International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2015): 78.96 | Impact Factor (2015): 6.391

Toxicity of Heavy Metals and their Effects on Freshwater Fish Cyprinus Carpio in River Bhavani

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Abstract: ***The environment is everything that surrounds us and gives us life and health. The aim of the study is to determine the accumulation of heavy metals in fish Cyprinus carpio in river Bhavani. The accumulation of metals in water were observed and bioaccumulations of heavy metals like Cd, Cr, Cu, Fe, Pb, Zn, Mg, in fresh water fish were evaluated. The evaluations were calculated in percentage. Toxic pollution arrives from heavy metals, such as cadmium, chromium, copper, iron, lead, zinc, magnesium. These metals pollute the surface water and ground water. It affects the fish and human beings. The accumulation of metals in tissues like gill, liver, intestine, kidney and muscle were observed and evaluated. The changes in river and fish were noted.***

Keywords: Cyprinus carpio, Bhavani river, metals- Cd, Cr, Cu, Fe, Pb, Zn, Mg, Accumulation, Bioaccumulation.

1. Introduction

Over two thirds of Earth's surface is covered by water, less than a third is taken up by land. As Earth's population continues to grow, people are disposing ever-increasing pressure on the planet's water resources. Pollution is a *human problem* because it is a relatively recent development in the planet's history. Before the 19th century Industrial Revolution, people lived more in harmony with their immediate environment. As industrialization has spread around the globe, the problem of pollution has spread with it. When Earth's population was much smaller, no one believed pollution would ever present a serious problem. It was once popularly believed that the oceans were far too big to pollute. Today, with around 7 billion people on the planet, it has become apparent that there are limits. Pollution is one of the signs that humans have exceeded those limits. Pollution from toxic chemicals threatens life on this planet. Every ocean and every continent, from the tropics to the once-pristine polar regions, is contaminated." Water pollution can be defined in many ways. Usually, it means one or more substances have built up in water to such an extent that they cause problems for animals or people. Oceans, lakes, rivers, and other inland waters can naturally clean up a certain amount of pollution by dispersing it harmlessly. The chemicals, metals, fertilizers have an effect on the quality of the water. This, in turn, could affect the health of all the plants, animals, and humans whose lives depend on the river. (Chris Woodford, 2016).

Water pollution depends on the quantities, how much of a polluting substance is released and how big a volume of water it is released into. A small quantity of a toxic chemical may have little impact if it is spilled into the ocean from a ship. But the same amount of the same chemical can have a much bigger impact pumped into a lake or river, where there is less clean water to disperse it. Water pollution almost always means that some damage has been done to an ocean, river, lake, or other water source. A 1969 United Nations report defined pollution as: When we think of Earth's water resources, we think of huge oceans, lakes, and rivers. Water resources like these are called surface waters. The most obvious type of water pollution affects surface waters. A spill from an oil tanker creates an oil slick that can affect a vast area of the ocean. Not all of Earth's water sits on its surface, however a great deal of water is held in underground rock structures known as aquifers, which we cannot see and seldom think about. Water stored underground in aquifers is known as groundwater. Aquifers feed our rivers and supply much of our drinking water. They too can become polluted, for example, when weed killers used in people's gardens drain into the ground. Groundwater pollution is much less obvious than surface-water pollution, but is no less of a problem. In 1996, a study in Iowa in the United States found that over half the state's groundwater wells were contaminated with weed killers (Dana Koplin, 1997).

Surface waters and groundwater are the two types of water resources that are affected by pollution. There are also two different ways in which pollution can occur. If pollution comes from a single location, such as a discharge pipe attached to a factory, it is known as point-source pollution. Other examples of point source pollution include an oil spill from a tanker, a discharge from a smoke stack (factory chimney), or pouring oil from car down a drain. A great deal of water pollution happens not from one single source but from many different scattered sources. This is called nonpoint-source pollution. Most water pollution doesn't begin in the water itself. Take the oceans: around 80 percent of ocean pollution enters our seas from the land. Virtually any human activity can have an effect on the quality of our water environment. When farmers fertilize the fields, the chemicals they use are gradually washed by rain into the groundwater or surface waters nearby. Sometimes the causes of water pollution are quite surprising. Chemicals released by smokestacks (chimneys) can enter the atmosphere and then fall back to earth as rain, entering seas, rivers, and lakes and causing water pollution. That's called atmospheric deposition. Water pollution has many different causes and this is one of the reasons why it is such a difficult problem to solve.

Another kind of toxic pollution comes from heavy metals, such as cadmium, chromium, copper, iron, lead, zinc, magnesium and mercury. Lead was once commonly used in gasoline (petrol), though its use is now restricted in some countries. Mercury and cadmium are still used in batteries (though some brands now use other metals instead). Until recently, a highly toxic chemical called tributyltin (TBT) was used in paints to protect boats from the ravaging effects of the oceans. Ironically, however, TBT was gradually recognized as a pollutant: boats painted with it were doing as much damage to the oceans as the oceans were doing to the boats. The best known example of heavy metal pollution in the oceans took place in 1938 when a Japanese factory discharged a significant amount of mercury metal into Minamata Bay, contaminating the fish stocks there. It took a decade for the problem to come to light. By that time, many local people had eaten the fish and around 2000 were poisoned. Hundreds of people were left dead or disabled. Pollution matters because it harms the environment on which people depend. The environment is not something distant and separate from our lives. The environment is everything that surrounds us that gives us life and health. Destroying the environment ultimately reduces the quality of our own lives (Kosei Pub, 1997). There are many rivers in Tamilnadu state. But the major river is Bhavani and it is joined by other six rivers. The other six rivers are on the bank of Bhavani river.

Bhavani is a major river in Kongu Nadu region of Tamil Nadu, India. It is the second longest river in Tamil Nadu and a major tributary of the Kaveri River. Bhavani river originates from Nilgiri hills of the Western Ghats, enters the Silent Valley National Park in Kerala and flows back towards Tamil Nadu. The Bhavani is a 217-kilometre (135 mi) long perennial river fed mostly by the southwest monsoon and supplemented by the northeast monsoon. Its watershed drains an area of 0.62 million hectares (2,400 sq mi) spread over Tamil Nadu (87%), Kerala (9%) and Karnataka (4%). The main river courses majorly through Coimbatore district and Erode district in Tamil Nadu. About 90 per cent of the river's water is used for agriculture irrigation. Twelve major rivulets including West and East Varagar rivers join Bhavani draining the southern Nilgiri slopes. At Mukkali, Bhavani takes an abrupt 120-degree turn towards the northeast and flows for another 25 kilometres (16 mi) through Attappady plateau. It gets reinforced by the Kunda river coming from the north. Siruvani river, a perennial stream and the Kodungarapallam river, flowing from the south and southeast respectively join the Bhavani at Kerala-Tamil Nadu border (NDT, 2016). The river then flows east along the base of Nilgiris and enters the plains near Bathra Kaliamman temple at Mettupalayam after joining with Coonoor river coming from northwest.

About 30 kilometres (19 mi) downstream, Moyar River, a major tributary originating in Mudumalai National Park, flows in from the northwest, where it drains the valley between the northern slopes of the Nilgiris and the southern slopes of the Bilgiri Hills. After the Moyar it is blocked by the Lower Bhavani Dam, feeding Lower Bhavani Project Canal near Sathyamangalam in Erode District. The river continues east for over 160 kilometres (99 mi) through Erode District, traversing Kodiveri Dam, near Gobichettipalayam which feeds the Arakkankottai and Thadappalli canals constructed for agricultural purposes (Hindu, 2016). A small barrage across the river was built by Kalingarayan in 1283 AD to feed the 90-kilometre (56 mi) Kalingarayan irrigation canal The river joins Kaveri at Kooduthurai near SangameswararTemple, Bhavani where it is believed that the mystic Saraswati River also joins the confluence *(CSTI*, 2016, *TNAU, 2016)* Bhavanisagar.

Bhavanisagar dam is located on the Bhavani river in Erode district, Tamil Nadu, India (Indian Archaeology, 1994). The dam is one of the largest earthen dams in the world. The dam is situated some 16 km (9.9 mi) west of Sathyamangalam and 35 km (22 mi) from Gobichettipalayam. The Lower Bhavani Project was the first major irrigation project initiated in India after independence in 1948. It was completed by 1955 and opened for use in 1956. The dam was constructed at a cost of ₹210 million (US$3.1 million). The dam is 8 km (5.0 mi) long and 40 m (130 ft) high. The full reservoir level is 120 ft (37 m) and the dam has a capacity of 32.8×10^9 cu ft (930×10^6 m^3). The dam has two hydel power stations, one on the east bank canal and the other on the Bhavani river. Each has a capacity of 16 megawatts (21,000 hp) for a total capacity of 32 megawatts (43,000 hp). Industrial, municipal and agricultural pollution of the river results in poor water quality and negative impacts on the health of people, plants and animals dependent on the river water (Govt of TN, 2016).

The major river Bhavani consists of variety of fishes. Now a days this river is getting polluted by the chemical like dyes, pesticides, fertilizers, especially heavy metals like cadmium, chromium, copper, iron, lead, zinc, and magnesium. Fishes like *Cyprinus carpio, Cirrhinus mrigala, Catla catla, Labeo rohita* were found in this river. The above said metals accumulate in the fishes. Fish tissues are sensitive indicators of aquatic pollution (Mela et al., 2007). The exposure of fish to these contaminants is likely to induce a number of lesions in different organs like gills (Cengiz and Unlu, 2006), liver (Korkman et al., 2009), kidney (Bucher and Hofer, 1993), intestine (Brunelli et al., 2008), Muscle (Costa et al., 2009). These metals are absorbed by the gills and digestive tract and accumulate in the internal organs and tissues (Levesque et al., 2003). Gills are the primary organ for respiration, iono and osmoregulation, acid base balance. The gills in fish is a valuable model for assessing the effects of toxicants on cells and tissues (Mallatt et al., 1995). Liver and muscle plays an important role in vital functions in basic metabolism and it is the major organ of accumulation, biotransformation and excretion of contaminants in fish (Wu et al., 2008). Kidney and intestine is the predominant organ involved in the regulation of intra and extra cellular volume and control of electrolytes and acid-base balance and major site of foundation of hormones that influence systemic metabolic functions. The metals like cadmium, chromium, copper, iron, lead, zinc, and magnesium are of particular interest because they are toxic to aquatic organisms and are persistent in the environment in excess and they accumulate in different organs and many changes were observed and were discussed in the discussion part (Mendil et al., 2005).

2. Materials and Methods

Sample collection: Fish samples from both sites were caught using gill netsand analysis were carried out according to APHA. The nearest length (mm) and weight (gram) of each fish were measured. The fishes were washed using deionized water and place in separated polyethylene bags with ice. The samples were kept frozen at -20°C until ready for analyses. For water sampling, polyethylene bottles were acid-washed with 10% concentrated nitric acid HNO3 (v/v) and rinsed thoroughly with distilled deionized water. All glassware and equipment used were acid–washed. The bottles were rinsed three times and immersed about 10 cm below the water surface before sampling. Three 500 ml of water samples were taken at each sampling point, and kept in ice while been transported to laboratory. The samples were filtered through 0.45 µm micropore membrane filter and acidified with concentrated HNO3 (65%) to a pH less than 2. The samples were kept at 4°C before treatment.

Sample preparation for water: About 9ml of concentrated HNO3 were added to filtered water sample and heated gently at 70°C until the solution become transparent. The solutions were allowed to cool and filtered using 0.45µm micropore membrane filter. The solutions were then added up with ultra-pure of water to 100ml and analyzed for trace metal concentration.

Sample preparation of fish: All the glassware and plastics were soaked overnight in 10% (v/v) nitric acid rinsed with distilled water and deionized water and dried before being used. Five gram of boneless muscle tissue, gills, liver, intestine, kidney were removed using stainless steel knife and was digested to a strong acid digestion (H2O2+HNO3 conc.) mixture at 1: 3 ratios at 150°C for 20 minutes and allowed to cool at room temperature. Samples were processed in duplicate and then diluted to a total 50ml with ultra-pure water and filtered through 0.45 µm micropore membrane filter paper for analyses.

2.1 Reagents

All reagents were of analytical reagent grade. Ultra-pure water was used for all dilutions. The element standard solutions from Perkin Elmer that were used for the calibrations were prepared by diluting stock solutions of mg/mL.

2.2 Heavy metal analysis

All samples were digested in concentrated HNO3 and H2O2 in a beaker. The samples were then diluted until 50 ml with ultra-pure water. After filtration, the prepared samples were determined for Cd, Cr, Cu, Fe, Pb, Zn, Mg, by using atomic absorption spectrophotometer (AAS) and Inductively Coupled Plasma (ICP-MS). Heavy metals included in this study are: Cd (Cadmium), Cr (Chromium), Cu (Copper), Fe (Iron), Pb (Lead), Zn (Zinc), Mg (Magnesium), Element standard solution from Perkin Elmer was prepared by diluting stock solutions of 100mg/mL.

3. Result

Table 1. represents the accumulation of metals Cd, Cr, Cu, Fe, Pb, Zn, Mg in water and the lethal concentration of metal were determined as 1.4, 1.5, 1.7, 1.0, 8.5, 5.7, 4.2. Accumulation of different metals in fish Cyprinus carpio in gill, liver, intestine, kidney and muscle were evaluated in percentage and the changes were noted. The accumulation in liver and kidney were high in percent when compared to the gill, intestine and muscle. The liver and kidney plays an important role in the living organisms especially in fish.

Table 1: River Bhavani
Accumulation of Metals in Bhavani River

S.No	Metals	Accumulation of metals in water
1	Cd	1.4
2	Cr	1.5
3	Cu	1.7
4	Fe	1.0
5	Pb	8.5
6	Zn	5.7
7	Mg	4.2

Fish in River Bhavani
1. Cyprinus carpio

Accumulation of Metals
1. Cadmium
2. Chromium
3. Copper
4. Iron
5. Lead
6. Zinc
7. Magnesium

Bioaccumulation of Metals in Fishes

Cyprinus Carpio
Bioaccumulation of metals and their concentration in tissues of freshwater fish Cyprinus carpio

Metal Cadmium

Exposure period

Tissues	Control group	24	48	72	96	Percentage Change
Gills	1.4	1.6	1.8	2.0	2.4	82
Liver	2.0	2.3	2.4	2.6	2.8	80
Intestine	2.3	2.5	2.6	2.8	2.9	78
Kidney	2.2	2.3	2.5	2.6	2.8	78
Muscle	1.9	1.9	2.0	2.1	2.2	76

Metal Chromium

Tissues	*Control group*	*24*	*48*	*72*	*96*	*Percentage Change*
Gills	1.2	1.6	1.8	2.1	2.3	84
Liver	2.2	2.4	2.5	2.6	2.8	84
Intestine	2.0	2.2	2.3	2.5	2.6	79
Kidney	2.4	2.5	2.6	2.7	2.9	77
Muscle	1.7	1.9	2.2	2.3	2.5	80

Metal Copper

Tissues	*Control group*	*24*	*48*	*72*	*96*	*Percentage Change*
Gills	1.4	1.4	1.5	1.9	2.0	79
Liver	2.0	2.2	2.4	2.6	2.8	80
Intestine	1.9	2.1	2.3	2.4	2.6	79
Kidney	2.2	2.4	2.6	2.7	2.9	79
Muscle	1.4	1.6	1.8	2.0	2.1	81

Metal Iron

Tissues	*Control group*	*24*	*48*	*72*	*96*	*Percentage Change*
Gills	1.0	1.1	1.2	1.3	1.4	80
Liver	1.5	1.6	1.7	1.8	1.8	78
Intestine	1.2	1.3	1.3	1.5	1.6	78
Kidney	1.4	1.5	1.6	1.7	1.9	79
Muscle	1.3	1.4	1.5	1.6	1.6	78

Metal Lead

Tissues	*Control group*	*24*	*48*	*72*	*96*	*Percentage Change*
Gills	2.2	2.4	2.5	2.6	2.8	78
Liver	2.4	2.5	2.6	2.7	2.9	77
Intestine	2.0	2.2	2.3	2.5	2.6	78
Kidney	2.3	2.4	2.5	2.6	2.7	79
Muscle	1.7	1.9	2.2	2.3	2.5	80

Metal Zinc

Tissues	*Control group*	*24*	*48*	*72*	*96*	*Percentage Change*
Gills	.0	2.2	2.3	2.5	2.6	79
Liver	2.3	2.4	2.5	2.6	2.7	77
Intestine	2.2	2.4	2.5	2.6	2.8	78
Kidney	2.4	2.5	2.6	2.7	2.9	77
Muscle	1.2	1.6	1.8	2.1	2.3	84

Metal Magnesium

Tissues	*Control group*	*24*	*48*	*72*	*96*	*Percentage change*
Gills	2.4	2.5	2.6	2.7	2.9	77
Liver	2.5	2.7	2.8	2.9	3.0	78
Intestine	2.2	2.4	2.5	2.6	2.8	78
Kidney	2.3	2.5	2.6	2.8	2.9	77
Muscle	2.0	2.2	2.3	2.5	2.6	79

4. Discussion

On world wide scale the anthropogenic chemicals and metals have resulted ecotoxicological effects. Aquatic bodies are traditional recipients in industrial waste containing heavy metals, salts, chemicals and pesticides which when released in higher concentrations cause deleterious effect on organisms. Persistant presence of pollutants like heavy metals in aquatic ecosystems has reportedly caused metabolic stress in organisms even to extent of mortality (Shaffi et al., 2001). Among aquatic habitants, fish is the most susceptible to elemental contaminants than any other aquatic habitants. Fish community structure has been widely used to assess the effect of human import on aquatic ecosystem including water quality deterioration and habit changes. High levels of metals discharged in aquatic ecosystems might result in selective elimination of most sensitive life stage of vulnerable fish species (Bervoet et al., 2005).

The term bioaccumulation is defined as a process by which the chemicals are taken up by an organism either directly from exposure to a contaminated medium or by consumption of food containing the chemical. Where metals are concerned, it can be defined as the net accumulation of a metal in a tissue of interest or a whole organism that results from exposure. Metal bioaccumulation is influenced by multiple routes of exposure (diet and solution) and geochemical effects on bioavailability. As metals are not metabolized, bioaccumulation of metals and metalloids is of particular value as an exposure indicator. Similarly, bioaccumulation is often a good integrative indicator of the chemical exposures of organisms in polluted ecosystems. All trace metals are toxic at some bioavailability. Thus, aquatic organisms exposed to atypically high local bioavailable toxic metal may come under selection for changes in one or more physiological processes, including the rate of metal uptake from an available source of the metal, the rate of efflux and the rate of detoxification of accumulated metal into a relatively processing level. Fish gills comprise more than half of the body surface area with an epithelial environment. As a result of this close association between the water and blood, the gills and are strongly affected by environmental pollutants (Wood et al., 1990). Due to accumulation of these metals alterations like epithelial lifting, hyperplasia and hypertrophy of epithelial cells, oxygen uptake is impaired (Fernandes and Mazon, 2003). Liver and intestine causes the metabolic problems. The affect is the bile and digestion stagnation in the liver and intestine. The accumulation of bile indicates possible damage to the hepatic metabolism (Fanta et al., 2003). The heavy metals accumulates in kidney changes were noticed and may be due to renal excretion of undertoxified toxicant molecule resulting in severe pathological changes in haemopoietic tissues resulting severe necrosis, cloudy smelling of renal tubules, disintegration of interstitial tissue, pycnotic nuclei (Tilak et al., 2001).

One of the biggest problems with water pollution is its transboundary nature. Many rivers cross countries, while seas span whole continents. Pollution discharged by factories in one country with poor environmental standards can cause problems in neighboring nations, even when they have tougher laws and higher standards. Environmental laws can make it tougher for people to pollute, but to be really effective they have to operate across national and international borders. This is the way the international laws governing the oceans, such as the 1982 UN Convention on the Law of the Sea (signed by over 120 nations), the 1972 London (Dumping) Convention, the 1978 MARPOL International Convention for the Prevention of Pollution from Ships, and the 1998 OSPAR Convention for the Protection of the Marine Environment of the North East Atlantic. The European Union has water-protection laws (known as directives) that apply to all of its member states. They include the 1976 Bathing Water Directive (updated 2006), which seeks to ensure the quality of the waters that people use for recreation. Most countries also have their own water pollution laws.

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