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Spatial Distribution of Some Heavy Metal Dynamics in Bay of Bengal (from Kakinada to Kalingapatnam, Andhra Pradesh), India

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Authors' contributions

This work was carried out in collaboration between both authors in designing the study as well as protocol of the manuscript. Author TCD wrote the draft of the manuscript, managed the literature searches and performed the spectroscopy analysis. Author CM mentored and suggested the protocol of analytical and experimental work. Both authors read and approved the final manuscript.

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ABSTRACT

The present study was carried out to determine the concentrations of selected heavy metals Cr, Mn, Ni, Cu, Zn, Cd and Pb in four stations of east coast of Bay of Bengal waters. A total number of 60 samples were collected from offshore of Kakinada, Visakhapatnam, Bheemili and Kalingapatnam at different depths ranging from 0 to 40 meters. The heavy metals were estimated by Inductively Coupled Plasma Mass Spectrometry (ICP-MS), and statistical analysis was performed by One way ANOVA. The order of dissolved concentrations of these metals was found to be as follows: Zn>Ni>Pb>Mn>Cr>Cu>Cd. Metal enrichments observed close to major urban areas of Visakhapatnam and Kakinada waters are associated with industrialized activities rich in zinc and lead concentrations. The levels of these trace metals were found to be moderately high in Bheemili waters and relatively low in Kalingapatnam, which signify negligible pollution at this location. These results indicate the impact of anthropogenic inputs on distribution of these metals in sea waters.

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1. INTRODUCTION

The coastal environment is being altered at ever-increasing rates, due to a multitude of human activities. It receives a vast quantity of sewage and agricultural waste, dredge spoils, industrial effluents and river runoff affecting the composition and quality of coastal environment, causing marine pollution. Several individuals and groups carried out extensive work on chemical, biological, physical and geological aspects of harbour and coastal environment of Bay of Bengal during the last few decades [1,2,3,4,5,6,7,8]. Of these, metal pollution has become a serious environmental and public health hazard as the concentrations released into the environment from industrial processes often exceed the permissible levels. Due to their bioaccumulative and non-biodegradable properties, and high toxicity even in low concentrations can produce cumulative deleterious effects in a wide variety of aquatic organisms [9,10].

Limited studies have been carried out on the concentration of heavy metals in the coast of Andhra Pradesh [11,12,13,14,15]. In view of this, an attempt has been made to find out the concentrations of some heavy metals in water samples and investigate the pollution level at different stations to determine if industrial discharges significantly contribute to the occurrence of these elements in these areas. These studies help in predicting and preventing acute damage to marine environment and also regulate toxic waste discharges.

2. MATERIALS AND METHODS

The present study area extends off Kakinada to Kalingapatnam. The sampling sites were chosen based on proximity of expected anthropogenic emission sources. Kakinada station (S I) is the site close to the port, fertilizer plants, pulp and paper mills, gas power plant, agricultural as well as aquaculture farms. Visakhapatnam station (S II), a site close to fishing harbour and port, industrial plants like steel, zinc, fertilizer, oil refineries, and metal alloy. Bheemili station (S III) is the site close to pharmaceutical industries along with aquaculture farms. Kalingapatnam station (S IV) a site far away from potential emission sources was selected which is presumably less pollutant (Table 1 and Fig. 1). A total number of 12 water samples were collected vertically from four stations in three transects at depths of 10, 20 and 40 m using Niskin sampler and each sample was analysed for five determinants, keeping in view of the habitat of most edible fishes. Water samples were collected in pre cleaned, acid washed polypropylene bottles and filtered in Millipore filter paper (mesh size 0.45). The samples were acidified with 2 ml nitric acid to prevent precipitation of metals, reduce adsorption of the analytes onto the walls of containers to avoid microbial activity, and then stored at 4ºC until the analyses. The heavy metals were estimated by Inductively Coupled Plasma Mass Spectrometry (ICP-MS), available in the Centre for Bay of Bengal Studies, Andhra University. Statistical analysis was performed by one way ANOVA. The data set was tested for homogeneity of variance and for normal distributes. For all statistical tests, probability of $p<0.05$ was considered significant.

3. RESULTS AND DISCUSSION

In the present study, the order of concentration of these metals was found to be as follows: Zn>Ni>Pb>Mn>Cr>Cu>Cd. In this study, zinc concentration is fluctuating from 0.09 to 31.09 (µg/l) among the stations. The highest value was recorded at S I, II and moderate at S III and least at S IV. High concentrations of zinc are usually discharged from dry cell batteries [16], zinc containing fertilizers and pesticides through river runoffs. Manganese has many applications in industry for production of ferromanganese, steel, electrolytic manganese dioxide used in batteries, alloys, catalysts [17]. In the present study, manganese concentration ranged between 0.7 to 12.28 (µg/l) with highest at S III, moderate at S II, S I and least at S IV. Lead is generally a toxic and harmful pollutant and reaches the marine environment by human activities like mining, manufacturing, burning of fossil fuels, exhaust of vehicles run with leaded fuels through rain and wind dust [18]. Lead concentration ranges from 6.59 to 16.20 (µg/l) among the stations with high concentrations in S I moderate at S II, S III and low at S IV.

Nickel values range from 1.32 to 28.67 (µg/l) recorded highest at S I, moderate at S II, S III and least at S IV. Nickel is naturally found in all soils and is emitted from volcanoes. It is used as an alloy in the steel industry, electroplatings, Ni/Cd batteries, arc-welding, rods, pigments for

Table 1. Details of sampling stations

Transect	Depth (m)	Positions	
		Latitude	Longitude
Kakinada (S I)	10	17º04′04.88″N	82º29′56.25″E
	20	16º59′08.97″N	82º56′42.85″E
	40	16º41′55.49″N	83º17′51.66″E
Visakhapatnam (S II)	10	17º37′38.83″N	83º17′17.17″E
	20	17º37′35.75″N	83º19′19.58″E
	40	17º33′27.35″N	83º23′52.80″E
Bheemili (S III)	10	17º52′04.70″N	83º24′45.64″E
	20	17º51′30.82″N	83º50′05.41″E
	40	17º51′49.63″N	83º40′50.72″E
Kalingapatnam (S IV)	10	18º10′48.23″N	84º17′52.00″E
	20	18º11′05.71″N	84º04′47.83″E
	40	18º12′36.84″N	84º31′20.36″E

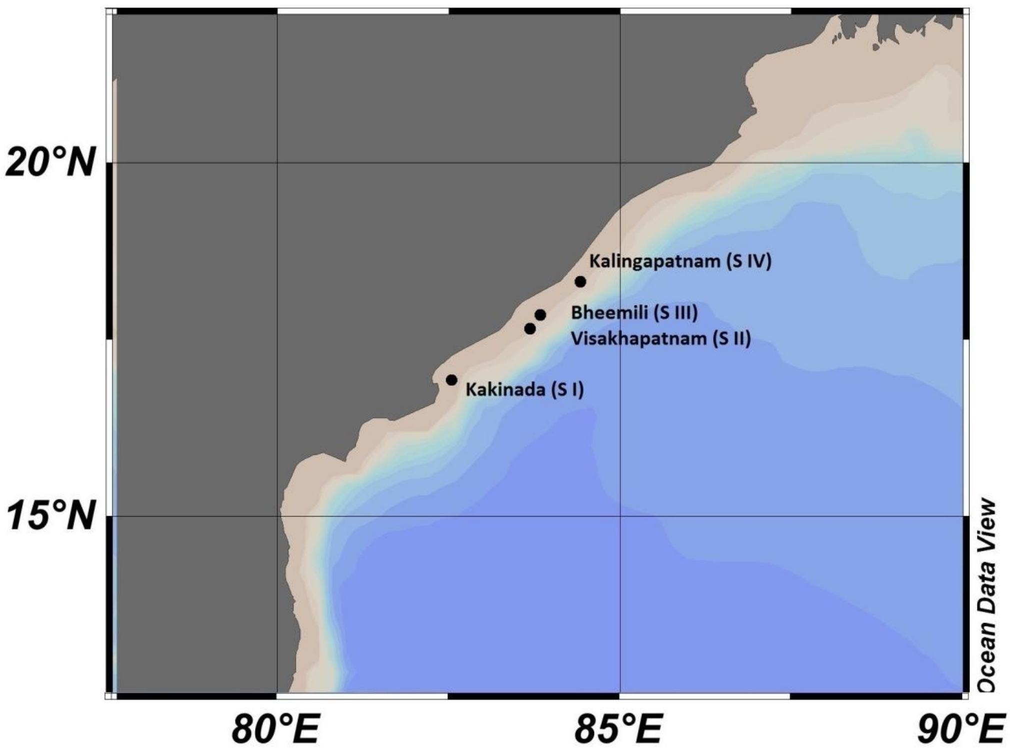
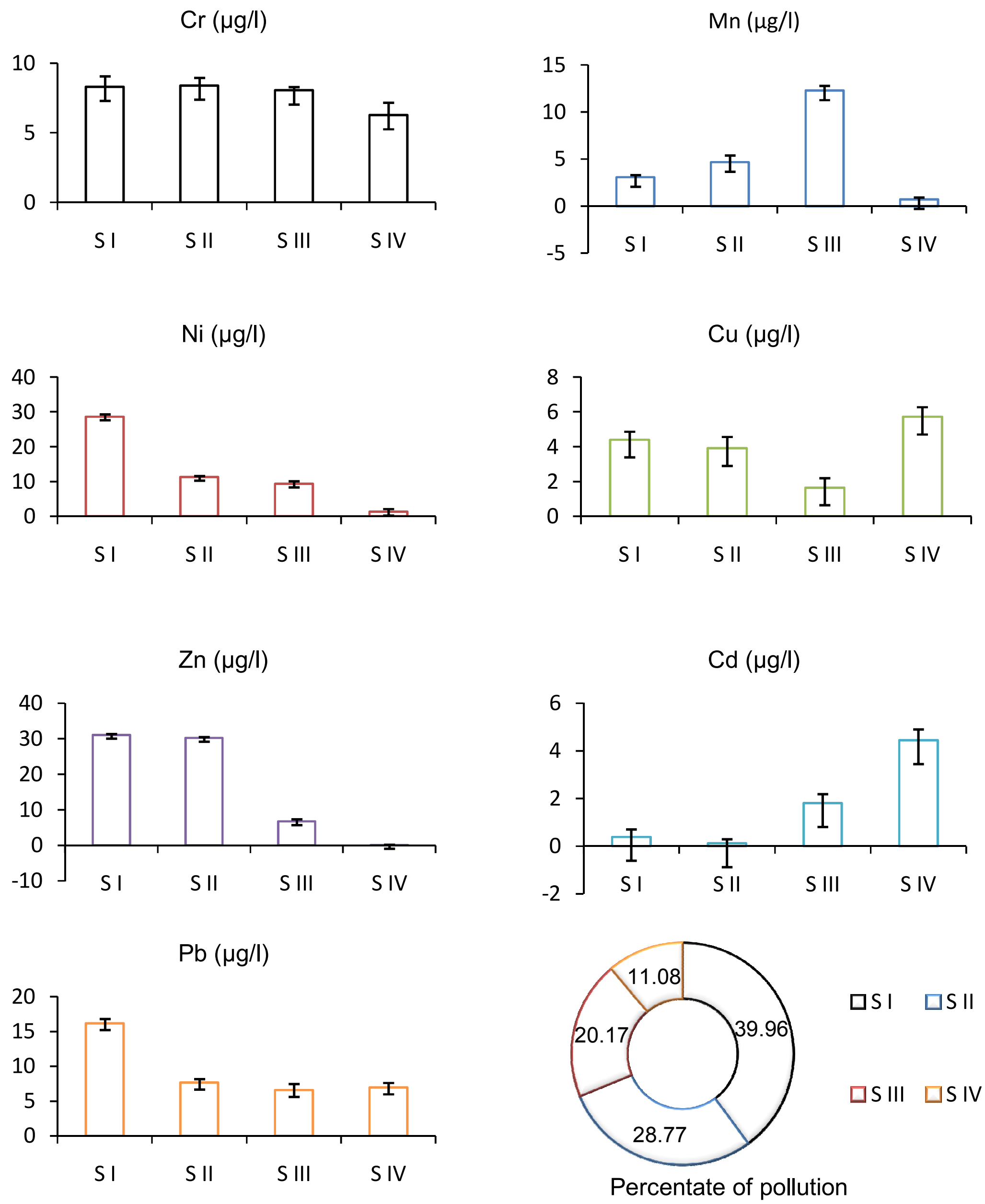


Fig. 1. Map showing sampling stations

paints and ceramics, surgical and dental prosthesis, molds for ceramic and glass containers, computer components, and catalysts [19,20,21]. Chromium concentrations are more or less similar at all stations ranging from 6.27 to 8.39 (µg/l) with highest concentrations at S II and least at S IV. It is discharged from industrial and domestic wastes of various synthetic materials [22]. Though copper is an essential element of living organisms, it is toxic to aquatic life if present at relatively high concentrations [23,24]. It is widely used in wire production, electrical industry, water delivery system, copper fertilizers and kitchen ware. In this study, values range from 1.65 to 4.4 (µg/l), recorded high at S I moderate at S II, S IV and least at S III. Cadmium is usually found as a mineral with other elements in soils and rocks, including coal, used for batteries, pigments, metal coatings and plastics [25]. In present study, Cadmium concentrations were found high at S IV, moderately low at S I, S III and least at S II ranging between 0.39 to 4.45 (µg/l) (Table 2 and Graph 1).

In the past, relatively lower values of Fe, Cu, Mn, Zn and Hg were reported in stations north of Visakhapatnam [11]. In due course of time, the appraisal of industries paved a way to physicochemical dynamics in near shore and offshore coastal waters. This was supported by studies on distribution of trace metals in both dissolved and particulate phases of surface and bottom waters of Visakhapatnam harbour [12,13]. They reported that dissolved and particulate trace metals in Visakhapatnam harbour waters were higher when compared to the adjacent coastal waters.



Graph 1. Graphical distributions of some heavy metal concentrations at Kakinada, (S I), Visakhapatnam (SII), Bheemili (S III) and Kalingapatnam (S IV) coasts

Table 2. Spatial distribution of some heavy metal concentrations at Kakinada, Visakhapatnam, Bheemili and Kalingapatnam coasts

Transect	Depth	Parameter						
		Cr (µg/l)	Mn (µg/l)	Ni (µg/l)	Cu (µg/l)	Zn (µg/l)	Cd (µg/l)	Pb (µg/l)
Kakinada (S I)	10	6.8±0.88	2.5±0.79	24.2±0.74	3.1±0.99	28.2±0.77	0.28±0.58	14.11±0.64
	20	8.3±0.77	3.06±0.24	28.67±0.71	4.4±0.48	31.09±0.28	0.39±0.31	16.20±0.62
	40	7.4±0.64	2.8± 0.82	26.11±0.94	3.8±0.87	30.12±0.54	0.24±0.77	15.14±0.78
Visakhapatnam (S II)	10	7.32±94	3.89±0.79	10.53±0.88	3.41±0.92	24.17±97	0.1±0.9	6.7±0.91
	20	8.39±0.57	4.67±0.72	11.3±0.36	3.92±0.66	30.24±0.28	0.12±0.17	7.67±0.51
	40	7.9±0.85	4.2±0.76	11.2±0.83	2.98±0.87	29.11±0.91	0.14±0.71	5.8±0.82
Bheemili (S III)	10	7.2±0.8	10.5±0.91	8.4±0.72	0.87±0.88	5.24±0.79	1.24±0.74	5.42±0.86
	20	8.04±0.26	12.28±0.53	9.4±0.77	1.65±0.56	6.72±0.64	1.81±0.38	6.59±0.87
	40	6.8±0.99	11.34±0.69	9.1±0.87	1.2±0.94	5.9± 0.76	1.7±0.88	6.21±0.73
Kalingapatnam (S IV)	10	3±0.9	0.64±0.29	1.21±0.81	4.1±0.94	0.05±0.71	3.24±0.84	5.3±0.24
	20	6.27±0.9	0.71±0.22	1.32±0.85	5.72±0.57	0.09±0.11	4.45±0.45	6.98±0.63
	40	6.12±0.52	0.72±0.63	1.1±0.54	4.82±0.39	0.65±0.88	4.21±0.92	5.9±0.87

All the data is based on average of five determinations

Similar to our studies, the same observations were made concerning different stations of Bay of Bengal at China Veeranampatnam [6,26]. Relatively high values of Cu, Zn, Cd were documented in the waters off Nagapattinam (5). The present results also corroborate with the values of Mn and Cd [27], but the values of Cr, Ni, Pb and Zn are very low than the results recorded at present. The sea water was strongly polluted by Mn and less with Pb and Cd [28]. Increased Cd values and relatively low values of Cr, Mn, Cu, Ni and Zn were recorded indicating negligible pollution at sea waters of south western Bay of Bengal [29]. However, low concentrations of Pb and Cd were determined than the acceptable levels in coastal sea waters at Myanmar [30]. Similar low values of Mn, Cd, Pb, Cu, Ni and Zn reported in waters of Bay of Bengal from Chennai to Nagapattinam [31].

In all the transects the heavy metal concentrations were recorded high at 20 m depth compared to 10 and 40 m. The overall percentage of metal distribution observed in the present study is highest *i.e.,* 40% at S I, 29% at S II, 20% at S III and 11% at S IV. In stations S IV and S III all the observations were more or less within the threshold limits for sea water from WHO. But the values are exceptionally high at S I and S II exceeding the permissible limits where the waters are highly influenced by anthropogenic inputs.

4. CONCLUSION

The elevated levels of these heavy metals are apparently indicative of sea water pollution by toxicants, leading to bioaccumulation in aquatic organisms, which may surpass to humans causing diseases and deficiencies. Hence intensive studies to control and maintain the sea water parameters for sustainability of the valuable aquatic resources are in need.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Subramanian V, Mohanachandran G. Heavy metals distribution and enrichment in the sediment of southern east coast of India. Mar. Pollut. Bull. 1990;21:324-330.
2. Staffan Holmgren. An environmental assessment of the Bay of Bengal region. Swedish Centre for Coastal Development and Management of Aquatic Resources (SWEDMAR) BOBP/REP. 1994;67.
3. Sundarmanickam A, Sivakumar T, Kumaran R, Ammaiappan V, Velappan R. A comparative study of Physico-chemical investigation along parangipettai and caddalore coast. J. Envi. Sci and Tech. 2008;1(1):1-10.
4. Muduli Bipra Prasanna, Panda Chitta Ranjan. Physico-chemical properties of water collected from dharma estuary. Intern. J. Envi Sci. 2010;1(3):334-342.
5. Sankar R, Ramkumar L, Rajkumar M, Jun Sun, Ananthan G. Seasonal variations in physico-chemical parameters and heavy metals in water and sediments of Uppanar estuary, Nagapattinam, India. J. Envi. Bio. 2010;31(5):681-686.
6. Solai A, Suresh Gandhi M, Sriram E. Implications of physical parameters and trace elements in surface water off Pondicherry, Bay of Bengal, South East Coast of India. Intern. J. Envi Sci. 2010; 1(4):529-542.
7. Pradipta R, Muduli NV. Vinithkumar Mehmuna Begum, Robin RS, Vishnu Vardhan K, Venkatesan R, Kirubagaran R. Spatial variation of hydrochemical characteristics in and around Port Blair Bay Andaman and Nicobar Islands, India. Wor. App. Sci. J. 2011;13(3):564-571.
8. Singh. Assessment of coastal water quality at Bakkhali. J. Env. Sci. Eng. 2012;54(2): 217-226.
9. Fowler SW. Biological transfer and transport processes. In: Kullenberg G (ed) Pollutant transfer and transport in the Sea. CRC Press, Boca Raton, FL. 1982;2:1-65.

10. Bryan GW. Pollution due to heavy metals and their compounds. In: Kinne O (ed) Marine ecology. John Wiley & Sons, Chichester. 1984;5:1289–1430.
11. Ganapathi PN, Raman AV. Pollution in the Visakhapatnam Harbour. Curr Sci. 1973; 490-492.
12. Satyanarayana D, Rao IM, Prasada Reddy BR. Chemical oceanography of Harbour and coastal environment of Visakhapatnam (Bay of Bengal) Part I – Trace metals in water and particulate matter. Ind. J. Mar. Sci. 1985;14:139-146.
13. Subrahmanyam, MNV, KVV, Ananthalakshmi Kumari. Trace metals in water and phytoplankton of Visakhapatnam harbour area, east coast of India. Ind. J. Mar. Sci. 1990;19:177-180.
14. Ramesh R, Purvaja R, Ahana Lakshmi. National assessment of coastal pollution loading and water quality criteria- Bay of Bengal coast of India. Food and Agriculture Organisation (FAO), BOBLME Project; 2011.
15. Diana TC, Manjulatha C. Effect of pollution on the thread fin bream, *Nemipterus japonicus* in the harbour water of Visakhapatnam. The Bioscan. 2012;7(1): 119-122.
16. Momtaz M. Geochemical studies of Heavy Metals in the seawater along Karachi Makran Coast, in Chemistry. University of Karachi, Karachi. 2002;414.
17. Bradi BH. Heavy metals in the environment. Interface Science and Technology, ed. Hubbard, A., Elsevier Academic Press: Neubrucke. 2005;6.
18. Castro P, Huber M. Marine Biology. WCB/McGraw Hill. 2 ed; 1997.
19. Sivaperumal P, Sankar T, Viswanathan Nair P. Heavy metal concentrations in fish, shellfish and fish product from internal markets of India vis-a-vis international standards. Food Chem. 2007;10(2):612-620.
20. Hussain T. Study of environmental pollutants in and around the city of Lahoore. Department of Chemistry, Thesis, University of Panjab, Lahoore; 1991.
21. Ikema A, Egieborb N. Assessment of trace elements in canned fishes (mackerel, tuna, salmon, sardines and herrings) marketed in Georgia and Alabama (United States of America). J. Food. Comp. Anal. 2005;18: 771-787.
22. Taylor SR, McLennan SM. The continental crust: Its composition and evolution. London, Blackwell Publs. 1985;312.
23. Dural M, Goksu LM, Ozak AA. Investigation of heavy metal levels in economically important fish species captured from the Tuzla lagoon. Food Chemistry. 2007;10(2):415-421.
24. Moore JW. Inorganic contaminants of surface water. New York: Springer Verlag. 2 ed; 1991.
25. Singh VP. Metal toxicity and tolerance in plants and animals. Sarup and Sons. 2005;328.
26. Solai A, Suresh Gandhi M, Kasilingam K, Sriraman E. Heavy metal accumulation in the surface sediments off Pondicherry, Bay of Bengal, South East Coast of India. Inter. J. Innov. Res. Sci, Engi and Techn. 2013; 2(10):5741-5753.
27. Shareef Khalil Muzyed. Heavy metal concentrations in commercially available fishes in Gaza strip markets, Gaza. Deanery of higher studies faculty of science department of Chemistry. Thesis, Islamic University; 2011.
28. Asma Binta Hasan, Sohail Kabir AHM, Selim Reza, Mohammad Nazim Zaman, Mohammad Aminul Ahsan, Mohammad Ahedul Akbor, Mohammad Mamunur Rashid. Trace metals pollution in seawater and groundwater in the ship breaking area of Sitakund Upazilla, Chittagong, Bangladesh, Marine Pollution Bulletin. 2013;71(1–2,15):317-324.
29. Padhi RK, Biswas S, Mohanty AK, Prabhu RK, Satpathy KK, Nayak L. Temporal distribution of dissolved trace metal in the coastal waters of South western Bay of Bengal, India. Water. Envir Res. 2013; 85(8):696-705.
30. Kyaw Naing, Ye M. Aung, Win Aung, Myat K. Thu, San S. Myint, Thida Win, Soe S. Naing, Myat M. Thaw, Aye A. Myat, Swe Z. Win, Khin M. Cho, Kyi K. Lwin, Aye A. Lwin, Khin Htay. Some physicochemical properties of sea water in Tanintharyi Coastal Zone, Myanmar Thai Environmental Engineering Journal. 2012; 145-149.
31. Gowri VS, Ramesh R, Nammalwar P, Satheesh N, Rajkumar J, Kakolee

Banerjee, Sesha Bamini N. GIS approach in assessing the status of neritic water quality and petroleum hydrocarbons in Bay of Bengal (From Chennai to Nagapattinam, Tamilnadu), India. International Journal of Geomatics and Geosciences. 2012;3(1): 249-258.

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