A STUDY ON SEA WATER POLLUTION LEVELS IN VASAI REGION, MUMBAI, INDIA

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ABSTRACT

This paper reports a study carried out in the industrial suburb of Vasai is located in Maharashtra in Western India. The study comprises of analysis carried out on water samples from four sampling stations in the region. The data collected indicates that there is deterioration in the quality of water due to pollution caused by point and non point sources.

INTRODUCTION

Concern over the state of environment has grown the world over since the sixties. The decline in environmental quality has been evidenced by increasing pollution, loss of vegetation cover and biological diversity, excessive concentration of harmful chemicals in the ambient environment, in food chain, growing risk of environmental accidents and threat to life support systems (Agarwal, 1991).

Water is our most valuable natural resource. This fact though recognized by man has not stopped him from polluting the rivers, lakes and oceans.

The cause of water pollution could be municipal, agricultural and industrial. All three major causes have rampantly deteriorated the quality of water the world over. This has resulted in the decrease in the quality of drinking water available, and has also caused the decline of resources from our marine sources as the runoff water from the land is ultimately destined for the seas. Monitoring of water quality levels is thus important to assess the levels of pollution and also to assess the potential risk to the environment.

STUDY AREA

Fig. 1 Location of Vasai in Maharashtra

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Thane district lies in the north- west part of the state of Mahahrashtra. The western part of this region is a coastal plain. Dahanu, Palghar,Vasai make up this region. Vasai is an industrial suburb located in Thane district, 50 km north of Mumbai. It is located on the northern banks of Vasai Creek, part of the estuary of the Ulhas River which ultimately flows in to the Arabian Sea.

Four sampling stations were selected to monitor the water pollution levels in the region. Non point sources pollution arises from a broad group of human activities for which the pollutants have no obvious point of entry into the receiving water body. Non point sources include excess fertilizers, herbicides, insecticides from agricultural lands and residential areas, oil grease and toxic chemicals from urban run off and energy production, sediment from improperly managed construction site, crops and forest lands and acid drainage from abandoned mines (Ahmed, *et al.* 2003).

In contrast point source pollution represents those activities where water is routed directly in to receiving water bodies. The pollution at two of our sampling stations can be identified to point sources whereas at the other two stations it is due to non point sources.

Sampling station S_1 is at Chinchpada in Vasai region. The sampling point can be described as a point of discharge of industrial effluent in to a water body. The effluents are released by small scale industrial units in the region manufacturing adhesives, dyestuff and chemicals. Sampling station S_2 at

Fig. 2 Location of sampling stations in Vasai (Not to scale)

Goraipada is a fresh water pond. The water from this point is being used by private tankers to supply drinking water in the region. The sources of pollution are difficult to identify, hence pollution at this point can be attributed to non point sources. The non point sources at this station could be as varied as dispersal of municipal sewage, run-off from streets, local industries and transportation.

Sampling station S_3 is located at the downstream of Tungareshwar River which flows down from the Tungareshwar Mountains. Here once again the pollution is due to diffuse non point sources. It can be attributed to municipal sewage, waste water effluents, run off from forest area cleared for urbanization, urban run off, polluted run off routed directly in to the receiving water body.

Sampling station S_4 at Vasai station Industrial Estate is a point of discharge of industrial effluent. The effluents are released from industries involved in the manufacture and fabrication of steel based alloys, paints, printing inks and pharmaceuticals. Pollution at this point is due to point sources.

Water sample collection and analysis

Water samples were collected at monthly intervals from all the four sampling stations between May-2006 to October 2006. The samples were collected three times during each collection. Each of the samples was brought to the analytical lab and was analyzed for various parameters by standard methods. The results obtained were statistically analyzed using Statistical package for Social Sciences.

RESULTS AND DISCUSSION

The results of the analysis carried on water samples from the four sampling stations are summarized in tables 1 & 2.Minimum, Mean and Maximum values of water quality parameter measured for sampling stations S_1 to S_4 are given in the Tables 1-2.

pH is a measure of acidity or alkalinity and measures the concentration of H^+ ion in solution. The pH of water samples from station S_1, S_2, S_3 have remained in the slightly alkaline range during the summer months. These values however have moved to the slightly acidic range during the monsoon months (Fig. 3). This could be due to the increased SO_x and NO_x gases in the atmosphere and the associated acidic deposition during monsoon. The water samples from the S_4 site exhibited pH values in the highly acidic range of 1.57- 2.42. Untreated acidic effluents discharged from industrial effluents could

be responsible for these values. These acidic pH values are of concern as the effluents could cause serious damage to the vegetation in the vicinity of the sampling point. Damage to trees take the form of visible damage to leaves and needles, a decline in growth and loss of resistance to diseases and other stresses (McCormick, 1995).

The recommended value of DO in normal drinking water is 8 ppm while the saturated value of DO is 14 ppm (Mitra, 1982).The values of DO measured at all the four sampling stations are much below the accepted limit which is again an indicator of the high degree of pollution.

High BOD and COD values are observed for stations S_2 and S_3.The high BOD and COD value for water samples from S_3 is of serious concern as this point is being used as a source of drinking water. Though there is no fixed guideline for BOD, COD values for Drinking water quality,(W.H.O. 2004) the values measured at this station are higher than the values accepted for industrial effluents (USEPA, 1986) The pollution at the two points S_2 & S_3 are attributed to non point sources and hence difficult to identify. The BOD, COD values improved marginally during the monsoon due to purifying effect of rain water. Comparatively the BOD, COD values were much higher at Stations S_1 and S_4. Maximum values for

BOD (531.00 mg/L) and COD (923.00 mg/L) was observed at S_1 These values are indicative of very high levels of pollution at S_1 & S_4. The pollution at these two points can be clearly identified to the discharge of industrial effluents.

Cl^- ion concentrations at sites S_1 S_2 and S_3 are well within acceptable limits of 250 mg/L. But sampling station S_4 exhibits a very high Cl^- ion concentration with a maximum value of 2621mg/L during May 2006. The values of NO_3^- at station S_3 , a source of drinking water is much higher than the accepted MCL of 10 mg/L as accepted by EPA standards. This is a matter of concern as the ingestion of nitrate in drinking water by infants can cause low oxygen levels in the blood, a potentially fatal condition (Puckett L.J. 1994)Also nitrogen not used by plants or returned to the atmosphere is converted to nitrates in soil which is soluble in water and can easily leach into the water table. NO_3^- can persist in ground water for decades and can accumulate to higher levels as more nitrogen is applied to the land surface every (Noolan, *et al.* 1997)

The values of both SO_4^{2-} and NO_3^- ions increased during the monsoon at all the sampling stations (Fig.4). This is again a pointer towards the more serious concern of acidic deposition of dissolved NO_x and SO_x gases.
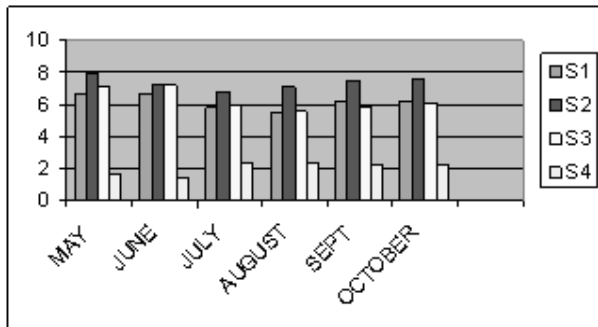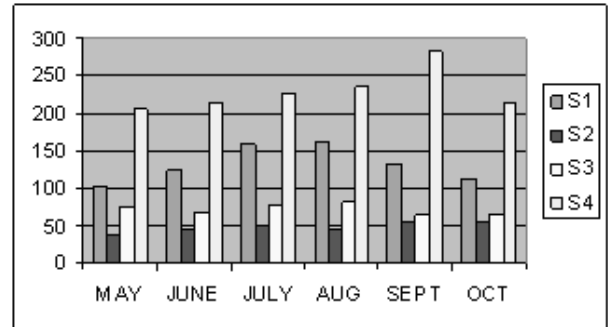

Fig. 3 Variation in pH during May-October 2006

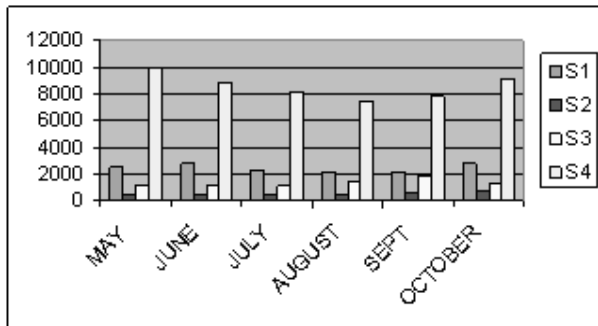**Fig. 4** Variation in SO_4^{2-} ion during May-October 2006

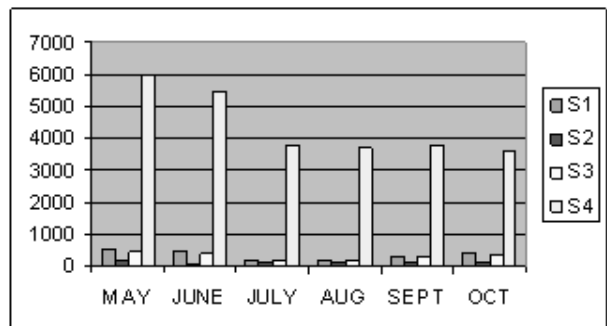**Fig. 5** Variation in TDS during May-October 2006

Fig. 6 Variation in Total Hardness during May-October 2006

Table 1. Ranges of physico-chemical parameters analysed for sampling station s_1 & s_2

Parametr	Sampling Station S_1				Sampling Station S_2			
	Min	Mean	Max	S.D	Min	Mean	Max	S.D.
Temperature	26.00	33.00	38.00	4.32	27.50	34.00	38.5	4.37
pH	5.55	6.15	6.67	0.402	6.18	7.35	7.88	0.35
D.O	4.30	4.19	5.50	0.410	6.20	6.93	7.40	0.41
BOD	316.00	422.00	531.00	91.68	38.00	42.66	47.00	3.55
COD	515.00	694.00	923.00	177.31	58.00	62.16	66.00	6.08
Cl^-	318.00	616.55	915.20	283.33	51.00	62.91	78.10	9.88
NO_3^-	72.00	82.67	114.00	16.94	34.00	43.50	52.00	6.47
SO_4^{2-}	102.00	132.21	162.00	23.85	38.00	48.00	56.00	6.22
PO_4^{3-}	2.514	2.95	3.59	0.393	0.28	0.33	0.35	0.039
TDS	2148.00	2451.50	2801	272.94	443.00	538.33	728.00	110.82
TS	2282.00	2337.00	2945.00	529.20	625.00	779.16	912.00	104.94
T.H	214.00	364.83	560.00	141.69	100.00	144.33	180.00	27.34
Ca	30.46	67.77	145.90	49.00	25.00	66.56	63.00	26.85
Mg	14.61	26.00	47.75	13.91	9.70	18.97	28.00	7.725

All parameters except pH & Temp are in mg/L; S.D- Standard Deviation , TDS- Total Dissolved Solids;
T.S- Total Solids ; T.H- Total Hardness

Table 2. Ranges of physico-chemical parameters analysed for sampling station S_3 & S_4

Parametr	Sampling Station S_1				Sampling Station S_2			
	Min	Mean	Max	S.D	Min	Mean	Max	S.D.
Temperature	28.50	32.00	35.80	3.02	27	34.00	36	3.48
pH	5.62	6.30	7.22	0.68	1.57	2.02	2.42	0.38
D.O	5.10	5.96	6.80	0.62	1.80	2.28	2.82	0.41
BOD	33.00	43.50	53.00	8.22	226.00	291.00	382.00	62.18
COD	47.00	58.66	74.00	12.12	440.00	544.16	714.00	113.97
Cl^-	136.00	263.15	418.00	115.58	722.00	1341.66	2621.00	810.78
NO_3^-	32.00	45.00	54.00	7.69	112.00	164.83	242.00	49.54
SO_4^{2-}	78.00	71.83	64.00	7.33	205.00	229.66	282.00	27.72
PO_4^{3-}	0.98	1.20	1.52	0.20	2.58	3.35	3.81	0.45
TDS	1140.00	1365.33	1802.00	213.83	7428.00	9392	9924.00	926.31
TS	1210.00	1383.50	1992.00	172.51	8132.00	9392.00	10150.00	3611.41
T.H	216.00	334.66	462.00	101.66	3624.00	4397	6000.0	948.98
Ca	38.00	66.56	104.20	28.56	601.00	894.10	1202.45	236.20
Mg	12.00	29.30	49.70	14.33	112.10	411.00	729.00	236.25

All parameters except pH & Temp are in mg/L; S.D -Standard Deviation , TDS- Total Dissolved Solids;
T.S- Total Solids; T.H- Total Hardness

High levels of PO_4^{3-} were observed at S_3 and S_4. The high levels of PO_4^{3-} at S_3 could be due to the discharge of domestic sewage in these bodies. High PO_4^{3-} levels of 8-11.2 mg/L during 1996-1997 & 40-172 mg/L during 1996-1997 in the Kakatiya Canal at Warangal have been established to be eutrophication factors (Satyanarayana, *et al.* 1998).

High values of TDS with a maximum of 9924mg/L(Fig. 5) and TS with a maximum of 10150 mg/L were observed at S_4 due to discharge of untreated industrial effluents. These values are well above the accepted limits. Water samples from S_4 showed very high levels of hardness with a maximum value of 6000mg/L (Fig.6). A common feature observed with respect to all sampling stations was that all the measured parameters were maximum in the month of May during the study period.

The results obtained were statistically analyzed. The mean standard deviation values were calculated. Pearson correlation coefficient was determined to find out the correlation between the various parameters. Significant correlations were observed for DO, BOD values and DO, COD values at stations S_1,S_2 & S_4. Significant correlations were observed for Cl^- &

Table 3. Pearson correlation for analysed parameters of station S_1

	pH	D.O	BOD	COD	Cl⁻	SO_4^{2-}	PO_4^{3-}	NO_3^-	TDS	TS	T.H	Ca	Mg
p H	1												
D.O	-0.52	1											
BOD	0.43	-0.94*	1										
COD	0.57	-0.96*	-0.94*	1									
Cl-	0.34	-0.92*	0.99*	0.95*	1								
SO_4^{2-}	-0.06	0.78*	-0.89*	-0.84*	-0.90*	1							
PO_4^{3-}	0.53	-0.90	0.94*	0.13	0.89*	-0.87*	1						
NO_3^-	-0.48	0.45	-0.23	-0.25	0.36	0.36	0.31	1					
TDS	0.10	-0.71*	0.59	0.62	0.61	-0.62	0.77	0.90*	1				
TS	-0.51	-0.85*	0.75*	0.82*	0.72*	0.68	0.77*	0.90*	0.90	1			
T.H	0.46	0.99*	0.99*	0.97*	0.99*	0.61	0.97*	-0.26	0.80*	0.80*	1		
Ca	0.47	0.30	0.48	0.48	0.92*	0.60	0.69	0.66	0.72*	0.72*	0.93*	1	
Mg	0.82*	-0.87*	0.91*	0.95*	-0.72*	-0.72*	0.95*	0.80*	0.86*	0.86*	0.93*	0.82*	1

* Significantly Correlated

Table 4. Pearson correlation for analysed parameters of station S_2

	pH	D.O	BOD	COD	Cl⁻	SO_4^{2-}	PO_4^{3-}	NO_3^-	TDS	TS	T.H	Ca	Mg
p H	1												
D.O	0.01	1											
BOD	-0.79*	0.01	1										
COD	0.30	-0.18	0.23	1									
CL-	-0.66	-0.69	0.42	-0.04	1								
SO_4^{2-}	-0.48	0.77*	0.49	-0.33	-0.32	1							
PO_4^{3-}	-0.80	0.09	0.59	-0.01	0.63	0.27	1						
NO_3^-	-0.58	0.04	-0.30	0.49	0.49	-0.40	0.34	1					
TDS	-0.75*	0.12	0.84*	-0.17	0.27	0.72*	0.39	-0.58	1				
TS	-0.59	0.18	0.53	-0.60	0.34	-0.60	0.48	0.96*	-0.07	1			
T.H	-0.62	-0.56	0.48	-0.28	0.65	-0.08	0.34	-0.62	0.42	0.37	1		
Ca	-0.56	0.19	0.31	-0.71*	0.08	0.68	0.08	0.90*	0.76*	0.98*	0.34	1	
Mg	-0.56	-0.27	0.87*	-0.11	0.72*	0.35	0.62	0.88*	0.84*	0.95*	0.72	0.94*	1

* Significantly Correlated

BOD values at stations S_1, S_3 & S_4. A negative correlation between pH and TS was observed at all sampling stations. Gupta *et al.* (1997) had reported significant correlation between NO_3^- and TDS in a study carried on ground water of Agra. Similar correlations have been observed at S_1, S_3 & S_4. A negative correlation is observed between pH and NO_3^- at all the stations. The inverse correlation with NO_3^- suggests anthropogenic NO_x as the most effective acidifying agents (Aiuppa *et al.* 2003).Similar correlations have been observed at S_1, S_3 & S_4. All correlation factors have been given in Tables 3, 4 & 5.

CONCLUSION

Maximum pollution levels were observed at Chinchpada (S_1) sampling site and at Vasai East (S_4) site. The levels at the other two sampling stations Goraipada (S_2) and Tungareshwar (S_3) comparatively are lower. But the measured water quality parameters at all the stations well are above the accepted standards. Thus water pollution levels are on the higher side in the industrial town of Vasai, thus calling for urgent remedial action.

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Table 5. Pearson correlation for analysed parameters of station S_3

	pH	D.O	BOD	COD	Cl⁻	SO_4^{2-}	PO_4^{3-}	NO_3^-	TDS	TS	T.H	Ca	Mg
pH	1												
D.O	-0.78*	1											
BOD	0.70	-0.87*	1										
COD	0.84*	-0.94*	0.72	1									
Cl⁻	0.94*	-0.88*	0.9*	0.84*	1								
SO_4^{2-}	-0.03	0.28	-0.62	-0.06	-0.33	1							
PO_4^{3-}	-0.15	-0.20	0.56	-0.11	0.18	-0.85*	1						
NO_3^-	-0.58	0.90	-0.84	-0.75	-0.76	0.55	0.10	1					
TDS	-0.23	0.45	-0.17	-0.59	-0.20	-0.37	-0.37	0.10	1				
TS	-0.15	-0.06	0.13	-0.05	0.22	0.13	0.13	-0.38	0.23	1			
T.H	0.79*	-0.88*	0.99*	0.75	0.95*	-0.56	-0.56	-0.84*	-0.12	0.23	1		
Ca	0.90*	-0.94*	0.92*	0.91*	0.99*	-0.34	-0.34	-0.81*	-0.32	0.12	0.95*	1	
Mg	-0.14	-0.92*	0.97*	0.83*	0.98*	-0.46	-0.46	-0.83*	-0.23	0.88*	0.99*	0.99*	1

* Significantly Correlated

Table 6. Pearson correlation for analysed parameters of station S_4

	pH	D.O	BOD	COD	Cl⁻	SO_4^{2-}	PO_4^{3-}	NO_3^-	TDS	TS	T.H	Ca	Mg
pH	1												
D.O	0.7	1											
BOD	-0.84*	-0.88*	1										
COD	-0.26	0.00	0.11	1									
Cl⁻	-0.96*	-0.78*	0.94*	0.29	1								
SO_4^{2-}	0.56	0.21	-0.51	-0.24	-0.57	1							
PO_4^{3-}	-0.36	-0.62	0.47	-0.64	0.36	0.28	1						
NO_3^-	-0.94*	-0.78*	0.9	0.45	0.97*	-0.58	0.22	1					
TDS	-0.61	-0.72	0.68	0.45	0.45	-0.61	0.28	0.79*	1				
TS	-0.64	-0.75*	0.88*	0.03	0.03	-0.70	0.20	0.70	0.89*	1			
T.H	-0.98*	-0.81*	0.88*	0.17	0.96*	-0.53	0.45	0.94*	0.67	0.73	1		
Ca	-0.82*	-0.92*	0.97*	-0.09	0.89*	-0.48	0.61	0.83*	0.66	0.79*	0.90*	1	
Mg	0.05	-0.4	0.32	-0.83*	-0.83*	0.14	0.76*	-0.1	-0.12	0.21	0.07	0.46	1

* Significantly Correlated

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