Heavy Metals Causing Toxicity in Fishes

Hadeel MHuseen¹ and Ahmed J Mohammed²

¹ Department of Biology, college of science, university of Baghdad
² Department of Biology, college of science, university of Baghdad

Email: hadeelhuseen87@gmail.com

Abstract. The heavy metals mainly include Pb, Hg, Cd, Cr, Cu, Zn, Mn, Ni, Ag, etc. The heavy metals, Pb, Cu, Zn are considered most toxic to humans, fishes and environment. Highly concentrations of heavy metals are harmful. They destabilize ecosystems because of their bioaccumulation in organisms, and toxic effects on biota and even death in most living beings. All heavy metals, in spite some of them are essential micronutrients, have their toxic effects on living organisms via metabolic interference and mutagenesis. The bioaccumulation of toxic metals can happen in the body and food chain. So, the toxic metals generally exhibit chronic toxicity. The heavy metals like Pb has significant toxic effects. The heavy metals are important pollutants for fishes, because these are not eliminated from aquatic systems by natural methods, such as organic pollutants, and are enriched in mineral organic substances. The fishes are a population which can be highly affected by these toxic pollutants. Heavy metals can have toxic effects on different organs. They can enter into the water by drainage, atmosphere, soil erosion, and all human activities in different ways. As the heavy metals concentrated more in the environment, they enter biogeochemical cycle, leading to toxicity.

Keywords: environment, fishes, heavy metals, toxicity

1. Introduction

The metal which has a relatively high density and toxic at low quantity is referred as ‘heavy metal’, e.g., arsenic (As), lead (Pb), mercury (Hg), cadmium (Cd), chromium (Cr), thallium (Tl), etc. Some ‘trace elements’ are also known as heavy metals, e.g., copper (Cu), selenium (Se) and zinc (Zn). They are essential to maintaining the body metabolism, but they are toxic at higher concentrations. The heavy metals can enter the bodies to a small extent via food, drinking water and air[1]. The heavy metals concerned with the environmental science chiefly include Pb, Hg, Cd, Cr, Cu, Zn, manganese (Mn), nickel (Ni), silver (Ag), etc.[2]. Further, the heavy metals are metallic elements which have a relatively high density, and they are poisonous at low quantity.

The excess quantities of heavy metals are detrimental as these destabilize the ecosystems because of their bioaccumulation in organisms, and elicit toxic effects on biota and even death in most living organisms[3].

Due to the formation of toxic soluble compounds, certain heavy metals become toxic. However, some metals are without any biological role or they are not needed by the body and they become
poisonous only in specific forms. However, any amount of Pb can result to detrimental effect. The ‘lighter metals’, e.g., beryllium can also be toxic in certain circumstances. Some ‘essential elements/metals’, e.g., iron (Fe) may also be toxic. Sometimes, the action of essential elements can be changed by the toxic metals, resulting in toxicity by interfering with the metabolic process. Therefore, most of the heavy metals are poisonous, while some metals are less toxic, e.g., bismuth (Bi)-Metalloids like As and polonium may also be toxic. Besides, both radiological and chemical toxicities can be induced by the radioactive metals. Similarly, the metals with abnormal oxidation phase can also be poisonous, e.g., Cr(III) is an essential trace element, while but Cr(VI) exhibit the carcinogenic effect\[4\]. All heavy metals, in spite some of them are essential micronutrients, have their toxic effects on living organisms via metabolic interference and mutagenesis. Such toxic effects of heavy metals include the reduction in fitness, interference in reproduction leading to carcinoma and finally death\[2\]. The heavy metals are important pollutants for fishes, because these are not eliminated from aquatic systems by natural methods, such as organic pollutants, and are enriched in mineral organic substances. The metal contaminants are mixed in the aquatic system through the smelting process, effluents, sewage and leaching of garbage which cause severe harm to the aquatic system.

2. Environmental and Health Risks by Heavy Metals

The heavy metals are accumulated in living organisms when they are taken up, and stored faster than they are broken down (metabolized) or excreted. They enter into the water supply by industrial and consumer materials, or even from acidic rain breaking down soils and releasing heavy metals into streams, lakes, rivers, and groundwater. The three most pollutant/environmental heavy metals have been reported include Pb, Hg and Cd\[1\], but some other heavy metals can also badly affect the environment. ‘Heavy metals toxicity’ has been reported to be caused by different means; e.g., from contamination of drinking-water (Pb pipes), high ambient air concentrations near emission sources, or from the food chain. The heavy metals are poisonous since they bioaccumulate. The ‘bioaccumulation’ means an increase in the level of a chemical/toxicant in a biological organism over time, compared to the chemical/toxicant level in the environment\[1\][3]. It is important to point out here that the most of the zoos which were once located on the outskirts of the cities and towns are now surrounded by human activities, such as vehicular traffic and industries. All these activities can cause heavy metal pollution, which may adversely affect the health and wellbeing of the wild animals housed in such protected areas\[3\].

2.1. Environmental and Health Risks by Lead:

Exposure of Pb can cause many effects depending on the level and duration of Pb-The developing fetus and infant are more sensitive than the adult. Mostly, the bulk of Pb is received from food; however, other sources may be more important like water in areas with Pb piping and plumb solvent water, air near a point of source emissions, soil, dust and paint flakes in old houses or contaminated land. In air\[2\], the Pb levels are brought in food through deposition of dust and rain containing metal on crops and soil. Eight broad categories of Pb use are: batteries; petrol additives; rolled and extruded products; alloys; pigments and compounds; cable sheathing; shot; and ammunition\[3\]. In the environment, the Pb comes from both natural and anthropogenic sources. The Pb exposure can be through drinking water, food, air, soil and dust from old paint. The Pb is among the most recycled non-ferrous metals, so its secondary production has grown steadily. The high levels of Pb may result in toxic effects in humans which in turn cause problems in the synthesis of hemoglobin (Hb), effects on kidneys, gastrointestinal tract (GIT), joints and reproductive system, and acute or chronic damage to nervous system\[4\]
2.2. Environmental and Health Risks by Copper:

In humans, the Cu is essentially needed but in high doses, anemia, liver and kidney damage, and stomach and intestinal irritation may occur—During Wilson’s disease, it affects greatly. It is normally found in drinking water from Cu pipes and additives designed to control the algae growth.[4][5]

2.3. Environmental and Health Risks by zinc

The human body contains 2–3 g zinc, and nearly 90% is found in muscle and bone. Other organs containing estimable concentrations of zinc include prostate, liver, the gastrointestinal tract, kidney, skin, lung, brain, heart, and pancreas. Oral uptake of zinc leads to absorption throughout the small intestine and distribution subsequently occurs via the serum, where it predominately exists bound to several proteins such as albumin, α-microglobulin, and transferring[6][7]

3. Material and method:

The samples of local fish, included:

River fish where samples of river fish had been collecting samples from the Tigris River to the south of Baghdad City (20 km) (Fig.1). The samples had included (Cyprinus carpio, Grass carp, Liza abu).

A particular weight from each sample had been taken of about 100 - 250 g and they were placed in the plastic box and clean and sterilized sacks for preventing the sample damage; particularly, the meat samples which later placed in an ice box and transferred to a laboratory to be tested immediately.[8]

![Figure.1 Tigris River to the south of Baghdad City (20 km).](image)

3.1. Lab. Tests:

Sample of 50-100g had been taken from each specimen with 3 replicates. For the meat samples, the meat was cut by a sharp knife into small pieces for increasing the area exposed for heat. For the fodder samples in form of grains (wheat, barley, poultry feed, and fish feed) were ground by the electric mill. All samples were dried by the oven at 70°C for two hours. After drying process was completed, the samples were transferred to Muffle Furnace at 450-500°C for four hours as the
furnace temperature was gradually increased on basis of 50Co per time so that all samples can be transformed into ash. After transforming all the samples into ash, the stage digestion was started.[8]

3.2. Digestion:

One gram of powdered sample was taken in tubes and digested by using HCl and HNO3 1:3 v/v 2 ml HCl and 6 ml HNO3 and heated for one hour in water bath at 70°C to ensure complete digestion. Shacked during the heating. Then cooled at room temperature, each tube was filtered by using filter paper the filtrate was collected in polyethylene tubes, then each filtrate was diluted with de-ionized the water to complete the volume to 25 ml. Tubes were capped with polyethylene films and kept at room temperature until analyzed for heavy metals content by flame atomic absorption Spectrometry model (2002).

Standard solutions had been used for the four elements out of high purity material supplied by Fluke and BDH companies. Also, control sample was prepared by using of 2 ml HCL + 6 ml HNO3 without adding meat powder to them. Then the volume was completed to 25 ml de by ionized water. The control sample was used for calibration of the apparatus prior to conducting the measurements of study samples.[9]

3.3. Statistical analysis:

The Statistical Analysis System- SAS (2012)[10] program was used to effect of different factors in study parameters. Chi-square test was used to significant compare between percentage and Least significant difference–LSD test (ANOVA) was used to significant compare between means in this study.

4. Results and Discussions:

Concentration of heavy metals in local fish meat

4.1. Lead concentration in Cyprinus Carpio:

Present study results showed seasonal variations of Pb concentrations in Cyprinus carpio. The concentrations of Pb in this study were found to be varied among the muscle, liver, gills. Study result revealed that the highest concentration of Pb was 9 mg/kg in Autumn in Cyprinus Carpio gills while the lowest concentration of Pb was 0.04 mg/kg in winter in Cyprinus Carpio muscle.

The results showed that the lead concentrations in fish meat were higher than the acceptable limit which is 1 mg/kg according to FAO/WHO Standards. The results study agree with the findings of George [11] Found the same results which were supported present study findings.[12]

The statistical analysis of the data revealed a significant differences in Pb concentration between the muscle, the liver, and gills. Present study findings showed that the higher concentration of lead in fish meat was 9 mg/kg found in Autumn which may be related to the region of river were the hunting of fish, because it polluted with hydrocarbons discharge from diesel which used in electrical generators that used by the near restaurants and pollution the air from cars fumes and the rate of lead accumulation was dependent on both holding salinity and the temperature.fish held at high temperature accumulated lead more rapidly than fish held at low the temperature. therefor lead concentration highly in Autumn because temperature is (22°C).[13] so lead accumulation was deplete the holding salinity

4.2. Lead concentration in Ctenopharyngodon idella (Grass carp):

Present study results showed seasonal variations of Pb concentration in Grass carp. The concentrations of Pb in this study were found to be varied among the muscle, gills and liver. Study
result revealed that the highest concentration of Pb was 5.47mg/kg in Autumn in liver, while the lowest concentration of Pb was 0.06 mg/kg in spring in the muscle.

The results showed that the lead concentrations in grass carp especially the liver was higher than the acceptable limit which is 1mg/kg according to FAO/WHO standards. The results study agree with the findings of Petkevich [14] Found the same results which were supported present study findings.

Statistical analysis of the data revealed that there were significant differences in Pb concentrations between the muscle, liver and the gills in the season of summer and autumn. While no significant differences between the gills, liver and muscle in season of winter and spring. Also the presence of lead in fish may be due to the contamination of the river itself because it located near Al-Dora refinery station which led to increase the concentration of lead and the rate of lead accumulation was dependent on both holding salinity and the temperature. fish held at high temperature accumulated lead more rapidly than fish held at low temperature. therefore lead concentration highly in Autumn because the temperature is(22°c).

4.3. Lead Concentration in Liza Abu:

Present study results showed seasonal variations of Pb concentration in Liza Abu. The concentrations of Pb in this study were found to be varied among the muscle, gills, liver. Study result revealed that the highest concentration of Pb was 10.8mg/kg in Autumn in muscle, while the lowest concentration of Pb was 0.002 mg/kg in liver in spring.

The results showed that the lead concentrations higher than the acceptable limit which is 1 mg/kg according to FAO/WHO Standards. The results study agree with the findings of Potula [15] Found the same results which were supported present study findings. Statistical analysis of the data revealed significant differences in Pb concentration between the gills, muscle and liver in Autumn and winter, while no significant difference between gills, muscle and liver in summer and spring. Heavy metals enter fishes not only by ingestion but also through dermal absorption and respiration.

Most fishes absorb heavy metals from the gills and intestine, then transfer to blood and other parts of the body. When these chemicals are taken by the fish, they bioaccumulate, biomagnify, and remain in the fish till they are caught and use as food by humans or eaten by bigger fishes which are eventually eaten by humans.

4.4. Copper concentration in Cyprinus Carpio:

Present study results showed seasonal variations of Cu concentration in Common carp. The concentrations of Cu in this study were found to be varied among the muscle, gills, liver. Study results revealed that the highest concentration of Cu was 26mg/kg in summer in gills, while the lowest concentration of Cu was 0.208 mg/kg in winter in muscle.

The results showed that the copper concentrations higher than the acceptable limit which is 2 mg/kg according to FAO/WHO Standards.

The results study agree with the findings of Mehj[16] Found the same results which were supported present study findings.

Statistical analysis of the data revealed significant differences in Cu concentration between the gills, the muscle and liver in summer and Autumn. While no significant differences in Cu concentration between the gills, the muscle and liver in winter and spring. Copper was a naturally occurring element that was found in air, water and food. Fish take up copper from the water they live in as they feed[17]
4.5. Copper concentration in grass carp:

Present study results showed seasonal variations of Cu concentration in Grass carp. The concentrations of Cu in this study were found to be varied among the muscle, gills, and liver. Study results revealed that the highest concentration of Cu was 5.7 mg/kg in summer in gills, while the lowest concentration of Cu was 0.01 mg/kg in spring in liver. The results showed that the copper concentrations were higher than the acceptable limit which is 2 mg/kg according to FAO/WHO Standards.

The results of the study agree with the findings of Ploetz [18] who found the same results which were supported by the present study findings.

Statistical analysis of the data revealed significant differences in Cu concentration between the gills, the liver, and muscle in summer and autumn. Also, statistical analysis showed no significant differences between the muscle and the liver in winter and spring. A greater concentration of copper in fish meat may be due to a greater intake of copper by contaminated fish feed. The main sources of copper contamination may be industrial wastes, pesticides, and fungicides.

4.6. Copper concentration in Liza abu:

Present study results showed seasonal variations of Cu concentration in Liza abu. The concentrations of Cu in this study were found to be varied among the muscle, gills, and liver. Study results revealed that the highest concentration of Cu was 6.05 mg/kg in autumn in liver, while the lowest concentration of Cu was 0.02 mg/kg in spring in liver. The results showed that the copper concentrations were higher than the acceptable limit which is 2 mg/kg according to FAO/WHO Standards. The results of the study agree with the findings of Zarith [19] who found the same results which were supported by the present study findings.

Statistical analysis of the data revealed significant differences in Cu concentration between the liver, the muscle, and gills in autumn season only. Also, statistical analysis showed no significant differences between the muscle and gills in summer, winter, and spring seasons.

Study results showed the higher concentration of Cu in fish liver because there are lots of business activities going on along the river course. Mechanic workshops, car wash, due to a greater intake of copper by contaminated fish feed.

4.7. Zinc concentration in Cyprinus Carpio:

Present study results showed seasonal variations of Zn concentration in Common carp. The concentrations of zinc in this study were found to be varied among the muscle, gills, and liver. Study results revealed that the highest concentration of Zn was 9.78 mg/kg in autumn in gills, while the lowest concentration of Zn was 0.01 mg/kg in spring in muscle. The results showed that the Zinc concentrations in gills were higher than the acceptable limit which is 3 mg/kg according to FAO/WHO standards.

The results of the study agree with the findings of Zubcov [20] who found the same results which were supported by the present study findings.

While the concentration of Zn in liver and muscle were within the acceptable limit which is 3 mg/kg according to FAO/WHO standards.

Statistical analysis of the data revealed significant differences in Zn concentration between the gills, the liver, and muscle in summer and autumn and winter, also statistical analysis showed no significant differences between the muscle and the liver and gills in spring only. Present study findings showed...
that higher concentrations of Zn in fish gills because contamination the source of water river it was near Al- Dora refinery which led to increasing the concentration of Zn

4.8. Zinc concentration in Grass carp:

Present study results showed seasonal variations of Zn concentration in grass carp. The concentrations of Zinc in this study were found to be varied among the muscle, liver, gills. Study results revealed that the highest concentration of Zn was 5.264mg/kg in Autumn in gills, while the lowest concentration of Zn was 0.13mg/kg in winter in muscle and liver. The results showed that the Zinc concentrations in gills were higher than the acceptable limit which is 3mg/kg according to FAO/WHO standards.

The results study agree with the findings of mehj [16] Found the same results which were supported present study findings.

While the concentration of Zn in liver and muscle were with in the acceptable limit which is 3mg/kg according to FAO/WHO standards.

Zinc was bioaccumulative, that means it was persistent and increase with time since it was non-biodegradable.

The study results showed that the high concentration of Zn in fish gills may be related to use the worm treatment in water, also drinking contaminated water breathing contaminated air near the burning of fossil fuels or municipal waste.

4.9. Zinc concentration in Liza Abu:

Present study results showed seasonal variations of Zn concentration in Liza Abu. The concentrations of Zn in this study were found to be varied among the muscle, gills and liver. Study results revealed that the highest concentration of Zn was 3.630mg/kg Summer in muscle, while the lowest concentration of Zn was 0.10mg/kg in spring in liver. The results showed that the Zinc concentrations in all type of tissues except muscle in summer were with in acceptable limit which is 3mg/kg in fish according to FAO/WHO standards. The results study agree with the findings of shovon[21] Found the same results which were supported present study findings. they found that the meat of fishes showed the highest concentration of Zn. But within the acceptable limits.

Statistical analysis of the data revealed that significant differences in Zn concentration between the fish muscle, gillis and liver in summer and Autumn and winter, no significant differences in Zn concentration between the gills, and liver in spring only. Zinc is present at low levels in most food making the largest contribution to dietary exposure[22].

5. Conclusion

The heavy metals Pb, Cu and Zn are most toxic to all human beings, animals, fishes and environment. The excess levels of heavy metals cause severe toxicity. Though some heavy metals are essential for animals, plants and several other organisms, all heavy metals exhibit their toxic effects via metabolic interference and mutagenesis. The Pb cause severe toxicity in all. Fishes are not the exception and they may also be highly polluted with heavy metals, leading to serious problems and ill-effects. The heavy metals can have toxic effects on different organs. They can enter into the water via drainage, atmosphere, soil erosion and all human activities by different ways. With increasing heavy metals in the environment, these elements enter the biogeochemical cycle leading to toxicity in animals, including fishes.
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