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Investigating the effects of accumulation of lead and cadmium metals in fish and its impact on human health

Abstract

The spread of various types of pollution, including heavy metals in water sources, has caused many marine and freshwater ecosystems and their living organisms, especially fish, to be negatively affected. Heavy metals are naturally found in very low concentrations in the water environment, but their concentration has increased due to human activities. Heavy metal poisoning can have many effects on human health and damage the functioning of organs such as the brain, kidneys, lungs, liver, and blood. The toxicity of heavy metals such as lead and cadmium can have acute or chronic effects, since the fishing industry provides part of the food needs of society, the transfer of various pollutants such as heavy metals through the food chain to the human body can be a threat to health.be considered a human society.

Keywords: aquatic animals, heavy metals, human health, pollution

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Introduction

The spread of various types of pollution, including heavy metals in water sources, has caused many marine and freshwater ecosystems and their living organisms, especially fish, to be negatively affected.[1–5] Since the fishing industry provides part of society's food needs, the transfer of various pollutants such as heavy metals to the human body through the food chain can be considered a threat to the health of human society. In general, most metals Heavy metals are toxic to the body at a very low level; therefore, the increase of these metals in the tissue of fish is associated with many risks.[6–10] Among different pollutants, in addition to the level of pollutant toxicity, small amounts of their emissions are also important issues that are considered in various studies. To assess the impact of high concentrations of metals on terrestrial ecosystems, a major distinction must be made between the risks/effects of heavy metals related to (i) the soil ecosystem (soil organisms/processes and plants) and (ii) human or animal health and health resulting from bioaccumulation. The accumulation of heavy metals in the food chain is considered particularly important in the case of cadmium (Cd), mercury (Hg), and to some extent lead (Pb). Accumulation ultimately leads to toxicity to humans (i) by affecting the quality of food crops and animal products, as well as the quality of drinking water, and (ii) animal health by affecting the quality of forage and direct consumption of contaminated soil. This Overview aims to show how critical concentrations of Cd, and Pb are given their potential impacts on human health and animal health.

The main mechanism of heavy metal toxicity includes the production of free radicals to cause damage to biological molecules such as:

a. enzymes

b. proteins

c. Lipids

d. DNA damage

The presence of these metals in water environments is the result of two main sources of pollution, which include:

a) Natural sediments

b) Human activities such as urban, industrial, and agricultural activities.

Heavy metals are naturally found in very low concentrations in the water environment, but their concentrations have increased due to human activities. These are pollutants that can remain in aquatic environments for a long time without decomposition and cause damage to aquatic animals.[11] Fish consumption is considered one of the main ways of human contact with heavy metal pollution.

The two main ways through which heavy metals enter the aquatic food chain:

a. Direct consumption of water and food through the digestive system

b. Other pathways in permeable membranes such as muscle and gills

Fish usually reflect the number of metals that are taken from sediments and the aquatic environment, and are also able to absorb and accumulate heavy metals along the surface of the gills and kidneys, digestive tracts, and liver.[12]

When do the toxic effects of these heavy metals occur?

Excretory, metabolic, storage, and detoxification mechanisms can no longer cope with absorption, which ultimately leads to physiological and histological changes. In addition, many factors such as sex, age, size, reproductive cycle, swimming patterns, feeding behavior, and living environment can affect the absorption of these metals.[13]

Environmental pollution is one of the most important challenges in modern human society. Environmental pollution by heavy metals is a serious and worrying threat to the environment[14] Industrialization and extensive urbanization have caused the pollution of the environment by heavy metals and since 1940, the speed of their movement and transfer in the environment has accelerated.[15]

The increase in demand for aquatic products, as a valuable source of food, especially in recent years, has led to the all-round growth and

development of the fishing and aquaculture industry in the country. Along with the increase in demand, the increase in the pollution of water environments has seriously aggravated the possibility of quality problems in these valuable food source.[16] Non-degradable pollutants such as compounds and salts of heavy metals accumulate in the environment. Accumulation of toxic substances in the food chain may increase their concentration in animals of higher levels of the food chain. Aquatic mammals due to their position at the top of the food chain, aquatic mammals have the potential to deposit heavy metals and trace elements in their tissues.[17] The accumulation and biological role of heavy metals in marine animals can endanger human health due to these metals. These metals often have strong and harmful effects when consumed by humans. Heavy metals are among the environmental pollutants that human exposure to some of them through water and food such as lead and cadmium can cause chronic and sometimes acute and dangerous poisonings.[18]

Heavy metals

Toxins are substances that harm organisms if absorbed, inhaled, or ingested in sufficient quantities. Toxicity is the degree of a substance (or poison) that can harm humans or animals. Acute toxicity involves harmful effects on an organism through short-term exposure. Chronic toxicity is the ability of a substance or a mixture of substances to cause harmful effects in a long-term period, usually in repeated or continuous exposure. So far, there have been various reports of different types of poisons, and among these substances, heavy metals are of significant study importance.

Heavy metals are generally defined as metals with relatively high atomic weight or atomic number density. So far, various criteria have been defined for heavy metals.[19] For example, in metallurgy, a heavy metal may be defined based on its density. While in physics, the criterion of distinction may be the atomic number. While a chemist probably pays more attention to the chemical behavior of matter. In a common definition that has received more attention, it is stated that heavy metals are a group of metals that have a specific weight of more than 6 grams per cubic centimeter, however, being a heavy metal has little to do with density and more it is related to chemical properties.

The electronegativity of metals (the power of elements to absorb and accept electrons in a compound) is related to their ecological effects and toxicity in aquatic organisms. If the negative nature of the electron is more, the toxicity will be more.[20] Heavy metals are not degradable and remain in the environment for a long time even after removing the source. These findings indicate that heavy metals are considered among the most dangerous pollutants in toxicology studies.[11] It cannot be denied that metals play a fundamental role, but when their concentration in aquatic ecosystems exceeds the threshold, they act as pollutants and cause stress in fish. Heavy metals are persistent pollutants that, unlike organic compounds, they do not break down in nature through chemical or biological processes. One of the important results of the stability of heavy metals is the large biological extent in the food chain, so as a result of this process, their amount in the food chain can increase several times the amount found in water or air.[21] Fish are constantly exposed to heavy metals in polluted waters; the accumulation of heavy metals in different tissues of fish in polluted aquatic ecosystems is different and depends on the ecological needs of body metabolism and other factors such as salinity, water pollution level, food, and sediment. It saves itself. Humans also absorb heavy metals through the consumption of foods containing heavy metals, and this mechanism leads to acute and chronic effects in humans.[22]

Accumulation of heavy metals in fish tissue and transfer to the human food chain

Bioaccumulation is the gradual accumulation of substances such as pesticides or other chemicals in an organism. Bioaccumulation occurs when an organism absorbs or excretes a substance at a faster rate than it is destroyed by catabolism and excretion. Therefore, the longer the biological half-life of a toxic substance, the risk of chronic toxicity increases, even if the environmental levels of the poison are not very high. Heavy metals are one of the most important environmental pollutants that enter the food chain. Researchers have stated that the transfer of heavy metals from the subsets of the food chain to the upper components causes danger in the ecosystem because these substances tend to accumulate and can be transferred from one food chain to another. The two main methods through which heavy metals enter the aquatic food chain are direct consumption of water and food through the digestive system and other pathways in permeable membranes such as muscles and gills. Considering this, fish usually reduce the number of metals that sediments and the aquatic environment are taken, reflect. Fish can absorb and accumulate heavy metals along the surface of the gills and kidneys, digestive tracts, and liver.[12]

Bioaccumulation of heavy metals by organisms may be passive or selective. Differences in the accumulation of heavy metals by organisms may be the result of differences in absorption, digestion, or both. According to research, non-essential heavy metals such as cadmium (Cd) and lead (Pb) have no essential role in living organisms and are considered essential threats to all forms of life, especially human health. The toxic effects of these substances occur when the excretory, metabolic storage and detoxification mechanisms can no longer cope with absorption, which ultimately leads to physiological and histological changes.[13]

The review of the obtained sources has shown that the bioaccumulation of heavy metals by fish and their subsequent distribution in the organs is very specific. In addition, many factors such as sex, age, size, reproduction cycle, swimming patterns, feeding behavior, and living environment (i.e., geographic location) can affect the absorption of these metals. Heavy in the body of fish is a function of some environmental parameters such as pH, temperature, pollutant type, and sampling location[23] Among the most important fish tissues that play a significant role in human nutrition is the muscle tissue, for this purpose, most of the research has been conducted on measuring the concentration of heavy metals in the body of fish, and this edible tissue has been studied.[24] Because it has considerable importance in terms of its effective role in the nutritional health of consumers.[25] Also, the need to determine the concentration of these metals in muscle tissue in addition to the major role that they play in the food chain of humans and other species. Play a role, it is also considered a kind of biological marker and can determine the approximate level of these elements in the environment of fish.[26] So far, a high level of heavy metal effluents has been reported from areas that are increasing settlement, road construction, and agricultural activities. Considering this issue, the entry of these effluents into aquatic environments, especially seas, causes the accumulation of heavy metals in aquatic tissues. It will be like fish. Therefore, the consumption of these organisms will be a danger to food security and the health of human life. According to this issue, to protect aquatic organisms, the amount of contamination of trace elements should be determined through chemical bioassays and the evaluation of biomarkers that indicate biological effects.

The effect of heavy metals on human health

Heavy metal poisoning can have many effects on human health. Heavy metals can damage the function of organs such as the brain, kidneys, lungs, liver, and blood. Heavy metal toxicity can have acute or chronic effects. Long-term exposure of the body to heavy metals can gradually lead to muscular, physical, and neurological degenerative processes that are similar to diseases such as Parkinson's disease, multiple sclerosis, muscular dystrophy, and Alzheimer's disease. Researchers also stated that long-term exposure to some heavy metals may cause cancer.[27]

Lead (Pb)

Lead is the most widely used heavy metal and belongs to group IVB of the periodic table. Lead is very heavy, soft, malleable, and bluish-gray in color. This metal with an atomic mass of 21.207 has a melting point of 327 degrees Celsius and a boiling point of 620 degrees Celsius.[28] Lead element is unnecessary and has no metabolic role in vital communities of ecological cycles. After entering the human body, lead disrupts the process of forming red blood cells, first anemia and further damage to bone tissue, kidney disorders, and damage to muscle tissue.[29] This metal is very toxic, and its widespread use has caused environmental pollution and health problems in many regions of the world. And despite its low geochemical mobility, this metal has spread all over the world. A large amount of lead has been reported only in the muscle tissue of fish in areas that had a lot of agricultural and industrial activity and the entry of untreated urban wastewater into the aquatic environment.[30] Lead is one of the four metals that has the most adverse effects on human health and is the most widespread heavy and toxic element in the environment.

The sources of exposure to lead mainly include industrial processes, food, smoking and drinking water, sewage, battery factories, ammunition manufacturing, etc. It enters the water, and after entering the body, it replaces bone calcium in the production of enzymes It plays a role in the production of blood hemoglobin and causes disturbances. It also disrupts the production of kidney enzymes and bone problems (pluralism and blood and kidney diseases).

Lead has many negative effects on babies and in addition to the above dangers; it causes mental retardation.[31] Lead causes an increase in intracellular calcium by changing the distribution of calcium and by changing calcium exchange. Master pump Na+K ATPase by lead, activation of protein kinase C, increase of vasoconstrictor hormonal factors such as endothelin, changes in endothelium-dependent factors, NO, and reduction of vascular smooth muscle response to β-adrenoceptor agonists are among the possible mechanisms of lead on hypertension. One of the sources of exposure to lead metal is eating fish contaminated with this metal. Lead is a neurotoxin and is responsible for many metal poisonings in humans. The most important effect of this metal is on the fetus.[32] Lead poisoning is mostly related to the digestive system and central nervous system in children and adults. Poisoning with this metal can be acute or chronic. Acute exposure to lead can cause headaches, loss of appetite, abdominal pain, fatigue, insomnia, hallucinations, dizziness, kidney dysfunction, high blood pressure, and arthritis, while chronic exposure can lead to birth defects. Mental retardation, autism, psychosis, allergies and paralysis, weight loss, hyperactivity, muscle weakness, kidney damage, injury, and may even cause death.[19] Although lead poisoning is preventable, it is still a dangerous disease because it can affect most parts of the body. Exposure to high levels of lead can lead to the movement of the plasma membrane of the blood-brain barrier in the interstitial space, which leads to swelling.[33] Also, exposure to lead metal can disrupt the intracellular messenger system and the functioning of the nervous system. Change the center. The developing fetus and child are affected by neurotoxic effects due to exposure to lead metal.

The Centers for Disease Control in the United States reduced the tolerable level of lead in children's blood from 25 to 10 micrograms per deciliter and recommended universal blood lead screening for all children.[33] Lead metal has extensive effects on the central nervous system. It leads to brain cancer and lung cancer. According to the standards of the World Health Organization (WHO) and FAO (FAO), the maximum allowable amount of lead metal for fish is 0.5 ppm. Wet weight was determined.[34]

Cadmium (Cd)

Cadmium is a toxic non-essential metal that belongs to group IIB of the periodic table with an atomic mass of 1124, a melting point of 321 degrees Celsius, and a boiling point of 767 degrees Celsius. Cadmium is a soft pure element with moderate activity and its harmful compounds Metallic cadmium oxide and its less harmful compounds are cadmium sulfides. Which is dangerous for both human and animal health. This metal exists naturally in the environment as a pollutant that comes from agricultural and industrial sources. Cadmium, which enters the water through galvanized tanks and pipes, electronic industrial waste, insecticides, plastics and paints, nickel-cadmium batteries, etc., replaces zinc after entering the body and disrupts the work of some enzymes. Including adenosine triphosphatase.[35] The amount of cadmium absorption in food is caused by the way animals are fed, kidneys and liver are suitable places for cadmium concentration, and sea shells also have a high concentration of cadmium. The absorption of cadmium through the skin is very limited. The biological half-life of cadmium in humans in soft tissues and bones is ten to thirty years. The main effects of cadmium toxicity on the lungs are the kidneys and bones. The absorption of cadmium through the lungs is more effective than in the intestine.[36] So far, various researchers have investigated the effects of cadmium transfer from fish to humans and stated that humans may be exposed to this metal through inhalation and ingestion and suffer acute and chronic poisoning. Effects of exposure to cadmium are aggravated due to the inability to excrete it in the human body. Cadmium is reabsorbed by the kidney and thus limits its excrement. Short-term exposure to cadmium inhalation can cause severe lung damage and respiratory irritation, while higher doses can cause stomach irritation, resulting in vomiting and diarrhea. Long-term exposure to cadmium leads to its deposition in bones and lungs, similarly exposure to cadmium can cause bone and lung damage.[37] Absorption of an excessive amount of it in the body causes disturbances in the blood circulation system and kidneys, and like lead, it is considered a mineral, which causes environmental pollution due to some industrial activities and mining.[38,39] Some studies have shown that increased cadmium toxicity is associated with an increased risk of bone fractures in women, as well as decreased bone density and shorter height in both men and women. Cadmium is very toxic to the kidney and accumulates in higher concentrations in proximal tubular cells, so exposure to cadmium can cause kidney dysfunction and kidney disease. Also, exposure to cadmium can cause disturbances in calcium metabolism, formation of kidney stones, and hypercalciuria (high amount of calcium in urine). Cadmium is a metal that has a half-life of 30 years in bones and was introduced by the International Agency for Research on Cancer as a carcinogenic agent.[40,41] Also, the researchers stated that cadmium can cause testicular atrophy and is a potential risk factor for prostate cancer. It is worth mentioning that

according to international standards, including WHO and FAO, the maximum permissible amount of cadmium metal in fish is 0.05 ppm.[27]

Conclusion

In general, most heavy metals are toxic to the body at a very low level. The main mechanism of heavy metal toxicity includes the production of free radicals to cause oxidative stress, damage to biological molecules such as enzymes, proteins, lipids, nucleic acids, and DNA damage. The key is cancer as well as neurotoxicity. Some heavy metal toxicity may be acute while others may be chronic. Therefore, long-term exposure to these substances can lead to damage to several organs in the body, such as the brain, lungs, liver, and kidneys. In the present study, the high toxicity of lead and cadmium heavy metals was determined in fish. Therefore, if the permissible amount of these metals in the edible tissue of fish increases, it can cause many problems and problems in the health and health sectors of society. Considering this issue, it is recommended that careful monitoring and control be done on the quality of the consumables, especially Fish that are sold in the wholesale market and retailers should be adopted. Of course, it is worth mentioning that the realization of this goal is not possible except with the cooperation of related organizations and institutions such as the Fisheries and Environment Organization at the national and international levels.

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Conflicts of interest

The Authors declare that there are no conflicts of interest.

References

1. Sattari M, Bibak M, Vajargah MF, et al. Trace and major elements in muscle and liver tissues of Alosa braschnikowy from the South Caspian Sea and potential human health risk assessment. *J Mat Environ Sci*. 2020;11(7):1129–1140.
2. Vajargah MF, Namin JI, Mohsenpour R, et al. Histological effects of sublethal concentrations of insecticide Lindane on intestinal tissue of grass carp (*Ctenopharyngodon idella*). *Vet Res Commun*. 2021;45(4):373–380.
3. Yalsuyi AM, Vajargah MF. Recent advance on aspect of fisheries: a review. *J Coastal Life Med*. 2017;5(4):141–148.
4. Chorehi MM, Ghaffari H, Hossaini SA, et al. Acute toxicity of Diazinon to the Caspian vimba, *Vimba vimba persa* (Cypriniformes: Cyprinidae). *Int J Aqua Biol*. 2013;1(6):254–257.
5. Vajargah MF, Hossaini SA, Hedayati A. Acute toxicity test of two pesticides diazinon and deltamethrin on spirlin (*Alburnoides bipunctatus*) larvae and fingerling. *J Toxicol Environ Health Sci*. 2013;5(6):106–110.
6. Vajargah MF, Hedayati A. Acute toxicity of butachlor to and in vivo condition. *Transyl Rev Sys Ecol Res*. 2017;19(3):85–92.
7. Vajargah MF, Hedayati A, Yalsuyi AM, et al. Acute toxicity of Butachlor to Caspian Kutum (*Rutilus frisii Kutum* Kamensky, 1991). *J Environ Treatment Tech*. 2014;2(4):155–157.
8. Sattari M, Bibak M, Forouhar Vajargah M. Evaluation of trace elements contaminations in muscles of *Rutilus kutum* (Pisces: Cyprinidae) from the Southern shores of the Caspian Sea. *Environ Health Eng Manag J*. 2020;7(2):89–96.
9. Vajargah MF, Hedayati A. Toxicity effects of cadmium in grass carp (*Ctenopharyngodon idella*) and big head carp (*Hypophthalmichthys nobilis*). *Transyl Rev Sys Ecol Res*. 2017;19(1):43–48.
10. Vajargah MF. A review on the effects of heavy metals on aquatic animals. *J Biomed Res Environ Sci*. 2021;2(9):865–869
11. Ali H, Khan E, Ilahi I. Environmental chemistry and ecotoxicology of hazardous heavy metals: environmental persistence, toxicity, and bioaccumulation. *J Chem*. 2019.
12. Rajeshkumar S, Li X. Bioaccumulation of heavy metals in fish species from the Meiliang Bay, Taihu Lake, China. *Toxicol Rep*. 2018;5:288–295.
13. Jia Y, Wang L, Qu Z. Effects on heavy metal accumulation in freshwater fishes: species, tissues, and sizes. *Environ Sci Pollut Res*. 2017;24(10):9379–9386.
14. Radkhah AR, Eagderi S, Sadeghinejad Masouleh E. Investigation of antimicrobial properties of silver nanoparticles (AgNPs) to control diseases and health management in aquaculture systems. *J Ornament Aquat*. 2020;7(1):7–15.
15. FAO. The State of World fisheries and aquaculture 2020. Sustainability in action. Rome. 2020;244pp.
16. Liamanso R, Cheung Y, Chan KM. Metal concentration in the tissues of rabbit fish collected from Tolo harbour in Hong Kong. *Mar Pollut Bull*. 1999;39:123–134.
17. Mousavi SP, Ramzanipour MM, Vajargah MF. An overview on *Lutra lutra*. *J Biomed Res Environ Sci*. 2023;4(4):714–718.
18. Mona T, Heba MA, Eman S, et al. Impact of occupational cadmium exposure on bone in sewage workers. *Int J Occup Environ Health*. 2018;24(3–4):101–108.
19. Pourret O. On the necessity of banning the term "heavy metal" from the scientific literature. *Sustainability*. 2018;10(8):2879.
20. Jyothi NR. *Heavy metal sources and their effects on human health*. IntechOpen. 2020.
21. Jill CM, Hoseph JPM, Stephan DS. Metals. In: Wallace A Hayes, *Principles and methods of toxicology*. 4th Ed. Taylor and Francis. 2001;469–683.
22. Yilmaz AB, Dogan M. Heavy metals in water and in tissues of himri (*Carasobarbus luteus*) from Orontes (Asi) River Turkey. *Environ Monit Assess*. 2008;144(1–3):437–444.
23. Radkhah AR. Presence of heavy metals in aquatic ecosystems: A study on environmental consequences and provide principled solutions. The second national and specialized conference on environmental research in Iran. *Hegmataneh Assoc Environ Assess*. 2014;8pp.
24. Azaman F, Juahir H, Yunus K, et al. Heavy metal in fish: analysis and human health-a review. *Jurnal Teknologi*. 2015;77(1):61–69.
25. Castilhos ZC, Rodrigues-Filho S, Rodrigues APC, et al. Mercury contamination in fish from gold mining areas in Indonesia and human health risk assessment. *Sci Total Environ*. 2006;368(1):320–325 .
26. Birungi Z, Masola B, Zaranyika M, et al. Active biomonitoring of trace heavy metals using fish (*Oreochromis niloticus*) as bioindicator species. The case of Nakivubo wetland along Lake Victoria. *Phys Chem of the Earth*. 2007;32(15–18):1350–1358 .
27. Carver A, Gallicchio VS. Heavy metals and cancer. In book: *Cancer causing substances*. 2018.
28. Pais I, Jones JB. *The handbook of trace elements*. St. Lucie press New York, 2000.
29. Vajargah MF, Hossaini SA, Niazie EHN, et al. Acute toxicity of two pesticides Diazinon and Deltamethrin on Tench (*Tinca tinca*) larvae and fingerling. *Int J Aquat Biol*. 2013;1(3):138–142.
30. Derinola OJ, Clarke EO, Olarinmoye OM, et al. Heavy metals in surface water, sediments, fish and perwinkles of *Lagos Lagoon* American-Eurasian. *J Agri Environ Sci*. 2012;5:609–617.

31. Salvato JA, Nemerow NL, Agardy FJ. Environmental engineering and sanitation. John Wileyand Sons. 2000.

32. Kaplan O, Yildirim NC, Yildirim N, et al. Assessment of some heavy metals in drinking water samples of Tunceli, Turkey. *J Chem*. 2011;8(1):276–280.

33. Ahmed A, Baki M, Kundu MA. Human health risks from heavy metals in fish of Buriganga river, Bangladesh. *SpringerPlus*. 2016;5(1):1697.

34. Brar HK. Accumulation of heavy metals in fishes of freshwater. FAO/ WHO 2016. 2021.

35. Bigi H. Water health and treatment principle, Iran Rafie Andisheh, Ed 1. 2003

36. John R, Ahmad P, Gadgil K. et al. Effect of cadmium and lead on growth, biochemical parameters and uptake in *Lemna polyrrhiza* L. *Plant Soil Environ*. 2008;54(6):262–270.

37. Engwa GA, Ferdinand PU, Nwalo FN. Et al. Mechanism and health effects of heavy metal toxicity in humans. *Poisoning in the modern World- New tricks for an old dog?* IntechOpen. 2019.

38. Organization WH. Guidelines for drinking-water quality: recommendations: World Health Organization. 2004.

39. Sankar TV, Zynudheen AA, Anandan , et al. Distribution of organochlorine pesticides and heavy metal residues in fish and shellfish from Calicut region, Kerala, India. *Chemosphere*. 2006;65:583–590.

40. Carvalho M, Santiago S, Nunes ML. Assessment of the essential element and heavy metal content of edible fish muscle. *Anal Bioanal Chem*. 2005;382(2):426–432.

41. Fergusson JE. The heary elements: chemistry, environmental impact and health effects. Pergamon press, Oxford. 1990;614pp.

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