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# PHYSICOCHEMICAL CHARACTERISTICS OF CROSS RIVER AND COASTAL AREAS OF CROSS RIVER AND AKWA IBOM STATES, NIGERIA.

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**ABSTRACT**

A study was carried out to determine the physico-chemical characteristics of the water of the Cross River and coastal areas of Cross River and Akwa Ibom States of Nigeria. Water samples were collected in dry (March and December) and wet (July and October) seasons during four cruises on parts of Cross River and Ibeno coastline of Akwa Ibom states between 1999 and 2002. Surface (0-15cm) and bottom (2-13m) waters were assessed at nine stations for temperature, dissolved oxygen (D.O), hydrogen ion concentration (pH), total dissolved solids (TDS) total suspended solid (TSS), salinity, nitrite, nitrate, ammonium, phosphate, sulphate, silicate, calcium magnesium, sodium, chloride, and potassium. Spatial variations ($p<0.05$) were observed in the water quality parameters examined while temporal variations were generally not. Station 8(a marine station and site of major oil industry activity) was significantly different from all other stations ($p<0.05$) in all parameters considered. It was concluded that the water quality of the area should be monitored regularly to keep track of the water quality as all these areas were impacted by a major oil spillage in 1999.

## INTRODUCTION

Nigeria has a vast population of coastal and inland fisheries resources which are largely threatened by pollution and over fishing. Oil pollution is a major cause for concern in oil producing areas often leading to long standing conflicts with oil companies. Aquatic lives, economic activities, fishing grounds and recreational uses of water bodies are lost. There is unemployment and loss of drinking water.

Cross River and Akwa Ibom states of Nigeria possess oil and gas fields in the coastal and offshore areas. And these areas are also rich in fisheries. A study of the physicochemical characteristics of this water is important in order to monitor the changes in water quality and possible effects of on the aquatic resources of these coastal areas.

The aim of this study is to evaluate the physicochemical characteristics of coastal areas of Cross River and Akwa Ibom States impacted by a major oil spill in 1999.

**MATERIALS AND METHODS**

The study area is located in Cross River and Akwa Ibom states of Nigeria between latitudes $4^0 00^1$ and $8^0$ $00^1$ and longitudes $9^0$ and $11^1$E. The coastal area is low-lying found between latitudes $4^0 30^1$ - $5^0 15^1$ and longitudes $6^0$ $00^1$ - $8^0$ $10^1$ E and is influenced by semi-diurnal tides (Asuquo *et al.,* 1999). The surface of the Cross River is about 39,000 hectares (*Ita et al.,* 1985) while Ibeno coastline covers about 10 kilometres of the Atlantic coastline and lies between latitudes $4^0 32^1$ N and longitude $8^0 16^1$ E. The shore is flat with fine –grained sand. At low tide the beach is about 130m wide. Two major currents: Benguela and Guinea currents flow through the coastal and offshore areas (Asuquo *et al.,* 1995; Bassey and Asuquo, 1999). The major vegetation is made of mangrove and nypa palms forests (Petters, 1993).

Nine sampling locations (impacted by a major oil spill) : Calabar River Estuary, Oron water channel, Ibaka water channel (also called Tom Short or Jamestown), James Island , Ikang water channel, Calabar River at Odukpani, the bridgehead at Ayadehe, Qua Iboe terminal at Ibeno and Ifeta ,the reference location (representing stations 1 to 9 respectively, Fig .1) were studied.

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The dissolved oxygen content and percentage saturation of oxygen were measured with an Oxyguard Handy Mk 11 electronic meter (± 1.0% sensitivity), the conductivity, total dissolved solids and temperature were recorded using Hach Conductivity / TDS meter (Model 4460), pH kit (WTLF-90) to record pH, the turbidity of the water was measured with a secchi disc while an echo sounder was used to measure the water depth on the field . Surface (0-15cm) and bottom (2-13m) water samples were collected at each station and analyzed for nutrients and other parameters not measured *in situ* (American Public Health Association, 1979and 1989).The data obtained were subjected to Analysis of variance and simple correlation tests were used to establish relationships among parameters in surface and bottom waters.

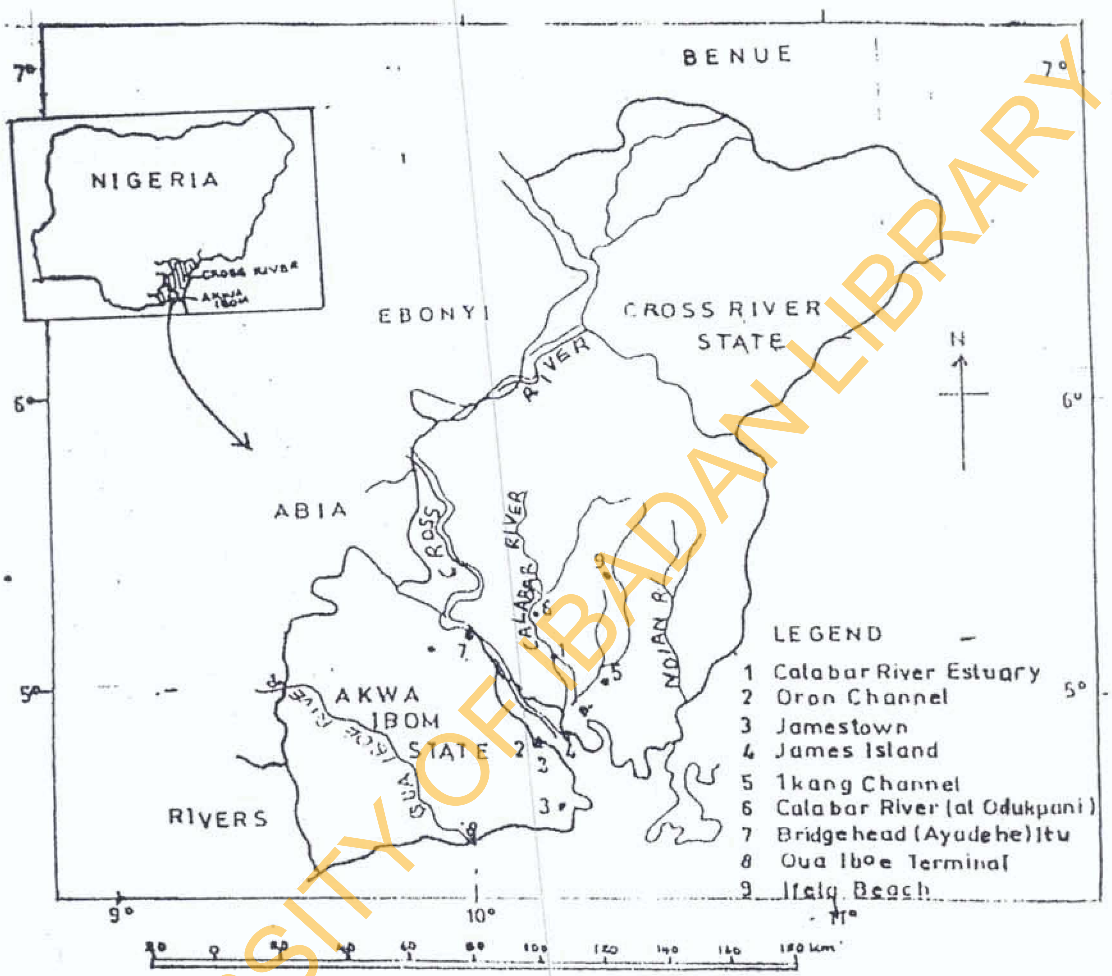


FIG.1 : MAP OF AKWA IBOM AND CROSS RIVER STATES SHOWING THE STUDY LOCATIONS

## RESULTS

The correlation matrices are shown on tables 1 and 2 .The highest values of most parameters were recorded in the late dry season (March) and at station 8(Please see figures.2 to 21). The water depth ranged from 2 cm to 13m with mean dry and wet season values at 6.7 and 4.4 m respectively

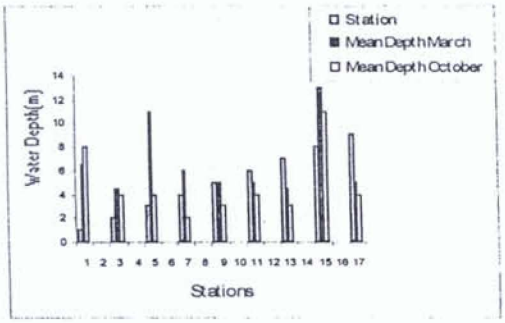


Fig.2. Water Depth (m) in the Study Area


Fig.3.Water Temperature (°C)


Fig 4.Dissolved Oxygen (Mg/L)

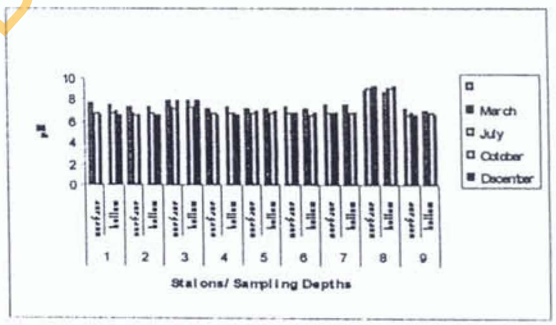


Fig 5 .Hydrogen ion concentration

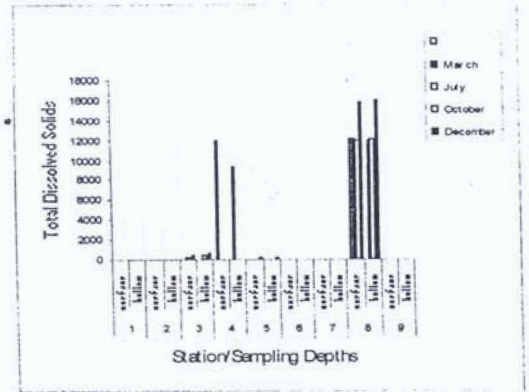


Fig 6.Total dissolved Solids (Mg/L)

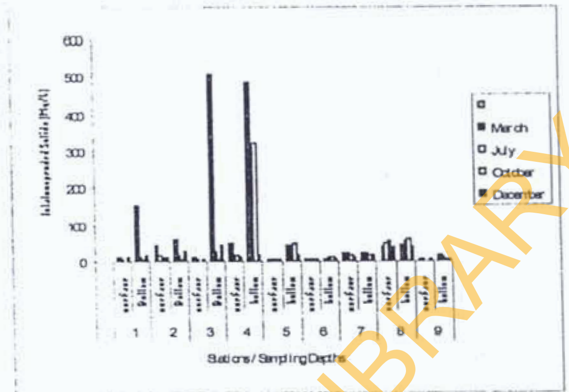


Fig7. Total Suspended Solids (Mg/L)

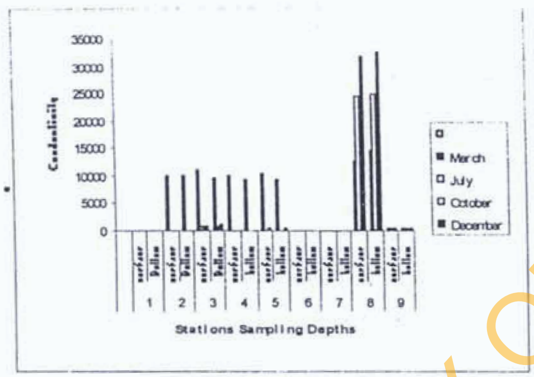


Fig 8.Conductivity (µs/cm)

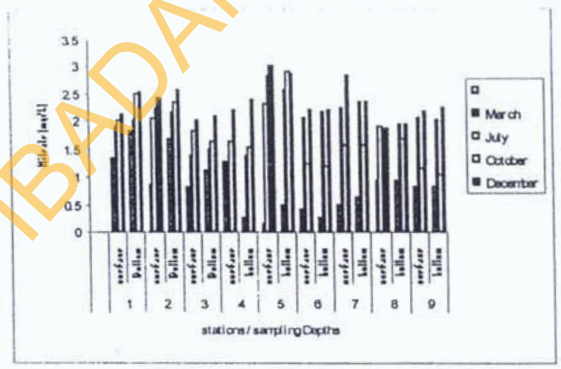


Fig 9. Nitrate (Mg/L)

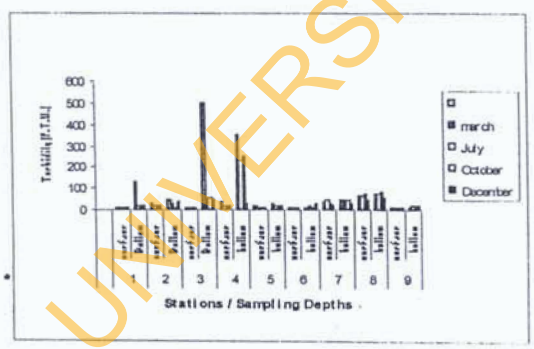


Fig 10.Turbidity (F.T.U)

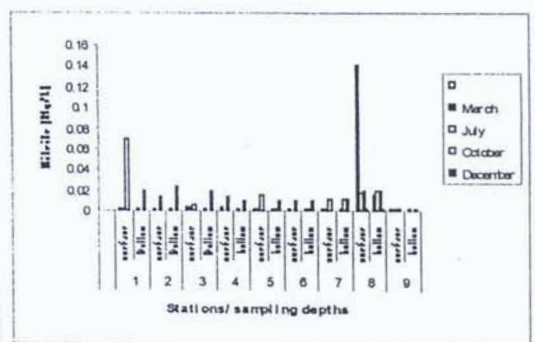


Fig. 11. Nitrite (mg/l)

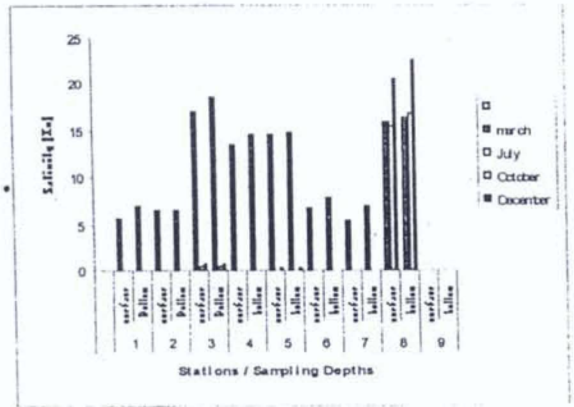


Fig 12.Salinity (parts per thousand)

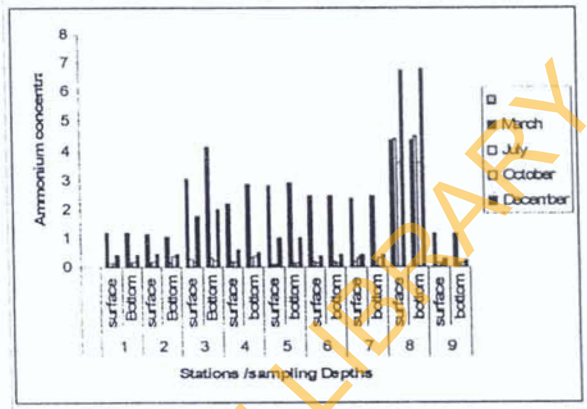


Fig 13. Ammonium in water (Mg/L)

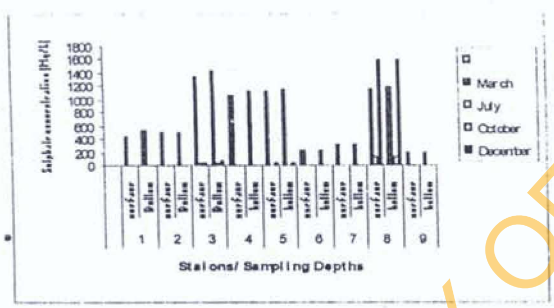


Fig .14. Sulphate Content in water(Mg/L)

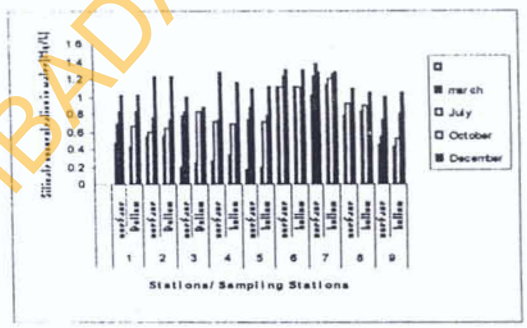


Fig 15. Silicate content in water (Mg/L)

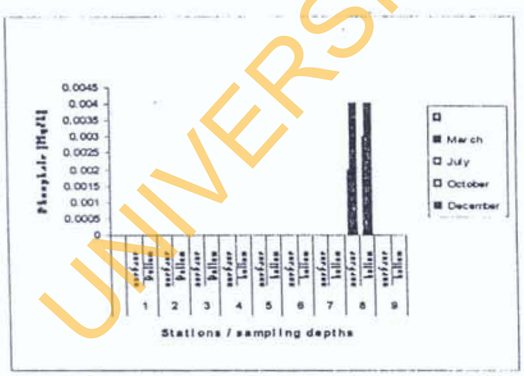


Fig 16.Phosphate content in water (Mg/L)

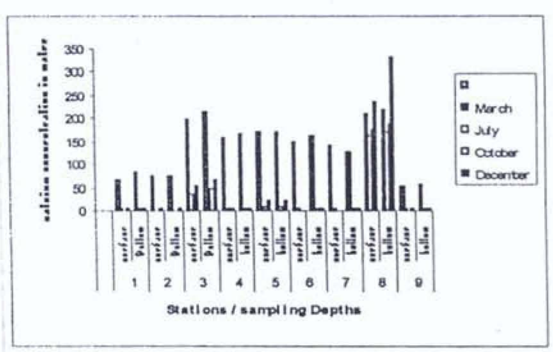


Fig.17.Calcium content in water (Mg/L)

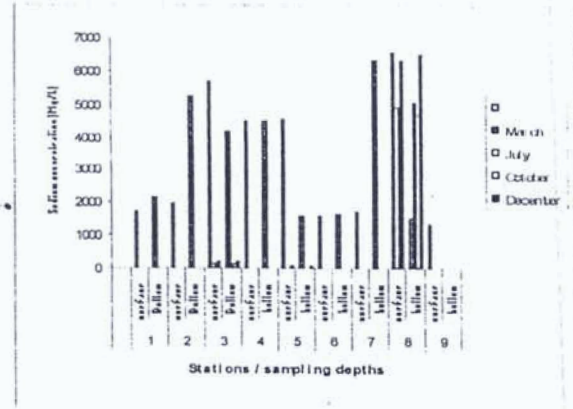


Fig.18 Sodium content (Mg/L)

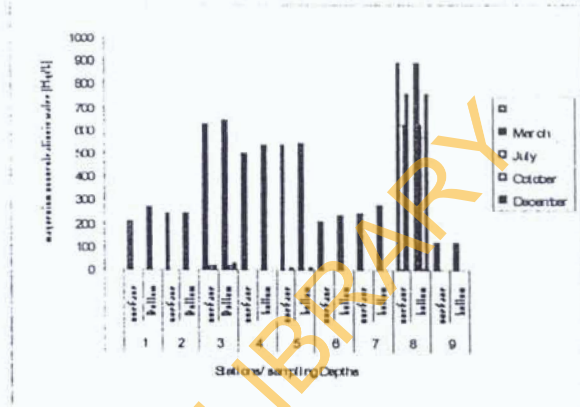


Fig. 19.Magnesium content (Mg/L)

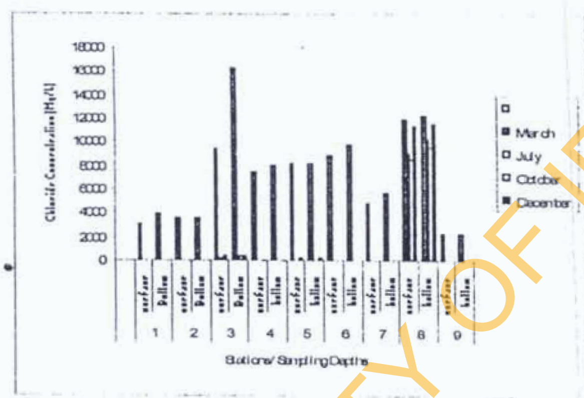


Fig 20.Chloride in water (Mg/L)

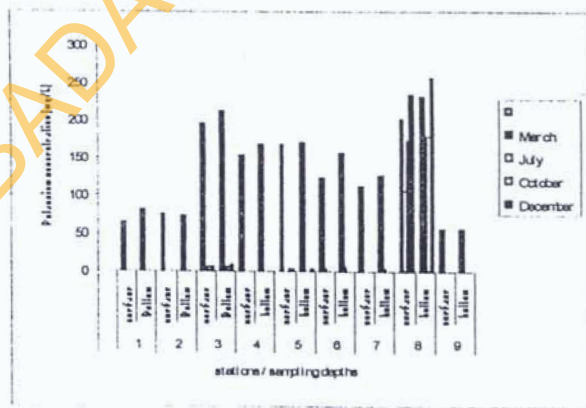


Fig 21.Potassium in water (Mg/L)

**Table 1: Correlation matrix for physico-chemical characteristics in Surface water**

| Variables | Water Temp. | DO | pH | TDS | TSS | Conductivity | Turbidity | Nitrites N | Salinity |
|---|---|---|---|---|---|---|---|---|---|
| Water temperature | 1 | | | | | | | | |
| DO | 0.04 | 1 | | | | | | | |
| PH | -0.6 | 0.25 | 1 | | | | | | |
| TDS | -0.6 | 0.3 | 0.95* | 1 | | | | | |
| TSS | 0.013 | -0.12 | 0.09 | | 1 | | | | |
| Conductivity | 0.18 | 0.89* | 0.15 | 0.31 | -0.11 | 1 | | | |
| Turbidity | -.00 | -0.09 | 0.2 | 0.26 | 0.98* | -0.08 | 1 | | |
| Nitrites N | 0.26 | -0.17 | -0.08 | -0.26 | -0.25 | -0.28 | -0.24 | 1 | |
| Salinity | -0.033 | 0.48 | 0.70* | 0.83* | 0.37 | 0.52 | 0.43 | -0.5 | 1 |

**Table 2: Correlation matrix for physico-chemical parameters in bottom water.**

| Variables | Water Temp. | DO | pH | TDS | TSS | Conductivity | Turbidity | Nitrites N | Salinity |
|---|---|---|---|---|---|---|---|---|---|
| Water temperature | 1 | | | | | | | | |
| DO | 0.09 | 1 | | | | | | | |
| PH | -0.72 | -0.24 | 1 | | | | | | |
| TDS | -0.47 | -0.12 | 0.91* | 1 | | | | | |
| TSS | -0.48 | -0.29 | 0.90 | | | | | | |
| Conductivity | -0.24 | 0.86* | 0.09 | 0.09 | -0.03 | 1 | | | |
| Turbidity | -0.63 | 0.47 | 0.92* | 0.83* | 0.91* | -0.08 | 1 | | |
| Nitrites N | -0.75* | -0.16 | 0.84 | 0.74* | 0.74* | 0.02 | -0.75* | 1 | |
| Salinity | -0.63 | -0.25 | 0.99* | 0.95* | 0.93* | 0.06 | 0.90 | 0.90 | |

Correlations are significant at $p < 0.05$

**DISCUSSION**

Water depths fluctuated at different stations during this study and this could be due to changing tides and the process of silt and mud deposition during the rainy season when runoff from land sources brought more particles to the water bodies due to erosion .Higher water temperatures were recorded in the dry (March /December) than rainy season (July /October).The water temperatures recorded in the dry and rainy seasons in surface and bottom waters were within limits given for Nigerian coastal waters,35 $^0$C (Federal Environmental Protection Agency, 1991). No significant variation was observed in the temperature between bottom and surface water, season and stations but water temperatures may have been influenced by climate and water turbulence as reported by other studies (Asuquo, 1999, Akpan and Offem, 1993).

Surface and bottom dissolved oxygen concentrations were less than 5 mg/l recommended for aquatic organisms (Odiete, 1999). Low D. O. concentrations have been recorded for the coastal water, Cross River and its tributaries (Asuquo, 1999) and the area has a reducing environment due to low oxygen tension (less oxygen production than consumption), marshy conditions and chronic hydrocarbon pollution (Bassey and Asuquo, 1999; Deuser, 1975). The D.O. concentrations recorded in this study were however higher than reported by studies a few weeks following the major oil spill in the area (Asuquo *et al*, 1999).

Apart from March , the pH recorded at other periods in the study area was higher than recommended for drinking water by WHO (Onyeike and Ogbuja,1999).The changes in pH could result from the interaction between fresh water and saltwater. The total dissolved solids are made up of inorganic salts, organic matter and dissolved materials. The concentrations of TDS in this study were generally lower than 2000mg/L recommended (FEPA, 1991) except for station 8. Bottom water contained more total suspended or filterable solids than surface water and the highest content of TSS was recorded at station 3 in March. The presence of suspended solids affect the swimming, growth rate and clog gills of fish (Odiete, 1999) and FEPA (1991) recommended a TSS limit of 30mg/l for Nigerian waters.

Conductivity is a measure of the ability of the water to conduct electricity. Surface water ranged from 8.47 to 313538 µs/cm and the bottom water from 10.75 to 32434 µs/cm for surface and bottom waters respectively. The high levels of conductivities recorded in this study at some stations may have been due to salt water intrusion The World Health Organization, (1984) stated waters with conductivities greater than 2000µs/cm have associated heath risks unless desalinated.

The presence of suspended matter such as silt, clay, finely divided organic matter and plankton makes water turbid. Higher turbidities were recorded in the dry than rainy seasons, which could be caused by turbulence or wave action, which released particulate matter into the water from sediments. A simply linear equation was established between turbidity and TSS:
Turbidity =11.30 + 0.079 TSS ($R^2$=0.94; =0.94; S.E. = 13.682; N=18)

Generally, low nitrite concentrations were recorded in the study area which were less than recommended for drinking water (Odiete ,1999). The salinity of the water ranged from 0.002 to 20.5 and 0.003 to 22.53‰ in surface and bottom water respectively. The salinity of the Cross River system has been reported as highly fluctuating (R.P.I, 1985; Asuquo, 1989). The tidal regime also affects the salinity of water (Asuquo, 1999) with the lowest salinities recorded at ebb tide.

Nitrate-N ranged from 0.140 to 2.99 mg/L and 0.258 to 2.862 mg/L in surface and bottom waters respectively. The result obtained for Nitrate –N during this study were similar to other studies (Wheaton (1972, Bassey and Asuquo, 1999). Most stations recorded increased concentrations of nitrate during the early dry season .Ammonium-N ranged from 0.108 to 6.717 mg/L in surface water. Higher levels of $NH_4^+$-N were generally recorded in the late dry season. Ammonium exists in equilibrium with ammonia with high pH favouring ammonia which is very toxic.

Phosphate in the surface and bottom waters ranged from 0.00 to 0.04 mg/L. There was significant ($P<0.05$) spatial variation with station 8 consistently recording the highest values during the period. Seasonal variations in the orthophosphate concentrations were attributed to marine inputs of organic matter, bacterial mineralization-assimilation but low concentrations could be due to high phytoplankton density (Akpan and Offem, 1993). In the absence of zooplankton, phosphate concentrations could decrease during a phytoplankton bloom (Antia *et al.*, 1963).

Sulphate is an important anion in water and ranged from 0.928 to 158.7 mg/L and 0.948 to 1589.9 mg/L while Silicate content ranged from 0.165 to 1.368 mg/L for surface and bottom waters respectively. The silicate concentrations in this study were lower than or within the ranges obtained for the South Eastern Atlantic which was 0.75-6.0 (Wheaton, 1972).

The calcium content ranged from 1.11 to 237.8 and 1.76 to 330.4 mg/L in surface and bottom waters respectively. Higher concentrations of calcium in water were recorded in the dry than rainy season and significant ($p<0.05$) spatial variations indicted that water at each station might have been influenced by local inputs of materials.

Magnesium and sodium ranged from 0.44 to 890.11 mg/L and 0.46 to 893.5 mg/L; 3.2 to 6325 mg/L and 3.0 too 6532 mg/L in surface and bottom waters respectively. Reductions in the concentrations sodium occurred during the rainy season at all stations implying dilution by freshwater. Chloride values ranged from 5.40 to 11,772.9 mg/L and 569 to 16223.1 mg/L in surface and bottom water respectively. .Potassium in water ranged from 0.13 to 233.7 and 0.21 to 254.3 mg/L for surface and bottom water respectively.

## CONCLUSIONS

For all parameters, spatial variations (Differences in study locations) were significant ($p<0.05$) indicating local influences which could affect such variations but temporal variation (Time/season) was not significant though most parameters were highest in March. Ibeno coastline (8) differed significantly ($p<0.05$) from all other stations in all parameters studied. High salinities at all stations indicated possible salt intrusion especially in the dry season. Regular monitoring of the water quality and enforcement of environmental laws recommended.

**REFERENCES**

Akpan, E.R. and Offem, J.O (1993). Seasonal Variation and Water Quality of the Cross River, Nigeria. *Rev. Hydrobiol. Trop.,* 26 (2) pp 95-103.

American Public Health Association (APHA, 1979). Standard Methods of Examination of Water and Wastewater 13th Edition Washington D.C.

American Public Health Association (APHA, 1989). Water Pollution Methods for the Examination of Water and Wastewater. 18th Edition Washington D.C.

Antia, N.J; McAllister, C.D. Parsons, T.R.; Stephens, K. and Strickland, J.D.H (1963). Further Measurements of Primary Production of Using Large Volume Plastic Sphere. *Limonology and Oceanography* 8: Pp.66-183.

Asuquo F.E. (1989) Water Quality of the Calabar River, Nigeria. *Tropical Ecology,30* Pp31-40.

Asuquo, F.E. (1999). Physicochemical Characteristics and Anthropogenic Pollution of the surface water of Calabar River, Nigeria. *Global Journal of Pure and Applied Science*; 5 (4). Pp 595-600.

Asuquo, F.E. Morah, F.N.I; Nya, A.E. and Ehrhadt, M. (1995). Trace Metals in Crude Oil and beach tars from Nigerian Coastline. *International Journal of Marine Science,* 24: pp16-18.

Asuquo, F.E. Ogri, O.R.and Bassey, E.S. (1999). Distribution of heavy metals and Hydrogen in Coastal water and Sediments of Cross River State, South Eastern Nigeria. *International Journal of Tropic Environmental,* 1 (2) pp 229-242.

Bassey, E.S. and Asuquo, F.E. (1999). Seasonal Changes in the Water Quality of Ibeno Coastline, S.E. Nigeria. *International Journal of Tropical Environment*, 2 pp 138-150.

Deuser, W.G. (1975) Reducing Environment . In: J.P. Riley and G. Skirrow (Eds). In: Chemical Oceanography. 2nd Edition. Academic Press, New York. 16, pp. 1-37.

Federal Environmental Protection Agency (1991) Guidelines and Standards for Environmental Pollution Control in Nigeria. Pp. 1-238.

Ita, E.; Sado, E.K. Balogun, J.K Pandogria A. and Ibitoye, B (1985). Inventory Survey of Nigeria Inland Waters and their Fisheries Resources. 1: A Preliminary Checklist of Nigeria Water Bodies with Special Reference to Ponds, Lakes, Reservoirs and Major Rivers. *Kanji Lake Institute Technical Paper Series*, No. 14, 51 pp.

Odiete, W.O (1999). Environmental Physiology of Animals and Pollution. Diversified Resources Limited, Lagos.

Onyeike ,E.N.and Ogbuj, S.I. (1999).Physicochemical Characteristics of Soils and Rivers in Some Oil –Producing areas of the Niger Delta under the influence of Crude Oil Spillage. *Journal of Applied Science and Environmental Management*,Pp23-28.

Petters S.W.(1993). Cross River State .In: Nigeria, Giant in the Tropics. Volume 2.State Surveys (Eds. Udoh R.K and Mamman, A.B.) ,Lagos

Research Planning Institute (RPI, 1985). Environment Baseline Studies for the Establishment of Control Criteria and Standard Against Petroleum-related Pollution in Nigeria, RPI/84/4/15-7. Final Report pp 118-127

Wheaton ,F.W.(1972).Aquaculture Engineering. Ocean Engineering. John Wiley and Sons Publishers, pp 669

W.H.O. (1984). Guidelines for Drinking Water Quality (111), Health Criteria and Supporting Information. World Health Organization, Geneva, pp 62-315.