# A Comparative Study on Heavy Metal Concentration in the Sediments of Perumal Lake and Uppanar River of Cuddalore District, Tamilnadu, India

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**Abstract:** ***The heavy metals are carcinogenic, mutagenic and they are Persistent, Bio-accumulative and Toxic (PBT) – move among air, water and soil and cross human boundaries. The mixing of toxic heavy metals into the water bodies deterioratesthe quality of water, sediment and aquatic organisms. It is a threat to the several endemic fish species due to the heavy metal pollution of rivers and lakes. Further, the heavy metals could also pass to human beingsthrough the food chain and create various health hazards. These heavy metals have been discharged into the ecosystems by means of various industrial and other anthropogenic activities. In order to study the industrial pollution, the sediments of Perumal lake and the Uppanar river which were found very close to the industrial area of Cuddalore district of Tamilnadu, India have been chosen to assess the concentration of heavy metals. About 4 sediment samples were totally collected from these two water bodies and analyzed for the heavy metal concentrations. The study revealed that both of the water bodies show theaccumulation of heavy metals like Cr, Cu, Ni, Zn and Co at an alarming rate. There is an urgent need to control the industrial pollution and save the above two water bodies for the welfare of the present and future generations.***

**Keywords:** Samples, Heavy metals, Contamination, Concentration and Industries

## 1. Introduction

Rivers and lakes are a very important part of our natural heritage. Pollution of heavy metals in an aquatic ecosystem is growing at an alarming rate and has become an important worldwide problem, [1]. As heavy metals cannot be degraded – they are deposited, assimilated or incorporated in water, sediment and aquatic animals and thus, causing heavy metal pollution in the water bodies, [2].
Wong et al, [3] showed that heavy metals are potentially toxic to crops, animals and humans when contaminated soil is used for crop production. Consumption of plant products and fish from the contaminated site poses great health risk to human beings.Heavy metal pollution in an aquatic environment has become a serious problem and also an important factor responsible for the decline of water, sediment and fish quality, [4].

The '**Heavy metals**' are chemical elements with a specific gravity at least 5 times that of water. The specific gravity of water is 1 at 4°C, [5]. Environmental Protection Agency list out the eight most common heavy metals (As, Cd, Cr, Cu, Pb, Hg, Ni and Zn) discharged by the industries like metallurgy, chemical, alloys, paint, pulp and paper, leather, textiles, fertilizers, petroleum refining, coal burning, etc.
These metals are released into the eco-system by various industrial activities and they bio-accumulate in the living organisms. For example, lead bio-accumulate in bones and teeth, cadmium build up in kidneys and mercury attaches itself to protein especially in the liver, [6].

A comparative study of heavy metal concentrationinthe sediments of the Perumal Lake and the Uppanar River which were found very close to the industrial area of the Cuddalore district of Tamilnadu, India has been carried out by taking into considerationof the industrial pollution and the toxic effect of the heavy metals.

The present study is carried out with a view tofind out whether the heavy metal concentration level in the water body sediments was within the permissible limit or above the permissible limit. The study also aimed to know the effect of the industrial activities on the nearby aquatic environment.

## 2. Literature Survey

The heavy metals are significant because of their toxic action on man and other life forms.The presence of heavy metals in the human body develop the following health hazards, Arsenic poisoning produces skin, liver and lung cancers, [7].
The effects of cadmium are: dysfunction of the adrenal, anemia, hypertension, bone-marrow disorder, cancer, etc., [8]. The victims accumulated about 500 - 600 mg of Cd in their body over several years of consuming the contaminated rice as their staplefood and finally succumbed due to the so called "*Itai-Itai* or *Ouch-Ouch*", disease, [9].

Hexavalent chromium is found to be much more toxic than the trivalent chromium. Toxicity of chromium ($Cr^{+3}$ and $Cr^{+6}$) in aquatic organisms is generally low and chromium is not actually toxic to humans. However, $Cr^{+6}$ is more toxic than $Cr^{+3}$ because of its high rate of absorption through intestinal tracts, [10].

The liver is the main storage site for copper. The copper in liver is called '*hepatocuprein*'. Copper is also present in the kidneys, heart, bone-marrow and hair, [11].

Lead (Pb) can enter into the lungs through inhalation and into the skin through mere contact. The common disease '*plumbism*',occurs which causes intoxication, colic gastrointestinal disturbance, anemia, weakness in wrist and legs and impaired functioning of central nervous system, [12].

Mercury (Hg) is the most toxic heavy metal. Presence of mercury in the human body causes enzyme inhibition, cellular dysfunction, neurological disorders, erethism and teratogenic effects. This mercury poisoning produced a crippling and often fatal disease called "Minamata *disease*", [10].

Dermatitis or nickel-itch is common among workers involved in making nickel-containing jewelry and those using nickel plated watches and nickel-containing detergents. Nickel dusts are reported to be carcinogenic, [9].

Zinc plays a vital role in plant nutrition; paddy grown in soils containing less than 20 ppm suffers from zinc deficiency. Soil containing Zn about 1000 ppm may be harmful to the paddy plants. Ingestion of excessive amounts of cobalt causes intercellular hypoxia and polycythemia. Chronic exposure of cobalt may lead to goiter, [13].

## 3. Previous Work

In the study area, there are several agencies belonging to the State and Central Government organizations which periodically take out survey related to water potential, water quality and lithology of the region. The Public Works Department (Ground Water Division), Tamilnadu Water and Drainage Board (TWAD) and Agricultural Engineering Department periodically conductgeophysical survey in various places of the study area. Further, every year the water level fluctuations and water quality report were prepared by the organizations like TWAD, PWD and Central Ground Water Board (CGWB). Apart from these organizations, the nearby Annamalai University Earth Science Department also published several research articles about the hydrogeological conditions of the area. The Centre for Advance Studies in Marine Biology of Annamalai University at Portnovo campus has also published several M.Phil and Ph.D. Dissertation works related to pollution of Uppanar River.

The dissertation work entitled 'Environmental Pollution and its management in Cuddalore District, Tamilnadu' is also prepared by one of the Post-Graduate students of Department of Environmental Sciences, Tamilnadu Agricultural University, Coimbatore. The discharge of SIPCOT industrial effluents have been periodically monitored by the Tamilnadu Pollution Control Board (TNPCB).

## 4. Methods

The Perumal lake and the river Uppanar lie on the eastern side of the coastal district of Cuddalore of Tamilnadu State, India (Fig No: 1). Both the water bodies are found in the low lying area, hence, they are perennial in nature. The Perumal Lake is spread in the NW – SE direction for a length of about 11.5 km and shows the average width of about 1 km in the east – west direction. The river Uppanar is flowing very near and almost parallel to the coast and finally it confluences in the Bay of Bengal.

The Perumal Lake is the major recharge area for the river Uppanar. The Uppanar River also receives water from the canals like Murattaru, Manambattan and Buckingham canals found on the southern side of the Uppanar River. The total length of the river Uppanar is about 22 km. The study area lies between the East longitude of 79° 37´ - 79° 47´ and North latitude of 11° 30´ - 11° 43´ and falls in the Survey of India toposheet of 58 M/10 & M/14.

Small and large scale SIPCOT industries were situated on the banks of river Uppanar. Through inter-connected upstream water ways, the Uppanar River is connected with Perumal Lake and the Perumal Lake receives water from Paravanar River. The main source of water for river Paravanar is the water dischargedfrom mines of the Neyveli Lignite Corporation (NLC), Neyveli.

With the help of the Survey of India topographic map of 1:50,000 Scale, the study area base map has been prepared.About 4 sediment samples (3 from Uppanar river and 1 from Perumal lake) were totally collected in order to study the heavy metal concentration.


**Figure 1:** Study Area Location Map

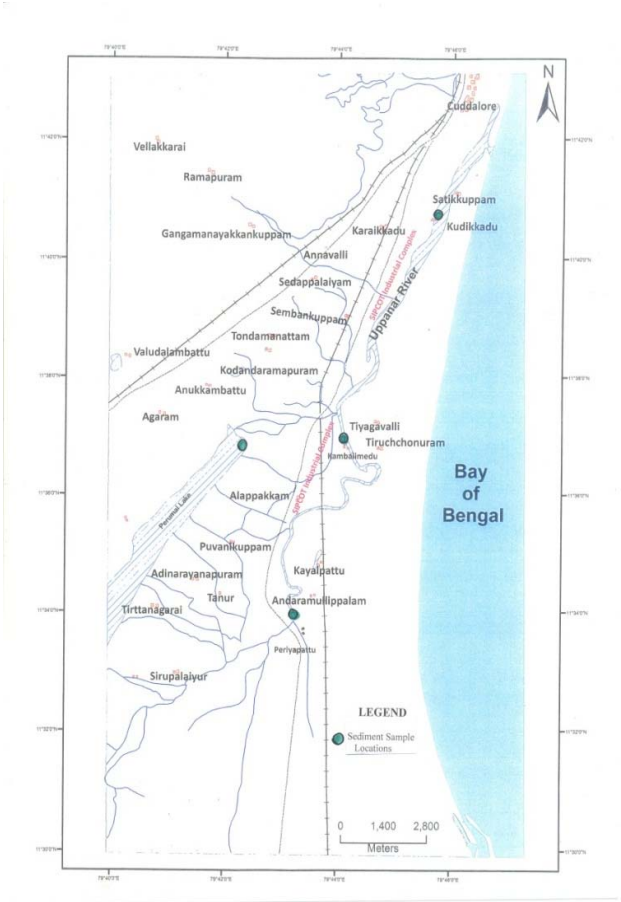


**Figure 2:** Map showing the sampling locations

In the Perumal Lake the sediment was collected from the northern portion of the lake and in the Uppanar River the samples were collected in such a way as to cover the entire river basin.

Geographic Information System (GIS) software is used to mark the sampling sites in the map (Fig No 2). By adopting standard procedures, [14] and by using modern and advanced instrumentlike AAS the collectedsediment samples were analyzed in the laboratory. The results were fed into MS-Excel software to show the level of each metal concentration in the form of bar diagrams.

## 5. Results

The result of sediment analysis of the Perumal lake and the Uppanar river reveals that heavy metals were concentrated in the order of Zn > Cr > Cu > Ni > Co. Soil samples represent an excellent media to monitor heavy metal pollution because anthropogenic heavy metals are usually deposited in the top soil, [15].

The plants absorb heavy metals from soil, water and air. However, the chief source of metal absorption is soil. Crops and vegetables grown in soils contaminated with heavy metals demonstrated greater accumulation of heavy metals than those grown in uncontaminated soil, [16], [17].

The Perumal lake sediment shows the chromium concentration of about 45.8 mg/kg. In the Uppanar River, the chromium concentration of sediments was in the range of 16 - 43.4 mg/kg. The desirable limit of Cr in soil sample is 35 mg/kg, [18].

The study reveals that the Perumal lake sediment shows that the Cr concentration was above the desirable limit of 35 mg/kg. In the case of river Uppanar, the chromium heavy metal is distributed throughout the river basin and out of the 3 sediment samples only one sample exceeded the desirable limit and the other two sedimentsampleswere below the desirable limit of chromium.

Further, from the study it is also revealed that the Perumal lake sediment shows higher concentration (45.8 mg/kg) of chromium than the Uppanar river sediments.

According to Kabata-Pendias A and Pendias H [19], 60 - 125µg/g Cu on total fractions in sediments would be considered toxic to plants. The Perumal lake sediment shows the Cu concentration of 10.5 mg/kg and exceeds the toxic limit of Cu. Uppanar River sediments, the metal Copper is found in all the 3 locations and its range of concentration is 5.31 - 23.5 mg/km. Out of the 3 sediment samples, only one sample showed that the copper concentration below the toxic limit and the other 2 samples exceeded the toxic limit (> 60 µg/g).

The desirable limit of nickel in soil is 20 mg/kg, [18]. The Perumal lake sediment shows the nickel concentration of about 3.86 mg/kg, the value is below the desirable limit of Ni concentration.

In the Uppanar river sediments, the range of nickel concentration is about 6.15 – 23.8 mg/kg. Out of the 3 samples analyzed, two samples showed well above the desirable limit (20 mg/kg) of nickel and only one sample was below the desirable limit.

The Perumal lake sediment shows the Zn concentration of about 46.1 mg/kg. The Uppanar river sediments show that the Zn concentration is in the range of 37.5 – 131 mg/kg.

According to Kabata-Pendias A and PendiasH [19], 70 - 400 µg/g Zn on total fractions in soil would be considered toxic to plants. The sediments of Perumallake and all the 3 sediment samples of Uppanar river show the Zn metal concentration was above the toxic limit (>70µg/g).It is also observed that the Uppanar river sediments showed higher concentration of Zn than the Perumal lake sediment.

The desirable limit of Cobalt concentration in the soil is 10 mg/kg [18]. The Perumal lake sediment sample shows the Co metal concentration of about 8.29 mg/kg.

One sediment sample analyzed for Co metal in the Uppanar River shows that the concentration of Co is about 5.36 mg/kg. The Perumallake and Uppanar river sediments show the Cobalt concentration is well below the desirable limit.

The result of analysis of sediment samples of Perumal Lake and Uppanar River have been represented in the Table No.1 and 2. The distribution of heavy metals in the sediment samples were also shown in the form of MS Excel graph (Fig No. 3 & 4).

**Table 1:** Heavy metal concentration in the Sediments of the Perumal Lake

| *Cr* | *Cu* | *Ni* | *Zn* | *Co* |
|---|---|---|---|---|
| 45.8 | 10.5 | 3.86 | 46.1 | 8.29 |

All the values are expressed in mg/kg - dry wt.

**Table 2:** Heavy metal concentration in the Sediments of the Uppanar River

| *No* | *Location* | *Cr* | *Cu* | *Ni* | *Zn* | *Co* |
|---|---|---|---|---|---|---|
| 1 | Periyapattu | 43.4 | 23.5 | 23.8 | 37.5 | - |
| 2 | Kambalimedu | 20.9 | 5.31 | 22.6 | 131 | - |
| 3 | Kudikkadu | 16 | 8.05 | 6.15 | 44.3 | 5.36 |

All the values are expressed in mg/kg - dry wt.

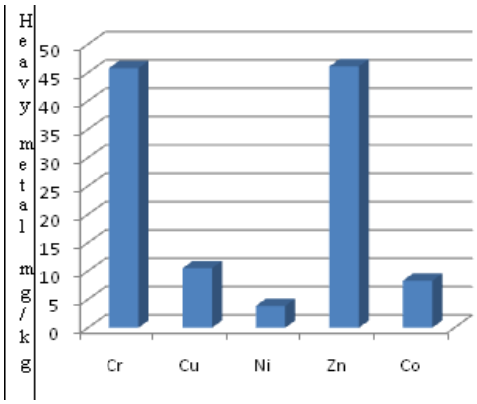


**Figure 3:** Heavy metals in the sediments of Perumal Lake

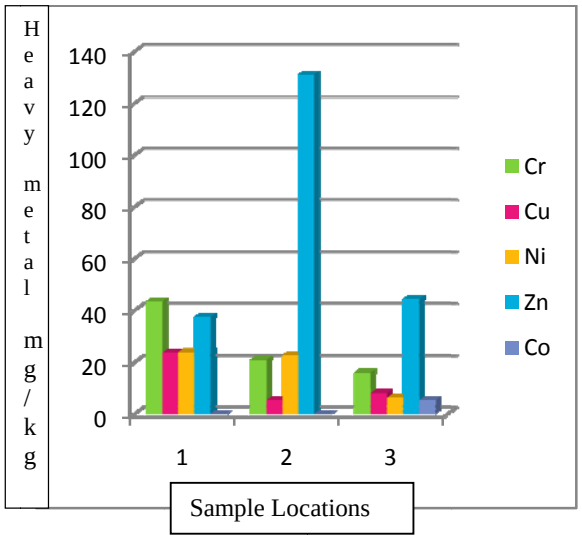


**Figure 4:** Heavy metals in the sediments of Uppanar River

## 6. Conclusion

The study reveals that there were about 5 heavy metals like Cr, Cu, Ni, Zn and Co concentrated in the Perumal Lake as well as in the Uppanar river sediments. The order of abundance of heavy metals in both the water bodies sediment is Zn > Cr > Cu > Ni > Co. Among the five heavy metals, the heavy metal Zinc concentration is higher than the remaining metals.

The study also revealed that the Perumal lake sediment shows higher concentration (45.8 mg/kg) of Chromium and Cobalt (8.29 mg/kg) than the Uppanar river sediments. The level of Nickel concentration of the Perumal lake sediment is lower (3.86 mg/kg) than the Uppanar river sediments. As the heavy metal concentration in the sediments of the above water bodies were at an alarming rate, the short-term and long-term strategies to be taken up immediately to save these coastal eco-systems.

It is suggested that the industrial waste can be reduced, reused and recycled within the industrial premises and there should be a zero discharge from the industries. The Government organizations should monitor periodically the discharge point of the industries which were polluting the water bodies.

Public awareness and self-discipline ofindividuals are also required to protect our natural resources like water and minerals.With the co-operation of the people, NGOs and the Government - the industries and the river basins should be *sustained for the future generations*.

## 7. Future Scope

Heavy metal concentration study should also be carried out in plants and the aquatic organisms to understand the degree of bio-accumulation. If the heavy metals were mobilized into the food chain, the health hazard caused to the human beings must also to be considered.

**Limitations:** The topic is inter-disciplinary and needs involvement of subject experts from various fields.

**Benefits:** The modern industrial development activities normally affect the environment, therefore, the research to know the level of contamination is highly useful to monitor and control the pollution.

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