A Review on Role of Aquatic Organisms As Bioindicator on Aquatic Ecosystem Due To Lead(Pb) And Cadmium(Cd) Pollution

Dr. Suchismita Chatterjee Saha

Assistant Professor, Nabadwip Vidyasagar College, Nabadwip Nadia, West Bengal, India

drschatterjee12@ gmail.com

Abstract

The biosphere is the living objects' natural world. It includes the planet and comprises surface portions of the lithosphere, the body and the hydrosphere. For species to live in the atmosphere, a reasonably homeostatic condition is important. To track any abnormal transition due to economic advancement and consequential growth of civilization, this includes the analysis of the chemical composition of air, water, and soil. Over the last few decades, the volume of water waste worldwide has risen. One of the most important water contamination sources is the application of extremely hazardous and non-degradable heavy metals (such as Lead, Cadmium, etc.) The effect on marine ecosystems is very fantastic. These heavy metals are taken explicitly from the water by water creatures, and indirectly by other animals belonging to the food chains. Since heavy metal ingestion is involved, certain physiological modifications are happening within the heavy metals such as reduction in growth and developmental defects and reduction in survival. Some organisms such as the Atlantic mackerel (*Scomber scombrus*) are used for calculation of heavy metal emissions as bioindicators and biomonitors. The purpose of this study is to discuss the significance of this organism in observing both the volume and quality aspects in relation to heavy metals, particularly lead and cadmium, in the water bodies' surroundings and how this heavy metal exposure can be avoided or managed.

Keywords: Aquatic Organisms, Bioindicator, Heavy Metal Pollution, Aquatic Ecosystems

INTRODUCTION

The quality of water is of critical importance for humanity, as this directly connects to human welfare[19]. Water is one of the most important natural resources. The pollution of soil and water is a major environmental concern due to the dispersal of urban and industrial waste created by human activity. Applications of water sludge to agricultural soil are responsible for moving pollutants into uncontaminated sites including dust and leachate, leading to habitat pollution, including regulated and unaccompanied disposal, accidental and process spillage, mining and metalliferous mine smelting [14]. A broad variety of contaminants such as inorganic and organic compounds include heavy metals, fuel and putrescible chemicals, toxic wastes, explosives, gasoline, phenol and textile dyes have great impacts on marine life. Heavy metals are the principal component responsible for the inorganic infections. They have other issues than organic pollutants[13].[10]. Sea metal contamination is less obvious and straight forward than other aquatic pollution, but its effect on marine and human environments is very common.

The incidence of metals depends on the age, the stage of development and other physiological factors. Fish accumulate large amounts of lead in their tissues and may thus constitute a major food source for humans. Fish are man's only big sources of lead and cadmium. Lead is a known poison to humans, and fish are the main sources of human lead exposure. Lead biotransformation is a harmful public health problem[11]. Soil microorganisms may degrade organic pollutants, whereas metals need physical removal or immobilization. Although many metals are important to the production of free radicals, all metals are toxic at elevated concentrations because they induce oxidative stress. Metals can also be toxic because they are capable of replacing essential metals with pigments or enzymes that disrupt their function. Thus, metals make the land unfit for plant growth and biodiversity destruction[14].

AIMS AND OBJECTIVES

The objective of this study is to discuss the effects of heavy metal pollution focusing the lead and cadmium pollution in marine life. We want to study the process of consumption of these heavy metals as well as the significance of the biomonitoring organism we have taken, i.e. Atlantic Mackerel (*Scomber scombrus*) in observing both the quantitative and qualitative aspects in relation to heavy metals, particularly lead and cadmium, in the water bodies' surroundings and also how we can control or manage this heavy metal exposure to the aquatic organisms.

Effects on fishes and other marine animals

Fish larvae are rising very rapidly. Many environmental factors such as temperature and accessible food and toxicants affect growth of fish larvae. The fish increase both in body length and mass under ideal conditions, at an adequate temperature and in ample amounts of food. On the other side, fish growth may be inhibited in water polluted by toxicants, e.g. heavy metals. Development inhibition is one of the distinct signs of metal toxicity in fish larvae. Thus, the length and mass of the fish body are environmental indicators[22]. Analysis results[4] have shown that 10 different fish species have the highest concentration of heavy metals in the kidney and liver. Contaminated sediments could endanger for benthic creatures and expose to dangerous concentrations of toxic chemicals for worms, crustaceans and insects. Certain toxic sediments by consuming benthic species reduce the supply of food for larger animals, including fish. Benthic species in the process of bioaccumulation pick up some pollutants in the sediment. When larger animals feed on these infected species, toxins are transported through their bodies and increase the food chain concentrations in a process called biomagnification[4]. Heavy metal components (carbonate, sulphate, organic compounds, humic, fulvic, amino acid) which form the insoluble salts or complexes are diluted and affected by different components on the surface water. It is calculated that these salts and complexes do little damage to marine species. Any of these plunge into sediments and are accumulated. However, as water pH decreases, heavy metals may be mobilised, released into the aquatic column and become toxic to aquatic biota. Low heavy metal concentrations can also cause persistent stress that cannot destroy the individual fish but can lead to lower body weight and smaller size, decreasing their competitive capacity for food and living conditions. Javed and Usmani[17] examined the toxic effects of heavy metals on soil microorganisms in situ and noted a detrimental effect on actinomycetes, mineral nitrogen assimilation, and oligonitrophilic bacteria[10]. Aquatic species, such as fish, directly and indirectly absorb toxins from polluted water across the food chain.

Using chemical fertilizers that contain heavy metal trace, allows fish to be polluted with these metals. In many species under field conditions, the effect of toxic materials on the completeness and activity of DNA was studied[25]. Several biomarkers were used as methods for genotoxic pollutant exposure detection. Such biomarkers include DNA adducts, chromosome aberrations, bridging of the

DNA strand, and micronuclei measurements. Erythrocytes are used primarily as centinel markers of genotoxic compounds exposure in fish. The analysis by[8] reported a ratio of cadmium to $P<0.05$ to ferritin(Fe). But the metal Pb could not substitute it with ferritin(Fe) in a fish blood.

The findings showed that other tissues absorbed this metal by increasing the lead density in fish[4]. Heavy metals in water are particularly harmful to fish and could drastically reduce fish populations' size or even extinct the whole fish population in contaminated reservoirs. Many authors' data show that heavy metals reduce fish larvae's survival and development. They may also cause behavioral defects (for instance, performance impairments of locomotives that increase predators susceptibility) or structural damage (mainly vertebral deformities). In laboratory condition popular carp larvae showed slower growth rates and decreased survivality when exposed to lead and copper containing water[24]. Exposure to copper has shown a substantial increase in the red cells' concentrations, blood glucose, and total cholesterol, which is prevented by skeletal ossification while lead induces scoliosis[15]—Vinodhini et al.[26] obsereved typical carp exposure from fish to heavymetals. Serum iron and copper levels have been raised. The findings showed that vitamin C decreased activity during prolonged heavy-metal exposure, suggesting oxidation caused by reactive oxygen species. In fish, physiological functions, individual development, reproduction, and mortality are impaired by heavy metals' toxic effects. The main route of the absorption of this metal was observed by food and through gills since the main way of the manganese penetration was done through gills, which was detected in high concentrations in different fish species' gill tissues. The reduced growth was observed in marine elf fish speciesin the northern Gulf for 20 days or more exposure to heavy metal concentrations (Cd and Pb). These heavy metals are accumulated in liver, stomach and gill tissues[2]. But high Pb concentrations observed in gills[9]. Cd also accumulated mainly in gill tissues[3].

The concept of bioindicator and biomonitoring

A biomarker is an organism (or part of an organism or an organism community) that contains information on environmental quality (or a part of the environment).

On the other hand, a biomonitor is an organism (which is part of a body or a body population) with knowledge on quantitative environmental quality aspects. A biomonitor does not always fulfillall the requirements[20]. Heavy metals are natural water-based trace components, but their levels have increased due to the manufacturing, agricultural, and mining activities. This exposes marine species to high concentrations of heavy metals. The amounts of metals in the top sections of the food chain, such as fish, are also higher than those in the water or sediments. Aquatic species differ according to its metal uptake capacity. The regulators (excluders) and accumulators can be grouped into two types (non-excluders). Heavy metal accumulation was described as an indirect measure of metals' concentration and availability in marine environment in tissues of marine species. This is why fish tissue monitoring is a critical early indicator for sediment pollution or related water quality issues and helps us to take effective steps to protect public health and the environment[21]. Heavy metal levels are typically controlled by measuring water, sediments and related biota concentrations in water environments that normally occurs at lower levels of water and exceed a substantial sediment and biological concentration[9].

Aquatic organisms as biomonitor or Bioindicator

Over the past decades, many species have been studied to determine their potential as a biomonitoring organism and marine fish are famous for heavy metal monitoring. Therefore, the impact of accumulation and purification of heavy metals on the biomonitoring organism must be assessed. Pb and Cd are non-essential and considered significant industrial hazards. Still, many heavy metals are trace nutrients that cause serious toxic effects in higher animals at acute or chronic exposures. These two elements are extremely persistent and in fish form in biological systems stable inorganic and organic complexes[1]. In the water world, the water species take heavy metals in dissolved form readily where they are closely connected and accumulate in their tissue with sulfohydride protein groups. Fish consume metals dissolved or usable and can therefore function in a water ecosystem as a reliable metal contamination indicator. Atlantic mackerel (*Scomber scombrus*), due to its feeding activity and bottom-feeding habits, was considered an excellent research organism for heavy metal contamination[1]. The most susceptible to contaminants is commonly regarded as fish embryos and larvae, so they are widely used as bioindicators for water quality assessment[12].

MATERIALS AND METHODS

Detection of heavy metals in fish samples

The choice of analytical method depends on the material to be studied, its availability and the intent of the study[5]. For the determination of trace and toxic metals in a variety of environmental samples, many analytical techniques have been suggested, including flamma atomic absorption spectrometry (AAS), furnace graphite atomic absorption spectrometry (GFAAS). Flame spectrometry (FAAS) is one of the most common conventional analysis techniques for trace element determination and low susceptibility. The trace quantity of heavy metals in environmental samples must be calculated using pre-concentration methods combined with spectroscopic methods like ICP-AES and FAAS[7].

RESULT AND DISCUSSION

Several researchers have studied heavy metal levels in different Species of Atlantic Meckerel which can easily be collected and detected in any season. Tables 1 to 5 summarize some of the findings for heavy metal levels in marine fish examined by several scientists and their levels in several organs (flesh, liver, gills and bone). This study addresses two common heavy metals: lead and cadmium. All these metals are natural substances, mostly at low levels in the atmosphere. They can be harmful in greater quantities. El Bialy et al.[10] studied these heavy metals as shown in Table 1. Two types of samples, dry ash and wet ash, reflect various types of fish muscle tissue through atomic absorption spectrometry. The Pb and Cd levels obtained are higher by the wet ash method than the dry ash method . Owing to the high temperature (450°C – 600°C),the ashing process is completed, causing a partial or full loss through several trace elements' volatilisation.

Table 1:Concentration of Lead and Cadmium in fish muscle of *Scomber scombrus* (µg/g) [10]

Heavy Metals	Dry Ash Method (µg/g)	Wet Ash Method (µg/g)
Pb	1.55-2.58	2.13-8.90
Cd	1.39-2.94	1.80-3.90

Khaled[18] has examined some heavy metals obtained from El Mex Bay, Alexandria, Egypt, in muscles, gills, livers and bones, which were seen in the winter in Table 2.

Table 2: Mean concentration of heavy metals (µg/g wetwt.) in the selected fish species (*Scomberscombrus*)[18]

Elements	Flesh (µg/g)	Liver (µg/g)	Gills (µg/g)	Bones (µg/g)
Pb	0.58-0.94	1.51-3.17	3.32-4.49	5.45-8.69
Cd	0.18-0.54	0.71-2.70	0.74-1.16	0.80-1.09

In this analysis, Cd's distribution pattern was decreasing by liver > gills > bone > muscle. This indicates that the liver tended to be the highest organ of Cd that accumulates. Bone was the organ with the highest body build-up. The findings show that the metal concentrations in gill and liver tissues are the highest in comparison to muscles.Gills and liver tissue are active metabolic tissues.As gills and liver of fish is not consumed by human beings so there is little chance of contamination by these heavy metals.

Heavy metal concentrations have been identified in sixty fish samples from Antalya Bay in Turkey during autumn, winter, spring and summer seasons which are summarized below in Table 3.

Table 3: Heavy metal concentrations in different tissuesof *Scombers combrus*from Antalya Bay (mg/kg)[3]

Tissues	Muscle (mg/kg) (Perugini, 2014)	Liver (mg/kg) (Vieira, 2011)	Gills (mg/kg) (Makedonski, 2017)
Pb	0.36-50.69	0.12-30.36	1.47-111.80
Cd	0.07-0.11	0.06-0.12	0.09-0.36

The pollutants in fish obtained from the New Jersey supermarkets inducing cadmium and lead were calculated by Burger and Gochfeld[6].The Pb and Cd range is shown in Table 4, (ppm, wet weight). Fish toxins may put the fish itself, their predators and the people who eat them at risk of health. In general the public does not have access to pollutant information on these large ranges of metals in commercial fish, and the researchers indicated that further information is required on the levels of pollutants in fish from particular regions. Such data on levels of pollutants in fish from specific regions of the world would allow people to decide which fish to eat to reduce their risk of contaminants.

Table 4: Concentration range (ppm, wet weight) in fish (*Scomber scombrus)* from New Jersey markets(Burger and Gochfeld 2005)[6].

Elements	Flesh (ppm)
Pb	0.14-.0.22
Cd	0.0001-0.01

In edible tissue and gills of *Scomber scombrus*, Stanchevai et al.[23] have calculated and compared the heavy metal (Pb and Cd) material. Two separate areas of the Black Sea, Varna Lake and Nesebar, have collected the fish samples. Table 5 presents the data obtained for the content of heavy metals in studied fish.

Table 5: Heavy metal concentration in *Scomberscombrus* (mg/kgwetweight)(mean ± SD) [23]

Location	Varna Lake		Nesebar	
Tissues	Muscle (mg/kg)	Gill (mg/kg)	Muscle (mg/kg)	Gill (mg/kg)
Cd	0.029±0.007	0.034±0.008	0.017±0.007	0.018±0.007
Pb	0.12±0.06	0.13±0.07	0.10±0.05	0.12±0.06

Fom the above mentioned table we observe that the rate of heavy metal consumption in the different body tissues of *Scomber scombrus* collected from Varna Lake is greater than the same species collected from the Nesebar. It is also observed that the higher consumption rate of lead than the cadmium and the consumption of heavy metals in the tissues of gill are greater than the tissues of muscle in fishes collected from the Varna lake and Nesebar both. From this result we can conclude that the rate of lead pollution is quite higher than the cadmium pollution in the both Varna lake and Nesebar, and also the Nesebar has less toxicity of heavy metals than the Varna lake.

Heavy metals accumulate in various tissues with varying concentrations, according to this report that the metal concentration was usually less in the muscles than gills. Cadmium formed mostly in gills while the edible tissue had lower concentrations of heavy metals. The findings provide us new evidence on how these metals are distributed in fish gills and comestible tissue.
These findings can be used to assess fish's chemical content to determine the potential risk of human consumption. A certain degree of bio-accumulation also suggested the concentration of heavy metals reported in the fish pieces.

CONCLUSION AND RECOMMENDATIONS

Aquatic pollution affecting the physiology, production, growth, or survival of fish influence fish's human consumption at the top of the food chain [12]. Heavy metal accumulation in organism tissues can lead to chronic disease and potentially harmful to the population. In biological trials, water quality effluent and surface water were also used by aquatic animals. The production of biological fish monitoring techniques provides the possibility of regulation of water contamination by reacting rapidly to low levels of direct toxicants. The development of chemical and biological procedures for effective environmental control of heavy metals is an area of concern and a crucial phase in developing the management of environmental waste[1]. The study showed clearly that the organ of fish species has a large accumulation of heavy metals, and that marine fish can accumulate contaminants in the aquatic environment that can be used as bioindicators of marine metals. Potential bioindicators for aquatic contamination and their point of view for essential biomarkers were suggested and used. Aquatic pollution usually includes different chemicals that interact. Studies on metal-metal interactions are also important. Instead, some metals are easily connected to organic substances and cannot, therefore, be identified in water, but may be accessible later in fish-food. Fish of different species, gender, size and age should be taken into account in field studies. A definitive analysis document will entail additional work. Initial modeling studies using physical and chemical constants may provide strong but large biogeochemical output estimates. The recommendations mentioned above can then lead to early environmental surveys strategies for investigating heavy metal pollution in marine biota.

In the management of point and point source dislodges, the impact of long-term stress on marine species particularly on fish is a key factor and the ability to adapt to heavy metal contaminants' persistent stresses. The development of laboratory test systems to assess chronic stress is therefore important. Efforts should focus on chronic and bioaccumulation results. The methods should predict these effects and predict the lower and higher biological organisation levels under field conditions.

These studies' goal should be to quantify the available biological heavy metals and how all these factors interrelate with the spatial and temporal scales. The resulting changes in species composition and abundance will help shed light on the long-term low level of pollutant input to coastal systems. Due to our present inability to distinguish between pollutant effects and natural variability, such improvements are frequently confused. The authorities responsible should implement and enforce a more rigorous strategy to curb the dumping of waste from heavy metals in the marine environment.

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