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Seasonal changes in the water quality of Ibeno coastline, S. E. Nigeria.

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ABSTRACT - The levels and concentrations of physicochemical parameters, nutrients and total hydrocarbons in surface and interstitial waters along Ibeno Atlantic coastline in dry and wet seasons were studied. The results show that the waters were moderately acidic to alkaline in nature having a mean pH of 5.65-8.35 during the period. The coastline was acidic in the dry season and alkaline in the wet season. The amounts of dissolved oxygen measured showed mean concentrations in the ranges of 3.04-5.9 mg/l in the dry and 0.98-5.11 mg/l for the wet season. BOD_5 values were low during the season (1.1-1.4mg/l and 0.4-3.0 mg/l respectively). The variations in water temperature (24.7-29.3 C) were within the normal range for tropical waters.The organoleptic parameters (turbidity and colour) were generally high, 24.8-252.6 (FTU) for the dry season and 152.1-433.9 (Pt. Co. unit) for the wet season. Nutrients (PO_4, NH_4, NO_3 and SiO_2) were observed to be higher in dry season than wet season. Marked total hydrocarbon (THC) levels were measured in interstitial than surface waters in both dry and wet seasons. Values varied from 1.30 mg/l in the surface water (wet season) to 25.56 mg/l in the interstitial waters (dry season). The observed THC values for interstitial waters were higher than Department of Petroleum Resources (DPR) recommended limit (20 mg/l) for coastal waters.

Key words: Seasonal Changes, Surface water, Interstitial water, physicochemical parameters, THC.

INTRODUCTION:

Coastal areas of the world are known for their high productivity with regards to fishing, transportation, sports and associated maritime activities (Ehlin, 1995). A great and increasing part of the world's population live in these areas and are exposed to uncontrolled dumping and discharge of domestic, municipal and industrial wastes from human activities. The Nigerian coastal zone plays a major role in the economic development of Nigeria. Apart from being a major contributor to the domestic fish supply, it also contributes about 23, 486,000 tons of oil annually to the Nigerian economy (World Resources, 1990). The Nigerian coastline stretches over 800km from Bakassi in the east to Badagry in the west. The Ibeno coastline where the study was carried out covers a distance of about 10 km of the Atlantic Coastline. It lies between Latitude 4°32" and 4°36" N and Longitude 8°00" and 8°16"E. The foreshore is flat and characterised by low gradient and fine grained sand with numerous beach ridges. At the lowest tide, the active beach measures about 130m wide. The beach is rather hard and dewatered and the sediment is composed of micaceous and calcareous minerals (Asuquo et al. 1995).

Reports on the coastal oceanography of Nigerian coastline is very scanty. This Study aimed at assessing the physicochemical characteristics and seasonal variations in the water quality of the Ibeno coastline, Nigeria.

METHODOLOGY:

A total of 84 samples from surface and interstitial waters were collected for chemical analyses. Samples were taken during high, low and slack tides at hourly intervals at an anchor station (Fig 1). Surface samples were collected using plastic buckets and interstitial waters collected from ecological boreholes of maximum depth, approximately 30cm.

Insitu/Field Measurements

Water temperature, pH and dissolved oxygen were measured on site. Dissolved oxygen and water temperature were measured with oxyguard Handy MK II electronic meter (sensitivity +1.0%). BOD_5 was measured after five days of incubation at 27°C as a difference between initial and final DO with Oxyguard meter. pH was measured with WTW LF-90 electronic meter.

Laboratory Analysis.

Water samples for physicochemical analysis were collected in 1-litre polytethylene bottles and stored in cool box at approximately 4°C before analysis in the laboratory within 5 days of collection. Water samples for total hydrocarbons (THC) were collected with 500ml brown glass bottle sealed with aluminium foil until extraction within 5 days of collection. All analyses were carried out in Environmental Laboratory, Institute of Oceanography, University of Calabar. All nutrient samples were filtered at low vacuum through 0.45μm membrane filter.

Physicochemical and Chemical Analysis:

Turbidity and colour were measured spectrophotometrically according to HACH (1990). Nitrate was measured as nitrite after reduction in a copperised cadmium reduction system (Parsons et al, 1984). Ammonium was measured by direct Nesslerization method (Parsons et al, 1984). Phosphate and silicate were measured spectrophotometrically by molybdenum blue method (Parsons et al, 1984). Chemical Oxygen Demand (COD PV TEST) was measured titrimetrically (Rodier, 1975) while total hydrocarbon in water samples were determined by the spectrophotometric method after extraction with n-hexane and subsequent concentration of the extract by evaporation (Rump and Krist, 1988., HACH, 1990).

RESULTS:

The levels and concentrations of the physicochemical parameters, nutrients and THC in the surface and interstitial waters during the dry and wet seasons are presented in Table 1. Figs 2(a) -(i) show the temporal or seasonal variations of the measured parameters. pH showed remarkable variation from acidic to alkaline medium. Fluctuations in DO was normal except for a decreasing trend in the wet season. The coastline was generally marine (salinity >13.0 ppt) except in the wet season (August) where the coastal salinity was influenced by dilutions from land drainage and much precipitation. The organoleptic parameters (turbidity and colour) varied from 39.75 - 252.6 (FTU) and 204.4 - 433.9 (Pt. Co. unit) in the dry season and 24.8 -67.2 (FTU) and 152.1 - 296 (Pt. Co. unit) in the wet season.

PO_4 (0.005 - 0.023mg/l) and SiO_3 (0.34 - 0.86mg/l) levels were low while NH_4 (2.7 -5.2 mg/l) were observed to be high in both dry and wet seasons. NO_3 was low in the wet season (0.19 -2.12 mg/l) and high in the dry season (4.39 - 5.2mg/l). THC levels were higher in interstitial than surface waters in both dry and wet seasons. The measured concentrations were 3.31-25.56 mg/l (dry) and 1.51-1.67 mg/l (wet) in interstitial water and 0.45-0.50 mg/l (dry) and 1.30-2.18 mg/l (wet) in the surface waters.

DISCUSSION:

The coastal zone is a highly dynamic environment due to the close proximity of the water column to the benthos. Pronounced changes in water quality is evident especially when the shoreline receives inflows from fresh water discharge. Adjoining the Ibeno shoreline where the study was carried out are the Cross River estuary to the east and Qua Iboe River estuary to the west (Fig. 1). Fresh water discharge (inland drainage) from these estuaries contribute immensely to the observed changes in water quality. During this study, the pH values showed moderate acidity (5.65-6.7) in the dry season and neutral to alkaline (7.2 -8.35) in the wet season. The acidic nature observed in dry season for the surface and interstitial waters might also be associated with bacterial nitrification processes. Tidal resuspension of organic detritus in the nearshore which acts as substrate for bacteria leads to increased nitrification in water column (De Vries and Helder, 1983) resulting in elevated hydrogen ion concentrations especially in the wet season (Boyd, 1982). The pH levels observed in the wet season depict normal ocean pH for surface waters and is quite constant due to the great buffering capacity of the oceanic system (Sverdrup et al. 1942). Water temperature for surface and interstitial water for dry season (Table 1) were observed to be within the acceptable limits (FEPA, 1992) for coastal waters (less than 35°C). The wet season months showed a low temperature range (Table 1) though slightly high in the month of May but within the acceptable range (FEPA, 1992). The pH variation in surface water was comparable to the interstitial waters

Turbidity of the surface and interstitial waters in November was observed to be very high. Turbidity levels for January, may and August were however low. The highest turbidity in November could be due to addition from harmattan dust which is prevalent at the onset of the dry season. Generally, high turbidity values observed were attributed to turbulence generated in the coastal zone due to the constant impingement of the shoreline by the swash action of waves. These perturbations of the underlying sediment releases much particulate matter into the water column. Turbidity decreased from dry season to wet season during the period due to dilution from high fresh water discharge from the nearby Qua Iboe River estuary (Fig 1).

The levels of dissolved oxygen in surface and interstitial waters in dry and wet seasons (Table 1) were observed to be lower than the dissolved oxygen range in tropical coastal waters (6-8 mg/1). Temporal variations in DO (Fig .2c) showed that higher levels were measured in the dry than the wet season. This is confirmed by the reductive potential values of the environment showing oxidisability in the dry and primarily reducing in the wet season. Reducing conditions can arise in natural water only where the consumption rate of oxygen exceeds that of supply (Deuser, 1975). In marine environment, the consumption rate of oxygen is intimately linked to the oxidation of organic matter (both living and dead) and the dissolved oxygen which is used in this oxidation is derived from the atmosphere and photosynthesis. Low levels of DO induces stress to aquatic organisms and can lead to an anaerobic state. DO was higher in the surface than interstitial waters.

Biochemical Oxygen Demand (BOD_5) in both surface and interstitial waters in dry season were low (below 3.0mg/1). The low values detected may be due to the presence of high population of microbial aerobes utilising available dissolved oxygen for degradation activity. The presence of tar balls on the water surface and beach (Asuquo et al, 1995) adds to the particulate load of the environment and thus the depletion of oxygen. The wet season results showed a higher value in both surface and interstitial waters in May than in August during the period.

The levels of chemical oxygen demand in surface and interstitial waters in both seasons were low (<1.04 mg/1). This low levels could be due to the presence of high concentration of ocenic debris including tar balls on the water and beach surface (Asuquo et al, 1995). This suggests that the coastal nearshore waters are moderately contaminated.

The colour of the surface and interstitial waters were observed to be high (Table 1) in both dry and wet seasons. Temporal variation (Fig. 2d) showed higher levels during the dry than the wet season. The minimal increase in the month of May might be due to enhanced salinity caused by transient stationary state of the outer estuary (Small et al, 1972) (onset of rains) which enhances flocculation process resulting in the precipitation of clayey-silt particles that contribute to turbidity and colour. Colour decreased from dry to wet season.

The levels of ammonium in surface and intersitial waters in dry and wet seasons (Table 1) were observed to be higher when compared to the maximum amount of ammonium found in marine waters (0.025 mg/1) (Wheaton, 1972). Temporal variations (Fig. 2e) showed that dry season months had higher concentrations than the wet season months. During the dry season, intertidal portion of the beach are occupied by tourist and visitors for recreational activities such as hockey, football etc. Human wastes are usually littered on the beach face which can contribute to ammonium/ammonia build-up in the waters.

Nitrate levels in surface and interstitial waters for dry season were observed to be higher than the World's ocean ranges in the Tropics (Wheaton, 1972). These ocean ranges can only be compared to wet season values (Table 1) in Ibeno coastal waters. During this study, nitrate levels were higher in dry than wet season (Fig .2f). This confirms the report of Wheaton (1972) that nitrate concentrations are higher than ammonium in surface waters. The interstitial waters were also observed to have higher concentrations of nitrate than even the surface waters attributed to nutrient seepage.

The levels of silicate in surface and interstitial waters in both seasons (Table 1) were observed to be lower than the World Ocean ranges (South Eastern Atlantic), 0.75-6.0mg SiO_2/l; Equatorial Pacific, 0.75-12.75mg SiO_2/1; Indian Ocean, 0.35-2.25 mg SiO_2/1 (Wheaton, 1972). Temporal variations (Fig. 2g) showed that the mean concentration measured during the study in August was the highest in both surface and interstitial waters. In the dry season, (November and January), almost similar concentrations in both surface and interstitial waters were observed. This is attributed to much requirements of silicate for building of biological cysts and spicules by certain species of yellow-brown algae and sponges (Wheaton, 1972). Also in wet season, marked concentrations of silicate appeared to depend on exchange of siliceous materials between water and the bottom sediments and rate of break down of plants containing silicon (Wheaton, 1972).

The levels of phosphate in the surface and interstitial waters in dry and wet seasons studied (Table 1) were lower than previous observation along the West Coast of Africa, 0.076-0.24 mg PO_4/1 and the World's Ocean (Wheaton, 1972). These values clearly indicated that levels of phosphate in our coastal waters are far below the World's ocean values. Temporal variations (Fig. 2h) show that mean conccentrations of phosphate was higher in dry season for both surface and interstitial waters than the wet season. The difference might be due to much inflow of water through rivers and precipitation during wet season that aided the dilution of the dissolved phosphates in the nearshore waters. On the other hand, phosphate concentrations present in water may be reduced through absorption by bacteria, phytoplankton and macrophytes (Rigler, 1959, 1964; Hayes and Phillips, 1958).

Total hydrocarbon (THC) levels in surface and interstitial waters in both dry and wet seasons were high (Table 1). Mean concentrations showed that the month of May had the highest concentration in surface waters, while the month of November had the highest mean concentration in interstitial waters (Table 1). The high hydrocarbon content measured in November in interstitial waters might be due to the degradation of buried tar balls in the intertidal portions of the beach (Asuquo et al 1995). Horn et al. (1970), had described many of the characteristics of tar balls. The lumps contain the low boiling fraction of the crude oils suggesting that the particles could be relatively young with ages perhaps weeks. The high temperature in November could melt the low boiling fractions which can seep or percolate down the sediments. Temporal variations (Fig. 2i) showed that THC in surface water was higher in May at flood tide. This remarkable observation might be due to low rate of evaporation in the ocean due to low temperature. Also the interstitial waters had higher concentrations in dry season months than wet season months. However these concentrations may be compared to the work of Riley and Skirrow (1975), where they found petroleum hydrocarbon levels in Baltic Sea to range between 0.3-1.0 mg/l. In this report THC levels at surface were higher (ranged 1.30 -2.18 mg/l) than concentrations found in the Baltic waters. Temporal variations (Fig. 2i) revealed that November, January and August had higher levels of THC in interstitial waters except May.

CONCLUSION:

From this study, it has been shown that:

(a) The waters of Ibeno Atlantic coastline are moderately acidic in dry season and alkaline in wet season.

(b) Temperature for the coastal waters are within the acceptable limits (FEPA 1992), less than 35°C.

(c) The BOD and COD values as reported suggest high concentration of particulate material in the system which also contributes to the low dissolved oxygen content and turbidity of the water.

(d) Ammonium and nitrates were higher while phosphates and silicates were lower than the World Ocean ranges.

(e) THC levels observed were higher in the dry season and interstitial waters than the wet season and surface waters

(f) Temporal variations showed marked seasonal difference for most of the parameters investigated. Much more research is necessary to fully characterise this coastline.

(g) The management of coastal waters is presently receiving world-wide attention. This report therefore serves as an environmental tool and baseline data for assessing and solving ecological problems that may arise from anthropogenic activities.

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Table 1. Results of Physicochemical, Organoleptic, Nutrients, and Total Hydrocarbon measurements for dry and wet seasons along Ibeno Coastline, Nigeria

PARAMETERS	NOVEMBER. 1996		JANUARY. 1997		MAY. 1997		AUGUST. 1997	
	DRY SEASON				WET SEASON			
	S.W	I. W	S.W	I.W	S.W	I.W	S.W	I.W
pH	6.7 ± 0.84	6.53 ± 0.91	6.68 ± 0.373	5.65 ± 2.08	7.2 ± 0.16	7.35 ± 0.07	8.35 ± 0.07	8.2 ± 0.10
Water Temperature (OC)	29.1 ± 1.40	29.3 ± 2.03	29.28 ± 1.39	28.4 ± 2.14	28.3 ± 0.94	26.6 ± 0.223	25.3 ± 0.69	24.7 ± 0.09
Dissolved Oxygen (mg/l)	5.9 ± 0.75	3.04 ± 3.39	5.3 ± 2.715	3.58 ± 1.09	5.41 ± 0.37	3.92 ± 0.41	1.55 ± 0.23	0.98 ± 0.09
Conductivity (ms/cm)	24.4 ± 8.49	27.8 ± 4.8	30.3 ± 10.8	34.5 ± 2.85	36.1 ± 5.4	20.5 ± 2.1	10.66 ± 0.38	4.80 ± 0.103
Turbidity (FTU)	252.6 ± 503	140.0 ± 265.6	39.75 ± 52.89	48.4 ± 91.56	67.2 ± 46.4	64.1 ± 30.6	28.6 ± 33.4	24.8 ± 17.1
BOD 5	1.36 ± 0.55	1.4 ± 0.33	1.25 ± 0.55	1.1 ± 0.54	3.0 ± 1.22	2.53 ± 0.61	0.4 ± 0.3	0.16 ± 0.07
Colour (Pt Co, unit)	433.9 ± 335.5	365.0 ± 359.8	308.8 ± 337.4	204.4 ± 1709	296 ± 24.0	196.8 ± 149.2	221.6 ± 181.6	152.1 ± 45.2
Total Hardness (mg/l)	1001.8 ± 351.9	956 ± 450.8	631.0 ± 304.2	742.1 ± 85.95	391.9 ± 127.9	507.7 ± 90.12	413.7 ± 46.4	455.1 ± 27.5
Total Alkalinity (mg/l)	90.4 ± 34.8	106 ± 42.7	96.25 ± 10.68	131.1 ± 33.3	95.0 ± 13.98	1033 ± 7.5	102.7 ± 117	103.8 ± 6.97
Chloride (mg/l)	8395 ± 2840.7	8481 ± 2442	11116.5 ± 2412.2	12429.4 ± 1113.1	13054.4 ± 1991.8	7411.3 ± 755.3	3824.5 ± 129.7	4089 ± 95.8
Sulphate (mg/l)	1173.9 ± 397.2	1174.8 ± 338.3	1554 ± 337.5	974.7 ± 807.9	1818.9 ± 272.6	1936.3 ± 105.6	536.6 ± 18.44	572.7 ± 12.2
Salinity (ppt)	14.8 ± 5.23	15.2 ± 4.6	20.08 ± 4.36	22.4 ± 2.01	23.5 ± 3.52	13.4 ± 1.36	6.87 ± 0.36	7.4 ± 0.151
Ammonium (mg/l)	3521 ± 1.25	3.25 ± .33	4.38 ± 0.94	5.20 ± 0.20	3.93 ± 0.53	2.70 ± 0.226	3.322 ± 0.889	2.816 ± 0.196
Nitrate (mg/l)	4.387 ± 3.901	5.20 ± 3.192	4.912 ± 0.29	5.08 ± 0.34	0.19 ± 0.04	0.285 ± 0.144	0.446 ± 0.346	2.12 ± 0.84
Phosphate (mg/l)	0.018 ± 0.003	0.011 ± 0.007	0.024 ± 0.004	0.023 ± 0.001	0.19 ± 0.002	0.005 ± 0.002	0.005 ± 0.001	0.010 ± 0.003
Silicate (mg/l)	0.453 ± 0.11	0.633 ± 0.221	0.499 ± 0.21	0.505 ± 0.08	0.34 ± 0.08	0.697 ± 6.135	0.45 ± 0.094	0.960 ± 0.098
Total Hydrocarbon (mg/l)	1.76 ± 0.37	25.56 ± 19.89	2.03 ± 0.54	3.31 ± 1.89	2.18 ± 0.82	1.51 ± 0.12	1.30 ± 0.11	1.67 ± 1.06

SW = Surface water

IW = Interstitial water.

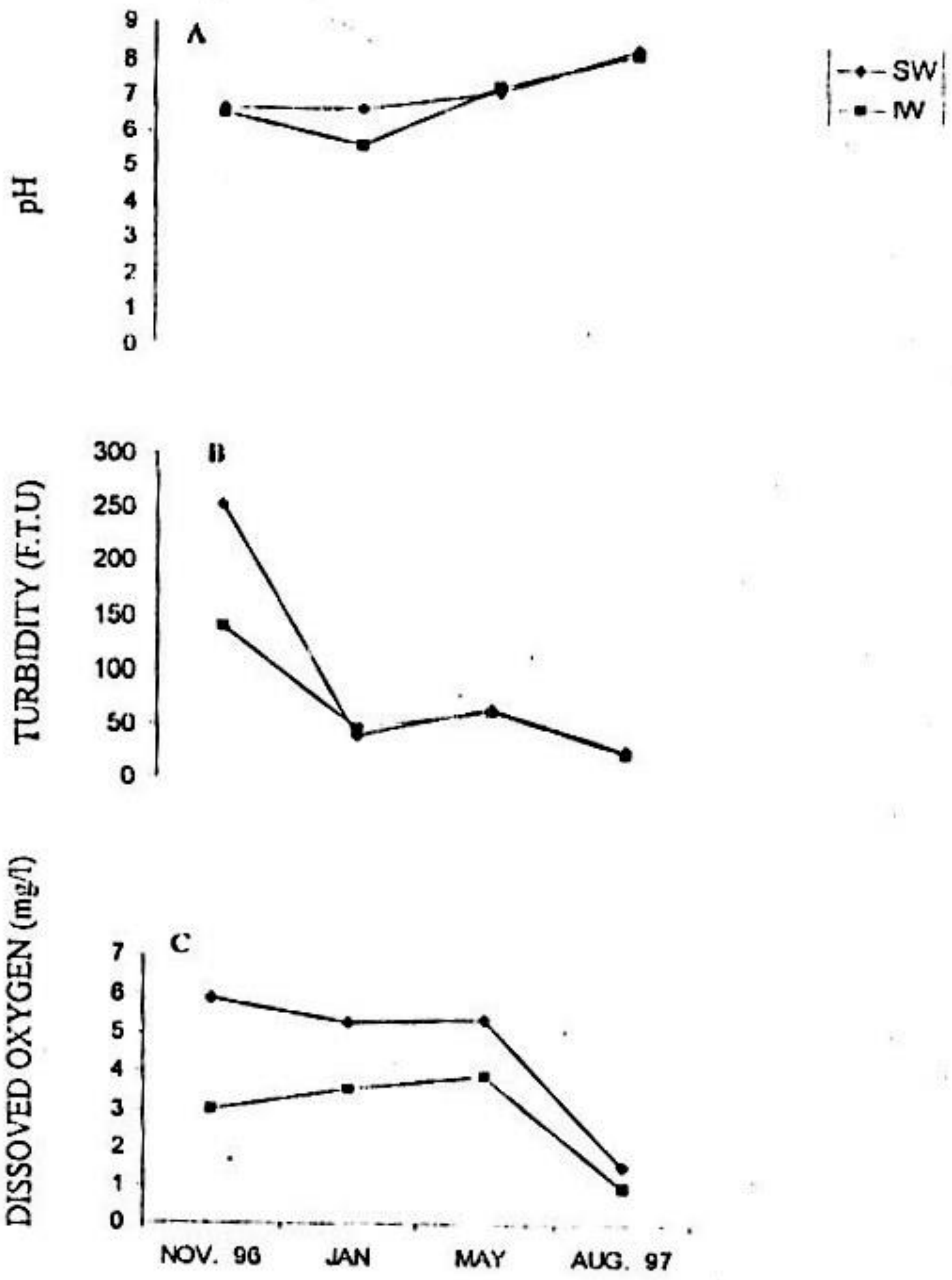

Fig. 2 a, b, c. **Temporal Variations of pH, Turbidity and Dissolved Oxygen in surface (SW) and interstitial (IW) waters along Ibeno Coastline, S. E. Nigeria.**

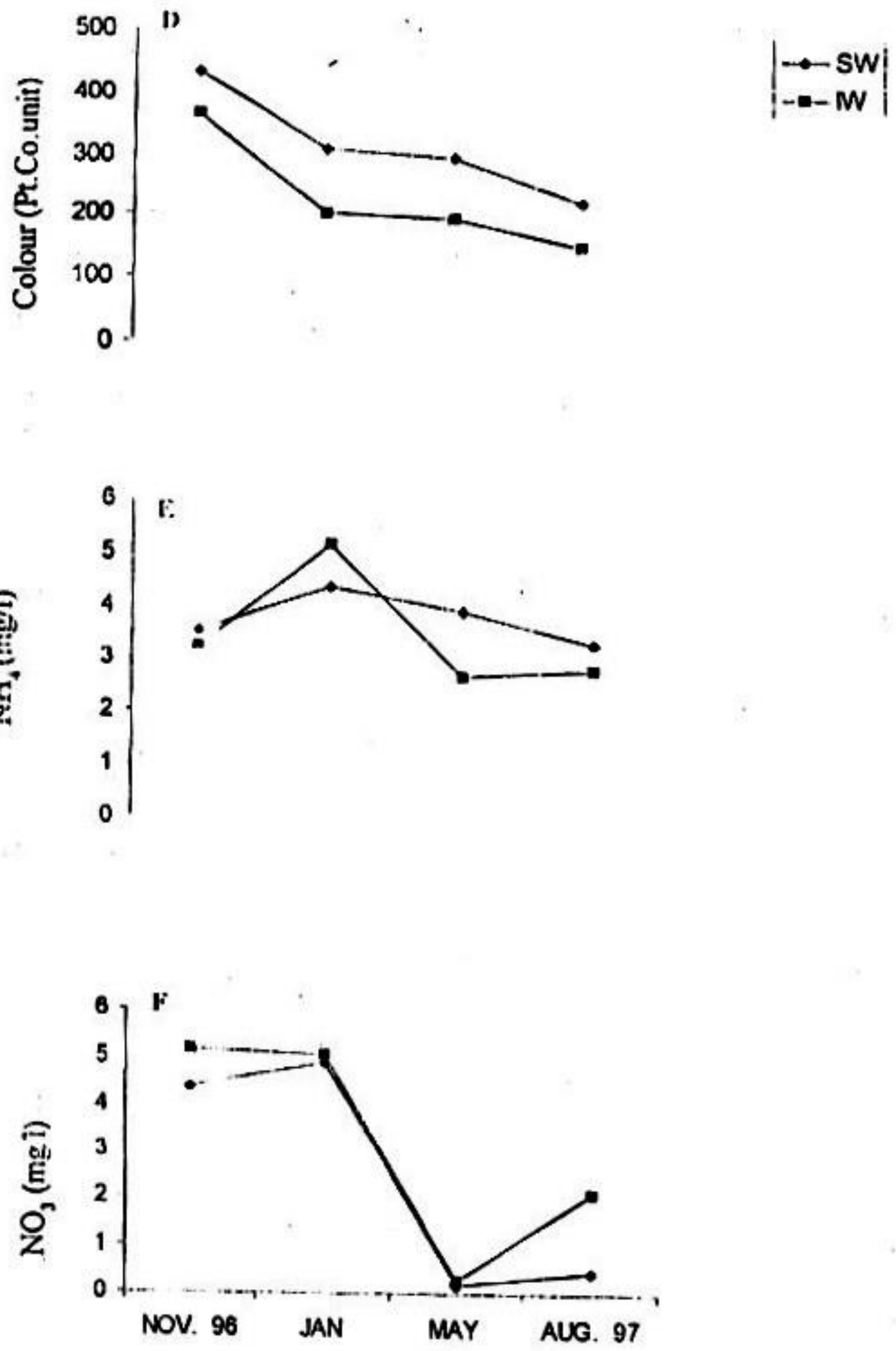

Fig. 2 d, e, f. **Temporal Variations of Colour, Ammonium and Nitrate in surface (SW) and interstitial (IW) waters along Ibeno Coastline, S. E. Nigeria.**

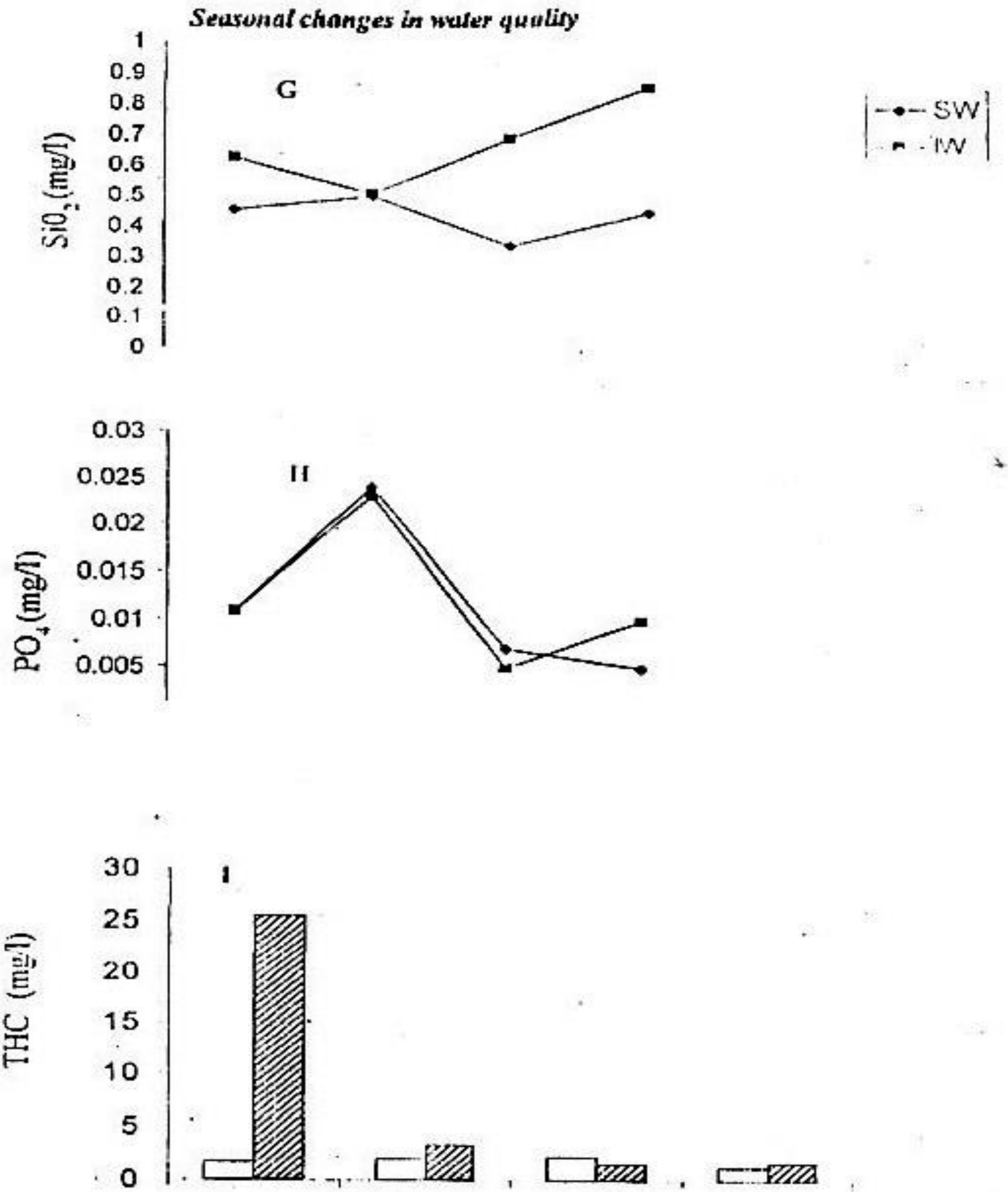

Fig. 2 g,h,i: **Temporal Variations of Sulphate, Silicate and To Hydrocarbon in surface (SW) and interstitial (I waters along Ibeno Coastline, S. E. Nigeria.**

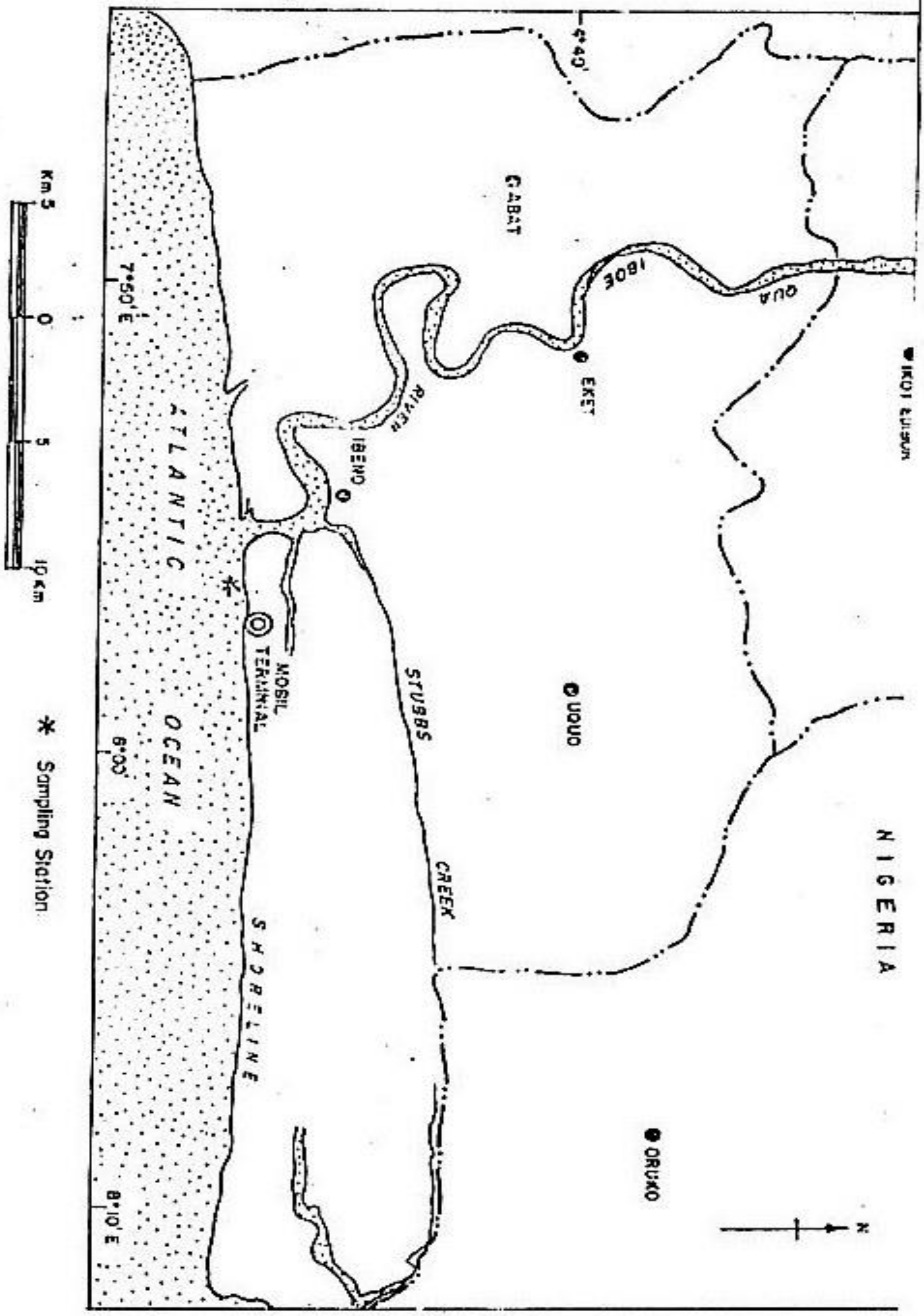

Fig. 1 : Location map of Ibeno showing the sampling station