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NUTRIENT DYNAMICS IN SEAWATER OF PARADISE POINT

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ABSTRACT

This study describes the nutrient dynamics in coastal area of Paradise Point that is mainly affected by the waste water of Karachi Atomic Nuclear Power Plant (KANUPP) and sewage from different sources (domestic and industrial). For this purpose, variation in nitrogen (NH_3, NO_3 and NO_2), Phosphorus (inorganic and organic) concentrations and hydrographic conditions (temperature, salinity, pH, dissolved oxygen, biological oxygen demand and, chemical oxygen demand) in surface seawater as well as in tide pools seawater of Paradise Point were determined. The samples of seawater were collected during the period of three years. The present study indicates that domestic and industrial urban sewage likely affects and increases the concentration of nutrient. The nutrients were mostly low in surface seawater as compared to tide pools. The nitrogen of seawater has positive insignificant correlation with phosphorus. It was noted also that the salinity was high in winter season and low in rainy season. The seasonal trend was found in temperature and dissolved oxygen and high values were found in summer (May to August) and lower values in winter (December to February). Significant differences were also observed in salinity, biological oxygen demand and chemical oxygen demand.

Key words: Nutrient, hydrographic conditions, surface seawater, tide pools seawater

INTRODUCTION

Pakistan has a coast line of about 1120 km bordering Arabian Sea in the south at 23°50' N latitude and 66° 40′ E longitude that covers the Sindh and the Balochistan coast. Karachi is the largest industrial and commercial city of Pakistan has been facing the big problem of marine pollution. Since its vast spreading development, rapid urbanization, and industrialization in the last thirty years, the chance of contamination of seawater has been increased due to the lack of resources utilization and old unsatisfactory sewage system of Municipal Corporation. The sewerage system of Karachi was designed for a population of two million. At this time about 300 mgd (909,050 m^3 per day) sewerage and waste water is generated from municipal and industrial sources and increased in population will almost double the present volume of sewerage (Rizvi *et al.,* 1995). The coast of Paradise Point is mainly affected by the waste water of Karachi Atomic Nuclear Power Plant (KANUPP), sewage (domestic and industrial) and effluents from different sources (Beg *et al*., 1975).

The characteristic of water masses in the ocean and problems such as potential fertility and oxidation of organic matter in seawater depends on the hydrographic conditions and the distribution of nutrient. The nutrients and hydrographic conditions of seawater undergo considerable tidal and seasonal variations. The Karachi nuclear power plant (KANUP) is situated near the paradise point beach, with a capacity of 137 KW and utilizes about 0.1 millions gallons of seawater per minute for circulation through it "once through" type cooling system (Rizvi ,1980). The oceanographic studies of the coastal water of Paradise Point have not been reported yet, although some studies have been made about the hydrography and chemistry of other coastal areas of Karachi (Ahmed, 1977; Ali and Jilani, 1995; Banse, 1968; Hussein and Samad, 1995; Qari and Siddiqui, 2005; Qasim *et al*., 1994; Rizvi *et al*., 1988; Rizvi *et al*., 1995; Saleem and Rahim, 1995). The aim of the present study was to assist the effects of discharge and effluent particularly from Karachi Atomic Nuclear Power Plant (KANUPP) and other industries, tanneries and sources in the coastal region of Paradise Point. For this purpose variation in nutrient and hydrographic conditions in surface and tide pools seawater were studied.

MATERIALS AND METHODS

The samples of seawater were collected at monthly intervals from two stations surface seawater and tide pools seawater at low water mark from the Paradise Point for three years (1989-1991). Paradise Point is a recreational beach, which lies at 24° 48' N and 66°47'. 20" E of Karachi between Pacha and Buleji covering a distance of about 18 km on the west of Karachi (Fig.1). The coast is open to sea front and the wave action is intense all along the coast. The shore is turbulent during the south west monsoon period .The rocky ledge of paradise point is mostly wave swept shores . The slope gradient of the shore line is sharp and as a result the intertidal zone is narrow . The land at the shore-end is considerably high (10-12M) with varying slopes towards the sea front at many places (Haq *et al*., 1978) .

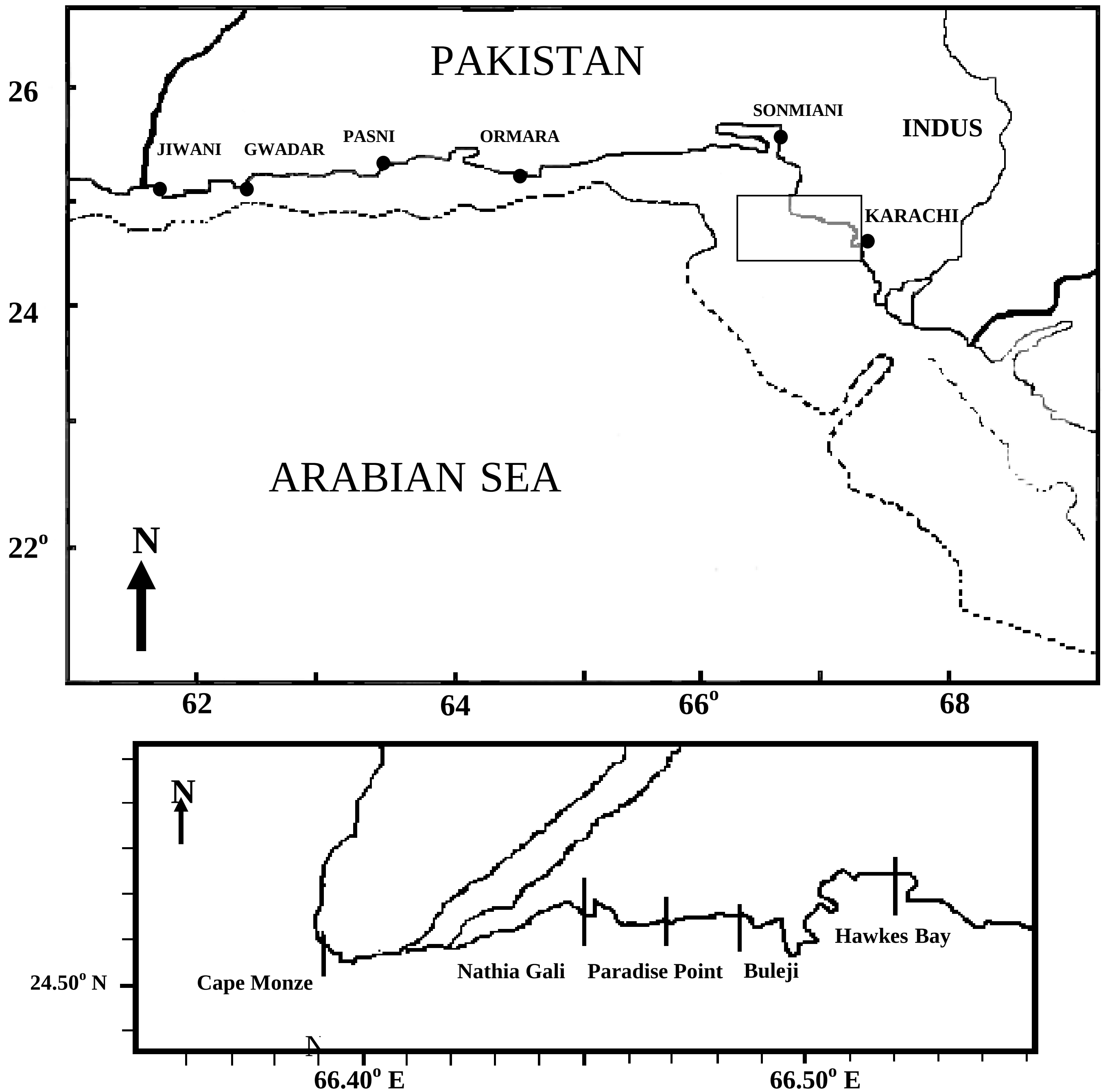

Fig.1. Top panel showing the coastal area of Pakistan with inset enlarged showing the study site, Paradise Point.

Nitrite nitrogen NO_2-N was carried out by the diazotization process (Martin, 1972) and nitrate was estimated by the most sensitive and generally applied technique of Strickland and Parson (1972) based on the reduction of nitrate using "cadmium-copper reduction column". The indophenol blue method (Berthelot reaction) is used to measure the ammonia concentration (Strickland and Parson, 1972). Total nitrogen was calculated by the addition of nitrite nitrogen, nitrate nitrogen and ammonia nitrogen. Inorganic phosphate phosphorus was analyzed by the method of Murphy and Riley (1962) and total phosphorus measured by the method of Grasshoff (1976). The organic phosphorus content of seawater was calculated from the difference between the inorganic phosphorus concentration and total phosphorus concentration (McGill, 1964).

Temperature was recorded using a mercury thermometer. The air temperature was also measured at each station. Digital pH meter (Model PM-65) was used for measuring the pH of seawater. Salinity was measured by the Salinometer (Model E-2 Ogawa Seiko Co. LTD Tokyo, Japan Tsunami Seiki). The dissolved oxygen was determined by the classical chemical method "Winkler titration" as modified by Martin (1972). For BOD the direct method and for COD Permanganate method were used (Rodier, 1972).

RESULTS AND DISCUSSION

The results of nutrient and hydrographic conditions in seawater both in surface and tide pools conducted on a seasonal and annual basis over three years. The values of each parameter are the mean of three years. The nutrient levels (nitrite-N, nitrate-N, ammonia-N, total N, inorganic phosphorus, organic phosphorus and total phosphorus) are summarized in Fig. **2-8.** The nitrite nitrogen of seawater ranged from 0.43-1.1 μg/l and the high concentration of nitrite nitrogen most of the time of study period in winter (0.7-1.1 μg/l) and low concentration was found in summer (0.43-0.57 μg/l) in both surface and tide pools seawater (Fig. **2**). The concentration of nitrate nitrogen in surface seawater was increased from January to September (1.14-3.77 μg/l) and then decreased (1.02-1.51 μg/l) where as in tide pools it was high in June (4.3 μg/l) as compare to other month (Fig. **3**). In both surface and tide pools seawater, the concentration of ammonia nitrogen (6.25-16.76 μg/l, 10.07-19.48 μg/l respectively) and total nitrogen (8.12-21 μg/l, 12.86-23.69 μg/l respectively) were more or less increased from January to September and then decreased except a little decreased in June and July in tide pools seawater (Fig. **4 and 5**). The inorganic phosphorus of seawater ranged from 1.7-5.4 μg/l. The data from surface seawater showed the concentrations were more or less same through out the study period except summer (May -June) where as in tide pools seawater the high peak of inorganic phosphorus value was also found in summer (May -June) (Fig. **6**). The highest concentrations of organic and total Phosphorus in both surface seawater (6.62 μg/l, 9.42 μg/l respectively) and tide pools seawater (4.95 μg/l, 8.31 μg/l respectively) were found in May and lowest in December for surface seawater (1.56 μg/l, 3.26 μg/l respectively) and for tide pools seawater (0.45 μg/l, 2.95 μg/l respectively) through out the study period (Fig. **6-8**).

The data of surface seawater and tide pools seawater showed that the salinity was more or less same throughout the year (37.11-37.95 ‰) except it was high in December (38.07 ‰) in surface seawater and in May (38 ‰) and December (38.53 ‰) in tide pools seawater (Fig. **9**). The highest temperature (28-29 ^oC) was recorded in period of summer (June-August) and the lowest temperature was recorded in winter (January-December) (21^-25^oC) (Fig. **10**).

The pH of seawater ranged from 6.48-7.17 and the high pH was recorded in summer (Fig. **11**). The highest concentrations of dissolved oxygen in both surface and tide pools seawater were recorded in winter (6.45-9.61 ml l^{-1}) and lowest in summer (5.33-6.32 ml l^{-1}) (Fig. **12**). In surface seawater and tide pools seawater the highest BOD was recorded in February (5.51 ml l^{-1}, 5.07 ml l^{-1}respectively), October (3.74 ml l^{-1}, 4.09 ml l^{-1} respectively) and November (3.41 ml l^{-1}, 4.44 ml l^{-1}respectively) as compare to other month (Fig. **13**). The COD of seawater ranged from 0.43-1.26 ml l^{-1} and the results of COD showed that there is no seasonal trend was found (Fig. **14**).

The present study reveals that the results of each parameter were not constant but varied between years, months and stations. The differences of nitrite nitrogen were found significant between years (F = 7.87) and stations (F = 7.02) but were not significant with month. For nitrate nitrogen variations were significant between years (F = 2.96) and months (F = 3.89) but there were no significant variations observed between stations. There were highly significant variations observed in ammonia nitrogen, total nitrogen, inorganic phosphorus and organic phosphorus between years (F = 26.37, F = 22.87, F = 14.73 and F = 16.12 respectively), months (F= 3.39, F = 3.66, F = 3.11 and F= 2.81 respectively) and station (F = 8.38, F = 5.64, F = 3.71 and F = 4.19 respectively). The total phosphorus showed significant variations between years (F= .15.19) and months (F= 6.64) but the variations were not significant between stations. There were significant variations found between years (F = 13.89) months (F = 14.78) and stations (F = 4.98) for temperature where as the significant differences were found for salinity between years (F = 24.09), and months (F = 2.24). For pH and dissolved oxygen significant differences were observed between years (F = 11.03 and F = 4.39 respectively) but there were no significant variations between months and stations. There were highly significant variations found between month for BOD (F = 5.04) and between stations for COD (F = 3.25).

The temperature has positive insignificant correlation with nutrient except with nitrite nitrogen it has negative insignificant correlation in surface seawater and negative significant correlation in tide pools seawater. Temperature also has no correlation with organic phosphorus in tide pools seawater. Salinity has negative insignificant correlation with nutrient in both surface and tide pools seawater except there was no correlation was found with nitrite nitrogen and organic phosphorus in surface seawater. The pH of surface seawater has positive insignificant correlation with nutrient except positive significant correlation with nitrate and total phosphorus and negative insignificant correlation with nitrite nitrogen. In tide pools seawater pH has no relation with nutrient except with nitrite nitrogen, organic phosphorus and total phosphorus negative insignificant correlation was found.

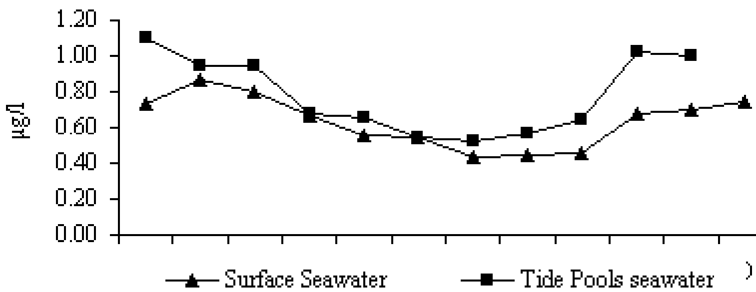

Fig.2. Variation of nitrite nitrogen in seawater.

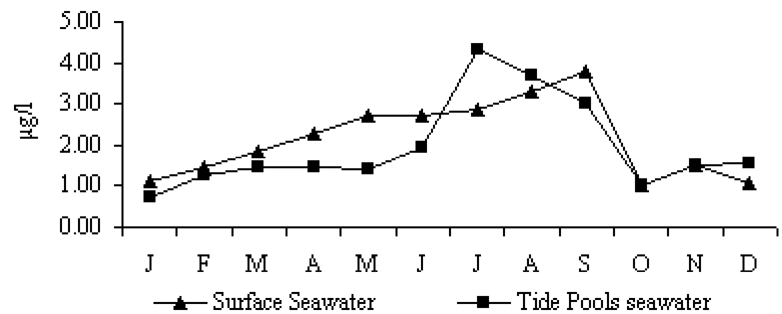

Fig. 3. Variation of nitrate nitrogen in seawater.

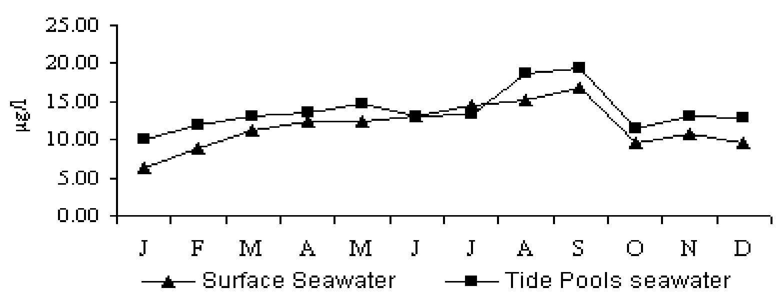

Fig. 4. Variation of ammonia nitrogen in seawater.

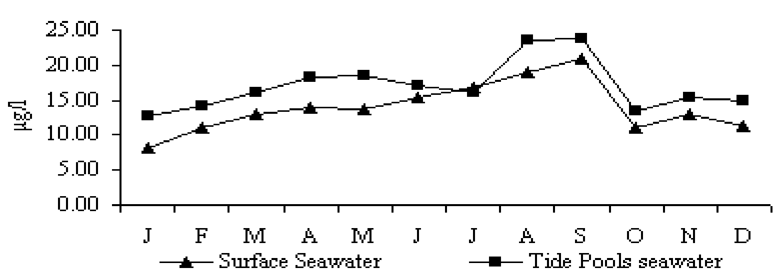

Fig. 5. Variation of total nitrogen in seawater.

The negative insignificant relationship was found in between dissolved oxygen and nutrients except there was no any relation with nitrogen species in surface seawater and inorganic phosphorus in tide pools seawater. Negative insignificant correlation found between biochemical oxygen demand and nutrients in surface seawater except nitrite nitrogen and in tide pools seawater no any relationship found between BOD and nutrients except with ammonia nitrogen insignificant correlation was found. In surface seawater chemical oxygen demand showed no any relation with nutrient species except positive insignificant correlation with inorganic phosphorus and negative insignificant correlation with organic phosphorus. Where as in tide pools seawater chemical oxygen demand showed positive insignificant correlation with nutrient species except NO_2, NO_3 and PO_4.

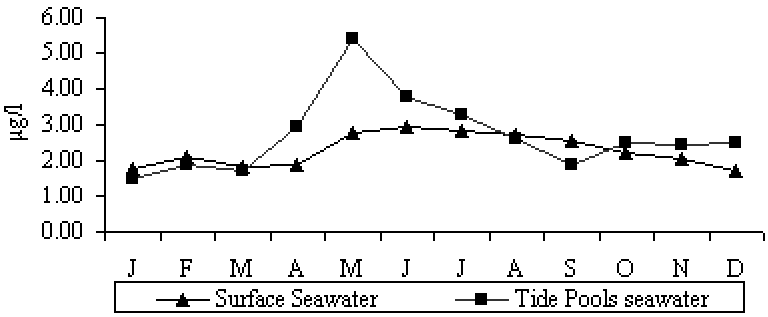

Fig. 6. Variation of inorganic phosphorus in seawater.

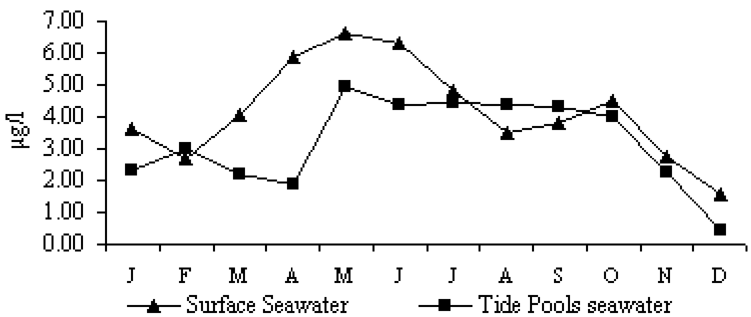

Fig. 7. Variation of organic phosphorus in seawater.

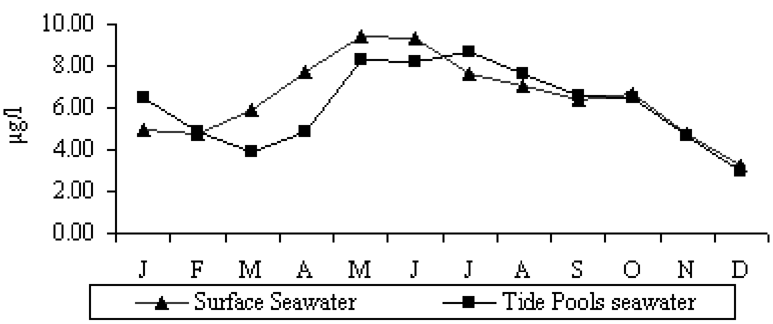

Fig. 8. Variation of total phosphorus in seawater.

The nutrient (nitrite-nitrogen, nitrate nitrogen, ammonia, total nitrogen, inorganic phosphorus, organic phosphorus and total phosphorus) mostly followed the same general trend of low concentration in surface seawater and high concentration in tide pools seawater. This may be attributed to an increase in uptake of microorganisms, great dilution with seawater, higher rate of photosynthesis activity and sewage does not penetrate to surface because of intense mixing (Rao *et al*., 1982; Sen Gupta *et al*., 1975). The enrichment of nutrients in tide pools may be due to microorganisms' die off by solar radiation or evaporation of water resulting in concentration of nutrients.

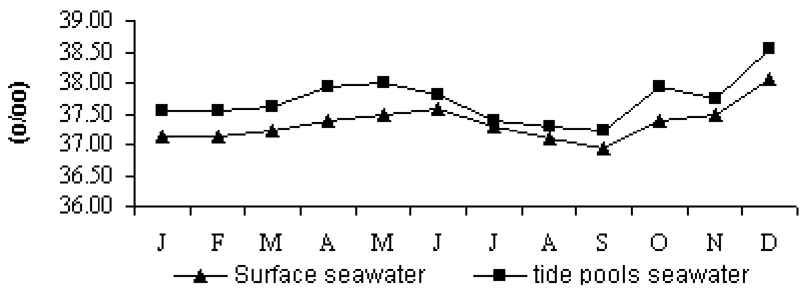

Fig. 9. Variation of salinity in seawater.

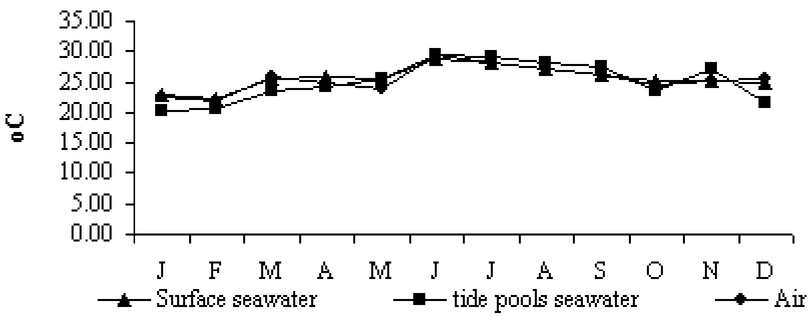

Fig. 10. Variation of temperature in marine environment.

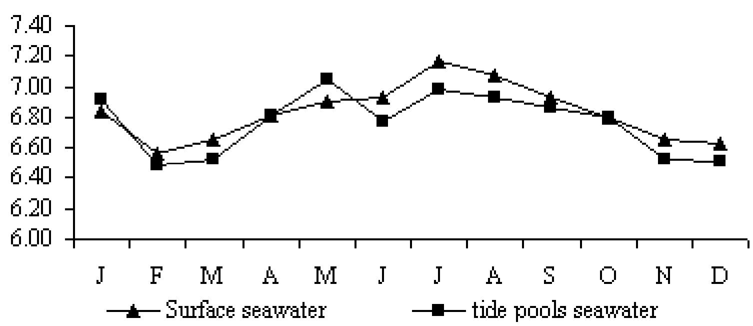

Fig. 11. Variation of pH in seawater.

The concentration of nitrite and nitrate nitrogen were high in present study as compared to the concentrations studied for the Bay of Navarin, Greece (Satsmadjis *et al*., 1985) and Western Saronikos Gulf (Friligos, 1983), Euboikos Gulf (West Aegean) (Friligos, 1985). The present results for NO2-N and NO_3-N were comparable with results obtained from Karachi harbour (Khan and Saleem, 1988), Bakran and Gharo creeks (Rizvi *et al*., 1988) and for estuary of Karachi coast (Saleem and Rahim, 1995). There was seasonal trend of nitrate found in tide pools i.e., generally increased during summer and decreased during winter The opposite situation was found in different seawaters of the world like seawater off Plymouth (Armstrong and Butler, 1963), Western Saronikos Gulf (Friligos, 1983), and Adriatic sea (Vukadin, 1991). The concentration of total nitrogen gave high results as compare to Bay of Navarin, Greece (Satsmadjis *et al*., 1985).

The inorganic phosphate concentrations were high in summer that is, due to upwelling (Ganapati *et al*., 1956) that brings up the higher concentration of nutrients to shallow depth where the primary producers utilize it. The concentrations of inorganic phosphorus were same and comparable with Piran submarine sewage outfall, North

Adriatic (Faganeli, 1982), the Gulf of Aden (Khan, 1976,1977), and shelf waters off Waltair (Ganapati *et al*., 1956). The concentration of phosphate phosphorus was lower when compared with previous study for Karachi harbour (Khan and Saleem, 1988). However the concentrations of inorganic phosphorus were comparable with the water of Bakran and Gharo creeks of Karachi (Rizvi *et al*., 1988).

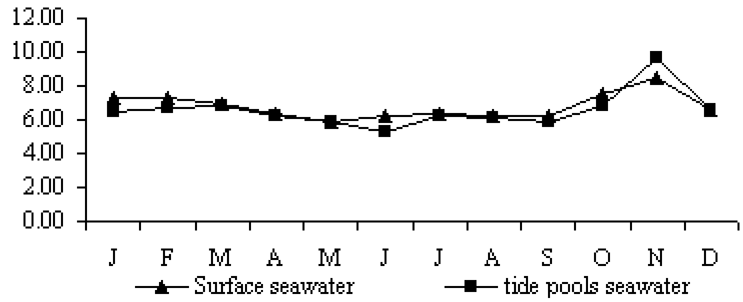

Fig. 12. Variation of dissolved oxygen in seawater.

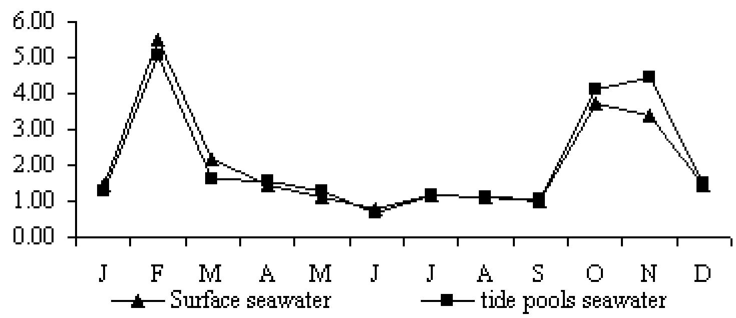

Fig. 13. Variation of biological oxygen demand in seawater.

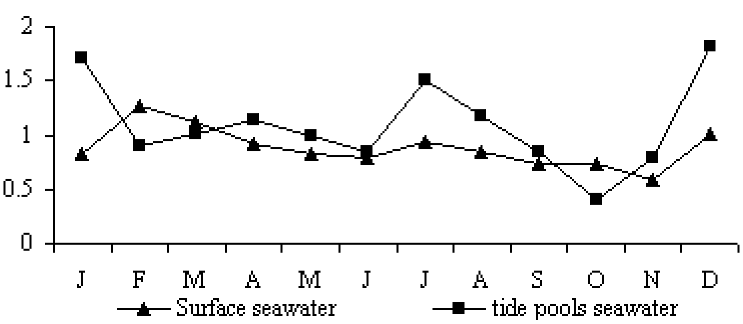

Fig. 14. Variation of chemical oxygen demand in seawater.

The results of temperature showed peak summer (May to August) and minimum winter (December to February) like Nathia Gali coast (Qari and Siddiqui, 2006), Cape Peninsula, South Africa (McQuaid, 1985) and in Bay of Bengal (Mitra *et al*., 1990). The pH values at surface seawater and tide pools seawater were relatively constant and no seasonal trend was evident. The results of pH agree with previous work of Qari and Siddiqui (2006), Hussein and Samad (1995) Khan and Saleem (1988), Rizvi *et al*. (1988), and Rao *et al.* (1982) done for coastal water of Nathia Gali, Sandspit Karachi harbour, Bakran Creek, and Madras respectively. The salinity was high in winter season (November to February) and it was low in rainy season (July-September) (Qari and Siddiqui, 2006; Hussein *et al.*, 1988). The reason of high salinity was more evaporation and low salinity due to large amount of fresh water discharge. Arabian seawater in general can be characterized by a relatively low content of dissolved oxygen. This is observed especially in the Northern part of the Arabian Sea (Khan, 1976/1977).

The quality of water with respect to nutrients in seawater along Karachi coast, examined were likely contaminated by different sources of pollution i.e., untreated industrial, domestic, sewage waste as well as mixing. The influx of discharge effluents increase most of the pollutant because these effluent are mostly in the form of total dissolved solids (131,000 metric tons), organic matter (16,000 metric tons), fixed nitrogen (800 tons) and phosphate (900 tons) (Beg *et al.*, 1975). The concentration of nitrite and nitrates likely increase due to the production of ammonium sulfate (17,200 tons per year) discharged by the Steel Mill (Rizvi *et al*., 1988). The high concentrations of nitrogen species (NO_2, NO_3, and NH_3) were due to land runoff (Rao and Indusekhar, 1989), precipitation and fixation of nitrogen by blue green algae (Vukadin, 1991).

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