Determination of Heavy Metals in Water, Sediment and Fish Tissues from the Cauvery River Kumbakonam Thanjavur District Tamilnadu India

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Abstract

In recent years, aquatic systems are highly polluted due to the discharges of various heavy metals from industrial, agricultural, mining and domestic activities. Fishes are richest source of essential healthy diet. They are ideal subject for the study of various effects of contaminants present on water samples since they can metabolize, concentrate and store water borne pollutants. Monitoring of heavy metals and their health effects in aquatic organisms not only provide insight into overall ecosystem health but also act as a sentinel for potential impacts on human being. Fishes are used as environmental biomarker of heavy metal pollution in water systems. Cauvery River in Kumbakonam, Tamilnadu is one of the largest aquatic systems in India. It was polluted by various human activities. Hence in the study, three samples such as water, sediments and fishes were collected from Cauvery River. The gills, liver and intestines were dissected out from fishes to examine the heavy metal damages. Water and sediment samples were equally collected from two sites for heavy metal determination by using Atomic Absorption Spectrophotometer. The highest concentration of heavy metals was detected in the sediment sample followed by the concentrations in the fish samples. Iron concentration detected was highest followed by nickel and cadmium mostly undetectable. Variations in the parameters determined were found to be statistically significant at p<0.05.

Keywords: Bioaccumulation; Heavy metals; Fishes; Fish Tissues and River Cauvery

1.Introduction

Water pollution is a major global problem. Water is essential to all living organisms. All the activities of human being depends on the water. The sources and quality of water have been impacted upon by both natural and anthropogenic process, leading to poor water quality and productivity of aquatic ecosystems (FAO 1992). Heavy metals are chemical elements with a specific gravity that is at least five times the specific gravity of water. The specific gravity of water is 1 at 4°C (39°F). The heavy metals have no beneficial functions to the body and can be highly toxic. If they enter into the body, accumulate in the various tissues through inhalation, ingestion and skin. The accumulation is very high than their body’s detoxification pathways (Ekpo \textit{et al}. 2008).

All over the world, rivers and water bodies reservoir for chemicals, organic and heavy metal pollutants. This is mainly because most industries and factories are located near the bank of the river (WHO/UNEP). It causes several cases of pollution in aquatic environments (Velez and montoro, 1998 and Conacher \textit{et al} 1993). Due to industrialization, urbanization, as well as commercial activities, huge amount of heavy metals are discharged from waste incinerators, dumpsites, purification of metals, electronics, cosmetics and various other
sources (Hutton and Simon 1986 and Kavitha et al. 2019). The metals are entering into water bodies either through direct disposal, emissions, tidal current flood or via water flow process (Stephen, 1984). In addition to heavy metals large amounts of organic materials are also released into water bodies and it may be broken down by bacterial activities resulting in reduction of oxygen level or anaerobic conditions in the variety of the effluents (Smith et al. 1999). Fishes have been noted for their notorious ability to concentrate heavy metals in their muscles and other part of their body (Sures 2003).

In water bodies, heavy metals are accumulated in some organisms such as phytoplanktons and zooplanktons. They can be transferred to fish and from the fish to scavenger birds and man which are higher in the food chain. In this regards progressive increase in the concentration of a substance in the food chain (biomagnifications) more intake of liquid than its excretion from an organism (Croteau, 2005). Heavy metals accumulation causes several health hazards such as nausea, diarrhoea, cancer, effects on haemoglobin synthesis etc., the health effects depend on route of exposure, duration of exposure, the age of the exposed organism and the dosage during exposure of heavy metals.

Recent studies have reported that human activities have created ecological pressure on the natural habitat of fish and other aquatic organism over time. Water pollution is a result of this deleterious effect. Moreover, factors such as high population growth accompanied by intensive urbanization, increase in industrial activities and higher exploitation of natural resources including cultivable land have caused pollution increases. Large amount of organic material are released into the water body although some industrial process such as industries and sugar processing plant also produce much finely divided organic material as waste product, which is broken down easily by bacteria activities resulting in the reduction of oxygen level or even anaerobic condition in the vicinity of an effluent Smith et al. 1999. by the bacterial action in the organic wastes in water bodies, low aerobic or anaerobic condition occur. In addition to direct depletion of oxygen, inorganic nutrients such as ammonia, nitrate and phosphorus are formed during the decomposition of large quantities of organic material. These enrichments considerably rise algae growth or bloom which can cause the wide daily fluctuations in oxygen and in extreme condition, fish death can result. This increased productivity caused by excessive organics deposition can cause reduced water quality and this symptom of over production is known as eutrophication (Atta et al. 1997, Kakulu and Osibanjo 1988).

Sediments have been reported that it form the major repository of heavy metal in aquatic system while both allochthonous and autochthonous influences could make a concentration of heavy metals in the water high. The presence of metal pollutant in fresh water is known to disturb the aquatic ecosystem. Fishes are notorious for their ability to concentrate heavy metals in their muscles hence human beings consumed the fishes as nutrient rich food. Instead of this, very important thing is to detect the unneeded high level of some toxic trace metals are not being transfer to man through fish consumption (Charis and Abbasi 2005). Earlier reports showed that industrial and domestic effluents are largest sources of heavy metal which steadily increasing metallic contaminant in aquatic and terrestrials environment in most part of the world (Kakulu et al. 1987).

Sediments are a sensitive indicator to monitor contaminants in aquatic environments. The sediments were polluted by various kinds of hazardous and toxic substances, including heavy metals. These accumulate in sediments via several ways, including disposal of liquid effluents, terrestrial runoff and leachate carrying chemicals originating from numerous urban, industrial and agricultural activities, as well as atmospheric deposition. Sediments effectively sequester hydrophobic chemical pollutants entering into the water bodies. Sediments provide
a useful archive of information on changing lacustrine and watershed ecology (Cohen 2003). Core sediments provide useful information on the changes in the water quality of the lake from a past period. Many researchers had studied the pollution history of aquatic ecosystem by core sediments (Mohamed 2005). Many researchers have used sediment cores to study the behavior of metals (Bellucci et al., 2003, Bertolotto et al., 2003, Borretzen and Salbu 2002, Weis et al. 2001). More studies in the distribution of heavy metals in water bodies reveal that the levels of heavy metals in the bottom sediment are usually higher than in the water columns (Charis and Abbasi 2005, Bryan 1971). In the paper, an attempt is aimed to observe heavy metal accumulation in water, sediment and various tissues of fishes in Cauvery river, Kumbakonam, Tamilnadu.

2. Materials and Methods

The two sample stations designated as Melacauvery (Station I) and Kumbakonam town (Station II) were selected randomly for the purpose of the study (Fig 1&2). Samples of the freshwater fish Mystus cavasius (Hamilton,1822), sediment and water were collected from the sampling Stations once in every three months from June 2018-Feb 2019. The fish samples were collected using cast nets which were thrown by the fisher men and withdrawn by the means of line attached to its opening. The fish caught by the net were collected, washed, weighed and preserved in refrigerators for a day before analysis. The fishes were dissecting out and remove gills, liver and intestines with the aid of a knife. They were taken in polythene bags and stored in a deep freezer at -10°C in the laboratory prior to treatment and evaluated the bioaccumulation of heavy metals in the organs (Obasohan et al. 2007).

The sediment and water samples were collected in plastic cups from Station I and II and kept inside a metal free stopper bottle. The soil sediments were dried at 70°C for 24 hours. The dried samples were then ground in homogenizer. The crucibles and the caps were washed in 10% HNO₃ and ashed at 750°C for 2 hours in a muffle furnace. The dried samples were weighed into the crucibles and ash was then scraped into vials and the crucibles rinsed with 10 ml acid with the aid of a repippetor. The vials were then capped and shaken thoroughly. The extract was diluted to 1 L with distilled water and the diluted extract was measured by atomic absorption spectrophotometer.

Figure 1: Sampling location Site 1 at Kumbakonam Cauvery river
2.1 Statistical Analysis

The data obtained from the chemical analysis were subjected to descriptive statistical analysis (mean and standard deviation at 95% confidential limit).

3. Results and Discussion

The concentrations of heavy metals determined in the samples are presented in Tables 1-3, Figure 1-3. Iron, Nickel and Cadmium were observed in the sediment while cadmium was not detectable. The concentration of iron is higher in the sediment than its concentration in the fish and water samples. The high content of iron in the sediment may be due to clayey material that may form the Cauvery river bed. It may be due to human activities such as the discharge of untreated sewage that contain iron as well as the ability of the sediment to act as a sink (Kakulu and Osibaanjo 1998). Moreover, it has been reported that iron occurs in high concentrations in soils. High concentrations of iron in the sediment had been reported by (Adeniyi and Yusuf 2007), who had carried out similar research in Cauvery river system. In the sediment Iron and Nickel were also detected while of cadmium was not detectable.

Table-1 Heavy metal concentration in water from Cauvery River Kumbakonam

<table>
<thead>
<tr>
<th></th>
<th>Iron</th>
<th>Nickel</th>
<th>Cadmium</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site 1</td>
<td>0.063±0.001</td>
<td>0.009±0.042</td>
<td>ND±0.000</td>
</tr>
<tr>
<td>Site 2</td>
<td>0.059±0.003</td>
<td>0.007±0.003</td>
<td>ND±0.000</td>
</tr>
</tbody>
</table>

Table-2 Heavy metal concentration in Sediment from Cauvery River Kumbakonam

<table>
<thead>
<tr>
<th></th>
<th>Iron</th>
<th>Nickel</th>
<th>Cadmium</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site 1</td>
<td>0.425±0.002</td>
<td>0.013±0.004</td>
<td>ND±0.000</td>
</tr>
<tr>
<td>Site 2</td>
<td>0.412±0.002</td>
<td>0.017±0.003</td>
<td>ND±0.000</td>
</tr>
</tbody>
</table>

Table-3 Heavy metal concentration in Fish Samples from Cauvery River Kumbakonam

<table>
<thead>
<tr>
<th>Heavy Metals</th>
<th>Gill</th>
<th>Liver</th>
<th>Intestines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron</td>
<td>0.021±0.011</td>
<td>0.029±0.002</td>
<td>0.019±0.002</td>
</tr>
<tr>
<td>Nickel</td>
<td>0.005±0.001</td>
<td>0.004±0.001</td>
<td>0.010±0.001</td>
</tr>
<tr>
<td>Cadmium</td>
<td>0.002±0.002</td>
<td>0.003±0.001</td>
<td>0.003±0.001</td>
</tr>
</tbody>
</table>
In the parts of the fish tissues analysed, the concentration of Iron ranged from 0.021±0.011, 0.029±0.002 and 0.019±0.002 mgkg⁻¹, while the concentration of Nickel ranged from 0.005±0.001, 0.004±0.001 and 0.010±0.001 mgkg⁻¹ with the concentration being more in the gills and intestines than parts of the fish. The concentration of iron ranged from 0.021±0.011, 0.029±0.002 and 0.019±0.002 mgkg⁻¹ with the highest concentration in the Liver. The concentrations of cadmium ranged from 0.002±0.002, 0.003±0.001 and 0.003±0.001 mgkg⁻¹. The low concentrations of cadmium in the fish samples analysed may be due to non-discharge materials rich in cadmium into the River Cauvery.

Most of the heavy metals were detected in the liver of the fishes. The gills and the intestines of the fish generally had low concentrations of heavy metals than the liver. The gills are considered as dominant contaminants absorption site from water because of their anatomical and physiological properties (Hayton and Baron 1990). Furthermore, the accumulation of chemicals in fish through membrane by ingestion of water, when the metals could be retained in the gills. Intestine is a depot site in all the higher organisms, therefore the high concentrations of the heavy metals stored in the intestines. High concentrations of metals in the digestive tracts of fish (Kock et al., 1998, Giguere et al 2004).
Generally, metals have been shown to have affinity for certain organs of the fish. But the concentration of heavy metals accumulation is different to among the fishes. It may be due to the feeding habits of the fish as well as age and the size of the fish (Canli and Atli 2003). In the fish the order of decrease in concentration is Fe>Ni>Cd. This order may be due to depends upon various environmental sources. Therefore, bioaccumulation of metals in fish is considered as an index of metal pollution in the aquatic system (Tawari-Fufeyin and Ekaye 2007, Karadede-Akin and Unlu 2007). It could be a useful tool to study the biological role of metals present at higher concentrations in fish (Dural et al. 2007 and Anim et al. 2011).

Cadmium was not detectable in the water and the sediment samples, iron being highest in concentration in both the water and sediment sample. The high concentration of iron is may be due to high environmental sources. The order of decrease of concentration is as follow, Fe>Ni; cadmium is not detectable. In the fish, the entire fish samples are within the IAEA-407 recommended level of 146 mgkg-1 of iron. In the sediments, the concentration of iron is also below the NOAA 2009. In the water sample, the concentration of iron was above the WHO.1993 and EPA. 2002 limit of 0.01 mgkg-1 and 0.3 mgkg-1 respectively. Cadmium was within the recommended levels in all the samples as they were not detectable. Thus, the concentration of the all the heavy metals in the fish samples except nickel were within the tolerable levels in the samples. Heavy metal has been associated with many health effects in man including cancer; therefore, its concentration above the recommended level dangerous to the aquatic organisms as well as human beings. Now a days the heavy metals concentration is continuously rises in Cauvery river, Kumbakonam due to improper disposal of wastes from various industries and household process. It is very toxic to both aquatic organisms and man with unabated generation. Thus, the evaluation of the heavy metal concentration in Cauvery River system is very needed one.

4. Conclusions

In the study, the heavy metals such as iron, nickel and cadmium were analysed in water, sediments and fish tissues of Cauvery River in Kumbakonam. These metals are generated from wastes of industrial and commercial activities of people. It causes deleterious effects to fishes and other living organisms in the water system. In addition to this, the heavy metals accumulated fishes are consumed by human beings as nutrient rich food. It causes many ill effects to people. So, everyone have social vision on our environment protection through proper disposal of wastes from various sources.

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