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LAND BASED POLLUTION AND THE MARINE ENVIRONMENT OF KARACHI COAST

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Surveys were carried out to assess the degree of pollution caused by the discharge of industrial and municipal effluents through Lyari river into the coastal areas of Karachi, initially between January and December in 1980 at monthly intervals and during 1981-82 at quarterly intervals. Several chemical parameters have been used to evaluate the quality of Lyari discharge and of the sea water. It is found that the former, being strong sewage is the major source of pollution in the Manora Channel.

The healthy growth of mangroves on the one hand and widespread pollution by Lyari effluents which supplies organic nutrients over the entire Manora Channel suggests that an ecological balance has been arrived at and the channel presents itself as a dynamic ecosystem receiving nutrients from Lyari and distributing and spilling it all over by tidal action.

The high bicarbonate content of the beaches is suggested to be due to air pollution on shore.

INTRODUCTION

It has been stated in earlier papers[1-5] that Lyari which becomes a perennial river when it enters the suburbs of Karachi, is an open drain from both chemical and microbiological point of view. The water flowing in it originates initially from discharge of domestic sewage and subsequently of industrial effluents. The latter is discharged by industries located in the SITE (Sind Industrial Trading Estate) area through natural channels which used to be dry in the past.

SITE covers an area of about 4,000 acres. It has approximately 300 major industries and almost three times as many small units. 60% of these enterprises are textile mills while the others deal with chemicals, detergents, vegetable oils, beverages, food products, iron and steel etc.

Lyari river finally discharges its effluents into Manora Channel. As may be noted from the accompanying map, the last named is an enclosed channel from where the water is not easily flushed out. The polluted water discharged by the river remains stagnant during low tide. This process keeps polluting the south-eastern creeks. Furthermore, since the currents move clockwise, the outgoing channel water contaminates the outer region. For at least three months during the north-east monsoon when the currents move anticlockwise, the outgoing water may also be carried towards Manora, Sandspit, Hawkesbay and Paradise Point which are the main picnic spots.

Previous papers in the series[1-5] have shown that the water flowing through Lyari is a mixture of raw sewage and untreated industrial effluents. It was pointed out that the contamination is quite extensive in that it has endangered the marine environment, in general, and has seriously deteriorated the quality of salt at the salt works located along one of the channels of the Lyari delta.

METHODOLOGY

Grab samples for the analysis of physical and chemical properties were collected at monthly intervals in 1980 and at quarterly intervals in 1981-82, from eight sampling points described as under:

Sampling pionts	Location
I	Lyari end
II	Coastal pump, Gulbai Salt works
III	Coastal pump, Luxmi Salt works
IV	Coastal pump, Habib Ocean Salt Works
V	Opposite Sandspit beach (near Hut No. 15).
VI	Sandspit Jetty
VII	Sandspit beach (Opposite Hut No. N-15).
VIII	Sandspit beach (Opposite Jetty)

The selection of sampling points was based on accessibility and was arranged so as to cover the maximum area affected by the effluent from Lyari.

Measurements of physical and chemical properties were conducted in the Laboratory, and some of them were recorded on the spot, by standard methods [6-7].

Tables 1 to 8 show the physical and chemical analysis of samples from different points at different intervals.

Table 1. Average analysis of Lyari water flowing into sea. Sampling point I.

Characteristics/ Constituents	1980	1981	1982
pH	7.3	7.1	6.9
Stability	Fail	Fail	Fail
Density	0.9988	0.9981	0.9978
Total solids (TS)	4,418 ppm	3,705 ppm	2,397 ppm
Volatile matter in TS	219 ppm	198 ppm	137 ppm
Total halides	1,710 ppm	1,583 ppm	775 ppm
Sulphates	845 ppm	608 ppm	490 ppm
Bicarbonates	550 ppm	450 ppm	380 ppm
Calcium	162 ppm	137 ppm	97 ppm
Magnesium	82 ppm	60 ppm	48 ppm
Sodium	750 ppm	580 ppm	400 ppm
Potassium	51 ppm	36 ppm	30 ppm

Table 2. Average analysis of sea water at Gulbai coastal pump. Sampling point No. 2.

Characteristics/ Constituents	1980	1981	1982
pH	7.5	7.7	7.8
Stability	F	F/4hr	F/24hr
Density	1.026	1.029	1.030
Total solids (TS)	46,426 ppm	51,527 ppm	56,139 ppm
Volatile matter in TS	6,638 ppm	7,231 ppm	8,672 ppm
Total halides	21,985 ppm	24,673 ppm	26,474 ppm
Sulphates	2,716 ppm	3,180 ppm	3,411 ppm
Bicarbonates	400 ppm	400 ppm	425 ppm
Calcium	480 ppm	400 ppm	421 ppm
Magnesium	1,819 ppm	2,043 ppm	2,085 ppm
Sodium	11,500 ppm	12,500 ppm	13,500 ppm

Table 3. Average analysis of sea water at Luxmi coastal pump. Sampling point No. 3.

Characteristics/ Constitutens	1980	1981	1982
pH	7.6	7.8	7.9
Stability	F	F	F
Density	1.029	1.031	1.035
Total solids (TS)	54,687 ppm	55,934 ppm	63,257 ppm
Volatile matter in TS	7,338 ppm	7,625 ppm	8,789 ppm
Total halides	26,685 ppm	26,956 ppm	30,942 ppm
Sulphates	3,559 ppm	3,627 ppm	4,246 ppm
Bicarbonates	400 ppm	425 ppm	450 ppm
Calcium	350 ppm	386 ppm	400 ppm
Magnesium	1,995 ppm	2,115 ppm	2,215 ppm
Sodium	13,460 ppm	13,665 ppm	15,500 ppm
Potassium	900 ppm	900 ppm	1,000 ppm

Table 4. Average analysis of sea water at Habib ocean coastal pump. Sampling point No. 4

Characteristics/ Constitutents	1980	1981	1982
pH	7.6	7.7	7.9
Stability test	F/7 days	F/7 days	F/5 days
Density	1.026	1.027	1.027
Total solids (TS)	46,992 ppm	48,422 ppm	49,685 ppm
Volatile matter in TS	6,444 ppm	6,940 ppm	7,656 ppm
Total halides	22,194 ppm	22, 387 ppm	22,834 ppm
Sulphates	3,160 ppm	3,359 ppm	3,438 ppm
Bicarbonates	350 ppm	350 ppm	365 ppm
Calcium	385 ppm	400 ppm	400 ppm
Magnesium	1,605 ppm	1,687 ppm	1,780
Sodium	11,800 ppm	12,000 ppm	12,000 ppm
Potassium	760 ppm	800 ppm	900 ppm

RESULTS

Sampling point I is located towards the end of SITE area whereafter Lyari splits into three streams. Point II, III and IV represent caostal pumps of the salt works situated on the Manora Channel and one of the delta streams of the river flows close to them. V and VI are points located on the enclosed beach of Manora Channel. The latter receives water from Lyari in the east and from the sea only at high tide. Sampling points VII and VIII are situated on the open sea and they are not directly linked with Lyari. The only chance of intermixing of the waters on the two sides is that when the swelling high tides push the collected water out of the stagnant pools in the Manora Channel.

The water samples collected may therefore be categorised in four types: (i) Lyari water comprising domestic and industrial waste, (ii) In-put for salt works, (iii) Manora Channel water representing the sewage mixed stagnant water in the enclosed area and (iv) water from the open beaches.

pH of the water samples for point I varies between 6.9 and 7.3, for II, III and IV it varies between 7.5 and 7.9 while for V to VIII it is 7.5 to 7.8 which is that of near shore water.

It may be observed from Table I that pH of the water at point I i.e., Lyari effluent, is gradually getting lower with the passage of time. This may either be due to the effects of dilution with less polluted water or interaction with in-

Table. 5. Average analysis of sea water at opposite sandspit beach (near Hut No. 15)
Sampling point No. 5

Characteristics/ Constitutents	Jan-April 1980	May-August 1980	Spe.-Dec. 1980	1981	1982
pH	7.8	7.6	7.8	7.7	7.8
Stability test	F/8hr	F/12 hr	F/8 hr	F/8 hr	F/6 hr
Density	1.025	1.024	1.024	1.024	1.025
Total solids (TS)	45,942 ppm	43,224 ppm	44,180 ppm	43,995 ppm	45,452 ppm
Volatile matter in TS	7,465 ppm	5,537 ppm	5,810 ppm	5,976 ppm	6,184 ppm
Total halides	21,290 ppm	20,589 ppm	20,998 ppm	20,882 ppm	21,522 ppm
Sulphates	2,864 ppm	2,724 ppm	2,871 ppm	2,734 ppm	2,878 ppm
Bicarbonates	260 ppm	270 ppm	230 ppm	240 ppm	250 ppm
Calcium	490 ppm	480 ppm	480 ppm	480 ppm	480 ppm
Magnesium	1,653 ppm	1,838 ppm	1,654 ppm	1,665 ppm	1,678 ppm
Sodium	11,500 ppm	11,000 ppm	11,300 ppm	11,250 ppm	11,700 ppm
Potassium	400 ppm	380 ppm	390 ppm	390 ppm	400 ppm

Table 6. Average analysis of sea water at Sandspit Jetty. Sampling point No. 6

Characteristics/ Constituents	Jan-April 1980	May-August 1980	Sep.-Dec. 1980	1981	1982
pH	7.8	7.6	7.8	7.7	7.8
Stability test	F/8 hr	F/12 hr	P	P	F/6 hr
Density	1.025	1.024	1.024	1.024	1.025
Total solids (TS)	46,566 ppm	43,310 ppm	44,250 ppm	44,026 ppm	45,548 ppm
Volatile matter in TS	7,545 ppm	5,774 ppm	5,884 ppm	5,987 ppm	6,215 ppm
Total halids	21,324 ppm	20,612 ppm	21,017 ppm	20,446 ppm	21,554 ppm
Sulphates	2,880 ppm	2,728 ppm	2,865 ppm	2,787 ppm	2,884 ppm
Bicarbonates	260 ppm	280 ppm	230 ppm	240 ppm	250 ppm
Calcium	490 ppm	480 ppm	480 ppm	470 ppm	480 ppm
Magnesium	1,675 ppm	1,625 ppm	1,662 ppm	1,668 ppm	1,680 ppm
Sodium	11,600 ppm	11,000 ppm	11,300 ppm	11,200 ppm	11,700 ppm
Potassium	400 ppm	380 ppm	390 ppm	390 ppm	400 ppm

Table 7. Average analysis of sea water at Sandspit Beach (opposite Hut No. N-15) Sampling point No. 7.

Characteristics/ Constituents	Jan-April 1980	May-August 1980	Sep.-Dec. 1980	1981	1982
pH	7.7	7.5	7.8	7.7	7.7
Stability test	P	P	P	P	P
Density	1.023	1.023	1.023	1.023	1.024
Total solids (TS)	40,987 ppm	40,262 ppm	40,440 ppm	40,760 ppm	42,835 ppm
Volatile matter in TS	4,360 ppm	4,112 ppm	3,600 ppm	3,365 ppm	4,675 ppm
Total halides	20,866 ppm	20,575 ppm	20,643 ppm	20,788 ppm	20,920 ppm
Sulphates	2,885 ppm	2,513 ppm	2,658 ppm	2,672 ppm	2,724 ppm
Bicarbonates	230 ppm	220 ppm	220 ppm	230 ppm	230 ppm
Calcium	480 ppm	460 ppm	470 ppm	470 ppm	480 ppm
Magnesium	1,655 ppm	1,476 ppm	1,525 ppm	1,548 ppm	1,682 ppm
Sodium	11,500 ppm	10,500 ppm	11,000 ppm	11,000 ppm	11,500 ppm
Potassiuum	390 ppm	380 ppm	390 ppm	390 ppm	390 ppm

Table 8. Average analysis of sea water at Sandspit Beach (opposite Jetty). Sampling point No. 8.

Characteristics/ Constituents	Jan-April 1980	May-August 1980	Sep.-Dec. 1980	1981	1982
pH	7.7	7.5	7.8	7.7	7.7
Stability test	P	P	P	P	P
Density	1.024	1.023	1.024	1.024	1.024
Total solids (TS)	42.103 ppm	40.324 ppm	40,451 ppm	40,826 ppm	42,960 ppm
Volatile matter in TS	4,429 ppm	4,230 ppm	3,686 ppm	3,524 ppm	4,790 ppm
Total halides	20,875 ppm	20,596 ppm	20,685 ppm	20,796 ppm	20,938 ppm
Sulphates	2,910 ppm	2,536 ppm	2,680 ppm	2,678 ppm	2,740 ppm
Bicarbonates	230 ppm	220 ppm	220 ppm	230 ppm	235 ppm
Calcium	480 ppm	460 ppm	470 ppm	470 ppm	480 ppm
Magnesium	1,668 ppm	1,490 ppm	1,534 ppm	1,566 ppm	1,695 ppm
Sodium	11,500 ppm	10,500 ppm	11,000 ppm	11,000 ppm	11,500 ppm
Potassium	390 ppm	380 ppm	390 ppm	390 ppm	400 ppm

dustrial effluents so as to precipitate out some pollutants and to give rise to lower concentration.

The slight rise in pH at points II, III and IV may have to be judged in the perspective of high total solids which is necessary for the input to salt works. Sewage brings in considerable quantities of bicarbonates which in the process of concentration as desired for salt works would increase the alkalinity. It may also be noted that pH of the sea water collected from open and enclosed beaches is lower than for standard sea water[8].

All the samples collected from points I, II and III fail the putrescibility test. Samples from point IV are slightly better than those from points II and III perhaps because this point is located at a fair distance from the deltaic channel.

Samples collected from point V failed during 1980, 1981 and 1982 while that from VI failed during 1980 and 1982 and passed during 1981. This might be indicative of the flushing process which is easier at the former point. It may be seen from the location map that point VI is

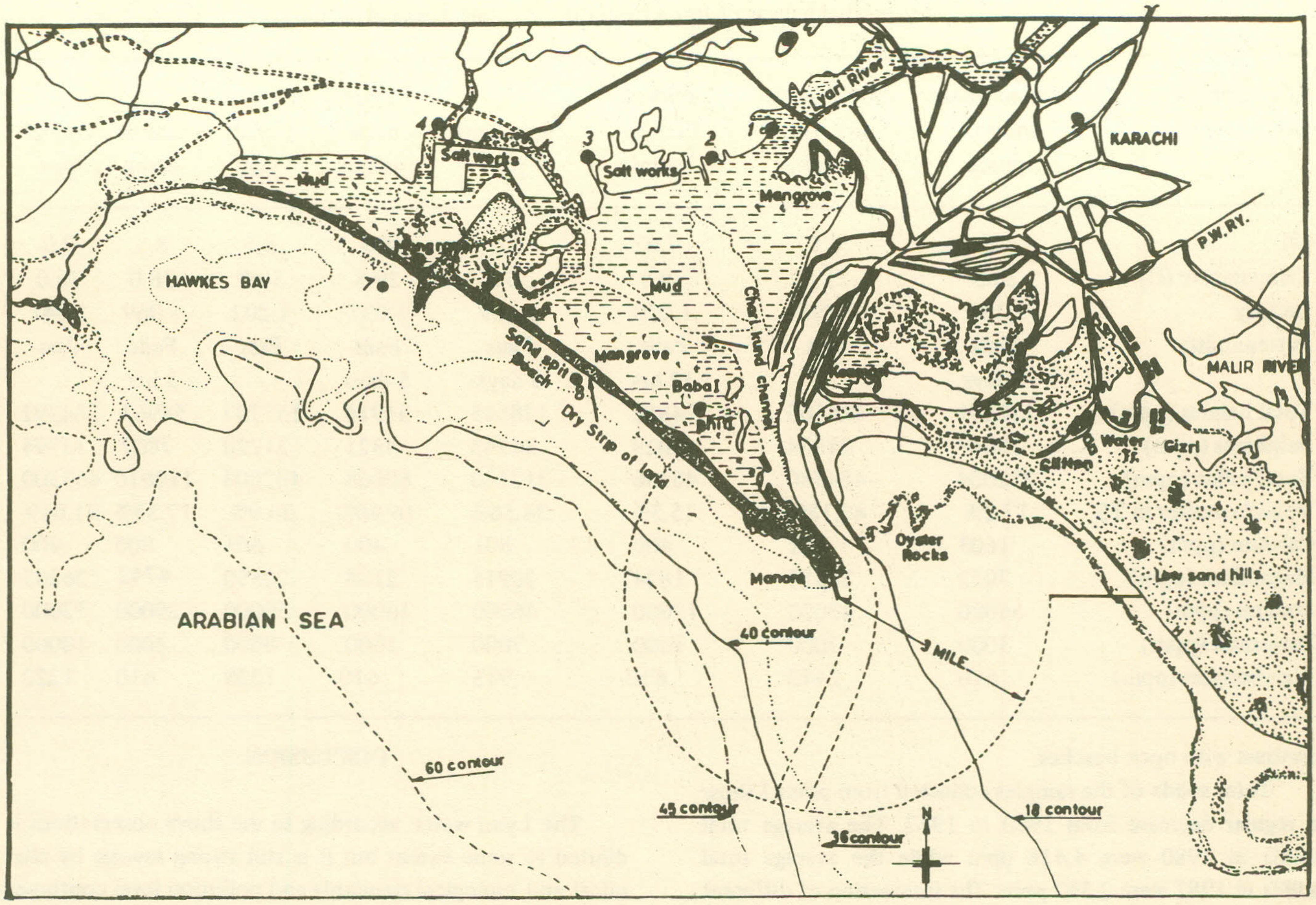

Table 9. Typical variations in the properties of coastal waters.

Characteristic/ Constitutents	Standard sea water	Point loma San Diego	Brazosport	Rantam river New Jersy	Karachi harbour (average)
pH	8.2	8.1	8.0	7.0	7.6
Total dissolved solids (TDS) (ppm)	35,000	33,400	36,250	24,000	37,000
Sulphate	2,712	2,610	2,900	1,960	2,700
Chloride (ppm)	19,350	18,920	20,750	12,400	20,500
Bicarbonate (ppm)	142	104	95	84	200
Calcium (ppm)	413	398	430		480
Magnesium (ppm)	1,294	1,280	1,400	4,000 as $CaCO_3$	1,450
Sodium (ppm)	10,760	–	10,700	–	11,500
Potassium (ppm)	387	–	445	–	400

accessible to high tides through a wider channel compared with point V which is not so favourably located. Density of the samples from point I show slight decrease from 1980 to 1982 which as suggested earlier may be due to dilution. Samples from point II, III and IV show higher densities in comparison with those from the river. These are expected to have a slightly higher concentration than sea water since they represent the input for the salt works. Samples from V and VI show higher densities than those from points VII and VIII since the water at the former points is stagnant in

Table 10. Analysis of Brine from different salt works [4].

Characteristics/ Constituents	Habib Ocean Ind.Ltd. pump	Habib Ocean Ind. Ltd. pan	Nasarwanji Coastal pump	Nasarwanji pan	Luxmi coastal pump	Luxmi pan	Gulbai pump	Gulbai pan
pH	8.5	8.5	7.0	9.0	8.0	8.5	8.5	9.0
Temperature (C)	28.5	35.5	29.5	35.5	29.5	30.0	36.0	36.0
Density	1.139	1.276	1.020	1.169	1.037	1.202	1.069	1.241
Putrescibility	Fails 7 days	Pass	Fails 12 hrs	Fails 5 days	Fails 5 days	Pass	Fails 3 hrs	Pass
Total halides (ppm)	116131	186165	24882	128545	31914	157797	54963	184392
Sulphates (ppm)	13647	21854	3029	34543	4321	21220	7807	33794
Total solids (ppm)	232004	484580	46156	317140	60068	402808	110810	463300
Volatile matter in TS	17.2%	42.18%	15.5%	34.56%	16.96%	34.9%	17.33%	31.01%
Calcium (ppm)	1603	601	400	801	400	601	800	400
Magnesium (ppm)	7052	20550	1824	20915	2188	20550	4742	26265
Sodium (ppm)	56000	43000	12000	46000	16000	59000	29000	72000
Potassium (ppm)	3000	7000	1000	7000	1000	8000	2000	10000
Bicarbonates (ppm)	610	2440	610	915	610	1220	610	1220

contrast with open beaches.

Total solids of the samples collected from point I show a regular decrease from 1980 to 1982. The average total solids in 1980 were 4,418 ppm while the average total solids in 1982 were 2,397 ppm. The interaction of different components of municipal wastes and industrial effluents, as suggested earlier in the case of lowering of pH may be one of the factors contributing to dilution or lowering in the dissolved solids content. The total solids content of samples collected from points II, III and IV is higher than those from others. This is the result of natural evaporation during the process of storing and pumping as required for the salt works. The concentration of total solids on the two sides of the land separating stagnant from the open beaches is different. The content noted at points V and VI is higher than at VII and VIII. On an average the concentration of total solids in the sample from the beaches are also higher than for an average open sea water sample. All the other constitutents e.g., total halides, sulphates, calcium, magnesium, sodium and potassium are as usual in conformity with total solids.

Estimation of volatile matter by noting the loss at 500°C has been taken as an index of organic matter, the same continues to be the main source of pollution for the salt works [4,5]. It has been found to be slightly high for sampling points: II, III and IV which are located near the river channels. The maximum organic matter 8,789 ppm was estimated at sampling point III in 1982.

DISCUSSION

The Lyari water, according to the above observations is diluted to some extent but it is still strong sewage by chemical and biological standards and pollution level continues to be high. The microbiological studies, reported separately [9], indicate a high Faecal Counts (918/dl) on the beaches and that the Faecal Counts (MPN) in the enclosed area is on an increase.

The entire channel area excepting the one close to Lyari has flourishing growth of mangrove which in spite of the pollution load continues to remain there. The sewage and wastes discharged by Lyari are apparently responsible for nutrient enrichment and eutrophication and hence for the growth of mangroves. The water entering at high tides fills the backwaters and creeks of the harbour, the mudflats and intake channels of salt works and the mangroves on the east and north-west extremes of the harbour. There is, therefore, a restoration of salt balance, if at all it is disturbed by the pollution load, thus providing a balanced eco-system.

The salt works are accessible through Chari Kund channel which is navigable also during low tide. Two of the deltaic streams of Lyari pour their effluents into the wider section of this channel while another stream by-passes the salt works. The latter is responsible for contaminating the input of the salt works. Some but not all of its water also reaches point IV and V since the samples there have been found to be less contaminated at times.

It may be seen that the volatile matter constitues approximately 4-6% of total solids in the Lyari effluent while it is 13-15% in the input of salt works and 12-16% on the enclosed beaches but is 9-11% for the open beaches. The volatile matter as estimated may not be truly representative of the carbonaceous material since it has been dtermined by observing theloss in weight at 500°C and it is possible that it would include oxidizable matter of all kind. When gauged in the light of the failure of samples in the putrescibility test and the presence of healthy growth of mangroves, it seems reasonable to believe that the total solids should contain a reasonable quantity of organic matter. The data, however, suggest that the organic matter as received from Lyari is deposited in the Manora channel and is mainly responsible for the nutrient balance and eutrophication. The backwash at high tides and the Lyari flow seem to maintain a dynamic ecological equilibrium in the Manora channel whose ionic concentration is slightly higher than the open beach which is again influenced by the outflow from the former during times when the tides start receding. A high content of organic matter in nearshore and esturine waters receiving waste discharges is not uncommon [8]. However, the land based pollution seems to be generally contained in the Manora channel.

The other chemical ingredients contributed by Lyari appear to be duly diluted since the analyses of sea water shows that it is not significantly affected by waste water. The sea water is already at least 15 times more concentrated than Lyari discharge. Moreover, the former is a highly buffered system and is susceptible to change only if the volume of the diluent is large. In the case of Lyari it is only of the order of 100 to 120 mgd. The analysis of samples, however, corresponds to concentrated sea water as is supported by their density and a comparison with density of brine[4].

It may be seen from the Tables showing analysis of sea water that its pH as well as bicarbonate content do not correspond to what is known as standard sea water. On the average the pH is 7.5 instead of 8.2 and bicarbonate 200 ppm instead of 140. This is possible if additional carbon dioxide is available nearshore. This would give rise to a shift in equilibrium as follows:

$$CO_2 + H_2O \rightleftharpoons H_2CO_3$$
$$H_2CO_3 \rightleftharpoons HCO_3^- + H^+$$
$$HCO_3 \rightleftharpoons CO_3^- + H^+$$

In earlier reports on effects of air pollution on the Karachi environment[1,10], it has been indicated that the increase in the number of vehicles and increased use of fossil fuel by industries and homes has given rise to generation of carbon dioxide beyond the absorption capacity of nearshore water. Since ocean is the sink for CO_2 it is reasonable to assume that the slight but siignificant fall in pH an also higher bicarbonate content of nearshore water is because of the onshore activity.

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