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Fish productivity of ado-ekiti water reservoir in relation to physicochemical characteristics and mopho-edaphic index

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ABSTRACT
A study on the physicochemical parameters of Ureje Reservoir, Ado-Ekiti was used to estimate the potential fish yield of the reservoir using the Morpoedaphic Index (MEI). Physicochemical characteristics of the water body were sampled monthly from October - December 2011. The results showed variations in the physicochemical parameters at different sampling stations in the reservoir. The temperature ranged from 24.8–29.4 °C, pH ranged from 6.20-8.42, alkalinity ranged from 28.24–39.25 mg/$CaCO_3$/L, dissolved oxygen ranged from 5.10–11.24 mg/L, transparency ranged from 0.06–1.18 m, conductivity ranged from 722.30–972.2 µs, phosphate ranged from 64.08–79.60 mg/L, nitrate ranged from 18.10–22.10 mg/L, TDS ranged from 0.30–0.70 mg/L and TSS ranged from 0.04-0.08. Estimation of the potential fish yield gave an estimate of 112.59 kg/ha. This estimation was higher than other small shallower and larger African reservoirs. The mean values of physical-chemical parameters obtained in the reservoir were well below the recommended permissible limits by WHO for drinking water. Thus, the water could be regarded as safe for drinking after normal treatment. There should also be regular monitoring and adoption of effective management techniques to enhance sustainable use of the reservoir's fishery resources.

Keywords: Fish productivity, ado-ekiti water reservoir, physicochemical characteristics, mopho-edaphic index

1. Introduction

A reservoir is an artificial impoundment on land used to store water. Reservoirs may be created in river valleys by the construction of dams on a large expanse of water or may be built by excavation in the ground or by conventional construction techniques such as brickwork or cast concrete. Reservoirs are sleeping economic giants for generating self-employment, increasing production, assuming nutritional security, rural development, generating value added aquatic products with public and private participation [1]. A small reservoir holds good potential for fish production enhancement [2].

Water is the most vital resources of all kinds of life on earth and essential for the sustainability of the earth's ecosystem [3]. Fresh water is essential to human health, agriculture, natural ecosystem and industry. Fresh water bodies are also used for stocking fish, domestic use, drinking and also for irrigation. Rapid growth of population, increasing living standard in urban areas and industrialization have resulted in greater demands of quality water [4]

The quality of any water body is governed by its physico-chemical factors. The monitoring of physical-chemical characteristics of the water body are vital for both long-term and short-term analysis [5]. Distribution and productivity level of aquatic organisms are largely determined by physico-chemical factors [6, 7]. 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 [8].

The fisheries sector plays a significant role in income and employment generation as it stimulates growth of a number of subsidiary industries and is a source of cheap and nutritious fish food. At the same time, it is an instrument of livelihood for a large sector of the economically backward population [1]. The utilization of reservoirs for fish production besides other primary uses has become common practice in many countries, especially industrialized ones, where a number of reservoirs are managed for the production of annual harvestable fish crops. Several limnological parameters such as conductivity, total dissolved solids, water quality and reservoir morphological have been used in estimating potential fish yield from reservoirs. The most widely accepted method was the morphoedaphic index MEI) developed by [9]. The simplicity of the morpho- edaphic index (MEI) for rapid calculation of the potential productivity of the lake's ecosystem and its predictive utility has been applied in tropical lakes [10]. The importance of the morphoedaphic index (MEI) and its generally good predictive capabilities has resulted in its application worldwide subject to regional modifications. The morphoedaphic index (MEI) demonstrates that as nutrients in water and depth increases, fish production increases [11].

This present study aims at determining the physico –chemical characteristics of Ureje reservoir, Ado-Ekiti, Ekiti State, Nigeria and using this to estimate the fish productivity of the reservoir by the morpho- edaphic index method.

2. Materials and methods

2.1 Study Area

Ureje reservoir is the headquarters of Water Corporation in Ekiti State, situated at water works Ureje quarters, Ajilosun Street in Ado - Ekiti, Ekiti State. It is one of the major reservoirs inherited by the state from the former Ondo State in 1996.

Geographically, Ado Ekiti is at an altitude of 433 meters above sea level and lies within the tropical rainforest zone of southwestern Nigeria between 7^o 35’ N and longitude 5^o 12’E. The reservoir was constructed by damming of Ureje river in 1958, and water from the dam is being supplied to the public for domestic purposes in Ado-Ekiti and neighbouring towns with fish production as an ancillary purpose

A stretch of grass covers the banks of the reservoir and among these are sparsely distributed trees. Notable herbs along the banks are *Talinum triangulare; Tridax* sp, Guinea grass, Elephant grass, (*Pennisetum purpureum)* giant star grass (*Cynodon plectostachyus*), Rhodes grass (*Chloris gayana*), Siam weed (*Eupatorium odoratum*).

Aquatic birds such as ducks visit the reservoir, several species of snails are present such as *Indoplanorbis exustus* and *Biomphalaria* species. Fish fauna found in the reservoir include the following: *Tilapia zilli, Clarias gariepinus, Oreochromis niloticus, Heterobranchus bidorsalis, Hepsetus odoe* and *Barbus* sp.

2.2 Field Sampling

Three sampling stations (coded A, B and C) were selected from the length of the reservoir for the present study. Bimonthly sampling was carried out from October 2011 to December 2011. On each occasion, water and fish samples were collected between 6:00 a.m. and 8:00 a.m. Standard methods of APHA (1998) were used for the determination of physico-chemical parameters.

The data for fish study was based on records of fish catches by local fishermen. The fishing gears used were hooks and line, cast-nets, and cages. The species of fishes caught were identified and classified using the identification guides of [12, 13, 14, 15]. The total number of individual species of fish caught from the reservoir was recorded; this enabled the determination of the relative abundance of the various species in the reservoir.

2.3. Morphoedaphic Index (M.E.I)

The morpho- edaphic index (M.E.I) was determined using the equation given by [16].

This formula is given as follows:

M.E.I = TDS/Z i.e. Total Dissolved Solid (ppm) /Mean depth

3. Results

3.1 Physicochemical Parameters

The monthly means of physical-chemical parameters recorded in the three stations of the reservoir from October – December 2011 are presented in Tables 1. (a-c) while the overall means and ranges of these same parameters in each location are presented in Table 2.

Table 1: Means of Physico-Chemical Parameters of Ado-Ekiti Reservoir (Ureje)

Physico-Chemical Parameters	Station A	Station B	Station C	Mean	Standard error	WHO/FEPA
pH	7.67	7.72	8.16	7.85	±0.004	7.0-8.5
Temperature (^{o}C)	27.40	27.10	26.9	27.10	±0.04	30-32
Alkalinity (mg/$CaCO_3$)	31.34	33.30	33.42	32.69	±0.89	20-200
DO_2 (mg/O_2/L)	7.18	7.18	7.86	7.40	±0.19	≥5
Transparency (m)	0.27	0.32	0.31	0.30	±0.004	1
Conductivity (µs)	839.18	777.87	910.85	842.63	±154.4	≤ 200
Phosphate (mg/L)	70.86	70.30	71.44	70.89	±0.21	≤ 75
Nitrate (mg/L)	19.56	22.53	22.14	21.41	±1.57	≥ 10
TDS (mg/L)	0.45	0.45	0.55	0.48	±0..001	5.5- 6.5
TSS (mg/L)	0.05	0.06	0.07	0.06	±0.006	≤5

Table 2: Correlation coefficients of Physico-Chemical parameters of Ureje Reservoir, Ado– Ekiti.

Physico-Chemical Parameters	pH	Temp	Alka	DO_2	Transp	Cond	PO_4	NO_3	TDS	TSS
pH	1.00	-0.399	0.140	-0.343	0.004	0176	-0.058	0.078	0.008	0.267
Temp		1.00	0.018	-0.100	0.225	-0.135	-0.109	-0.170	0.162	-0.495
Alka			1.00	0.236	-0.243	0.087	0.303	0.028	-0..131	0.196
DO_2				1.00	-0.310	0.050	0.553*	0.196	-0.154	-0.043
Transp					1.00	0.327	-0.134	-0.348	0.562*	-0.431
Cond						1.00	0.405	-0.357	0.482	0.117
PO_4							1.00	-0.004	-0.066	0.210
NO_3								1.00	-0.054	0.263
TDS									1.00	0.023
TSS										1.00

Correlation is significant at the 0.05 level (2-tailed)

Water temperature in three stations ranged between 26.9 to 27.4 ºC with mean value of 27.10 ºC ± 0.04 (Table 1). Station C recorded the lowest temperature of 26.9 ºC while the highest value of 27.4 ºC was recorded in station A (Table 2). The temperature had a slightly negative, but insignificant correlation with TSS (Table 2) and a positive significant correlation ($p<0.05$, $r = 0.644$) with *Tilapia zillii* (Table 4).
The hydrogen ion concentration ranged from 7.67 to 8.16 with a mean value of 7.85 ± 0.004. The highest pH value of 8.16 was recorded in station C while the lowest value of 7.67 was recorded at station A (Table 1). pH had no significant correlation with any of the physico-chemical parameters and the identified fish species .
The alkalinity of the water ranges from 31.34 to 33.42 mg $CaCO_3$ /L with mean value of 32.69 mg $CaCO_3$/L. The highest value of 33.42 mg $CaCO_3$ /L was recorded in station C while the lowest value of 31.34 mg $CaCO_3$/L was recorded in station A (Table 1). Alkalinity showed no correlation with any of the physical-chemical parameters, but had a significant negative correlation ($p<0.05$, $r = 0.642$) with *S. melanotheron* and a positive significant correlation ($p<0.05$, $r = 0.690$) with *Tilapia zillii* (Table 4).
Dissolved oxygen in the three stations ranged from 7.18 to 7.86 mg/L with a mean of 7.40 mg/L ± 0.09. The lowest value of 7.18 mg/L was recorded in station B while the highest value of 7.86 was recorded in station C (Table 1). Dissolved oxygen had a positive significant ($p<0.05$, $r = 0.553$) correlation with phosphate only (Table 2). DO_2 exhibited a negative, but significant correlation ($p<0.05$, $r = -0.511$; $r = -0.590$) with *C. gariepinus* and Red Tilapia respectively (Table 4).
The transparency of the reservoir ranges from 0.27 to 0.32 mg/L with a mean of 0.30 mg /L ± 0.0004. The lowest mean value of 0.27 mg/L was recorded in station A while the highest mean value of 0.32 mg/L was recorded in station B (Table 1). Transparency had a positive significant ($p< 0.05$, $r = 0.562$) correlation with TDS and insignificant correlation with other physico-chemical parameters (Table 2). It also had a positive significant correlation ($p<0.05$, $r = 0.525$) with *H. odoe* and a negative, but significant correlation ($p<0.05$, $r = - 0.653$) with *Tilapia zillii* (Table 4).
The conductivity of the reservoir water ranges from 777.87 µs to 910.85 µs with a mean of 842.63 µs. Conductivity recorded the lowest mean value of 777.89 µs in station B while the highest mean value of 910.85 µs was recorded in station C (Table 1).
Conductivity had no significant correlation with any of the physical-chemical parameters, but exhibited a strong negative, but significant ($p>0.05$, $r = 0.828$) correlation with one of the identified fish, *Tilapia zillii* (Table 4).
Phosphate in the three stations ranged from 70.30 to 71.44 mg of $CaCO_3$ /L with a mean of 70.89 mg of $CaCO_3$ /L ± 0.21 (Table 1). The highest value of 71.44 $CaCO_3$ /L was recorded in station B. Phosphate had no significant correlation with any other parameters (Table 2). It however exhibited a strong positive significant correlation ($p<0.05$, $r = 0.942$; $r = 0.673$; and are = 0.695) with *O. niloticus*, *H. odoe* and *Tilapia zillii* respectively (Table 4).
Nitrate was in the range of 19.6 mg $CaCO_3$/L to 22.53 mg $CaCO_3$/L with a mean value of 21.41 mg $CaCO_3$/L. Nitrate recorded the lowest value of 19.56 mg$CaCO_3$/L in station A while the highest mean value (22.53 mg $CaCO_3$/L) was recorded in station B (Table 1). Nitrate showed no significant correlation with any of the physical-chemical parameters, but exhibited a positive significant correlation with *O. niloticus* and *S. galilaeus* ($p<0.05$, $r = 0.533$; $r = 0.799$), respectively. It also had a negative but significant correlation with *C. gariepinus* ($p<0.05$, $r= -0.646$) (Table 4).
Total dissolved solids in the three stations of Ureje reservoir ranges from 0.45 mg/ L to 0.55 mg/L with a mean value of 0.48 mg/L ± 0.001 (Table 1). TDS had a positive significant correlation ($p<0.05$, $r= 0.562$, $r= 0.482$) with transparency and conductivity respectively (Table 2). TDS showed a positive significant correlation with *O. niloticus* ($p<0.05$, $r = 0.743$) and a negative significant correlation with *C. gariepinus* ($p<0.05$, $r = -0.575$) (Table 4).
Total suspended solids in the three stations ranged between 0.05 mg/L to 0.07 mg/L with a mean value of 0.06 mg/L ± 0.00006 (Table 1). Total suspended solids had a negative, but significant correlation ($p<0.05$, $r = -0.495$) with temperature (Table 2). It had a strong positive significant correlation *O. niloticus* and *S. melanotheron* ($p<0.05$, $r = 0.722$; $r = 0.704$) respectively (Table 4). It also had a strong negative significant correlation ($p<0.05$, $r = -0.739$; $r = -0.558$) with *C. gariepinus* and *H. odoe*, respectively (Table 4).

3.2. Fish Species and Abundance
Data on the species and abundance of fish in Ureje Reservoir, Ado – Ekiti reservoir is shown in Tables 3(a-d). A total of 6 species of fish was recorded from during the period of study.

3.3. Potential Fish Yield
The potential fish yield of Ureje Reservoir, Ado - Ekiti was estimated in Kg/ha/annum through the morphoedaphic index (MEI) as described by [9, 16]. This was obtained from the following relationship:

Yield (Y) = 23.281 x MEI $^{0.447}$
MEI = Mean conductivity of all 3 stations $^{(0.447)}$/ mean depth
Y= 23.281 x 842 .63 $^{(0.447)}$/ 4.2
Y = 23.281 x 20.312/ 4.2
Y = 23.281 x 4.836 = 112.59 kg/ha/annum

Table 3a: Fish Abundance of Ureje Reservoir, Ado – Ekiti during October 2011

	October 15th Catch	October 30th Catch	Total Catch	Mean Abundance
Oreochromis niloticus	26	38	64	32
Sarotherodon melanotheron	20	26	46	23
Sarotherodon galilaeus	30	34	64	32
Tilapia zillii	24	30	54	22
Clarias gariepinus	6	2	8	4
Hepsetus odoe	4	0	4	2

Table 3b: Fish Abundance of Ureje Reservoir, Ado – Ekiti during November 2011

Fish species	November 15th Catch	November 30th Catch	Total Catch	Mean Abundance
Oreochromis niloticus	50	44	94	47
Sarotherodon melanotheron	70	42	112	86
Sarotherodon galilaeus	35	29	64	32
Tilapia zillii	20	27	47	21
Clarias gariepinus	2	6	8	4
Hepsetus odoe	2	2	4	2

Table 3c: Fish Abundance of Ureje Reservoir, Ado – Ekiti during December 2011

Fish species	December 15th Catch	December 30th Catch	Total Catch	Mean Abundance
Oreochromis niloticus	46	44	90	45
Sarotherodon melanotheron	32	30	62	31
Sarotherodon galilaeus	40	32	72	36
Tilapia zillii	30	20	50	25
Clarias gariepinus	2	2	4	2
Hepsetus odoe	3	3	6	3

Table 3d: Total and Percentage Fish Abundance of Ureje Reservoir, Ado – Ekiti during the period of study

Fish species	Oct	Nov	Dec	Total	% Abundance
Oreochromis niloticus	64	94	90	248	29.07
Sarotherodon melanotheron	46	112	62	220	25.79
Sarotherodon galilaeus	64	64	72	200	23.45
Tilapia zillii	54	47	50	151	17.7
Clarias gariepinus	8	8	4	20	2.35
Hepsetus odoe	4	4	6	14	1.64
Total Abundance	240	329	284	854	
% Abundance	28.14	38.57	33.29	100	100

Table 4: Correlation coefficient values between physico-chemical parameters and fish abundance of Ureje Reservoir, Ado-Ekiti.

Physico-chemical parameters	*O. niloticus*	S. *melanotheron*	*S. galilaeus*	*Tilapia zillii*	*C. gariepinus*	*H. odoe*
PH	-0.110	0.481	-0.179	-0.021	0.189	-0.432
Temp	0.058	-0.198	0.456	0.644*	0.193	0.309
Alka	-0.234	-0.642*	-0.201	0.690*	0.424	-0.031
DO_2	0.334	-0.013	0.099	-0.590*	-0.511*	0.279
Transp	-0.094	0.419	0.080	-0.653*	0.000	0.525*
Cond	0.302	-0.083	0.583*	-0.828*	-0.296	0.647*
PO_3	0.942*	-0.080	0.098	0.695*	-0.132	0.673*
NO_3	0..533*	-0.034	0.799*	-0.423	-0.646*	-0.449
TDS	0.743*	0.165	-0.293	0.325	-0.575*	-0.356
TSS	0.722*	0.704*	0.287	-0.396	-0.739*	-0.558*

Correlation is significant at the 0.05 level (2-tailed)

4. Discussion

The observed variations and significant difference in physical–chemical parameters of the water at the different sampling stations indicate different anthropogenic activities in these areas. Water temperature range for Ureje reservoir compares well with those recorded for other tropical lakes [17] [18] [7] [19] and also falls within the optimal limits (28–32 ºC) for domestic purposes, drinking and fish production [20] [21].

The pH value of the reservoir is adequate for fish production and within the range for inland waters (6.5–8.5), as reported by [22]. The reservoir could be described as having the waters of neutral pH with slight fluctuation to alkaline conditions and this may be attributable to the cooling and the diluting effects of the rains. This is typical of tropical waters [23], similar observations were made by

[24] for Awba Lake, [25] for Eleiyele Reservoir and [26] for Asejire dam. This suggests that the pH range of Ureje reservoir is within the acceptable level of 6.0 - 8.5 for culturing tropical fish species and also within the recommended range of WHO/FEPA guideline for drinking water and for aquatic life.

The alkalinity obtained from all these sites fall within the optimal range for fish production 20-300mg$CaCO_3$/L) as classified by [27]. Also the alkalinity value obtained in ado reservoir during the study period fell with WHO/FEPA range for productive freshwater. According to [20], the total titrable bases in a water expressed as equivalent $CaCO_3$ is referred to as total alkalinity and or natural waters, values may range from less than 5 mg/L to several hundred mg/L. Natural water, which contains 40 mg/l or more total alkalinity as equivalent calcium carbonate are considered for biological purpose by limnologist as "hard" water while water with lower alkalinity are "soft" [28, 20]. By the above classification therefore, the reservoir studied can be grouped as soft water since none of the stations in the reservoir had alkalinity above 50mg/L. The low alkalinity may be due to lack of carbohydrate deposits in the surrounding soils.

The range and mean of dissolved oxygen observed in this study (7.40 mg/L ± 0.19; 7.18–7.80 mg/L) was higher than those reported by [25] for Eleyele Reservoir (6.3–8.3 mg/l), [29] recorded a mean value of 6.40 ± 0.3mg/L for Oyan Lake and [30] for Aiba Reservoir (7.23 mg/l ± 0.20 1.75–11.20 mg/l). The latter authors attributed high concentrations of dissolved oxygen to low organic enrichment. This may also be the case in Ureje Reservoir and the self – purifying capacity of the reservoir may probably not yet be exceeded. The dissolved oxygen range in the reservoir falls within the ranges documented by [31], [20] and [32] for good water quality, and WHO/FEPA optimal range for a productive fresh water (≥ 5) and this shows that Ureje reservoir is highly productive.

The low transparency of the reservoir could be due to washing of silts, debris and organic matter which flows with rainwater into the reservoir. This may be the reason for the increase in transparency observed in December of the study period.

The conductivity of a water body is sensitive to variation in dissolved solids, mostly mineral salts. This is important because it measures the productivity potential of the water body. The conductivity of most fresh water bodies ranges from 10 to 1000 µscm^{-1} [33]. The conductivity range (839.2–910.9 µs/cm) and the mean value (842.6±154.4 µs/cm) for Ureje reservoir during this study can be regarded as intermediate according to the classification by [34]. Conductivity levels below 50µmhos/cm are regarded as low; those between 50-600 µs/cm are medium while those above 600µs/cm are high conductivity levels. Similar range of conductivity had been observed by [35], who opined that the conductivity of Awba reservoir could be regarded as being intermediate (mean and standard deviation of 239±74.31 µS/cm and a range of 48.93-953.33 µS/cm).

Phosphate range recorded throughout the period of study was relatively high, this could occur as a result of allochthonous substances washed into the reservoir from runoffs from the surrounding farmlands, most which fertilizers have been applied to enhance good yield of crop plants [36] [37].

The mean nitrate content of the water was higher than the 10mg/L recommended by WHO/FEPA (1995) for drinking water and fish production. The mean value recorded for the nutrient (NO_3) is similar to those of Rivers Orogodo, Agbor, Delta State [38] and Adofi, Utagba-Uno, Delta State [39]. Higher values are often recorded during the rainy than dry seasons as observed by the afore-mentioned authors. This may be due to flushing of some of the organic-bond nutrients from the drainage areas by runoffs created by the rains and from decaying plants and animal materials, agricultural fertilizers and domestic sewage. The high rate of influx of floodwater laden with organic matter and nutrients from surrounding landmass during the wet season, thereby makes it possible for nitrate to be carried in flood through the highly chemically fertilized soils to percolate the water body. Excess nitrates in drinking water at levels above 45 mg/L is a health risk for infants less than six months old [40]. Drinking water containing more than 50 mg/L nitrate can cause methaemoglobinemia in infants. Nitrate causes overgrowth of algae, other organisms and fouls the water system. Epidemiological studies have also predicted association between exposure to nitrate and gastric cancer, because of the reaction of nitrate with amine in diet forming carcinogenic nitrosamine [41].

The total suspended solid of the studies ranges from 0.30–0.70 mg/L throughout the period of study. TDS in Ureje reservoir falls with WHO/FEPA range for productive water. TSS of Ureje reservoir was found to be moderate. Water with high suspended solids is unsatisfactory for bathing, industrial use and other purposes [42].

TDS is the term applied to the solids that are in dissolved state in solution. The TDS of Ureje reservoir was found to be moderate as the TDS ranges from 0.05 to 0.07 mg/L. This can be due to the fact that the period of study coincides with the end of the raining season, and as such, there is a reduction in the rate of water run-off into the reservoir from adjoining landmass and drainages. This may consequently reduce the amount of dissolved solids in the water samples. Water with high dissolved solids are generally of inferior palatability and may induce an unfavorable physiological reaction in the transient consumer [43].

The high potential fish yield of 112.59 kg/ha of the reservoir could be attributed to the high conductivity value and low mean depth of the reservoir using the morpho-edaphic index of [9] , modified by [16]. The reservoir is highly productive using the MEI [44]. The high potential fish yield of Ureje reservoir confirmed the reports that shallow reservoirs are highly productive than deep reservoirs. This is so because estimates from large deep tropical Africa reservoir such as Kariba, 60 kg/ha [45]; Nasser/Ubia 36-39 kg/ha [46]; Kainji 3.5-4.7 kg/ha [47] and Volta 12kg/ha [48] were lower than Ureje reservoir.

5. Conclusion

In order to ensure sustainable use and enhance this high potential fish in catch, the reservoir should be managed effectively. Management measures that could be adopted include regular monitoring of the water quality and quantity, fish stock assessment, prevention of eutrophication, sedimentation and other watershed abuse that could lead to water quality deterioration and inadequate fish assemblages, implementation of fishing regulations, stocking and conservation of desirable and indigenous fish species as well as the adoption of best management practices (BMP) for the reservoir.

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