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Review Article

Bioaccumulation and Toxicity of Heavy Metals in Fish

Gullu Kırat[1], Murside Dartay[2]

[1]*Geology Engineering, Faculty of Engineering and Architecture, Yozgat Bozok University, Yozgat, gullu.kirat@yobu.edu.tr , ORCID, 0000-0002-1167-0574*

[2] *Department of Fisheries Technology, Fisheries Faculty, Fırat University, Elazığ, mdartay@firat.edu.tr, ORCID 0000-0001-8875-8702*

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* Corresponding author

ABSTRACT

Heavy metals find diverse applications in industry, agriculture, food processing, and household settings, making them prominent environmental and industrial contaminants due to human-driven transformations. This investigation delves into the insights provided by various researchers regarding the impact of heavy metals on fish. Numerous studies indicate elevated levels of essential metals (Zn, Fe, Mn and Cu) crucial for aquatic organisms, contrasting with lower concentrations of non-essential metals. A comprehensive review underscores the role of fish as bioaccumulators of heavy metal pollution. Significantly, both essential and non-essential metals amass through the trophic chain in freshwater ecosystems. Despite lacking metabolic functions, non-essential metals, due to their bioaccumulation in fish, pose potential toxicity to humans even at minimal concentrations. The concentration of heavy metals in fish emerges as a critical factor for both ecological management and human consumption. Continuous research is imperative to assess the nexus between human health and metal toxicity in aquatic environments.

Introduction

Aquatic organisms rely on heavy metals as essential components, typically present in nature at minimal concentrations. The influx of heavy metals into freshwater and marine ecosystems primarily stems from diverse sources, including domestic activities, mining, and mechanical and cultivation practices, leading to regions with elevated heavy metal levels [1–8].

Fish accumulate heavy metals through direct and indirect means. Direct uptake occurs by ingesting contaminated food and water through the digestive tract, while indirect uptake occurs through permeable membranes such as the skin and gills. Metal concentrations in fish organs act as an indicator of environmental levels, occasionally surpassing them. Toxicity ensues when the accumulation surpasses metabolic, storage, and detoxification capacities [9, 10].

Non-essential heavy metals such as lead (Pb), cadmium (Cd) and mercury (Hg) cause extreme toxicity in living organisms even in minimal amounts, posing a significant threat to various life forms, especially human health. [10–13].

Rapid industrialization and population growth have led to increased pollution of freshwater with various pollutants, drawing concern over the past decades [14–18]. Natural water systems bear heavy contamination from heavy metals released by human-made domestic and industrial, activities [19, 20]. This contamination profoundly impacts the ecological balance and diversity of aquatic organisms [21], with fish being particularly vulnerable [22]. Studies in various fish species demonstrate changes in the physiological functioning and biochemical parameters of tissues and blood due to metal exposure, emphasizing the toxic and bioaccumulative effects of heavy metals [23, 24].

Several authors, such as Rashed [25], Rahman et al. [26], and Rajeshkumar and Li [10], have reported the pollution of freshwater and marine environments with heavy metals. Chromium, zinc, mercury, copper, lead, arsenic and cadmium are identified as significant contributors to water pollution, harming aquatic organisms. Seafood, including fish, shrimp, and crab, often accumulate high metal levels from water and sediment in their natural habitats [27, 28]. The subsequent consumption of aquatic organisms by humans poses health risks due to the transfer of accumulated heavy metals [29, 30].

Heavy Metal Sources

Heavy metals enter sea-going situations both actually and through human exercises. These metals are found completely different concentrations within the earth's hull, discuss, soil, water and all living life forms. Anthropogenic variables such as quick seriously urbanization, industrialization, globalization, natural controls and seriously farming contribute altogether to the spread of these components [19, 31–37]. Smelters, refineries, vehicle debilitate (tetraethyl lead), lead plumbing channels, lead-soldered nourishment cans, lead-based paints, paints, cleaning agents, photography, tanneries, mining, purifying, colors (cadmium yellow), electroplating, arrive application of fertilizers, plastics, creature excrement, sewage slime, wastewater water system, pesticides, uranium mining, petrochemical spills and others are the sources of overwhelming metals [38, 39]. In specific, mining operations in sea-going situations are the foremost source of heavy metal contamination. Poisonous metals in angle collect at concentrations hundreds or indeed thousands of times higher than in water and silt [40, 41]. Coordinate take-up of poisonous heavy metals in angle happens through contact with water and dietary admissions [42].

Defilement of water by heavy metals causes changes within the chemical composition of the sea-going environment and can influence the physiological, circulatory and behavioral designs of angle as well as their ionic adjust [43]. Past thinks about have emphasized that residential wastewater and anthropogenic exercises have altogether contributed to expanding levels of metallic poisons in sea-going situations globally [44]. The most important sources of heavy metals in sea-going situations are briefly given in Table 1 [45].

Table 1. Sources of Heavy Metals in Aquatic Environments [45, 46].

Heavy Metals	**Sources**
Zn and Cu	Smelting and refining, Electroplating industry, mining, biocatalysts
Fe	Iron alloys: cars, containers, washing machines, buildings, bridges, pharmaceuticals, iron fertilizers, chemicals, and insecticides.
Pb	Mining and purifying of metallic metals, civil sewage, burning leaded gasoline, paints, mechanical squanders wealthy in Pb.
Cd	Anthropogenic exercises, geogenic sources, metal refining and refining, phosphate fertilizers, burning fossil powers, sewage slime.
Hg	Woodland fires, volcanic emissions, outflows from businesses, coal, caustic pop, peat, wood additives, semiconductors, mining and refining, herbicides, coal-fired control plants, volcanoes, creature bolster added substances, petroleum refining.
Cr	Strong squander, electroplating industry, tanneries, slime.
Mn	Sewage slime, civil wastewater releases, mining and mineral preparing, steel and press fabricating, outflows from amalgam generation, burning of fossil fills.
Ni	Weathering of soils and geological materials, volcanic eruptions, landfill, balloon bursts and oceanic gas exchange, forest fires, industrial waste, surgical instruments, automotive batteries, kitchen utensils, steel alloys.

Effects of Heavy Metals on Fish

Certain aquatic organisms have the capacity to accumulate heavy metals to a certain threshold. While these metals themselves are harmless or toxic, they can enter the body through the food chain and pose potential risks to human health [47]. Generally, toxicity becomes evident when concentrations of heavy metals surpass specific thresholds. Furthermore, the progression of heavy metals through various stages in water can jeopardize ecosystem stability, impact fish, and pose health risks to humans [48].

Angle, at the beat of the oceanic nourishment chain, play a key part within the aggregation of metals in different tissues and organs [49]. Metal concentrations in angle regularly altogether surpass those found in water or dregs [22]. The collection of metals to harmful levels in angle tissues depends on particular natural variables, counting the multifaceted nature of the nourishment chain, predation competition, water chemistry (saltiness, pH, water hardness), and water hydrodynamics [50]. Also, the intuitive among distinctive metals can impact the generally amassing handle [51].

Effects of Heavy Metals on Human Health

The most course of human introduction to overwhelming metals is through utilization of sullied nourishment [52]. Potential wellbeing dangers related with the nearness of overwhelming metals in commercial angle have gotten consideration [53-55]. In this manner, it is fundamental to screen and get it the sum and concentration of overwhelming metals display in angle to ensure that they don't posture a danger to human wellbeing and stay inside satisfactory limits [56-58]. Natural activists are increasingly recognizing that overwhelming metal contamination may be a serious natural issue due to its tall harmfulness, tirelessness, and potential for collection within the human body, and postures a genuine wellbeing risk to urban populaces [45, 59].

Different universal organizations, counting the Nourishment and Farming Organization (FAO), the World Wellbeing Organization (WHO), and the European Union (EU), have set up rules for most extreme passable concentrations of overwhelming metals in different nourishments, counting fish [60, 61]. For illustration, the

European Union (2006) has set the greatest reasonable constrain (MTL) for lead (Pb) in consumable angle tissues at 0.3 mg/kg, whereas the extend for cadmium (Cd) and mercury (Hg) is 0.05 - 0.30 to 0.5 - 1.00 mg/kg damp weight depending on the sort of angle. Non-essential components such as Pb, Cd, and Hg are classified as exceedingly harmful and destructive to people and oceanic life indeed in little sums [62, 63]. In differentiate, fundamental components such as manganese (Mn), zinc (Zn), nickel (Ni) and copper (Cu) play imperative parts in natural frameworks [45].

Conclusion

Heavy metals stand out as highly toxic, detrimental, and perilous environmental pollutants. This study explores the repercussions of heavy metals on fish, delving into a comprehensive literature review on the subject. The deleterious impact of heavy metals extends to the physiological, biochemical, metabolic, systemic, and genetic functions of fish, resulting in detrimental effects on their growth, development, reproduction, feeding, and overall survival capabilities. Due to the inability of biological elimination for heavy metals and the lack of metabolic processes in both humans and fish to break them down, these contaminants can enter the human system through the consumption of fish, leading to severe health issues, even when fish do not surpass toxic concentrations.

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