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EVALUATION OF HEAVYMETAL POLLUTION IN SEA WATER AND SEDIMENTS OF MAHATMA GANDHI BEACH AREA IN KOLLAM COAST, SOUTH INDIA

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ABSTRACT

The rapid industrialization and economic development along the coastal environment introduce large amount of pollutants to the beaches. The present study was conducted to assess the extent of pollution in the Mahatma Gandhi Beach area in Kollam coast, South India, with special reference to heavy metals. For the study, six sites (S1 to S6)in the beach (approx. 2km) were selected, that are approximately 200 m apart.The water and sediment sampleswere collected during the months of January and March 2019. Physico-chemical parameters such as pH, temperature,TDS,electricalconductivity, alkalinity, chloride, salinity, hardness, sulphate, nitrate, phosphate, sodium, potassium and heavy metals (Pb,Cd,Cr,Mn,Zn,Cu,Fe) were analyzedin sea water following the standard procedures. In beach sediment samplestexture, bulk density,organic carbon, organic matter content,nitrates, phosphates, sulphates, sodium, potassium and heavy metals were also determined.Thetextural analysis shows that Kollam beach is a sandy beach. The study results indicate that the concentration of chlorides, salinity, sulphates, sodium,heavy metals (Pb, Cd, Cr, Mn, Zn, Cu, Fe) were high in water and sediments. High concentration of leadwas detected in sea water (0.11ppm)and sediments (88.3mg/kg) of the study area.The pollution load index ofheavy metals estimated in beach sediment sample from all sites show significantly high values(PLI>1), and found highest in site 1 in both sampling months.Therefore the study revealed that the Kollam Mahatma Gandhi beach area is polluted and contaminated with toxic heavy metals due to different anthropogenic activities like fishing, industries, and mining.

Key Words : Beach, Heavy metals, Pollution load index, Sea water, Sediment

INTRODUCTION

Coastal areas are commonly defined as the interface or transition areas between land and sea, including large inland lakes.However, development usually concentrated in coastal areas so that often create negative impact .The sea water is a component that interacts with the terrestrial environment, where sewage from the land will enter into coastal waters and marine ecosystem. Sewages partially soluble in water partially sinks to the bottom and was concentrated sediment, and partially into the body of marine organisms[1].The effects of beach and marine pollution has been devastating to the oceans environment and ruining the marine animal's habitat. Polluted beach water makes swimmers sick and hurts coastal economies. Illnesses associated with polluted beach water include stomach flu, skin rashes, pinkeye, respiratory infections, meningitis and hepatitis. In addition to the health effects of polluted beach water, there may be deep financial impacts[2].The analysis of physical, chemical and biological parameters like pH, salinity, electrical conductivity, total dissolved solids, phosphates, nitrates, sulphates, heavy metals, bacteriological analysis helps to identify the level of quality of coastal water and beach sediments.

AIM AND OBJECTIVES

The aim of the study is to evaluate the extent of contamination by heavy metals in the water and sediments of Kollam beach area. The objectives of the study are to assess physico–

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chemical characteristics of shoreline seawater and sediments in the Kollam beach and to suggest remedial measures to control pollution in the beaches of Kerala coast.

MATERIAL AND METHODS

Study Area

Kollam beach ($8^0$52'26''N$76^0$35'33''E), also known as Mahatma Gandhi beach at Kollam township is in Kerala, South India. Kollam beach is one among the few beaches in Kerala with a lifeguard out post. Kollam port is one of oldest and most important ports for international cashew trade on the Malabar coast of the Arabian Sea. Due to the tourism activities and human settlements near the beach make it more polluted. **(Fig. 1)**

Six study sites(S_1, S_2, S_3, S_4, S_5 and S_6) were selected at an interval of 200 m in the shoreline of Mahatma Gandhi beach area, Kollam. Water and sediment samples were collected from near shore area for the physico-chemical analysis.The samples were collected duringthe period January 2019- March 2019.

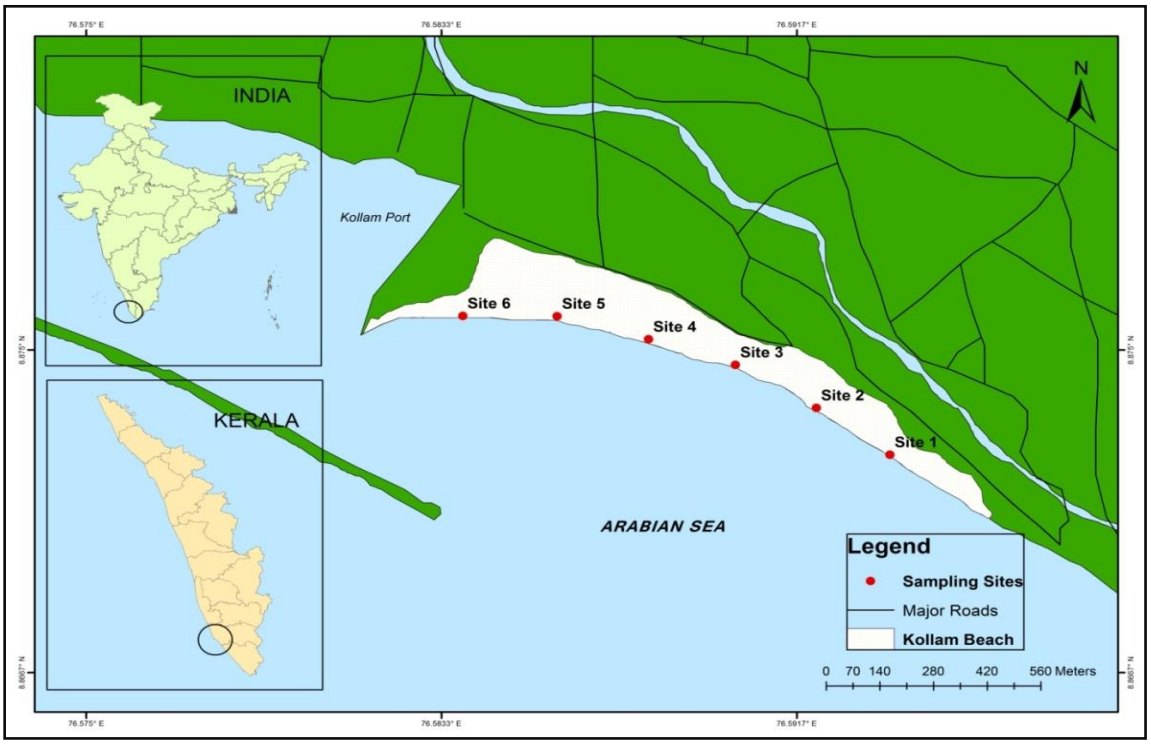

Fig.1 : Study area showing sampling sites

Physico-chemical analysis of sea water and beach sediments

The water and sediment sampleswere collected during the months of January and March 2019. Physico-chemical parameters such as pH, temperature, TDS, electrical conductivity, alkalinity, chlorides, salinity, hardness, sulph - ates, nitrates, phosphates, sodium, potassium and heavy metals (Pb, Cd, Cr, Mn, Zn,Cu,Fe) were analyzed in sea water following the standard procedures in APHA [3]and by Grasshoff[4]. In beach sediment samples texture, bulk density, organic carbon, organic matter content, nitrates, phosphates, sulphates, sodium, potassium and heavy metals were also determined following the standard procedures bySaxena[5], Trivedi & Goel[6].

Heavy metal analysis in water and sediments

100 ml of water sample was filtered (0.45µm micropore filter) into a beaker. The pH was adjusted between 2.2 to 2.8 using 0.5 M hydrochloric acid or 0.5 NaOH solutions as appropriate, added dropwise with stirring, before transferring the mixture to a 200 ml separating funnel 5 ml of the extracted solution (1% Ammonium pyrrolidinedithio carbonate and 10 ml of methyl isobutyl ketone (MIBK)

were added. The mixture was then shaken for 2 minutes and left for 30 minutes to allow the layer to separate. The lower aqueous layer was run off leaving behind the organic layer. The organic layer was then run into 10 ml volumetric flask and made up to the mark with pure methyl isobutyl ketone. The methyl isobutyl ketone extract was then aspirated into the Atomic Absorption Spectrophotometer (Perkin Elmer, Pinaacle 500) for the estimation of heavy metals Pb, Cd, Cr, Mn, Zn, Cu and Fe.

For sediment digestion, 0.5 g of fine sediment powder was weighed in a teflon crucible and added 4 ml perchloric acid and 15 ml hydrofluoric acid to it. Heated the crucible in a hot plate until it becomes an yellow cake. Then it was allowed to cool after adding 3 – 5 ml HNO_3. After proper cooling, the solution was made up to 50 ml with distilled water in a standard flask. Filtered the solution through a Whatman No 41 filter paper. The final solution was collected in a clean polyethylene container and the concentration of heavy metals (Pb, Cd, Cr, Mn, Zn, Cu, Fe) were determined using an Atomic Absorption Spect rophotometer.

Pollution load index (PLI): The assessment of the extent of contamination by metals in sediments was further calculated using the pollution load index (PLI) with the heavy metal data and world shale average values of the respective metals. It provide summative indication of the overall level of heavy metal pollution in a particular sample as described in the studies by Onjefuet al.[7] and Ogbeibu[8].

PLI was calculated using the equation,

$PLI = n\sqrt{(CF_{1x}CF_2xCF_{3x\ldots x}CF_n)}$

Where CF=Contamination factor, n=number of metals

$$\text{Contamination factor} = \frac{\text{Metal concentration in sediment}}{\text{Back ground value of metals}}$$

Back ground values of the heavy metals are Pb (14.7), Cd (0.68), Cr (163.74), Mn (182.06), Zn (86.43), Cu (43.99), Fe (1.95).

If PLI>1 indicates the sediment is polluted, whilePLI <1 indicates no pollution.

RESULTS AND DISCUSSION

Physico-chemical characteristics of sea water are shown in **Tables 1** and **Table 2**.The beach sediment characteristics are given in **Table 3** and **Table 4**.The heavy metal concentrations in sea water are given in **Fig. 2, Fig. 3** and that of beach sediments **Fig. 4** and **Fig. 5**.

The results of the physico-chemical parameters (**Table 1** and **Table 2**) shows that sea water have alkaline pH, showed high hardness and salinity. The sulphate content in sea water was high in both sampling months.The sodium content was higher than that of the potassium content in sea water samples.

The heavy metals were detected in sea water in both months of the study period (**Fig. 2** and **Fig. 3**) and its concentration slightly varied in each sampling site.The average value of heavy metals in seawater are in the order:Pb>Zn >Cd>Cr>Fe>Mn>Cu in January, and Pb> Zn > Cr>Mn>Cd>Fe>Cu during March. The lead content was high (0.107ppm) in the water samples.These concentrations are considerably higher than the average Pb concentration in oceans of 0.001 mg/L[9].The high concentration of lead detected in the seawater of Kollam beach area may be due to the different anthropogenic activities like fishing, sewage disposal.The average values of Zn content estimated in water was 0.0482 ppm, Cd was 0.0235ppm,Cr was 0.0209ppm,Mn was 0.0038 ppm, Cu was 0.0020 ppm, Fewas 0.0070 ppm.

The beach sedimentcharacteristics are given in **Table 3** and **Fig. 4**. Sediment also shows alkaline pH. The bulk density of sediment was also high due to the sandy nature of the sediment. Sodium content is higher than potassium. High organic matter content was recorded in the sediment samples collected during January while low in the March. Corresponding variations in the heavy metal concentrations are also detected in beach sediments.The average content of heavy metals varied in the order: Fe > Mn > Pb > Zn > Cr > Cu>Cd in January and it was in the order: Fe>Mn>Pb>Zn>Cu>Cr>Cd during March. Fe (8207mg/kg) and Mn(161.07mg/kg) content were found highest compared to other heavy metals. The average Cr content was low(0.0295 mg/kg), in his studies reported that the average Cr concentration recorded in the sediment cores of Ennore, South-east coast of India is 59.6 mg/kg. Also the maximum concentration recorded was 235.4 mg/kg[10-

[14].The adsorption abilities of heavy metals in sediments increased with increasing organic matter content.The average content of heavy metals were determined and iron content was found highest during the study months **(Fig. 6)**. Under variety of natural conditions iron changes its oxidation state readily with changes in the amount of oxygen and variations in pH conditions in the aqueous phase.[15-20]

Pollution load index (PLI) of the beach sediments during January and March 2019 were calculated, and are given in **Table 5**.[21-24] The site 1 shows high PLI(100.15) and may be due to more anthropogenic activities in the nearbyarea. The average concentration ofPb(88.3), Cd(1.886), Fe (772) exceeds their back ground concentration. PLI values were <1 for all the stations of transect Alleppey, Kayamkulam, Neendakara, Paravur and Veli with few exceptional stations Neendakara (10 km offshore) and all the stations of transect Cochin associated with the large harbor and fish processing activities.[25-27]

Table 1 : Physico-chemical characteristics of sea water during January2019

Parameter	W_1	W_2	W_3	W_4	W_5	W_6	Average
pH	8.98	8.99	8.92	8.94	8.96	8.92	8.95
Temperature (^{0}C)	30.1	30	29	30.2	30	30.1	29.9
TDS (ppt)	29.60	31.29	31.08	26.73	34.06	32.42	30.86
Electrical Conductivity (mS/cm)	69.92	69.24	69.99	69.60	69.93	69.46	69.59
Alkalinity (mg/L as $CaCO_3$)	113.63	159.09	125	147.72	147.72	136.36	138.25
Chlorides (mg/L)	39050	39050	36920	38340	35500	44020	38813.3
Salinity (ppt)	70.51	84.61	66.67	69.23	92.30	79.48	77.13
Hardness (mg/L as $CaCO_3$)	8100	8000	8100	8000	8100	8100	8066.6
Sulphates (mg/L)	144.62	144.08	59.83	51.419	154.58	78.62	105.52
Nitrates (mg/L)	0.245	0.087	0.025	0.051	0.087	0.028	0.087
Phosphates (mg/L)	0.024	0.031	0.038	0.022	0.031	0.013	0.027
Sodium (mg/L)	5732.5	6440	5987.5	5887.5	8542.5	5142.5	6288.8
Potassium (mg/L)	302.5	312.5	290	257.5	367.5	217.5	291.3

Table 2 : Physico-chemical characteristics of Sea water during March 2019

Parameter	W_1	W_2	W_3	W_4	W_5	W_6	Average
pH	8.73	8.78	8.79	8.79	8.79	8.79	8.77
Temperature(ºC)	30	30	30.2	30	30.1	30	30.05
TDS (ppt)	40.15	40.14	40.26	40.28	40.03	39.92	40.13
Electrical conductivity (mS/cm)	79.66	79.80	79.75	79.35	79.24	78.95	79.45
Alkalinity(mg/L as $CaCO_3$)	150	150	150	125	125	150	141.6
Chlorides (mg/L)	38340	36920	36920	36210	39050	36920	37393.3
Salinity (ppt)	69.20	66.67	**66.67**	65.38	70.51	66.67	67.44
Hardness (mg/L as $CaCO_3$)	8200	8000	8200	8300	8100	8200	8166.6
Sulphates (mg/L)	93.54	139.83	114.68	76.64	108.47	97.59	105.125
Nitrates (mg/L)	0.1299	0.0978	0.0189	0.0894	0.0630	0.0202	0.0698
Phosphates (mg/L)	0.017	0.01	0.028	0.03	0.026	0.013	0.021
Sodium (mg/L)	8102.5	6257.5	5685	8525	7812.5	8315	7449.5
Potassium (mg/L)	352.5	267.5	242.5	372.5	337.5	360	322.1

Table 3 : Physico-chemical characteristics of beach sediments - January 2019

Parameter	S_1	S_2	S_3	S_4	S_5	S_6	Average
pH	7.52	7.46	7.50	7.59	7.60	7.63	7.55
Temperature (ºC)	29	30	28	30	29	30	29.33
TDS (ppm)	457.1	339.8	506.6	290.8	320.2	283.8	366.3
Electrical conductivity (mS/cm)	0.8405	0.7358	1.118	0.6409	0.6706	0.5891	0.654
Bulk density (g/cm^3)	2.302	2.11	2.152	1.654	1.662	1.542	1.903
Chloride (mg/g)	603.5	603.5	639.5	532.2	514.75	532.5	570.99
Salinity (ppt)	1.119	0.635	1.183	0.991	0.9591	0.991	0.9796
Organic matter (%)	3.335	3.077	2.818	3.335	2.818	2.560	2.9905
Organic carbon (%)	1.935	1.785	1.635	1.935	1.635	1.485	1.735
Alkalinity (mg/g)	19.72	23.38	17.74	18.59	16.90	15.77	18.68
Nitrates (mg/kg)	0.26	0.5	2	0.28	0.34	1.18	0.76
Sulphates (mg/kg)	91.61	76.4	82.5	55.1	63.8	60.6	71.66
Phosphates (mg/kg)	0.5	1	1.5	1.5	2	1	1.25
Sodium (mg/g)	22.79	22.65	8.244	1.693	3.119	0.566	9.843
Potassium (mg/g)	0.163	0.1713	0.251	0.05	0.092	0.058	0.1308

Table 4 : Physico-chemical characteristics of beach sediments-March 2019

Parameter	S_1	S_2	S_3	S_4	S_5	S_6	Average
pH	8.39	8.11	8.29	8.20	8.24	8.46	8.28
Temperature(ºC)	31	26	26	29	30	28	28.33
TDS (ppm)	612.9	505	693.9	622.8	303	382.6	520.11
Electrical conductivity (mS/cm)	1.253	1.035	1.485	1.275	0.678	0.8104	1.0889
Bulk density (g/cm^3)	2.462	2.118	2.096	1.678	1.616	1.486	1.909
Chlorides (mg/g)	603.5	426	461.5	497	426	426	473.3
Salinity (ppt)	1.119	0.768	0.863	0.927	0.798	0.798	0.877
Organic matter (%)	0.486	0.243	0.486	0.486	0.486	0.486	0.445
Organic carbon (%)	0.282	0.141	0.282	0.282	0.282	0.282	0.258
Alkalinity (mg/g)	11.27	8.45	8.45	11.27	8.45	8.45	9.39
Nitrate (mg/kg)	0.5	0.3	0.28	3.4	0.18	2.4	1.176
Sulphates (mg/kg)	91.9	89.6	100	90.3	64.1	77	85.48
Phosphates (mg/kg)	1	1.5	0.5	3.5	1	0.5	1.333
Sodium (mg/g)	2.74	4.252	1.901	1.933	1.851	0.829	2.251
Potassium (mg/g)	0.07	0.076	0.053	0.018	0.044	0.044	0.0508

Table 5 : Pollution load index (PLI)of the beach sediments

Sample name	Pollution load index (PLI)	
	January 2019	**March 2019**
S_1	100.15	128.11
S_2	82.44	119.92
S_3	57.48	93.83
S_4	67.77	7.237
S_5	3.408	7.709
S_6	0.472	1.909

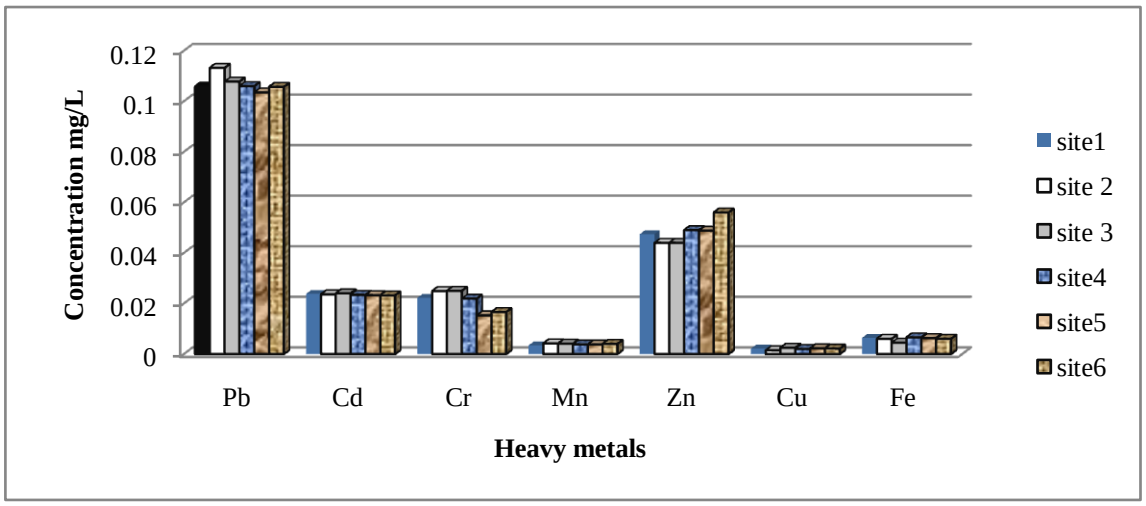

Fig. 2 : Heavy metal concentration in sea water-January 2019

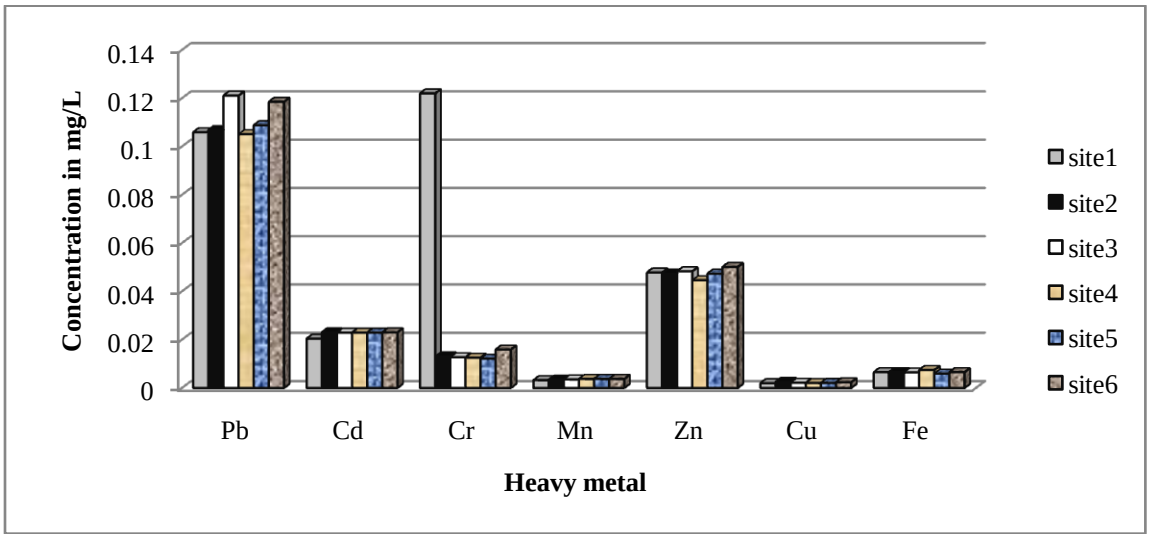

Fig. 3 : Heavy metal content in sea water-March 2019

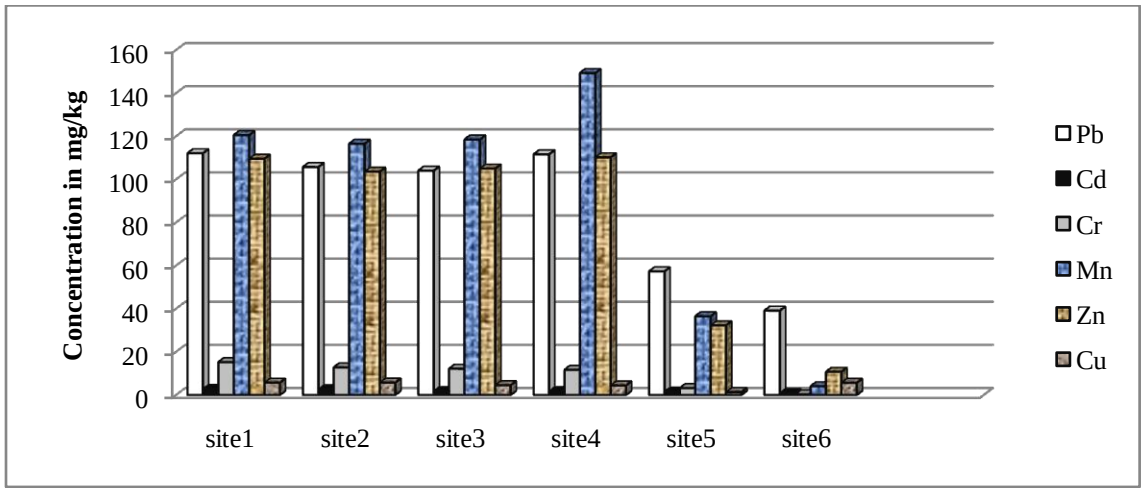

Fig. 4 : Heavy metal content in beach sediments-January 2019

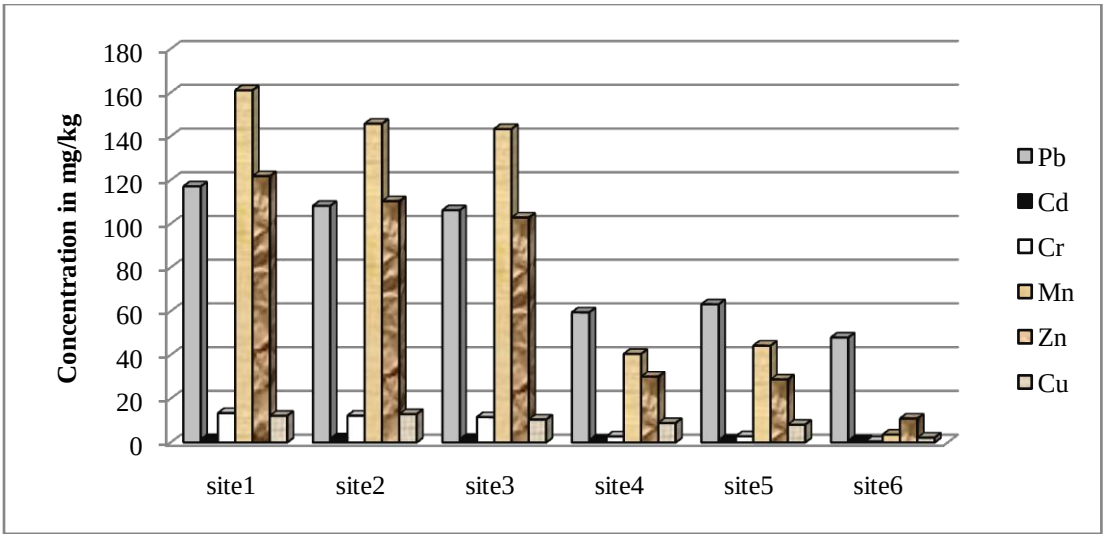

Fig. 5 : Heavy metal content in beach sediments-March 2019

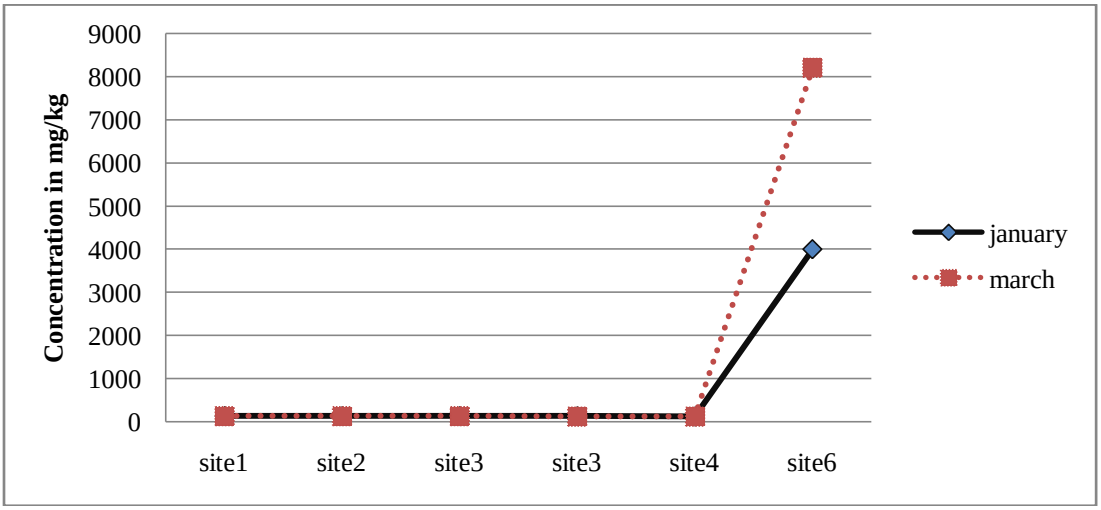

Fig. 6 : Iron content in beach sediments in Jan. and March 2019

CONCLUSION

The present study revealed the contamination of sea water and beach sediments inMahatma Gandhi beach with heavy metals Pb, Cd, Cr, Mn, Zn, Cu and Fe. Among the studied heavy metals, the lead concentration was found high in the sea water samples and Fe content was high in the beach sediments.The Pollution Load Index (PLI) estimated was>1 in the Kollam beach sediments which indicates high pollution load due to heavy metals.

RECOMMENDATIONS

Coastal protection authorities may take necessary steps to prevent uncontrolled and environmentally unsound development on the Kollam coast.Measures may be taken for the prevention of discharge of sewage and untreated effluents from industries to water bodies which reaches the sea.The Kollam beach, one of the biggest beaches in South India should be conserved by the Kollam Corporation authorities by conducting periodic beach cleaning activities.

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REFERENCES

1. Spanton P.I. and Saputra A.A., Analysis of Sea Water Pollution in Coastal Marine District Tubanto the Quality Standards of

Sea Water Using Storet Method, *Indon. J, Marine Sci. Technol.*, **10**(1), 103-112, **(2017).**
2. Devine J., The Impacts of Beach Pollution, Testing the Waters, NRDC The Earth Best Defence,24th edition**(2013).**
3. APHA, AWWA, WPCF, *Standard methods for examination of Water and Waste water,* American Public Health Association, Washington D.C., **22nd Edn**, **(2012).**
4. Grasshoff K., Kremling K. and Ehrhardt M.(Eds), *Methods of Sea Water Analysis*, **(2009)**.
5. Saxena M.M., Environmental analysis of water, soilandair. Agrobotanica publicat-ions, **2**, 28-71, **(1998).**
6. Trivedy R. K. and Goel P. K., *Chemical and biological methods for water pollution studies,* Environmental Publication, Karnataka, India, 37-68, **(1986).**
7. Onjefu S.A., Kgabi N. A. and Tole S.H., Heavymetal seasonal distribution in shore sediment samples along the coastline of Erongo region, Western Namibia, *Eur. J. Sci. Res.*, **139**, 49-63, **(2016).**
8. Ouseph P. P., Prasanthan V., Abhilash P. P. and Udaya Kumar P., Occurrence and distribution of some enteric bacteria along the southern coast of Kerala, *Ind. J. Marine. Sci.*, **38**(1), 97-103, **(2009).**
9. Tomlinson D. C., Wilson J. G., Harris C. R. and Jeffrey D.W., Problems in the assessment of heavy metal levels in estuaries and the formation of a pollution index, *Helgoland Marine Res.*, **33**, 566–575, **(1980).**
10. Broecker W.S. and Peng T.H., Tracers in the sea, Lamont-Doherty Geological Observatory Columbia University, Palisa-des, New York, USA, **(1982).**
11. Natesan U., Geochemical evidence for Heavy metal contamination In the sediment cores of Ennore, South Coast of India, *Doctoral dissertation,* Anna University, Tamilnadu, **(2013).**
12. Robin R. S., Paradipta R., Muduli K.,Vishnu Vardhan, Ganguly D., Abhilash K.R. and Bala Subramanian T., Heavy metal contamination and risk assessment in the marine Environment of Arabian Sea along the south west coast of India, *Amer. J. Chem.*, **2**(4),191-208, **(2012).**
13. Shenoy K. N., Ananya H. M. and Inchara R., Quality of open well water in udupi municipal area, Karnataka, India, *J. Environ. Res. Develop.*, **11**(01), 43-51, **(2016)**.
14. Khwaja M. Anwar and Aggarwal V., Studies on seasonal variation in ground water quality : A statistical approach, *J. Environ. Res. Develop.*, **11**(01), 123-131, **(2016)**.
15. Dutta M., Chanda K. S., Bhuyan M. and Kalita S., Study on physico-chemical properties and heavy metal contents in crude oil contaminated soil of Rudrasagar oil field, Assam, India, *J. Environ. Res. Develop.*, **11**(03), 527-534, **(2017)**.
16. Devi G. and Sarma H. P., Assessment of fluoride content in ground water sources of Kamalpur block under kamrup rural district of Assam, India, *J. Environ. Res. Develop.*, **11**(03), 563-567, **(2017)**.
17. Dubey M., Seasonal variations in surface water quality of river Narmada due to sewage effluent from different sources at Mandla town, near Jabalpur city, India, *J. Environ. Res. Develop.*, **11**(03), 568-577, **(2017)**.
18. Kaur Harpinder and Hundal S. S., Physico-chemical characteristics of some ponds and haematological parameters of labeorohita inhabiting these ponds of district Ludhiana, Punjab, India, *J. Environ. Res. Develop.*, **11**(04), 672-679, **(2017)**.
19. Upadhyay Hem Chandra, Monthly variation in physico-chemical parameters of snow-fed Sharda river, India, *J. Environ. Res. Develop.*, **11**(04), 687-692, **(2017)**.
20. Parihar Surendra Singh and Pandey Anish C., Microbiological water quality study of Madhav lake and human health, *J. Environ. Res. Develop.*, **11**(04), 699-707, **(2017)**.
21. Narwaria Y. S., Assessment of groundwater quality of Narwar block of Shivpuri district, Madhya Pradesh, India,

J. Environ. Res. Develop., **11**(04), 708-711, **(2017)**.

22. Soni Talukdar and Goswami D. C., Correlation analysis and linear regression of water quality in Pitkati wetland, Assam, India, *J. Environ. Res. Develop.*, **12**(01), 15-19, **(2017)**.
23. Soni Talukdar and Goswami D. C., Multiple regression modelling of water quality in Hohka wetland, Assam, *J. Environ. Res. Develop.*, **12**(01), 41-46, **(2017)**.
24. Ahmad T., Alam M. K., Uddin M. E., Moniruzzaman M., Saha B., Shilpi D., Sufian A., Das S., Hossain I. and Moniruzzaman M., Evaluation of microbial and physicochemi-cal properties of three selected lakes water in Dhaka city, Bangladesh, *J. Environ. Res. Develop.*, **12**(03), 264-274, **(2018)**.
25. Carpenter Sandeep, Jawalkar Manglesh and Pandey Subhash C., Physicochemical and bacteriological analysis of drinking water quality of public places of Bhopal, India, *J. Environ. Res. Develop.*, **13**(01), 61-67, **(2018)**.
26. Iram Faiza, Siddiqui Shazia, Shaikh J. D. and Ansari Taher Nayab, Impact of environmental pollution on hepatopancreas of freshwater crab barytelphusa cunicularis, *J. Environ. Res. Develop.*, **13**(01), 78-83, **(2018)**.
27. Bhattacharya Nandan and Chakraborty S. K., Application of a biotic index to assess the pol -lution load of three contrasting wetlands using the molluscan community with physicochemical water quality, *J. Environ. Res. Develop.*, **13**(02), 160-168, **(2018)**.