Proc. Symp. Mar. Chem. in the Arab Region, Suez., April, 1991 : 207 - 228

Water Quality At Different Locations In Bahrain Coast

By

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Abstract

Considering the importance of oceanographic conditions, and because of the lack of such information about Bahrain waters the study was conducted during the period between January and December 1983 to determine the distributions of temperature, salinity, pH, phosphate, ammonia, nitrite and nitrate at different locations in Bahrain water.

From the study, it could be said that in general water quality of the western and northern regions of Bahrain is better than the water quality of the eastern region. The east has, in general, higher pH, higher ammonia, nitrite, and phosphate levels than those in the other regions, reflects the urbanisation and industrialisation of this part of Bahrain, and the consequent discharges of waste material.

1 - Introduction

Bahrian (Fig. 1) is located in the Arabian Gulf at longitudes 50° 22` 45" - 50° 49` 45" N and latitudes 25° 32` 20" - 26° 17` 10" E, it is an archipelago of more than 33 islands. Bahrain island is the biggest, it measures 48 by 16 km. It is approximately 15 miles off the east coast of the Arabian peninsula, 150 miles west of the coast of Persia and 18 miles north-west the coast of the Qatar peninsula.

The western region of Bahrain is characterized by the presence of three islands Umm Nassan, Umm Sabban and Jeddah. There is an oil pipeline coming from Saudi Arabia. Down south is the newly constructed Saudi Arabia-Bahrain causeway. The northern extremity of this region called Budia has recently experienced etensive dredging and reclamation operations. The western region does not have any noticeable live-coral reefs nearer the shores or islands.

The northern region is more of open sea with the main watermass of the Gulf facing it on the north. This region has a major settlement of Bahrain on its coastline. The inshore waters are shallow for a considerable distance seawards and the intertidal and sub-tidal areas are studded with barrier traps (hadrahs). On the eastern side of this region there is a large island called Muharreq. This region is an important fishing area.

The eastern region especially its northern part is the most heavily industrialized area in Bahrain. It has majority of industries including an oil refinery, metal smelters, cement factory, sand washing and sewage treatment plants. Also there are several

raw sewage outfalls situated on this side. The port Mina Sulman and oil terminal of Sitra are also situated there. On this side there are two islands viz., Nabeeh Saleh and Sitra. West of these islands there is Tubli Bay, an etensive semi-enclosed sea area. There are some patches of mangroves and marshes distributed along this side refering to its high fertility. The northern part of the eastern region faces the famous big coral reef Fasht* Al-Adhum and seagrass beds. This side however is considered very important from fisheries point of view.

Due to the shape of Bahrain, the eastern and western sides of Bahrain meet at the south at a point of Ras Al-Bar.

The shallow marine habitats, or biotopes, of great significance around the Bahrain are as follows:

(a) Intertidal areas including mud-flats, sand flats and tidal creeks.

(b) Soft, sub-tidal sea-bed.

(c) Sea grass beds.

(d) Coral reefs.

Despite the relatively high levels of productivity in the Gulf and its valuable fishery resources, the water is not as rich in phytoplankton or zooplankton as one might expect. For example chlorophyll concentrations in the water cloumn are low (0.49 to 1.28* mg/cu.m) but this in contrasts with the level in the sediments which may reach as much as 236 mg/cu.m. thus emphasizing the importance of benthic productivity. This is further underlined by the presence of huge tracts of seagrasses (**Halophila ovalis** and **Halodule uninervis**) and benthic algae, sites of primary production which are key factors in the existence of several important species (Vine, 1986).

2 - Materials and Methods

Seventeen sampling stations were distributed all around Bahrain coast except the coast of the southern tip because it is a prohibited area. The position of the chosen stations are shown in Fig. 1. Surface water samples were collected during the period between January and December 1983 at forthnightly intervals. The parameters studied were atmospheric and water temperatures, salinity (total dissolved solids), pH, ammonia, nitrite, nitrate and phosphate.

The last four parameters were determined in the water samples according to Strickland and Parsons, 1972. The colour of the solutions were measured using Pye Unicam UV - Visible Spectrophotometer (SP600).

The temperature was measured immediately after the collection of water samples using THL-490-030W general purpose thermometer (-10 to 110X1 °C).

Total dissolved solids of water samples were determined using an Automatic Temperature Compensated Hand Refractometer Model 110419.

* Coral reefs or offshore banks are locaiiy Known as "Fasht" while the deeper ones are caiied "Hayer"

pH value was determined with a portable Digital pH/Millivolt meter (GLI Model 819).

3 - Results and Discussion

3.1 - Temperature

Monthly mean atmospheric and water temperatures are shown in Tables (1) and (2) respectively. Table (1) shows that monthly mean atmospheric temperature ranged between minimum of 15.5 °C at station 5 (Portugese Fort) during February and maximum of 35.5°C at station 9 (Hidd, ASRY causeway) during August. Generally, all the stations follow the same pattern.

Table (2) shows that monthly mean water temperature ranged from 14.0°C at station 5 (Portugese Fort) during February to 30.5°C at the same station during July.

The overall maximum encountered monthly average atmospheric temperature (Fig. 2) was 34.4°C in July, while the minimum encountered in February (18.1°C), a difference of 16.3°C. The maximum calculated overall monthly mean water temperature was 29.2°C during August, while the minimum (16.1°C) during February, a difference of 13.1°C (Fig. 2). It is noticed from Fig. 3 that water temperatures were always lower than that of atmospheric temperatures by an average of 3.8°C with a similar trend of high in summer and low in winter. The difference between atmospheric and water temperature during summer is higher than during winter.

Monthly mean atmospheric and water temperature increased steadily from its minimum in February until it reached its maximum in July in the case of atmospheric temperature or in August in the case of water temperature and then decreased till December.

3.2 - Salinity:

Dissolved matter or total dissolved solids, sometimes referred to as salinity, is shown in Table (3).

This Table shows that monthly means salinity fluctuated between 27.8‰. (Station 14, Ras Tubli) to 57.0‰. (Station. 3, Jasra), a difference of 29.2‰.

The local mean of all the months [Fig. (3)] shows that the maximum observed salinity was 54.6‰ at both Al-Zallaq (Station 2) and Jasra (Station 3), while the minimum is 39.3‰ at station 14, Ras Tubli because it is opposite to Tubli sewage treatment plant which discharge about 80,000 m^3 / day of treated sewage, followed by station 13, Nabeeh Saleh (41.9‰) because it is near to station 14 which means that it is affected by the sewage effluent. At Arad (Station 10), the monthly mean salinity (44.3‰) is slightly higher than the other adjacent northern stations (Fig. 3). The probable cause for this is that Arad Bay is a large shallow water Bay with a maimum depth of about one meter during the low tide. The Bay is connected to the main water by a narrow entrance of ca. 10m wide which allows water exchange during tidal movement.

In general, within the study area salinities of the western coast are the highest, followed by those of the northern and the eastern coasts respectively. This conclusion is

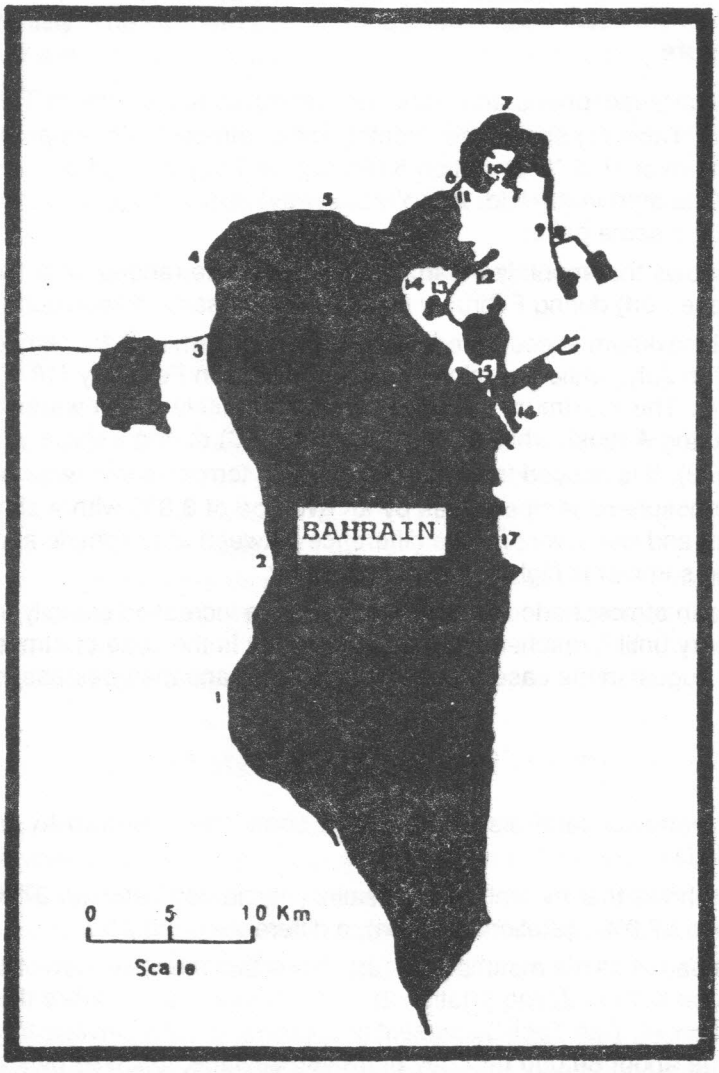

Figure (1)

Water sampling stations.

supported by an earlier study during 1978 by the same author (Al-Alawi, 1983). This might be because the eastern coast facing the entrance of the Gulf, the Strait of Hormuz which opens to the Gulf of Oman and the Indian Ocean, while the western coast faces the closed side of the Gulf. The probable cause for the low salinity in the northern coast is the presence of open water mass of the main body of the Arabian Gulf and fresh water springs, industrial and sewage outfalls along the north eastern coastline. There are many submarine springs around the Island of Bahrain. In the north east of the island there are more than twenty one submarine springs not far from the coast. Others are known further out to sea and it is not impossible that there are still others at present unknown which could be discovered later. The salinity of various springs range from 0.90 to 1.4 ‰ (Anon., 1969).

The highest encountered salinity was at the southern coast because it is the most enclosed one, it reached up to more than 65‰.

It is found that salinity in summer is somewhat higher than in autumn and winter (Table 3).

3.3 - pH

During the study period, it was found that pH ranged from 7.50 (station 5, Portugese Fort) during November to 8.51 (station 7, Ras Rayyah) during February, a difference of 1.01.

Monthly mean pH within the stations for the entire period of study (Table 4) indicate that Ras Tubli (station 14) has the lowest mean pH (7.88), probably because of the effect of the sewage discharge while Ras Rayyah (station 7) has the highest mean pH (8.20) followed by station 8, Hidd, east Asry causeway (8.16) and then station 9, Hidd, opposite the cement factory (8.12).

It was noticed that pH of the diluted sea water with fresh water from sewage discharge and fresh water springs is less than that of the sea water.

In general the western coast has lower pH than the eastern and northern coasts. The probable cause for this is the industrial discharge, dredging and land reclamation activities along the north-eastern coastline.

Within the months, the maximum encountered overall average pH (Fig. 4) was 8.25 during March and the minimum was 7.83 during December.

3.4 - Nutrients:

3.4.1 - Nitrogen

(i) Ammonia

During the study period, it was noticed that ammonia nitrogen exhibited the highest monthly average value of 739.0 ug/1 in September at station 17 (Asker) and the lowest value of 1.1 ug/1 in January at station 7 (Ras Rayyah). The overall maximum observed ammonia was 144.1 ug/1 during September, while the minimum (15.6 ug/1) during January (Table 5).

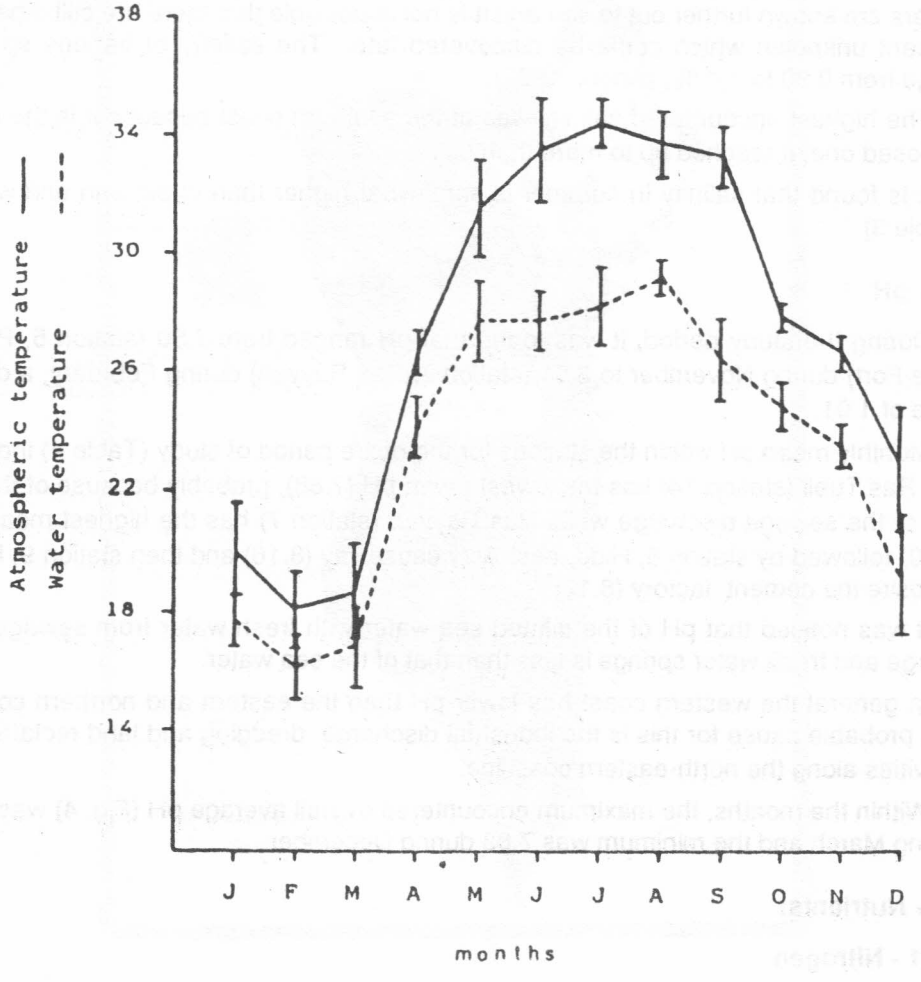

Figure (2)

Monthly mean atmospheric and water temperature over the year 1983 for the stations. The bars represent the standard deviation.

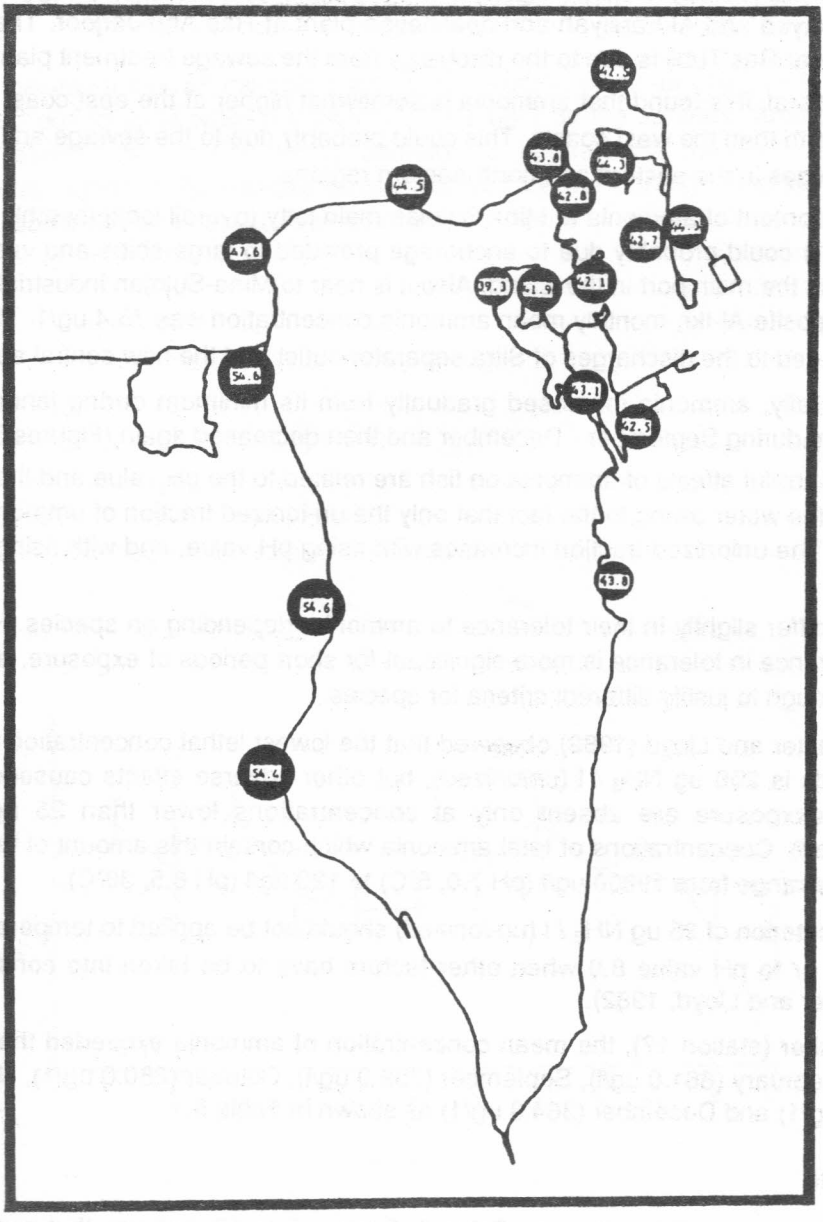

Figure (3)

Distribution of salinity, based on average readings over the year 1983

The highest encountered overall local monthly mean ammonia was at Asker (249.6 ug/l) followed by Ras Tubli (109.0 ug/l). Although Asker is an open sea area but it experiences a southerly drift coming from BAPCO refinery, untreated sewage outfalls at Ras Zuwayed and Al-Farsiyah and dealination plant at Ras Abu-Jarjoor. The highest ammonia at Ras Tubli is due to the discharge from the sewage treatment plant.

In general, it is found that ammonia is somewhat higher at the east coast followed by the north then the west coasts. This could probably due to the sewage and industrial discharges in the eastern and north-eastern regions.

High content of ammonia at Mina Sulman main jetty (overall local monthly mean of 77.2 ug/1) could probably due to anchorage provided to large ships and vessels because it is the main port in the island. Also it is near to Mina-Sulman industrial area. At Sitra, opposite Al-Ikr, monthly mean ammonia concentration was 75.4 ug/1. This might be attributed to the discharges of Sitra separator outlet and the new central abattoir.

Generally, ammonia increased gradually from its minimum during january to its maximum during September - December and then decreased again (Figures 5 to 13).

The harmful effects of ammonia on fish are related to the pH value and the temperature of the water owing to the fact that only the un-ionized fraction of ammonia is poisonous. The unionized fraction increases with rising pH value, and with rising temperature.

Fish differ slightly in their tolerance to ammonia, depending on species. However, the difference in tolerance is more significant for short periods of exposure, and is not great enough to justify different criteria for species.

Alabaster and Lloyd (1982) observed that the lowest lethal concentration found for salmonids is 200 ug NH_3 / l (unionized), but other adverse effects causedd by prolonged exxposure are absent only at concentrations lower than 25 ug NH_3 / l (unionized). Concentrations of total ammonia which contain this amount of un-ionized ammonia range from 19600 ug/l (pH 7.0, 5°C) to 120 ug/l (pH 8.5, 30°C).

The criterion of 25 ug NH_3 / l (un-ionized) should not be applied to temperatures below 5°C or to pH value 8.0 when other factors have to be taken into consideration (Alabaster and Lloyd, 1982).

At Asker (station 17), the mean concentration of ammonia exceeded the criterion during February (661.0 ug/l), September (739.0 ug/l), October (280.0 ug/1), November (360.9 ug/1) and December (364.9 ug/1) as shown in Table 5.

(II) Nitrite

Monthly mean nitrite-nitrogen, Table 6. Figures 5 to 13, indicate that nearly all nitrite curves follow the same pattern. It was noticed during the study period that within nitrogen and phosphorus salts, nitrite-nitrogen has the lowest concentraion at all the stations (Figures 5 to 13). This is because nitrite ion occurs generally in seawater at low concentration as intermediates in oxidation of ammonia ions (nitrification process).

Its concentration ranged from 1.4 ug/l during January at station 2 (Zallaq), station 6 (North the Muharreq causeway) and station 11 (South the Muharreq causeway) to 36.9 ug/l during February at station 15 (Sitra, opposite Al-Ikr), a difference of 35.5 ug/l (Table 6).

The maximum overall monthly mean concentration of nitrite (10.1 ug/l) was encountered during June while the minimum (3.1 ug/l) during January. Ammonia also has the lowest concentration during January. It appears that the trend of nitrite is some what higher in the eastern coast, followed by the northern and the western coasts respectively as in the case of ammonia.

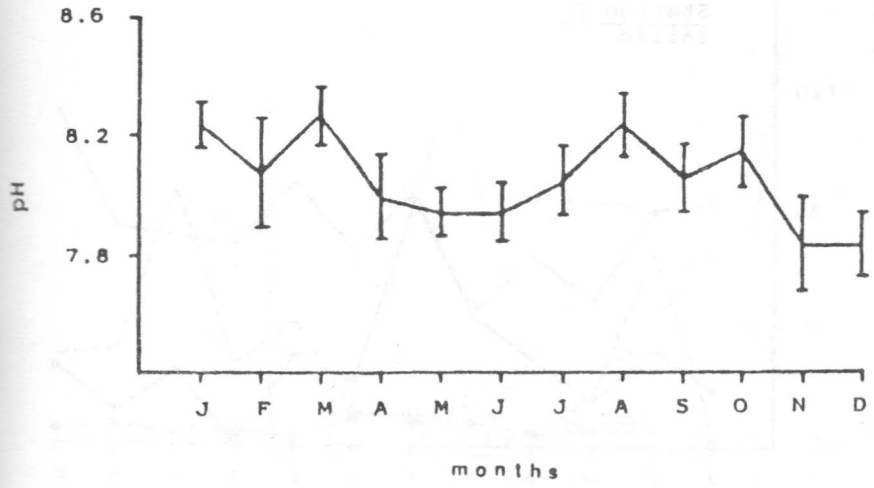

Figure (4)

Monthly mean pH over the year 1983 for the 17 stations.
The bars represent the standard deviation

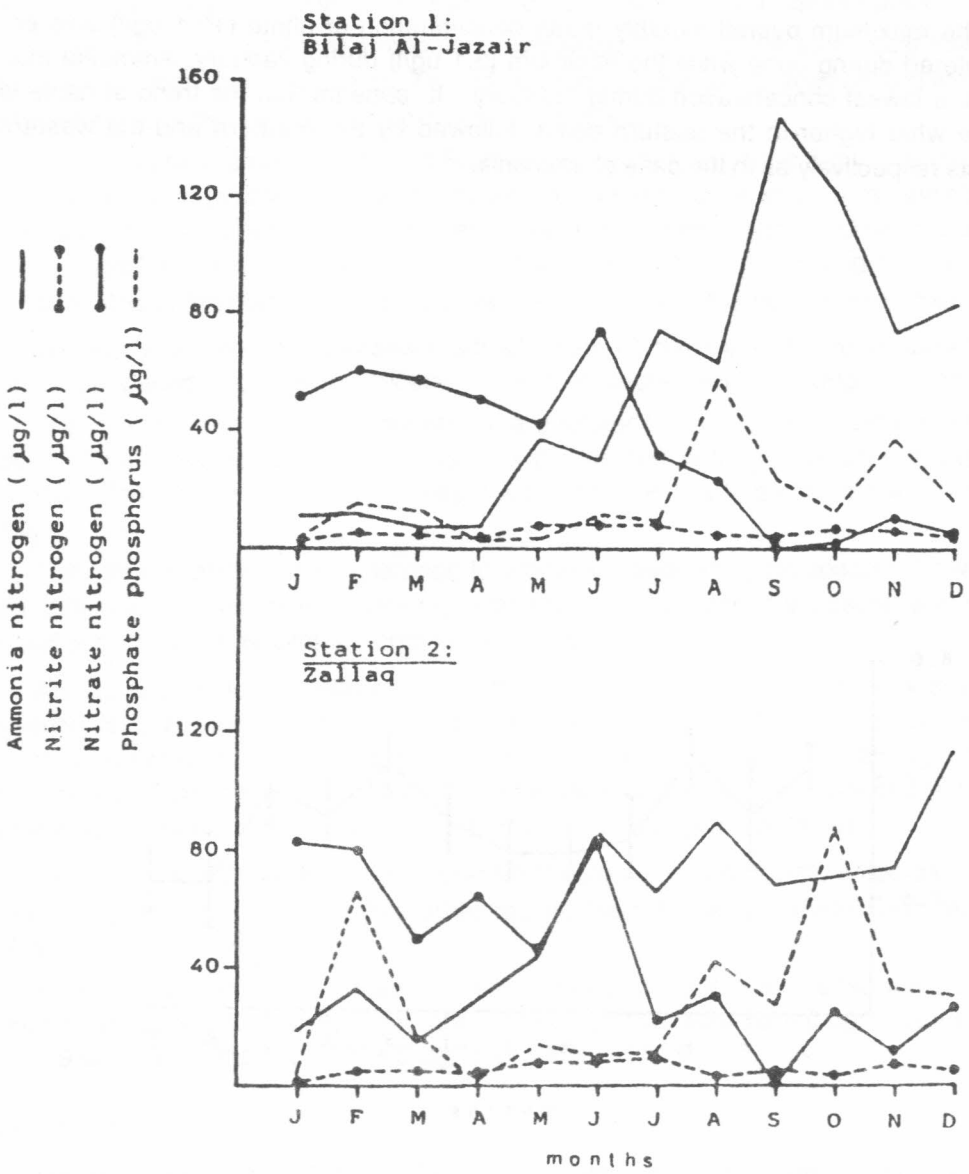

Figure (5)

Monthly mean ammonia nitrogen, nitrite nitrogen, nitrate nitrogen and phosphate phosphorus for stations 1 and 2

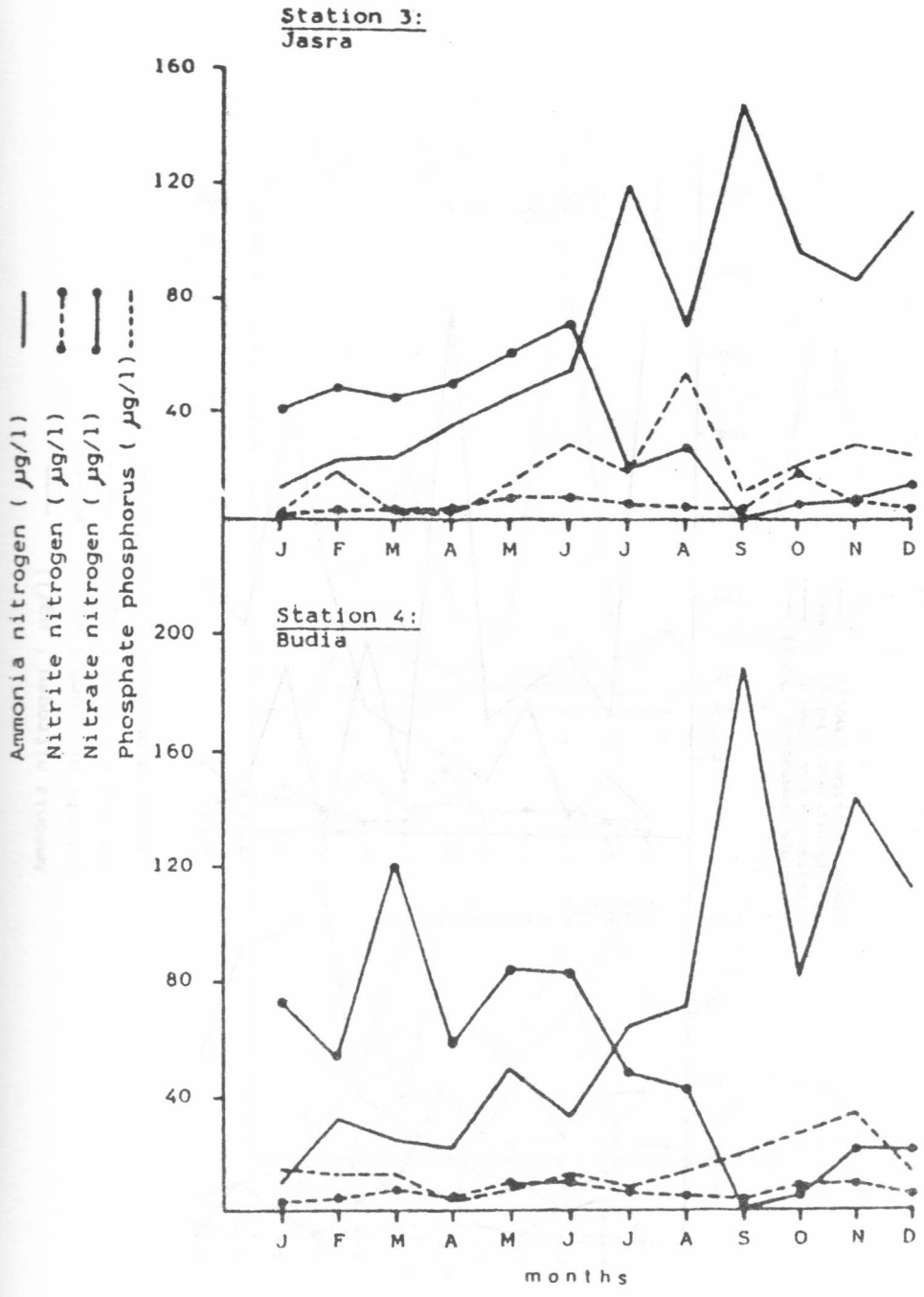

Figure (6)

Monthly mean ammonia nitrogen, nitrite nitrogen, nitrate nitrogen and phosphate phosphorus for stations 3 and 4

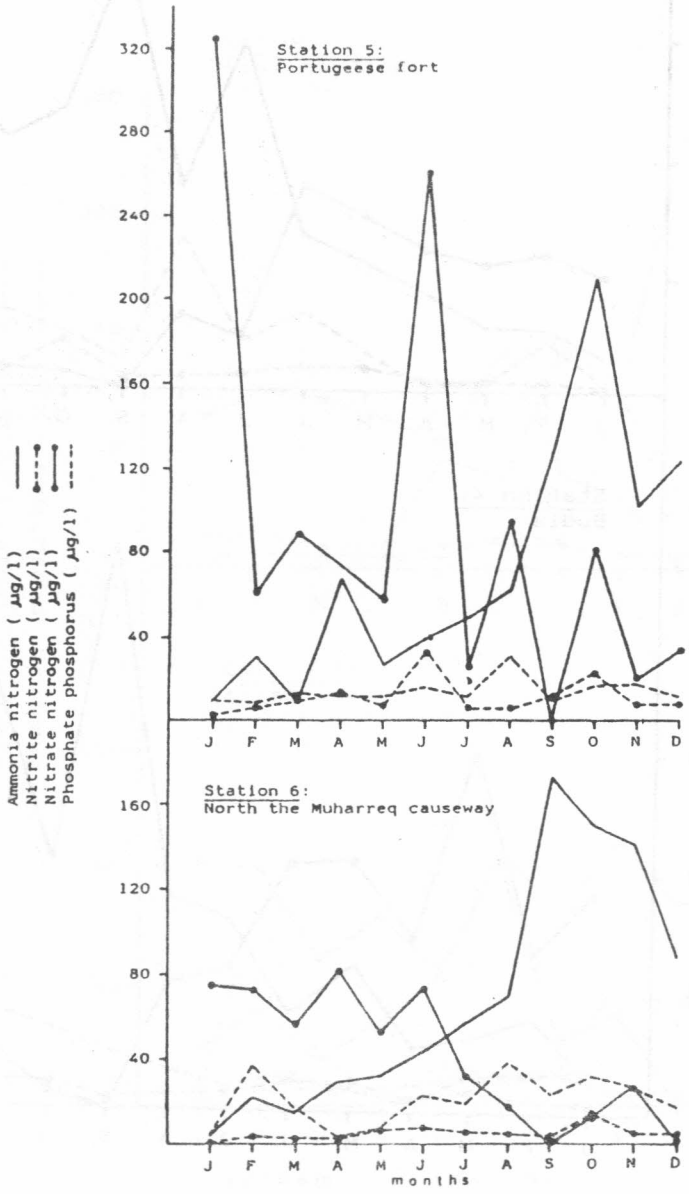

Figure (7)

Monthly mean ammonia nitrogen, nitrite nitrogen, nitrate nitrogen and phosphate phosphorus for stations 5 and 6

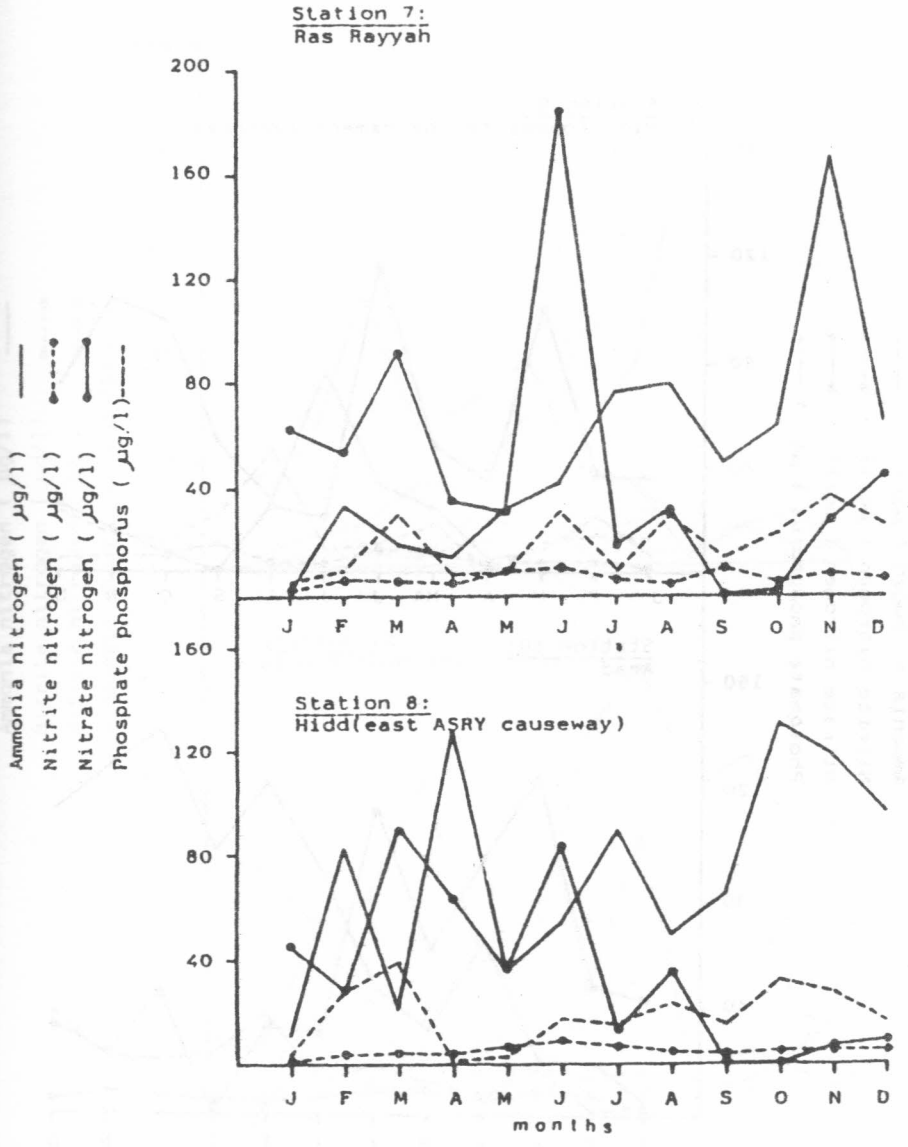

Figure (8)

Monthly mean ammonia nitrogen, nitrite nitrogen, nitrate nitrogen and phosphate phosphorus for stations 7 and 8

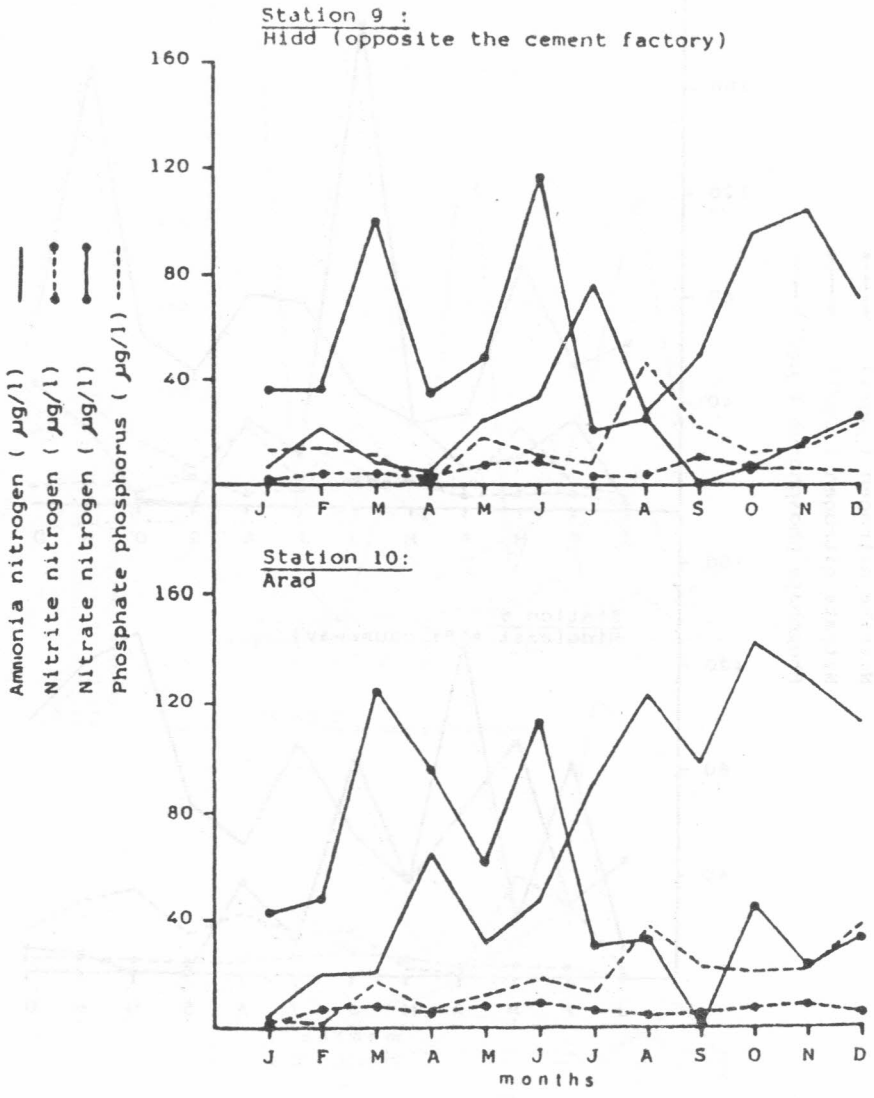

Figure (9)

Monthly mean ammonia nitrogen, nitrite nitrogen, nitrate nitrogen and phosphate phosphorus for stations 9 and 10

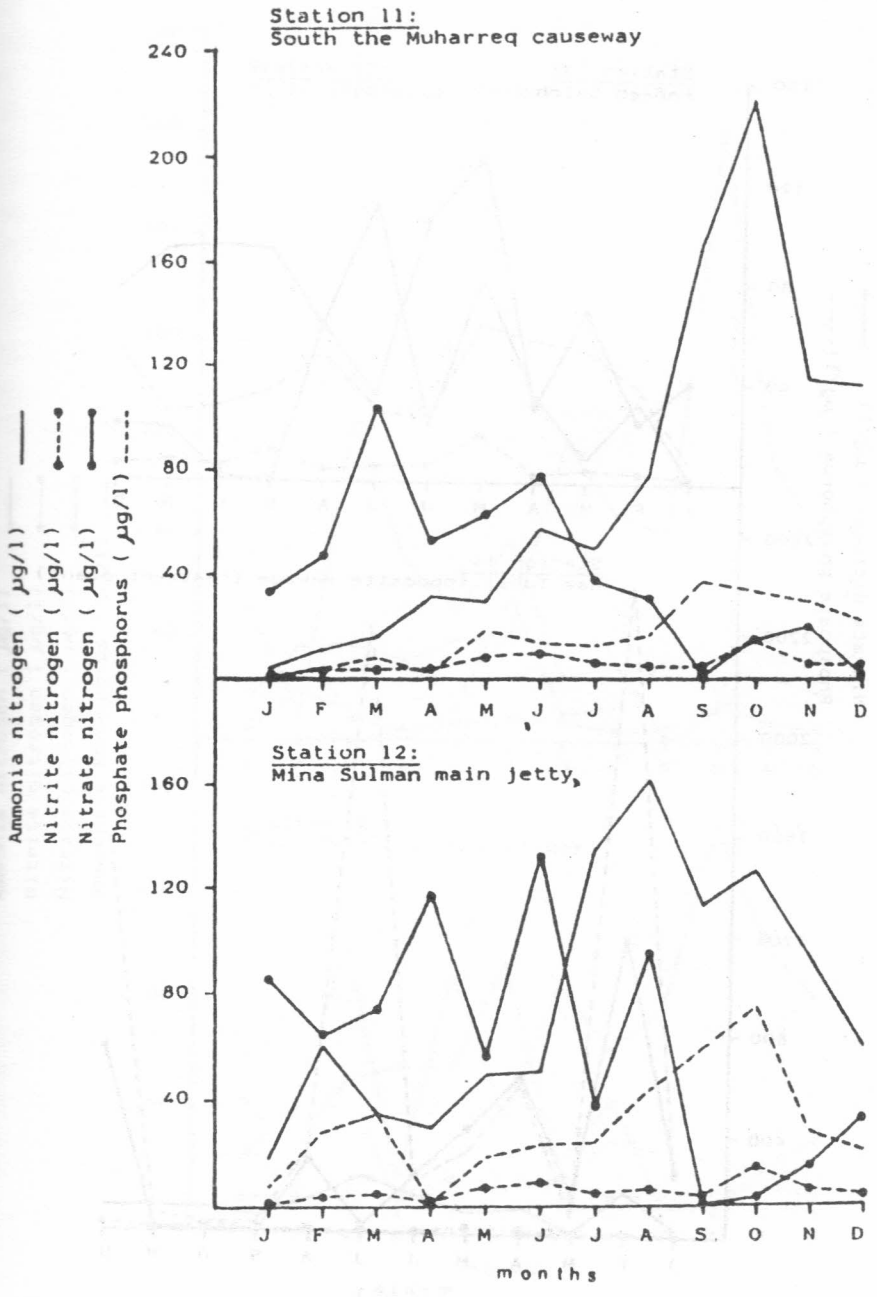

Figure (10)

Monthly mean ammonia nitrogen, nitrite nitrogen, nitrate nitrogen and phosphate phosphorus for stations 11 and 12

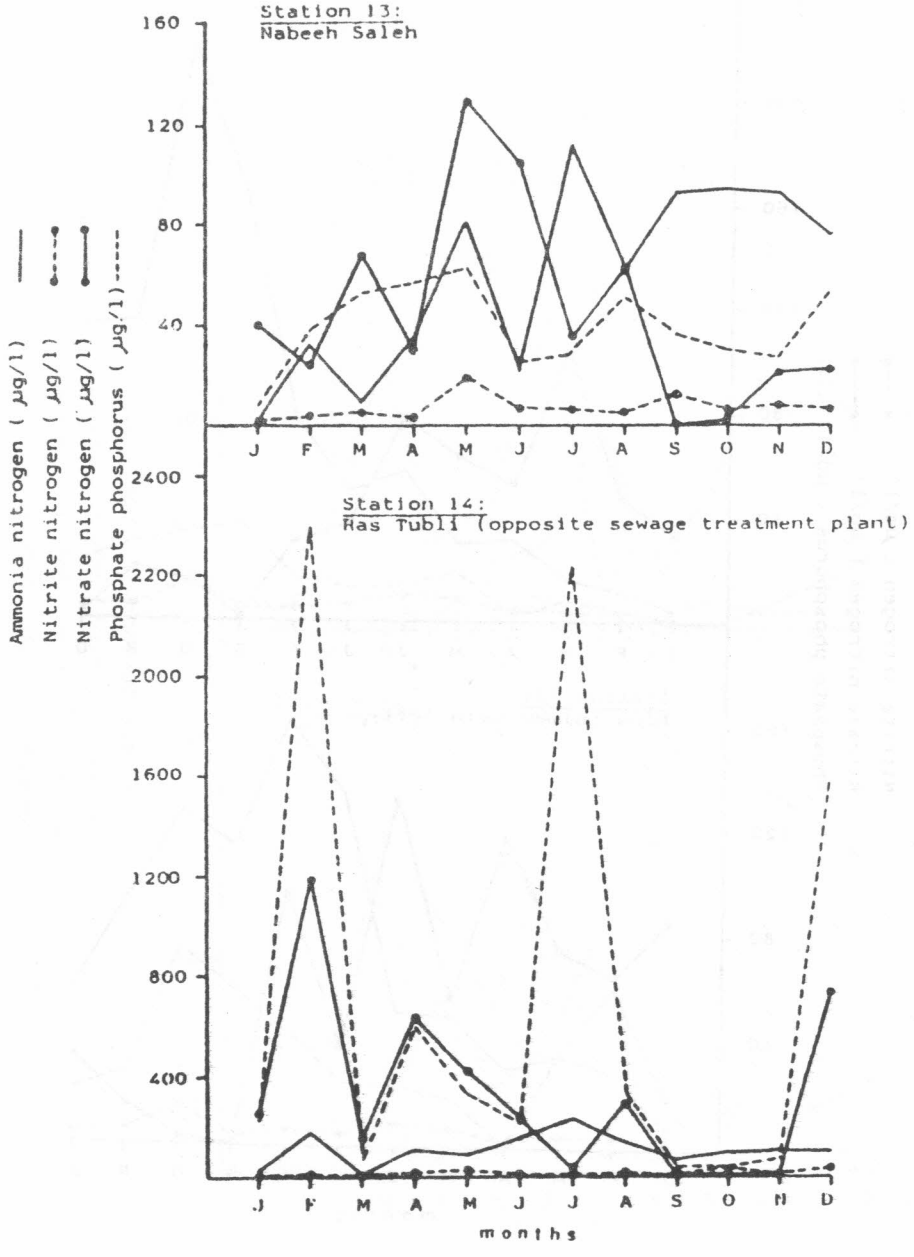

Figure (11)

Monthly mean ammonia nitrogen, nitrite nitrogen, nitrate nitrogen and phosphate phosphorus for stations 13 and 14

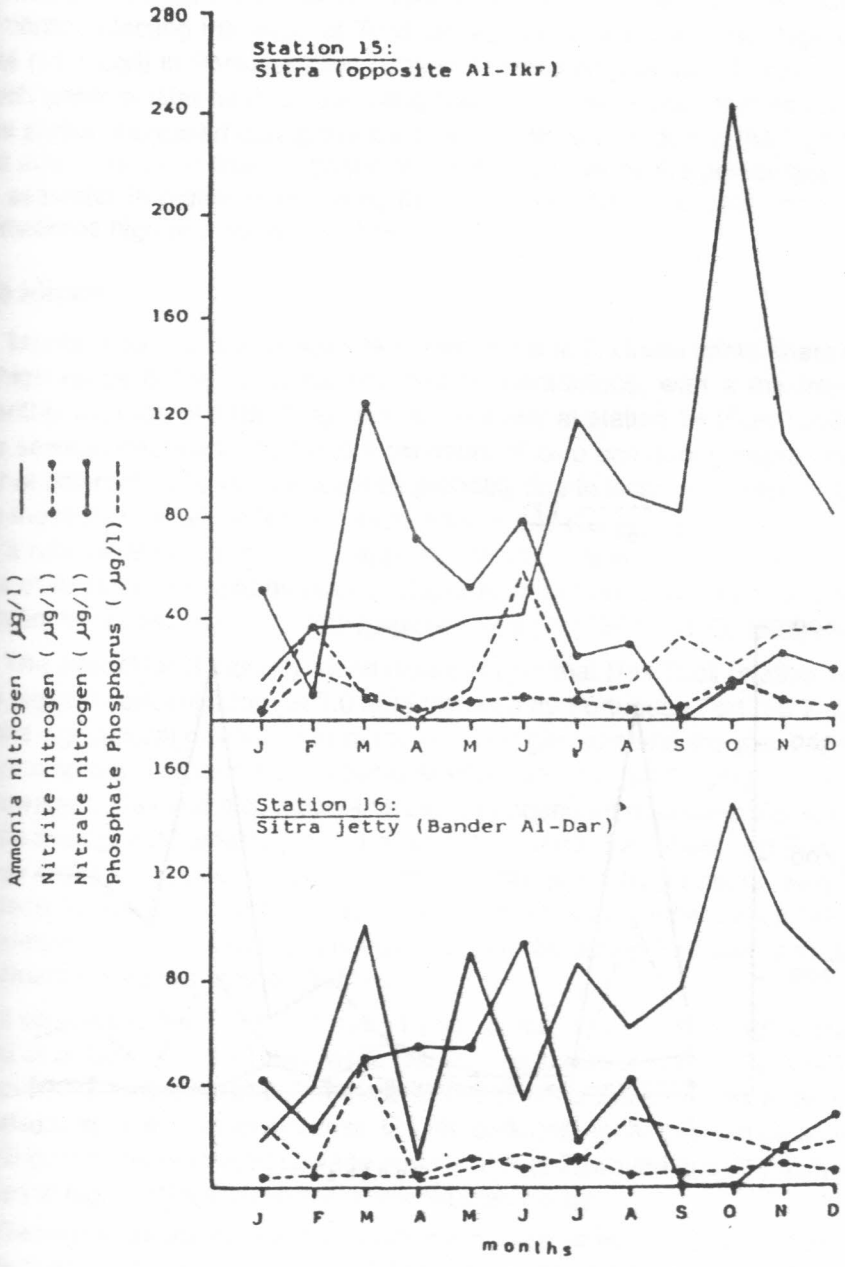

Figure (12)

Monthly mean ammonia nitrogen, nitrite nitrogen, nitrate nitrogen and phosphate phosphorus for stations 15 and 16

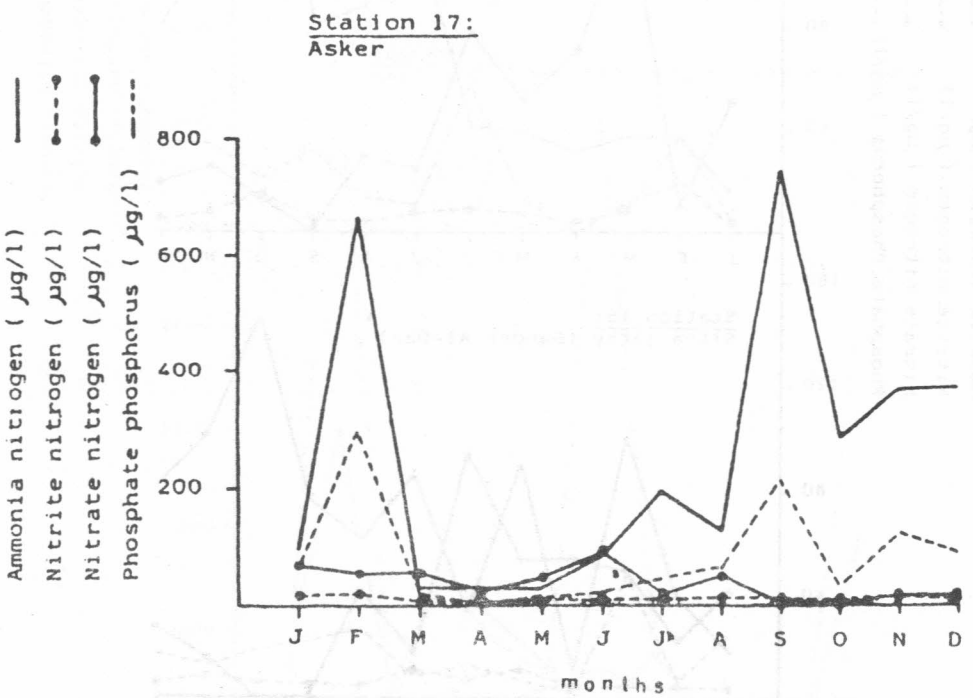

Figure (13)

Monthly mean ammonia nitrogen, nitrite nitrogen, nitrate nitrogen and phosphate phosphorus for stations 17

Station 14 (Ras Tubli) has the highest local monthly mean concentration (14.0 ug/l) of nitrite reflecting the effect of Tubli sewage treatment plant. The high content of nitrite (11.1 ug/l) in Portugese fort (station 5) could be probably due to the presence of fresh water aquifer near the sampling station. It was noticed that its concentration at this station increased during the low tide and decreased during the high tide because the aquifer became more exposed at low tide and hence the percentage of freshwater to seawater is higher than during the high tide. That is why its concentrations are sometimes high and sometimes low.

(iii) Nitrate:

Montly mean nitrate-nitrogen is shown in Table 7. Unlike nitrite, there is somewhat a high range between nitrate nitrogen concentrations, with a maximum observed monthly average of 1188.0 ug/l during February at station 14 (Ras Tubli) because of the sewage treatment plant and a minimum of zero ug/l during September and October at different stations.This could be probably due to increase in plakton biomass during these months which feed on such nutrient and cause depletion in its concentration. As a rule, nitrates are present in appreciable amounts in surface water, except for periods of intensive development of phytoplankton in bodies of water, at which time the content of nitrates may drop to negligible levels (UNESCO/WHO, 1978).

The overall local monthly mean nitrate shows that Ras Tubli (station 14) again has the highest concentration (329.0 ug/l) followed by Portugese Fort (95.7 ug/l) because of the agricultural discharge from the onshore gardens and the presence of the submarine spring. The next station being Arad (station 10) (54.0 ug/l) probably because of a sewage outfall and also it contains algae in abundant quantities. Fishermen from villages throughout Muharreq Island (Dair, Hidd, Qalali, Samaheej and Busaitain) collect these algae for use as bait to catch fish, mainly safee, by gargoors (wire traps). Jasra (station 3) which lies on the west coast has the lowest concentration (32.0 ug/l). The maximum overall monthly mean was encountered during February and June and the minimum during September (Table 7).

It could be noticed from Figures 11 and 13 that nitrate level is higher than ammonia level at station 14 (Ras Tubli), while the reverse is true at station 7 (Asker). This might be because the treatment of sewage at Tubli allows the ammonia to be converted to nitrate during the aeration process. On the contrast, Asker experience a southerly drift coming from the untreated sewage outfalls at Ras-Zuwayed and Al-Farsiyah which resulted in higher concentration of ammonia than nitrate.

Generally, all the nitrate and ammonia curves, in figures 5 to 13, follow the same pattern and show an interesting relationship, since as ammonia increases, nitrate decreases and vice versa.

3.4.2. Phosphate

During the study period, it was noticed that monthly mean phosphate-phosphorus (Table 8) fluctuated between zero N-D at station 11 (South the Muharreq causeway)

during January, station 9 (Hidd, opposite the cement factory) and station 15 (Sitra, opposite Al-Ikr) during April to 2295.0 ug/l at station 14 (Ras Tubli) during February reflecting the effect of the sewage. In general, phosphate concentration in the northern coast remained the lowest in comparison with that of the western and eastern coasts.

the highest recorded local overall monthly mean was at Ras Tubli (667.1 ug/l) due to its proximity to Tubli sewage treatment plant followed by Asker (80.5 ug/l) because of its proximity to Ras Zuwayed and al-Farsiyah sewage outfalls. Ammonia and nitrate were also high at these stations (stations 14 and 17).

The maximum encountered overall monthly mean phosphate was during February (170.8 ug/l) while the minimum (23.2 ug/l) during January (Table 8), but the highest encountered phosphate in most stations was during August.

4. Conclusion

From the study conducted, it could be said that in general the water quality of the western and northern regions of Bahrian is better than the water quality of the eastern region. The east has in general higher pH, ammonia, nitrite and phosphate levels than those in the other regions reflects the urbanization and industrialization of this part of Bahrain, and the consequent discharges of waste material. Within the east the areas most affected are Ras Tubli and Asker which are close to sewage discharges.

The concentration of material liable to cause deterioration shows a fluctuation throughout the year with no consistent annual pattern shown at all station. The fluctuations observed appear to be related to variations in discharge of contaminants from sewage works... etc. The concentration of ammonia seemed to be inversely related to the concentration of nitrate reflecting the known chemical changes in nitrogen cycle in the sea. The results for the latter half of 1983 may show disturbance due to the long distance effect of the Iranian Noroz oil spill which occurred in January 1983.

About 200,000 tonnes of crude oil were released in the Gulf as a result of an explosion in the Iranian Noroz oil field. The spill continued for several months. Large quantities of the spilled oil reached Bahrain coast and the first material from this disaster reached Bahrain later in 1983. The oil spillage from this incidence continued throughout 1983.

UNESCO/WHO, 1978 reported that petroleum and its derivations are a complex and varied mixture of substances composed of various hydrocarbons, numerous oxygen containing compounds, nitrogen, sulphur, as well as high molecular-weight unsaturated heterocyclic compounds whose structure have not accurately been established and which are divided into neutral resins, asphalt acids, and asphaltenes.

Hence, nitrogen compounds which are present in the oil could have caused elevation in these parameters in late 1983 samples.

The results of the present study could be used to study the relationships between the various measured parameters, and the presence and absence of different fish spe-

cies in certain areas and in various seasons. For example, the diversity of fish in Bahrain has been shown to be seasonally variable with a greater diversity in September to December (Abdul-Qader, 1986.Fish landing in the adjacent state of U.A.E. was studied by Ali and Cherian (1983) in relation to water temperature. A temperature oriented landing was observed in some of the common species. Queen fish, snapper and scad recorded the maximum percentage of landing (>70%) during May to October (warm water period) whereas major percentage (>70%) of landings of sardines, mackerel and king fish was during low temperature period (December - March). A more elaborate study is required to draw authentic conclusions regarding the relationships between the catch composition and prevailing water temperature of the region.

The Abundance of shrimps appear to be related to salinity with more Juveniles shrimps found in low salinity areas.

References

ABDUL-QADER, E.A.A. (1986). Study of bycatch generated by shrimp trawling in Bahrain water. M. Sc. thesis. University College of North Wales.

ALABASTER, J.S. and LLOYD, R. (1982). Water quality criteria for fresh water fish. Butterworths.

AL-ALAWI, Z.S. (1983). Some oceanographic observations in Bahrain waters during 1976 - 1980. Technical Circular No. 20. State of Bahrain. Ministry of Commerce and Agriculture. Directorate of fisheries.

ALI, R.M. and CHERIAN, T. (1983). Environmental conditions of the coastal waters of the United Arab Emirates during 1982. Ministry of Agriculture and Fisheries. Department of Fisheries. U.A.E.

ANONYMOUS (1969). Mission report. Government of Bahrain.

HARVEY, H.W. (1955). The chemistry and fertility of sea waters, 224 pp. Cambridge University Press, london.

LAEVASTU, T. and HAYES, M.L. (1981). Fisheries oceanography and ecology. ISBN 085238 1174. Fishing News books Ltd. Fanham. Surrey England.

STRICKLAND, J.D.H and PARSONS, T.R. (1972). A practical handbook of sea water analysis. Bull. Res. Bb. Can. (167). 310 pp.

TRANTER, D.J. and NEWELL, B.s. (1983). Deep Sea Res. 10,1.

UNESCO/WHO (1978). Water quality surveys. A guide for the collection and interpretation of water quality data. Studies and reports in hydrology 23. Paris, UNESCO; Geneva, WHO. (ISBN 92-3-101473-0).