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A study on Heavy Metal Contamination in Visakhapatnam, Meghadri Gedda Creek by Water Quality Pollution Index

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Abstract
A study was conducted on physico-chemical parameters and heavy metals in water samples of Meghadrigedda creek of Visakhapatnam city located in Andhra Pradesh, India to address functions of creek affects by human activities. Eight water samples were collected at Meghadri gedda creek and basic physical and chemical parameters such as pH, EC, TDS, captions such as Na, K and Ca nutrients like PO4, SO4, Cl and trace elements were analyzed using APHA 2005 standard methods. The water quality was assessed during low tide and high tide in the month of May 2014 according to the standard method APHA, 2005. The water quality of the Meghadri gedda creek has been studied with reference to various toxic metals. The quality of water has radically decreased because of accumulation of the heavy metals due to the rapid industrialization. Numerows pollution index calculated for identifying the pollutants, except sulphate all the physic chemical parameters show the values greater than one in all stations. According to the heavy metal pollution index, values vary between 3244 and 52293. Most of the metal ions were in higher concentration compared to the international standards it has been observed that the quality of water is not good for various aquatic flora and fauna and even unfit for irrigation purposes. The various functions of mangroves in Meghadri gedda creek are being affected by anthropogenic activities by showing high concentrations of trace metals. Mangroves present in Meghadri gedda creek have high ecological significance as it provides home to diverse flora and fauna, habitat for feeding and breeding and social interactions. This paper discusses an integrated approach of pollution indices to assess the intensity of heavy metal pollution discharged from various industries in Visakhapatnam port, therefore conservation and management measures need to be taken to improve the deterioration water quality of this area.

***Key words**: mangroves, physic chemical parameters, toxic metals, Numerows pollution index, Heavy metal pollution index*

Introduction

Surface waters quality plays an important role in all forms of aquatic life. In recent decades, the population, technology and industry expansion of industrial waste, chemical fertilizers, herbicides and pesticides have entered the soil and have degraded the quality of surface water. Water quality depends on different chemical components and their concentration, mainly arising from the geology of the region in particular. Mangrove plants are considered wetlands and one of the most productive tropical ecosystems (Clough 1992) has high values and has multiple roles and functions. Mangroves grow well along the banks of the river, estuaries, coastal with the presence of brackish water or saline where fresh water is found. Mangrove has unique features and special adaptations such as respiratory roots, buttresses and underground roots that allow and survive in mud, anaerobic conditions; and salty water. (Odum and Heald, 1972, 1975, Wattayakornet 1997, Robertsonet, 1992). The quality of poor water is harmful to the living organism and ecosystem. According to Winter et al. (1998), the interaction of groundwater and surface is influenced by anthropogenic activities, industrial effluents discharge, and natural processes can have adverse effects on the aquatic environment. Murty and Kumar (2011) stated that water pollution can charge quality decline. A vast area of mangroves had grown to meet developments such as real estate, plantations, aquaculture and other land developments. All these activities within the mangrove area had a negative effect on the ecosystem function (Paul Chai, 2010). So, we have to examine surface water quality studies in detail from the heavy metal pollution index and Nemerow pollution index.NPI was used to assess the status of existing water quality, providing information on the degree of contamination, in specific with the standard reference value for particular parameters. By computing and analyzing the NPI values of water quality. To examine Calculate toxic metal contamination rate of heavy metals (Prasad and Jaiprakas 1999, calculate weighted arithmetic average value of the concentrations of eight metals, iron, manganese, lead, copper, cadmium, chromium, Nickel and zinc, as it has HPI used in this work. Presents findings discusses situation of water quality based on Physico-chemical characteristics and heavy metals the impact on its mangrove dominated estuaries eco system.

Materials and methods

Location of the study area

Vishakhapatnam mangroves are located in the entrance channel Vishakhapatnam (VEC) 17 ° 42'37 "N83 ° 15'44" E is located on the east coast of India, bordered by the sea of Bay of 68hysic. Meghadrigedda, a non perennial water systems in Visakhapatnam Andhra Pradesh, India. The study parameters present to present a two-dimensional approach to describe the physical-chemical properties of water at various sampling points and the environmental sensitivity of the study of two stations given below.

Station 1 (Dock Yard Side): It is located at southern banks of the creek near Dockyard side of Eastern Naval Command, Visakhapatnam. Then the four sampling points shown in this station are labeled DYS1 (side site) Dys2, DYS3 and DYS4.Station 2 (near the airport): Located on the north bank of the stream near the airport. Four sampling points were selected this station and labeled as AS1, AS2, AS3 and AS4. Latitude and Longitude are given below for each sampling point in Table 1

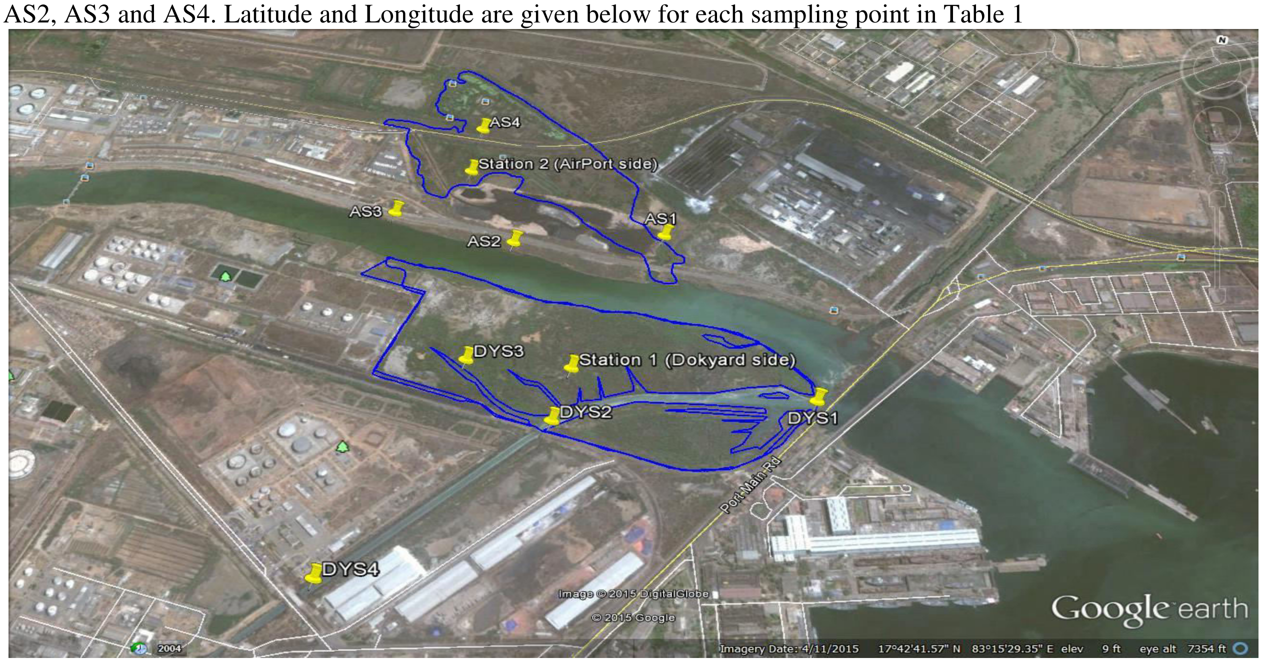

Fig. 1: Map showing the sampling locations for the distribution and abundance of mangroves

Table 1: GPS coordinates between sampling points of station 1 and station 2

S.No.	Sampling points	Latitude	Longitude
	Station 1 (Dockyard side)		
1.	DYS1	17°42'37.55"N	83°15'44.57"E
2.	DYS2	17°42'32.22"N	83°15'23.91"E
3.	DYS3	17°42'37.32"N	83°15'15.80"E
4	DYS4	17°42'19.56"N	83°15'13.16"E
	Station 2 (Airport side)		
5.	AS1	17°42'48.31"N	83°15'30.90"E
6.	AS2	17°42'50.75"N	83°15'19.20"E
7.	AS3	17°42'51.32"N	83°15'9.28"E
8.	AS4	17°43'4.19"N	83°15'11.91"E

Water sampling and preservation: Water samples from two stations located in the Megadri Gedda stream, which ends at Vishakhapatnam input channel (VEC) and merges with the Gulf of Bengal gathered. Each station has four sampling points selected and named accordingly. Water samples were collected from high and low tide during 2014. Surface water sample was collected about 10 cm under water with plastic bottles (500 ml). Standard procedures for collecting water samples and analyzing water samples (Amadi et al 2010 APHA, 2005) were followed.

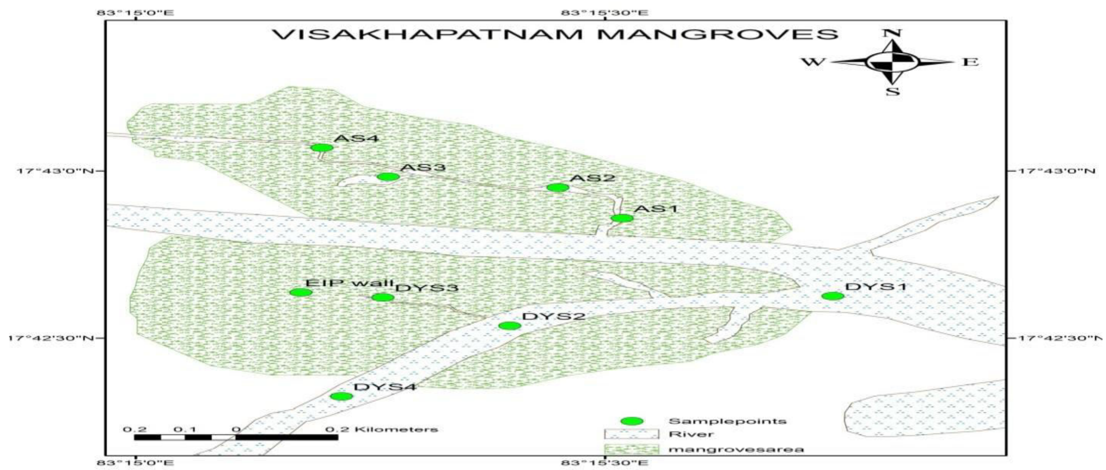

Fig. 2: Map showing the sampling locations and coordinates

Sampling Methodology

The laboratory analysis of samples was done using standard methods Analytical method used for determination of different physicochemical parameters. The selected parameters including Water pH, Total alkalinity (TA), Total dissolved solids (TDS), Total hardness (TH), Ca+2, Mg+2, Cl-, NO3-, SO4 -2 and metals. Eight surface water samples were collected in sterilized plastic bottles for Physico-chemical analysis of water using various standard methods. All the sampling containers were washed and rinsed thoroughly with the water to be taken for analysis during low and high tides.

Table-2: Experimental Methodology

S.NO.	Physico-chemical Parameters	Method
1.	pH	pH meter (ELICO L1615 Model)
2.	Electrical Conductivity	conductivity meter (ELICO CM180digital conductivity meter model)
3.	Total hardness	Complexometric titration
4.	Calcium	Complexometric titration
5.	Magnesium	Calculated method
6.	Chloride	Argentometric titration
7.	TDS	Evaporation method
8.	Sulphate	Spectrophotometry (SHIMAD2U UV-1800 model)
9.	Nitrate	Spectrophotometry
10.	Sodium	Flame photo meter (ELICO CM-378 Model)
11.	Potassium	Flame photo meter
12.	Trace metals	ICP-MS (Agilent Technologies 7500 model)

Nemerow's Pollution Index (NPI)

The method of evaluating the Nemerow index used to examine the water quality. NPI is evaluated for all parameters for each sample analyzed to identify the parameters that cause pollution. Evaluation of NPI by following equation,

NPI = $\boldsymbol{Ci/\ Li}$

Where, Ci is the Observed concentration of ith parameter, Li is the Permissible limit of ith parameter.

Each value indicates the relative NPI pollution provided by a single parameter, it should be less than or equal to one. NPI values above 1.0 indicate the presence of impurities in water.

Heavy metal pollution index: HPI's proposal developed a rating or weight age (Wi) assignment for each selected parameter. which reflects the relative importance of individual quality considerations, and can be defined as inversely proportional to the recommended standard (Si) for each parameter (Horton 1965 Mohan Et al. 1996; Reddy 1995). For this study, the concentration limits [i.e. highest permissive value for drinking water (Si) for each parameter] were taken from the Indian drinking water specifications (Indian Standard 1991, 10500).

$$HPI = \sum_{i=1}^{n} W_i Q_i \Big/ \sum_{i=1}^{n} W_i \rightarrow (1)$$

Where Qi is the sub index of the ith parameter. Wi is the unit weight age of ith parameter, and n is the number of Parameters considered. The sub index (Qi) of the parameter is calculated by
qi = 100(Vi /Si) → (2)

Where Vi is the monitored value of heavy metal of ith parameter, Si is the standard value of the ith parameter,

Result and discussion
The results of physical and chemical parameters of water samples are presented in Table-2. **P^H** The variation occurs in the pH values due to change in the values of CO2, carbonate and bicarbonate in the water. In the present study the pH range from 7.5 to 7.9 with an average value of about 7.7 in dockyard region and in airport region the ranges from 7.2 to 7.8 with an average value of about 7.3 it was evaluated that in low tide is higher values than high tide in study area. Dockyard stations show greater values than air port region. And higher values regarded at lowest low tide which compared to highest high tide.

Conductivity levels of the water samples in dockyard station 23000 µs/cm to 45030 µs/cm and it show an average value of about 29303 µs/cm. whereas the concentration of conductivity in the ranges from 15050 µs/cm to 17090 µs/cm with an average value of 16,237 µs/cm. in airport station . Higher values are regarded at highest high tide in both stations. The values of conductivity exceeds in dock yard station. These conductive ions come from dissolved salts and inorganic materials such as alkalis, chlorides, sulfides and carbonate compounds. The major anthropogenic sources such as mining, roads (de-icing salts), industrial and municipal effluents faulty septic systems, and urban/agricultural runoff.

Table-3: Physico chemical characteristics of surface water

S.No	Sampling point	*Tide	pH	EC (µs)	SO_4 (mg/l)	Na (mg/l)	K (mg/l)	PO_4 (mg/l)	TH (mg/l)	Cl (mg/l)	TDS (mg/l)	Ca (mg/l)
						Station 1						
1.	DYS1	H	7.6	33070	74.5	1801	220.8	12.3	5420	8799	19200	265
		L	7.9	24050	74.1	1666	202.0	11.5	5265	8099	16600	245
2.	DYS2	H	7.5	26050	76.3	1702	233.2	14.2	4950	7609	17800	246
		L	7.8	24020	73.6	1601	220.3	12.0	4565	7059	16560	226
3.	DYS3	H	7.6	45030	76.2	1632	215.7	12.6	4910	7092	18665	256
		L	7.8	23000	74.2	1251	219.4	11.2	4756	6984	17250	245
4.	DYS4	H	7.5	45521	80.2	1967	320.6	14.8	4927	9841	19258	264
		L	7.4	35468	73.8	1659	219.4	11.2	4756	6984	17250	245
						Station 2						
5.	AS1	H	7.2	17090	70.2	1671	133.4	0.61	3259	4659	10245	165
		L	7.6	15050	69.3	1661	120.2	0.58	3246	4598	10200	140
6.	AS2	H	7.2	16055	71.0	1451	122.6	0.56	3215	4568	9560	149
		L	7.8	15680	69.5	1442	119.2	0.52	3198	4325	9020	132
7.	AS3	H	7.3	17050	65.3	1425	106.3	0.49	2989	4269	9560	150
		L	7.2	16500	62.5	1406	98.5	0.52	2948	4013	9420	146
8.	AS4	H	7.5	15680	54.31	654	96.21	1.25	2086	3635	8210	105
		L	7.3	14688	52.83	604	92.27	0.42	2543	3287	8151	98

Table 4: Heavy metal analysis in water samples collected at station 1, station 2 and coring (Kakinada)

S.No	Sample	Cr^{3+}	Mn^{2+}	Fe^{2+}	Co^{2+}	Ni^{2+}	Cu^{2+}	Zn^{2+}	Cd^{2+}	Ba^{2+}	Pb^{2+}
1	DS1	16.43	12.1	232.3	0.291	7.943	35.63	159.6	0.75	47.37	12.32
2	DS2	15.49	8.23	544.65	0.64	7.498	20.14	61.12	0.45	39.24	11.65
3	DS3	19.95	4.64	659.92	1.16	6.49	25.49	94.62	0.94	31.65	10.54
4	DS4	16.76	16.56	693.43	2.93	8.94	29.48	69.44	0.65	79.51	18.92
5	AS1	5.838	2.4	109.603	2.1	1.683	3.56	20.59	0.62	64.55	1.002
6	AS2	4.6	8.23	126.62	2.06	2.45	2.65	19.73	0.29	46.27	2.269
7	AS3	9.44	6.47	694.55	1.49	1.457	1.64	15.64	0.65	35.19	1.494
8	AS4	6.47	5.19	19.63	1.06	0.166	0.48	12.49	0.57	29.47	0.14

Chloride is the most dominant anion in the waters of the study area. The artificial additions cannot have much influence on the chemistry of coastal waters. The concentration of chloride ranges from 6984mg/l to 8790mg/l with show an average value of about

7607 mg/L in the dock yard sampling region, whereas in airport station the values ranges from 4013 mg/L to 4659 mg/L with an average value of 4405 mg/L. greater values are regarded at higher high tide in both stations and Exceed the chloride concentration in dock yard region samples. Chloride (Cl-) is completely soluble and very mobile. Chloride in surface water can be toxic to many forms of aquatic life (fish, macro invertebrates, insects, and amphibians) and impacts vegetation and wildlife.

Sodium is the most dominant cation in the waters because most rocks and soils contain sodium compounds from which sodium is easily dissolved. The transport of sodium (Na+) in the environment is not as prominent as chloride due to ion exchange. In the present study The concentration of sodium ranges from 1251 mg/l to 1801 mg/l with median value of about 1608 mg/l in dockyard station. In airport station the sodium concentration ranges from1406 mg/l to 1671 mg/l with mean value of about 1509 mg/l whereas highest high tide water samples shows greater values and dock yard region samples regarded as excessive. It increases due to naturally occurring brackish water of some aquifers , water softener backwash , saltwater intrusion into wells in coastal areas , infiltration of surface water contaminated by road salt, precipitation leaching through soils high in sodium , groundwater pollution by sewage effluent , infiltration of leachate from landfills

Table 5: Numerows pollution index for water quality

		Ph	EC	SO4	Na	K	TH	Cl	TDS	Ca
DYS1	H	1.013333	14.69778	0.3725	9.005	2.208	9.033333	14.665	9.142857	1.325
	L	1.053333	10.68	0.37	8.33	2.02	8.775	13	7.9	1.225
DYS2	H	1	11.5	0.3	8.51	2.332	8.25	12	8.4	1.23
	L	1.04	10.67	0.36	8.005	2.203	7.60	11.765	7.8	1.13
DYS3	H	1.013333	20.	0.38	8.16	2.157	8.18	11.82	8.88	1.28
	L	1.04	10.	0.37	6.25	2.194	7.92	11.64	8.214	1.225
DYS4	H	1	20.2	0.401	9.83	3.206	8.21	16.4	9.17	1.32
	L	0.98666	15.7	0.369	8.295	2.194	7.92	11.64	8.21	1.225
AS1	H	0.96	7.6	0.351	8.355	1.334	5.43	7.765	4.87	0.825
	L	1.013	6.68	0.346	8.30	1.202	5.41	7.663	4.85	0.7
AS2	H	0.96	7.13	0.355	7.255	1.226	5.358	7.613	4.55	0.745
	L	1.04	6.968	0.347	7.21	1.192	5.33	7.208	4.295	0.66
AS3	H	0.97	7.577	0.32	7.125	1.063	4.98	7.115	4.55	0.75
	L	0.96	7.33	0.31	7.03	0.985	4.91	6.68	4.48	0.73
AS4	H	1	6.96	0.27	3.27	0.962	3.47	6.05	3.9	0.525
	L	0.97	6.5	0.26	3.02	0.922	4.23	5.47	3.88	0.49

Table-6: Heavy metal pollution index

	Cr qiwi	Mn qiwi	Fe qiwi	Ni qiwi	Cu qiwi	Zn qiwi	Cd qiwi	Pb qiwi	∑qiwi	HMI=∑qiwi/∑wi
DS1	2576	190	3642	3114	186	83	588	9659	20039	31949
DS2	2429	129	8540	2939	105	32	353	9134	23661	37725
DS3	3128	73	10348	2544	133	49	737	8263	25276	40299
DS4	2628	260	10873	3504	154	36	510	14833	32798	52293
AS1	915	38	1719	660	19	11	486	786	4632	7386
AS2	721	129	1985	960	14	10	227	1779	5827	9290
AS3	1480	101	10891	571	9	8	510	1171	14741	23503
AS4	1014	81	308	65	3	7	447	110	2034	3244

Sulphate Despite a relatively large amount of sulphur mostly in the form of sulphates, Sulfate may also result from the oxidation of the reduced form of sulfur, such as sulfide and sulfite or from the wastes of various industries. The recognized Sulfate concentrations in water lowest values were noticed 52.83 at sampling location AS4 in low tide and highest values lowest values were noticed 80.2 at sampling location DYS4 in High tide. The recognized Sulfate concentrations in soil lowest values were noticed 7.5 at sampling location As3andAS4 respectively and highest values were noticed 12.62at sampling location DYS1. The recognized Sulfate concentrations in sediment lowest values were noticed 11.9 at sampling location AS1 and highest values were noticed 19.55 at sampling location DYS4.

Total hardness: The recognized total hardness concentrations in water lowest values were noticed 2543 at sampling location AS4 in low tide and Highest values were noticed 5420 at sampling location DYS4 in high tide.

TDS A high level of TDS is an indicator of potential problems and deserves further investigation. Very often, high levels of TDS are caused by the presence of potassium and sodium chlorides. These ions have little or no effect in the short term, but toxic ions (lead, arsenic, cadmium, nitrate and others) can be dissolved in water.In the present study concentrations in water lowest values were noticed 8151 at sampling location AS4 in low tide and Highest values were noticed 19258 at sampling location DYS4 in high tide.

Heavy metals

The concentrations of various heavy metals of the study area are presented in table-3. The concentration of chromium ranged from 4.6mg/l t0 19.95mg/ higher amount of chromium due to cement use, paints and paper products, which eventually end up being washed into the lagoon. Manganese concentration varied from 2.4mg/l to 16.5mg/l, the highest concentration due to Contamination of aquatic ecosystem by sediments is most pollution issue attributed the toxicity, abundance, persistence, and subsequent bio-accumulation of this material. Iron concentration varied from 19.6mg/l to 694mg/l, concentration of cobalt ranged from 0.29 mg/l to 2.93mg/l. The pollution due to nickel is immediately connected with industrial metallurgical emissions and from the combustion of liquid fuels, nickel concentration varied from 0.166mg/l to8.94 mg/l, copper ranged from 0.48 mg/l to 35.63 mg/l, Zinc in water comes from sources of anthropogenic, discharges of smelter slags and wastes, mine tailings, coal and bottom fly ash, and the use of commercial products such as fertilizers and wood preservatives, in the present study the zinc concentration from 12.49 mg/l to 94.6 mg/l, Cd is a very mobile element and the metal that easily desorbs by ionic exchange processes, Cadmium concentration from 0.29 mg/l to 0.94 mg/l, Barium ranged from 21.02 mg/l to 79.51 mg/l, lead concentration from 0.14 mg/l to 18.9 mg/l, it Enters environment from industry, mining, plumbing, gasoline, coal, and as a water additive As per Nemerow's Pollution Index (NPI), the pollution creating parameters at each station is calculated and presented in Tables 4 These tables show the results of NPI. The predominant pollutants in the study area at each station are identified. All the parameters except sulphate in all stations NPI value exceeding 1.0 indicate the presence of more pollutants in water. The HPI proved to be a useful tool to evaluate the pollution of surface water. Study site water is primarily affected by the leaching of heavy metals heavy metal pollution index values are greater than 100. It revealed that the water is more contaminated.

Discussion

Therefore, inspection of the potential sources should be enforced immediately. In the absence of any mitigation measures, these levels may go high in the near future and therefore, it is essential that a long term monitoring of water quality need to be established along with the country guidelines. whereas environmental policy, such as regulating the discharge standards of industrial sewage, should be implemented to alleviate the heavy metal pollution so that the public health and integrity of Visakhapatnam Mangroves can be maintained sustainably

Conclusion

This study showed that the physical-chemical parameters of water quality of megadrigedda creek. The main pollutants observed in the present study are total hardness, chloride, calcium, sodium, total dissolved solids and electrical conductivity in high tide and low tide. However, data obtained for heavy metals such as Fe, Zn, Mn, Cd and Cr are higher than the maximum levels recommended for water. Heavy Metal pollution index indicates that the water quality is severally deteriorating. The overall quality states that the area which needs attention and the results of this paper are important for the development of proper management and remediation strategies to decrease source pollution.

Reference

APHA (American Public Health Association) (2005). *Standard Methods for the Examination of Water and Wastewater* (21sted.). Washington, DC: American Public Health Association

Bably Prasad, A.E Kumari Sangita, Heavy Metal Pollution Index of Ground Water of an Abandoned, Open Cast Mine Filled with Fly Ash: a Case Study, Mine Water Environ (2008) 27:265–267, DOI 10.1007/s10230-008-0050-8.

E.O. Lawson, Physico-Chemical Parameters and Heavy Metal Contents of Water from the Mangrove Swamps of Lagos Lagoon, Lagos, Nigeria, Advances in Biological Research 5 (1): 08-21, 2011.

Jameel, A. and Sirajudeen, J. (2006) Risk Assessment of Physicochemical Contaminants in Groundwater of Pettavaithalai Area, Tiruchirappalli, Tamilnadu, India. Environmental Monitoring and Assessment, 123, 299-312.

Lawson, E. O. (2011). Physico-Chemical Parameters and Heavy Metal Contents of Water from the Mangrove Swamps of Lagos Lagoon, Lagos, Nigeria. *Advance in Biological Research, 5,* 8-21

Murty, M. N., & Kumar, S. (2011). Water Pollution in Indian. Economic Appraisal, Indian Infrastructure Report

Odum, E.P., 1971. Fundamentals of Ecology. 3rd Edn. W.B. Saunders. Philadelphia, pp: 574.

Prasad B, Mondal KK (2008) The impact of filling an abandoned opencast mine with fly ash on ground water quality: a case study. Mine Water Environ 27:40–45.

P. Satheeshkumar & Anisa B. Khan, Identification of mangrove water quality by multivariate statistical analysis methods in Pondicherry coast, India, Environ Monit Assess (2012) 184:3761–3774, DOI 10.1007/s10661-011-2222-4.

Simeonov, V., Stratis, J. A., Samara, C., Zachariadis, G., Voutsa, D. Anthemidis, A., et al. (2003). Assessment of the surface water.

S.Swathi, S.Umesh, (2015), Nemerows pollution index:for ground water quality assessment, Journal of environmental science and pollution research,1(1), pp:23-31.

Singh, K. P., Malik, A., Mohan, D., & Sinha, S. (2004). Multivariate statistical techniques for the evaluation of spatial and temporal variations in water quality of Gomti River, (India) a case study. Water Research, 38, 3980–3992.

Seca Gandaseca, Noraini Rosli, Johin Ngayop and Chandra Iman Arianto, Status of Water Quality Based on the Physico-Chemical Assessment on River Water at Wildlife Sanctuary Sibuti Mangrove Forest, Miri Sarawak, American Journal of Environmental Sciences 7 (3): 269-275, 2011.

Winter, T. C., Harvey, J. W., Franke, O. L., & Alley, N. M. (1998). Ground Water and Surface Water. U.S. Geologist Survey.

Zohreh Marbooti, Rezvan Khavari, Farhad Ehya, Heavy Metal Contamination Assessment of Groundwater Resources in Behbahan Plain, Southwest Zagros, Open Journal of Geology, 2015, 5, 325-330.