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DISTRIBUTION OF PETROLEUM HYDROCARBON CONCENTRATIONS IN COASTAL SEDIMENTS ALONG TAMILNADU COAST, INDIA

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Abstract: The distribution of petroleum hydrocarbons along the coastal surface sediments of six stations between Pondicherry and Nagapattinam, Bay of Bengal, India were made during 2008. The Petroleum Hydrocarbon Concentrations (PHc) were in the range 1.48 to 4.23 ppm. The PHc in Bay of Bengal is comparatively lower than in the Arabian Sea. The petroleum hydrocarbon concentrations are high in clay rich sediments than sand. The study revealed that the PHc values of Tamilnadu coastal sediments are much lower than the values reported from selected costal areas including the sediment of the Indian coast.

Keywords: Petroleum hydrocarbons, Coastal sediments, Tamilnadu coast, Bay of Bengal, India

1. INTRODUCTION

Information on the distribution of Petroleum Hydrocarbon Concentrations in the coastal environment is necessary to determine the extent of oil pollution input in to the oceans. Limited information is available with regard to Petroleum Hydrocarbons concentration along the Indian coast. Prevention of petroleum hydrocarbon contamination is extremely important, as it is one of the world's worst kinds of oceanic pollutions, because of its randomness, toxicity, large pollutant area and long persistence in the environment. Pollution of the sea by petroleum hydrocarbons occurs mainly through marine operations, land based discharges, and atmospheric and natural inputs (GESAMP, 1993; Laws, 2000). The total input of petroleum to the oceans through man's activities and sources such as atmospheric fallout, natural seepage, etc, is estimated at 2.37 x $10^6 ty^{-1}$ (Kennish, 1997). Out of these, about 65.2% is discharged through municipal and industrial waters, urban and river runoffs, oceanic dumping and atmospheric fallout; 26.2% derives from discharges during transportation, dry docking, tanker accidents, de-blasting, etc, and remaining 85% comes from fixed installations like coastal refineries, off shore production facilities, marine terminals, etc (GESAMP, 1993). Dumitran & Onuțu (2010) developed an environmental risk management model for crude oil soil pollution. Studies on hydrocarbons in the aquatic environment can be used on the analysis of the water column, organisms and sediments. However, sedimentary hydrocarbons have received special attention because these compounds are readily adsorbed onto particulate matter, and bottom sediments ultimately act as a reservoir of hydrophobic contaminants. Sediments are composite materials consisting of inorganic components, mineral particulates and organic matter in various stages of decomposition. It is well known that they are sensitive indicators between natural and anthropogenic variables.

The aim of the present study is to study the distribution features of petroleum hydrocarbon in coastal sediment and obtain scientific results for application to the prevention and control of petroleum hydrocarbon pollution.

2. MATERIALS AND METHODS

2.1. The Study Area

Tamilnadu is the southern most state on the east coast of India with a coastline of ~ 1000km. This coast has extensive areas of estuaries, mangroves, brackish water lagoons all of which are connected to the Bay of Bengal as various locations along the east

coast. Delta-related deposits usually have a high potential of hydrocarbons as stratigraphic traps. The climate of the region is tropical and is characterized by high temperature (mean 27 to 30°C) and medium rainfall (900mm yr^{-1}).The map showing all the six sampling stations is given in table 1 and figure 1 respectively.

Table 1 Geographic detail for sampling locations

Sampling location	Sample ID	Latitude (N)	Longitude (E)
Pondicherry	S1	11° 54' 33"	79° 49' 49"
Cuddalore	S2	11° 42' 27"	79° 46' 52"
Parangipettai	S3	11° 29' 56"	79° 47' 07"
Karaikal	S4	10° 54' 22"	79° 51' 40"
Narimanam	S5	10° 49' 09"	79° 50' 47"
Nagapattinam	S6	10° 45' 29"	79° 50' 53"

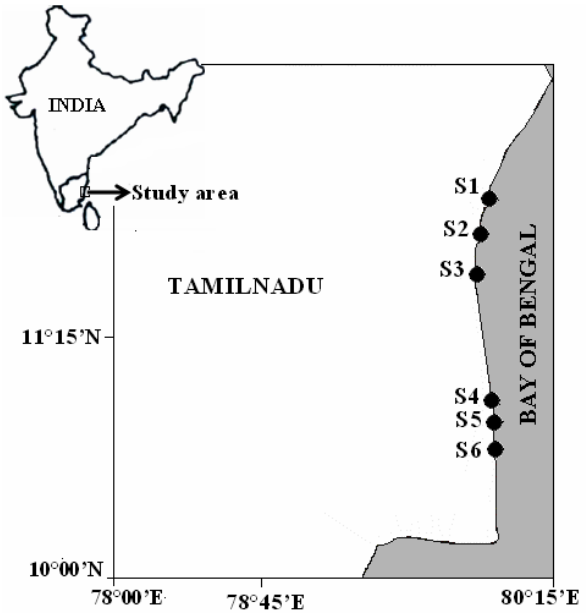

Figure 1 The study area

The above stations are selected based on the locations of estuaries, fishing harbours, industrial areas, tourist centers, oil wells and refinery as detailed below:

Station 1: Pondicherry – Tourist centre, Industial area, Sunnambar estuary, Ariyankuppam estuary and Fishing harbour;

Station 2: Cuddalore - Industrial area, Kedilam river estuary, Fishing harbour;

Station 3: Parangipettai – Vellar estuary and Fishing harbour;

Station 4: Karaikal – Industrial Area, Thirumalairajan river estuary, Arasalaru Estuary and Fishing harbour;

Station 5: Narimanam - Oil wells, Refinery, Vettar estuary and Jetty;

Station 6: Nagapattinam – Fishing harbour and Uppanar estuary.

2.2. Sampling and measuring methods

Coastal surface sediment samples from the above stations were collected during April 2008. Global Positioning system (Explorist 200) was used to determine the coordinates of the sampling points. The collected sediment samples were packed by self-packing polythene bags and it was stored in refrigerator against light.

2.3. Petroleum Hydrocarbon analysis

The collected sediment was thawed, saponified using KOH methyl alcohol mixture followed by extraction with n-hexane. The concentrated extract, after drying, was separated into alkane and aromatic fractions on an alumina column and the intensity of fluorescence of the aromatic fraction was measured (IOC - UNESCO, 1982).The samples were analyzed for Petroleum hydrocarbons using a Varian make Cary Eclipse Spectrofluorometer. The fluorescence of the samples was measured at 310nm excitation and at 364nm emission wavelength respectively. All blanks, standards and samples were measured in a Teflon – capped 1 cm silica fluorescence cell under identical instrumental settings and conditions. Duplicates, spikes and blanks were treated identically using Chrysene (Merck) as a standard reference to test precision, accuracy and solvent purity in the analytical procedure and the data were expressed in terms of Chrysene equivalents. Percentage recovery for spiked samples ranged from 96% to 99%, while precision agreed within 5%. Blank values were almost negligible. All the experiments were conducted in 5 replicates and the average of the values were reported along with standard deviations. The results, expressed in ppm, were treated statistically using Student's t-test ($p < 0.05$).

3. RESULTS AND DISCUSSION

3.1. Distribution of Petroleum Hydrocarbon concentrations

The Petroleum Hydrocarbon Concentrations in coastal sediments of the Tamilnadu coast varies over a wide range (1.48 to 4.23 ppm). The highest concentration (4.23 ppm) occurs at S5 (Narimanam), which receives hydrocarbon contents from oil refineries. The concentration of petroleum hydrocarbon at S3 (Parangipettai) is low (1.48 ppm), which is consider as a baseline for petroleum hydrocarbon in this region. The range of Petroleum Hydrocarbon Concentrations with baseline in Tamilnadu coastal sediments is shown in figure 2.

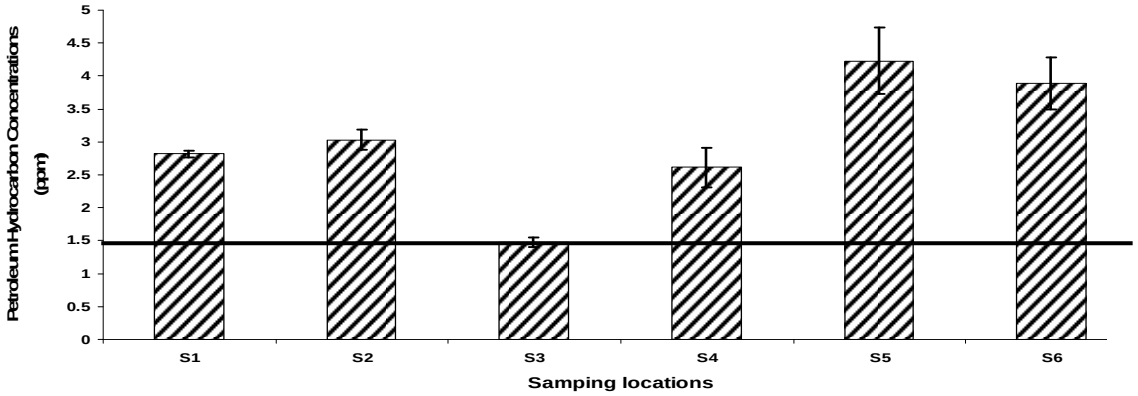

Figure 2 Distribution of petroleum hydrocarbon concentrations (Mean ± S.D) in sediments of Tamilnadu coast, India

3.2. Factors influencing petroleum hydrocarbon distribution

Petroleum hydrocarbon concentrations were not even and it was influenced by the distance from pollutant sources, scales of discharge, river transport and hydro dynamical factors such as current, wave, tide and wind. The difference was not negligible; for example, petroleum hydrocarbon concentration in Narimanam is 4.23 ppm but only 1.48 ppm in Parangipettai estuary. Narimanam, Nagappatinam and Cuddalore sediment samples contained high proportions of mud (silt+clay) but Pondicherry and Parangipettai sediments contained high proportions of sand.

The Fourier Transform Infrared spectroscopy results coastal sediments from north east coast (from Chennai to Parangipettai) of Tamilnadu show that quartz mineral is common and invariably present through out the coast. The crystallinity index of quartz is also low (well crystalline form). Moreover calcite, gibbsite, montmorillonite, smectite minerals are also present in these coastal sediments (Ramasamy, 2009). The Nagapattinam mineralogy also reflects the abundant of quartz present in Nagapattinam coastal area. Calcite, gibbsite, montmorillonite, smectite minerals are also present in the Nagapattinam coastal sediments (Senthilkumar, 2006). The minerals quartz and feldspar are abundant in Ponnaiyar and Vellar river sediments (Ramasamy et al., 2010 and 2006).

The extinction coefficient of clay mineral Kaolinite is in the following order (Ramasamy, 2009) Cuddalore > Pondicherry > Parangipettai. Senthilkumar (2006) showed that the Kaolinite is present in all the samples along Nagapattinam coast. According to Ramasamy et al (2009), organic carbon content is more in Cuddalore sediments than Pondicherry and Parangipettai sediments. In Nagapattinam coastal sediments also contained high organic carbon content (Senthilkumar, 2006). Sediments containing fine particles tend to be good accumulators of organic pollutants presumably because of their greater effective surface area (Law, 1981; Burns et al., 1982). The clay minerals are highly accumulating the pollutants such as, heavy metals, PHc, PAH, etc. The present petroleum hydrocarbon concentrations values are compared (Table 2) with those reported for selected costal areas including the sediment of the Indian coast.

Table 2 Comparison of PHc (ppm) in sediments of present study with estuarine and coastal regions of selected sites around the world

Location	PHc (ppm)	Reference
Arabian Sea along the Indian coast	0.6 – 5.8	Sengupta et al., 1993
Shetland Island, UK	7 – 8816	Kingston et al., 1995
Straits of Johor, Malaysia	0.7 – 36.7	Abdullah et al., 1996
Arabian Gulf	5.4 – 92.0	Al-Lihaibi & Ghazi, 1997
UAE coast	51,000	Shriadah, 1998
Changjiang estuary, China	2.2 – 11.82	Bouloubassi et al., 2001
Fraser River Basin, Canada	1.6 – 20.6	Yunker and Macdonald, 2003
Bassein-Mumbai coast, India	7.0 – 38.2	Chouksey et al., 2004
Bizerte lagoon, Tunisia	0.05 – 19.5	Mzoughi et al., 2005
Jiaozhou Bay, China	0.54 – 8.12	Wang et al., 2006
Gulf of Fos, France	7.8 – 180	Mille et al., 2007
Abu Dhabi, UAE	6.14 – 62.7	Abd EL Gawad et al., 2008
Tamilnadu coast, India	1.48 – 4.23	Present study

Interpretation of the data reveals that the range of concentrations of petroleum hydrocarbon in the Bay of Bengal is comparatively lower than in the Arabian Sea (Table 2). This may be due to the heavy oil tanker traffic along the shipping route in the Arabian Sea than in Bay of Bengal. There is no report on natural oil seeps and accidental oil spills reported near the study area in recent years. Therefore the elevated petroleum hydrocarbon concentrations in Tamilnadu coast may be mainly from the land based sources such as municipal waste waters, non refinery

industrial discharge, refinery discharge, urban runoff, river discharges, ocean dumping and fishing vessels operating in the localized area.

CONCLUSION

This study provides comprehensive information on the distribution of petroleum hydrocarbon concentrations in Tamilnadu coast, India. The PHc in Bay of Bengal is comparatively lower than in the Arabian Sea. The Petroleum hydrocarbon concentrations are more in clay rich sediments than sand particles. The lowest PHc obtained in Parangipettai coast. These results of the present investigation and the actual knowledge about the Petroleum hydrocarbon concentration in this sediments indicates that further research about the region of these PHc concentrations are certainly necessary in near future.

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