NIGERIAN INSTITUTE FOR OCEANOGRAPHY AND MARINE RESEARCH, LAGOS.

ISBN 978 - 2345 - 078

NIOMR TECH. PAPER No. 75

VARIATIONS IN THE PHYSICO-CHEMICAL FEATURES AND PHYTOPLANKTON OF THE NEW CALABAR RIVER AT ALUU, RIVERS STATE. NIGERIA

BY

EBERE S. ERONDU

AFRICAN REGIONAL AQUACULTURE CENTRE/NIGERIAN INSTITUTE FOR OCEANOGRAPHY & MARINE RESEARCH, PORT HARCOURT

AND

ALEX C. CHINDAH

INSTITUTE OF POLLUTION STUDIES, RIVER STATE UNIVERSITY OF SCIENCE & TECHNOLOGY, PORT HARCOURT.

DECEMBER 1991

ABSTRACT

The physico-chemical features and phytoplankton community of the upper reaches of the New Calabar river at Aluu were studied at high and low water slacks for a period of 12 months.

The water was acidic (pH 5.5 - 6.5) with low alkalinity (10 - 20mg $CaCO_3$ L^{-1}) and characteristically soft (total hardness ranging from 10 to 60mg $CaCO_3$ L^{-1}). There was obvious seasonal flux in the silica level, with dry season having higher values than wet season.

The phytoplankton was predominated by the diatoms which constituted more than 85% of the total phytoplankton population. The predominant taxa were *Melosira* sp. *Tabellaria* spp. *Surirella* spp. and *Navicula* spp. The phytoplankton density was significantly higher during the dry season than rainy season (Czekanowski's Coefficient. C_z = 0.332) but there was no significant difference between the high and low tide values (C_z = 0.66).

INTRODUCTION

Limited information is available on the water quality of the New Calabar river (Nwadiaro and Ezefili, 1986) especially as it affects its upper reaches. This paper deals with some physio-chemical features and phytoplankton of the river at Aluu. The use of Aluu as our sampling station is relevant because of its position as the transitional point between the swamp forest freshwater and the oligohaline stretches of the river; and also due to the use of the water (Aluu) as a point source for the new African Regional Aquaculture Centre fish farm. No detailed study on the effect of the tidal and seasonal influence on the hydro-chemistry and phytoplankton dynamics of the river has been conducted. This study is aimed at evaluating the physico-chemical and phytoplankton status of the river so as to give an insight into the quality of water (through the seasons) being received by the ponds and in addition provide information on the hydro-chemistry and phytoplankton of the river.

The Study Area

The New Calabar river is a black water type (RPT 1985) located in the Rivers State, Nigeria. It lies on the eastern arm of the Niger Delta and empties into some creeks and coastal lagoon bordering the Atlantic ocean (see Figs. I and II). At the source at Elele-Alimini the water is fresh and acidic but brackish and tidal at the mouth. Aluu is in the upstream part of the river, where the river is fresh and tidal. The climate of the area is characterised by a dry season during November to March and wet season during April to October with monthly average rainfall of 25.4cm.

MATERIALS AND METHOD

Sub-surface water samples were collected at high and low water slacks forthnightly from April, 1984 to March, 1985 for the physio-chemical and phytoplankton analyses. The water slacks represent the transition period between the high and low tides and at this time current velocity is near zero.

Samples for the physico-chemical analyses were collected with a Kemmrer bottle sampler and the analyses were carried out on the field. Water temperature was measured to the nearest 0.1°C with a mercury-glass thermometer. pH was measured with a 'Fisher Accumet - model 50' field pH meter while transparency was determined using a secchi disc. The dissolved oxygen content was determined by the Winkler method (Welch, 1948) while total alkalinity and hardness were determined with the Bausch and Lomb field titrimetric kit. The spectrophotometric determination of silica was done using the Bausch and Lomb mini spectronic 20 reagent system.

Phytoplankton samples were collected by filtering 100 litres of water sample through a 55µ mesh size plankton net. The filterate sample was washed into a collecting bottle and immediately fixed in 4% formalin. In the laboratory, the samples were allowed to stand for 48 hours before the supernatant was carefully pipetted off until a 50ml volume concentration was obtained. From a properly shaken sample, 1ml sub-sample was collected and transferred into a Sedgewick - Rafter counting chamber using a Stempel pipette. Identification and enumeration was done using a Leitz-Wetzlar binocular microscope at magnification between 40-400. For each sample, 3 replicates were counted.

Three indices were used to obtain the estimate of species diversity. These are (1) Taxa richness, S or number of genera present in a sample (2) Shannon-Wiener (1963) information function, H given by the equation:

$$H = -\sum_{i}^{s} pi \log pi$$

where pi is the proportion of the ith species in the sample, and (3) Equitability or evenness, E, given by Zuzas and Gibson's equation (cited in Sen Gupta and Kilbourne, 1974).

$$E = \frac{e^{\bar{H}}}{S}$$

S = number of taxa

E is only a measure of evenness and will have a maximum value of 1 when all species, regardless of their number are present in equal proportion (Sen Gupta and Kilbourne, 1974).

Correlation coefficient, r, was calculated for the physico-chemical parameters; and between the physico-chemical parameters and total phytoplankton to determine the relationships between the variables. Czekanowski's, C_z (Hellawell, 1978) was used to compute the level of similarities of the phytoplankton numbers at the different tides and seasons using the equation:

$$C_z = \frac{2W}{A + B}$$

where A = Sum of measures of sample A
B = Sum of measures of sample B
W = The sum of lesser measures of abundance common to both sample.

This coefficient has a maximum value of 1, the higher the value the more similar the sample under comparison. Student t- tests were also done to determine the differences between the high and low tide physico-chemical values.

The low phytoplankton density recorded is a feature of tropical black waters especially the black water types of the Niger Delta which are known to be less productive than other back water types (RPI, 1985). Other investigations have revealed this same low phytoplankton density and diversity (Hess et al, 1985; IPS, 1986 and Powell and Chindah, 1986). The general low abundance of phytoplankton in African black water types is associated with water colour, low pH and low concentration of inorganic ions (RPI, 1985; Adeniyi, 1986 and IPS, 1986). The limited resident time of the water system could also cause low phytoplankton density (Day, 1981) particularly because of the peculiar fast ebbing rate of the New Calabar - Bonny system (Dangana, 1985).

The three indices of diversity used (Shannon-Weiner diversity index, Evenness and taxa richness) show a comparatively low diversity of the phytoplankton. In other relatively rich systems the number of species exceed 400 while value of Shannon-Weiner range between 3.0 and 5.8 (Day, 1974). Nwadiaro and Ezefili (1986) reported low diversity of the algal flora in the New Calabar river and asserted that this resembled some of other Nigerian rivers already studied (RPI 1985; IPS 1990). Onuoha (1980) also reported low diversity (29 genera) of phytoplankton in the Bonny river. Seasonal and tidal variations were not shown in the taxa composition and diversity of the phytoplankton but these rather affected their abundance. The evenness values indicate a high degree of dominance of a few species as confirmed by four diatom general. The predominance of the Bacillariophyceae in the phytoplankton is a common feature of open lotic waters with fast currents (Egborge, 1974). In such waters the individuals of the genus *Melosira* are known to dominae as is the case in this study. The low occurence of the Cyanophyceae in number and diversity is in part due to the fast flowing nature of the river since these organisms thrive best in slow flowing to lentic water bodies.

The seasonal pattern of higher and lower densities of the total phytoplankton during the dry and wet seasons respectively agrees with the results of other investigators in tropical West Africa. Holden and Green (1960) found that during floods, high water levels dilute nutrient concentrations and phytoplankton numbers. Biswas (1966), Imevbore (1969), and Egborge (1974) have also shown this same increased nutrient level and the attendant high phytoplankton numbers during dry season. The greater day length during dry season than wet season is probably another reason for this seasonal pattern.

The negative significant relationship between temperature and transparency (r = 0.46) obtained in this study is possibly a result of the increased blocking effect of suspended matter on heat radiation with decreasing transparency. The radiated heat is stored more at the sub-surface layer with decreasing transparency.

Temperature was higher during the dry season; which also corresponds to the time of greater phytoplanktonic production, perhaps due to reduced flushing rate and increased nutrient. The evolution of more oxygen from greater phytoplanktonic activity may perhaps account for this temperature and D. O. relationship. The negative correlation of transparency with total hardness is at variance with the observation of Adebisi (1980) which indicated a close positive correlation between transparency and conductivity. The author adduced this relationship to increased adsorption of ions on suspended matter with increasing turbidity. For the New Calabar river, however, it may be that the ions (essentially, Mg^{2+}, HCO_3^-, CO_3^{2-}) exists predominantly in solution and not in very loosely adsorbed forms in suspended matter as reported in Adebisi (1980). Our study shows that a reduction in turbidity or increase in transparency would give inverse levels of temperature and hardness. The above related process is the likely reason for the positive significant relationship between temperature and hardness. At low transparencies which coincide with high hardness values, high temperatures are expected and achieved. The positive correlation of pH with silica is perhaps linked with the degradation of dead cells of diatoms which are sources of silica generation in waters. This degradation process is known to progress faster with increasing pH (Boyd and Lichktoplanton, 1979).

The positive correlation between alkalinity and total phytoplankton and also the latter and hardness is perhaps associated with the mineralization in the water system. Increase mineralization (i.e. increase in alkalinity and hardness) is known to boost phytoplankton production (Boyd, 1979) since there is increase level of free carbon dioxide used for algal photosynthesis. Moreover, alkalinity is regarded as a measure of productivity of natural waters and so its direct relationship with total phytoplankton is expected. The active utilization of silica by diatoms (which constitute the bulk of phytoplankton of the New Calabar river) for formation of their skeletal structure explains the positive relationship silica and total phytoplankton.

SUMMARY

Our results show that the New Calabar river at Aluu is soft, oligotrophic with low phytoplankton diversity. The phytoplankton is dominated by four genera of the bacillario-phyceae. Silica level and phytoplankton abundance had seasonal influence while no tide-related changes were observed in the physico-chemical properties and phytoplankton of the river. This could be attributed to the non-intrusion or negligible influence of brackishwater in the New Calabar river at Aluu; perhaps because Aluu is quite distant (about 60km) from the open sea and thus receives mainly freshwater inputs.

Although the presence of toxicants in the river was not determined in this study, available information (Erondu, 1983 and Erondu, unpubl.) shows that the water is suitable for acquatic life production. The acidity, softness and sub-optimal levels of other physico-chemical parameters and low productivity can be improved by liming and fertilization of ARAC ponds at Aluu which are currently in use.

ACKNOWLEDGEMENTS

We wish to acknowledge Dr ,C. S. Nwadiaro. Dr. D. D. Ibeibele and Mrs. G. C. Onuoha who corrected the script and also for their useful suggestions. Mr. E. C. Nduka is acknowledge for the statistical analyses and Mr. S. R. Tariah for typing the manuscripts. Finally, we are grateful to the Managements of Nigerian Institute for Oceanography and Marine Research (NIOMR/ARAC) and Institute of Pollution Studies, Rivers State University of Science and Technology for the funding and technical support.

TABLE 1: TOTAL PHYTOPLANKTON (No. of cells/ml of sample) of New Calabar River at Aluu April 1984-March 1985

TAXA	APRIL.		MAY		JUNE.		JULY		AUG.		SEPT.		OCT.		NOV.		DEC.		JAN.		FEB		MARCH	
BACILLARIOPHYCEAE	HWS	LWS	HWS	LWS	HWS	LWS	HWS	LWS	HWS	LWS	HWS	LWS	HWS	LWS	HWS	LWS	HWS	LWS	HWS	LWS	HWS	LWS	HWS	LWS
ASTERIONELLA	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.0	0	0	0.5	0
CYMBELLA	0	0	4	1	1.5	4.5	2	1	3	6	3	5	9	4.5	11	14.5	8.5	13.5	13	18.5	16	16	8.5	8.5
DIATOMA	2	0	1	0	4	3.5	0	0	0	0.5	0	0	0.5	0	3	0	1	0.5	10	2.5	10	1	15	3.5
EUNOTIA	0	0	0	2	0.5	1.0	0	2	1	3.5	0	2	7	11	1.5	10.5	0.5	7	6.5	9	7	12	3	4
COSCINODISCUS	5	2	3	0	6.5	1.5	2	0	0.5	1.5	1	0	2.5	0	5.5	0.5	10	2.5	24	5	28.5	7.5	23.5	6.5
CYCLOTELLA	3	0	3	0.5	1	0	0	0	1.5	0	0	6	2	0	8	3	8	3.5	11.5	5	17	4	7.5	1.5
FRAGILARIA	0	0	0	0.5	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0
GOMPHONEMA	0	0	0	0.5	0	0.5	0	0	0	1.5	0	1	0	3	1.5	0	3	0	9.5	0	13	0	7	0
MELOSIRA	218	104	33	15	51,5	20.5	2.1	15	14	11.5	38	27	182.5	43	194.5	80.5	201	94.5	218	72	340	70	311.5	83
NAVICULA	59	109	19.5	13	5	2	8	3	4.5	4.5	4	5	39.5	47	84.5	53	59.5	140.5	67	80.5	116.5	59	144	58
PLEUROSIGMA	23	0	9.5	5	9.5	1.5	8	0	6	2.5	8	10	11.5	2.5	19	5	30.5	0	44.5	5.5	46	11	32	7
PINNULARIA	0	17	0	1.5	3.5	2	1	0	1.5	0.5	0	2	2	10	5.5	15	8.5	19	6	2	14	5	2.5	1
SYNEDRA	6	8	2.5	3.5	1.5	3	2	0	1.5	1.0	4	4	0	3.5	1	0	3.5	0	[illegible]	0.5	13	5.5	12	6.5
SURIERELLA	17	21	3	5	12	9	11	6	9	3.5	3	0	55.5	12.5	7	22	.66	32	54.5	31.5	70.5	29	63	21
TABELLARIA	374	117	108	69	15	3.5	10	2	0	4.5	13	8	161	121.5	208.5	114	124	77.5	246.5	81	220	58.5	237.5	143
NITZSCHIA	2	0	2.5	1.0	2.5	0.5	0	0.	2	0.5	1	0	0	0.5	6	0.5	3.5	0	6	0.5	5	0.5	6	0
MERIDION	0	0	0	0	2	0	0	0	0	0	0	0	0	0.5	0.6	0	0	5	1.5	6.5	0	0	0	0.5
CYANOPHYCEAE																								
OSCILLATORIA	4	7	4.5	6.5	9	4	5	2	3	2	3	6	2	2	18.5	10.	24.5	24.	28	30	62	20	19	7.5
ANABENA	0	0	0	0	0	1	0	0	0	0	0	0	0	0	2.0	0	0.5	0	1	0	0	0	0	0
MARSSONIELLA	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SPIRULINA	0	0	0	0	1	0.5	1	1	0	0	0	0	0	0	3.5	1	2	1.5	0.5	0.5	5.5	1	0.5	0
CHLOROPHYCEAE																								
CLADOPHORA	0	0	1.5	2.5	0	0.5	0	0	0	0	0	0	0	0	1	0	0	3.5	0	2	0.5	0	0	0
SPIROGYRA	55	32	3	4	6	4	4	41	2	0.5	0	6	26.5	20.5	8	28	20	37	30	32.5	0	8	4	1.5
ULOTHRIX	0	0	2	5	0	0.5	0	0	0	0	0	0	0.5	1	0	2.5	4.5	3	0	1	1.5	0	0	0.5
COSMARIUM	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.5
ACTINASTRUM	0	1	0	0	0	0.5	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0.5	0	0
SCENEDESMUS	0	0	0	0	0	0	0	0	0	0	0	0	.0	0.5	0	1.5	0.5	0	0	0	0.5	0	0	0

HWS = High water slack

LWS = Low water slack

Table II: Mean Phytoplankton Diversity of the New Calabar River (April 1984 - March 1985). Number of Taxa (S), Shannon-Weiner's Diversity Index (D.I), High Water Slack (HWS), Low Water Slack (LWS).

Parameter	Zone	(S)	(D.I.)	Evenness
Total Phytoplankton	HWS	28	2.009	0.2761
	LWS	25	2.1208	0.3335
Bacillariophyceae	HWS	17	1.8086	0.3589
	LWS	16	1.8454	0.3957
Cyanophyceae	HWS	4	0.3844	0.3672
	LWS	3	0.2234	0.3126
Chlorophyceae	HWS	6	0.3879	0.2456
	LWS	6	0.4940	0.2731

Table III: The correlation Coefficient (r) Matrix for the Physico-chemical variables in New Calabar river (April 1984 - March 1985) * = significant value of $P \leq 0.05$

	Temperature	Transparency	D. O.	pH	Alkalinity	Hardness	Silica
Temperature							
Transparency	-0.4633*						
D. O.	0.4689*	-0.0527					
pH	0.1107	0.1125	0.1394				
Alkalinity	0.1047	-0.0367	0.23	0.3618			
Hardness	0.5554*	-0.4304*	0.1125	-0.0424	0.2466		
Silica	0.0235	0.0946	-0.0464	0.04862*	0.087	-0.1584	

Table IV: Correlation Coefficient (r) values of Total Phytoplankton and some Physico-chemical Parameters. (* = Significant value at $P \leq 0.05$)

Parameters	Calculated r
Total Phytoplankton and Temperature	0.2573
Total Phytoplankton and Transparency	-0.1752
Total Phytoplankton and D. O	0.2934
Total Phytoplankton and pH	0.3861
Total Phytoplankton and Alkalinity	0.4633*
Total Phytoplankton and Hardness	0.4751*
Total Phytoplankton and Silica	0.4554*

REFERENCES

Adebisi, A. A. 1980. The physico-chemical hydrology of a tropical season river - Upper Ogun, Nigeria. - *Hydrobiologia*, 79: 157-165.

Adeniyi, I. F. 1986. The ecology of Bonny estuary: Chemical composition of rivers and creeks. Paper presented at Man and Biosphere Workshop on Wetlands of Port Harcourt. 25pp.

APHA, 1985. American Public Health Association. *Standard methods for the examination of water and waste water*. 13th edn. New York p. 1043.

Biswas, S. 1966. Phytoplankton of Opi Lake, Anambra State of Nigeria *Verh. International Verein. Limnol.*, 22: 1180-1184.

Boyd, C. E. 1979. *Water quality in warmwater, fish ponds*. Auburn University, Alabama. 359pp.

Boyd. C. E. and F. Lichtkoppl. er, 1979. *Water Quality management in pond fish culture*. Research and development series No. 22. Project: AID/DSAN-9 0039. Auburn University, Alabama. 30pp.

Dangana, L. B. 1985. Hydro Geomorphological controls of the mangrove environment in parts of the Rivers State. *Proceedings of the Mangrove ecosystem of the Niger Delta Workshop. eds. B. H. R. Wilcox and C. B. Powell*. pp. 6-23.

Day, J. H. 1974. The econology of Mourrumbere estuary. In: Day. J. H. 1981. *Estuarine ecology with particular reference to S. Africa*. A. A. Balkema pub., Netherlands. p. 307.

Day, J. H. 1981. *Estaurine ecology with partieular reference to S. Africa*. A. A. Balkema pub., Netherlands. 411pp.

Egborge, A. B. M. 1974. The seasonal variation and distribution of phytoplankton in the River Oshun. Nigeria. *Freshwater Biol.*. 4: 177-191.

Erondu, E. S. 1983. Tidal and seasonal influence on the physico-chemical conditions of the New Calabar river at Aluu. M. Tech, thesis of Rivers State University of Science and Technology, Port Harcourt, 123pp.

Hellawell, J. M. 1978. *Biological surveillance of Rivers*. A. biological monitoring hand book. Water Research Centre. Elder way. England. 332pp.

Hess, S., P. Dunchan and C. B. Powell. 1985. *Plankton of the Niger Delta*. Paper presented at the Nigerian National Petr. leum Company conference, in Kaduna. pp. 1-15.

Hill. B. J. 1966. A contribution to the econoly of Umlalazi estuary. *Zool. Afri.*, 2: 1-24.

Holden, M. J. and J. Green, 1966. The hydrology and plankton of the River Sokoto. *J. Animal Ecol.*, 29: 65-84.

Imevbore, A. M. A. 1969. Planktonic algae of Eleiyele reservoir, Nigeria. *Nig. Journal of Sci.*, 2: 85-90.

IPS, 1986. Institute of Pollution Studies, Port Harcourt (Nigeria), Oshika Oil Spill (NAOC pipe line): Environmental Impact Assessment. Report No. RSUST/IPS/R/86 102: 1-178.

Nwadiaro and Ezefili, 1986. A preliminary checklist of the phytoplankton of New Calabar river, lower Niger Delta. *Hydrobiological Bulletin*, 19 (2): 133-138.

Nwadiaro, C. S. and S. N. Umuham, 1985. The chemical hydrology of Oguta Lake, Imo State, Southern Nigeria. *Arch. Hydrobiol.*, 105(2): 251-269.

Onuoha, G. C. 1980. Phytoplankton and oil pollution in Bonny River, Nigeria. M.Sc. Thesis, University of Port Harcourt, Nigeria. 79pp.

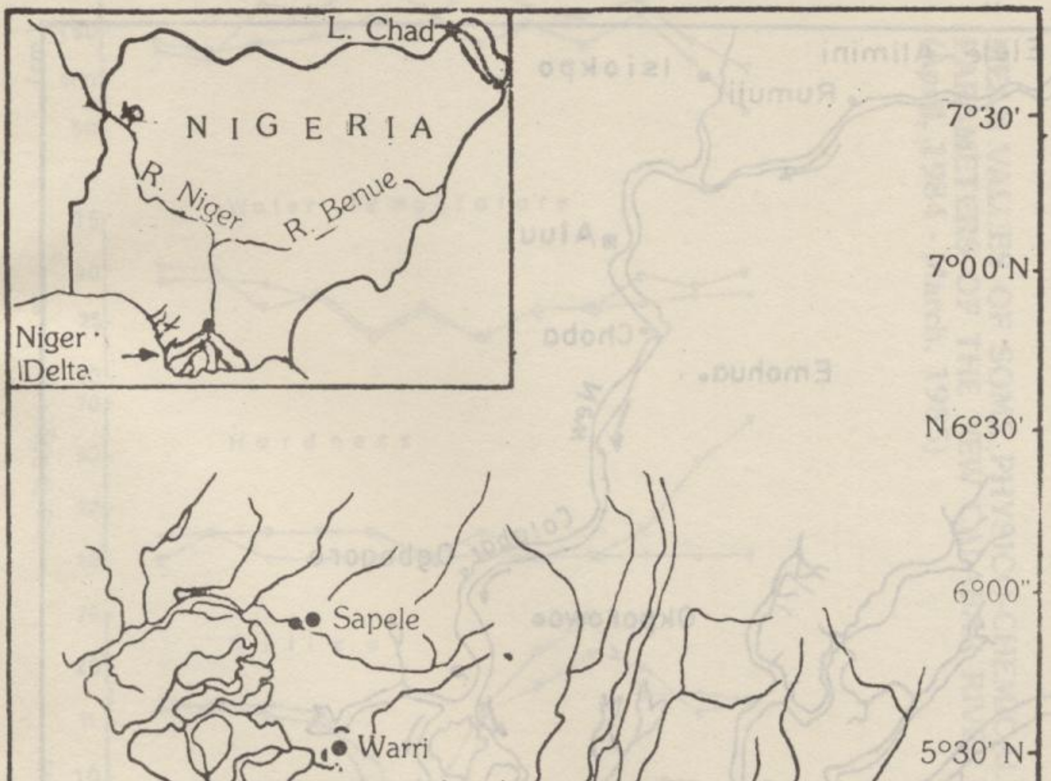
Powell, C. B. and A. C. Chindah, 1986. Variations in phytoplankton communities and densities along the middle and upper reaches of the Bonny/New Calabar estuary. Paper presented at the Man and Biosphere Workshop on Wetlands of Port Harcourt. 20pp.

RPI, 1985. Research Planning Institute, Inc. Columbia, USA. *Environmental baseline studies for the establishment of control criteria and standards against petroleum related pollution in Nigeria.* Report No. RPI/R/84/4/15-7.

Sen Gupta, B. K. and R. T. Kilobourne, 1974. Diversity of Benthic Formilifera on the Georgia Continental Shelf. *Geological Society of America Bulletin*, V. 85, p. 969 - 972.

Shannon, C. E. and W. Weiner, 1963. The mathematical thory of communication, University of Illionois Press, Urbana 360pp.

Fig. 1: MAP OF THE LOWER NIGER DELTA SHOWING THE POSITION OF THE STUDY AREA



KEY

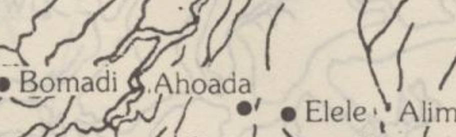
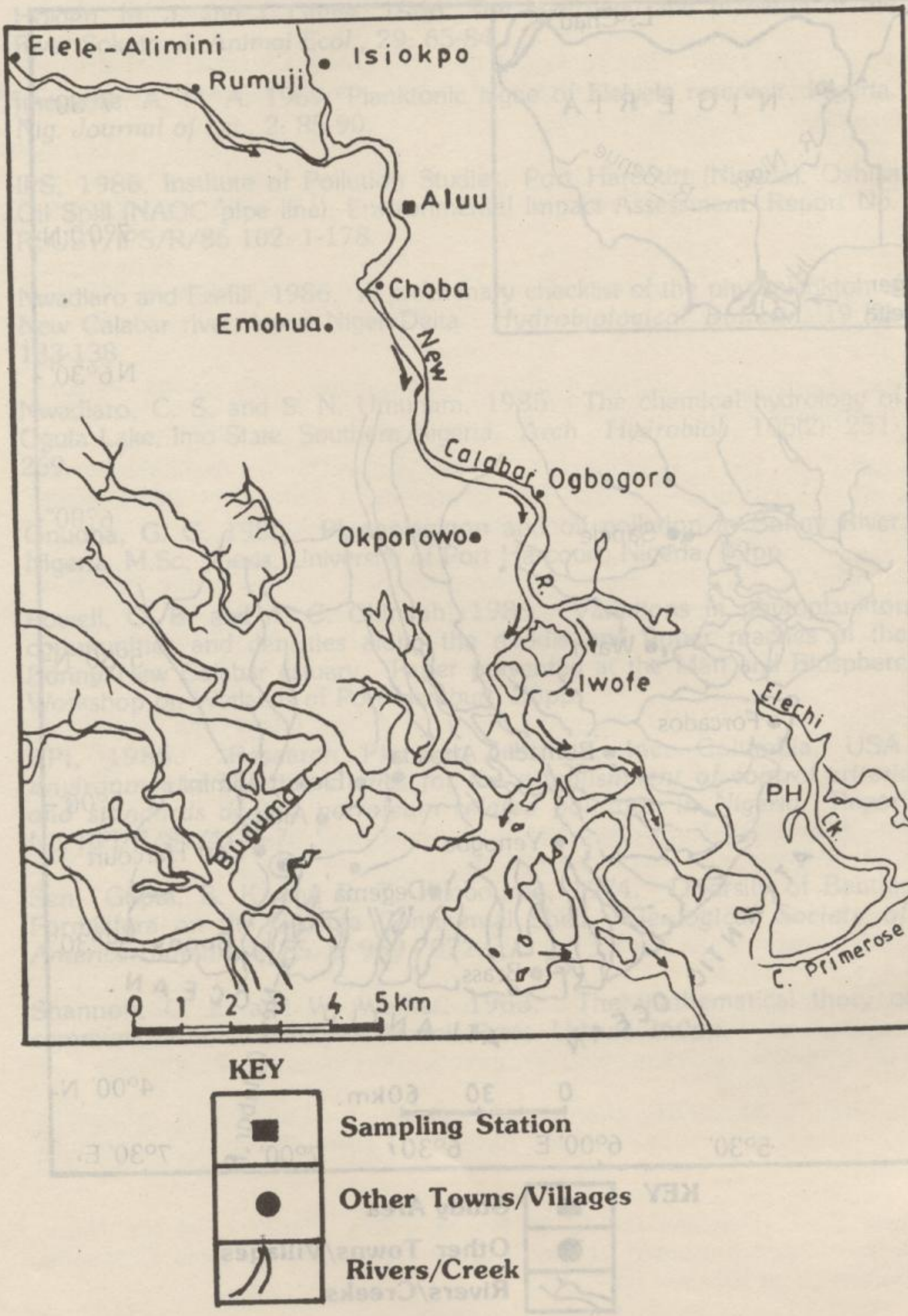


Fig. 2: **MAP OF THE NEW CALABAR RIVER SHOWING SAMPLING STATION**



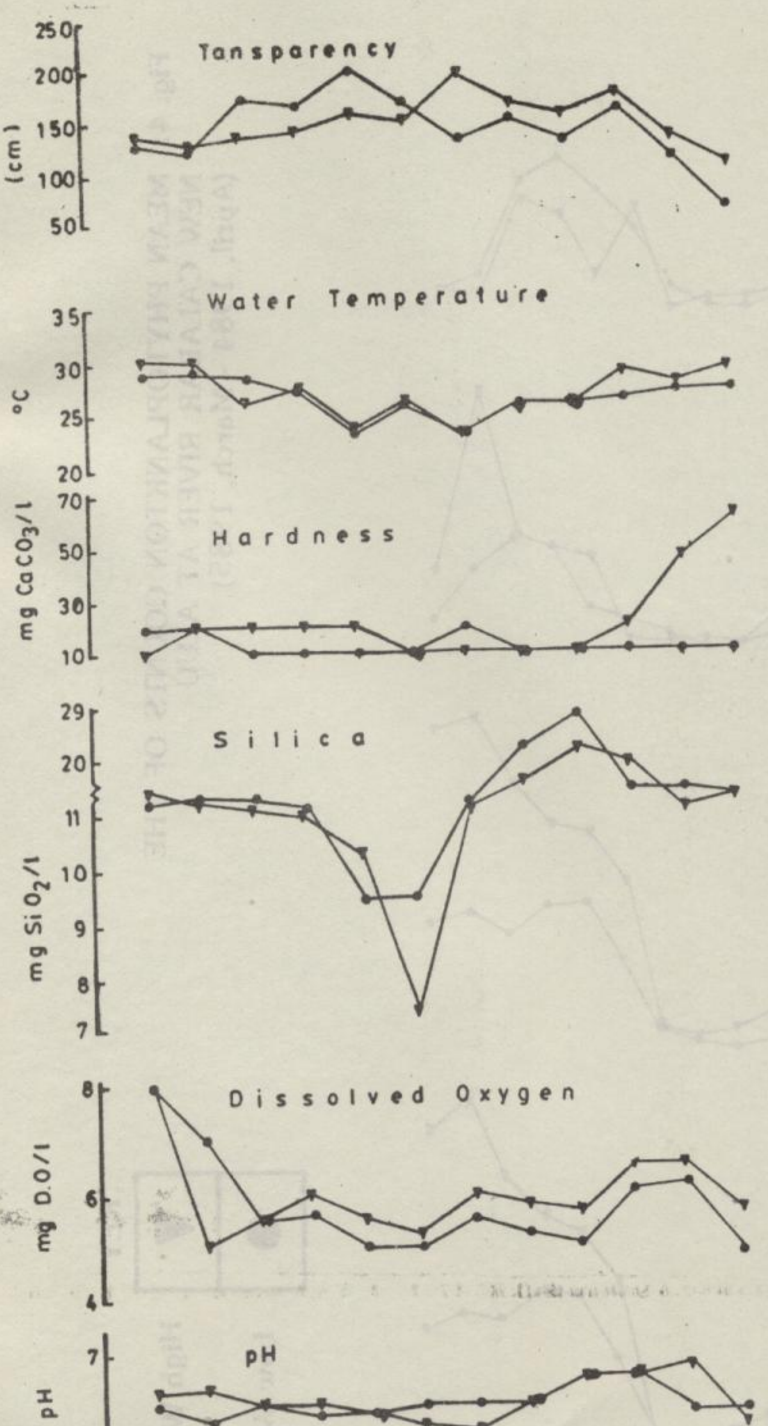


Fig. 3: MEAN VALUES OF SOME PHYSICO-CHEMICAL PARAMETERS OF THE NEW CALABAR RIVER AT ALUU (April, 1984 - March, 1985)

KEY

▼ High Water Slack

● Low Water Slack

Fig. 4: MEAN PHYTOPLANKTON COUNTS OF THE NEW CALABAR RIVER AT ALUU (April, 1984 - March, 1985)

KEY

▼	High Water Slack
●	Low Water Slack