metals has far-reaching effects on the food web. Fish eaters are indirectly affected by mercury levels in the water. After being digested, samples of fish from Stanley Reservoir in Tamil Nadu (including Labeokontius, Cirrhinuscirrhosus, C. reba, and Siloniasilundia) were analysed for the presence of heavy metals using a 210VGP Atomic Absorption Spectrophotometer. The found concentration of heavy metals was found to be significantly lower than the allowable level.

Keywords: Heavy metals, Toxic, Aquatic, Food chain,Bioaccumulation

I. INTRODUCTION

The cement industry, iron and steel sector, steam power plants, glass sector, garbage and waste mud incineration facilities, mining activities, smelters and foundries, piping, combustion, and transportation have all contributed to the widespread dispersal of heavy metals, which already occur in varying concentrations in the earth's crust, soil, air, water, and all biological matter. Wind, soil erosion, and volcanic activity are all natural ways for them to spread. Critical environmental challenges include pollution and the threats it poses as a result of rising agricultural operations, population expansion, urbanization, and industrialization. Heavy metal poisoning is undeniably the most severe form of chemical water pollution. Because of their toxicity and capacity to accumulate in living things, heavy metals pose a serious ecological and health risk. Heavy metals are toxic to people and can significantly alter ecological stability.

Heavy metals including zinc, iron, cobalt, and copper are needed in small amounts for enzyme function and other biological activities, but they become toxic when their concentrations rise over a safe threshold. However, some metals such as lead, cadmium, and mercury are toxic even at low doses and play no necessary function in living organisms.

Due to their toxicity, bioaccumulation, and biomagnification, heavy metals pose a significant threat to all forms of life. When a xenobiotic accumulates in an organism beyond its concentration in the environment, this process is known as bioaccumulation. When an organism absorbs a xenobiotic at a greater concentration than it does in its food sources, this process is known as biomagnification.

Fish absorb environmental heavy metals in a variety of ways, including through their gills, their food, their skin, and, in the case of freshwater fish, their water. Once ingested, these metals are transported to the fish's organs by carrier proteins via the blood path, where they can reach high concentrations by bonding to metal binding proteins. The levels of toxic elements in fish vary with factors such as species, age, geographic location, and time of year. Anthropogenic water pollution causes aquatic loss, which in turn upsets the delicate equilibrium of the food chain.

II. EFFECTS OF HEAVY METALS ON FISH

Certain aquatic creatures have the capacity to accumulate and store heavy metals. These heavy metals are not hazardous or toxic, but they can nevertheless damage human health if they make their way up the food chain. When concentrations of heavy metals rise over a specific threshold, poisoning usually follows. In addition, the accumulation of heavy metals in water poses a hazard to the health of ecosystems, aquatic life, and humans by making its way up the food chain. The aquatic food chain's apex predator, fish, may collect metals in its tissues and organs. Concentrations of metals in aquatic creatures like fish and shellfish are several times greater than those found in water or soil. Certain environmental factors, including food chain, predation competition, water chemistry (salinity, pH, water hardness), and hydrodynamics in the water, can lead to metals accumulating in fish tissues to toxic amounts. Accumulation may also be affected by interactions between metals.

Although some heavy metals are required for existence, studies on fish have shown that even these essential metals may have negative consequences on living creatures through metabolic interference and mutagenesis. Loss of fitness, reproductive disruption, cancer, and mortality are all unfavourable outcomes. Fish also experience stress due to heavy metal impacts, along with reproduction, hypoxia, overpopulation, and malnutrition. Pollution and other environmental stresses disrupt normal metabolic, physiological, and biochemical processes, having deleterious effects on growth, development, and reproduction. Metal contamination of aquatic environments has been linked to negative effects on fish physiology and biochemistry in both blood and tissue. Fish with compromised immune systems after being exposed to metals were more likely to contract and perish from infectious illnesses.

Although the carcinogenic consequences of heavy metals are not fully understood, some investigations have hinted at the possibility of genotoxic effects. Directly or indirectly, heavy metals increase genotoxicity by promoting the toxicity of other chemical agents. Fish that have been exposed to heavy metals show pathological alterations and a decrease in estrogenic and androgenic production.

III. REVIEW OF LITERATURE

Andem, Andem(2013)Between February and April of 2012, three species of freshwater fish (Tilapia zilli, Oreochomisniloticus, and Schilbemystus) were captured in the Cross River system. For the purpose of identifying heavy metals, the bone, liver, and gills of the three species were meticulously dissected. Perkin-Elmer Analyst 300 Atomic Absorption Spectrophotometer (AAS) was used to measure the concentrations of metals. Heavy metals were found in the highest concentration in the liver tissues, and in the lowest concentration in the bone tissues. O. niloticus has the greatest copper content, whereas Schilbemystus has the lowest. Schilbemystus had the highest concentration of cobalt, whereas T. zilli and O. niloticus had the lowest. Schilbemystus exhibited the lowest quantities of Lead (Pb), Iron (Fe), and Cobalt (Co) in its liver tissues, whereas T. zilli and O. niloticushad the highest. Significant ($P<0.05$) variations in the calculated values were discovered. The results showed that all three species had elemental concentrations much below levels considered unsafe for human consumption.

Malik, Riffat et al., (2013)The current study aimed to characterise the accumulation of trace metals in the organs of four edible fish species (Tor putitora, Cirrhinusmrigala, Labeocalbasu, and Channa punctatus) from Pakistan's Rawal Lake Reservoir. Atomic absorption spectroscopy was used to examine fish samples taken in May 2008 and October 2007 for the presence of heavy metals. Heavy metals accumulated mostly in the kidneys and liver. Following the monsoon, fish accumulated more metals in their tissues than they did before. This included their skin, muscles, and gills. The metals went in the same direction as the market before the rains. In pre-monsoon, the metals followed the trend Zn >Pb> Fe > Cr > Ni >Mn> Co > Cu > Cd > Li, while in the post-monsoon season, the trend was Fe >Pb> Cr > Ni > Zn > Cu > Co >Mn> Cd > Li. Except for T. putitora, the Ni, Cr, and Pb contents in the muscle of all of the fish species tested were much over the World Health Organization's recommendation levels for heavy metals in fishes intended for human consumption. C. mrigala and L. calbasu had Cu levels very close to the WHO maximum, while T. putitora and C. punctatus had lower Cu values. Rawal Lake Reservoir's water quality has to be restored and managed immediately, and risk assessment studies are urgently recommended.

Sharma, Madhuri et al., (2012)Heavy metals, chemicals, medications, diseases, and other pollutants/contaminants have all been detected in fish, just as they have in people and other animals. When discharged into the environment at a toxic dose, many aquaculture chemicals are by their very nature biocidal. This means that even non-target creatures might die. Mortality in non-target invertebrates from carbaryl pesticides, effects on nearby biota from organophosphate parasiticides, and effects of antibacterial residues in aquatic sediments on the associated microbial community are three classes of aquaculture chemicals. Liming materials and chemical fertilisers are the mainstays of pond aquaculture. Chemicals such as oxidants, disinfectants, osmoregulators, algicides, coagulants, herbicides, probiotics, and chemotherapeutants are employed in agriculture less frequently than other types of chemicals. 2 These chemicals are easily broken down or precipitated, so they don't build up in the ecosystem or harm wildlife in ponds that get their water supply from the wild. There was negligible, if any, danger to food safety from the vast majority of chemicals employed in pond aquaculture. The pollutants may be biomagnified in the animal tissue, making them more toxic to consumers.

Couture, Patrice & Pyle, Greg (2011)Since the Earth's early history, metals have been naturally in the environment. Over the course of evolution, several of these metals have been incorporated into life's most fundamental molecules and metabolic processes, while safeguards have been built up against their presence in both non-essential and excess quantities. The first signs of human civilisation coincide with the beginning of anthropogenic metal pollution of terrestrial and aquatic systems. However, the severe environmental repercussions of metal mining and smelting operations did not begin to represent a major danger to animals until the heavy industrialization of the eighteenth century. Because of their ability to biomagnify and induce toxicity to the upper levels of the food web, such as birds and people, mercury and selenium were the initial focus of field study leading to environmental protection laws. For low-level, chronic exposure scenarios, however, scientists have only lately begun to elucidate the processes of metal buildup and toxicity on fish and other species. Fish in aquatic areas take in metals through their water and food. Chronic metal exposure, common in metal-contaminated environments, has more nuanced consequences than their acute counterparts and is fundamentally different from them. Direct toxicity has been linked to bioenergetic effects including reduced development rate and condition, and selective pressures have been shown to diminish genetic diversity in populations. Both positive and negative indirect impacts on fish populations might result from direct metal poisoning at other trophic levels. The complexity of biotic and abiotic variables influencing metal accumulation and toxicity in wild fish makes field modelling difficult. However, our ability to safeguard fish and their environment from anthropogenic metal pollution is rapidly increasing as a result of the growth in knowledge discussed in this chapter on the accumulation and consequences of metals in wild fish.

Okocha, Reuben &Adedeji, Olufemi (2011)Heavy metals provide health risks to aquatic creatures even at levels below those considered acceptable when they are discharged into the aquatic environment from a variety of sources. Fish and other aquatic creatures are particularly vulnerable to the toxicity caused by these contaminants because of their pervasiveness and the fact that they tend to accumulate in organisms. Cadmium is one of the most toxic heavy metals, and this page provides a quick introduction of the metal and its toxicity. The toxic effects of cadmium on aquatic biota, particularly fish, and the public health impact are discussed in this review.

Valavanidis, Athanasios &Vlachogianni, Thomais (2010) There is a wealth of research on metal deposition in ecosystems because of their status as a major toxic contaminant. Volcanoes and natural weathering of rocks release metals into the biosphere on a regular basis, but so do a wide variety of human-caused activities including mining, fuel burning, industrial and urban waste, and agricultural practises. There is now overwhelming evidence that human activities have poisoned the environment with heavy metals on a worldwide scale, from the polar regions to the equatorial regions, and from the mountaintops to the ocean depths. Metal contamination in marine, freshwater, and terrestrial environments and their animals will be reviewed here. The use of bioindicator organisms for the biomonitoring of metals in the environment, as well as the related toxicity mechanisms and ecological effects of heavy metal pollution, will be discussed, as will the speciation of metals, their bioacummulation in biota, and the abiotic and biotic factors affecting their bioavailability.

Khayatzadeh, Jina&Abbasi, E. (2010) Heavy metals make up less than 1 percent of the mass of all living things, and the variations in their density are thought to be the root of various health problems. Surface waters and acidic rains can sweep pollutants like these metals into the ocean. Heavy metals are seldom seen in their natural state near bodies of water. The impacts of metal pollution on marine ecosystems and humans are far reaching, despite the fact that it is far less common than other forms of water pollution. The use of industrial wastes in aquaculture has toxic consequences on fish and other aquatic life. Pollutants in the water are taken in both directly and indirectly by aquatic species through food chains. Heavy metals have a number of toxic effects on fish and aquatic invertebrates, including a decrease in developmental growth, an increase in developmental anomalies, a decrease in fish survival (especially at the onset of exogenous feeding), and, in extreme cases, the extinction of an entire fish population in polluted reservoirs. These repercussions have the potential to influence the geological, hydrological, and, ultimately, biological cycles. Therefore, it appears that greater thought should be given to bioconservation procedures.

Deshpande, Aditi et al., (2009)Heavy metals in seafood are a product of environmental pollution and can be toxic to humans. Our research focused on analysing metals including lead, copper, cadmium, mercury, and arsenic in fish muscle tissue to evaluate this type of pollution. Four ports in the city were scoured for the most popular types of fish for human consumption, including Bramabrama (Pomfret), Rachycentroncanadus (Surmai/King Fish), Rastrelligerkanagurta (Mackerel), Eleutheronematetradactylum(Ravas/Indian salmon), and Metapenaeusmonoceros (Brown Prawn). Voltammeter and cold vapour atomic absorption spectrophotometer readings were used to calculate the concentrations of metals in fish tissue samples. The amount of heavy metals found in the fish tissues was highly variable between collection sites. Arsenic, copper, cadmium, and lead were all within acceptable limits, however mercury was found to be much higher than the threshold considered safe for human consumption in food (1 microg/g). Heavy metals have been analysed from two sites of Ganga River at Patna.

IV. MATERIAL AND METHODS

Sample area

Sone – Gana river junction at Danapur Patna and Punpun –Ganga river Junction at Fatuha Patna Bihar.

Sample Collection and Identification

Fish were caught once a month between 16:00 and 17:00 with the help of artisanal fisherman using gill nets with mesh sizes ranging from 0.16 millimetres to three millimetres. Ice was used to keep the specimens fresh on the journey to the Fisheries and Aquaculture Technology Laboratory.

Determination of heavy metals

The fish were rinsed in distilled water to remove any adhering contaminants. The gill was also dissected from the muscle it belonged to. Drying was place in a Gallenkamp moisture extraction oven at 105°C for eight hours for both the gills and the muscles. To digest the materials, we crushed them into a powder, homogenised them, and added 20 ml of a mixture of concentrated nitric acid and 62% perchloric acid (ratio 2:1) to a 200 ml Kjeldahl digestion flask on a hotplate. The mixture was then heated until the emergence of copious white vapors, indicating the decomposition of nitric acid. Finally, the solution was transferred to a 250 ml volumetric flask and brought to volume with deionized water before being subjected to an AAS bulk (210VGP) determination of metal concentrations per AOAC, 2006.

Statistical analysis

The concentration of heavy metals in the fish species was compared using multivariate analysis of variance (P=0.05), and the concentration in the gills and muscles was compared using the T-test (P0.05). (16.0). The tables were presented with the use of descriptive statistics.

V. RESULT AND DISCUSSION

Table 1 displays the levels of heavy metals found in the gills and muscle of the species studied. Below the WHO, FEPA, and FAO acceptable limits, the concentrations of metals varied considerably (P<0.05) across the four species. When looking at the four different species, the concentration of metals in the gills was considerably (P<0.05) greater than the concentration in the muscle. From 0.215±0.02 mg/kg in Cirrhinus cirrhosus to 0.260±0.02 mg/kg in C. reba, and from 0.007±0.01 mg/kg in Silonia silondia to 0.013±0.00 mg/kg in Labeo kontius, the concentration of Cu in the gills varied. The lowest Cr content was found in C. reba (0.036±0.03 mg/kg), whereas the highest was found in Cirrhinuscirrhosus (0.100±0.00 mg/kg). Cirrhinus cirrhosus had a mean Pb content of 0.185±0.03 mg/kg, while Cirrhinus reba had a mean Zn concentration of 0.486±0.21 mg/kg. C. reba had a Mn concentration of 0.370±0.05 mg/kg, while Silonia silondia had a concentration of 0.290±0.03 mg/kg.

Table 1: Concentration of Heavy metals in the gill and muscle of fish

Parts	Metals	Siloniasilundia	C. reba	Labeokontius	Cirrhinuscirrhosa	WHO, (2003)/ FEPA, (2003)	FAO, (2007)
Gills	Cu	0.223 ± 0.02b	0.260 ± 0.02d	0.235 ± 0.03c	0.215 ± 0.02a	3.00	3.00
	Cd	0.007 ± 0.01a	0.010 ± 0.00b	0.013 ± 0.00c	0.010 ± 0.00b	0.50	0.20
	Cr	0.043 ± 0.03b	0.036 ± 0.03a	0.065 ± 0.04c	0.100 ± 0.00d	0.50	0.50
	Pb	0.107 ± 0.01a	0.133 ± 0.04b	0.153 ± 0.06c	0.185 ± 0.03d	2.00	2.00
	Zn	0.527 ± 0.06b	0.486 ± 0.21a	0.598 ± 0.10d	0.553 ± 0.03c	30.00	30.00
	Mn	0.290 ± 0.03a	0.370 ± 0.05b	0.363 ± 0.01b	0.300 ± 0.00a	0.50	0.50
Muscle	Cu	0.170 ± 0.02d	0.160 ± 0.12c	0.103 ± 0.00a	0.125 ± 0.02b	3.00	3.00
	Cd	0.000 ± 0.00a	0.004 ± 0.00bc	0.005 ± 0.01c	0.003 ± 0.00b	0.50	0.20
	Cr	0.007 ± 0.00a	0.010 ± 0.01b	0.025 ± 0.01d	0.028 ± 0.00c	0.50	0.50
	Pb	0.017 ± 0.01a	0.027 ± 0.03c	0.033 ± 0.02d	0.020 ± 0.02b	2.00	2.00
	Zn	0.277 ± 0.02d	0.026 ± 0.03c	0.208 ± 0.01a	0.235 ± 0.03b	30.00	30.00
	Mn	0.107 ± 0.01a	0.130 ± 0.03b	0.150 ± 0.08c	0.108 ± 0.01a	0.50	0.50

Mean ± SD in the same row with homogenous superscript are not significantly different (P>0.05)

VI. CONCLUSION

Heavy metals are among the most dangerous and toxic contaminants in the world. The results of a literature review and an experimental investigation on the effects of heavy metals on fish were presented here. Fish species, age, sex, size, nutrition, and preferred habitat; water chemistry and physics; heavy metal interactions; and bioavailability all play a role in these impacts. The physiological, biochemical, metabolic, systemic, and genetic processes of fish are disrupted by heavy metals, threatening their capacity to grow, develop, reproduce, aliment, and survive. Heavy metals are physiologically inert and non-metabolizable, thus even if their quantities do not reach toxic levels in fish, they may still be ingested by humans and cause serious health issues.

Even though all six metals analysed were present, the concentration of heavy metals in the studied fish species was often below the permitted level specified by WHO, FEPA, and FAO in fish. The gills were found to bioaccumulate more metals than the muscle of the four fish species studied. More metals were bioaccumulated by Cirrhinus cirrhosa and Labeo kontius than by Silonia silondia and C. reba. Therefore, human interference in the area should be kept to a minimum, and the fisheries of the region should be subject to continual monitoring in order to increase fish productivity and variety and guarantee safe fish food for human consumption.

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