

***Assessment of heavy metals pollution in the sediments of Ennore
Creek, Tamil Nadu***

Submitted in partial fulfilment of the requirements for the award of Bachelor of
Science degree in Biotechnology

By

Balaji U (40770006)



DEPARTMENT OF BIOTECHNOLOGY

SCHOOL OF BIO AND CHEMICAL ENGINEERING

SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY

(DEEMED TO BE UNIVERSITY)

Accredited with Grade "A" by NAAC

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the Bonafide work of Balaji U (40770006) B.Sc Biotechnology, Sathyabama Institute of Science and Technology, Chennai has carried out the project entitled **"Assessment of heavy metals pollution in the sediments of Ennore Creek, Tamil Nadu"** Under the supervision of Dr. S. Sivaraj, Col. Dr. Jeppiaar Research Park, Sathyabama Institute of Science and Technology, Chennai from November 2022 to April 2023.

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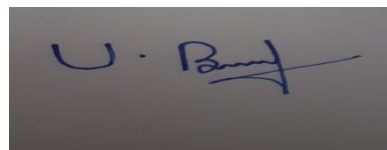
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DECLARATION

I Balaji U (40770006) hereby declare that the Project Report entitled “**Assessment of heavy metals pollution in the sediments of Ennore Creek, Tamil Nadu**” was completed under the guidance of Dr. V. RAMESH KUMAR (Internal) and Dr. S. Sivaraj (External) at Centre for Ocean Research, Col. Dr. Jeppiaar Research Park, Sathyabama Institute of Science and Technology is submitted in partial fulfilment of the requirements for the award of Bachelor of Science degree in Biotechnology.

DATE:12/5/23

PLACE: Chennai

A rectangular box containing a handwritten signature in blue ink. The signature appears to be 'U. Balaji' with a stylized flourish at the end.

SIGNATURE OF THE CANDIDATE

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ABSTRACT

In the present study, we are going to evaluate the concentration of heavy metals in water and sediment samples collected from the Ennore creek in Tamilnadu, India. The water and sediment sample were collected during monsoon 2022. Ennore creek is considered as polluted environment due to the discharge of contaminants by various anthropogenic activities. The water bodies is surrounded by thermal power plant is most exploited and polluted, and other industries were located in the vicinity of Ennore creek. We observed the heavy metal concentration in water and sediment by Atomic Absorption Spectrophotometer (AAS). The heavy metals concentration in water sample were Pb (0.418µg/l), Cr (0.090µg/l), Cd (0.068µg/l), Zn (0.03µg/l), Fe (0.026µg/l), Cu (0.021µg/l) with the following order Pb>Cr>Cd>Zn>Fe>Cu. In the studied metals Ca and Cr were above the permissible limits as prescribed by WHO (2003). The heavy metal concentration in sediment sample with the following order Pb (0.26 µg/g), Zn (0.17µg/g), Cr (0.13µg/g), Cd (0.10µg/g), Fe (0.07µg/g), Cu (0.06µg/g). The metals Ca, Cr and Pb in sediments samples were above the WHO (2006) permissible limits. The exceeding limits of heavy metals in water and sediment were reported owing to anthropogenic activities take place in the vicinity of Ennore creek. Based on the study, the government should conduct the long-term pollution monitoring study in the respective area in order to implement the optimal mitigation measures.

LIST OF ABBREVIATION

TOC-Total Organic Carbon

AAS-Atomic Absorption Spectroscopy

Wt-Weight of air-dry soil

Km-Kilometre

g-gram

H₂SO₄-Sulfuric acid

HNO₃-Nitric acid

H₃PO₄-Phosphoric acid

M-Molarity

V blank-Volume of solution required to titrate the blank

V sample- Volume of solution required to titrate the sample

mL-Millilitre

WHO-World Health Organization

m-Meter

%-Percentage

Cd-Cadmium

Cr-Chromium

Cu-Copper

Fe-Iron

Pb-Lead

Zn-Zinc

µg/l- Microgram per liter

µg/g- Microgram /gram

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CHAPTER 1

INTRODUCTION

Environmental problem is serious concern in the presence of heavy metals in aquatic systems. Heavy metals from sources like waste, mining, and agriculture can contaminate and enrich sediment in freshwater systems, accumulating in various compartments of the aquatic system and negatively impacting human health. Sediments serve as a source of secondary contamination, with 99% of heavy metals adhering to sediment. Heavy metal concentration is higher in the lower river length due to sediment deposition and effluent intake (Chettri *et al.*, 2022). Heavy metals are group of metals and metalloids having atomic density greater than 4 g/cm³. Exceeding safe levels of heavy metals, such as chromium (Cr), copper (Cu), and zinc (Zn), can pose various non-carcinogenic health hazards to humans, including liver disease, neurological impairments, and headaches (Achary *et al.*, 2016).

As a natural component of the aquatic environment, sediment acts as a reservoir for a broad range of contaminants. The existence of excessive heavy metal loads in sediment as a result of human influence can endanger water supplies and cause changes in natural conditions. Additionally, benthic creatures, the biota, the purity of the water, and numerous invertebrates that use sediment as a food source are all adversely affected by heavy metal pollution in sediments. Since heavy metals can bioaccumulate in invertebrate animals, they might then get to the other trophic levels in the cycle (Calmuc *et al.*, 2021). They have a high ecological importance because they are not eliminated from water by self-purification, but instead collect in reservoirs and reach the food chain. The most reliable sign of a rise in metal concentrations in a pond is an increase in their concentrations in the bottom sediment (Loska and Wiechula, 2003).

River water mixes with sea saline water in estuaries, where geological and biogeochemical processes like deposition, precipitation, and flocculation of particulate matter take place. The evolution of particle the composition in the creek's mixing zone shows that heavy metals do not act cautiously and are influenced by shifting physicochemical circumstances such as salinity, pH, and redox. Under toxic circumstances, the impact of changing redox conditions on the geochemical behaviour of heavy metals in the water column is addressed. Heavy metals can be

attached to a variety of organic matter, including living creatures, debris, and mineral particle coatings. The solid phase's fine-grained size portion is where heavy metal concentrations primarily occur (Che *et al.*, 2003). Sediment is a solid substrate composed of detritus, inorganic and organic fragments, and is comparatively diverse in terms of physical, chemical, and biological properties (Sarkar *et al.*, 2004). Metals are partitioned with the nearby water ways sediments serve as significant trace metal carriers in the hydrological cycle and serve as a good indicator of the health of aquatic ecosystems. Sediment geochemical properties can be used to figure out weathering patterns and contamination sources (Selvaraj *et al.*, 2004).

Sediments are complex mixtures that contain inorganic components, mineral particles, and organic matter in different stages of decomposition. They are widely recognized as sensitive indicators of natural and human-induced changes in aquatic environments. Although metal pollution of the sea may not be as visible or direct as other types of marine pollution, it can have significant and far-reaching effects on marine ecosystems and human health. To assess the abundance and availability of metals in the marine environment, researchers study the bioaccumulation of metals in the tissues of marine organisms, which led to the development of the bio-indicator concept (Kucuksezgin *et al.*, 2006).

The availability of metals and the degree to which they accumulate in and are released from estuarine sediments are not only influenced by the ambient metal concentrations but also depend on the spatial and temporal variations in the physico-chemical properties of the estuary. Various environmental factors, including salinity, pH, suspended and particulate matter, and oxygen concentration, are known to vary spatially and temporally along an estuarine system, and they can have complex effects on the release and speciation of metals (De Wolf *et al.*, 2007). The rapid growth of urban and industrial activities in cities worldwide has led to a significant increase in contaminants being introduced into rivers, estuaries, and coastal regions. This pollution has been ongoing for decades, with pollution levels continuing to rise without effective control measures (Jayaprakash *et al.*, 2008).

Estuaries are highly sensitive regions that act as a natural channel for the transportation of urban, industrial, and agricultural contamination into the ocean. The detrimental effects of long-term heavy metal pollution in the marine

environment, particularly in estuaries, have prompted numerous inquiries into the impact of these contaminants on the biological processes of marine organisms. (Padmini and Rani, 2009). Core sediments have the potential to provide insights into the pollution history of aquatic ecosystems, and the geochemical properties of sediments can be utilized to deduce the trend of weathering and the origin of pollution. In recent decades, the examination of sediment cores has proven to be an exceptional approach for determining the impact of human-induced and natural events on depositional surroundings. Coastal and estuarine areas are critical locations for many persistent pollutants, which accumulate in bottom sediments and organisms. Analysing dated sediment profiles from industrialized estuaries is an extremely valuable technique for evaluating sediment quality. Sediment cores provide insight into events that transpired in prehistoric times within lakes and their surrounding catchment regions. Vertical pollutant profiles in sediment cores are often utilized as "pollution records." Researchers from various parts of the world have reported on the trace element pollution of sediment in aquatic environments brought on by industrialization. Many researchers have used sediments to study the behaviour of metals over time of sedimentation (Harikumar and Nasir, 2010).

Estuaries are areas where the sea and land meet and experience complex physical, chemical, and biological processes due to their unique hydrodynamic conditions. Due to human activities, most of the suspended particulate matters (SPMs) from rivers are deposited in estuaries. Some of these SPMs are then redistributed towards nearby continental shelves. Suspended particulate matters (SPMs) play a crucial role in transporting heavy metal pollutants, and their behaviour within estuaries is relatively predictable (Fan *et al.*, 2023). Individuals who use water or consume fish sourced from heavy metal-polluted rivers may experience severe health impacts. Heavy metals are known as conservative pollutants because they exhibit a stable and unreactive behaviour in all types of environmental samples (Arisekar *et al.*, 2020). The Ennore creek is exposed to various pressures resulting from human activities, including the release of industrial waste and sewage from households. The consistent discharge of industrial waste and domestic sewage has caused the estuarine water in Ennore to undergo eutrophication, which is not observed to the same extent in the nearby coastal regions. Research conducted in the past has indicated that there are elevated levels of heavy metals present in

different types of aquatic organisms, such as polychaetes, fish, and green mussels, in the Ennore estuary (Savurirajan *et al.*, 2022). To gain an understanding of the concentration of heavy metals in the sediment and water of the Ennore estuary.

CHAPTER 2

LITERATURE SURVEY

A careful literature of review regarding to metal contamination in water and sediment were listed.

Kasilingam *et al.* (2016) studied the trace element concentration in surface sediments of the Palk Strait, southeast coast of Tamil Nadu, India. The authors found that the sediments were contaminated with trace elements such as chromium, copper, nickel, and lead. They noted that the contamination was likely due to anthropogenic activities such as industrialization and urbanization in the surrounding areas. The study recommended regular monitoring and management practices to prevent further contamination of the sediments. Chettri *et al.* (2022) conducted a study on the pollution index assessment of the Teesta River in India, with a focus on heavy metals in surface water and sediment quality. The authors found that the river was polluted with heavy metals such as lead, cadmium, copper, and zinc, and that the pollution was likely due to anthropogenic activities such as urbanization, industrialization, and agricultural practices.

Zhang *et al.* (2023) conducted a study on the distribution, risk assessment, and source analysis of heavy metals in surface sediments and near-lakeshore soils of a plateau lake in China. The study found that the sediments and soils were contaminated with heavy metals such as lead, cadmium, and zinc, with the highest levels of contamination found near urban areas and industrial sites. The study recommended the implementation of pollution control measures to reduce the heavy metal contamination of the lake and its surrounding areas. Calmuc *et al.* (2021) conducted a study on heavy metal pollution levels in sediments and ecological risk in the lower Danube River, Romania. The authors found that the sediments were contaminated with heavy metals such as lead, cadmium, copper, and zinc, with the highest levels of contamination found near urban and industrial areas. The study recommended the implementation of pollution control measures and the regular monitoring of the river's ecological health.

Loska and wiechula (2003) conducted a study on the estimation of the sources of heavy metal contamination in surface sediments from the Rybnik Reservoir using

principal component analysis (PCA). The authors found that the sediments were contaminated with heavy metals such as lead, cadmium, and zinc, with the highest levels of contamination found near industrial and urban areas. The study concluded that PCA is an effective tool for identifying the sources of heavy metal contamination in sediments. The study conducted by Yue Che *et al.* (2003) investigates the distribution of particulate heavy metals and its indication to the transfer of sediments in the Changjiang Estuary and Hangzhou Bay, China. The authors analyze sediment samples for concentrations of heavy metals and use statistical methods to determine the spatial distribution of heavy metals. This study provides valuable insights into the transport and distribution of heavy metals in the region, and the potential impact on marine ecosystems.

The study was made by Reddy *et al.* (2004) examines the levels of heavy metals in sediments from the Alang-Sosiya ship scrapping yard in India. The authors found that the sediments had high levels of heavy metals, including lead, zinc, and copper, which are likely to have been released during the ship scrapping process. The study highlights the importance of proper waste management practices in preventing environmental contamination in industrial areas. Selvaraj *et al.* (2004) focused on evaluating metal contamination in coastal sediments of the Bay of Bengal, India using geochemical and statistical approaches. The authors analyse sediment samples for concentrations of heavy metals and use statistical methods to determine the sources of contamination. This study provides valuable insights into the extent of metal pollution in the Bay of Bengal and the potential sources of contamination.

The study conducted by Sarkar *et al.* (2004) analysed the levels of elements in the surficial estuarine sediments of the Hugli River in northeast India and their environmental implications. The authors examine sediment samples for concentrations of various elements and use statistical methods to determine the sources of contamination. This study provides important information on the levels of elements in the sediments and their potential impact on the environment and human health. The study conducted by Singh *et al.* (2005) investigates the distribution and fractionation of heavy metals in Gomti river sediments, a tributary of the Ganges in India. The authors analyse sediment samples for concentrations of heavy metals and use sequential extraction procedures to determine the fractionation of the

metals in the sediment. This study provides important information on the potential mobility and bioavailability of heavy metals in the sediments, which can have implications for the health of the ecosystem and human health. Ribeiro *et al.* (2005) investigated the bioaccumulation and effects of organochlorine pesticides, PAH, and heavy metals in eels at the Camargue Nature Reserve, France. They reviewed previous studies on bioaccumulation and discussed the potential health effects on both eels and human consumers. The authors concluded that the eels showed bioaccumulation of pollutants and that there was a potential risk to both eel and human health from consuming contaminated eels.

Yakovelev *et al.* (2022) evaluated heavy metals distribution and environmental risk parameters in bottom sediments of the Pechora River estuary in the Arctic Ocean Basin. The study found that heavy metal concentrations varied significantly across the study area, with the highest concentrations found in the central part of the estuary, close to the river delta, attributed to the input of heavy metals from anthropogenic activities upstream. The authors used several environmental risk assessment parameters to evaluate the potential ecological risks of heavy metals in the sediments, highlighting the need for further monitoring and remedial actions. Kucuksezgin *et al.* (2016) assessed marine pollution in Izmir Bay, focusing on nutrient, heavy metal, and total hydrocarbon concentrations. The study found high levels of nutrients, heavy metals, and total hydrocarbons in some areas of Izmir Bay, indicating potential environmental risks.

Acevedo *et al.* (2006) investigated trace metals in sediments of two estuarine lagoons in Puerto Rico. The study found high levels of trace metals, such as lead, zinc, and copper, in the sediments of both lagoons, indicating potential environmental risks. The authors suggested that future research should focus on identifying pollution sources and developing management strategies to mitigate the impacts of trace metals on the ecosystem and human health. Magalhaes *et al.* (2007) studied the impact of trace metals on denitrification in estuarine sediments of the Douro River estuary, Portugal. The study found that trace metals, particularly copper, had a negative impact on denitrification rates in the sediments, potentially leading to increased nitrogen loads in the estuary. The authors highlighted the need for further research to better understand the mechanisms of trace metal impacts on

microbial processes in estuarine sediments and to develop effective management strategies to mitigate their effects.

De Wolf *et al.* (2007) studied the spatio-temporal variation in the energy content of the periwinkle *Littorina littorea* in the western Scheldt estuary, Netherlands. The study found that pollution had a negative impact on the energy content of periwinkles, which could affect their health and fitness of the resident biota. The authors suggested that the energy content of periwinkles could be used as a biomonitoring tool to assess pollution levels in estuarine ecosystems. Zhang *et al.* (2007) investigated heavy metal contamination in sediments of western Xiamen Bay and its vicinity, China. The study found elevated levels of heavy metals in sediments from industrialized areas, indicating potential environmental risks. The authors suggested the implementation of appropriate pollution control measures to prevent further contamination and protect the health of the ecosystem.

Jayaprakash *et al.* (2008) conducted a study on acid-leachable trace metals in sediments from Ennore Creek, an industrialized region of Chennai City, South East coast of India. The study found high levels of trace metals in the sediments, which could have negative impacts on the local ecosystem and human health. The authors recommended regular monitoring of the area to assess and control the levels of metal contamination. Honglei *et al.* (2008) conducted a study on heavy metal fraction distribution and risk assessment in sediments of Moshui Lake. The study found that the sediments were contaminated with heavy metals, with the highest concentrations of Cu and Zn.

Harikumar and Nasir (2010) conducted an ecotoxicological impact assessment of heavy metals in core sediments of a tropical estuary. Zhang *et al.* (2010) investigated the levels of heavy metals in water, soils, and plants in riparian wetlands in the Pearl River Estuary, South China. Nobi *et al.* (2010) conducted a geochemical and geostatistical assessment of heavy metal concentration in sediments of different coastal ecosystems in the Andaman Islands, India. Rajaram and Ganeshkumar (2019) investigated the anthropogenic influence of heavy metal pollution on the southeast coast of India. Swain *et al.* (2021) conducted time-series monitoring and ecological risk assessment of heavy metal pollution in the Mahanadi estuary, east coast of India. Fan *et al.* (2023) investigated the spatiotemporal

variations of heavy metal historical accumulation records and their influencing mechanisms in the Yangtze River Estuary. Lyla *et al.* (2022) conducted a spatial analysis, ecological risk assessment, control factors, and sources of heavy metal pollution in the shelf surface sediments of the southwest Bay of Bengal, India. They concluded that anthropogenic activities were the main sources of heavy metal pollution in the region.

Tholkappian *et al.* (2018) used Energy Dispersive X-Ray Fluorescence Spectroscopy (EDXRF) with a statistical approach to assess heavy metal toxicity in sediments of Chennai Coast of Tamil Nadu. They analysed the concentrations of various heavy metals and conducted statistical analysis to assess the toxicity and sources of contamination. The authors recommended regular monitoring and management strategies to prevent future contamination. Vinothkannan *et al.* (2022) conducted a study on the ecological risk assessment and seasonal variation of heavy metals in water and sediment collected from the industrially polluted Cuddalore coast in South-eastern India. Kumar *et al.* (2022) conducted a study on heavy metal contamination, distribution and source apportionment in the sediments from Kavvayi Estuary, South-west coast of India. And concluded that the levels of heavy metals in the sediments exceeded the permissible limits set by regulatory bodies, indicating potential environmental risks. Du *et al.* (2022) studied the effects of emerging contaminants and heavy metals on bacterial communities in estuarine sediments. The study found that these contaminants significantly affected the bacterial community structure and diversity, which may have negative implications for estuarine ecosystem health.

Li *et al.* (2020) conducted a study on the effects of heavy metals on microbial communities in sediments and the establishment of bioindicators based on microbial taxa and function for environmental monitoring and management. The study found that heavy metals significantly affected the diversity and composition of microbial communities in sediments. The authors suggest that microbial bioindicators can be used for effective environmental monitoring and management of heavy metal pollution. Liu *et al.* (2019) studied the effects of dissolved oxygen, salinity, nitrogen, and phosphorus on the release of heavy metals from coastal sediments. The study found that these factors significantly affected the release of heavy metals, with dissolved oxygen and salinity having the strongest effects. The authors suggest that

these findings can be used to develop effective management strategies for reducing heavy metal pollution in coastal sediments. Christophoridis *et al.* (2019) investigated the effects of anthropogenic activities on the levels of heavy metals in marine surface sediments of the Thessaloniki Bay, Northern Greece.

Adani *et al.* (2022) conducted a study on the bioaccumulation of heavy metals in water and sediments in the coastal waters of Kalpakkam, Southeast coast of India. The study found that the food components contained high levels of heavy metals, which were attributed to anthropogenic sources such as industrial activities and urbanization. The authors suggest that the results have implications for food safety and the health of the local population. Achary *et al.* (2016) conducted a study on the health risk assessment and seasonal distribution of dissolved trace metals in surface waters of Kalpakkam, southwest coast of Bay of Bengal. The study found that the surface water samples contained high levels of dissolved trace metals, which posed potential health risks to human and aquatic life. Li *et al.*, (2019) investigated the inter-annual variability and distribution of heavy metals in the Yangtze River estuary sediment, China. The study found that the sediment samples contained high levels of heavy metals, which exhibited inter-annual variability and spatial variations. The authors suggest that the results can be used to guide future environmental management and remediation efforts in the region.

CHAPTER 3

AIM AND SCOPE

To assess the extent of heavy metal contamination and total organic carbon levels in sediment samples from Ennore Creek and to evaluate the potential impact on the environment.

- To identify the major sources of heavy metal pollution in the Ennore creek.
- To determine the organic load in the sediment of Ennore creek.
- To analysis the heavy metal concentration in water and sediment of Ennore creek.
- To provide recommendations for the sustainable development of the Ennore creek, taking into account the impacts of heavy metal pollution and other environmental stressors.

CHAPTER 4

MATERIALS METHOD

1. STUDY AREA

Ennore estuary is a small but ecologically important wetland ecosystem located on the east coast of India, in the state of Tamil Nadu. It is situated at the mouth of the Ennore Creek, which is formed by the confluence of the Kosasthalaiyar River and the Buckingham Canal. The estuary covers an area of approximately 11 km² and is bounded by the Bay of Bengal on one side and the Ennore Port on the other (Muralidharan and Sukumaran, 2012).

1. *Geology and Topography*

The Ennore estuary is situated at the mouth of the Kosasthalaiyar River, which originates in the Eastern Ghats and flows for about 136 km before joining the Bay of Bengal. The estuary is formed due to the deposition of sediments carried by the river, which is also responsible for the fluctuation of the water level in the estuary. The topography of the estuary is characterized by a flat and marshy terrain with a few small islands.

The Ennore estuary is also an important feeding and breeding ground for various species of birds, including migratory birds such as sandpipers, plovers, and terns. The estuary is home to around 160 species of birds, including 15 species of waterfowl making it an important bird watching site in the region.

The fish population is also diverse, with around 62 species of fish reported to inhabit the estuary. The major fish species found in the estuary are *Clupea harengus*, *Liza macroleois*, *Etroplus suratensis*, and *Mugil cephalus*.

4.1.2. *Threats to Ennore Estuary*

The Ennore estuary is facing a range of threats due to anthropogenic activities such as industrialization, urbanization, and overfishing. The estuary is located in close proximity to the Ennore Thermal Power Station, which is one of the major sources of pollution in the area. The discharge of untreated effluents from the power station

has led to a deterioration in the water quality of the estuary, which has adversely affected the aquatic flora and fauna.

The Ennore estuary is also facing the threat of encroachment due to urbanization and industrialization. The estuary is surrounded by several industrial and residential complexes, which has led to the degradation of the surrounding habitats. The construction of a new port at Ennore has also raised concerns about the impact of dredging and other associated activities on the estuarine ecosystem.

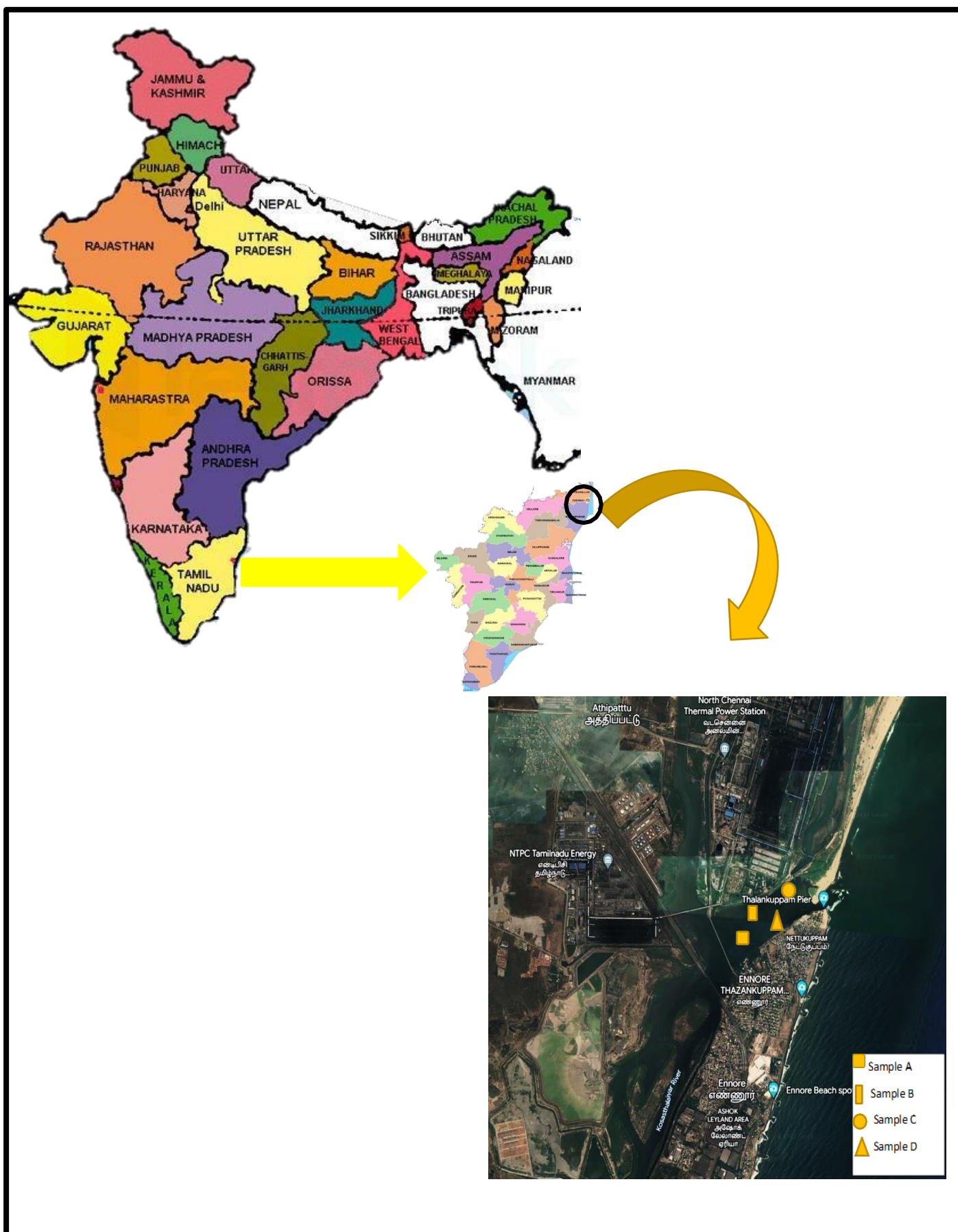
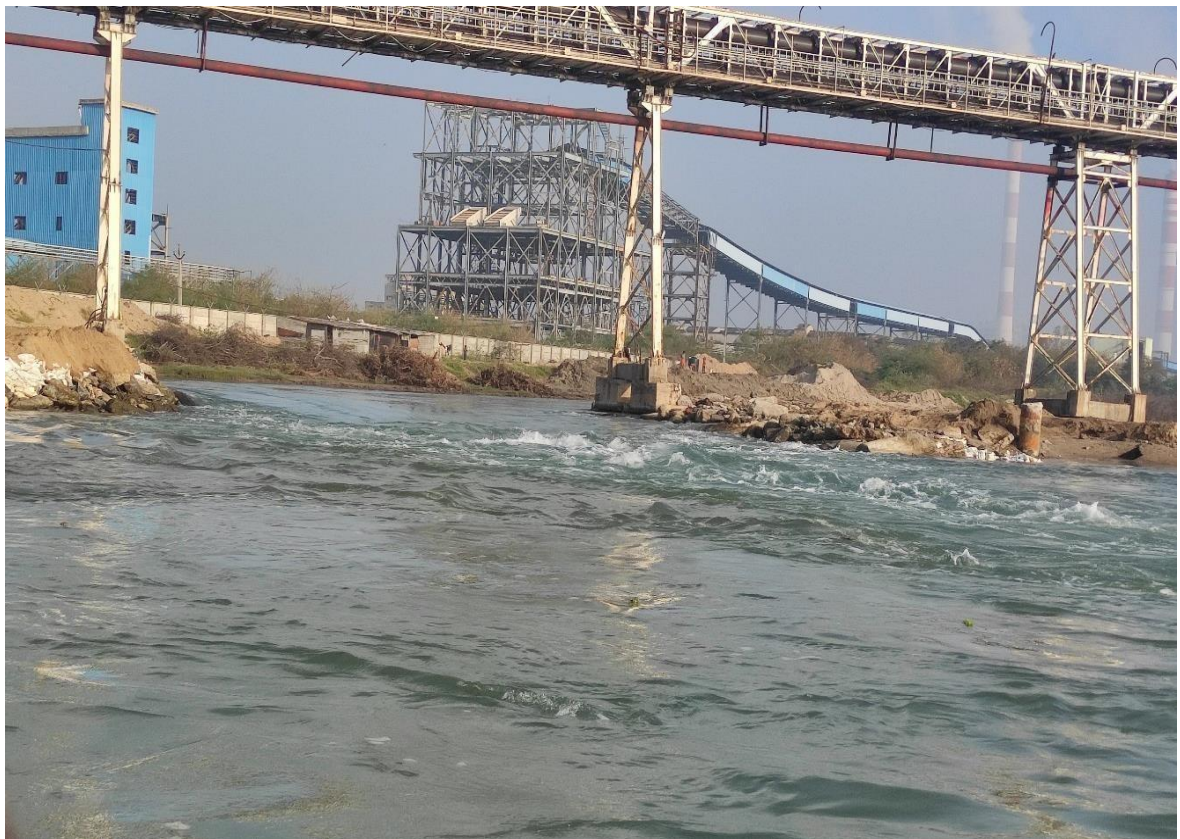


Fig:4.1. STUDY AREA MAP

4.2. Sampling stations





4.2.1. Sampling

The Ennore Estuary is a unique ecosystem that supports a diverse range of aquatic flora and fauna. To understand the environmental quality of the estuary, it is essential to collect representative samples from different locations within the estuary. In this study, we have collected 4 sediment samples and 3 water samples from the Ennore Estuary.

The sampling sites were selected based on their proximity to potential sources of pollution, such as industrial and residential areas. The first sampling site was located near the Ennore Thermal Power Station, which is a major source of pollution in the area. The second sampling site was located near the estuary mouth while the third and fourth sampling sites were located in bridge and local fish landing site.

The triplicate sediment samples were collected using a van Veen grab sampler. The van Veen grab sampler is a widely used device for collecting sediment samples from aquatic environments. It consists of two hinged jaws that are operated by a spring-loaded mechanism. The jaws are opened when the sampler is lowered to the bottom of the water body, and they close when the sampler is lifted. This allows the sampler to collect a representative sample of the sediment from the bottom of the estuary.

At each sampling site, the sampler was lowered to the bottom of the estuary and operated according to the standard protocol. The collected samples were packed in a thick polyethylene bag and properly labelled before adopting further laboratory geochemical analysis. In the laboratory, the sediment samples were dried and homogenized before analysis.



Fig:4.2. sample collection



Fig: 4.3 van Veen grab sampler



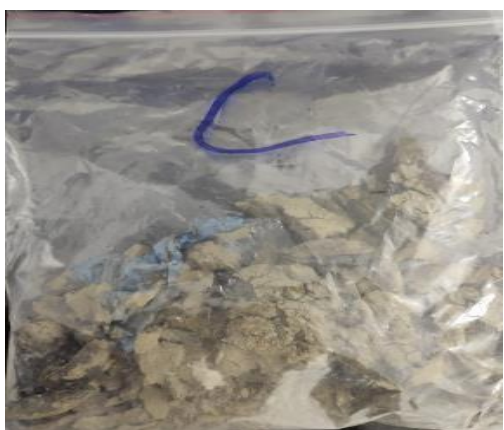
Fig: 4.4 Water samples



Sample A



Sample B



Sample C



Sample D

Fig: 4.5. Sediment samples

4.3. MATERIALS

- van Veen grab sampler
- Polypropylene bag
- Plastic container
- Plastic tray
- Beaker
- Pipette
- Test tubes and vials
- Potassium dichromate
- Concentrated H_2SO_4
- Concentrated HNO_3
- Concentrated H_3PO_4
- Perchloric acid
- Phenolphthalein indicator
- Ferrous ammonium sulphate
- Hot plate
- Whatman filter no 42
- Weighing machine
- Magnetic stirrer
- Mortar pestle
- Burette

4. METHODOLOGY

1. *Total Organic Carbon (TOC) analysis using titration*

Total Organic Carbon (TOC) is a measure of the amount of organic carbon present in a sample. TOC analysis is widely used in various fields, including environmental science, geology, and chemistry. It provides valuable information about the quantity and quality of organic matter in a sample, which can have significant implications for environmental and geological studies.

The titration method is one of the commonly used analytical techniques for determining TOC content in a sample. This method involves the oxidation of organic carbon in the sample using a strong oxidizing agent in the presence of a strong acid.

The excess oxidizing agent is then titrated with a reducing agent, and the amount consumed is proportional to the TOC content in the sample.

TOC analysis using titration is particularly useful in sediment studies, where it can provide insight into the depositional environment, the source and quality of organic matter, sedimentation rates, and environmental changes over time. This information can be used to better understand the history of an area and make informed decisions about future land use and management practices.

4.4.1.1. Determination of organic carbon in sediment

- Samples were collected from Ennore creek.
- The collected samples were dried and powdered using mortar pestle.
- 1g of air-dried sample were taken in 500 ml beaker.
- Leave the mixture for 30 mins.
- Added 200ml DL water, then add 10ml concentrated H_3PO_4 using a dispenser, and place the mixture to cool.
- Then Added 10 - 15 drops phenolphthalein indicator solution add a Teflon coated magnetic stirring bar, and place the beaker on a magnetic stirrer.
- Titrate with 0.5m ferrous ammonium sulphate solution, until the colour changes from violet blue to green
- Prepared two blanks containing all reagents but no soil and treat them in exactly the same way as the soil suspensions.

4.4.1.2. TOC Calculations

$$M = 10/V_{\text{blank}}$$

$$\text{Oxidizable organic carbon} = \frac{(V_{\text{blank}} - V_{\text{sample}}) \times 0.3 \times M}{1}$$

$$\text{Total organic carbon (\%)} = 1.334 \times \text{oxidizable organic carbon (\%)}$$

$$\text{Organic matter (\%)} = 1.724 \times \text{total organic carbon (\%)}$$

$$\text{Average blank} = 9.06$$

$$M = \frac{10}{V_{\text{blank}}}$$

$$= \frac{10}{9.06}$$

$$= 1.03$$

sample A calculations.

$$V_{\text{blank}} = 9.06$$

$$V_{\text{sample}} = 6.5$$

$$M = 1.103$$

$$\text{Oxidizable organic carbon (\%)} = \frac{(V_{\text{blank}} - V_{\text{sample}}) \times 0.3 \times M}{W_t}$$

$$= \frac{(9.06 - 6.5) \times 0.3 \times 1.103}{1}$$

$$= \frac{2.56 \times 0.3 \times 1.103}{1}$$

$$= \frac{0.847104}{1}$$

$$= 0.847104$$

$$\text{Oxidizable organic carbon} = 0.847$$

$$\text{Total organic carbon (\%)} = 1.334 \times \text{Oxidizable organic carbon\%}$$

$$= 1.334 \times 0.847$$

$$= 1.129898$$

$$\text{TOC} = 1.129\%$$

The same calculation method is used to calculate the remaining Sediment samples B, C and D

4.4.2. Estuarine sediment and water analysis using AAS

The AAS (Atomic Absorption Spectroscopy) method is a widely used analytical technique for the determination of heavy metals in various environmental and biological samples. This method involves the atomization of a sample solution in a

flame, followed by absorption of light by the analyte atoms at specific wavelengths. The amount of light absorbed is proportional to the concentration of the analyte, which allows for quantitative analysis.

The significance of AAS method lies in its high sensitivity, accuracy, precision, and selectivity, which make it an ideal method for the detection and quantification of heavy metals in complex matrices such as estuarine sediments. It is also a relatively simple and cost-effective method that requires minimal sample preparation, making it a popular choice for routine monitoring of heavy metal pollution in aquatic systems. The AAS method has enabled researchers and regulators to better understand the extent and sources of heavy metal pollution in estuarine sediments and its impacts on aquatic organisms and ecosystems.

4.4.2.1. Protocol for Sediment and water Heavy Metal Analysis using AAS.

- Samples were collected from Ennore creek.
- The collected samples were dried and powdered using mortar pestle.
- 1g dried sample were taken.
- 20ml of Concentrated HNO_3 were added.
- Leave the mixture for 24 hrs.
- The sample was evaporated to dryness on a hot plate at 120°C until the residue turned from yellow to white.
- After drying, a 4:1 mixture of nitric acid and perchloric acid was added.
- Evaporated the mixture to near dryness
- If the supernatant solution was either clear or slightly yellow, the sample was fumed to dryness.
- In case if the supernatant liquid is orange colour
- An additional aliquot of nitric and perchloric acid was added, and the sample was fumed to dryness.
- Allow the dry residue to cool and add 10ml of 10% nitric acid.
- Transferred the contents to a 20ml polytopo vial and allow this mixture to stand for 2 hours for the residue to settle.
- The supernatant liquid was filtered using a Whatman no. 42 filter and then transferred in to the vials
- The filtered supernatant liquid was given to AAS for heavy metal analysis.

CHAPTER 5

RESULTS AND DISCUSSION

1. . RESULTS

1. *TOC RESULTS*

Table: 5.1 Total organic carbon recorded in sediment samples of Ennore creek

Sediment Samples	Results
A	1.129%
B	1.305%
C	2.938%
D	0.732%

In our study, we measured the TOC concentrations of four different sediment samples, labelled A, B, C, and D. The results of the analysis showed that sample C had the highest TOC concentration of 2.938%, indicating a relatively high level of organic carbon present in the sample. This may be due to a variety of factors such as the source of the sample, the environmental conditions, or the type of organic matter present. Sample B had a slightly higher TOC concentration of 1.305% compared to sample A, which had a TOC concentration of 1.129%. These results suggest that sample B has a slightly higher level of organic carbon than sample A. The differences in TOC concentrations between samples A and B may be due to variations in the organic matter present in each sample or other environmental factors. Sample D had the lowest TOC concentration of 0.732%, indicating a relatively low level of organic carbon in this sample.

Overall, the TOC results of the four samples shows the variations in the levels of organic carbon present in each sample. These results help to gain insights into the sources and characteristics of the samples, as well as their potential impact on the environment.

5.1.2. WATER HEAVY METAL RESULTS

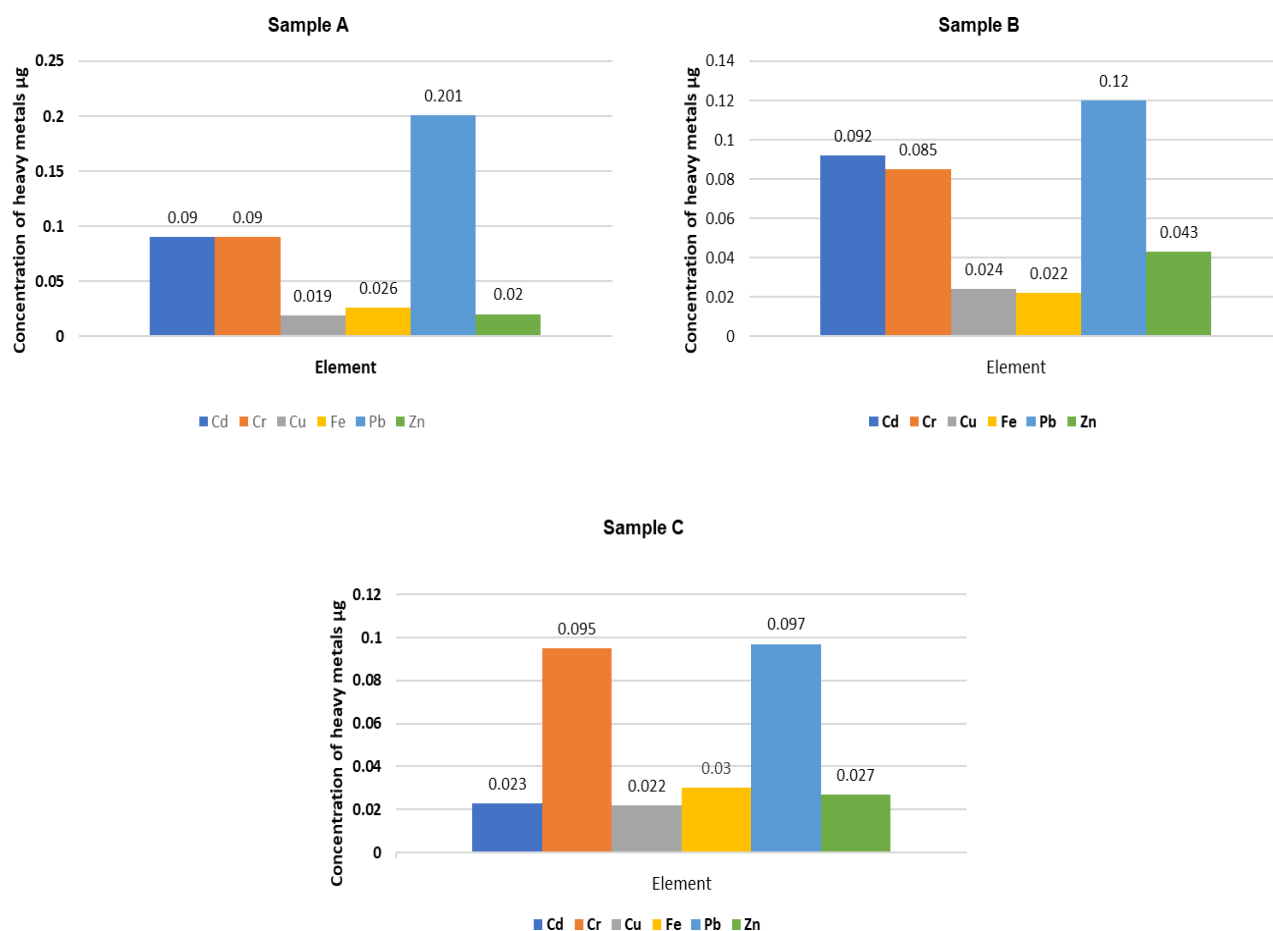


Fig: 5.1. WATER RESULTS

The heavy metal content of the water sample was analysed using Atomic Absorption Spectroscopy (AAS), and the results of sample A are as follows: Cd 0.09 µg/l, Cr 0.09 µg/l, Cu 0.019 µg/l, Fe 0.026 µg/l, Pb 0.201 µg/l, and Zn 0.02 µg/l. It is observed that the concentration of Pb is significantly higher than the other metals, indicating a potential source of contamination. The concentration of Cu and Zn are also relatively high. The concentration of heavy metals recorded in the water sample A in the following order Pb>Fe>Cu>Cd>Cr>Zn.

In sample B the concentration of Pb is significantly higher than that of the other metals, with a value of 0.12µg/l. The concentrations of Cd and Cr are also relatively high compared to Cu, Fe, and Zn, with values of 0.092µg/l and 0.085µg/l for Cd and Cr. Likewise lead, these metals can also be harmful in high concentrations. In contrast, the concentrations of Cu, Fe, and Zn are relatively low, with values of 0.024µg/l, 0.022µg/l, and 0.043µg/l, respectively. The concentration of heavy metals recorded in the water sample B in the following order $Pb > Cd > Cr > Zn > Cu > Fe$.

Cd has the lowest concentration level in sample C among all the heavy metals, with a value of 0.023µg/l. This suggests that there is very little Cd present in the. Cr has a higher concentration level compared to Cd, with a value of 0.095µg/l. This indicates that Cr is present in a greater amount in the sample than Cd. Cu has the second-lowest concentration level among all the heavy metals, with a value of 0.022µg/l. This suggests that Cu is present in very small quantities in the sample. Iron has a slightly higher concentration level compared to Cu, with a value of 0.03µg/l. This indicates that Fe is present in a slightly greater amount in the sample than Cu. Pb (Lead) has the highest concentration level among all the heavy metals, with a value of 0.097µg/l. This suggests that there is a significant amount of pb present in the sample. Zn has a concentration level similar to Cd and Cu, with a value of 0.027µg/l. This indicates that Zn is present in small quantities in the sample. The concentration of heavy metals recorded in the water sample C in the following order $Pb > Cr > Fe > Zn > Cd > Cu$.

The results of the three samples, it is evident that the concentrations of the heavy metals vary considerably between the samples. For example, the concentration of Cd is highest in sample B, followed by sample A and then sample C. Similarly, the concentration of Pb is highest in sample A, followed by sample B and then sample C. The concentrations of the other heavy metals (Cr, Cu, Fe, and Zn) also vary between the samples, with each sample having a unique combination of metal concentrations. For instance, sample A has relatively high concentrations of Fe and Zn, while sample B has relatively high concentrations of Cu and Zn. The overall concentration in waters samples follows as $Cd > Pb > Zn > Fe > Cu > Cr$.

Table:5.2 Permissible limit for water (WHO 2003)

Element	Water Permissible limit (WHO 2003)
Cadmium (Cd)	0.001-0.005µg/l
Chromium (Cr)	0.1µg/l
Copper (Cu)	3.00 µg/l
Iron (Fe)	5.00 µg/l
Lead (Pb)	0.1 µg/l
Zinc (Zn)	5.00 µg/l

The concentration of Cd in the sediment sample A is quite high at 0.09 µg/l, which is much higher than the permissible limit of 0.001-0.005 µg/l set by WHO (2003). permissible limit of 0.1 µg/l.

On the other hand, the concentrations of Cr, Fe, and Zn are well within the permissible limits set by WHO (2003). The concentration of Cu is also within the limit, but at 0.019 µg/l, it is much lower than the permissible limit of 3.00 µg/l.

The concentration of Cd in the sample B is much higher than the permissible limit set by WHO (2003). The concentration of Cr, on the other hand, is within the permissible limit. The concentration of Cu, Fe, and Zn are also well within the permissible limits set by WHO (2003) and the concentration of Pb in the sample is much higher than the permissible limit set by WHO (2003).

Cadmium (Cd) is present in the sample C at a concentration of 0.023µg/l, which is within the permissible limits of 0.001-0.005µg/l set by WHO (2003). Chromium (Cr) is present at a concentration of 0.095µg/l, which is higher than the permissible limit of 0.1µg/l set by WHO (2003). Copper (Cu) is present at a concentration of 0.022µg/l, which is well within the permissible limit of 3.00µg/l set by WHO. Iron (Fe) is present at a concentration of 0.03µg/l, which is within the permissible limit of 5.00µg/l set by WHO (2003). Lead (Pb) is present at a concentration of 0.097µg, which is higher than the permissible limit of 0.1µg/l set by WHO (2003). Finally, Zinc (Zn) is present at a concentration of 0.027µg/l, which is within the permissible limit of 5.00µg/l set by WHO (2003).

5.1.3. SEDIMENT HEAVY METAL RESULTS:

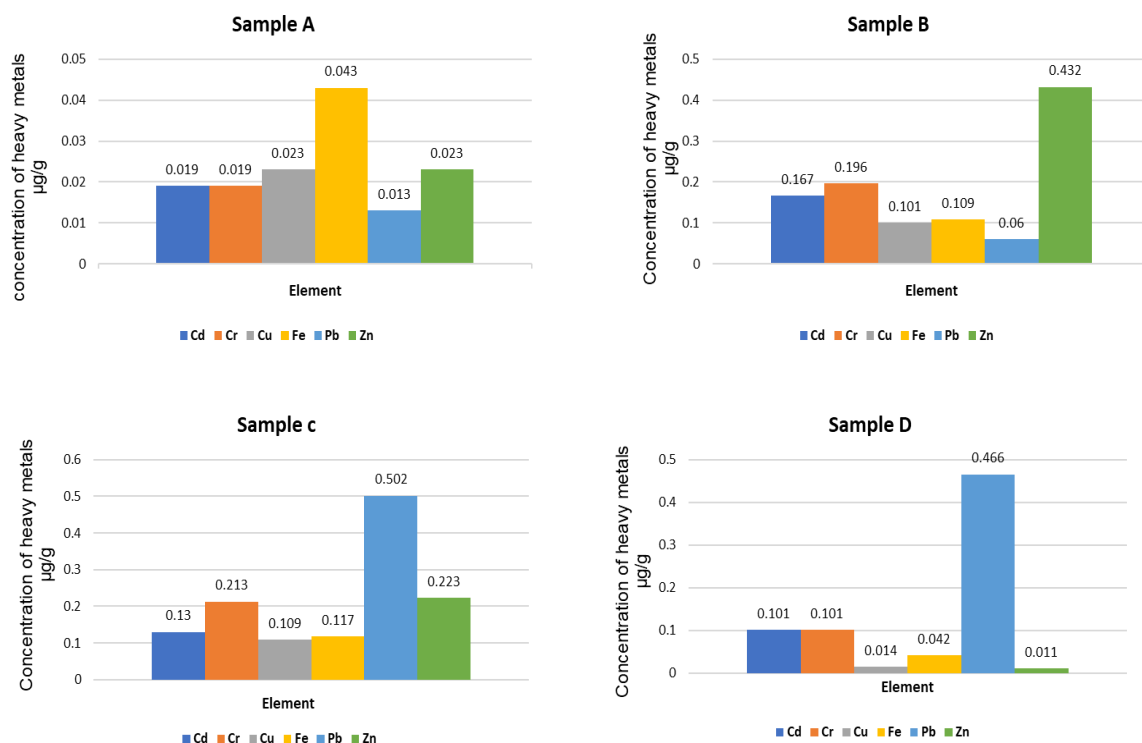


Fig: 5.2. Sediment results

Based on the AAS analysis results, it shows that the concentration of Iron (Fe) in the sediment sample A was 0.043µg/g, which is relatively high compared to the other heavy metals measured, followed by copper (Cu) and zinc (Zn). The concentrations of cadmium (Cd), chromium (Cr), and lead (Pb) were relatively low in concentration. The concentration of heavy metals recorded in the sediment sample A in the following order Fe > Zn > Cu > Cd > Cr > Pb.

The concentration of zinc (Zn) in sediment sample B is significantly higher than that of any other heavy metal analysed. This is followed by chromium (Cr) and cadmium (Cd), while the concentrations of copper (Cu), iron (Fe), and lead (Pb) are relatively low in concentration. The concentration of metals recorded in the sediment sample B in the following order Zn > Cr > Fe > Cu > Cd > Pb.

In the sediment sample C, the concentration of lead (Pb) in the is significantly higher than that of any other heavy metal analysed. This is followed by chromium (Cr) and zinc (Zn), while the concentrations of cadmium (Cd), copper (Cu), and iron (Fe) are relatively lower. The concentration of metals recorded in the sediment sample c in the following order Pb > Zn > Cr > Fe > Cu > Cd.

The analysis reveals that the concentration of lead (Pb) in the sediment sample D is notably higher than the other heavy metals analysed. Cadmium (Cd) and chromium (Cr) exhibit the next highest concentrations, while copper (Cu), iron (Fe), and zinc (Zn) have comparatively lower concentrations. The concentration of metals recorded in the sediment sample D in the following order $Pb > Cd > Fe > Cr > Cu > Zn$.

The heavy metal concentrations in sediment samples A, B, C, and D were determined. The results showed that the concentration of lead (Pb) was highest in sample D, followed by sample C, sample B, and then sample A. Sample B had the highest concentration of Zn, followed by sample C, sample A, and then sample D. Sample C had the highest concentration of chromium (Cr), followed by sample B, sample A, and then sample D. Cadmium (Cd) concentrations were highest in sample B, followed by sample C, sample A, and then sample D. Cu concentrations were highest in sample A, followed by sample C, sample B, and then sample D. Fe concentrations were highest in sample A, followed by sample B, sample C, and then sample D. The overall concentration of metals recorded in the sediment sample were in the following order $Pb > Zn > Cr > Cd > Cu > Fe$. These results can be used to evaluate the potential impact of heavy metal pollution in the sediment samples and to assess the environmental risk associated with the use of the sediment for various purposes. WHO (2006) permissible limit for sediment. Cadmium (Cd) $0.1 \mu\text{g/g}$, Chromium (Cr) $0.03\text{--}0.3 \mu\text{g/g}$, Copper (Cu) $0.05\text{--}0.15 \mu\text{g/g}$, Iron (Fe) $5.00 \mu\text{g/g}$, Lead (Pb) $5.00 \mu\text{g/g}$, Zinc (Zn) $\leq 1 \mu\text{g/g}$.

Table: 5.4 Comparision of studied metals with the other regions in India

Locations	Cd	Cr	Cu	Fe	Pb	Zn	Reference
Ennore creek	0.10	0.13	0.06	0.07	0.26	0.17	Present study *
Thondi coast, palk bay, south	1.2	14.1	290.3	52802	54.7	252.9	Perumal <i>et al.</i> (2021)
Average crustal	0.2	100	55	56300	12.5	70	Taylor and McLennan. (1995)
Coromandel Coast, Bay of Bengal	19	109.45	76.45	7144	49.629	78.76	Anbuselvan <i>et al.</i> (2018)
Southeast coast of India	–	191.3	6.7	2780	19.7	58.7	Kumar <i>et al.</i> (2017)
Van Island, Gulf of Mannar, India	–	108.73	57.81	31219	348.4	52.5	Krishnakumar <i>et al.</i> (2017)
Koswari island, gulf of mannar.	–	67.5	54.2	30988	496.7	16.9	Krishnakumar <i>et al</i> (2017)
Of Chennai, India	–	200.1	113.2	15032	325	123.9	Gopal <i>et al.</i> (2017)
Cuddalore, SE coast of India	–	127	40	10982	33.9	37.7	Jayaprakash <i>et al.</i> (2016)
Palk Strait, southeast coast of India	0.4	302	69	55680	19	244	Kasilingam <i>et al.</i> (2016)
Parangipettai coast, India	–	77.8	30.6	11804	30.12	44.7	Sundaramanickam <i>et al.</i> (2016)
Tuticorin Coast, India	–	15	52	28717	42	247	Magesh <i>et al.</i> (2013)
East Coast of India	–	133.22	140.14	85800	-	-	Alagarsamy <i>et al.</i> (2010)
Tuticorin Coast	0.2	15	52	28717	42	247	Magesh <i>et al.</i> (2013)
Bay of Bengal, of Ennore	6.58	194.8	506.2	27200	32.36	126.8	Raj <i>et al.</i> (2008)
Pitchavaram Mangrove region	6.6	14.2	43.4	32482	11.2	93	Ramanathan <i>et al.</i> (1999)

**Present study, reported metals were expressed in µg/g*
- Data not available

The present study measured the concentrations of six heavy metals, namely Cd, Cr, Cu, Fe, Pb, and Zn, in the Ennore estuary. The data were compared with the concentration found in other areas along the Indian coast, including Thondi coast, Palk Bay, Coromandel Coast, Van Island, Koswari Island, Chennai, Cuddalore, Palk Strait, Parangipettai coast, Tuticorin Coast, Bay of Bengal, and Pitchavaram Mangrove region (Perumal *et al.*, 2021). The comparison allows for an assessment of the level of heavy metal pollution in the Ennore estuary relative to other areas.

The results of the study showed that the concentrations of Cd, Cr, Cu, Fe, Pb, and Zn in the Ennore estuary were lower than those found in most other areas along the Indian coast. For instance, the concentrations of Cd, Cr, and Cu in the Ennore estuary were only 0.10 µg/g, 0.13 µg/g, and 0.061 µg/g, respectively, while the concentrations of these metals in the Thondi coast, Palk Bay, and Coromandel Coast were much higher, ranging from 1.2 µg/g to 19 µg/g for Cd, from 14.1 µg/g to 109.45 µg/g for Cr, and from 6.7 µg/g to 506.2 µg/g for Cu.

Similarly, the concentrations of Fe, Pb, and Zn in the Ennore estuary were also lower than those found in most other areas. The concentrations of Fe in the Ennore estuary and Palk Strait were 0.077 µg/g and 55680 µg/g, respectively, while the concentrations of Fe in the Thondi coast, Palk Bay, and Coromandel Coast ranged from 52802 µg/g to 85800 µg/g. The concentrations of Pb in the Ennore estuary and Pitchavaram Mangrove region were 0.26 and 11.2 µg/g, respectively, while the concentrations of Pb in other areas ranged from 19.7 µg/g to 496.7 µg/g. Finally, the concentrations of Zn in the Ennore estuary and Pitchavaram Mangrove region were 0.17 µg/g and 93 µg/g, respectively, while the concentrations of Zn in other areas ranged from 16.9 to 252.9 µg/g. The present study suggests that the Ennore estuary is relatively less concentration by heavy metals than most other areas along the Indian coast.

5.2. DISCUSSION

Ennore estuary has been affected by coastal pollution for more than two decades and has been identified as a hotspot of metal contamination. The present study reports on metal in seawater, sediment from the Ennore. The depth of Ennore Estuary varies between the sampling stations from 4 to 5m at the Bar mouth to 0.5 to 1m in the river inlet. Sampling sites are located near the Ennore thermal power

plant which is influenced by the discharges from smaller channels near to the downstream end of Pulicat Lake and Kosasthalaiyar River which are drained by point and nonpoint sources. The sediment composition in Ennore Estuary is sandy in the bar mouth and clay with loose texture (upto 0.2m to 0.5m depth) in other station. This may be due to the discharge of large amounts of untreated municipal wastewater with organic matter load. The total organic carbon measured in Ennore Estuary is comparable with organic content reported in the range of 0.732 to 2.938%.

The loose clayey sediment with organic matter continuously accumulates in the sediment until flushing by freshwater inflow during monsoon floods. Heavy rainfall occurred in Chennai between November and December 2015 as a rare event. Therefore, the seasonal and spatial variations of metals in water and sediment are influenced by the source of discharges, bio-geochemistry of sediment and residential time of sediment. Higher metal concentrations in water are explained by the freshwater inflow in the upstream of estuary leading to enhanced redox activity, adsorption into suspended organic matter and formation of insoluble organic complexes in lesser saline waters. Lack of significant correlation in spatial and seasonal distribution of metals in seawater attributed to sources, periodicity of discharges and dilutions. According to the WHO (2003) permissible limit we observed that in water Sample A, Cadmium (Cd) and Chromium (Cr) are present at concentrations of 0.09 and 0.09 µg/l, respectively, which are both higher than the permissible limit set by WHO(2003) of 0.001 to 0.005 µg/l for Cd and 0.1 µg for Cr. Copper (Cu) and Zinc (Zn) are present at concentrations of 0.019µg/l and 0.02 µg/l, respectively, which are well within the permissible limits of 3.00µg/l and 5.00 µg/l set by WHO. Iron (Fe) is present at a concentration of 0.026 µg, which is within the permissible limit of 5.00 µg set by WHO (2003). Finally, Lead (Pb) is present at a concentration of 0.201 µg/l, which is higher than the permissible limit of 0.1 µg/l set by WHO (2003).

In Sample B, all elements are within the permissible limits set by WHO (2003). Cadmium (Cd) and Chromium (Cr) are present at concentrations of 0.092µg/l and 0.085 µg/l, respectively, which are well below the permissible limits of 0.001µg/l to 0.005µg/l for Cd and 0.1 µg for Cr. Copper (Cu), Iron (Fe), Lead (Pb), and Zinc (Zn) are all present at concentrations within the permissible limits set by WHO (2003). In

Sample C, Cadmium (Cd) is present at a concentration of 0.023 µg/l, which is within the permissible limits of 0.001 to 0.005 µg/l set by WHO. Chromium (Cr) is present at a concentration of 0.095 µg/l, which is higher than the permissible limit of 0.1 µg/l set by WHO (2003). Copper (Cu), Iron (Fe), Lead (Pb), and Zinc (Zn) are all present at concentrations within the permissible limits set by WHO (2003). In summary, Samples A and C contain higher concentrations of some elements than the WHO (2003) permissible limits. It is important to note that these results are only for the three samples tested, and further testing of other samples may be required to get a more accurate representation of the overall contamination levels in the water.

In Sediment the sample A contains levels of Cd, Cr, Cu, Fe, Pb, and Zn that are all within the WHO (2006) permissible limits (Table 5.2). However, the Zn concentration in this sample is at the upper limit of the permissible range of ≤ 1 µg/g. Cd and Cr levels in sediment sample A are well below the WHO (2006) permissible limits, with Cd at 0.019 µg/g and Cr at 0.019 µg/g. Cu levels in sediment sample A are slightly above the permissible range of 0.05-0.15 µg/g, at 0.023 µg/g. Fe levels in sediment sample A are also within the permissible range, at 0.043 µg/g. Pb levels in sediment sample A are very low, at 0.013 µg/g, which is well below the WHO (2006) permissible limit of 5.00 µg/g. In summary, sediment sample A has concentrations of Cd, Cr, Cu, Fe, and Pb within the WHO (2006) permissible limits, with only the Zn concentration approaching the upper limit of the permissible range of ≤ 1 µg.

The heavy metal concentrations in sediment sample B are generally higher than the WHO (2006) permissible limits. The concentration of Cd in sample B is 0.167 µg/g, which exceeds the WHO limit of 0.1 µg/g. The concentration of Cr in sample B is 0.196 µg/g, which is above the permissible range of 0.03 to 0.3 µg/g. The concentration of Cu in sample B is 0.101 µg/g, which is within the permissible range of 0.05 to 0.15 µg. The concentration of Fe in sample B is 0.109 µg/g, which is below the WHO limit of 5.00 µg/g. The concentration of Pb in sample B is 0.06 µg, which is below the WHO (2006) limit of 5.00 µg/g. The concentration of Zn in sample B is 0.432 µg/g, is also within the WHO (2006) limit of 1 µg/g.

Sediment sample C has heavy metal concentrations within permissible limit range for Cr and Cu. The concentration of Cu in the sediment sample falls within the permissible limit range of 0.05-0.15 µg/g set by WHO (2006). The concentration of

Cr in the sediment sample falls within the permissible limit range of 0.03-0.3 µg/g set by WHO (2006). The concentration of Fe in the sediment sample is below the permissible limit of 5.00 µg/g set by WHO (2006). However, the concentration of Cd in the sediment sample exceeds the permissible limit of 0.1 µg/g set by WHO (2006). Similarly, the concentration of Pb in the sediment sample exceeds the permissible limit of 5.00 µg/g set by WHO (2006). On the other hand, the concentration of Zn in the sediment sample is below the permissible limit of 1.00 µg/g set by WHO (2006).

The results from sample D indicate that some heavy metals in the sediment are above the permissible limits set by WHO (2006). Specifically, the concentrations of Cadmium (Cd) and Chromium (Cr) are above the limits, while the concentration of Copper (Cu) is within the range. The concentration of Iron (Fe) is much lower than the permissible limit, while the concentration of Lead (Pb) exceeds the limit. Zinc (Zn) is below the permissible limit.

The higher concentrations of metals in estuarine water can be attributed to anthropogenic activities such as agriculture and industrial discharges. Perhaps, the higher concentration of metals in Ennore estuary is due to the longer residential time of sediment, lesser mobility of water and untreated sewage discharges from metropolitan Chennai. The higher correlation coefficient between metals in sediment indicates the continuous anthropogenic discharge, even distribution of suspended matters from water column, accumulation and persistence of metals. The results of the present study revealed that the metal concentration in sediment exceeded the WHO permissible limits, indicating the effects of metal toxicity which may affect fishery potential and biodiversity of Ennore estuary. Consequently, artisanal fishermen are hard-pressed for their livelihood since most of them are presently dependent on the exploitation of polychaetes from sediment as an alternative source of income. The higher concentration of metals in aquatic ecosystems affect biota by modifying the metabolic activities. Higher levels of Cr, and Pb in the ambient waters can cause physiological and genetic effects to fish due to accumulation. These results confirmed that Ennore estuary is under moderate to considerable ecological risk from heavy metal pollution. Ennore estuary are attributed to higher enrichment and contamination of non-essential heavy metals like Cd, Cr, Cu, Fe, Pb and Zn discharged from various sources through anthropogenic activities.

CHAPTER 6

SUMMARY AND CONCLUSION

Ennore Estuary is a significant water body in Chennai, India, which is impacted by anthropogenic activities, leading to heavy metal pollution.

The level of heavy metals such as lead, cadmium, copper, and zinc were found to be above the permissible limits in Ennore Estuary, posing a threat to the ecosystem.

The main sources of heavy metal pollution in Ennore Estuary are industrial effluents, sewage discharge, and agricultural runoff.

The impacts of heavy metal pollution in Ennore Estuary include the accumulation of heavy metals in the sediment and biota, alteration of aquatic biodiversity, and the contamination of fish and other aquatic organisms, which may seriously cause to the consumers.

Water samples A and C have concentrations of certain elements that exceed the permissible limits set by WHO (2003), while Sample B has all elements within the permissible limits.

In the sediment, sample D, the metal concentrations show that Cd and Cr exceed WHO (2006) limits, Pb exceeds the limit, Cu is within range, Fe is much lower than the limit, and Zn is below the limit.

The assessment of heavy metal pollution in Ennore Estuary highlights the need for effective management strategies to control and prevent further contamination and to protect the health of the ecosystem and the people who depend on it.

In conclusion, heavy metal pollution in Ennore Estuary is a significant environmental issue that requires immediate attention. The high levels of heavy metals in the water, sediment, and biota pose a serious threat to the ecosystem and human health. Effective management strategies, including the treatment of industrial effluents, proper sewage disposal, and agricultural runoff control measures, must be implemented to prevent further contamination. Additionally, regular monitoring and assessment of heavy metal pollution levels in Ennore Estuary are crucial to ensure the continued health and well-being of the ecosystem and the people who rely on it.

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