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Adverse Effects of Heavy Metals on Aquatic life

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ABSTRACT

The metals that are highly dense and toxic at low quantities are termed as heavy metals. These metals include Lead, Mercury, Cadmium, Copper, Zinc, Manganese, Nickel, Arsenic and Silver etc. Among these metals Arsenic, Cadmium, Chromium and Lead are considered most toxic to humans, animals and fish. Heavy metals enter the aquatic ecosystem through disposal of industrial, agricultural and municipal wastes and bioaccumulates in the food chain. Chromium is generally present in aquatic ecosystems between the range 1-10 µg/L which is highly toxic. Higher concentration of Chromium in aquatic ecosystem can result in accumulation in fish and have adverse effects on consumers' health. Cadmium and Lead deposit on the gills of the fish and cause suffocation which may lead to death of the fish. Accumulation of Cadmium is generally associated with organ damage and anemia that results in death of the fish and its consumer. In the presence of Cadmium, the toxicity of Lead generally increases the toxicity drastically in *Gambusia affinis.*

INTRODUCTION:

The term heavy metal is used for such metals that have high density and toxicity even at very low quantities. Such metals include Arsenic (As), Mercury (Hg), Cadmium (Cd), Thallium (Tl), Lead (Pb) and Chromium (Cr). Other than these metals, some trace elements such as Copper (Cu), Zinc (Zn) and Selenium (Se) are required by the human body for metabolic processes but high concentrations of these elements can be very toxic. These elements are also known as trace elements and considered heavy metals due to their toxicity. Such elements are usually ingested through food or inhaled through air [1]. The heavy metals that are dealt in environmental sciences usually include Pb, Cd, Hg, Cr, Cu, Zn, Manganese (Mn), Silver (Ag) and Nickel (Ni) etc.

Some heavy metals such as Lead (Pb) and Beryllium can be very toxic at low concentrations. These heavy metals can also affect the action of essential elements such as Iron (Fe) by interfering with the metabolic processes which lead to increased toxicity of such metals. Other than the chemical toxicity of metals, some metals also have radiological toxicities. Other than these properties, the oxidation state may contribute to the toxicity of some metals, e.g., Cr(III) is a trace element and is required in metabolic processes but Cr(VI) is carcinogenic [2].

Heavy metals are present in environment in form of biomass as well as freely. In cases of aquatic environment, heavy metals are present in fish species depending on their growth, development and other physiological factors. These fish are studied to evaluate the effect of heavy metals on aquatic environment and health of aquatic animals. Therefore, consuming sea food can also effect human health if it contains large quantities of heavy metals [3].

Since metals are soluble in water, these are readily absorbed by aquatic animals but even small concentrations can be very harmful as metals undergo bioconcentration which makes their concentration higher in the organism than that of the

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external environment. Metal toxicity does not directly kill an organism but cause sublethal effect by affecting the growth, metabolism, development and reproduction of organisms [4]

Although sea food is considered nutritious and therapeutic as it contains minerals, vitamins and unsaturated fatty acids such as omega-3 fatty acids [5] but since fish are situated at the top of aquatic food chain so they can accumulate heavy metals from water, food and sediments which may have adverse effects on human health if consumed [6] and [7]. High consumption of sea food contaminated with heavy metal may lead to liver failure, renal damage and cardiovascular disorders which may lead to death of the consumer [8] and [9]. Many studies have emphasized on the concentration of metals in edible parts of the fish but some researches have also studied the effect of these metals organs such as liver, kidneys, heart, brain and gonads. These studies have suggested that there are many factors that influence the metal accumulation in fish which include reproductive cycle, swimming patterns, living environment and feeding behavior [7] and [10].

Chromium:

History of Chromium

Chromium was discovered in the form of a red crystalline mineral named crocoite ($PbCrO_4$) in 1761 and was used as a pigment. This is why it was derived from Greek word "chroma" that means color. Now Chromium is extracted in the form of an ore chromite ($FeCr_2O_4$) which is the source of chromium used for pigment extraction [11].

Properties of Chromium Metal

According to the periodic table, Chromium is one of the transition elements and is considered the 24th most abundant element in earth's crust. There are three isotopes of this metal that are present in nature with atomic numbers of 52, 53 and 54. Among these isotopes, ^{52}Cr is the most abundant one. Chromium III is an essential nutrient and is required for the metabolism of carbohydrates but Cr (VI) is toxic and carcinogenic [12]. Cr (VI) is more toxic but it can reduced to Cr (III) to decrease the toxic effect as it will not be able to enter the cell [13].

Sources of Chromium

Various chromium compounds such as sodium chromate and dichromates are available for commercial use and enter the aquatic ecosystem through effluents of various industries. These industries commonly include metal finishing, mining, textiles and tanneries, ceramic and pharmaceutically industries [14] and [15].

Effects on Aquatic Life

The overall effect of chromium on environment is adverse but in case of aquatic animals, it accumulates in the fish and may affect the consumer's health [3]. It is estimated that the chromium concentration in lakes and rivers ranges between 1-10 µg/L. However the recommended or safe level, according to United States Environmental Protection Agency, ranges between 50-100 µg/L. Chromium does not readily accumulate in the bodies of fish but is taken up through gills. If chromium is present in high quantities in the area near to fish habitat, then chromium is ingested or taken up by gills and damage the tissues [16] and [17]. There are various toxic effects of Chromium reported in fish that include morphological and hematological changes, tissue damage, growth retardation, damaged immune functions and immune system impairment [18] and [19]. Since it enters the bodies of fish through gills, excessive accumulation may lead to acute poisoning leading to damage in respiratory epithelium resulting in death of fish due to suffocation [20]. The overall consumption and accumulation is highly dependent on the site of fish habitat with respect to the disposal of industrial effluents containing chromium. Fish are at higher levels of food chain among other aquatic animals so accumulation of chromium also depends on the food intake of the fish [21].

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Cadmium:

Discovery of Cadmium

Cadmium was first discovered as an impurity in zinc carbonate by Friedrich Stromeyer and Karl Leberecht Hermann in Germany in 1817 [22].

Properties of Cadmium

Cadmium is an element with symbol Cd and atomic number of 48. It is soft and bluish white in color and is chemically similar to zinc and mercury. Cadmium is a trace element but its ability to accumulate in living bodies is currently an environmental concern [23] and [24]. Usually, metals are prone to corrosion but cadmium is corrosion resistant and is often used as an outer protective layer on other metals to prevent corrosion. Another interesting property of chromium is that it is not flammable but it may release toxic fumes if burned in powdered form [25].

Sources of Cadmium

Cadmium is released to the aquatic environments through multiple setups including various industries such as batteries, pigment and electroplating industries. This lead to the contamination of the aquatic environments to alarming levels [26]. Other than industrial settings, agricultural wastes, chemicals, pesticides and fertilizers also contain cadmium in minute quantities that may alter the aquatic ecosystem if continuously dumped in the rivers and oceans [27]. It is also evident that fossil fuels and municipal waste are also among largest sources of release of cadmium in the environment that may enter the water bodies [28].

Effects of Cadmium on Aquatic Life

The most toxic form of cadmium is also the one that occurs most abundantly in the form of divalent ion. This divalent metal is known to damage kidneys, hearts, livers and gills of freshwater fish by accumulating in these organs and causing pathological changes [29] and [30]. When present in low concentrations in fish and humans, this metal induces the synthesis of metallothionen, a low molecular weight protein that decreases its toxic effect by binding to it. But if the concentration of cadmium is very high then metallothionen produced is not enough to detoxify the cadmium which in turn leads to the destruction of erythrocyte that eventually leads to anemia due to hemoglobin deficiency [31] and [32]. Other toxic properties of cadmium include chronic toxicity leading to impaired reproductive, excretory and hepatic functions. It is also evident that high concentrations of cadmium may interfere with certain metabolic pathways and lead to hyperglycemia in fish [33].

Lead:

History of Lead

The history of lead dates back to 7000-6500 BC in Asia as the initial example of metal smelting. Lead has been extensively linked with extraction of silver from some lead minerals and ores. It is evident Egyptians were the first one to use lead in cosmetics, glasses, enamels and ornaments [34].

Properties of Lead

Lead has been assigned the symbol Pb and has atomic number 82. It is relatively denser than other metals and has low melting point. It is soft and when freshly cut appears in bluish white color that changes to dull gray when exposed to air. It is also used in paints as it has the ability to adhere to wood and imparts brightness to the color. It is considered one of the hazardous metals. There are two forms of lead, Lead (II) and Lead (IV) [35] and [24].

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Sources of Lead

Though lead is a naturally occurring metal, but it is discharged in water bodies through smelter and industries by dissolution of pesticides, precipitations, lead plumbing and municipal waste. It was not considered toxic until the late 19th century and since then it is considered a global issue. It is still a great concern due to its use in battery manufacturing industries. It enters the body of living organisms through inhalation, ingestion and absorption [36].

Effects of Lead on Aquatic Life

Lead deposits in the soft tissues, organs, digestive tract and gills of the fish and may lead to permanent damage to any of the organs and systems. This leads to various inabilities and disorders in the fish bodies [37]. Lead in water deposits on the gills of fish and lead to suffocation. If present in low concentration for long periods of time, it may lead to chronic toxicity and act as a neurotoxin [38]. It is also evident from the recent researches that exposure of lead in combination with cadmium have synergistic effect and the toxicity is increased drastically in mosquito fish *Gambusia affinis* [39].

CONCLUSIONS

High concentrations of heavy metals in environment are threat to all ecosystems but its severity is very high for aquatic ecosystems because of the disposal industrial, agricultural and municipal waste in freshwater and oceans. This had led to chronic toxicity in fish and bioaccumulation of metals in fish and ultimately humans who consume seafood. Though the effect of metals highly depends on the age, environment, habitat, exposure time and species of the fish but overall heavy metals have adverse effects on aquatic animals.

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