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Review Article

Review on the Occurrence, Spatial Distribution, and Ecological Impact of Heavy Metals in Rivers of Tamilnadu, India

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Abstract: *One "pillar" of sustainable development is the recognition of the significance of a clean environment. On the other hand, the environmental release of heavy metals poses a severe global health risk and is often dangerous. In Tamil Nadu, heavy metal monitoring data is inadequate for aquatic ecosystems. Here, we reviewed research on the concentrations of heavy metals in freshwaters. Research indicates that increased concentrations of heavy metals in aquatic ecosystem sediments tend to increase their abundance, which can then enter the food chain through processes known as bioaccumulation. Increased use of rivers by humans, such as Thamirabarani in Thirunelveli and Kaveri in Trichy. Tamil Nadu further complicates this picture by offering constantly-changing causes for heavy metal contamination through industry, tourism, aquaculture, and recreation. After accounting for every heavy metal that was tested, it was found that localized anthropogenic activities were associated with rising levels of heavy metals like zinc, copper, and leads in rivers. The majority of the time, heavy metal concentrations in sediments and aquatic biota exceeded permitted limits, as determined by sediment guidelines and assessments of the risks to human health. This review, which is extremely important for the environment's health and the economy, calls for more monitoring studies on the levels of heavy metals in organisms and inland urban rivers to find the sources of pollution and implement better control measures with the local government enforcing strict policies to reduce pollution.The water quality of the Tamirabari River system from south India, a crucial source of water for drinking and domestic purposes, industrial usage, and irrigation, was assessed here. Variations in levels of toxic heavy metals in the river system during the COVID-19 pandemic lockdown might potentially assist in development of a public health risk mitigation system associated with the water consumption. An analysis of the toxic metals (Cr, Cu, Zn, and Pb) in comparison to the pre-lockdown period suggests a 20% decrease in the contamination ratio during the lockdown period. Through ingestion and dermal absorption exposures, the health risk assessment models (HQ, HI, and TCR) highlighted carcinogenic and non-carcinogenic hazards for both children and adults. During the lockdown, the HI values for as and CR both beyond the permitted limit (>1), however the possible harm to adults and children was still minimal as compared to the pre-lockdown period. According to our findings, the Thamirabarani River system remained hazardous to human health even during the lockdown, necessitating routine monitoring by a volunteer water quality committee that includes both the public and private sectors.*

Keywords: *Rivers, Environments, Biota, Heavy Metals, Thamirabarani, Cauvery, Thirunelveli, Trichy.*

I. INTRODUCTION

As a class of elements with large atomic weights and hazardous characteristics, heavy metals can build up in the environment.The increased release of heavy metals into the environment, especially freshwater ecosystems like rivers, is a result of their widespread use in a variety of industrial, agricultural, and domestic activities. Because rivers are a significant route for the dispersion and accumulation of heavy metals, they are essential to the transportation and fate of these materials in the environment.

Rivers can get heavy metal contamination from both natural and man-made sources. Weathering and soil erosion are two natural processes that contribute to the presence of heavy metals in rivers. However, the main causes of heavy metal contamination in rivers are human activities including mining, industry, agriculture, and urbanization. Significant amounts of heavy metals can be released into rivers by industrial processes including mining, smelting, and manufacturing through wastewater discharge, atmospheric deposition, and accidental spills. The usage of pesticides and fertilizers in agriculture can also lead to the buildup of heavy metals in waterways. Heavy metals may be released into rivers as a result of urbanization, which includes the creation and upkeep of roads and structures and storm water runoff.

Heavy metals can have a major effect on river ecosystems, which could have an adverse effect on the environment and human health.Heavy metals can be hazardous to aquatic life, causing stunted growth, decreased ability to reproduce, and even death. Additionally, they have the ability to build up in the food chain, endangering human health when ingested by fish and other aquatic life. Furthermore, heavy metals can linger in the environment for extended periods of time, which could lead to chronic, permanent harm to freshwater ecosystems.

Research aimed at comprehending the sources, distribution, and impact of heavy metals in rivers is becoming more and more necessary given the possible risks connected to them. Researchers have looked into the presence and activity of heavy metals in rivers, as well as any possible health risks to humans and aquatic life. Additionally, management plans have been created and put into practice to lessen the amount of heavy metal contamination in rivers. These tactics consist of cleaning up polluted areas, controlling industrial operations, and implementing pollution prevention measures.

The goal of this research article is to evaluate the literature on heavy metals in rivers, paying particular attention to their management, impacts, sources, and distribution. An overview of the physicochemical characteristics of heavy metals and their presence in rivers, covering both natural and man-made sources, will open the study. The distribution of heavy metals in rivers, together with the variables affecting their flow and fate, will next be covered in the study.The impact of heavy metals on river ecosystems, including how they affect water quality, sediment quality, and aquatic biota, will next be examined in the paper.Lastly, the study will examine the approaches used now to monitor and control heavy metal contamination in rivers, with an emphasis on the application of laws, regulations, and remediation technology.

All things considered, this study will further knowledge of the hazards to the environment and public health that heavy metals in rivers pose, as well as the management techniques required to protect freshwater ecosystems. The study will shed light on the difficulties and possibilities involved in managing heavy metal pollution in rivers and will emphasize the necessity of continuing research in this important field.

II. REVIEW OF LITERATURE

Heavy metal pollution of aquatic habitats has grown in concern over the past few decades and is now frequently regarded as harmful (Jacobetal., 2018).The final locations of pollutants for receiving systems are rivers, lakes, coastal areas, and marine habitats (Poteetal.,2008;Ruilianetal.,2008; Davutluoglu et al., 2011).Because heavy metals have detrimental effects on benthic animals and can linger in aquatic settings for extended periods of time, they have the potential to significantly damage the food chain (Wang et al., 2013; Rainbow and Luoma, 2011: Paul., 2017).Furthermore, exposure to environmental media may result in health risks associated with humans (Zhang et al., 2012; Colak et al., 2015; Redwan & Elhaddad, 2016).

Heavy metal pollution of water and sediment can result from both naturally occurring weathering processes and human-caused anthropogenic activities (He et al., 2008).In aquatic ecosystems, sediments are thought to act as a sink for inorganic pollutants like metals, and their concentration is sometimes many times greater than that of the water above them (Zahra et al., 2014; Goher et al., 2014: Goher et al., 2019). Emerging heavy metal contamination worldwide has been reported to be contaminated by punctual and diffusion sources, such as untreated urban effluents, hospital effluents, industrial effluents, leachated raining, landfilling, dumping urban waste, surface runoff, and atmospheric depositions (Díaz-Somoano 2009;Devarajanetal.,2015;Huberetal.,2016;Kayembeetal., 2018).

Heavy metals are typically found in dissolved phases and have been linked to sediments (Sundaray et al., 2011; Huber et al., 2016).Additionally, metals bonded to sediments may become separated from the water column (Goheretal., 2019).Numerous physical and chemical factors, such as particle size and density, pH, organic matter, carbonates, and chemical fractionation, have an impact on the accumulations of heavy metals in sediments (Jiangetal.,2013;Kouassi etal.,2015).

Tamil Nadu is rapidly urbanizing and has a large number of commercial zones with expanding industries. Tamil Nadu is a major economic force in India, home to more than 70 million people. However, the issue of heavy metal contamination in the aquatic system has grown significantly over time (Paramasivam et al., 2015; Kartikaye et al., 2018; Sundaramanick et al., 2016).

A significant issue of river pollution is also connected to the transboundary river that separates Tamil Nadu from neighboring states. This review will assist in determining the causes of heavy metal contamination and its effects on aquatic ecosystems, as well as the level of metal contamination in aquatic systems in a tropical climatic system.Moreover, it will address the decline in organic pollutants. The majority of the investigations were mainly concerned with how contaminated the water column and surface sediments were.

However, Tamil Nadu's heavy metal contamination is gradually getting worse due to the state's ongoing economic development over the past few decades, which has included a rapid expansion in industry, reclamation of land, dredging, and aquaculture. To combat the environmental threat, managing or controlling heavy metal pollution necessitates understanding of its sources, effects, and spatial distribution. In order to address the current state of heavy metal contamination and sources in sediments of the river habitats and organisms from Tamil Nadu, India, the current review has been conducted.

A. Objectives:

The major objectives of present study:

- To investigate and analyze the presences of heavy metals in river Cauvery, and Thamirabarani.
- To identify the baseline sources of heavy metal accumulation in river Cauvery, and Thamirabarani.
- To correlate and geological case study between Thamirabarani and Cauvery rivers.

B. Study Area:

Figure 1: Study Area of Tamilnadu

- One of the main rivers of Tamil Nadu, a state in southern India, is the Thamirabarani River. The river empties into the Bay of Bengal after passing through the districts of Thoothukudi and Tirunelveli, which are located in the Western Ghats. The river has a catchment area of about 4,400 square kilometers and a length of about 125 km. The Thamirabarani River's geographic coordinates are roughly 8.7084° N latitude and 77.5062° E longitude.

- One of the largest rivers in South India, the Cauvery River rises in the Western Ghats and passes through the states of Tamil Nadu and Karnataka. The river has a catchment area of about 81,155 square kilometers and a length of about 765 km. The Cauvery River's geographic coordinates are roughly 12.3839° N latitude and 76.8497° E longitude.

C. Intensive Research Area:

a) Samples Collections Area 1:

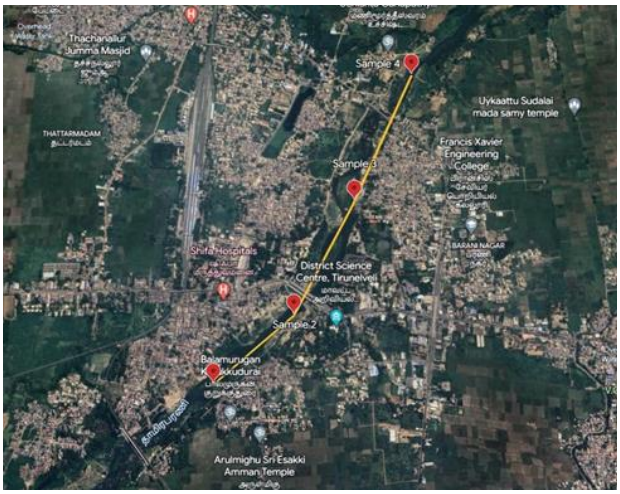


Figure 2: Thamirabarani River, Tirunelveli

b) Sample Collection Area 2:

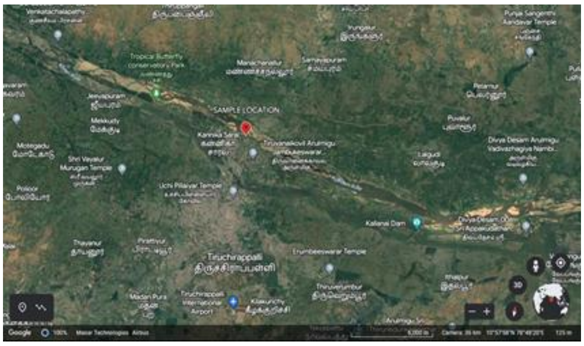


Figure 3: Cauvery River,Thiruchirapalli

III. MATERIALS AND METHODS

A. Sample Collection:

Using sterile, labeled containers, water samples were taken from a variety of sources, such as groundwater and rivers. Samples were gathered from several sites in order to get representative samples for examination.

Sample preparation involved subjecting the collected water samples to a number of pre-treatment techniques in order to eliminate suspended particles, correct pH, and transform the heavy metals into a form that could be analyzed using AAS. Acidification, Digestion, and Filtration were the pre-treatment steps. In order to eliminate suspended particles, the water sample was filtered using a 0.45 µm filter. The sample was heated in a digestion block using a solution of nitric and per chloric acid to convert the heavy metals into ionic forms during the acidification step, which required adding hydrochloric acid to lower the pH to 2-3.

B. Instrument Calibration:

Standard solutions with known concentrations of heavy metals were used to calibrate the AAS instrument prior to analysis. The instrument response was plotted against the metal concentration to create the calibration curve, which was produced by analyzing standard solutions with various heavy metal concentrations.

C. Sample Analysis:

The prepared water sample was placed into the AAS instrument following calibration.The sample was atomized and ionized in a graphite furnace or high-temperature flame.The ions were identified and quantified according to their ability to absorb light at particular wavelengths. The concentration of the heavy metals in the sample was calculated by comparing the absorbance of the heavy metals in the sample to the calibration curve.

D. Data analysis:

To ascertain the concentration of the heavy metals in the sample, the measured absorbance values were compared to the calibration standards. The analytical data were presented as the total mass of the heavy metal in the sample or as the concentration of the heavy metal in the sample. Recovery tests and spike recovery tests were used to evaluate the accuracy of the results, and replicate measurements were used to evaluate the precision..

The AAS procedure created for this project offers a trustworthy and precise way to measure the concentration of heavy metals in water samples. The technique can be applied to evaluate the efficacy of pollution management measures as well as the routine monitoring of heavy metal contamination in water samples.The technique can be used to measure a variety of heavymetals, such as lead, cadmium, arsenic, mercury, and chromium, in a variety of water samples, including groundwater and river water.

Figure 4: Atomic Absorption Spectroscopy

IV. RESULTS AND DICUSSION

A. Standard/Samples (Thamirabarani)

a) LEAD

Table 1: LEAD Results in Thamirabarani

Std/Sample Name	Weight (gms)	Volume (ml)	Dilution Factor	Abs.	Conc.(ppm)	Conc. In Sample (ppm)
Std	-	-	-	0.026	10.00	
Sample 1	1.00	1.00	1.00	-0.014	0.00	0.00
Sample 2	1.00	1.00	1.00	-0.005	0.00	0.00
Sample 3	1.00	1.00	1.00	-0.007	0.00	0.00
Sample 4	1.00	1.00	1.00	-0.012	0.00	0.00

b) ZINC

Table 2: ZINC Results in Thamirabarani

Std/Sample Name	Weight(gms)	Volume(ml)	Dilution Factor	Abs.	Conc.(ppm)	Conc. In Sample (ppm)
Std	-	-	-	0.75	10.00	
Sample 1	1.00	1.00	1.00	0.029	0.18	0.18
Sample 2	1.00	1.00	1.00	0.030	0.20	0.20
Sample 3	1.00	1.00	1.00	0.021	0.07	0.07
Sample 4	1.00	1.00	1.00	0.054	0.55	0.55

c) Cromium

Table 3: Cromium Results in Thamirabarani

Std /Sample Name	Weight (gms)	Volume(ml)	Dilution Factor	Abs.	Conc.(ppm)	Conc. in Sample(ppm)
Std	-	-	-	0.75	10.00	
Sample 1	1.00	1.00	1.00	0.000	0.00	0.00
Sample 2	1.00	1.00	1.00	0.000	0.00	0.00
Sample 3	1.00	1.00	1.00	0.009	0.88	0.88
Sample 4	1.00	1.00	1.00	0.000	0.00	0.00

d) Copper

Table 4: Copper Results in Thamirabarani

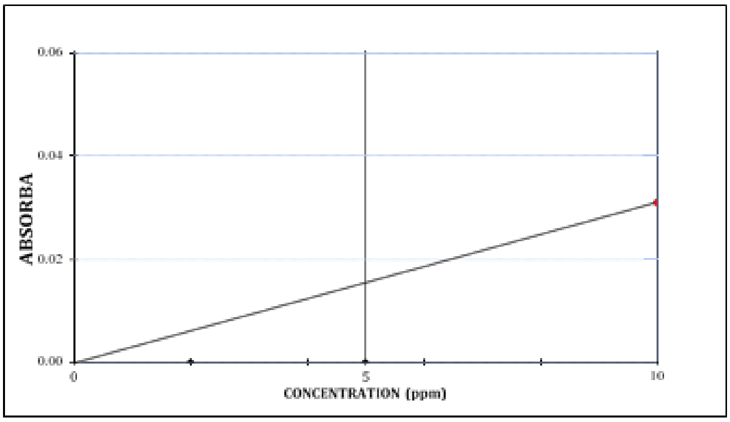
Std / Sample Name	Weight (gms)	Volume(ml)	Dilution Factor	Abs.	Conc.(ppm)	Conc. In Sample (ppm)
Std	-	-	-	0.164	10.00	
Sample 1	1.00	1.00	1.00	0.014	0.10	0.10
Sample 2	1.00	1.00	1.00	0.014	0.10	0.10
Sample 3	1.00	1.00	1.00	0.004	0.03	0.03
Sample 4	1.00	1.00	1.00	0.003	0.02	0.02

B. Standard / Sample (Cauvery)

a) LEAD

Table 5: LEAD Results in Cauvery

Std / Sample Name	Weight (gms)	Volume(ml)	Dilution Factor	Abs.	Conc.(ppm)	Conc. In Sample (ppm)
Std 3	-	-	-	0.031	10.00	
Sample 1	1.00	1.00	1.00	-0.006	0.00	0.00

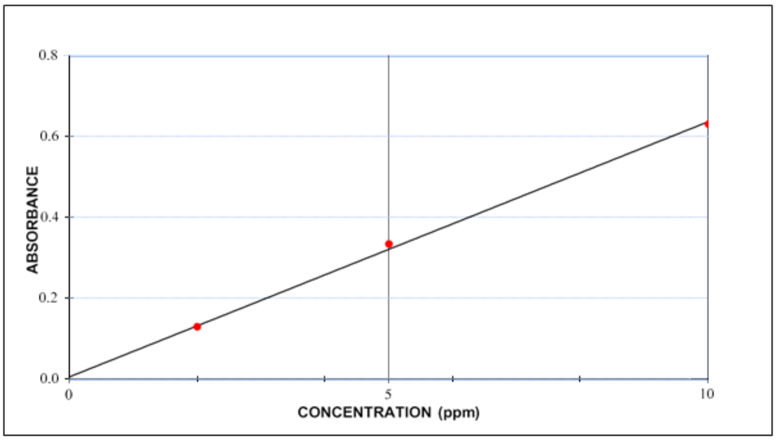


Graph 1: LEAD

b) ZINC

Table 6: ZINC Results in Cauvery

Std/SampleName	Weight(gms)	Volume(ml)	Dilution Factor	Abs.	Conc.(ppm)	Conc. inSample(ppm)
Std1	-	-	-	0.129	2.00	
Std2	-	-	-	0.334	5.00	0.45
Std3	-	-	-	0.630	10.00	
Sample1	1.00	1.00	1.00	0.033	0.45	

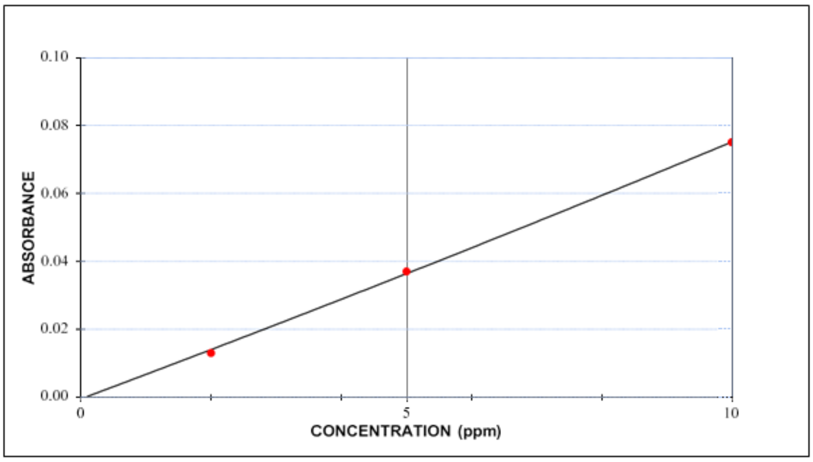


Graph 2: ZINC

c) CROMIUM

Table 7: CROMIUM Results in Cauvery

Std/Sample Name	Weight (gms)	Volume(ml)	Dilution Factor	Abs.	Conc.(ppm)	Conc. in Sample (ppm)
Std1	-	-	-	0.013	2.00	-
Std2	-	-	-	0.037	5.00	-
Std3	-	-	-	0.075	10.00	-
Sample1	1.00	1.00	1.00	0.000	0.07	0.07



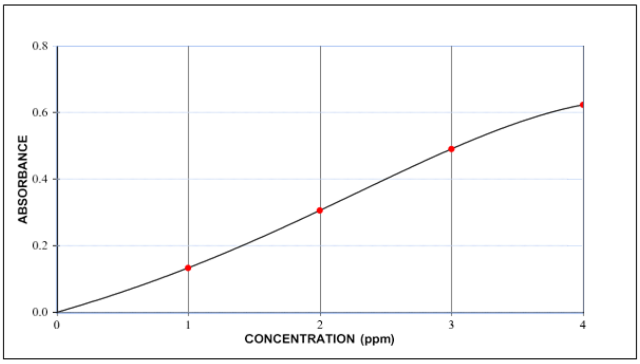
Graph 3: CROMIUM

Calibration Graph: (QUADRATIC) 3.89860
*Eqn(-0.0005+0.0072*X+0.0000*X^-2)*

d) COPPER

Table 8: COPPER Results in Cauvery

Std/Sample Name	Weight (gms)	Volume (ml)	Dilution Factor	Abs.	Conc.(ppm)	Conc. in Sample (ppm)
Std1	-	-	-	0.134	1.00	-
Std2	-	-	-	0.306	2.00	-
Std3	-	-	-	0.491	3.00	-
Std4	-	-	-	0.623	4.00	-
Sample1	1.00	1.00	1.00	0.024	0.20	0.20



Graph 4: COPPER

Calibration Graph: (4thorder)0.08415
*Eqn(0+0.1145*X+0.0158*X^-2+0.0048*X^-3-0.0015*X^4)*

The study's objective was to evaluate the amount of heavy metals in rivers and any possible effects they might have on the environment and human health.

The study's main objective was to analyze water samples taken from several rivers, and the findings showed that the rivers contained traces of heavy metals.

Lead, copper, zinc, and chromium were found to be the most prevalent heavy metals in the waterways, according to the analysis. It was discovered that these heavy metal levels were below the permitted limits established by regulatory organizations.It was noted, nevertheless, that the gradual buildup of these heavy metals in rivers may result in levels that rise above allowable bounds, posing a risk to human health and the environment.

These heavy metals were shown to have their origins in household trash, industrial processes, and agricultural practices.These actions contribute to the heavy metals that are released into rivers, where they build up and can contaminate water and aquatic life.

To ensure that heavy metal contamination in rivers is kept to a minimum, the study's findings point to the necessity of ongoing monitoring and regulation of industrial operations, agricultural practices, and home waste disposal. To ascertain the long-term impacts of heavy metal poisoning on the ecosystem and human health, more research is required.

Table 9: Permissible Limit

Heavy Metal	**Permissible Limit**				
	WHO	**USEPA**	**ISI**	**CPCB**	**ICMR**
Lead(mg/l)	0.05	-	0.10	Norelaxation	0.05
Copper(mg/l)	1.0	1.3	0.05	1.5	1.5
Zinc(mg/l)	5.0	-	5.0	15.0	0.10
Chromium (mg/l)	0.1	-	0.05	Norelaxation	-

WHO; World Health Organization, USEPA; United States Environmental Protection Agency ISI; Indian Standard Institution, ICMR; Indian Council of Medical Research, CPCB; Central Pollution Control Board

V. CONCLUSION

Because of the possible effects heavy metals may have on the environment and human health, there is increasing worry about their presence in rivers. In order to comprehend the origins, distribution, and accumulation of these contaminants in aquatic systems, it is crucial to investigate heavy metals in rivers. This study has shed light on the origins and destiny of heavy metals in rivers and emphasized the significance of tracking and reducing these pollutants.

The results of this study show that a variety of sources, such as mining, natural weathering, industrial discharge, and agricultural runoff, can contribute heavy metals to waterways.These contaminants can have a negative impact on aquatic and human health when they build up in sediments and aquatic organisms. There are several factors that affect the concentration of heavy metals in rivers, such as temperature, pH, flow rate, and the presence of other contaminants.

Effective monitoring and control measures are required to lessen the negative effects of heavy metals on river systems.Industries should use best practices that lessen the release of heavy metals, and regulatory frameworks that restrict the discharge of heavy metals into rivers should be put in place. Advanced monitoring techniques can be used to identify contamination sources early on by tracking and detecting the movement of these contaminants.

Rivers that contain heavy metals represent a serious risk to both human health and the ecosystem.Understanding the origins, distribution, and accumulation of these pollutants in aquatic systems requires an understanding of heavy metals in rivers.It takes efficient monitoring and control measures to lessen the negative effects of these pollutants on river systems and safeguard aquatic and human health.

VI. SUMMARY

Using clean, labeled containers, samples were collected from multiple sources, such as groundwater and river water, and gathered from different places to generate representative samples for analysis. One of the main rivers in the southern Indian state of Tamil Nadu is the Tamirabarani River. It rises in the Western Ghats and passes through the districts of Thirunelveli and Thoothukudi before emptying into the Bay of Bengal.

One of the largest rivers in South India, the Cauvery River rises in the Western Ghats and passes through the states of Tamil Nadu and Karnataka. The river has a catchment area of approximately 81,155 square kilometers and is about 765 kilometers long. The obtained water samples underwent many pre-treatment methods aimed at eliminating suspended particles, adjusting pH, and transforming the heavy metals into a state suitable for AAS measurement.

The AAS instrument was calibrated using standard solutions containing known quantities of heavy metals prior to analysis. Plotting the instrument response against the metal concentration produced the calibration curve, which was created by analyzing standard solutions with various heavy metal concentrations.

A. Sample Analysis:

The prepared water sample was placed into the AAS apparatus following calibration. The sample was heated to a high temperature in graphite or flame furnace to atomize and ionize it. The ions were identified and quantified according to their absorption of light at particular wavelengths. The concentration of the heavy metals in the sample was ascertained by comparing the absorbance of the heavy metals in the sample to the calibration curve.

B. Data Analysis:

The content of heavy metals in the sample was ascertained by comparing the measured absorbance values to the calibration standards. The analysis's findings were presented as the total mass of the heavy metal in the sample or as the concentration of the heavy metal in the sample. Replicate measurements were used to assess the precision, and recovery tests and spiker tests were used to assess the accuracy of the data.

Lead, copper, zinc, and chromium were the most often found heavy metals in the waterways, according to the investigation. It was discovered that these heavy metal levels were below the permitted limits established by regulatory organizations. It was highlighted, although, that the gradual buildup of these heavy metals in the rivers may result in levels that rise above allowable bounds, posing a risk to the environment and public health.

It is crucial to investigate heavy metals in rivers in order to comprehend the origins, paths, and build-up of these pollutants in aquatic environments. This study has shed light on the origins and ultimate destination of heavy metals in rivers and emphasized the significance of keeping an eye on and managing these contaminants. The results of this study indicate that in order to ensure that heavy metal contamination in rivers is kept to a minimum, there is a need for ongoing monitoring and regulation of industrial activities, agricultural practices, and home waste disposal.To ascertain the long-term impacts of heavy metal poisoning on the ecosystem and human health, more research is required.

The ecosystem and human health are seriously threatened when heavy metals are present in rivers. Understanding the sources, distribution, and accumulation of these contaminants in aquatic systems requires an understanding of heavy metals in rivers. In order to limit the effects of these pollutants on river systems and safeguard the health of people and aquatic life, effective monitoring and management measures are needed.

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