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Heavy Metals Contamination of Sediment and Impact on Ecosystem of Pulicat Lake; South East Coast of India

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Abstract:
The coastal water bodies include estuaries, lagoons, backwaters etc. have been encroached upon world over for human activities like horbours, ports, fish landing centers, settlements, thus causing enormous degree of pollution in these environments. Coastal lagoon formation where by a rising sea floods lowland areas. The present study area i.e. Pulicat Lake is located along the south Andhra coast receives lot of aqua and agricultural effluents and thus provides an ideal site for pollution studies. Pulicat Lake is a brackish water Lake (Mixed with fresh water and salt water). Coastal lagoons are shallow, generally averaging less than 2–3min depth, but depths of up to 30m have been recorded in some tidal channels of these systems.

Keywords: *Coastal water bodies, Effluent discharge, Physical factors, Contamination, Anthropogenic Inputs, Lacustrine sediments*

1. Introduction

The southeast coast of India has been receiving industrial, agricultural and aquaculture effluents and causing environmental pollution in the Bay of Bengal and surrounding coastal water bodies. The present study area i.e. Pulicat Lake is located along the south Andhra coast receives lot of aqua and agricultural effluents and thus provides an ideal site for pollution studies. The increased usage of pesticides and fertilizers in both agriculture and aquaculture sectors along the coastal tracts east coast has been additionally responsible for increased effluent discharge into coastal water bodies of Arani and Kalangi, Uppateru rivers causing immense stress on ecosystem in and around the Pulicat Lake.

1.1. Anthropogenic Effects

The increased usage of pesticides and fertilizers in both agriculture and aquaculture sectors along the coastal tracts of Pulicat Lake has been additionally responsible for increased effluent discharge into coastal water bodies. Comparisons within the same estuary between relatively un-impacted and anthropogenically impacted (Sundara raja reddy B.C, jayaraju N {9} 2012) areas are often more reliable (Alve {1}, 1995). Heavy-metal speciation and subsequent toxicity and bioavailability (Bourg, {2} (1995). Jayaraju and Reddi {6} (1996) evaluated the potential for biological effects of sediment-sorbed contaminants sampled, tested and chemically analyzed in the estuarine environments throughout the southeast coast of India. The chemical data indicate relative degrees of contamination among the sampling sites. Coastal lagoons are used for fisheries and aquaculture, energy production, biotechnology, transportation, shipping, and many other human uses (Kennish and Paerl, {7} 2010b). Watersheds surrounding coastal lagoons are often heavily populated and developed because of the great commercial and recreational value of these water bodies, their exceptional ecosystem services, and the access they afford to coastal ocean waters. Bottom sediments serve as a repository and secondary pool of these hazardous substances. Aquaculture operations can markedly degrade water quality in confined areas. In many systems, organic loading contributes to elevated BOD (Biological Oxygen Demand) levels and significant oxygen depletion leading to system impairment.

1.2. Sediments

Sediments soften consist of fine silts and clays, much of which flocculate and are deposited at the mouth of the influent systems. Fine-grained sediments also accumulate near the lagoonal shoreline in proximity to salt marshes which Facilitate deposition of silts and clays. Coarser sediments generally are found in proximity to the back barriers and tidal inlets. These sediments, which are typically better sorted than those near the mainland, primarily derive from marine and back barrier. Pulicat Lake the effects of biogeochemical cycling, bioturbation and other interactions between the bottom sediments and the overlying water column may be far greater than those in deeper estuaries. Pulicat lagoon also provide ideal nursery and feeding habitats for many marine fauna (Kennish and Paerl, {7} (2010b).

1.3. Ecosystem

The relationship of organism with the ecosystem at and near-shore, off shore, shallower, deeper, warmer, colder, lagoonal, estuarine, backwater, tidal pools and back reef regions is a complex phenomenon for understanding the ecosystem of the individual source and its interpretation. Nevertheless, the interaction of organisms with the ecosystem can be conveniently and effectively interpreted provided the ecological factors are systematically studied. According to Bhalla {4}1968), the microfaunal crop in the Bay of Bengal is poor presumably because of low organic matter in the shelf sediments. The variation in the water chemistry is obscured to some extent due to meteorological conditions.

2. Methodology

In this work, samples are collected from Pulicat Lake, Nellore district of Andhra Pradesh and Tiruwallur district of Tamil Nadu, Southeast coast of India. Livingstone core indicated that beneath an upper section of marsh sediments, the core comprised of microfossils indicating it was deposited in an open lake in June, 2011, piston and gravity cores were taken in the open-water part of the lake in order to obtain lake sediments of the same age as that of the sediments in the upper part of the Lake. Together, these cores provide a continuous lake sediment record extending back to older than recent years. In addition to the continuous paleoclimate record archived in the cored sediments, the composite sequence of lacustrine sediment allows a comparison among modern, recent past, and ancient limnological conditions, as well as an assessment of human impacts on the lake. A total of 10 cores at a depth of 10m from the surface were collected and we are also collecting the water samples at 42 fixed stations at the end of 2011. All the cores were labeled and water samples are collected in polyethylene bottles and labeled and preserved in laboratory, schematically arranged to study the overall sediment nature of the vertical section.

For carrying out grain size and geochemical analysis, samples were thawed overnight. Each sample was mixed thoroughly and deionized water over a 63-µm mesh nylon sieve. Samples, separated into mud fraction (<63µ m) and sand fraction (>63 µ m), were dried in an oven at less than 50°C. The mud fraction was weighed using an electronic balance and retained for geochemical analysis. The sand fraction was weighed and later used for grain-size analysis. (Appendix III). Multivariate analyses included only samples used in all individual analyses.

The sediment samples were first washed over a sieve which is an average opening of 0.625mm. This process helps to wash the sample free of sea water, fixatives, and the fine silt and clay size sediment particles. Then, the sample was air-dried and a suitable sample weighing about 100 grams was obtained by coning and quartering quantitatively.

For geochemical analysis of sediment and water samples were carried out with Inductively Coupled Plasma Mass Spectrometry (ICP-MS) in National Geophysical Research Institute (NGRI), Hyderabad, Andhra Pradesh on payment basis. The ICP-MS is a multi-element technique, capable of measuring elemental concentrations to very low detection limits (ppm to ppt). A huge data was generated by using sediment sample of < 63mm for all samples. Over 25 water and 33 elements data is generated

3. Study Area

The study area i.e. Pulicat lake is located in the Survey of India topo sheetsno: 66 B/2, 66 B/3, 66 C/2 respectively at the scale of 1: 50,000. The lake lies between longitudes 80o 02' – 80o 20'E and latitudes 13o22'-13o 45' N. The total area of the lake is about 250 Km^2. The Pulicat Lake is a small brackish water basin and is particularly attractive for studying the interaction between hydrography and the underlying sediment cover because of its proximity to the Bay of Bengal. The important ephemeral rivers that join the lake include Arani and Kalangi. Enormous quantities of fresh water influx along with sediment loads are discharged into the study area during monsoon. The alluvium of these rivers is essentially composed of sand, silt and clay in varying proportions and is restricted to very narrow strips in the banks of the river and tributaries. They are usually pale gray and occasionally dark brown and resulted due to admixture with laterites which derived from laterite deposits cropping out in a large area of coastal lands. The study area is a tropical sub humid type of climate with an annual mean temperature of 25^0C. Usually summers are long and hot shooting mercury from 33^oC to 45^0C, winters are short and mild with temperature range of 24^oc to 29^oc.

In natural systems, potentially toxic heavy metals can originate from rocks, ore minerals, and volcanoes. Weathering releases metals during soil formation and transports them to surface and or aquifer waters.

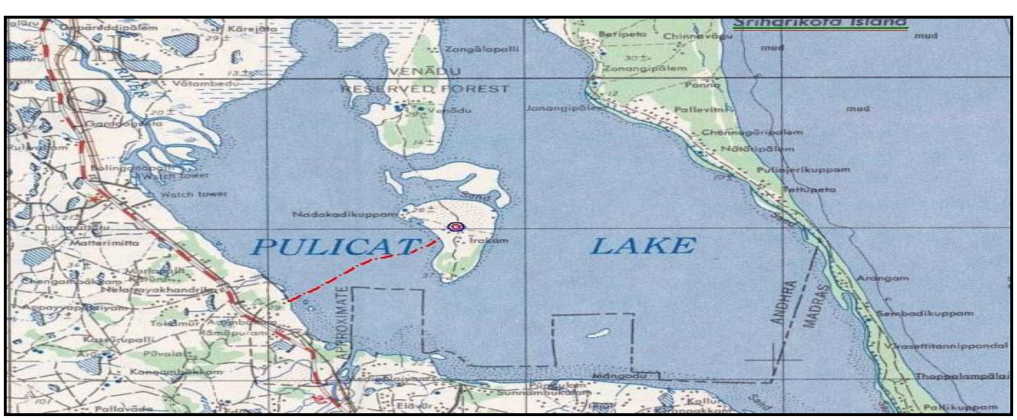

Figure 1: Location map of the Pulicat Lake

4. Results and Discussions

The metal concentrations in our study area might be a result of the cosmopolitan nature of environment. The highest metal concentration observed (989µg · g−1) was for Zn, whereas Cd levels tended to be lowest (0.42µg · g−1). It is presumed that road traffic, run-off, industrial waters, untreated domestic waters and other anthropogenic sources are major contributors of heavy metals. The metal concentration data indicate that the surface sediments are moderately to strongly contaminated, probably as a result of anthropogenic activities, and provide a useful means of distinguishing between natural and anthropogenic sources of metals entering the coastal zone through river inputs. Comparison of the metal levels from the lake indicated that there is a detectable anthropogenic input into the Pulicat Lake.

The concentrations of these heavy metals (Cd, Co, Cr, Cu, Ni, Pb, and Zn) which fluctuate from one station to another with high correlations of these heavy metals, which fluctuate from one station to another with high values, suggest anthropogenic sources.

The percentage of deformed tests was less in sample numbers 1,2, 6, 8, 10, and 11. At unpolluted and minimally polluted sites the values of deformed test are moderate (0.2–4%). These small percentages of abnormal individuals do not seem excessive i.e., abnormalities are too infrequent to indicate environmental stress caused by pollution. Alve {1}1991). The fine material is efficiently dispersed from the study area by the hydrological regime of the area, contamination is still recorded in the sandy sediments.

Industries resulted along the coastal front of the study area are numerous and their effluents are also highly toxic. Usually, these toxic effluents are released untreated in to the nearby water body which ultimately flows down in to river catchment area. Source of heavy metal pollution effect causes of industries like Kaveri cements, Kwality petrochemicals and SHAR center discharge of sewage water flow into Pennar and Kalangi estuaries get immense stress of pollution on ecosystem of Pulicat Lake.

This study revealed a significantly higher level of Zn and Cu and their presence was maximal in the Pulicat Lake, indicating a highly polluted ecosystem. Concentrations of Cd, Pb and Zn were comparable with levels reported to occur in polluted areas.

Sampling Stations	Cd	Co	Cr	Cu	Ni	Pb	Zn
1	0.42	19.1	75.4	86.2	36.3	156	530
2	0.58	15.6	70.4	74.6	37.8	130	989
3	1.46	14.3	58.9	62.8	44.5	147	790
4	0.57	15.7	64.5	76.2	46.9	170	650
5	0.59	19.5	75.3	78.4	54.8	110	560
6	0.79	20.3	90.5	74.3	58.6	78.4	520
7	0.84	18.6	110.3	90.8	74.6	68.4	820
8	0.69	19.5	110.1	114.3	64.5	65.3	850
9	0.76	21.3	96.5	110.4	76	68	810
10	0.43	16.5	87.6	96.9	58.5	75.2	745
11	0.56	18.4	96.4	89.5	68.5	70.2	685
12	0.64	17.6	98.5	96.5	49.5	69	598
13	0.73	18.9	79.9	95.4	72.3	65.3	610
14	0.92	20.2	86.4	89.5	68.4	57.6	590
15	0.65	16.9	90.3	91.2	53.9	50.3	473
16	0.75	18.4	118.2	78.4	55.8	115	560
17	0.76	15.8	102.2	75.3	55.6	78.23	520
18	1.20	20.2	98.6	90.8	72.6	68.4	891
19	1.1	20.1	99.7	88.9	40.2	98.5	890
20	0.98	19.4	84.4	87.5	44.5	89.6	450
21	0.87	18.4	85.2	112.1	64.5	78.9	789
22	0.89	16.2	78.9	102.2	45.5	45.2	452
23	0.78	17.4	98.2	86.5	80.5	108.2	899
24	1.2	19.4	110.0	99.5	65.4	110.2	874
25	1.1	16.2	109.5	98.5	66.5	98.6	985
26	0.95	18.7	111.0	84.1	66.8	98.5	956
27	1.1	18.8	98.9	82.2	75.6	99.5	845
28	0.85	19.7	99.7	89.6	80.5	102.2	756
29	0.89	20.1	86.5	84.2	75.4	104.5	658
30	0.95	20.8	87.5	88.5	78.9	110.0	798
31	0.85	19.8	88.9	88.6	72.1	113.2	785
32	0.88	18.7	99.5	85.4	68.5	102.2	945
33	0.99	18.6	98.6	99.5	70.1	98.8	964
34	0.87	18.8	94.8	98.6	68.5	99.5	874
35	0.85	15.4	98.5	113.2	66.2	86.7	652
36	1.2	19.7	98.5	102.4	66.3	88.4	742
37	1.1	20.4	98.4	103.5	66.2	89.7	658
38	1.4	18.4	99.5	107.2	67.5	88.5	989
39	0.82	15.5	99.7	104.2	66.2	98.5	874
40	0.74	16.5	85.2	98.5	68.5	89.4	945
41	0.89	18.4	89.1	97.4	49.8	98.5	458
42	0.85	18.1	80.2	89.4	50.1	99.0	475

Table 1: Analysis data of heavy metals

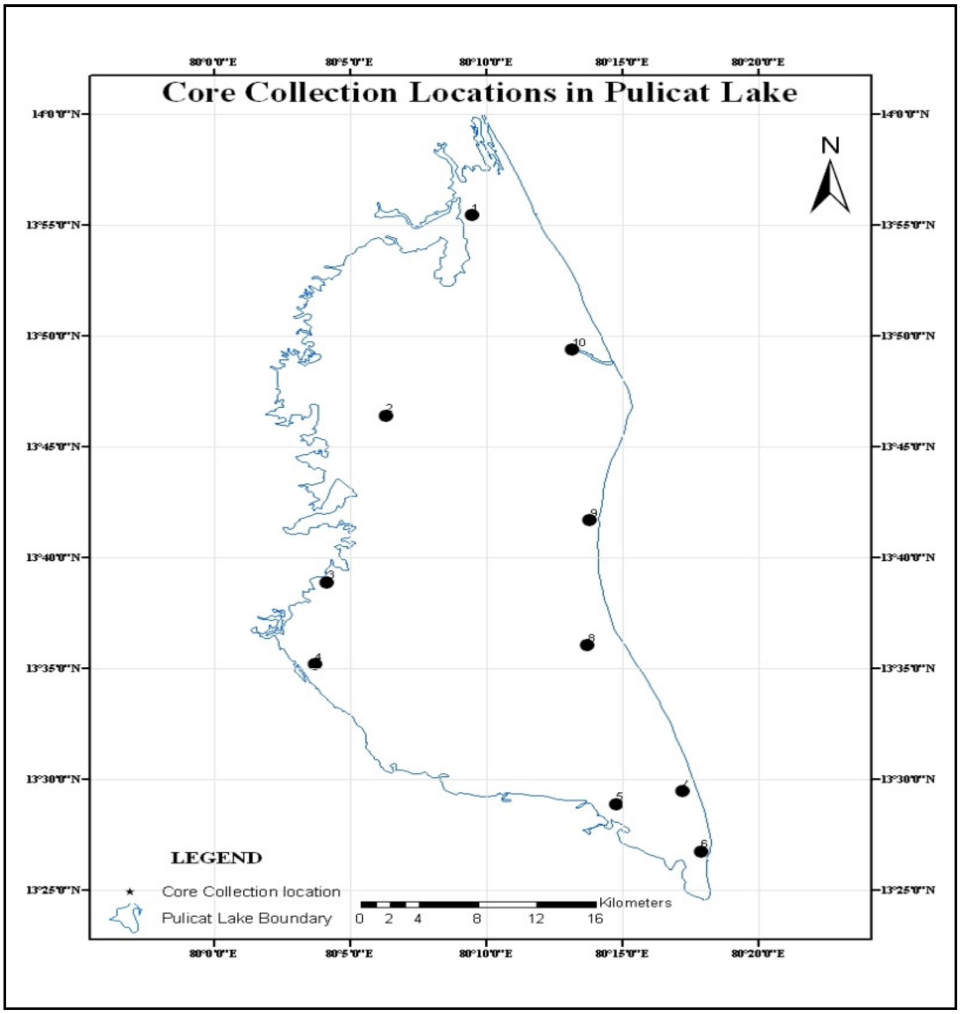

Figure 2: Sampling location of Pulicat Lake.

Sample no	Longitude	Latitude
1	80.10193	13.59121
2	80.095	13.57308
3	80.09152	13.55454
4	80.06372	13.46477
5	80.04113	13.38947
6	80.03707	13.3524
7	80.0811	13.31243
8	80.17956	13.26783
9	80.14134	13.36572
10	80.13207	13.4943

Table 2: Sample collection details with latitudes and longitudes

5. Conclusions

The average bulk concentrations of metals along the Pulicat Lake are Cu (114.3μg · g−1); Ni (80.5μg · g−1) and Zn (989μg · g−1) [2, 38]. These data are for the central part of the eastern coast, particularly off the major peninsular rivers such as Arani and Kalangi. Observations may be explained in terms of the geology of the drainage basins. This study revealed a significantly higher level of Zn and Cu and their presence was maximal in the Pulicat Lake, indicating a highly polluted.

A detailed study of Pulicat Lake, analysis of surface sediment samples, which are currently receiving industrial wastes, indicates heavy metal enrichment in Cr, Cu, Pb and Zn. On the other hand, sediment samples which receive only agricultural and aquacultural drainage water, have heavy metal concentrations slightly higher than normal levels, the following conclusions could be inferred.

Pulicat Lake is beset by similar problems such as depleted dissolved oxygen. Other sources of heavy metals to Coastal-marine environments include effluents from power plants and desalination plants, and leaching of fertilizers and pesticides (Brown {3}1987), agriculture and aquaculture. Still other organisms may be tolerant of heavy metals and will accumulate concentrations greatly in excess amounts in a growth environment without any damage (Siegel {8} 2002). Laboratory analyses must be performed to determine the concentrations of heavy metals in sediments. However, these results alone do not offer an effective basis for estimating the potential for harmful effects to living resources. Even metals that are biologically essential have the potential to be harmful to humans and other living organisms at high levels of exposure (Hu {5}2002). Heavy metal pollution has a more deleterious effect on agricultural and aquacultural. Species specific, heavy metal specific abnormalities warrants cultures studies in the future. The present study suggests that future research should focus on regional transports of contaminants and the effects of several transports of contaminants of several pollutants (Agricultural, Aquacultural, Anthropological, etc.).

To prevent severe heavy metal contamination of the lake, especially at and in the vicinity of communities exposed to agricultural and industrial metal loadings, it is imperative to implement timely pollution monitoring (Yanko {10}1998) and remediation strategies to alleviate the loadings and cumulative concentrations of heavy metals in near-shore sediments. It is emphasized that industrial plants in and around the river must develop suitable treatment systems to reduce the loadings of toxic heavy metals. Furthermore, international regulations and standards designed to protect the environment must be adopted by all companies and countries that are currently polluting the estuarine environment beyond international guidelines.

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