GLOBAL JOURNAL OF AGRICULTURAL SCIENCES VOL. 4, NO. 2, 2005: 139 - 148
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SOME ASPECTS OF THE PHYSICO-CHEMICAL AND BIOLOGICAL PROPERTIES OF CROSS RIVER, AN INLAND WATER BODY IN SOUTH-EASTERN NIGERIA.

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(Received 6 February, 2004; Revision accepted 10 June, 2005)

ABSTRACT

Some aspects of Physico-chemical and Biological properties of Cross River were investigated once every month from May 2001-May 2002. Measurements were made from the surface water at three locations, Ikot Okpora in Biase, Obubra, and Ikom. The temperature of the river varied from27.38±0.74°C at Ikot Okpora to 27.79±0.49°C at Ikom, the highest temperature of 29.3°C was recorded in the month of December at Obubra, while the lowest temperature of 25.9°C was recorded at Ikot Okpora in March. The Biochemical oxygen demand fluctuate widely and varied from 1.23±0.35mg/l at Ikot Okpora to1.21±0.26mg/l at Ikom, the highest BOD of 1.80mg/l was recorded at Ikot Okpora, in the month of April, while the lowest BOD of 0.70mg/l was recorded at Ikom in May. The pH varied from 6.63±0.31 at Ikot Okpora to 6.79±0.56 at Ikom, the highest pH of 7.89 was recorded at Ikom, in the month of September, while the lowest pH of 5.17 was recorded at Obubra in November. Dissolved oxygen concentration varied from 4.8±0.02 at Ikot Okpora to 5.02±0.50 at Ikom, the highest DO_2 of 5.9mg/l was recorded at Ikom and Obubra, in the month of March and November respectively, while the lowest DO_2 of 4.3mg/l was recorded at Ikom and Obubra in December and January respectively. The electrical conductivity varied from 69.13±18.37 µS/cm at Ikot Okpora to 322.28±248.40µS/cm at Ikom, the highest conductivity 710.4µS/cm was recorded at Ikom, in the month of February, while the lowest conductivity of 20.01µS/cm was recorded at Ikot Okpora in September. TSS varied from 18.62±6.12mg/l at Ikot Okpora to 39.85±23.66mg/l at Ikom, the highest TSS of 75.0mg/l was recorded at Ikom, in the month of November, while the lowest TSS of 11.0mg/l was recorded at Ikot Okpora in January. Turbidity varied from 20.31±5.31 FTU at Ikot Okpora to 21.12±14.31 FTU at Ikom, the highest turbidity of 29.0FTU, was obtained during June at Obubra, while the lowest of 10.0FTU occurred in Ikom in April, Total Alkalinity varied from100.68± 22.93 at Ikot Okpora to 119.38± 27.05 at Ikom, the highest alkalinity of 181.0mg/l was obtained during February at Obubra, while the lowest of 10.8mg/l occurred at Ikom in June. Total hardness varied from 52.25± 18.92 at Ikot Okpora to 47.48± 23.02 at Ikom, the highest value of 91.06mg/l was recorded at Ikom in the month of March while the lowest value of 12.83mg/l was recorded at Ikot Okpora in the month of April. The river had high level of nutrients, phosphate varied from 0.11±0.08mg/l at Ikot Okpora to 0.202±0.13mg/l, the highest value of 0.362mg/l was recorded at Ikom in the month of September, while the lowest level of 0.006mg/l was recorded at the three stations in April. Nitrate varied from 0.37±0.39mg/l to at Ikot Okpora to 1.01±0.69mg/l the highest value of 3.14mg/l was recorded at Obubra in March, while the lowest value of 0.8mg/l was recorded at Biase in the month of June. Silicate varied from 1.60±0.71mg/l at Ikot Okpora to 2.39±1.38mg/l at Ikom, colour (89.0-247.0, 78 0-199.0, 87.0-287.0) mg/l, at Ikom, Obubra and Ikot Okpra respectively. The major ions fluctuate widely between February and May, highest value was recorded in February and lowest in May, Calcium varied from14.06±5.27 at Ikot Okpora to 24.28±4.0 at Ikom, the highest value of 30.78mg/l was recorded at Obubra during the month of February, while the smallest value of 9.17mg/l was recorded at Ikot Okpora during the month of May. Chloride varied from 24.77±0.0 at Ikot Okpora to 93.92±62.30mg/l at Ikom, the highest value of 40.65mg/l was recorded at Obubra during the month of January, while the smallest value of 10.65mg/l was recorded at Ikom during the month of May. Sulphate varied from4.53±0.0mg/l at Ikot Okpora to 10.54±9.78mg/l at Ikom, the highest value of 38.34mg/l was recorded at Ikom during the month of February, while the smallest value of 0.9mg/l was recorded at Ikom during the month of May. Ammonium varied from 0.42± 0.14mg/l at Ikot Okpora to 0.84± 0.47mg/l at Ikom, the highest value of 1.89mg/l was recorded at Ikom during the month of July, while the smallest value of 0.287mg/l was recorded at Ikot Okpra during the month of April. Metal fluctuated widely in the river, Copper varied from 0.71±1.0mg/l at Ikot Okpora to 2.06±2.36mg/l at Ikom, the highest value of 6.28mg/l was recorded at Obubra during the month of February, while the smallest value of 0.02mg/l was recorded at Obubra during the month of April. Iron varied from 10.54±1.92mg/l at Ikot Okpora to 0.202±0.13mg/l at Ikom, the highest value of 13.15mg/l was recorded at Ikot Okpora during the month of February, while the smallest value of 0.196mg/l was recorded at Obubra during the month of April. Phytoplankton was represented by five families: Chlorophyceae, Dinophyceae, Cyanophyceae, Cryptophyceae and Chrysophyceae. *Dictyosphaerium sp* in the family Cryptophyceae dominated the Phytoplankton with value of 17,780cells/ml at Obubra, 213,815cells/ml at Ikot Okpora and 295,185cells/ml at Ikom, and the lowest number recorded was *Tetraedron sp* with 580cells/ml at Obubra, 567cells/ml at Ikot Okpora, and 956cells/ml at Ikom. Zooplankton was dominated by ciliata, *Tintinnopisis sp*, with value of 4,65,00cells/ml, 2,500,650cells/ml, and 5,356,000cells/ml for Obubra, Ikot Okpora, and Ikom respectively and the Zooflagellate, *Collodictyon tricilliatum* with value of 2,330,000cells/ml, 678,000cells/ml, and 4,105,000cells/ml for Obubra, Ikot Okpora, and Ikom respectively, while the copepod (*Naupili*) with value of 400cells/ml, 567cells/ml, 375cells/ml for Obubra, Ikot Okpora, and Ikom respectively represent the least zooplankton species, Ten bacterial species: *Aeromonas sp., Vibrio sp., Acinetobacter sp., Moraxella sp., Streptococi sp., Corynebacterium sp., Bacillum sp., Neisseria sp., Pseudomonas sp, and Micrococcus sp.,* were enumerated . *Corynebacterium sp and Vibrio sp* are the most dominant species with value of 9.6x10104cells/ml each. Biase is the most endemic area.

KEY WORDS: Physico- Chemical studies, Biological studies, Cross River, Inland Water, Nigeria.

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Table 1: summary of physico-chemical parameters of the cross river at three locations (Ikom, Obubra, and Biase)

S/N	Physico-Chemical parameter	Location	Range	Mean ± S.D
1	Temperature (°C)	Ikom Obubra Biase	27.3-28.9 27.1-29.3 25.9-28.8	27.79±0.47 27.89±0.75 27.38±0.74
2	Ph	Ikom Obubra Biase	6.00-7.89 5.17-6.80 6.10-6.92	6.79±0.56 6.19±0.42 6.63±0.31
3	Dissolved oxygen (mg/l)	Ikom Obubra Biase	4.3-5.9 4.3-5.9 4.6-5.2	5.02±0.50 4.89±0.45 4.79±0.17
4	Biochemical Oxygen Demand (mg/l)	Ikom Obubra Biase	0.70-1.40 0.83-1.60 0.80-1.80	1.09±0.21 1.21±0.26 1.23±0.35
5	Total Suspended Solid (mg/l)	Ikom Obubra Biase	10.0-75.0 13.0-29.0 11.0-27.00	39.85±23.66 22.12±5.60 18.62±6.12
6	Turbidity (FTU)	Ikom Obubra Biase	10.0-23.0 15.0-29.0 11.0-31.0	21.12±14.31 23.69±3.97 20.31±5.31
7	Total Alkalinity (mg/l)	Ikom Obubra Biase	10.8-180.0 54.0-181.0 40.0-120.3	119.38±27.05 120.77±40.10 100.68±22.93
8	Total Hardness (mg/l)	Ikom Obubra Biase	22.44-91.06 16.03-17.70 12.83-76.95	47.48±23.02 59.77±35.24 52.25±18.92
9	Conductivity (µS/cm)	Ikom Obubra Biase	32.0-710.4 49.99-118.2 20.01-314.0	322.28±248.40 83.28±25.84 69.13±18.37
10	Colour (mg/l)	Ikom Obubra Biase	89.0-247.0 78.0-199.0 87.0-287.0	146.77±44.56 152.77±37.67 175.77±63.77
11	Calcium (Ca^{2+}) (mg/l)	Ikom Obubra Biase	16.03-34.15 12.82-30.78 9.17-23.08	24.28±4.00 20.76±5.76 14.06±5.27
12	Chloride (Cl^-)(mg/l)	Ikom Obubra Biase	10.65-210.0 16.55-40.65 14.15-113.6	93.92±62.30 29.78±8.14 24.77±0.0
13	Sulphate (SO_4^{2-}) (mg/l)	Ikom Obubra Biase	0.99-38.34 2.31-8.5 2.13-15.48	10.54±9.78 4.82±2.15 4.53±0.0
14	Magnesium (Mg^{2+}) (mg/l)	Ikom Obubra Biase	0.783-13.88 0.781-15.76 0.783-13.15	5.73±4.64 3.56±5.14 9.14±21
15	Copper (Cu^{2+}) (mg/l)	Ikom Obubra Biase	0.032-6.24 0.020-6.28 0.031-3.20	2.06±2.36 1.05±0.10 0.7084±1.0
16	Ammonium (NH_4^+) (mg/l)	Ikom Obubra Biase	0.292-1.89 0.294-0.820 0.287-0.825	0.84±0.47 0.60±0.17 0.42±0.14
17	Nitrate (NO_3^-) (mg/l)	Ikom Obubra Biase	0.16-2.76 0.08-3.14 0.095-1.14	1.01±0.69 0.97±0.99 0.3742±0.39
18	Silicate (SiO_2) (mg/l)	Ikom Obubra Biase	0.767-4.210 0.801-4.768 0.701-2.326	2.39±1.38 2.07±1.39 1.60±0.71
19	Phosphate (PO_4^{3-}) (mg/l)	Ikom Obubra Biase	0.006-0.362 0.006-0.288 0.006-0.221	0.202±0.13 0.149±0.11 0.11±0.08
20	Iron (Fe^{3+}) (mg/l)	Ikom Obubra Biase	0.201-1.800 0.196-1.408 0.783-13.15	0.708±0.50 0.77±0.61 10.54±1.92

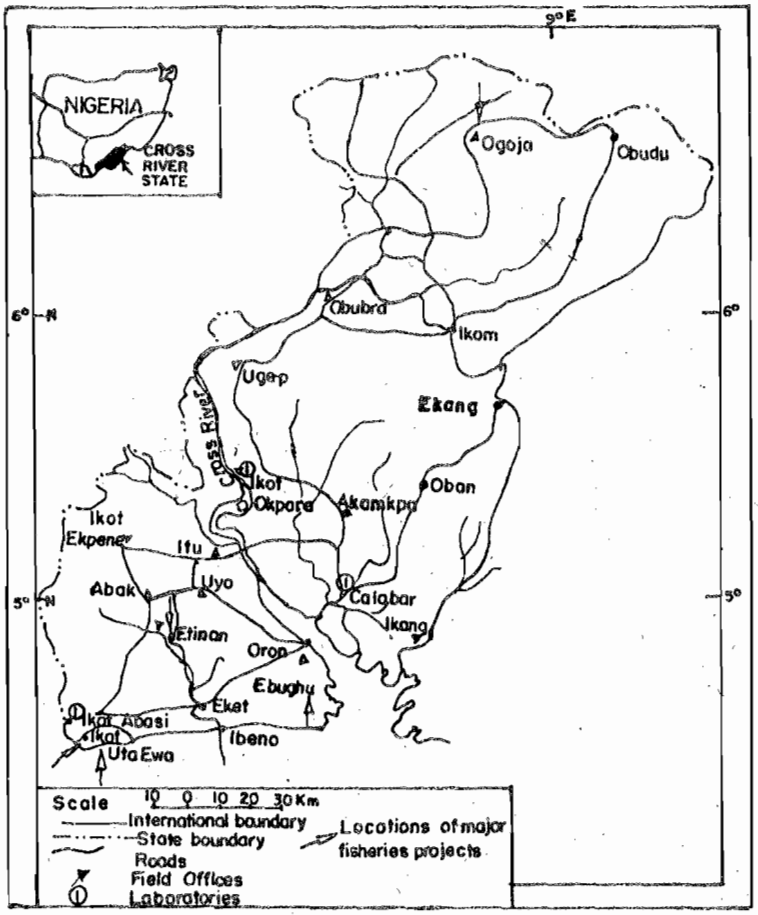


Figure 1: Map of Cross River State showing the sampling locations at Ikot Okpora in Biase, Obubra and Ikom.

INTRODUCTION

Knowledge of the physico-chemical and biological characteristics of a water body is very important in assessing its productivity and its value (Adebisi 1981). Present by much concern is focused on ascertaining the quality of the environment associated with increased human activities. The advancement in science and technology is associated with environmental problems, which required both local and international attention (Asuquo 1999). Rivers and streams impinge on the atmosphere and on land at their edge and it is across these boundaries that movement of materials and energy take place. Materials that enter the river channel from the atmosphere are gases and water. Man-made inputs into the aquatic environment include agricultural discharges from farms, pesticide spillage, industrials effluents from sewage treatment plants, direct industrial discharge and land drainage (Lloyd, 1992).

A further input of materials from the terrestrial system takes the form of dead organic matter of plant and animals origin. This may be blown or washed or fall into the river channel. Other factors that will influence the characteristics of a water body include type of soil over which the water flows, vegetation cover over the watershed, presence or absence of logging activities, and metal mining within the vicinity (Svobodova *et al*, 1993).

Dickens and Graham (2002) Stated that the assessment of biota in rivers is a widely recognized means of determining the condition or health' of rivers. Benthic macro invertebrates, in particular, are recognized as valuable organisms for bioassessments. The physico-Chemical factors influence vertical and horizontal migration of organisms, their distribution and feeding regime (Adeniyi, 1978).

Many chemicals are soluble in water, some rapidly and others over long periods. As there is such a huge volume of water on the planet, and much has been present for a substantial period of time, contemporary water bodies contain many chemicals in solution. The principal sources of solutes are minerals and rocks with which water is in contact. If these minerals contain sodium chloride it leaches into water and makes it salty. Similarly, if underlying rock strata contain calcium salts, this leach out into solution, increasing calcium ic ' content. Many works have been done on the Physico-chemical and biological parameters of natural lake in Nigeria, which include Lake Asejire (Egborge, 1979), Oguta Lake (Nwadiaro & Umeham, in press), Lake Chad (Umeham, 1989) Reservoir (Imevbore, 1967; Onuoha 2001). Other similar work on the physico-chemical and biological parameters of rivers in Nigeria include Ogun River (Adebisi 1981), Calabar River (Asuquo 1999), and Cross River estuary system (Akpan 1998).

The Cross River estuary system has remained the richest sources of inland fisheries in Nigeria (Akpan 1998). This study is an investigation of the physico-chemical and biological characteristics of the Cross River.

STUDY AREA

The Cross River system is located at 7° 30' – 10° 00' E and 4° 00' -8° 00' N (Figure 1). The Cross River covers an area of 54, 000km^2, 39, 500km^2 of which lie within Nigeria and 14,500km^2 in the Republic of Cameroon. The river is subject to seasonal flooding, the flood occurring between July and October. The total area liable to flood in Cross River basin is 8,303km^2 and Cross River estuary is relatively highly productive in term of primary and secondary production (Moses 1980). There is a high dependence on tertiary production that militates against the optimal exploitation of the estuary, because low net energy output is realized at high tropic level (Nawa, 1980).

MATERIALS AND METHODS

The physico-chemical and biological properties of Cross River were monitored monthly from May 2001 to May 2002 at three locations: Ikom (Northern zone), Obubra (central zone) and Ikot Okpora in Biase (Southern zone) (Figure 1). At each location a water sample was collected in a clear one litre plastic container and stored in a cool box until analysis.

The analysis was carried out within 24 hours of sampling at the Environmental Laboratory, Institute of Oceanography, University of Calabar, Nigeria. The water temperature was taken at the point of sampling using mercury-in- glass thermometers. All temperature readings were recorded to the nearest 0.1°C. pH was measured using a digital pH meter (Mettle Toledo 320). DO_2 was measured using a digital, dissolved oxygen meter (Jenway 9071); BOD was determined as the difference between initials and final dissolved oxygen after incubation for 5 days at room temperature (27°C). Turbidity and Total suspended solid (TSS) were measured spectrophotometrically at 450nm and 810nm respectively.

Total Hardness, Total alkalinity, silica, colour were analyzed using "HACH" portable Laboratory test kits. A "HACH" conductivity meter (Model 16300) was used for the conductivity measurement. The minerals, Calcium and Magnesium were analyzed using standard methods as described by American Public Health Association (1989). Nitrate, ammonium, silicate and phosphate were determined using conventional colorimetic methods (APHA, 1980). Iron (Fe) was determined by O-phenanthroline method (APHA 1980). Identification and enumeration of biological parameters were performed with the aid of Zeis inverted plankton microscope.

RESULT AND DISCUSSION

A summary of the physico-chemical parameters of the Cross River at three locations (Ikom, Obubra, and Biase) is presented on Table 1, and the level of variation are presented in figure 2A-C. The lowest temperature was recorded at Biase (25.9°C) whereas the highest was recorded at Obubra (29.3°C). There was no significant difference in the mean temperature over the three locations.

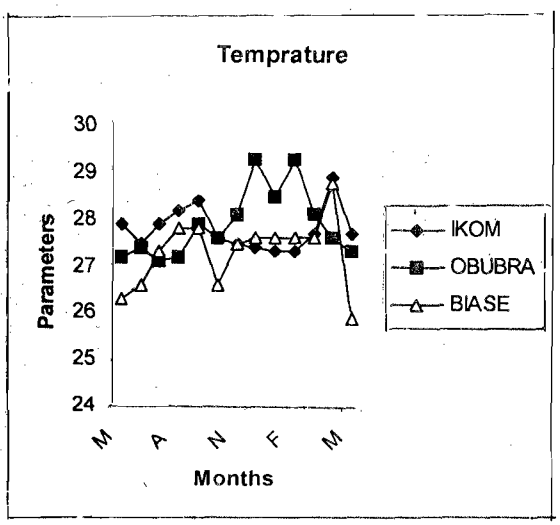
The pH was slightly acidic in both Obubra (range 5.17-6.80) and Biase (range 6.10-6.80) whereas it ranged from being slightly acidic to being slightly basic (6.00-7.89) at Ikom. The result of present study agreed with the work of Adebisi (1981) who reported that the pH of River Ogun ranged between 6.9-7.9, he said further that the water was more alkaline (pH 7.6-7.9) between May and July. Similar results were reported by Baijot *et al* (1997) who observed neutral or slightly alkaline in pH values in Tapoo Reservoir in Burkina Faso. Onuoha (2001) observed that pH fluctuated from acidic to alkaline in a new concrete reservoir in Umudike Eastern Nigeria and claimed that it was adequate for fish production.

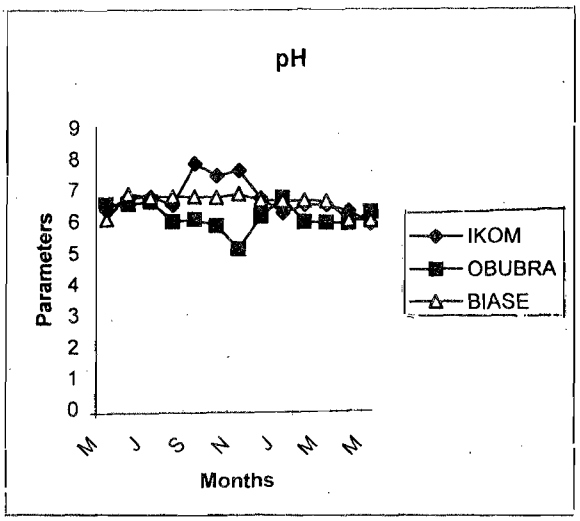
Peak DO_2 occurred in March, August and September while lowest value was recorded in May and July. The dissolved oxygen ranged from 4.3mg/l- 5.9mg/l in Ikom and Obubra and from 4.6mg/l-5.2mg/l at biase, Adebisi (1981), recorded 4.94mg/l – 5.10mg/l for Ogun River, while Asuquo (1999) stated that the dissolved oxygen concentration content of Calabar river ranged from 2.40mg/l to7.mg/l with low oxygen levels at ebb tide and high levels at flood tide. Duodoroff and Fry (1959), recommended 5mg/l for warm water fish species.

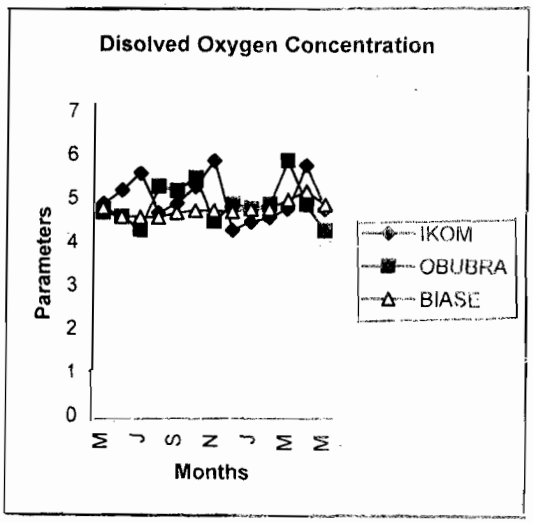
The Biochemical Oxygen Demand averaged 1.09±0.3 at Ikom and 1.21±0.26 and 1.24±0.35 at Obubra and Biase respectively. The total suspended solids ranged from 10-75 with a mean of 39.85±23.66 at Ikom; 13-29 with mean of 22.12±5.5982 at Obubra and 11-31 with a mean of 18.62±6.12 at Biase. The very wide range at Ikom was caused by a heavy rainfall in the Northern Etung prior to sampling in March 1998, which raised the TSS level from 13 the previous month to 75 that month.

Turbidity values for Ikom were 21.12±14.39 (FTU); at Obubra and Biase were 23.69±3.97 (FTU) and 20.31±5.31 (FTU) respectively. Total Alkalinity values averaged 119.39±27.05mg/l for Ikom, 120.77±40.10 mg/l for Obubra and 100.68±22.93mg/l at Biase. Waters with total alkalinities of 20-150mg/l contain suitable quantities of CO_2 to permit plankton production for fish culture (Boyd and Lichtkoppler, 1979)

At Ikom, total hardness varied from 22.44-91.06mg/l (mean 47.48±23.02mg/l, at Obubra the value ranged



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IKOM
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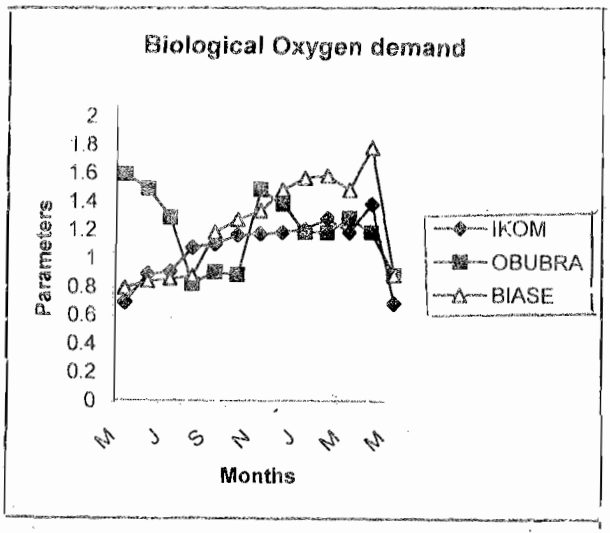
BIASE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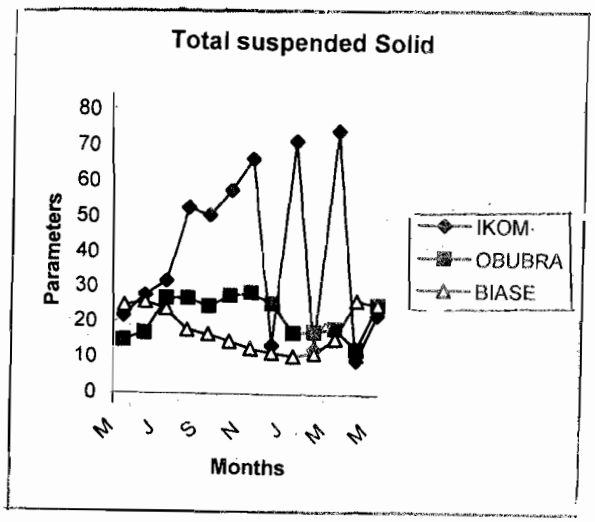
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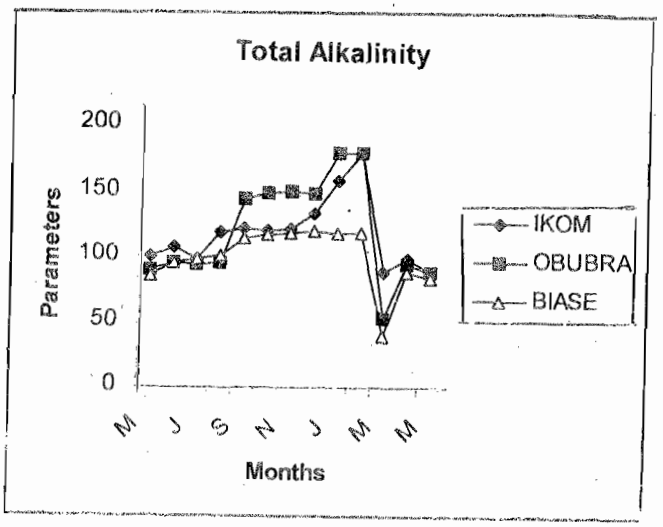
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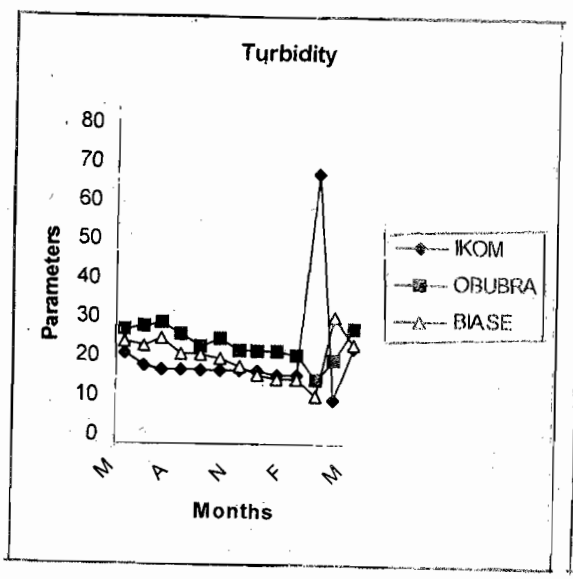
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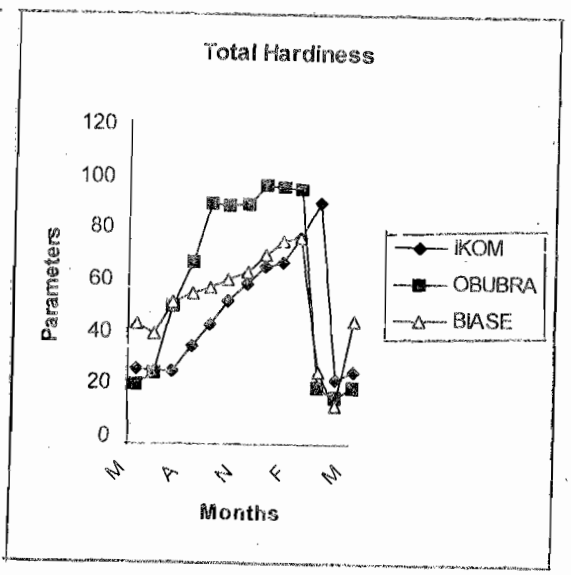
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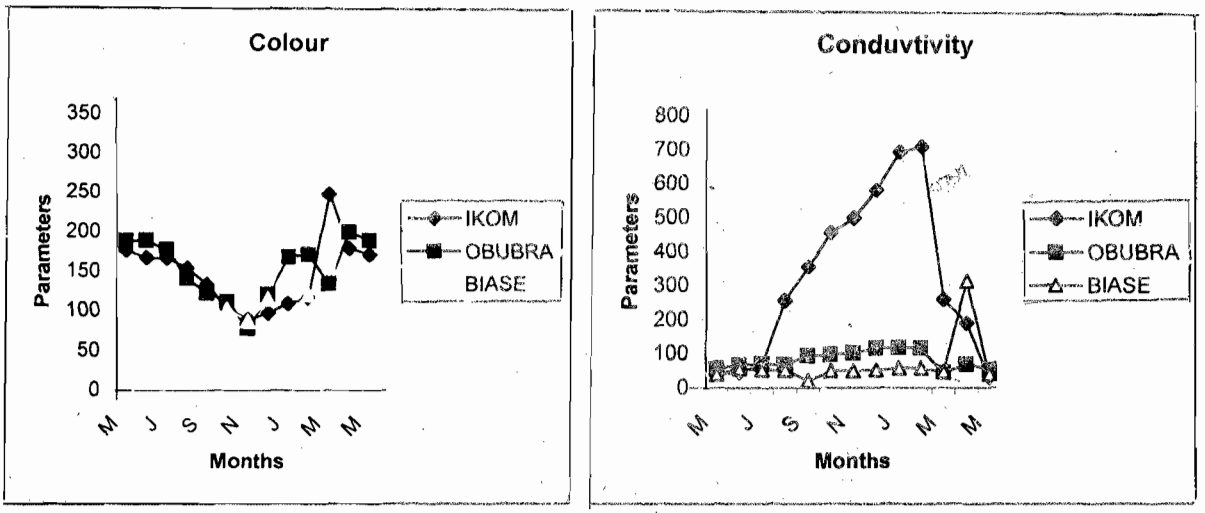


Figure 2a: Graphs showing the spatial variation of Physical parameters in Cross River between May 2001-May 2002.

from16.03-17.70mg/l (mean 57.76±35.24mg/l and at Biase the total hardness ranged from 12.83-76.95mg/l (52.25±18.93mg/l. There was no significant difference in the mean total hardiness values for the three locations.

The range for conductivity was largest at Ikom (22.44-710.4µS/cm), lowest at Obubra (49.99-118.2µS/cm) and intermediate at Biase (20.01-314.0µS/cm). The highest value of 710µS/cm was recorded at Ikom in October, while the lowest value of 118.40µS/cm was recorded in May at Obubra.

Colour ranged from 89.0-247.0, 78.0-199.0, and 87.0-287.0 mg/l with mean of 146.77±44.56mg/l, 152.76±37.67mg/l, and 175.77±63.77mg/l, at Ikom, Obubra and Biase respectively. There was no significant difference in the colour of the water at the three different locations. There were variations in cations level of the river. The chloride varied from 10.65-210mg/l with mean value of 93.92±62.30 at Ikom, 16.5-40.65mg/l with mean value of 29.78 ±8.14 at Obubra, and 14.15-113.6 with mean value 24.77±0.0mg/l. The highest value of 210mg/l was recorded at Ikom in January, while the least value of 10.65mg/l was recorded in the month of May.

Magnesium ranged from 0.783-13.88mg/l with mean of 5.73±4.6 at Ikom, 0.78-15.76 with mean of 3.56±5.14 at Obubra and 0.78-13.15 with a mean of 9.14±21 at Biase. The highest value of 15.76mg/l was recorded at Obubra in the month of February while the least value of 0.781mg/l was recorded in April. Calcium ranged from 16.03-34.15mg/l with mean of 24.28±4.00mg/l at Ikom, 12.82-30.78, mean value of 20.76±5.76 at Obubra and 9.17-23.08, mean of 14.06±5.27mg/l at Biase. The highest value of 34.15mg/l was recorded at Ikom in February while the least value of 9.17mg/l was recorded at Biase in the month of May.

Sulphate ranged from 0.99-38.34mg/l, with mean of 10.54±9.34mg/l at Ikom, 2.31-8.5mg/l, with mean of 4.82±2.15 at Obubra and 2.13-15.48mg/l, with mean of 4.53±0.0mg/l at Biase, highest value of 38.34mg/l was recorded at Ikom in the month of February, and the lowest of 0.99mg/l was also obtained at Ikom in the month of May. High nutrient levels were recorded during the period. Nitrate varied from0.16-2.76mg/l, mean value of 1.01±0.69mg/l at Ikom, 0.08-3.14mg/l, mean value 0.97±0.99mg/l at Obubra and 0.095-1.14mg/l, mean value 0.37±0.39mg/l at Biase. The highest value of 3.14mg/l was recorded at Obubra in the month of March, while the lowest value of 0.08mg/l was recorded at Obubra in the month of December.

Phosphate varied from 0.006-0.362mg/l, mean value 0.202±0.13mg/l at Ikom, 0.006-0.288mg/l, mean value of 0.149±0.11mg/l at Obubra, and 0.006-0.221mg/l mean of 0.11±0.08mg/l at Biase. The highest value of 0.32mg/l was recorded at Ikom in Fubruary, while the lowest of 0.006mg/l was recorded at the three stations in the month of April. Silicate ranged from 0.78-4.2mg/l mean value of 2.39±1.38mg/l, at Ikom, 0.80-4.77mg/l, mean value2.07±1.39mg/l at Obubra, and 0.70-2.33mg/l, mean value of 1.60±0.71mg/l at Biase, the highest value of 4.77mg/l was recorded at Obubra in the month of February, while the lowest value of 0.70mg/l was recorded in Biase in month of June 2001.

Copper varied from 0.032-6.24mg/l, with mean of 2.06±2.36mg/l at Ikom, 0.020-6.28mg/l, with mean of 1.05±0.10mg/l at Obubra, and 0.031-3.20mg/l mean of 0.708±1.0mg/l the Biase. The highest value of 6.28mg/l was recorded at Obubra in the month of Februrary, while the lowest value of 0.02mg/l occurred in Obubra in the month of May. Iron varied from 0.021 -1.80 mg/l, mean of 0.708±0.50mg/l at Ikom, 0.196-1.408 mean of 0.77±0.61 at Obubra and 0.783-13.15mg/l, mean of 10.54±1.92mg/l at Biase. Highest value of 13.15mg/l was recorded at Biase in the month of Febuary, while the lowest value1.96mg/l was recorded at Obubra at month of April.

Table 2, presents the results of the biological measurement in the Cross River. The results show that there are five phytoplankton families – Chlorophyceae, the Dinophyceae, the Cryptophyceae, the Cyanophyceae, and the Chrysophyceae; four Zooplankton families – the Copepoda, the Rotifera, the Ciliata, and the Zooflagellata, and ten bacteria species. The Chlorophyceae, represented by 13 species, are the most important in terms of the species diversity and abundance. *Dictyosphaerium sp* is the most abundant at the three locations with 174,780cell/ml, 213,815cell/ml, and 295,182cell/ml at Obubra, Ikot Okpora, and Ikom respectively, while *Ulothrix zonata* and *Tetraedron* sp are the least.

The family Dinophyceae is represented by two species, *Peridium,*and *Gymnodium sp.* The species *Peridinium* is the more abundant at the three locations, Obubra, Ikot Okpora, and Ikom with 17,478cell/ml, 23,521cell/ml and 12,392cell/ml respectively. The families Cryptophyceae, Cyanophyceae and Chrysophyceae are represented by one species each. *Cryptomonas sp. Oscillatoria sp.* and *Dinbryon*

Table 2: BIOLOGICAL PARAMETERS

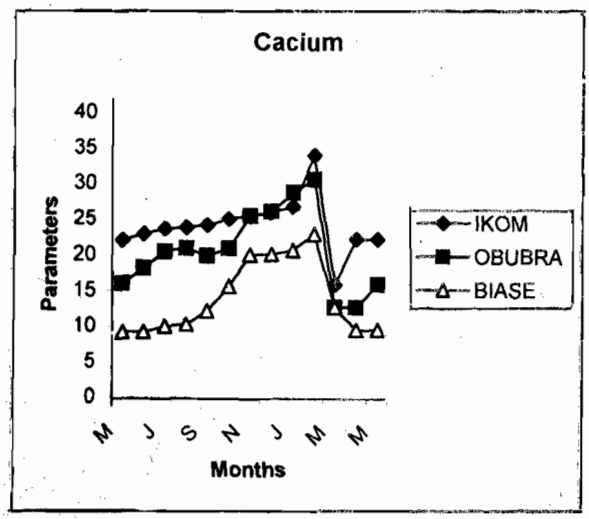
SPECIES (Cell/ml)	OBUBRA	IKOT OKPORA	IKOM
PHYTOLANKTON			
Chlorophyceae			
Ankistrodesmus	1,165	1,895	1,395
Chlamydomonas	18,643	23,956	12,456
Closterium	1,165	9,955	850
Closteriopisis longissima	2,330	3,960	2,250
Arthrodesmus octocormis	1,748	1,896	1,567
Cosmariums	2,913,	2,812	2,895
Dictyosphaerium	174,780	213,815	295,182
Euastrium gematum	1,165	959	1,678
Scenedesmus sp.	2,330	1,856	1,356
Tetraedron sp.	580	489	956
Scelenastrum	1,165	1,562	1,325
Ulothrix zonata	583	567	492
Volvox	1,748	1,952	1,253
Dinophyceae			
Peridinium sp.	1,748	23,521	12,392
Gymnodinium sp.	1,746	952	1,345
Cryptophyceae			
Cryptomonas sp	5,826	9,325	4,256
Cyanophyceae			
Oscillatorica sp.	583	492	1,562
Chrysophyceae			
Dinobryon serlaria.	2	-	10
ZOOPLAKTON SPECIES (Cell/ml)			
Copepods			
Nauphlii	400	567	875
Rotifera			
Epiphanes	4,000	6,700	9,350
Polyarthra	2,000	1,850	1,956
Cilliate			
Tintinnopsis	4,650,000	2,500,650	5,356,000
Zooflagillate			
Collodictyon tricilliatum	2,330,000	3,678,000	4,105,000
Euglenophyceae			
Trachelamonas volrina	1,748	1,195	1,893
BACTERIAL SPECIES (Cell/ml)			
Aeromonas sp.	-	8.2×10^5	9.2×10^5
Vibrio sp.	6.5×10^5	2.10×10^5	9.5×10^5
Acinetobacter sp.	3.6×10^4	8.2×10^5	2.4×10^5
Moraxella sp.	6.0×10^5	8.2×10^5	1.7×10^4
Streptococi sp.	2.0×10^5	9.6×10^4	1.4×10^5
Corynebacterium sp.	1.5×10^5	9.6×10^4	-
Bacillum sp.	2.0×10^5	2.1×10^5	9.2×10^5
Neisseria sp.	6.0×10^5	-	-
Pseudomonas sp.	-	9.6×10^4	9.2×10^5
Micrococcus sp.	-	2.1×10^5	-

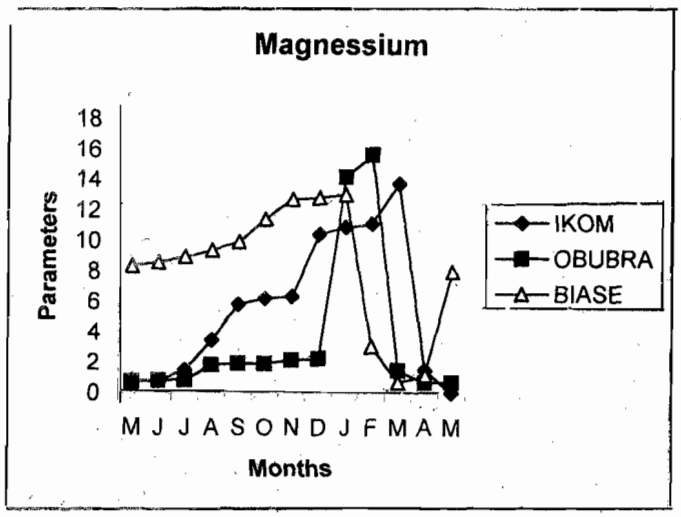
serlaria, were very abundant at Ikom during the rainy season. Chrysophyceae is not represented at Ikom.

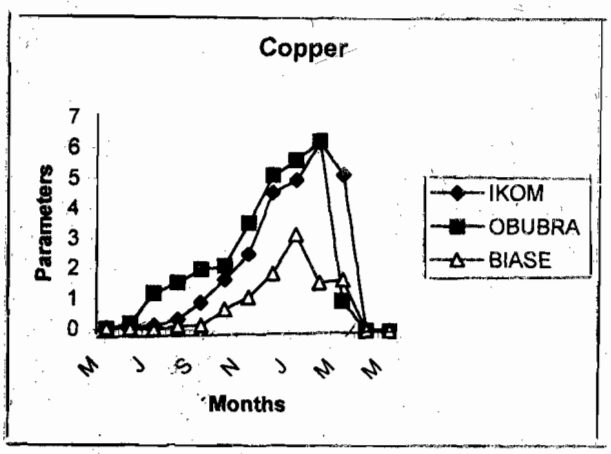
The ciliate species, *Tintinnopsis* and the Zooflagellate, *Collodictyon tricilliatum* are the most dominant zooplankton. For the former, the range is from 2.5×10^6 cell/ml at Obubra to 5.356×10^6 cell/ml, at Biase; whereas for the latter species, the range is from 2.33×10^6cell/ml at Ikom to 4.105×10^6cell/ml at Biase. The Copepods, *Nauphli* were the fewest zooplankton encountered in the study. Density as low as 400cell/ml at Ikom to 875cell/ml at Biase. Rotifera were much more abundant than copepod (400-9,350cell/ml, *Epiphanes* and 1,850-2000cell/ml of *Polyarthera*) but much less than ciliate and zooflgellates.

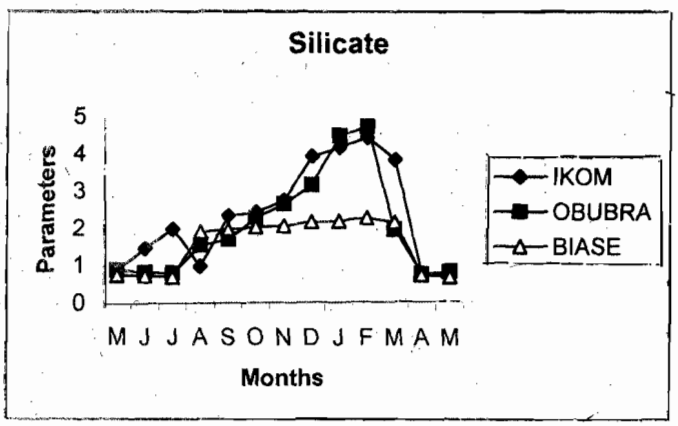
Bacterial species observed in the Cross River are *Areomonas sp., Vibrio sp., Acinetobacter sp., Morexella sp., Streptococci sp., Corynebacterium sp., Bacillum sp., Neisseria sp., Pseudomonas sp and Micrococcus sp.* At Obubra, 7 bacteria species observed include Vibro sp (6.5×10^4) cell/ml, *Acinetobacter sp* (3.6×10^4) cell/ml, *Morexella sp* (6.0×10^5) cell/ml, *Streptococci sp* (2.0×10^5) cell/ml, Corynebacterium *sp.*(1.5×10^5) cell/ml, *Bacillum sp* (2.0×10^5) cell/ml and *Neisseria sp* (6.0×10^5) cell/ml. *Vibro sp* with value of (6.5×10^4) cell/ml is the dorminant and *Corynebacterium sp* is the least at Obubra.

Ikot Okpora had the highest in bacteria population









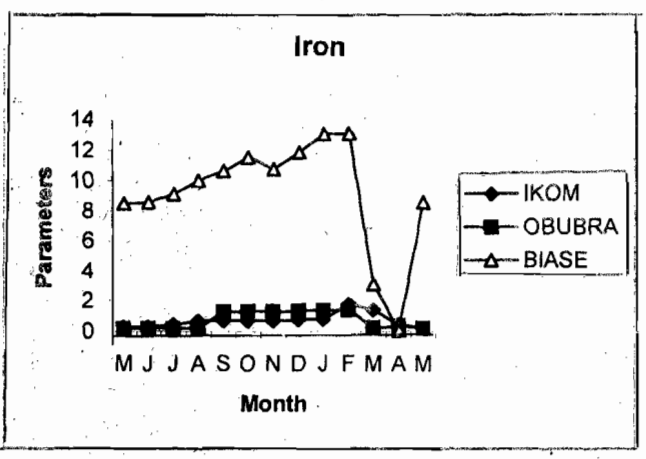


Figure 2b: Graphs showing the spatial variation of Chemical parameters (Cations) in Cross River between May 2001-May 2002.

with 9 species identified, which include *Areomonas sp.* ($8.2x10^5$) cell/ml, *Vibro sp* ($2.1x10^5$) cell/ml, *Acinetobacter sp*($8.2x10^5$) cell/ml, *Morexella sp*($8.2x10^5$) cell/ml, *Streptococci sp*($9.6x10^4$) cell/ml, *Corynebacterium sp* ($9.6x10^4$) cell/ml, *Micrococcus sp.* ($2.1x10^5$) cell/ml, *Pseudomonas sp*(9.6x104) cell/ml, and *Bacillum sp* ($2.1x10^5$) cell/ml. *Areomonas sp, Acinetobacter sp* and *Morexella sp* are the most abundant with the total number of ($8.2x10^5$) cell/ml each, while *Vibro sp,*

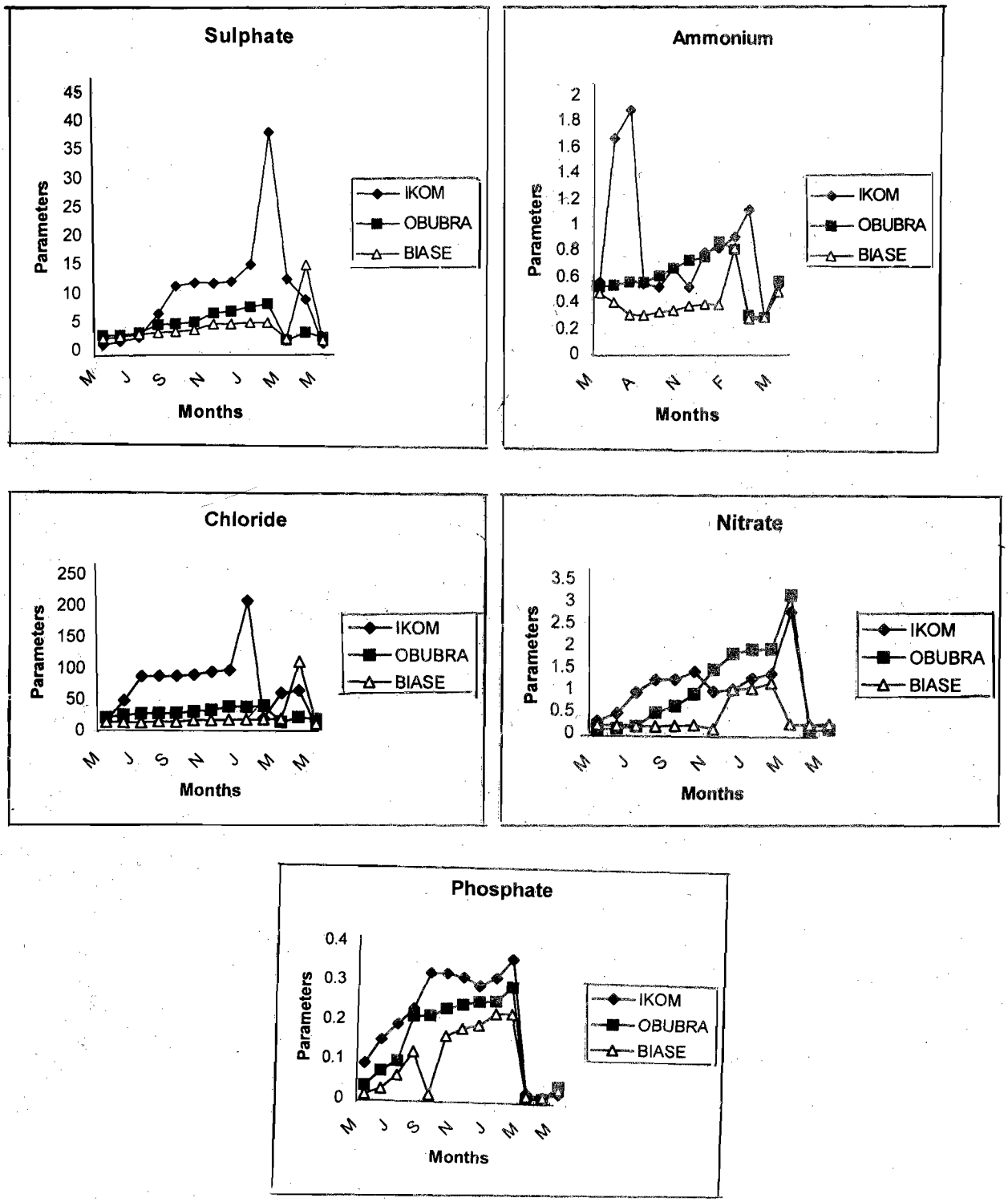


Figure 2c: Graph showing the spatial variation of Chemical parameters (Anions) in Cross River between May 2001-May 2002.

Micrococcus sp, and *Bacillum sp* were the least with ($2.1x10^5$) cell/ml each. Seven bacterial species is represented at Ikom which include, *Areomonas sp* ($9.2x10^5$) cell/ml, *Vibro sp*, ($9.5x10^5$) cell/ml, *Acinetobacter sp*($2.4x10^5$)cell/ml, *Morexella sp* ($1.4x10^5$) cell/ml, *Streptococci sp*($1.4x10^5$) cell/ml, *Bacillum sp* ($9.2x10^5$)cell/ml, and *Pseudomonas sp* ($9.2x10^5$) cell/ml. *Vibro sp*, is the most dominant with ($9.5x10^5$)cell/ml. High densities of bacteria was recorded during the dry season (December through February) which may be responsible for high incidence of water borne diseases in the area.

CONCLUSION

The present study has revealed that the water quality of Cross River fluctuate widely, from the southern part to the Northern part, the water quality parameters were higher during the raining season when the water volume was high, and low during the dry season.

The River shows wide diversity of planktons and Bacteria. The high density of bacteria may have been responsible for annual cases of water borne diseases in Cross River.

ACKNOWLEDGEMENT

The authors are very grateful to Miss, Njenku Magdalene, the research assistant, Mr. E.S. Bassey for his technical assistance and the entire staff of Environmental Laboratory, Institute of Oceanography, University of Calabar, Nigeria.

REFRENCES

Adebisi, A. A.., 1981. The physico-chemical hydrology of a tropical seasonal, river, Upper-Ogun River. *Hydrobiologia* **79**: 157-165.

Adeniyi, I.F., 1978. Studies of the Physico-chemical factors and the planktonic algae of lake Kainji, Nigeria. Ph.D Thesis, University of Ife, Ile Ife, Nigeria.

Akpan, E.R., 1998. Possible environmental impact of channelization and dredging on the ecology of the Cross River estuary system – Nigeria. *Tropical* Freshwater Biol. **7:** 53-61.

APHA ., 1980. Standard methods for examination of water and wastewater. Washington DC American Public Health Association (APHA), 15th Edition.

APHA ., 1989. Standard method for examination of wastewater and water (17th ed). Washington D.C., 891pp.

Asuquo, F.E ., 1999. Physico-chemical characteristics and anthropogenic pollution of the surface waters of Calabar River, Nigeria. Global J. Pure and Applied Sci., **5** (4): 595-600.

Baijot, E., Bouda,S and Ouedraogo, L., 1997. Physical, chemical, and biological characteristics of reservoir in Burkina Faso: In Hydrological aspect of fisheries in small reservoirs in the Sahel Region. C.T.A. Publ. 283Pp

Boyd, C.E and Lichtkoppler, F., 1979. Water quality in warm water fishpond. Agricultural Experimental station, Auburn University, AL 359Pp.

Dickens, C.W.S and Graham, P.M., 2002. The South African Scoring system (SAAS) Version 5, Rapid Bioassesment methods for rivers. Afri. J. Sci., **27**:11-20.

Duodorof, D. & Fry, F. E. J., 1959. How should we determine dissolved oxygen critical for fresh water fisher? Trans 2nd Seminar, Biology on problem of water pollution W. S. H. S. W Pp1-10

Egborge, A. B. M., 1979. The effect of impoundment on the water chemistry of Lake Asejire. *Freshwater Biology* **9**: 403-412

Imevbore, A.M.A., 1967. Hydrology and plankton of Eleyele Reservoir, Ibadan, Nigeria. *Hydrobiologia* **30**:154-176.

Lloyd, R., 1992. *Pollution and freshwater fish.* Fishing News Books, Oxford, UK. Pp192.

Moses, B.S., 1980. Preliminary estimation of potential yield of Cross River Inland (Fresh) water fisheries. *Proc. First* Cross River State Fish Conf. Pp. 42-46

Nawa, I . G., 1980. Prospect for mariculture in the Cross River estuary. *Proc. Cross River State Fish. Conf.* Pp. 66-68.

Nwadairo, C.S & Umeham, S.N (in press). The chemical hydrology of Oguta lake, Imo State, Nigeria. *Arch. Fur.Hydrobiol*

Onuoha, C. G ., 2001. Studies on the Physico-chemical characteristics and productivity of a concrete reservoir. *Global J. Agric. Sc.* Vol. 1

RPI., 1985. Envinromental Baseline studies for the establishment of control criteria and standard against petroleum-related pollution in Nigeria. Research Planning in Nigeria. RPI, Inc USA. Final Report for NNPC, Lagos, Nigeria Pp.118-127.

Svobodova, Z. Llody R., Machova J. & Vyusoda, B., 1993. Water quality and fish health. EIFAC Tech. Paper No. 54, Rome: FAO.

Umeham, S.N., 1989. Some aspects of the Physico-chemical limnology of Lake Chad (Southern Sector). *J. Aqua. Sc.*, **26**: 21-26.