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WATER QUALITY OF THE CALABAR RIVER, NIGERIA

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Abstract: Water quality parameters temperature, pH, dissolved oxygen, nitrites, nitrates, ammonium ion, phosphates, dissolved silicon, suspended solids and salinity were analysed monthly form surface and bottom water samples taken at a sampling station on the Calabar River. pH ranged from 6.2–7.3 and saline water intrusion (salinity range<1.0–7.13 ppt) was minimal especially in the early months of the year. The concentration of the dissolved nutrients showed slight monthly variations: nitrites 0.02–2.0 µmol/1; nitrates 0.2–12.10 µmol/1; ammonium ion 0–7.4 µmol/1; phosphates 0–0.65 µmol/1 and dissolved silicon 29–146 µmol/1. The level of dissolved oxygen (4.55–6.76 mg/1) and the range of pH appeared to have no adverse effect on the biota. The dissolved oxygen percent saturation values were very close to saturation. The river is characterised by low but variable total suspended solids (<36.5 mg\1).

Résumé: Les Paramètres de la qualité de l'eau, temperature, pH, oxygène dissous, nitrites, nitrates, ion ammonium, phosphates, silicium dissous, solides en sspension et salinité, ont été analysés mensuellement â partir d'échantillons d'eau de surface et de profondeur, pris dans une station d'échantillonnage sur la rivière Calabar. Le pH varie de 6.2 â 7.3 et les intrusions salines (salinité < 1.0 = 7 ppt) sont minimales dans les premiers mois de l'année. La concentration des éléments dissous montre de légères variations mensuelles : nitrites 0.02–2 µmol/1; nitrates 0.2–12 µmol/1; ion ammonium 0–7 µmol/1; phosphates 0–0.6 µmol/1 et silicium dissous 29–146 µmol/1. Le niveau de l'oxygène dissous (4,5–6,7 mg/1) et la variation du pH ne semblent pas avoir d'effet néfaste sur la biocènose. Les valeurs du pourcentage de saturtion en oxygène dissous sont très proches de la saturation. La rivière est caractérisée par une faible mais variable quantité de solides en suspension (<36 mg/1).

Resumen: En muestras de agua superficial y de fondo en una estacion del rio Calabar en Nigeria, se analizaron mensualmente los parámetros siguientes: temperatura, pH oxigeno disuelto, nitritos, nitratos, iones amonio, fosfatos, silice disuelto, sólidos suspendidos y salinidad. El rango de pH fué de 6.2 a 7.3 la intrusión de agua salina (con rango de salinidad < 1.0 a 7.1 ppt) fué minima especialmente durante los primeros meses del año. La concentración de nutrientes disueltos mostró una ligera variación mensual: nitritos 0.02–2 µmol/1; nitratos 0.2–1.2 µmol/1; iones de amonion 0–7 µmol/1; fosfatos 0–0.65 µmol/1 y silice disuelto 29–146 µmol/1. El nivel de oxigeno disuelto silice (4.2–6.7 mg/1) y el cambio del pH parece no tener ningùn efecto adverso dobre la biota. El procentaje de oxigeno dsuelto estuvo muy cerca de la saturación. El rio se caracteriza por una baja pero variable concentración de sólidos suspendidos (<36 mg/1).

Resumo: Os parâmetros de qualidade da âgua como a temperatura, pH, oxigenio dissolvido, nitritos, nitratos, amoniaco, fosfatos, silica dissolvida, solidos em suspensão e salinidade foram mensalmente analizados numa estacão–amostra no Río Calabar. As amostras de âgua foram recolhidas ao longo dum perfil vertical da superficie ao leito. O pH variou entre os 6.2 e os 7.3 e as intrusões de âgua salina (o intervalo de salinidade < 1,0–7.1 ppt) foram minamas, especialmente nos primeiros meses do ano. A concentracão dos nutrientes dissolvidos mostram variações mensais ligeiras: nitritos 0.02–2 µmol/1; nitratos 0.2–12 µmol/1; amoniaco 0-7 µmol/1; fosfatos 0-0,65 µmol/1e silica dissolvida 29-146 umol/1 nivel do oxigènio dissolvido (4.5–6.7 mg/1) e o intervalo de variacão do pH não parecem ter qualquer efeito adverso sobre o biota. Os valores percentuais de saturacão do oxigènio dissolvido eram muito proximos da saturacão. A âgua do rio é caracterizada por um baixo valor, embora variâvel, de sólidos totais em suspendão (<36 mg/1).

Key Words: Water quality, Nutrients, Calabar River, Nigeria.

INTRODUCTION

The need to investigate and document baseline data of most Nigerian rivers is currently receiving attention from limnologists and those concerned with environmental pollution. Water quality of some Nigerian rivers has been investigated (Adeniji and Mbagwu 1983, Adeniji and Oive 1981, Adeniji and Ovie 1982, Ajayi and Osibanjo 1981, Ajayi and Adelaye 1977, Imevbore 1970 and IOC Report 1986) indicating that some rivers especially those flowing through urban areas are grossly polluted and few maintained a pristine nature.

The necessity of a baseline study of the Calabar River is prompted by the gradual industrialisation of the Calaber Metropolis and the exodus of workers from rural areas both of which will increase the discharge of effluents into the river.

There is no information on the topography and hydrographic conditions of the major rivers that flow into the Cross River estuary. An understanding of the level of physical and chemical substances in the rivers will give an insight into the quality of the estuarine water. In January 1987, the Marine Pollution Research team of the Institute of Oceanography, University of Calabar, proposed a small-scale ecological study of the major riverine inlets to the Cross River estuary (Calabar River, Great Kwa River, Cross River, Mbo River and Akpayafe River). As a follow up, monthly water sampling and analysis of the Calabar and Great Kwa rivers were initiated, with the aim of monitoring the levels of some of the physico-chemical parameters and nutrients in order to establish the bassline levels of these quantities for future reference work.

THE STUDY AREA

The Calabar River originates from the hilly regions of the northern Cross River State, Nigeria and flows through several towns, villages and farmlands before emptying into the Cross River estuary. The Calaber River is located in the tropical rain forest belt of Nigeria and lies between latitude 4°54' and 5°50'N and longitude 8° and 8°20'E (Fig. 1). The river has a shallow depth ranging from 1.0m to 10.0m at flood tide in the navigational channels dredged by the Nigerian Port Authority for sea-going vessels. The shoreline consists of soft-dark mud flats usually exposed during low tide. The river has semi-diurnal tides with a tidal difference of 3.0 m. It has an estimated length of 65 km and 1.5 km wide at its maximum. Several governmental and a few industrial establishments are located along the Calabar River. The sampling station (11 km from its mouth) was chosen such that the influence of waste discharges from these establishments and the Calaber metropolis could be effectively monitored (Fig. 1). This sampling station is representative of the Calaber River estuary since a feasibility survey showed uniformity in the levels of parameters measured from the surface (1.0 m) and near bottom (9.0 m) samples to 15 km upstream probably because the shallow depth of the river facilitates turbulent mixing of the river and ocean waters (Conomos *et al.* 1972).

MATERIALS AND METHODS

Surface and bottom water samples were collected with a Nansen water sampler and subsampled for physico-chemical parameters and nutrient determinations. Samples were collected at flood and ebb tides on the same day. Water temperature and pH were taken as soon as the water sampler was retrieved. The dissolved oxygen levels were fixed on site and later determind by the modified

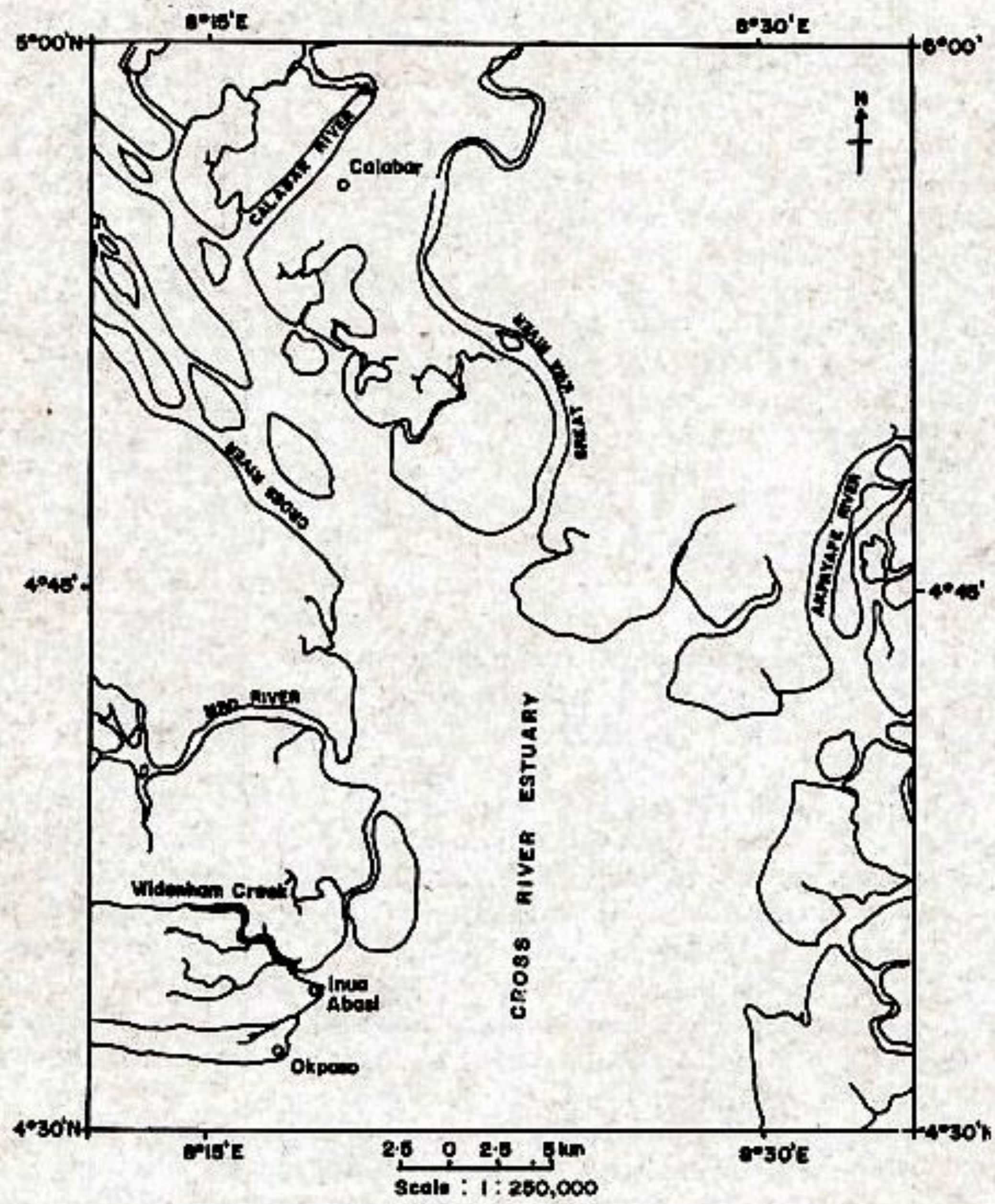

FIG. 1. Map of Cross River Estuary showing the Calabar River and the sampling station.

Winkler method (Grasshoff *et al.* 1983). Oxygen % saturation values were calculated according to Vowles and Connell (1980). Salinity levels were determind by titrimetry using 0.1N $AgNo_3$ solution with 10 ml samples. Colorimetric methods were used to monitor nitrites, nitrates, ammonium, dissovled silicon (Grasshoff *et al.* 1983) and suspended solids. All analytical determinations were conducted within a few hours of sample collection except for salinity samples which were stored at -4°C until analysis. Apart from the routine monthly monitoring, the sampling station was occupied over one tidal cycle in the months of March, April, May and June.

RESULTS AND DISCUSSION

Table 1 shows the mean concentrations and levels of some physico-chemical parameters, salinity

TABLE. 1: Mean concentrations of water quality parameters in the Calabar River, Nigeria (1987 and 1988)

Parameter	(1987) 0		03		05		07		12	(1988) 01		02	
	E	F	E	F	E	F	E	F	E	E	F	E	F
Water temp. (°C)	22.5	30.0	30.2	30.0	30.0	30.8	28.0	29.9	29.0	28.5	29.0	30.5	30.3
pH	7.1	6.4	6.4	6.8	7.2	7.0	6.6	6.6	6.2	6.6	7.6	6.2	6.6
Nitrate-N (µ mol/l)					11.6	12.1			0.2	5.2	2.8	1.1	1.9
Nitrite-N (µ mol/l)	0.3	0.02	0.4	0.7	0.3	0.4			0.2	0.1	0.1	0.2	0.2
Phosphate-P (µ mol/l)	*	*.	0	*	0	0	0.2	0.2	0.6	0.2	0.3	0.3	
Dissolved Silicon (µ mol/l)	28.9		50.4	36.1	50.4	51.4	37.8	7.4		63.0	84.0		
Ammonium-N (µ mol/l)			0.9	0.7	0	0.1	2.8	0.9	0.3	0.5	0.16	4.0	5.6
Suspended solids (mg/l)			0	14.5	25.0	26.5	9.0	15.0	15.0	12.0	18.5	*	
Dissolved oxygen (mg/l)	5.6	3.3	5.7	6.3	5.81	6.3	5.5	6.6	6.4	4.5	5.8	5.3	5.6
Oxygen saturation (%)	66.4	44.3	76.0	84.5	72.1	85.7	70.4	65.0	84.4	58.7	76.4	72.9	74.3
Salinity (ppt)		3.0	5.0	7.1	2.33	2.7	0.48	0.6			1.1	0.8	1.1

E = Ebb, F = Flood; * < 0.1 µ mol/l.

values, dissolved nutrients and suspended matter during the survey period. Figs 2 to 5 show the results of two-hourly monitoring of nutrient concentrations plotted as a function of time over a full tidal regime. The levels of the dissolved nutrients in the surface and bottom water samples showed low variability in most months.

Very low levels of nitrites, phosphates and ammonium nutrients were recorded except in June when ammonium concentration increased sharply during the flood tide. Further gradual increases were observed to August, the peak of the rainy season. This increase is attributed to additions from land drainage containing fecal material. The level of nitrogen (10.15 µmol NH_4^+ l^{-1}) were generally higher than phosphorus (0.55 µmol PO_4 l^{-1}). The highest concentrations recorded during the study period were for silicon (28.94 – 145.95 µmol l^{-1}).

Nutrient concentrations were expected to increase during the rainy season because of the drainage from the land of particulate matter, fertilizers, domestic wastes, etc. However, except for NH_4^+ the observed changes were very small.

The pH values (range 6.2 – 7.25) fluctuated in the acceptable range for unpolluted water (Prati *et al.* 1971). The suspended mater concentrations are generally low and the highest values of 36.5 m l^{-1} was obtained during flood tide in June. The river has a low dissoved chemical content (salinity range < 1.0 – 7.13 ppt) and the values decreased from January through August. The dissolved oxygen levels does not show any significant change with months, an indication that the river has not received high volume of organic waste from the surrounding industries and local community.

Gauffin (1973) discussed some of the organic pollution factors resulting from organic pollution that can bring about changes in the quality of aquatic ecosystem including: increases in dissolved nutrients, decreases or increase in dissolved oxygen levels, production of undesirable plant growth and increases in water temperature. In the Calabar River the concentration of dissolved nutrients are generally low and are not significantly different from the natural background state. Only nitrogen and dissolved sillicon show some slight hourly variation (Fig. 2–5) while the phosphate levels were persistently low.

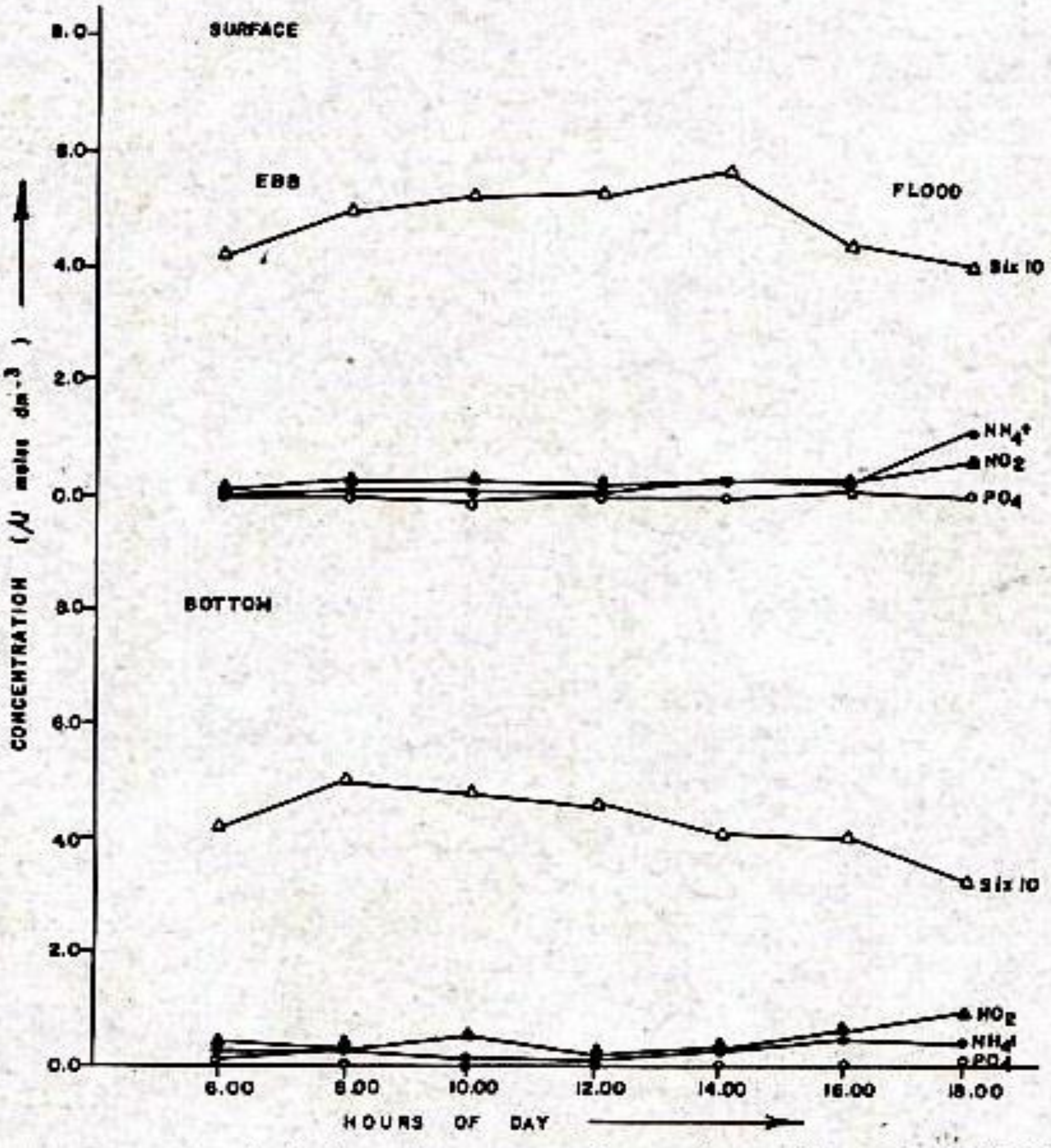

FIG. 2. Two-hourly variation in nutrient concentrations at the sampling station in Calabar River, March 1987.

The dissovled oxygen levels are high enough for normal metabolic and physiological activity of fishes and other warm water organisms. The % saturation values were very close to saturation. The water temperature values are typical of the tropical rivers and a maximum of 31.2°C was recorded in February. There is no physical evidence of any undesirable growth and the river has a low suspended load.

The relationship between meteorological factors, salintiy and water temperature is illustrated in Fig. 6 . There is an overall decrease in salinity and water temperature as the rainfall increases. At the peak of the rainy season, the salinity values remained low and almost constant (July and August). The highest average monthly rainfall (40.15 mm) was recorded in December corresponding to an average humidity of 82% and water temperature of 29°C . The lowest relative humidity (80%) was recorded in January corresponding to the lowest recorded rainfall. The lowest water temperatuer (26.4°C) occurs in August and is associated with the high humidity during that month (Fig. 6). Salinity values varied from 7.13 ppt in March to less than 1.0 ppt in August.

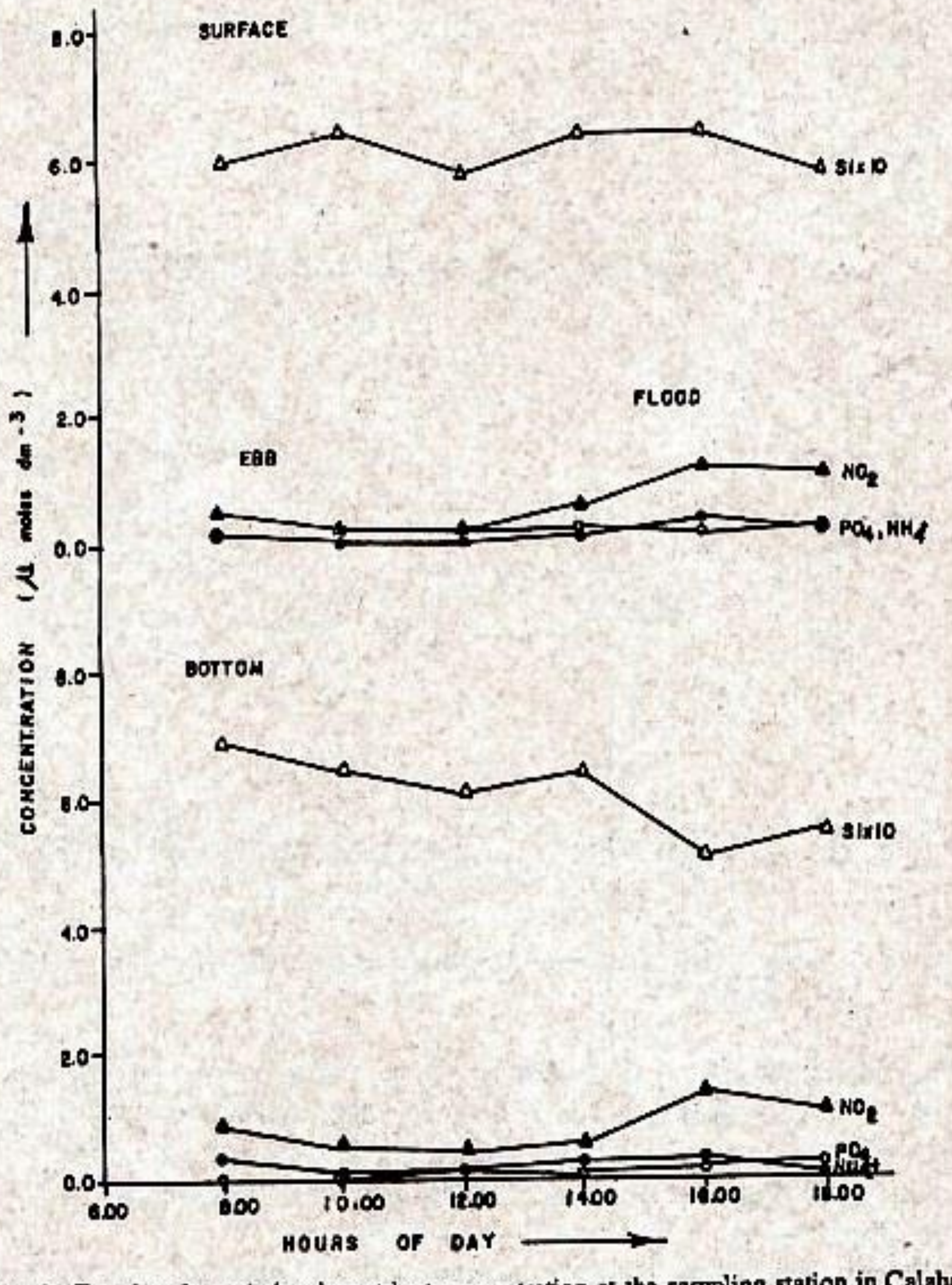

FIG. 3. Two-hourly variation in nutrient concentration at the sampling station in Calabar River. April 1987.

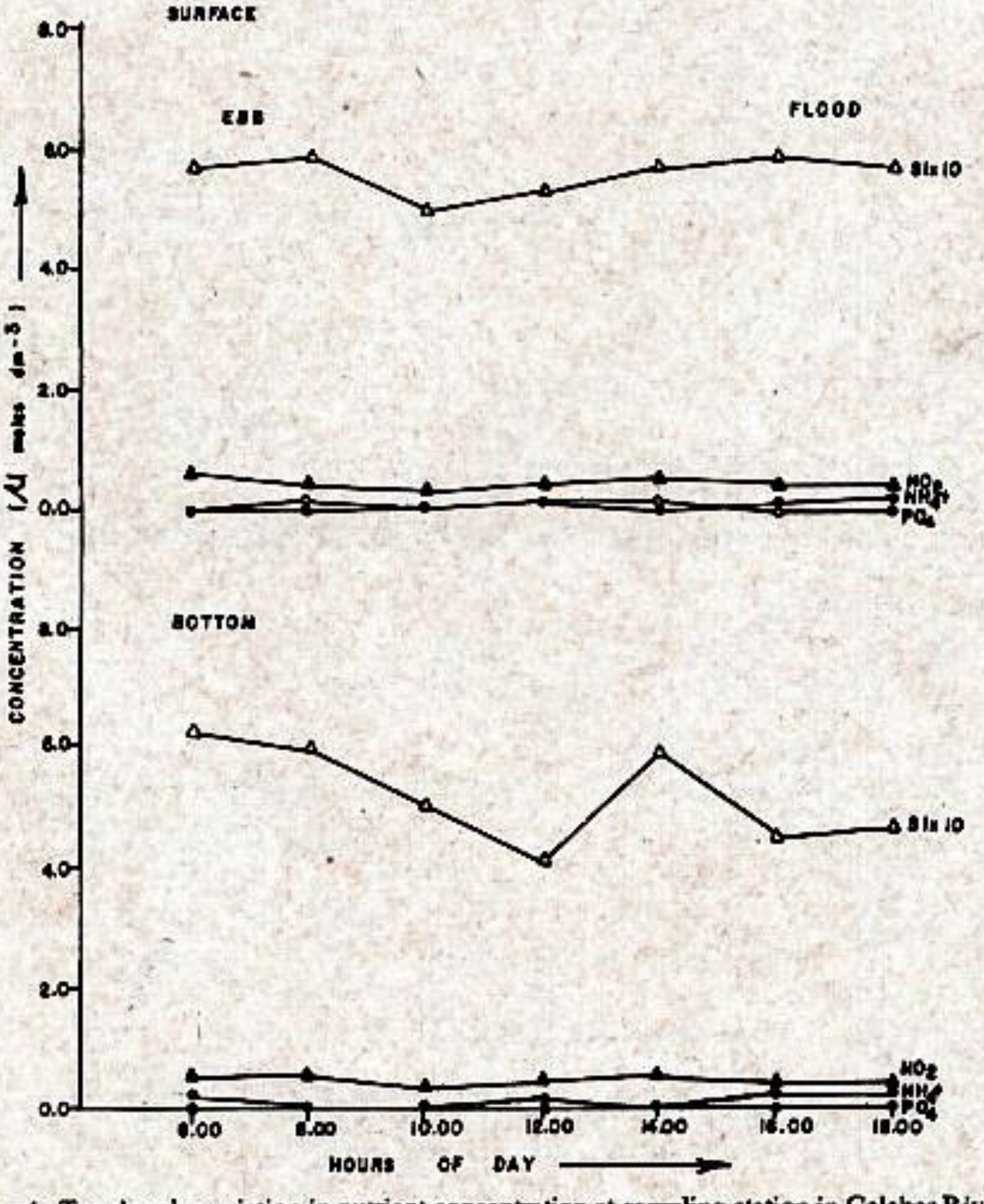

FIG. 4. Two-hourly variation in nutrient concentration at sampling station in Calabar River, May 1987.

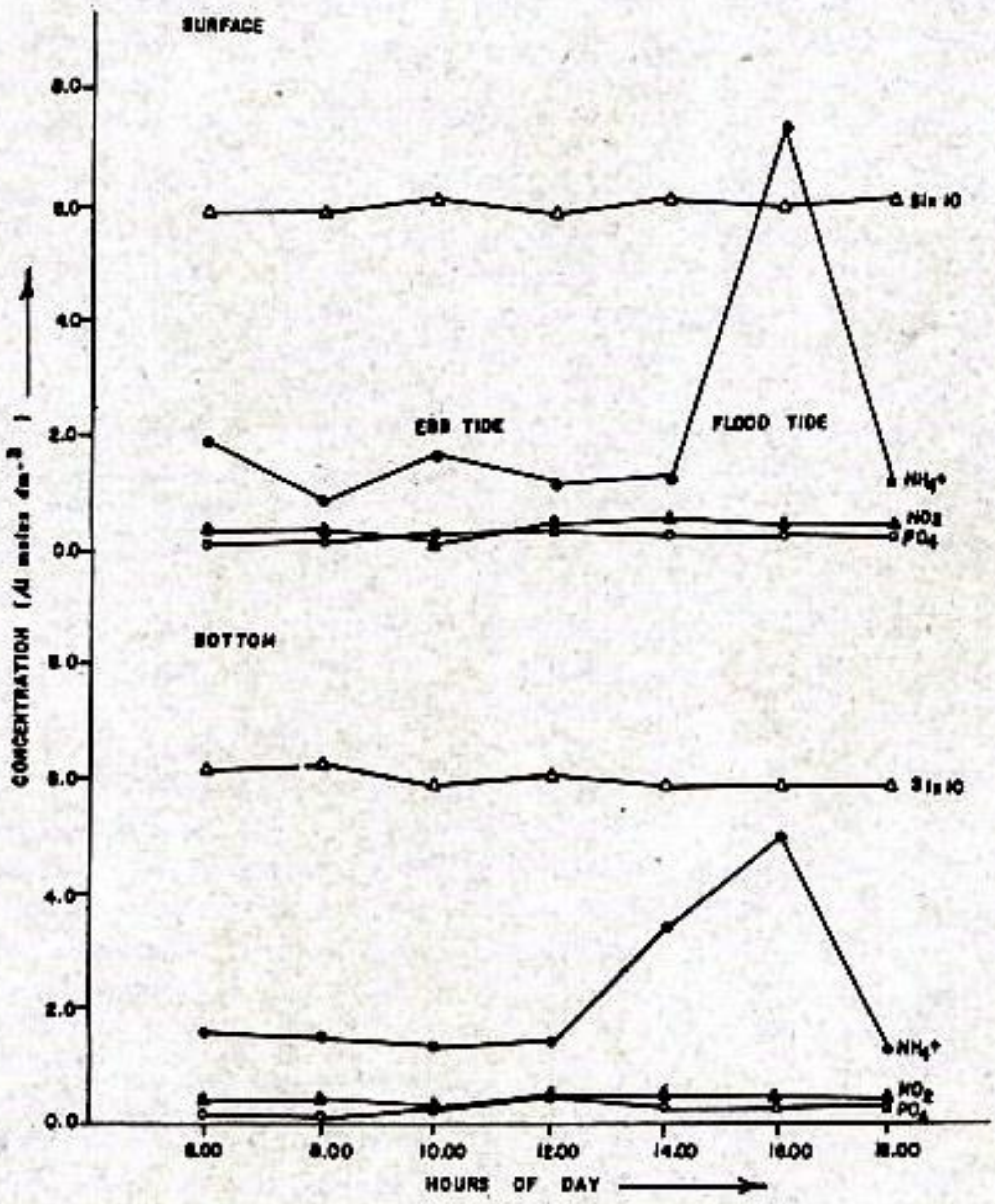

FIG. 5. Two-hourly variation in nutrient concentrations at the sampling station in Calabar River. June 1987.

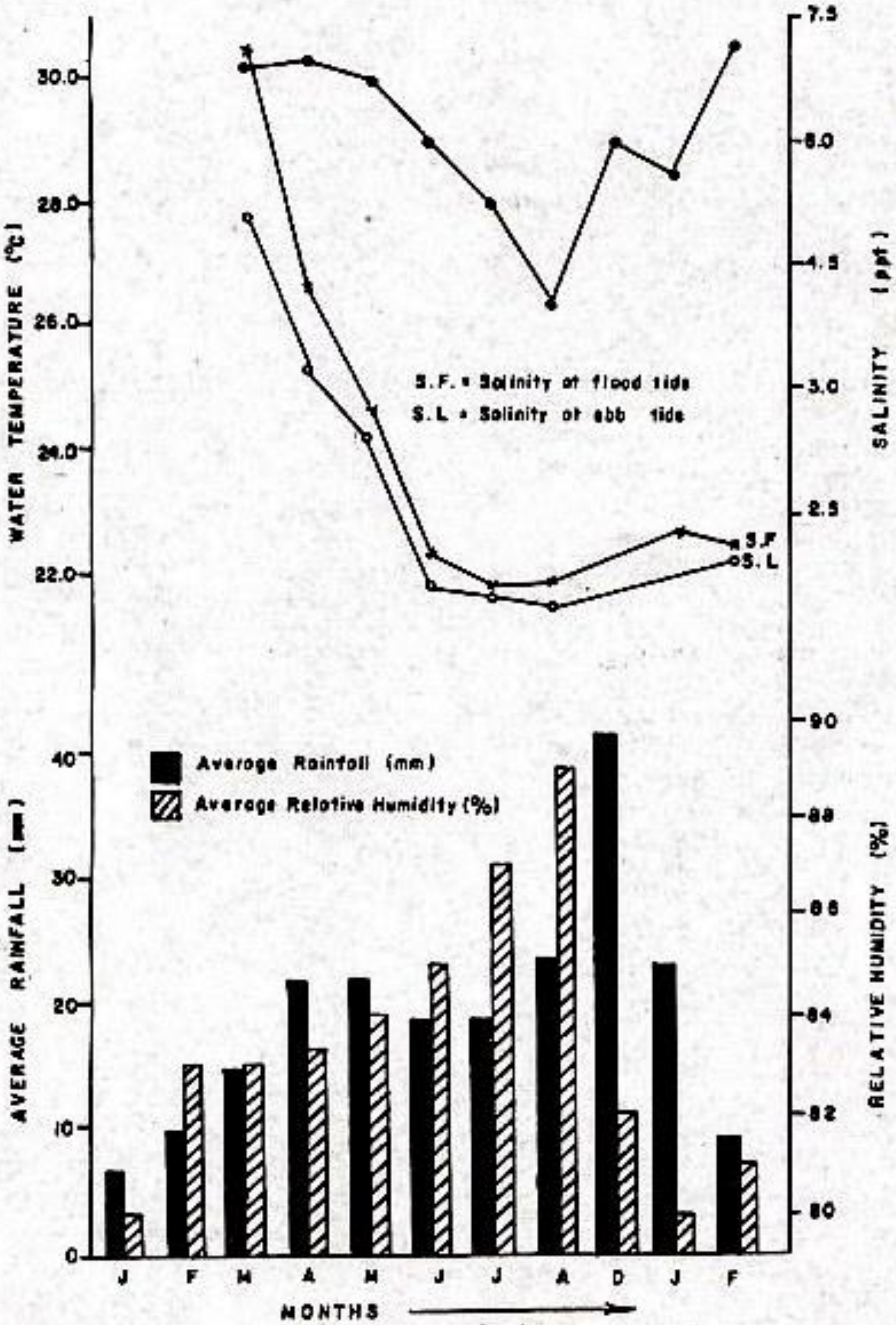

FIG. 6. Average monthly variation of meteorological data, salinity and water temperature during the survey period.

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