Heavy Metal on Fish

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Abstract: In general, metals can be categorized as biologically essential and non-essential. The nonessential metals (e.g., aluminum (Al), cadmium (Cd), mercury (Hg), tin (Sn) and lead (Pb)) have no proven biological function (also called xenobiotics or foreign elements), and their toxicity rises with increasing concentrations. Essential metals (e.g., copper (Cu), zinc (Zn), chromium (Cr), nickel (Ni), cobalt (Co), molybdenum (Mo) and iron (Fe)) on the other hand, have a known important biological roles.
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Introduction

Due to feeding and living in the aquatic environments fish are particularly vulnerable and heavily exposed to pollution because they cannot escape from the detrimental effects of pollutants [1-3]. Fish, in comparison with invertebrates, are more sensitive to many toxicants and are a convenient test subject for indication of ecosystem health [4-17]. Heavy metals are produced from a variety of natural and anthropogenic sources [18]. In aquatic environments, heavy metal pollution results from direct atmospheric deposition, geologic weathering or through the discharge of agricultural, municipal, residential or industrial waste products, also via wastewater treatment plants (WWTPs) [19-22]. Coal combustion is one of the most important anthropogenic emission sources of trace elements and an important source of a number of metals [23]. The contamination of heavy metals and metalloids in water and sediment, when occurring in higher concentrations, is a serious threat because of their toxicity, long persistence, and bioaccumulation and bio magnification in the food chain [24,25]. Fishes are considered to be most significant biomonitors in aquatic systems for the estimation of metal pollution level [26,27], they offer several specific advantages in describing the natural characteristics of aquatic systems and in assessing changes to habitats [28]. In addition, fish are located at the end of the aquatic food chain and may accumulate metals and pass them to human beings through food causing chronic or acute diseases [29]. Studies from the field and laboratory works showed that accumulation of heavy metals in a tissue is mainly dependent on water concentrations of metals and exposure period; although some other environmental factors such as water temperature, oxygen concentration, pH, hardness, salinity, alkalinity and dissolved organic carbon may affect and play significant roles in metal's accumulation and toxicity to fish [30-35]. Ecological needs, size and age of individuals, their life cycle, feeding habits, and the season of capture were also found to affect experimental results from the tissues [36-38]. Fish have the ability to uptake and concentrate metals directly from the surrounding water or indirectly from other organisms such as small fish, invertebrates, and aquatic vegetation [39]. Fish accumulate pollutants preferentially in their fatty tissues like liver and the effects become apparent when concentrations in such tissues attain a threshold level [40].

The pollution of the aquatic environment with heavy metals has become a worldwide problem during recent years, because they are indestructible and most of them have toxic effects on organisms. Among environmental pollutants, metals are particular concern, due to their potential toxic effect and ability to bioaccumulate in aquatic ecosystems [41, 42].

There is increasing concern about the quality of foods in several parts of world. The determination of toxic elements in food has prompted studies on toxicological effects of them in food. Heavy metals are considered the most important form of pollution of the aquatic environment because of their toxicity and accumulation by marine organisms [43, 44].

Aquatic foods have essential amino acids, fatty acids, protein, carbohydrates, vitamins and minerals. Among sea foods, fish are commonly consumed and, hence, are a connecting link for the transfer of toxic heavy metals in human beings. Heavy metals have the tendency to accumulate in various organs of marine

organisms, especially fish, which in turn may enter into the human metabolism through consumption causing serious health hazards.

Fishes are major part of the human diet and it is therefore not surprising that numerous studies have been carried out on metal pollution in different species of edible fish. Predominantly, fish toxicological and environmental studies have prompted interest in the determination of toxic elements in seafood [45-46].

A heavy metal is generally regarded as any relatively dense metal or metalloid of environmental concern. The term originated with reference to the harmful effects of metals like cadmium, mercury and lead, all of which are denser than iron. Commonly encountered heavy metals are chromium, cobalt, nickel, copper, zinc, arsenic, selenium, sliver, cadmium, antimony, mercury, thallium and lead.

Metals are introduced in aquatic systems as a result of the weathering of soils and rocks, from volcanic eruptions, and from a variety of human activities involving the mining, processing, or use of metals and/or substances that contain metal pollutants. The most common heavy metal pollutants are arsenic, cadmium, chromium, copper, nickel, lead and mercury.

What Happens When an Excess of Metals Enters Freshwater Ecosystems?

Where there is marked effect on speciation and strong binding of metal at the biological surface, the dominant effect of a decrease in pH will be to increase the metal availability.

Generally the ionic form of a metal is more toxic, because it can form toxic compounds with other ions. Electron transfer reactions that are connected with oxygen can lead to the production of toxic oxyradicals, a toxicity mechanism now known to be of considerable importance in both animals and plants. Some oxyradicals, such as superoxide anion (O^{2-}) and the hydroxyl radical (OH^{-}), can cause serious cellular damage. [47-48]

Bioaccumulation of Heavy Metals:

Metals in natural waters occur in particulates or in soluble forms, including labile and nonlabile fractions. The labile metal compounds are the most dangerous to fish. They include various ionic forms of different availability to fish. The results of many field studies of metal accumulation in fish living in polluted waters show that considerable amount of various metals may deposited in fish tissues without causing mortality. Various metals are accumulated in fish body in different amounts. These differences result from different affinity of metals to fish tissues, different uptake deposition and excretion. Generally, the higher metal concentration in the environment, the more it may be taken up and accumulated by fish. Relationship between metal concentrations in fish and water was observed in both, field and laboratory studies [49-50] (Fig. 1-4). Metals level in live fish usually follow the ranking; Fe>Zn>Pb>Cu>Cd>Hg

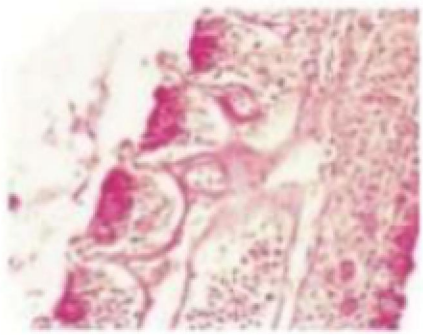


Fig. 1: Hyperactivation of goblet cells. Kargin, F. and C. Erdem, [50]

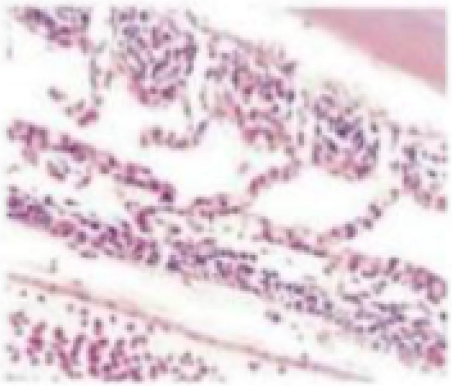
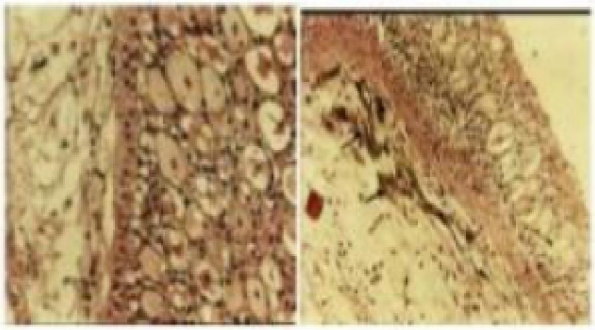


Fig. 2: Gills of Tilapia fish exposed/reared in areas heavily polluted with heavy metals showing lamellar edema and separation Kargin, F. and C. Erdem, [50]



Figs. 3 & 4: Skin of fish reared in polluted area with heavy metals showing hyperactivation of goblet cells and dermal melanosis. Kargin, F. and C. Erdem, [50]

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