GLOBAL JOURNAL OF AGRICULTURAL SCIENCES VOL. 1, NO. 1, JANUARY 2002: 11-20

STUDIES ON THE PHYSICO-CHEMICAL CHARACTERISTICS AND PRODUCTIVITY OF A CONCRETE RESERVOIR.

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(Received 14 August 2000; Revision accepted 7 September 2001)

ABSTRACT

Studies on the physico-chemical characteristics and biological production in a new concrete reservoir in Umudike were carried out from February 1998 to February 1999. The temperature of the water ranged from 25°C to 29°C with a mean of 26, 75°C ± 1.71. The water had high levels of nutrients, nitrates (NO_3) ranged from 0.5 to 1.0mg/l, while phosphates ranged from 2 to 16 mg/l. The P^H with slight fluctuations to alkaline and acidic conditions obtained in this study was adequate for fish production. Dissolved oxygen was also high, with values ranging from 5.8 to 7.6 mg/l. Dissolved organic matter was high during the rainy months. Values ranged from 6.4 to 7.4 mg/l. Highest transparency was obtained in March and lowest in August during the rains with values ranging from 25 to 50cm. Estimates of plankton cells/ml. showed increase in the number of cells from June to September, during the rainy months with values ranging from 34 to 149 cells / ml. The standing crop estimate of net phytoplankton and zooplankton showed a unimodal curve with highest densities in June. This trend seems to be correlated with the start of the rains and also improved nutrition of the plankton with the application of organic manure and uneaten feed. A high concentration of organic matter of 20 to 95.42 mg/l and phosphate – phosphorus of 2 to 10 mg/l accounted for the nutrient enrichment of the reservoir water. A strong correlation occurred between dissolved organic matter and the phytoplankton, both greens and blue-greens and the flagellates. Correlation values ranged from r = 0.794 for *Coelastrum*, 0.812 for *Chlorella*, 0.964 for *Staurastrum* for the greens; r = 0.868 for *Microcystis*, 0.957 for *Gleocapsa* for the blue –greens; to r = 0.920 for *Euglena*, 0.939 for *Phacus* and 0.874 for *Trachelomonas* for the flagellates. Also, the water level had a strong correlation with the preponderance of plankton. High water level correlated strongly with the green algae and rotifers, r = 0.775 for the green plankton and r = 0.732 for the rotifer *Asplanchna*. Low water level correlated with the blue –greens and correlated strongly with nematodes (r = 0.853 for nematode worms). Thus high nutrient level favours high plankton production.

A general positive correlation between the concentrations of the principal nutrients and primary production is apparent from the results observed. The other interactions between the concentrations of nutrients and other factors influencing production especially transparency or turbidity, and water level are also pertinent.

Key words: Concrete, Reservoir, Physico-Chemical Characteristics, Plankton, Production, Umudike.

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INTRODUCTION

The homestead concrete fish pond (CFP) came into limelight in Nigeria in the 1980s. This undertaking was aimed at improving fish production by families in order to increase fish protein intake which is far below the recommended level of 35g/capita/day, recommended by the food and Agricultural Organization (FAO) (Olayide and Olayemi, 1975). Although there are limited reports in Nigeria on fish production in concrete reservoirs (tanks) (Egwui, 1988), there exist many studies on the productivity and photosynthetic activity of algae in tropical water bodies (Imevbore and Boszormenyi, 1975; Adeniyi, 1978; Onuoha, 1994; Aguigwo, 1998).

In a normal ecosystem, there are algae and some bacteria which can synthesize high energy organic compounds from low energy compounds such as water and carbondioxide, using either light or chemical energy as their energy source. These organisms are called autotrophs and are

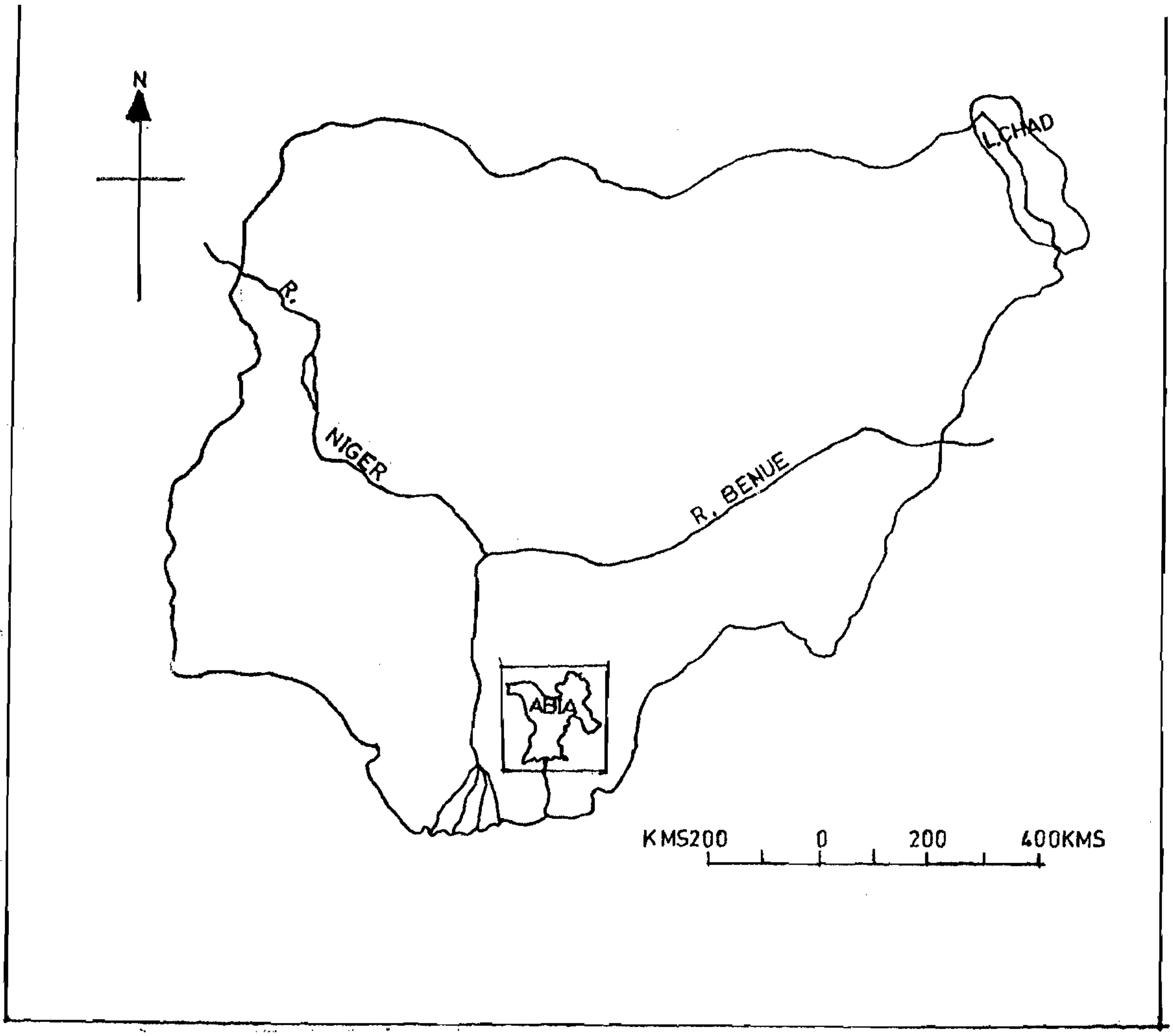

Fig.1: FIG 1: MAP OF NIGERIA SHOWING ABIA STATE STATE

often referred to as primary producers as they form the basic or the first trophic level in the food chain.

Primary production is the observed increase in the biomass of the photosynthetic plant tissue over a period of time, plus possible losses through such processes as excretion, respiration, tissue damage, death or grazing. Primary production is thus the total quantity of new organic compounds created by photosynthesis. The rate at which this primary production is produced is called primary productivity. The production and productivity depend on the physico-chemical qualities of the environment as well as the community structure and biomass of the producers involved (Holden and Green, 1960; Onuoha, 1980; Hess *et al.*, 1985).

There is therefore the need for more studies on concrete reservoirs, tanks and ponds to complement the existing data. The principal objectives of this study were to determine the species diversity of the flora and fauna, the trophic structure and physico-chemical dynamics of a concrete pond situated in Umudike, Abia State of Nigeria. The study also sought to measure the particulate organic matter and species succession in the reservoir from stocking to cropping and to note the succession of and occurrence of major net plankton forms.

MATERIALS AND METHODS.

Location of the Concrete Reservoir.

The study was carried out at the premises of the Michael Okpara University of Agriculture, Umudike, a rainforest zone of south eastern Nigeria. The University is situated at latitude 05°29'N and longitude 07°33'E about 8 kilometres from Umuahia, Abia State, along the Ikot-Ekpene road(Figs 1 & 2),whereas the concrete reservoir constructed in 1995 and measuring 16m^2 is located within the quadrangle of the new Academic Complex housing the two Colleges of Biological and Physical Sciences (CBPS) and Natural Resources and Environmental Management (CNREM) (Fig.2). The concrete reservoir was abandoned after the completion of the construction of the Academic Complex. This was then cleared of the debris, plastered and renovated in January, 1998.

Filling of the concrete Tank with water:

Water from the National Root Crops Research Institute (NRC R1) dam, which was constructed in 1965-1966 by the United States Agency for International Development (USAID), which receives water from Anya river all the year round was introduced into the concrete reservoir up to 1.5m depth, using the University water tanker. Pond water level was determined by means of a calibrated pole. The water was allowed to stand for a month before the introduction of fish samples. This was to allow sufficient time for the stabilization of the cement work (plastering on the concrete tank).

Stocking of fish and feeding regime:

Fifty Tilapia Fish (*Oreochromis niloticus)* were introduced into the tank in February, 1998. The weights ranged from 3 to 5g with standard length of 4 to 5cm. Forty juveniles of the hybrid catfish from *Clarias gariepinus* female and *Heterobranchus bidorsalis* male were later stocked in a polyculture trial. Their lengths ranged from 4 to 5cm. and weighed 2 to 3g. Fish were fed with formulated pelleted diet (35% protein; by the Nigeria Institute for Oceanography and Marine Research, NIOMR.) twice a day at 5% of biomass.

Sampling Programme For Physico-Chemical Parameters:

An all year round limnological study began in February 1998 and continued through February 1999. Routine water samples from the reservoir were collected

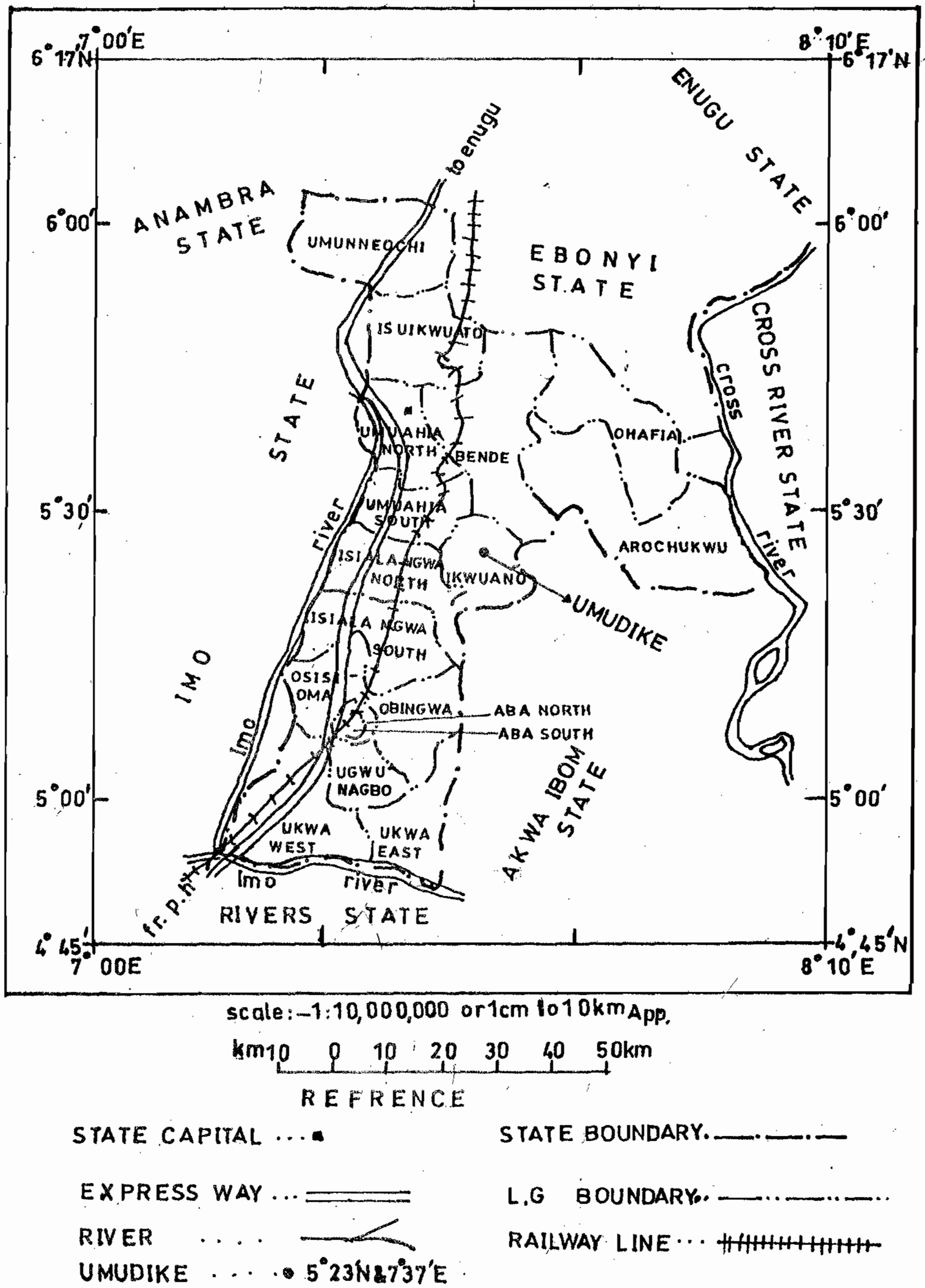

FIG 2: MAP OF ABIA (POLITICAL) SHOWING UMUDIKE IUDIKE

with a fabricated plastic water sampler of 1L capacity, usually between 9am to 12 pm on a monthly basis for the determination of the physico-chemical parameters or characteristics such as temperature, pH, dissolved oxygen, nutrients such as nitrate - nitrogen (NO_3-N) and phosphate – phosphorus PO_4-P). Transparency was measured using a Secchi disc of 15cm. radius and inserting it into the reservoir. The mercury (Hg) thermometer (°C) was inserted directly into the water sample collected and read off, while the hydrogen ion concentration (pH) was measured with a Jenway Electrical pH meter after standardization with buffer solution of pH 7.0. The dissolved oxygen content was determined using the standard Winkler's method according to Wetzel and Likens (1979). At the site, water sample was gently run into the Winkler's bottles so as not to trap in air bubbles and fixed with manganous –alkaline iodide reagents. The samples were then taken to the laboratory for analysis.

Ammonia levels were estimated by colorimetric methods using sulphanilic acid diazotization method (APHA, 1975). PO_4-P was determined by the Yellow Vanadomolybdate Method, and Nitrogen by the semi-micro distillation method (APHA, 1975). Organic matter content was analyzed using a wet acid method (Walkley and Black, 1947), followed by the ashing. Sodium and potassium contents were also determined by the flame photometric method (APHA, 1975).

Sampling for Biological Parameters:

Integrated vertical hauls of water samples for the determination of organic matter were collected with a water sampler from the surface, mid and bottom depths and mixed up. About 20 litres of this water were allowed to settle and sieved through a fine mesh plankton net (65u'm mesh size) into a bottle. One litre of water sample was

TABLE 1

MONTHLY VARIATION I NTHE PHYSICO-CHEMICAL AND BIOLOGICAL CHARACTERISTICS OF UMUDIKE CONCRETE RESERVOIR FEBRUARY 1998 TO FEBRUARY 1999.

Characteristics	1998											1999	
	Feb.	Mar.	Apri.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.
Water Level (mm)	1.5	1.5	1.2	1.3	1.8	2.2	2.0	2.2	2.0	2.1	2.0	1.8	1.6
Water Temp (°C)	29	29	28	27	26	25	25	26	27	28	29	28	29
Hydrogen ion concentration (pH)	6.0	6.0	6.2	6.3	7.0	7.2	7.2	7.3	7.1	7.0	7.0	7.0	7.0
Dissolved Oxygen (mgl)	7.5	7.6	6.3	6.2	6.0	5.8	5.8	6.0	6.1	6.2	6.3	6.5	6.4
Transparency (cm)	50	50	40	35	30	30	30	25	30	30	25	25	30
NO_3-N (mg/l)	0.03	0.03	0.06	0.05	0.8	0.2	0.25	0.3	10.2	0.2	0.3	0.2	0.2
NH_3-N (mg/l)	0.01	0.01	0.01	0.1	0.3	0.5	0.2	0.1	0.1	0.2	0.2	0.1	0.05
PO_4-P (mg/l)	0	0	0	0.05	1.10	1.0	14	6	6	6	2	4	2
Dissolved Organic matter (mg/l)	2.25	2.30	4.15	10.5	20.5	95.42	50.2	30.25	30.25	10.25	8.10	4.25	4.00

TABLE 2

MONTHLY OCCURENCE OF PHYTOPLANKTON SPECIES (CELLS/ML) IN THE UMUDIKE CONCRETE RESERVOIR

FEBRUARY 1998 TO FEBRUARY 1999

Phytoplankton	Feb. 1998	Mar	Apr	May	June	July	Au	Sep	Oct.	Nov	Dec	Jan 1999	Feb.
Scenedesmus spp	3	4	8	0	0	0	3	10	15	8	10	4	5
Closterium spp	0	0	0	0	1	1	3	5	4	4	3	0	0
Coelastrum spp	0	0	0	4	3	5	10	7	5	3	1	0	0
Chlorella spp	0	0	0	3	4	6	6	8	0	0	0	0	0
Tetraspora spp	0	0	0	0	2	1	4	3	1	1	1	0	0
Staurastrum spp	1	0	0	1	1	5	4	3	3	0	0	0	0
Microcystis aeruginosa spp	0	0	0	4	20	25	20	20	15	10	5	0	0
Microcystis flosaquae spp	0	0	0	0	15	10	8	5	2	0	0	0	0
Gleocapsa spp	0	0	0	0	5	10	8	5	2	0	0	0	0
Euglena spp	0	0	0	0	3	6	6	5	0	0	0	0	0
Phacus spp	0	0	0	0	2	5	3	2	0	0	0	0	0
Lepocinclis spp	0	0	0	0	3	4	6	3	0	0	0	0	0
Trachelomonas spp	0	0	0	0	3	4	5	3	0	0	0	0	0

emptied into a measuring cylinder into which 3 drops of Lugol's iodine was added for plankton enumeration. The supernatant was siphoned out to obtain fifty mls. of the sedimented algal material from which one ml. subsample was put into a Sedgewick rafter-counting chamber and counted. Qualitative samples of net phytoplankton were also obtained by making vertical hauls with a plankton net of 65um mesh size. The samples were preserved in 4% formalin.

Plankton Identification:

For each sample, three replicates of the concentrate were examined under the low power (100x) and high power (400x) magnifications using Prescott (1984) as a guide.

Treatment of Data:

Correlation coefficient (r) was calculated for the various physico-chemical and biological parameters to determine the relationships between the various factors.

RESULTS:

The results of the physico-chemical characteristics of the Umudike concrete reservoir are presented in Table 1. The surface water temperature values ranged from 25 to 29 ^{0}C with a mean value of 26.75^{0}C $\pm$ 1.71. The lowest water temperature of 25^{0}C was recorded in July at the peak of the rains, while the maximum temperature of 29^{0}C was recorded in the drier months of January and February. The turbidity of the water increased as the rains set in. Highest transparency was obtained in the drier periods in February and March with a value of 50cm. The values ranged from 25 to 50cm, with the lowest value of 25cm. obtained in August. The dissolved oxygen content was fairly high and ranged from 5.8 to 7.6 mg/l, with the highest value obtained in March, while the lowest values were obtained in July and August. The pH values fluctuated slightly between alkaline and acidic conditions. Slightly higher pH values of 6.3 to 7.2 with higher biota production were obtained during the rainy months of May to July. The nutrient PO_4-P was quite high during the peak of the rains (July to September). Values ranged from 0 to 16mg/l with the highest value in July and lowest value of Omg/l from January to

March at the beginning of the study. The NH_3-N content ranged from 0.01 to 0.5 mg/l. Low nitrate-nitrogen values were obtained in the periods before the onset of the rainy season. Values ranged from 0.03 to 0.25mg/l. The lowest value of 0.03 mg/l was obtained in January and February 1998, but progressively increased to 0.25mg/l in August.

Similarly, the dissolved organic matter was quite high during the rainy period with values being up to 95.42 mg/l, with the highest value in July and lowest value (2.25mg/l) in February. Table 2 shows the monthly species diversity of the phytoplankton. The green algae Scenedesmus, *Chlorella, Staurastrum* were very abundant. Cell count for Scenedesmus ranged from 3 to 15 cells /ml., that for *Coelastrum* ranged from 1 to 10 cells /ml., the count for *Chlorella* ranged from 3 to 8 cells /ml., and the count for *Staurastrum* and *Closterium* ranged from 1 to 5 cells /ml each respectively, while the count for *Tetraspora* ranged from 1 to 4 cells /ml. These gave way to the blue – greens, *Microcystis* and the flagellates *Euglena, Phacus, Trachelomonas*, as the rains set in and intensified.

Microcystis was very abundant from June to September. The cell count ranged from 0 to 25 cells /ml. This was followed by *Gleocapsa* with cell count ranging from 2 to 10 cells /ml., followed by the Euglenoids - *Euglena* with cell count of 3 to 6 cells /ml., *Phacus* with cell count of 2 to 5 cells /ml., *Trachelomonas* with cell count of 3 to 5 cells/ml and *Lepocinclis* with cell count of 3 to 6 cells / ml. Table 3 shows the component of the zooplankton species with a total number of seven genera. The species consisted essentially of rotifers. *Asplanchna* was the most abundant with cell count ranging from 8 to 20 cells /ml., followed by *Monostyla* and *Proales* with counts ranging from 4 to 10 cells /ml each respectively. *Epiphanes* comes next with cell count ranging from 2 to 7 cells /ml, *Euchlanis* with cell count of 1 to 5 cells /ml., and *Filina* with 4 to 5 cells /ml.Nematodes worms also became abundant during the rains.

The nutrient PO_4-P had strong correlation (r = 0.842, 0.662, 0.727, 0.654) with the green algae *Scenedesmus*, *Coelastrum*, the rotifer *Epiphanes*, and nematodes respectively. There was also a strong correlation between NH_3-N and the zooplankton *Proales* and *Euchlanis* spp. (r = 0.755 and 0.916) respectively.

A strong correlation also occurred between dissolved organic matter and the phytoplankton both greens and blue-greens. Correlation values (r) ranged from r = 0.794 for *Coelastrum*, r = 0.812 for *Chlorella* r = 0.964 for *Staurastrum* r =0.868 for *Microcystis* and r = 0.957 for *Gleocapsa*. A strong correlation also occurred between

TABLE 3
MONTHLY OCCURRENCE OF ZOOPLANKTON SPECIES (CELLS/ML) IN THE UMUDIKE CONCRETE RESERVOIR FEBRUARY 1998 – FEBRUARY, 1999

Zooplankton Genera	Feb. 1998	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan. 1999	Feb.
Asplanchna spp.	0	0	0	8	12	20	20	15	20	10	8	0	0
Monostyla spp.	0	0	0	4	6	6	10	5	6	0	0	0	0
Proales spp.	0	0	0	4	10	8	5	5	4	0	0	0	0
Filina spp.	0	0	0	0	5	4	0	0	0	0	0	0	0
Epiphanes spp.	0	0	0	0	4	4	5	7	4	3	2	0	0
Euchlanis spp.	0	0	0	0	3	5	2	1	1	0	0	0	0
Nematode (Worms)	0	0	2	6	10	20	18	20	20	25	20	25	0

dissolved organic matter and the flagellates, r = 0.874; r = 0.920; and r = 0.939 for *Trachelomonas*, *Euglena* and *Phacus* respectively.

Initially, there was a high correlation between the water level and the green phytoplankton *Closterium (r = 0.775)* and *Microcystis aeruginosa(r = 0.746)* respectively. The water level had a strong correlation with the preponderance of the plankton. High water level also correlated strongly with the rotifers (r = 0.732 for *Asplanchna*) and low water level correlated with the blue-greens and nematodes (r = 0.853 for nematodes).

DISCUSSION:

The physico-chemical characteristics as presented in Table 1 showed that the surface water temperature of the concrete reservoir was within limits of 25 –35°C for fish production. The warming up of air caused continuous evaporation of the water in the concrete reservoir. The turbidity increased as the rains set in. In Table 1, the initial water introduced into the concrete tank was humic, clear, and transparent, up to 50cm. The feed added to the tank increased the suspended solids in the system, as it helped in the fertilization of the pond water, and therefore boosted plankton production, thus resulting in the greening of the pond water. It was also observed that this increased the productivity of the pond water thus resulting in eutrophication.

Dissolved oxygen is probably the most sensitive of all the variables that affect water quality and on which the condition of the fish cultured depend. The sensitivity of fish to low dissolved oxygen differs from species to species and also between the various stages of fish life development (Alabaster and Lloyd 1982). The level of dissolved oxygen obtained in this study however was adequate for aquatic life. The dissolved oxygen concentration in any aquatic medium is usually controlled by the temperature of the water, the higher the temperature, the less the dissolved oxygen in solution. In agreement however with Kemdirim (1993), the dissolved oxygen concentration was high in the dry season, due to high photosynthetic activities of the phytoplankton at the period. Low dissolved oxygen concentration during the rainy months was likely caused by increased organic material content of the water which exerted a high biochemical oxygen demand (BOD) on the water. The pH value of 6.0 to 7.3 obtained in this study is adequate for fish production. Tarzwell (1957) associated pH range of 6.5 to 8.5 to productive waters and Winger (1981) gave a pH range of 5 to 9.5 as suitable for aquatic life. Slightly higher pH values with higher biota production were obtained during the rainy months of May-July. The production of the system due to greater population of the plankton enhanced the pH level by increased release of oxygen and uptake of the carbon dioxide in circulation, thereby buffering the system.

The nutrient PO_4-P was quite high during the peak of the rains (July to September). The high PO_4-P and NO_3-N levels in July corresponded to the period of high plankton bloom and increased the turbidity of the reservoir due to uneaten feed. This indicated high nutrient production level which favours high plankton production (Schindler, 1978). The absence of the nutrient PO_4- P in the 2 - year old established reservoir in the dry season from February to April is understandable, as it needed time to build up. Similarly, the low transparency during the May to August rainy period indicates the preponderance of suspended matter in the water column.

Tables 2 and 3 showing the density of the monthly species diversity of the phytoplankton and zooplankton counts also confirm the increase in density of the organisms during the rains as a result of increased nutrients. The increase in nematode worms is also understandable due to increase in detrital matter resulting from the collapse of the plankton pulse.

The high plankton production coincided with the high nutrient levels of PO_4-P and No_3 –N and high pH-values. Low NO_3-N values indicate the dry periods and period of establishment of the system before the onset of the rainy season, and the period just before the first plankton bloom. This agrees with the observation of Kemdirim (1990) in a similar study. The strong correlation between the nutrient PO_4-P and the green algae *Scenedesmus* spp, *Coelastrum* spp and the rotifer *Euchlanis* spp and nematodes agrees with the statement that increase in phytoplankton biomass results in overgrazing (Raymont, 1980). This is because shortly after the development of the small phytoplankton, the zooplankton will start to multiply with the appearance of macro – zooplankton, they consume a large proportion of the smaller zooplankton. The bigger zooplankton soon "overgrazes" the Phytoplankton and the oxygen production slows down, and they eventually die from lack of oxygen and food and sink to the bottom and decompose after which a new cycle of phytoplankton and zooplankton starts again.

A general positive correlation between the concentrations of the principal nutrients and primary production is apparent from the results observed. The other interactions between the concentrations of nutrients and other factors influencing production, especially transparency or turbidity and water level are also pertinent.

ACKNOWLEDGEMENTS

I am grateful to Mr. Suanu N.Deekae who critically read the manuscript, Miss Uzoamaka Udeh is acknowledged for help during some of the sampling periods. Miss Ijeoma Isaac is also acknowledged for typing the manuscript'

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