# Preliminary Study On The Limnology And Plankton Abundance In Relation To Fish Production In Some Niffr Reservoirs

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**Abstract:** The limnological character and plankton abundance of four different reservoirs in the National Institute for Freshwater Fisheries (NIFFR), New Bussa, including their impact on fish production was studied from December, 2008 – June 2009. Samples were collected monthly for analyses of physico-chemical parameters, zooplankton and phytoplankton. Primary productivity, Potential Fish Yield (PFY) and Sorenson's index of similarity were also tested. One way ANOVA with post test was used to statistically analyze for the relationship between the physico-chemical parameters and the plankton abundance in the different reservoirs. The results showed that there was no significant difference (P>0.05) between the water quality parameters in the different reservoirs and were within standard permissible limits and typical of Nigerian inland waters. Phytoplankton abundance was generally high - 57,884, 73,374, 43,802, and 24,423 (cells $ml^{-1}$), with low occurrence - 15.34, 23.19, 21.41 and 15.81 ($ind.l^{-1}$) - of zooplankton for R1, R2, R3 and R4 respectively. Gross pelagic primary productivity was found to be 2.24, 3.17, 2.61 and 1.69 ($go_2^{-}m^{2-}d$) for R1, R2, R3 and R4 respectively. Sorenson's index of similarity showed generally a high level of zooplankton similarities between the reservoirs. Potential Fish Yield was considered to be high - 93.33, 89.13, 79.43 and 69.18($kgha^{-1}$) - when compared with findings from other reservoirs. There was significant difference (P<0.05) between: physico chemical parameters and the phytoplankton, phytoplankton and zooplankton, phytoplankton and the Gross Pelagic Primary Productivity (GPP) in most of the reservoirs but R2 showed a higher significance. Observed differences in the 4 reservoirs are discussed and recommendations made. [Report and Opinion 2010;2(6):9-15]. (ISSN:1553-9873).

**Key words:** Physico-chemical, Assessment, Phytoplankton, Zooplankton, Sorenson, Reservoir, Class, Specie

## 1. Introduction

A good management practice is essential for any aquatic system used for fish production. Within the recent past decades, there has been considerable interest in the relevance of limnological information to the productivity, development and management of aquatic environments (Bolatito, 2005; Mir et al, 2005; Subhashini and Saradhamani, 2003; Ovie, 1994, 2009). Often times, limnological studies involve different approaches and objectives. While on the one hand Zabbey *et al* (2008) highlighted studies which involved regular or periodic investigation into the ecology of water to provide insight into the status of the physical and chemical indices for monitoring purposes, Adeniji and Ovie (1996) on the other, focused on the availability of natural food as an important factor governing fish recruitment and production in the wild. Studies have shown that there is a close link between the quality of water and the composition and abundance of plankton in any aquatic system. Ovie (1995) citing Green (1967 and 1971) reported that among others, physico chemical factors are known to be major factors influencing zooplankton species richness of different ecosystems. Against this backdrop, this study was therefore conducted to investigate water quality and plankton abundance as well as how they relate in some NIFFR'S reservoirs.

## 2. Materials and methods

### 2.1 Description of Study Area

National Institute for Freshwater Fisheries Research (NIFFR) is located within the Kainji lake region which lies within latitude 9°50' – 10 ° 55' N and longitude 4 ° 25' – 4 ° 45' E. The average rainfall and temperature of the area are about 100± 40cm and 28 ° c respectively. It has a distinct rainy season from April\May to October and a dry season from November to March. The heaviest rains occur between June and September with an occasional break in August. November to February is completely rain free months (Ovie, 1993).

Four reservoirs code – named R1, R2, R3 and R4 for (Reservoirs 1, 2, 3, and 4) were used in this study (figures 1, 2, 3 and 4) respectively. These reservoirs are briefly described. The first reservoir at the integrated fish production area above which the poultry house was built was constructed in 1981 as a result of the impoundment of a small stream that flows through the NIFFR estate. It had an original total area of 1.5 hectares and a maximum depth of 1.5 meters (m). It was primarily constructed to store water for release by gravity into experimental ponds located behind it. The next two reservoirs were constructed in 2000 and has dimensions of 80m × 70m× 3m for the one directly linked to the first reservoir and 70m × 70m × 3m for the adjoining one. Water volume was initially supplemented from the main Kainji Lake through pipes, but at present, rain is the only source of supply to these three reservoirs though the first reservoir serves the other two ponds during dry season via interconnecting sluice. The fourth reservoir was constructed in 1980 as a result of the impoundment of a small stream that takes its source from a tributary of the Oli River. Originally, supply of water to this reservoir was supplemented by water from the main Kainji Lake during dry season. It has a maximum length of 147 m, maximum width of 32m, maximum depth of 4 m and a full capacity of 18816m$^3$. Its main function was to supply water to the estate for domestic use but was later stocked with fish (Abohweyere, 1984; Ita *et al*, 1984). At present, rain water is also the main source of supply to this reservoir. All the reservoirs recede progressively as the dry season intensifies. Polyculture is being practiced in all the reservoirs. Feeding has been extensive, which means the plankton community plays a major role in the food chain of these reservoirs.


Figure 1: NIFFR reservoir 1 showing poultry house.


Figure 2: NIFFR reservoir 2 showing typical of how the water recedes during dry season.


Figure 3: NIFFR reservoir 3 at full capacity.


Figure 4: NIFFR reservoir 4 taken from a platform.

All samples were collected in the second week of every month. The physico – chemical parameters ( Dissolved oxygen, free $Co_2$, alkalinity, temperature, pH, $No_3$, $Po_4$, $NH_3$, $Ca^{2+}$, $Mg^{2+}$, $Na^+$, $K^+$, $Co_2^-$, $So_4^-$, $Cl^-$, conductivity and transparency ) were analyzed using methods as described in the American Public Health Association (APHA), 1998. Primary productivity was measured using the light and dark bottle method as described in the Regents of the University of Michigan (2005) and Rhode's 1965 formula as described by Karlman (1973):

$$\sum_a = Z_{0.1}\ jmpc \times a_{max}$$

Where:

$\sum_a$ = gross pelagic primary productivity per unit area

$Z_{0.1}$ = depth (m) of the 10% light transmission level for the most jmpc penetrating component.

Zooplankton samples were collected using No. 20 silk bolting zooplankton net with mesh sieve of 76µm and mouth diameter of 12.50 cm. Samples were preserved in 4% formalin and were allowed to stand undisturbed for over 24 hours on a flat surface to allow organisms settle. Thereafter, the sample volume was reduced to about 25ml by siphoning with a pipette fitted with a flexible rubber tubing of 5mm diameter. The tip of the pipette was also fitted with a

76µm mesh size zooplankton net to prevent accidental loss of organisms during siphoning (Wetzel and Likens, 1979 as cited by Ovie 1997). Phytoplankton samples were collected by obtaining one liter of the reservoir water to which two drops of Rose Bengal stain was added. The samples were then preserved in 4% formalin (Throndson, 1978 as cited by Zabbey *et al,* 2008). Qualitative and quantitative analysis of plankton was done following methods described in Jeje and Fernando, (1986) and APHA (1998). Sorenson's index of similarity was computed using the equation:

$$S = \frac{2c}{a + b} \times 100$$

Where:

a = total number of species in one ecosystem

b = total number of species in the second ecosystem

c = total number of species common to both ecosystem being compared. Ovie (1995)

Potential fish yield was estimated using the Morpho Edaphic Index (MEI) method given by the equation:

$$\log Y = 0.9420 + 0.3813 \log X$$

where:

Y = fish yield in kg/ha

X = MEI = Conductivity in µmhos/cm at $20^{o}$c / mean depth in meters.

One way ANOVA with post test was used to statistically analyze for the relationship between the physico chemical parameters and the plankton abundance in the different reservoirs.

## 3. Results and discussion

### 3.1 Physico-chemical status of the reservoirs

The means and standard deviation of physicochemical parameters are presented in Table 1. Reservoir 4 is deepest (1.65m) while reservoir 1 the shallowest (1.04m). transparency was highest (0.28m) in reservoir 2. Lowest Dissolved oxygen (6.89 mg $l^{-1}$) was recorded in R4 while the highest (8.18 mg $l^{-1}$) in R1. This shows that even the lowest concentration of oxygen in the reservoirs was above the level injurious to fish. Temperature was highest ($28.48^{o}$c) in R2 and lowest ($26.34^{o}$c) in R4. In general, the temperatures recorded in this study falls within the range which is best for the growth of warm water fish ($25^{o}$c – $32^{o}$c).

pH values both at the lowest (7.39) and highest (7.54) recorded were favorable for fish production as they are not anywhere close to death points for fish.

Waters with total alkalinities of 20 – 150mg $l^{-1}$ contain suitable quantities of carbon dioxide to permit plankton production for fish growth. In the present study, total alkalinity was generally high. The highest (286 mg $l^{-1}$) being in R4 while the lowest (202 mg $l^{-1}$) in R1. Despite the high concentration of total alkalinity in R4 which supposedly should increase phytoplankton density, it was not found to be so. This may be as a result of some oily film observed on the surface of the water which could be spillage from the water pumping machine situated close to the reservoir. This may have significant effect on the process of primary production. However, since the concentration was equally high in the other reservoirs, it is evident that there was high plankton production in them. This may explain why free $Co_2$ was generally low as the algae could have used it up for photosynthesis.

According to Vajrappa and Singh (2005), water having conductivity below 750 µmhos/cm is satisfactory in so far as salt content is concern, although salt sensitive plants may be adversely affected. In this study, conductivity levels were minimum- 380.00 and maximum - 544.29 (µmhos $cm^{-1}$) in R2 and R4 respectively; both values can be said to be within the limit hence, favorable for the growth of phytoplankton.

One way ANOVA test shows that there was no significant difference (P>0.05) between all the parameters in the different reservoirs. The similarity in the physical parameters such as water temperature, transparency may have been caused by the almost same weather pattern in the period under investigation. Since the reservoirs (especially the first three) are connected via monks/sluice, it can be said that the similarities of chemical parameters may have been caused by constant seepage and mixing of water through the monks/sluice.

Gross pelagic primary productivity was lowest (1.69) in R4. This is far below the findings (25.9, 20.4 $go_2cm^{-2}d^{-1}$) of Atule (1985) and Adeniji, (1980) respectively as cited by Adeniji et al (1989). However, it was generally observed that the GPP in all the reservoirs compared favorably with other past findings around kainji and averagely when compared to other water bodies in other parts of the world. (Ovie et al, 2000; Adeniji, 1990; Boswas, 1978; Imevbore and Boszor-menyi, 1975; Karlman, 1973; Talling, 1969). GPP in the other reservoirs were 2.24, 3.17, and 2.61 for R1, R2 and R3 respectively.

Table 1: Physico chemical parameters of the reservoirs

| Parameters | Mean/Standard deviation | | | |
|---|---|---|---|---|
| | R1 | R2 | R3 | R4 |
| Mean depth (m) | 1.04±0.14 | 1.22±0.14 | 1.26±0.12 | 1.65±0.29 |
| Dissolved $O_2$ (mg $l^{-1}$) | 8.18±0.56 | 7.63±0.68 | 7.16±0.42 | 6.89±0.42 |
| Free $Co_2$ (mg $l^{-1}$) | 0.00±0.00 | 0.00±0.00 | 0.06±0.04 | 1.35±0.74 |
| Total alkalinity (mg $l^{-1}$) | 202.40±5.41 | 208.66±41.20 | 280.20±30.35 | 286.50±38.22 |
| Air Temp. °C | 31.40±1.39 | 30.17±1.60 | 29.65±1.06 | 30.00±1.94 |
| Water Temp. (°C) | 28.33±0.81 | 28.48±0.68 | 28.18±0.67 | 26.34±0.57 |
| pH | 7.55±0.03 | 7.44±0.04 | 7.39±0.11 | 7.54±0.04 |
| $NO_3$ (mg $l^{-1}$) | 2.09±2.51 | 1.00±0.40 | 0.80±0.57 | 1.30±0.91 |
| $PO_4$ (mg $l^{-1}$) | 0.04±0.06 | 0.06±0.07 | 0.06±0.07 | 0.04±0.04 |
| $NH_3$ (mg $l^{-1}$) | 0.72±0.58 | 0.23±0.09 | 0.18±0.13 | 0.29±0.20 |
| Conductivity (µmhos $cm^{-1}$) | 516.67±171.99 | 544.29±146.46 | 402.31±147.74 | 380.00±33.59 |
| Transparency (m) | 0.15±0.06 | 0.28±0.07 | 0.23±0.02 | 0.21±0.05 |
| GPP ($go_2$ $m^{-2}d^{-1}$) | 2.24±0.77 | 3.17±0.43 | 2.61±0.46 | 1.69±0.56 |

The average concentrations of the major cations and anions discussed in this study along side their normal concentrations in freshwater (Bowen, 1966) and those given for hard waters (Rodhe, 1941) as cited by Johnson (2005), as well as their proportions are presented in Table 2. The concentrations were richer than that of the normal except $CO_3$ and $SO_4$, this is indicative of a condition of less salinity. When compared with the values of hard waters, it can be said that the water in the reservoirs are soft as they contain lesser concentration except chlorine which recorded higher concentrations in all the reservoirs. This may not be unconnected to the high evaporation that normally occurs due to the sunny pattern of that period of the year. The proportions of these ions as compared with the standard: Ca>Mg>Na>K and $CO_3$>$SO_4$>Cl, as proposed by Rodhe (1949), shows deviations from the normal in all the reservoirs except in R1 where the cations are in the normal proportions. Deviations such as the one observed in this study have been reported by other scientists (Johnson 2005, Wetzel, 1975). Chlorine concentration was found to be higher than for the hard water, this may be due to accumulation as a result of high evaporation of water during that period of the year.

Table 2: Major ions (mg $l^{-1}$) in the reservoirs with the normal concentrations of world freshwaters and hard waters

| *Ions* | *R1* | *R2* | *R3* | *R4* | *Freshwater (Bowen, 1966)* | *Hard waters (Rodhe, 1949)* |
|---|---|---|---|---|---|---|
| $Ca^{2+}$ | 20.84 | 24.94 | 25.14 | 27.26 | 15.0 | 59.0 |
| $Mg^{2+}$ | 3.24 | 5.06 | 9.33 | 5.80 | 4.1 | 9.9 |
| $Na^{+}$ | 8.63 | 7.75 | 6.50 | 8.50 | 6.3 | 16.6 |
| $K^{+}$ | 6.02 | 3.84 | 4.35 | 4.16 | 2.3 | 6.0 |
| $CO_3^{-}$ | 0.00 | 0.00 | 0.00 | 0.00 | 55.0 | 103.2 |
| $SO_4^{-}$ | 2.78 | 1.25 | 2.50 | 0.50 | 11.0 | 34.9 |
| $Cl^{-}$ | 28.75 | 39.00 | 30.12 | 27.00 | 7.8 | 16.6 |
| | | *Proportions* | | | | |
| **Cations:** | Ca>Na>K>Mg; | Ca>Na>Mg>K; | Ca>Mg>Na>K; | Ca>Na>Mg>K; | | |
| **Anions:** | Cl>$So_4$>$Co_3$ | Cl>$So_4$>$Co_3$ | Cl>$So_4$>$Co_3$ | Cl>$So_4$>$Co_3$ | | |

**3.2 Biological parameters**

A checklist and mean values of total Plankton abundance in the different reservoirs for the entire period of study is shown in table 3 while the gross abundance of zooplankton and phytoplankton in each month are shown in figures 5 and 6 respectively. Zooplankton species analyzed totaling 17 were found to fall within the three major taxas (Rotifer, Cladocera and Copepod) while phytoplankton species totaling 23 were categorized under five taxas (chlorophyta, cyanophyta, chrysophyta, pyrrhophyta and euglenophyta). It was generally observed that though phytoplankton species were high in R4, there mean abundance was the lowest (24,423) compared to the rest of the reservoirs which had 57,884, 73,374 and 43,802 (cells $ml^{-1}$) for R1, R2 and R3 respectively. This had affected the productivity level of the water as the lowest gross pelagic primary productivity was recorded in the reservoir. The zooplankton count was highest (21.41 ind.$l^{-1}$) in R3. This may be due to the all year round availability of water in the reservoir unlike in the other reservoirs which is caused by gravitational movement of the water through the monk/sluice from R1 to R2 then R3 leaving the first two virtually empty in dry season. The mean count in the other reservoirs were 15.34, 23.19, 15.81 ( Ind. $l^{-1}$) for R1,R2 and R4 respectively.

Further Tests also revealed there was significant difference ($P<0.05$) between: physico chemical parameters and the phytoplankton, phytoplankton and zooplankton, phytoplankton and the gross pelagic primary productivity (GPP) in reservoirs 1,2 and 3. But there was no significant difference ($P>0.05$) between the parameters and the phytoplankton, zooplankton and GPP in reservoir 4. This is of interest as the parameters in R4 did not differ with the rest of the reservoirs, however, it was not unexpected due to the oily substance observed in most part of the study period.

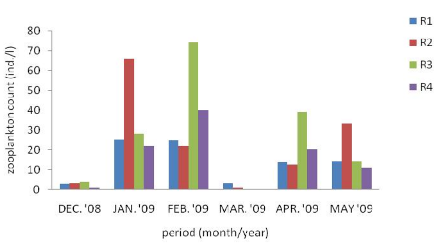


Fig. 5: zooplankton densities in the reservoirs

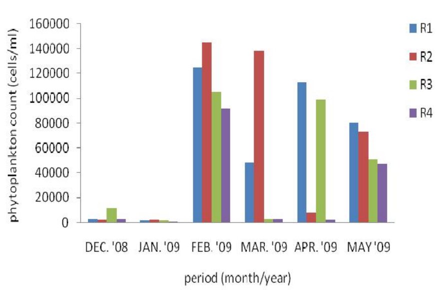


Fig. 6: Phytoplankton densities in the reservoirs

### 3.3 Sorenson's index of similarity

Sorenson's index of similarity of zooplankton between the reservoirs is given in figure 7. Since similarity is only significant when values are greater than 50% (Pieterse, 1987), It can be said that the zooplankton community were all similar in December '08, February and May '09. The rest of the months also recorded at least 50% similarity.

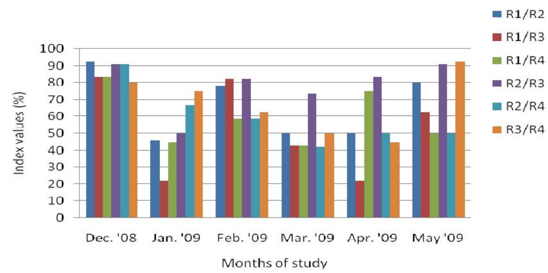


Figure 7: Zooplankton Sorenso's similarities between the reservoirs

### 3.4 Potential Fish Yield (PFY)

The potential fish yield of the different reservoirs is given in Table 4. R1 had the highest (93.33 kg $ha^{-1}$) while R4 the minimum (69.18 kg $ha^{-1}$). All the reservoirs are considered to have high potentials when compared with findings from Ojirami (49.6), Dadin Kowa (30.2) and Kiri (42.7) reservoirs (Ovie et al., 2009, 2000). Since higher productivity is characterized with higher conductivity and low mean depth (Ovie et al., 2009), the high potential fish yield recorded in this study may be as a result of high conductivity 516.67, 544.29, 402.31 and 380 (µmhos $cm^{-1}$); as well as low mean depths 1.04, 1.22, 1.26 and 1.65 (m) in R1, R2, R3 and R4 respectively.

Table 4: Potential fish yield in the resevoirs

| Reservoirs | (kg $ha^{-1}$) |
|---|---|
| R1 | 93.33 |
| R2 | 89.13 |
| R2 | 79.43 |
| R4 | 69.18 |

Table 3: A checklist and mean values of plankton abundance in the reservoirs

| Zooplankton | R1 | R2 | R3 | R4 | Phytoplankton | R1 | R2 | R3 | R4 |
|---|---|---|---|---|---|---|---|---|---|
| **Rotifera** | | | | | **Chlorophyta** | | | | |
| *Filinia opoliensis* | - | - | + | - | *Volvox tertius* | - | + | + | + |
| *Filinia longifilis* | - | + | - | - | *Scenedesmus quadricauda* | + | + | + | - |
| *Brachionus falcatus* | + | + | + | + | *Scenedesmus incrassatulus* | + | + | + | + |
| *Brachionus angularis* | + | + | + | + | *Chlorella ellipsoidea* | + | + | + | + |
| *Brachionus calyciflorus* | + | + | + | + | *Pediastrum simplex* | + | + | + | + |
| *Asplanchna sp* | + | + | + | + | *Microspora* | + | + | + | + |
| *Polyarthra sp* | + | + | - | - | *Staurastrum cornuta* | + | + | + | + |
| *Lecane acronycha* | + | + | - | - | *Arthrodesmus* | - | - | - | + |
| *Lecane bulla* | - | + | - | - | *Closterium kuetzingii* | + | - | - | + |
| *Trichocerca* | + | + | + | - | **Cyanophyta** | | | | |
| **Cladocera** | | | | | *Anabaena* | + | + | + | + |
| Moina sp | + | + | + | + | *Arthrospira* | - | + | + | + |
| Diaphanosoma exisum | + | + | + | + | *Anacystis* | + | + | + | + |
| Bosmina sp | + | - | + | + | *Microcystis* | + | + | + | + |
| Ceriodaphnia cornuta | - | - | - | + | **Chrysophyta** | | | | |
| **Copepod** | | | | | *Nizschia* | + | + | + | + |
| Cyclopoid sp | - | + | + | + | *Diatoma* | - | - | - | + |
| Calanoid | + | + | + | + | *Melosira* | + | - | + | + |
| Nauplii | + | + | + | + | *Cyclotella* | - | - | + | - |
| | | | | | *Fragilaria* | + | + | + | + |
| | | | | | *Synedra* | - | - | - | + |
| | | | | | *Navicula* | + | + | + | - |
| | | | | | *Stipitococcus* | - | - | - | + |
| | | | | | **Pyrrhophyta** | | | | |
| | | | | | *Hemidinium* | + | - | - | + |
| | | | | | **Euglenophyta** | | | | |
| | | | | | *Phacus* | + | + | + | + |
| **Mean total zooplankton (ind./l)** | **15.34** | **23.19** | **21.41** | **15.81** | **Mean total phytoplankton/ml (cells/ml)** | **57884** | **73374** | **43802** | **24423** |

Key: + = Present; - = Absent

## 4. Conclusion and recommendations

In this study, It was found that the physico chemical parameters of the reservoirs tested were not harmful for the production of fish, rather they were significant in the improvement of productivity, Measurements of the concentrations of the parameters are within permissible limits. However, reservoir 4 which is located apart from the first three, had some inexplicable character as the parameters tested therein did not differ significantly with those of the other reservoirs, yet there was no evidence that it contributed to the productivity of the water. As explained earlier, this phenomenon is not unconnected to the oily substance observed on the water surface. It is recommended that further test be carried out in order to ascertain the cause. The potential fish yield of the reservoirs that was considered high should be looked into as fish production in these reservoirs will be of enormous benefit. Generally, the reservoirs can be said to be in good condition for fish production.

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