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FISH PRODUCTIVITY ON THE KONTAGORA RESERVOIR, NIGER STATE, NIGERIA IN RELATION TO PHYSICO-CHEMICAL CHARACTERISTICS AND MORPHO – EDAPHIC INDEX

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Abstract
A study of the physico-chemical characteristics and morpho-edaphic index in relation to its potential for fish production was conducted on Kontagora Reservoir, Niger State, Nigeria, from January to December, 2007. The physico-chemical characteristics determined bimonthly include temperature, water depth, pH, electrical conductivity, dissolved oxygen total alkalinity, phosphate-phosphorus and Nitrate-nitrogen. Morpho-edaphic index was determined using Henderson and Welcome equation. The hydrogen ion concentration (pH) (6.59–7.58), total alkalinity (26.73–65.13mg/l), conductivity (68.07–98.67µs) and dissolved oxygen (3.23–6.29) were within the range adequate for fish production. However, phosphate- phosphorus (2.84–8.31mg of $CaCO_3$/l) and Nitrate-nitrogen (1.57–10.91mg of $CaCO_3$/l) values were low and fell below the range necessary for fish production. The morpho-edaphic index value was low (4.15–15.54) and corresponds with low primary productivity. Therefore, the mean estimated potential fish yield of the reservoir, during the study period was low.

Keywords: fish yield, Lakes, months, sampling stations.

Introduction
Nigeria is blessed with more than 12 million hectares of inland water, capable of producing about 2.3 million metric tones of fish annually, if properly managed (Ita *et al*., 1985). The use of abiotic factor to assess the fishery potential of water bodies in developing countries is scanty, and where such data are available, they are not properly applied for management purposes, in the development of indigenous fisheries. The knowledge of the Physico-chemical characteristics of a water body is therefore, valuable in determining its productivity. It serves as the basis for considering the richness or otherwise the biological productivity of an aquatic environment (Imevbore, 1970). Ryder *et al.* (1974) and Jekin (1982), classified some lakes based on their trophic status and potential fishery production related to abiotic factors. Attempt by Noble (1980) to explain further, the variations in fish production in both lakes and reservoirs, indicated that the mean depth and total dissolved solid are principal factors that determined fish production and distribution. Other factors including shore line development, water exchange rates etc. have substantial effects. The importance of depth and total dissolved solids expressed in Henderson and Welcomme (1974) empirical formular Morpho -edaphic Index (MEI), for rapid calculation of potential productivity of lake ecosystem, and its predictive utility, has been applied in tropical lakes (Wade and Anadu, 1987). Henderson and Welcomme (1974) reported some relationship between fish yield to

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morpho-edaphic index, and the number of fishermen in Africa inland waters.

The primary objectives of this study are: to assess the productive potential of Kontagora Reservoir using abiotic factors, and, to proffer possible management strategies.

Materials and method

Study area

The study was conducted on Kontagora Reservoir, in Niger State, Nigeria. The reservoir located on River Kontagora , a seasonal river , lies in the Northern Guinea Savannah zone, between latitude 3°20' and 7°40' East, and longitude 8° and 11°3' North (Fig. 1). The climate was characterized by distinct dry and wet seasons. The reservoir which was created primarily for domestic water supply, has a total storage capacity of 17.7 million cubic metre, and a surface area of 143 Square Kilometres. The height of the reservoir is 20 metres, while the crest length is 1000 metres.

Sampling Stations

Water samples were collected from five sampling stations bimonthly from January to December, 2007, with corked specimen bottles (Figure 1). Station I is located at the southern basin of the reservoir, Tunga – Hajiya . Station II is at the middle of the reservoir at Tunga-Kawo. Station III is the Northern part of the reservoir at Jantaye. Station IV located at Loko-Kamboli on the eastern part of the reservoir. Station V at Loko-Kuka covers the western part of the reservoir.

Determination of the physico-chemical characteristics

Air and water temperatures were measured at each sampling station using mercury thermometer in degree centigrade. Water depth was measured using a calibrated measuring tape weighted at one end. Pye Unicam model (292), after standardization with buffer solution at pH 4.0, 7.0 and 9.0 was used for pH. The modified Winkler-azide method (Lind, 1979 and APHA, 1985) was used to determined dissolved oxygen (DO). Electrical conductivity was measured using Pyeunicam model (292) conductivity meter, pre-rinsed and set at zero point. Total alkalinity was determined by using standard method of Boyd (1979) and APHA (1992). Phosphate-phosphorus was determined using the Denges method Lind (1979) and APHA (1985). Nitrate-nitrogen was determined by phenoldisulphonic acid method as described by Mackereth (1963). Total dissolved solid (TDS), was determined by method of O'Wen (1979), by multiplying the specific conductivity values of the water sample from the reservoir by 0.65.

Morpho-edaphic index (M.E.I.)

Morpho-edaphic index (M.E.I.) was determined using the equation given by Henderson and Welcomme (1974).

For the equation,

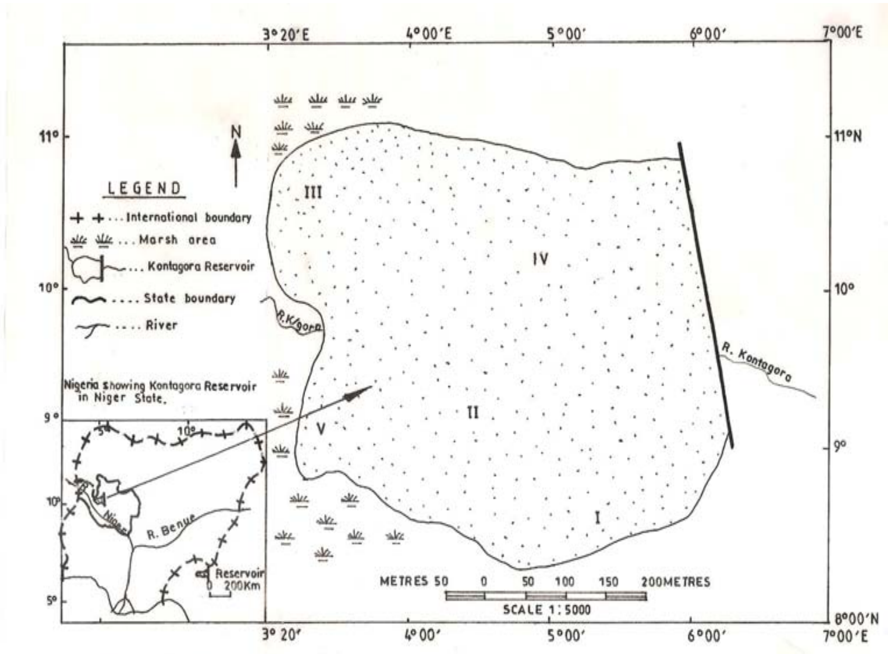
$$\text{M.E.I} = \frac{\text{TDS}}{\text{Z}} = \frac{\text{Total Dissolved Solid (ppm)}}{\text{Mean Depth (m)}}$$

Statistical analysis

Statistical Analysis of the results was based on the use of one way analysis of variance (ANOVA), with the means compared using Duncan Multiple range test (DMRT) (Steel and Torrie, 1980).

Results

The results of the physical and chemical characteristics of the reservoir are presented in Table 1, 2 and 3. A marked monthly variation was observed. The water temperature range was 18.87 – 29.73^{o}C (Table 1). The lowest mean value was recorded in January, while the highest in June. The pH of the reservoir was neutral through out the year (pH 6.5–7.58)



Map of Kontagora Reservoir at Tunga Kawo (Source: Niger State Ministry of Land and Survey Kontagora Area Office).

(Table 1). There was no seasonal variation in the pH values for the reservoir (Table 2).The conductivity values of the reservoir ranged between 68.07 – 98.67µs for the year, with the maximum value in April and minimum in September (Table 1). The mean dry season value was higher than that of the rainy season (Table 2). Dissolved Oxygen concentration range was 3.23 – 6.29mg/l (Table 1), with the highest value in January and lowest in October. Maximum alkalinity value was recorded in June (65.13 mg/l), while the minimum value (26.73mg/l) in February (Table 1). Phosphate-phosphorus occurred within the range of 2.84 – 8.31mg of $CaCO_3$/l, the maximum value was obtained in April and the minimum in August (Table 1). The mean dry season value (6.86 mg of $CaCO_3$/l), was significantly higher ($p<0.05$), than that of the rainy season (Table 2). Nitrate-nitrogen value was highest in February (10.9 mg of $CaCO_3$/l), and lowest in December (1.57 mg of $CaCO_3$/l) (Table 1). The mean dry season value of Nitrate - nitrogen was significantly higher ($P<0.05$), than that of the rainy season (Table 2). The morpho-edaphic index (M.E.I.) value for the reservoir was low, with the mean monthly range of 4.15 – 15.4 (Table 1). The lower M.E.I. values were obtained during the rain, while the highest value was obtained in December (dry season). Analysis of Variance (ANOVA) (Table 3) showed that there were significant variations in all the physico- chemical characteristics for the months and the sampling stations. However, the (ANOVA) showed that the interaction between the months and sampling stations showed significant variations for the physico-chemical characteristics, except for pH and Nitrate – nitrogen.

Table 1. Mean monthly values of some physico-chemical characteristics of Kontagora Reservoir, Niger State, Nigeria (January – December, 2007)

Month	PHYSICO-CHEMICAL CHARACTERISTICS										
	Air Temp. ^{o}C	Water Temp. ^{o}C	Depth (m)	pH	Conductivity (µs)	Dissolved Oxygen	Alkalinity (mg/l)	PO_4P (mg 0f $CaCO_3$/l)	NO_3-N (mg 0f $CaCO_3$/l)	Total Dissolved Solid (ppm)	Morpho-edaphic Index (M.E.I.)
Jan	25.73^{e}	18.87^{f}	5.85^{f}	6.85^{f}	79.20^{e}	6.29^{a}	27.33^{h}	5.67^{ef}	7.43^{b}	38.87^{f}	7.58^{c}
Feb	28.60^{d}	25.00^{de}	6.32^{e}	7.23^{bc}	88.73^{bc}	4.94^{b}	26.73^{h}	7.44^{bc}	10.91^{a}	44.67^{bc}	7.06^{cd}
Mar	32.20^{b}	25.67^{d}	6.18^{e}	6.59^{g}	92.20^{b}	6.01^{a}	28.20^{h}	8.30^{a}	3.37^{e}	45.87^{b}	7.42^{c}
Apr	30.73^{c}	27.73^{bc}	6.34^{e}	7.58^{a}	98.67^{a}	4.28^{c}	28.73^{h}	8.31^{a}	4.75^{cde}	49.31^{a}	7.78^{c}
May	31.60^{bc}	29.60^{a}	6.41^{e}	7.27^{b}	96.80^{a}	5.09^{b}	52.27^{c}	6.58^{d}	4.16^{de}	48.61^{a}	5.16^{ef}
Jun	33.20^{a}	29.73^{a}	7.89^{c}	7.01^{cde}	80.73^{e}	4.30^{c}	65.13^{a}	6.09^{ed}	6.06^{bc}	42.93^{ed}	5.44^{ef}
Jul	28.67^{d}	27.00^{c}	7.32^{d}	7.25^{bc}	84.50^{d}	4.98^{b}	60.97^{b}	4.61^{g}	3.70^{de}	42.00^{e}	5.73^{e}
Aug	27.87^{d}	24.87^{e}	9.15^{a}	7.13^{bcd}	90.13^{b}	4.30^{c}	51.87^{c}	2.84^{h}	4.77^{cde}	45.01^{bc}	4.92^{g}
Sept	30.53^{c}	27.07^{c}	7.95^{c}	7.03^{ed}	68.07^{f}	3.45^{e}	36.67^{g}	7.55^{ab}	5.01^{cde}	34.40^{g}	4.33^{gh}
Oct	30.87^{c}	28.13^{b}	8.35^{b}	7.03^{ed}	68.60^{f}	3.23^{e}	40.27^{f}	6.74^{cd}	5.21^{cd}	34.67^{g}	4.15^{gh}
Nov	30.73^{c}	27.00^{c}	8.04^{c}	6.96^{ef}	86.53^{cd}	4.34^{c}	44.93^{e}	6.56^{d}	3.20^{e}	43.53^{cd}	14.81^{b}
Dec	30.87^{c}	27.80^{bc}	7.54^{d}	7.16^{bcd}	90.93^{b}	3.81^{d}	48.73^{d}	5.01^{fg}	1.57^{f}	45.40^{b}	15.54^{a}

Means with the same alphabet within the same column are not significantly different using Duncan Multiple Range Test (DMRT) (Steele and Torrie, 1980)

Table 2. Mean dry and rainy season values of some physico-chemical characteristics of Kontagora Reservoir, Niger state, Nigeria (January – December, 2007)

Season	PHYSICO-CHEMICAL CHARACTERISTICS									
	Air Temp. ^{o}C	Water Temp. ^{o}C	Depth (m)	pH	Conductivity (µs)	Dissolved Oxygen	Alkalinity (mg/l)	PO_4P (mg 0f $CaCO_3$/l)	NO_3-N (mg 0f $CaCO_3$/l)	Total Dissolved Solid (ppm)
Dry	29.96b	25.74b	6.94b	7.06a	86.41a	4.70a	53.38a	6.86a	4.74b	43.19a
Rainy	30.37a	27.65a	7.74a	7.15a	84.05b	4.42b	34.99b	5.53b	5.21a	42.59b

Means with the same alphabet within the same column are not significantly different using Duncan Multiple Range Test (DMRT) (Steele and Torrie, 1980)

Table 3. ANOVA showing variations of physico-chemical characteristics at sampling stations of Kontagora Reservoir and months

Sources of variation	Df	Air Temp .^{o}C	Water Temp. ^{o}C	Depth (m)	pH	Conductivity (µs)	Dissolved Oxygen	Alkalinity (mg/l)	PO_4P (mg 0f $CaCO_3$/l)	NO_3-N (mg 0f $CaCO_3$/l)	Total Dissolved Solid (ppm)
Treatment(trt)	59	13.76*	24.83**	7.76**	0.19*	322.95*	2.88*	527.18**	8.59*	18.01*	74.18*
Station	4	1.92*	0.71*	37.49**	0.06*	48.63*	0.14*	45.35*	1.95*	5.00*	27.99*
Month	11	63.79**	123.58**	16.92**	0.91**	1447.26**	12.98**	2717.11**	38.46**	84.73**	345.99**
Station X Month	44	2.33*	2.33*	2.92*	0.02^{ns}	66.80*	0.60*	23.51*	1.73*	2.51^{ns}	10.43*
Error	120	1.72	1.03	0.11	0.05	19.68	0.21	11.22	1.01	4.74	3.92

*Significant (p<0.05) **Highly Significant (p<0.01) ns- Non Significant

Discussion

Water temperature range for the reservoir compares well within those recorded for other tropical lakes (Adebisi, 1981; Ovie and Adeniji, 1993; Adakole *et. al.*, 2003). The normal range to which fish is adapted in the tropics is between 8°C and 30°C (Alabaster and Lloyd, 1982). The water temperature range of 25.74°C – 27.65°C for Kontagora reservoir is within the range of 10°C and 50°C for rivers and dam water meant for domestic purposes and for fish culture in tropical waters (WHO, 1984; Huet, 1977)

The neutral hydrogen ion concentration (pH), obtained through out dry and rainy season, is adequate for fish production and within the range for inland waters (pH 6.5-8.5), as reported by Antoine and A-Saadi (1982). Winger (1981), also observed a pH range of 5 – 9.5, as suitable for aquatic life, and, Boyd and Lichtkoppler (1979), reported similar pH range of 6.09 and 8.45, as being ideal for supporting aquatic life including fish. Thus, the pH range obtained in this study is within the acceptable level of 6.0 – 8.5 for culturing tropical fish species (Huet, 1977). And also, within the recommended range of Federal Environmental Protection Agency (FEPA) pH 6.5 – 8.0 for drinking and 6.0 – 9.0 for aquatic life. Winger (1981) reported that land use in the watershed strongly influences the amount of nutrients that enter receiving waters. Hynes (1975) identified substantial amount of energy input into water, as coming from allochtonous organic input. Therefore, agricultural practice in the catchments area is recommended as a means of increasing the organic matter content and carbon dioxide of the reservoir, in order to enhance primary productivity and fishery potential of the reservoir. The mean alkalinity fall within the range documented by Moyle (1946) and Boyd (1981) for natural waters. The alkalinity is higher in the dry season. Hem (1970) gave a range of 75-200ppm of $CaCo_3$, as adequate buffering capacity for productive warm water streams. The high alkalinity during dry season, which is an indication of high buffering capacity of the reservoir, implies high productivity. This situation may possibly be related to the nature of bedrock and rocks of the catchments area (Ufodike *et al.*, 2001). According to Shoup (1974) alkalinity reflects the geochemistry of the watershed. Therefore, artificial liming of the water could enhance the primary productivity and fishery potential of the reservoir. The conductivity range reported in this study is within the range for tropical water. Higher dry season conductivity value obtained could be attributed to concentration effect as a result of reduced water volume from their main tributary channels. Ovie and Adeniji (1993), and, Kolo and Oladimeji (2004), observed a similar trend of higher dry season conductivity value for Shiroro lake. The low conductivity observed in the rainy season, may be due to low content of bivalent cations, such as Ca^{++} and Mg^{++}. This situation could be improved through increased in the allocthonous organic inputs by agricultural practice in the catchments area. White (1966) reported that a high concentration of suspended matter influences the availability of ions in water, probably through adsorption effects of these ions on surface of suspended matter.

Mean dissolved oxygen range recorded for the reservoir fell within the ranges documented by Swingle (1969), Boyd (1979), and, Alabaster (1982) for good water quality. The dissolved oxygen in the reservoir was higher during the dry season than the rainy season. The high oxygen value for the dry season coincides with the periods of lowest turbidity and temperature. Kemdirin (1990) reported that the high oxygen concentration during dry season may be related to the high phytoplankton activity during this period. According to Adeniji (1973) and Ibe (1993) the amount of dissolved oxygen in water is not constant but fluctuates, with temperature, depth, wind and amount of biological activities such as degradation.

The low phosphate-phosphorus and Nitrate-nitrogen concentrations obtained fell below the values obtained in some productive waters. According to Kemdirin (1990) the low nutrient titres, also relates to the low phytoplankton density in water bodies. The high dry season mean value of phosphate-phosphorus could be as a result of concentration effect because of reduced water volume. It could also be due to low water hardness (House, 1990; Heleen *et al.*, 1995). The higher Nitrate-nitrogen concentration during the rainy season could be due to surface run-offs that brought in fertilizers in solution into the reservoir, and, also decomposition of organic matter, which is a continuous process through out the year. Ufodike *et al.* (2001) made similar observation for Dokowa Mine Lake. Kennedy and Hains (2002) also reported that Nitrate-nitrogen increase with surface run-off, and at deeper depths. According to Coming *et al.* (1983), high nitrate concentrations in lakes are related to inputs from agricultural lands. Nitrate and phosphate are limiting nutrients for phytoplankton growth and primary productivity. Schinder (1978) reported that high concentration of Nitrate and Phosphate have been found to stimulate primary production and accelerate eutrophication.

The mean estimated potential fish yield of the reservoir was low. The low morpho-edaphic index (M.E.I.) value for the reservoir, correspond with low primary productivity , and may be due to low total dissolved solids, which causes low specific conductance. Hem (1970), reported that dissolved solid is closely related to specific conductance. However, this finding differ from that of Balogun *et al.*, (2000), who obtained a high morpho-edaphic index (M.E.I.), value for Zaria Dam, which correspond with high primary productivity. The higher M.E.I. value was as a result of low depth. It could also be due to extensive macrophytes and sudd communities with considerable high nutrients from run-off from the large agricultural catchments area, which received fertilizer application annually (Olatunde, 1977). According to Young and Heimbuch (1982) morpho-edaphic index accounted for 60-70% of the variations in fish yield observed in a set of data, and maximum fish yield was obtained at index values of 50-100.

The morpho-edaphic index has proved useful in reflecting the temporal seasonal variations in the productive status of the reservoir. Therefore, it is recommended for the assessment of the primary productivity and fishery potential status of water bodies for management purposes.

The physico-chemical characteristics, also from the foregoing have been observed to play a significant role in determining the amount of fish produced in a water body. It therefore, becomes, necessary to study, monitor and control these parameters in order to get maximum productivity from a water body.

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