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Research Article
Impact of Physicochemical Parameters on Benthic Macro-invertebrates Assemblage of Erelu Reservoir in Oyo Town, Nigeria

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Abstract
Background and Objective: Seasonal variations of physicochemical properties exert a very serious influence on the occurrence and abundance of both aquatic flora and fauna. Impact of physicochemical properties on benthic macro-invertebrates of Erelu reservoir was investigated. **Materials and Methods:** Water and benthic samples were collected monthly from June, 2013 to May, 2015 from 7 stations. Temperature and transparency were determined *in situ* with mercury in glass thermometer and secchi disc. Other water quality parameters were analyzed using standard methods, while benthic macro-invertebrates were collected using Van-veen grab of 66.6 cm^2. Benthos identification was done with standard identification guide. Species diversity and abundance were examined using Margalef, Shannon wiener and other indices. Data collected were analyzed using descriptive statistics and Pearson's correlation coefficient. **Results:** Turbidity, NO_3^-, DO were higher in values in rainy season while transparency, temperature, BOD and EC values were high in dry season. The EC, Temp. TDS and transparency had inverse correlation with all orders of benthic macro-invertebrates. Turbidity and phosphate was significantly ($p<0.05$) related with Hygrophila (0.713) and Capitellida (0.942). The NO_3^- and TA had significant inverse correlation with (Unionidea). **Conclusion:** Physical and chemical properties of Erelu reservoir had significant seasonal variations and benthic macro-invertebrates abundance are independent of the physicochemical parameters excepts turbidity, phosphate and nitrate that influenced the abundance of some orders of benthic macro-invertebrates.

Key words: Limnology, water quality, ecological indices, turbidity, phosphate, Erelu reservoir, macro-invertebrates

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

A healthy environment is necessary for any organism, since life depends upon the continuance of a proper exchange of essential substances and energies between the organism and its surrounding. Water has a unique place on planet as it supports life on earth. Man uses this important resource by obstructing the streams and constructing reservoir because of industrial development and unplanned urbanization[1]. The adverse impact of this misuse of resources is felt on the unique physical and chemical properties of water. The benthic macro-invertebrates and other organisms that inhabit these reservoirs are additionally influenced which in turn affect the function of the reservoir[2]. Therefore, determination of physicochemical properties of water is pertinent for evaluating the suitability of water for various purposes like drinking, domestic, industrial and irrigation. The ground water quality may also vary due to seasonal changes and is primarily governed by the extent and composition of dissolved solids from overflow and sewage released[3,4].

Benthic macro-invertebrates are the organisms that inhabit in the bottom of an aquatic body. Benthic communities are usually dominated by different species of gastropods bivalves, worms (Polychaetes and Oligochaetes), chironomids etc. Benthos assume an essential role in food chains in an aquatic ecosystem[5,6]. Macrobenthic organisms may be affected positively or negatively by physicochemical parameters of the environment depending on their sources[7]. Benthic organisms varies in size and also could be classified based on the position they occupied as in-fauna (living inside the sediment) and epi-fauna (living above the sediment)[8]. Benthic macro-invertebrates are the most commonly used organisms for aquatic health biomonitoring, this because they are easy to collect, identified, sensitive (intolerant) have poor mobility which is the reason behind their weakness and susceptibility to environmental stress[9-12].

Impact of physical and chemical properties on benthic macro-invertebrates cannot be disregarded since numerous aquatic habitats, particularly free flowing water streams and water with acceptable water quality support an array of macro-invertebrates communities. However, many habitats especially disturbed ones are dominated by few species. Among the major factors responsible for aquatic macro-invertebrates abundance and diversity in an aquatic ecosystem include, water temperature, water velocity, transparency and turbidity[13,14]. According to Sarker *et al.*[15], who reported that temperature is the most imperative parameter in water body because it has major influence on biological activities of Bakkhali and Meghna rivers of Bangladesh. Dissolved oxygen was reported to influence the abundance of the two rivers, however, positive correlation of TDS with macrobenthic fauna was also observed[16]. Ishaq and Khan[17] observed inverse correlation of macrobenthos with temperature, velocity, turbidity, TDS, TS and TA but positive relationship with transparency, pH, Ca and Mg. Abundance of *Chironomus* sp., *Culex* sp. and *Libellula* sp. had inverse association with DO while *Chironomus* sp. has negative relationship with water velocity as reported by Popoola and Otalekor[18] in Awba stream, Ibadan. This study was investigated to examine the impact of physicochemical parameters on the distribution and abundance of benthic macro-invertebrates so as to determine the occurrence and assemblage of benthos and quality of the water body.

MATERIALS AND METHODS

Description of study area: The study area was Erelu reservoir. It lies approximately between latitude 7°8'N and 7°9'N and longitude 3°54'E and 3°55'E. The reservoir was built in 1961. Impoundment is 161.07 ha and its catchment area is 243.36 km. It is situated in Oyo town in Oyo West Local Government Area (Fig. 1).

Water sampling and analysis: Water samples were collected monthly (June, 2013-May, 2015) at 7 sampling stations with 4 L plastic containers already washed with detergents and nitric acid to remove any contaminants[19]. Surface water temperature and transparency were measured *in situ* using mercury in glass thermometer and secchi disc, TA was analyzed using methyl orange indicator[20]. Nitrate was determined using Hannah instrument (Model: H183200). Phosphate was measured by spectrophotometer (Model: Analyst A10PGP) as recommended by AOAC[21]. Other Physico-chemical parameters were analyzed using standard methods.

Benthic macro-invertebrates collection and identification: Benthic sampling was done alongside with water sampling. Sediments were collected from the seven stations using Van-veen grab with surface area of 66.6 cm^2 into polythene bag labelled according to station number, which was later washed with sieve of 0.5 mm mesh size. The organisms collected were sorted, air-dried and identified using aquatic taxonomic keys of Thompson[22], Pennak[23] and Oscoz *et al.*[24] to at least species level.

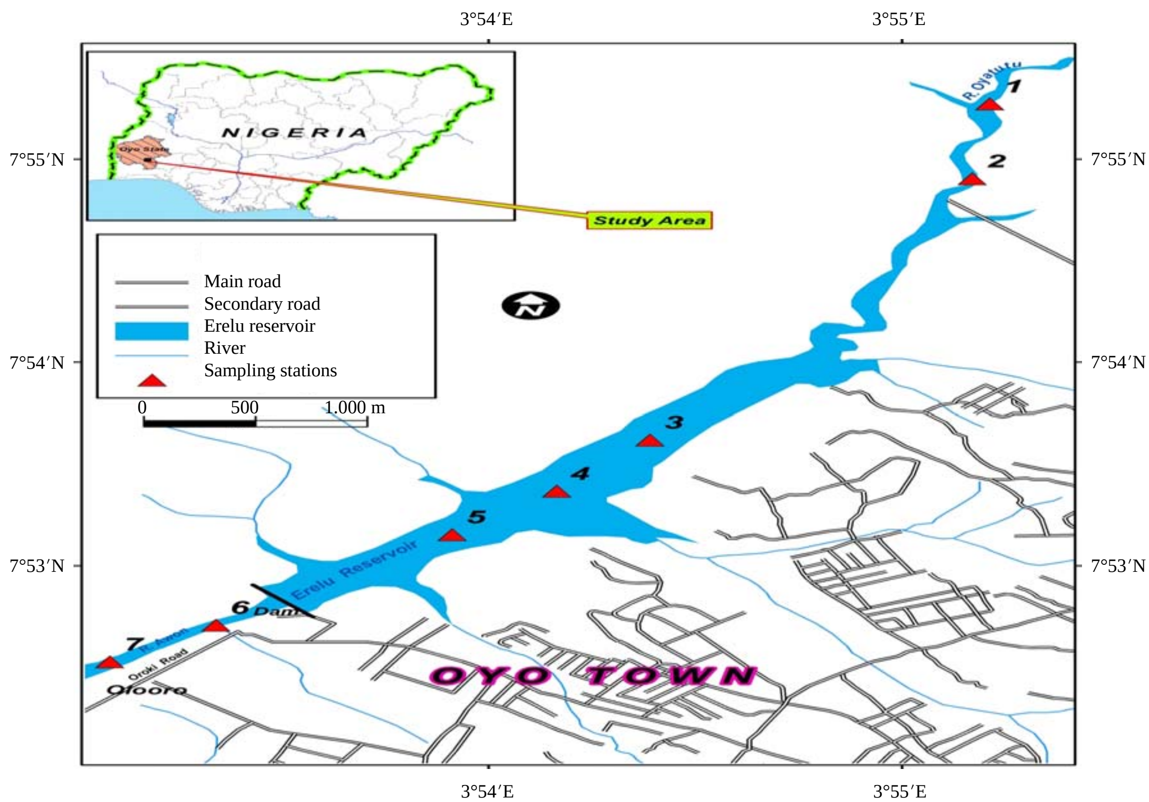

Fig. 1: Map of the 7 sampling stations along Erelu reservoir on Oyo town

Ecological index analysis: Margalef diversity index (d) is a measure of species richness and was expressed as:

$$\text{Margalef's index } (d) = \frac{S-1}{\ln N}$$

Where:

S = Number of species
N = Total no of organisms
ln = Natural or Naperian logarithm[25]

Shannon Wiener's diversity index (H) examine family and species abundance and was expressed as[26]:

$$\text{Shannon index } (H) = \frac{N \log N - \sum f_1 \log f_1}{N}$$

Equitability or evenness measures how evenly the species are distributed in the samples community and was expressed as[27]:

$$\text{Equitability} (J) = \frac{H}{\text{LogS}} = \frac{H}{H_{max}}$$

Where:

H = Shannon Wiener's index
H_{max} = Maximum possible diversity value given as logS
S = Numbers of genera

Jaccard's similarity index measures how similar are the species of organisms in the sample stations which was expressed as[28]:

$$\text{Jaccard index} = \frac{J}{a + b - J}$$

Where:

a = Number of species in sample A
b = Number of species in sample B
J = Number of species common to both samples

Berger-Parker Dominance (d) is a simple measure of the numerical importance of the most abundant species. The reciprocal of index 1/d is often used, so that an increase in the value of the index accompanies an increase in diversity and a reduction in dominance.

Where:

$$d = \frac{N_{max}}{N}$$

Where:

N_{max} = Number of individuals in the most abundant species
N = Total number of individual in the sample[29]

Statistical analysis: Data are reported as Mean+SEM. Pearson's correlation coefficient (r) was used for relationship between physico-chemical parameters and benthic macro-invertebrates of Erelu reservoir.

RESULTS

Seasonal variation of physicochemical parameter of Erelu reservoir: The Table 1 showed that the transparency recorded the highest mean of 79.36±1.90 cm in station 5 among the sampling sites and mean dry season value of 96.30±5.19 cm from station 5 and least value of 58.50±5.43 cm from station 2 were recorded. Turbidity least rainy mean value was 11.87±4.74 Ntu in station 4 and highest mean value of 18.48±6.94 Ntu was recorded in station 7 while dry season lowest mean value of 2.68±0.89 Ntu in station 5 and highest mean of 10.58±6.30 in station 2 were recorded.

Temperature has highest mean value 28.10±0.34°C in station 4 and lowest mean 27.52±0.32 was recorded in station 6 during rainy season, while highest mean values of 30.08±0.29°C was recorded in stations 6 during dry season. Calcium ion concentration in the rainy months has highest mean value of 17.32±2.44 mg L^{-1} recorded in stations 1 and lowest values of 14.74±1.93 mg L^{-1} in station 5. Mean dry season values recorded 20.16±1.63 and 20.00±1.43 mg L^{-1} for stations 6 and 7 and least mean value of 17.20±I 1.11 was recorded in station 5. Magnesium ion recorded the highest mean value of 10.88±1.93 in station 5 and lowest mean value of 8.37±1.78 was recorded in station 1, but during dry season highest mean value of 6.68±2.43 was recorded for station 3 and lowest mean value 4.54±0.78 was recorded for station 5.

The present result showed that phosphate and nitrate has highest mean values during rainy season and lowest mean values during dry season across stations of Erelu reservoir. The highest DO mean value was higher 8.85±0.50 mg L^{-1} in station1 and lower value of 8.48±0.40 mg L^{-1} was recorded in stations 4 during rainy season while dry mean values were higher with 8.44±0.54 mg L^{-1} in station 6 and lowest value 7.54±0.51 mg L^{-1} was recorded in station 3, respectively. The concentrations of dissolved oxygen showed marked variation between rainy and dry season.

The BOD lowest mean rainy and dry values of 0.93±0.23 and 0.75±0.36 mg L^{-1} were recorded in station 5. The result indicated low BOD values in the reservoir during the period of study which supports low organic enrichment. Total Alkalinity recorded higher rainy mean values in all stations than dry season values except station 1 with least value in rainy season period compared to the dry season. The mean values of pH, TDS and conductivity range were higher in values during dry seasons than in rainy season in all cases (Table 1).

Relationship between physicochemical characteristics and benthic macro-invertebrates: The results in Table 2 indicated that transparency, Ca^{2+}, TDS, TA, temperature and conductivity had negative insignificant ($p>0.05$) correlation with all orders of benthic macro-invertebrates, that is there is no significant effect of these parameters on benthos abundance. Turbidity was significantly related with Hygrophila (0.713*) (*Lymnae natalensis*) while Mg^{2+} and TA have negative association with Unionidea (-0.683* and -0.763*) (Mussel). Nitrate exhibit negative relationship with Unionidea (mussel) and Capitellida (worms), while phosphate had a strong positive relationship with capitellida (0.942**) also. Pearson's correlation co-efficient analysis showed a positive relationship of DO with Unionidea (Mussel, 0.798*) and BOD with Sorbeoconcha (Gastropoda, 0.678*).

Ecological index of Erelu reservoir: Shannon index in stations 4 (1.056) and 6 (1.0522) had high values while other ecological indices had low values across stations (Table 3).

DISCUSSION

The lower transparency and higher values of turbidity observed during rainy season across sampling stations could be attributed to influx or turbid flood from the rivers and run offs into the reservoir which in turn decreases light penetration. This may also be as a result of heavy cloud in the atmosphere during rainy season, hence reduces the amount of light penetration into the water body[30]. This result is similar to the results reported by Ugwumba and Ugwumba[31], Koloanda and Oladimeji[32] and Ayoade *et al.*[33], who worked on various man made waters. Highest mean value of temperature recorded in station 4 could be attributed to vegetation cover in the station and atmospheric air during rainy season while highest values during dry season may be due to intense of

Table 1: Seasonal variation in mean values (Mean+SE) of physico-chemical parameters of Erelu reservoir in Oyo between 2013-2015

Parameters	Seasons	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6	Station 7
Transparency (cm)	Rainy	44.07±3.88	41.86±3.32	76.07±1.40	78.40±1.65	79.36±1.90	41.61±3.69	40.46±3.77
		22.50-75.00	23.00-75.00	70.00-85.00	70.00-90.00	70.00-95.00	23.00-70.00	22.00-75.00
	Dry	61.00±4.82	58.50±5.43	92.25±3.51	94.75±3.62	96.30±5.19	61.50±5.82	60.20±5.49
		40.00-80.00	25.00-85.00	72.50-110.00	77.50-115.00	75.00-120.00	35.00-90.00	35.00-85.00
Turbidity (Ntu)	Rainy	13.92±3.59	13.50±3.89	15.38±5.25	11.87±4.74	12.78±4.18	17.86±7.02	18.48±6.94
		0.00-50.72	0.00-57.90	0.00-64.60	0.54-66.80	0.96-63.50	0.13-101.5	0.00-19.13
	Dry	6.68±3.33	10.58±6.30	4.20±0.98	2.90±0.76	2.68±0.89	3.94±0.97	5.07±1.91
		0.40-36.00	0.23-64.70	1.42-11.21	0.72-8.50	0.00±7.82	0.00±8.40	0.00±19.13
Temperature (°C)	Rainy	27.54±0.39	27.69±0.39	28.00±0.29	28.10±0.34	27.70±0.41	27.52±0.32	27.60±0.39
		25.50-29.20	25.50-29.50	25.70-29.00	25.80-29.20	25.50-29.20	25.60-29.00	25.40-29.80
	Dry	29.39±0.28	29.82±0.39	29.40±0.30	29.67±0.29	29.72±0.32	30.08±0.29	29.93±0.25
		28.00-30.60	28.30-32.60	28.00-30.90	28.20-31.10	28.50-31.60	28.40-31.80	29.10-31.70
Calcium ion (mg L^{-1})	Rainy	17.32±2.44	16.72±2.11	16.02±2.23	14.78±2.00	14.74±1.93	15.90±1.97	15.75±2.11
		2.44±35.20	2.93-30.40	3.42-32.00	2.93-28.80	3.90-28.00	3.42-28.00	2.93-29.60
	Dry	18.00±2.46	19.44±2.31	18.40±1.38	19.68±1.94	17.20±1.11	20.16±1.63	20.00±1.43
		7.20-35.00	8.00±31.20	11.20-24.80	11.20-32.00	12.00-24.00	10.40-28.00	11.20-27.20
Magnesium ion (mg L^{-1})	Rainy	8.37±1.78	9.15±2.20	9.81±2.21	9.04±2.02	10.88±1.93	8.38±1.42	8.64±2.00
		1.46-26.00	0.98-34.00	0.97-30.00	0.98-30.00	1.46-29.00	0.49-20.00	0.49-26.00
	Dry	6.06±1.09	5.45±1.24	6.68±2.43	4.70±0.87	4.54±0.78	5.85±2.14	6.64±2.29
		0.82-12.00	0.62-11.71	0.34-28.00	0.43-10.00	0.43-8.30	0.48-24.00	0.62-26.00
Phosphate (mg L^{-1})	Rainy	0.10±0.04	0.10±0.03	0.11±0.04	0.11±0.06	0.26±0.19	0.30±0.18	0.28±0.19
		0.01-0.48	0.01-0.43	0.01-0.59	0.01-0.77	0.02-2.73	0.01-2.50	0.01-2.73
	Dry	0.08±0.03	0.09±0.04	0.10±0.04	0.09±0.03	0.09±0.04	0.10±0.04	0.09±0.04
		0.01-0.37	0.01-0.44	0.02-0.46	0.01-0.37	0.01-0.41	0.04-0.45	0.20-0.44
Nitrate (mg L^{-1})	Rainy	0.82±0.20	0.86±0.20	1.47±0.33	1.43±0.36	1.60±0.37	0.88±0.18	0.75±0.20
		0.05-2.66	0.00-2.69	0.005-3.89	0.00-2.79	0.03-3.89	0.02-2.45	0.04-2.88
	Dry	0.30±0.020	0.36±0.25	0.65±0.33	0.64±0.33	0.62±0.36	0.26±0.15	0.31±0.18
		0.00-2.09	0.003-2.54	0.00-3.12	0.00-2.92	0.00-2.79	0.00-1.56	0.002-1.89
Dissolved oxygen (mg L^{-1})	Rainy	8.85±0.50	8.75±0.42	8.76±0.48	8.48±0.40	8.58±0.26	8.55±0.35	8.55±0.40
		6.10-14.60	6.22-13.20	6.44-14.00	5.68-12.00	6.76-10.80	6.42-12.00	6.18-12.20
	Dry	8.00±0.62	8.00±0.42	7.54±0.51	8.33±0.36	8.00±0.26	8.44±0.54	8.08±0.15
		3.96-11.00	5.47-10.70	3.36-9.20	6.96-11.30	6.30-9.38	6.02-12.20	6.95-8.62
Biological oxygen demand (mg L^{-1})	Rainy	1.00±0.29	1.13±0.28	1.08±0.29	1.00±0.28	0.93±0.23	1.03±0.26	0.99±0.24
		0.03-4.23	0.06-4.39	0.04-4.38	0.04-4.01	0.15-3.39	0.14-3.95	0.05-3.72
	Dry	1.73±0.72	1.29±0.58	1.41±0.59	1.46±0.65	0.75±0.36	1.65±0.70	1.40±0.61
		0.00-7.03	0.14-6.19	0.09-4.90	0.19-6.77	0.01-3.84	0.23-7.38	0.01-5.20
pH (mg L^{-1})	Rainy	7.22±0.09	7.22±0.08	7.31±0.10	7.19±0.12	7.38±0.13	7.39±0.13	7.54±0.10
		6.64-7.71	6.80-7.80	6.80±8.11	6.80-8.60	6.60-8.80	6.80-8.15	7.00-820
	Dry	7.49±0.16	7.66±0.17	7.50±0.12	7.48±0.13	7.52±0.14	7.62±0.15	7.60±0.16
		6.97-8.29	7.0-8.43	7.14-8.37	6.80-7.21	6.96-7.30	7.00-8.22	7.20-8.13
Total alkalinity (mg L^{-1})	Rainy	98.21±11.07	101.29±11.33	104.71±11.34	101.29±11.11	102.86±11.47	94.43±11.10	94.00±9.87
		48.00-166.00	50.00-176.00	50.00-168.00	50.00-170.00	30.00-172.00	30.00-160.00	46.00-146.00
	Dry	101.20±9.01	93.80±9.28	96.20±7.50	99.80±9.38	102.40±8.38	93.40±8.82	92.60±7.32
		58.00-148.00	50.00-140.00	64.00-156.00	74.00-174.00	64.00-154.00	60.00-160.00	64.00-150.00
Total dissolved solid (mg L^{-1})	Rainy	118.95±20.99	119.80±20.54	125.94±21.18	126.36±20.60	130.97±19.46	125.96±20.27	126.91±20.22
		14-256.00	22.0-254.00	22.00-256.00	28.00-256.00	52.00-256.00	30.00-260.00	26.00-258.00
	Dry	159.12±36.68	159.52±38.61	156.18±36.46	157.62±35.76	156.85±35.47	173.06±37.43	174.48±36.98
		63.40-468.00	63.30-486.00	66.74-465.00	68.50-459.00	75.50-457.00	56.10-476.00	57.00-474.00
Conductivity (μs cm^{-1})	Rainy	170.07±30.58	173.19±30.38	183.29±31.72	183.87±31.00	189.99±29.27	190.92±32.98	186.60±30.84
		11.43-372.00	31.43-377.00	31.43-382.00	40.00-387.00	74.29-390.00	42.86-453.00	37.14-392.00
	Dry	238.66±51.82	234.62±53.64	229.89±50.99	234.16±50.58	230.54±50.03	253.93±51.72	255.61±51.09
		87.90 -678.00	88.40-689.00	102.50-04.00	109.10-62.00	103.10-54.00	101.20-76.00	103.00-694.00

heat during dry seasons[30,34] deviated from Ibrahim *et al*.[35] and Anhwange *et al*.[36]. Higher values of calcium ion during dry season could be due to evaporation of water body during this period as supported by Sahni and Yadav[37] and Akindele and Adeniyi[38] and departed report was made by Ayoola and Ajani[39]. Calcium ion concentrations were also higher in stations 6 and 7 which could be as a result of low level of water in these river stations. Highest values of Magnesium ion during rainy season could be attributed to inward flow of flood during rainy season which helps in bringing in $MgSO_4$ into the water body. Similar report was made by Ayoola and Ajani[39] but departed from Sahni and Yadav[37].

Table 2: Pearson's correlation coefficient (r) between physico-chemical parameters with benthic abundance in Erelu Reservoir

Parameters	Architaenioglossa	Capitellida	Hygrophila	Diptera	Pulmonata	Sorbeoconcha	Unionidea
Transparency (cm)	-0.520	-0.139	-0.053	-0.374	-0.227	-0.641	-0.505
Turbidity (NTU)	0.421	-0.113	0.713*	0.567	0.199	0.372	0.051
Calcium ion (mg L^{-1})	-0.116	-0.589	-0.141	-0.063	-0.573	-0.450	-0.606
Magnesium ion (mg L^{-1})	0.024	-0.658	0.488	0.045	-0.394	-0.386	-0.683*
Phosphate (mg L^{-1})	0.107	0.942**	-0.171	-0.266	0.138	0.542	0.454
Nitrate (mg L^{-1})	0.024	-0.699*	0.312	0.070	-0.502	-0.536	-0.684*
DO (mg L^{-1})	0.078	0.620	-0.326	0.014	0.585	0.501	0.798*
BOD (mg L^{-1})	0.430	0.257	0.336	0.612	0.463	0.678*	0.536
TDS (mg L^{-1})	-0.266	-0.388	-0.300	-0.491	-0.580	-0.627	-0.628
Total alkalinity (mg L^{-1})	-0.215	-0.666	0.139	-0.084	-0.576	-0.663	-0.763*
PH	0.527	0.292	0.412	0.057	-0.313	0.499	-0.150
Temperature (°C)	-0.380	-0.123	-0.446	-0.618	-0.478	-0.568	-0.439
Conductivity (µscm)	-0.237	-0.414	-0.272	-0.469	-0.587	-0.627	-0.643

*Correlation is significant at the 0.05 level (2-tailed), **Correlation is significant at the 0.01 level (2-tailed)

Table 3: Diversity and other indices of benthic macro-invertebrates in the study stations of Erelu reservoir

	Sampling stations						
Diversity indices	1	2	3	4	5	6	7
Shannon wiener index (H)	0.5578	0.7956	0.8105	1.056	0.9839	1.0522	0.5734
Margalef richness index (d)	0.3643	0.4776	0.4215	0.3234	0.3816	0.3387	0.3627
Equitability index (J)	0.5834	0.7467	0.7532	0.8545	0.8956	0.8555	0.8585
Jaccard index (D)	0.4446	0.6656	0.7677	0.6575	0.6432	0.7523	0.6823
Berger-Parker index (d)	0.6558	0.6476	0.6358	0.4845	0.5661	0.4461	0.5624

The highest mean values of phosphate and nitrate during rainy season might be due to runoff or flood during rainy which might have washed down some nutrients into the water body[40]. Higher concentrations of Nitrate and phosphate during rainy were also reported by Ibrahim *et al.*[35], Patil *et al.*[41] and Agaoru[42] and contrary values were reported by Sahni and Yadav[37] and Akindele and Adeniyi[38].

The concentration of dissolved oxygen in this study that were higher during rainy season months and lower during dry months could be attributed to the aeration of the reservoir during rainy season and higher temperature during dry season which in turn lower the concentration of oxygen in the reservoir. The higher DO reported in the dry season could be attributed to low organic enrichment of the reservoir. Similar observations were observed by Mason[43], Idowu and Ugwumba[6], Ikomi *et al.*[44] and Chakraborty *et al.*[45]. Highest values of BOD obtained during dry season may be due to increase in ambient and water temperature and consequent rise in metabolic rate of aquatic organisms in the dry season. Similar observations were reported by Ayoola and Ajani[39] and Idowu *et al.*[46] and departed observation was made by Atobatele *et al.*[47], who reported highest BOD range which was related to effluent discharge and was an indication that the river is being grossly polluted during study period. The mean values of pH, TDS and conductivity range that were higher during dry seasons than in rainy season could be associated with the reduction in the water level as a result of evaporation due to intense heat which is associated to increase evaporation due to high temperature[48-56].

The insignificant inverse correlation of the transparency, Ca^{2+}, TDS, TA, temperature and conductivity on macro-benthic invertebrates could be attributed to their values that fall within the required limits and that the abundance and distribution of benthos were independent of these parameters. This result corroborated the report of Ishaq and Khan[17], Idowu *et al.*[46] and Aiwerioghene and Adedolapo[51]. Turbidity that was significantly related with Hygrophila (*Lymnae natalensis*) might be related to nutrient washed into the reservoir during rainy season that assert a strong effects on the abundance of the species. This result contrasted the report of Ayoade and Olusegun[52], Ishaq and Khan[53] and Akaahan *et al.*[54], who reported negative significant correlation of turbidity with order Hygrophila (*Lymnae natalensis*). The Mg^{2+} and TA that had inverse relationship with Unionidea (Mussel) may be due to other ecological imbalances in the reservoir, this work is in line with the report of Omonijo *et al.*[57], who recorded negative correlation of TA with *M. tuberculata*. Contrary observations were made by Ishaq and Khan[17] and Oloyede *et al.*[55].

Nitrate that exhibited negative relationship with Unionidea (mussel) and Capitellida (worms) may be due to low nitrates recorded across stations during sampling, similar observation were made by Oloyede *et al.*[55] and Yap *et al.*[56], while phosphate that had a strong positive relationship with capitellida, may be due to worms being always found in water containing high nutrients[58] and deviated from Oscoz *et al.*[24]. Positive relationship of DO with Unionidea (Mussel) may be due to high photosynthetic activities in the reservoir and DO values being within the limit for aquatic organisms survival[47,54,59]. The BOD that related to Sorbeoconcha (Gastropoda) showed that BOD has a strong effects on the abundance of gastropods and that low values of BOD observed indicated low organic pollution[54,57,60].

The high values of Shannon index in stations 4 and 6 could be attributed to low waste discharge in the stations as also reported by Olomukoro and Oviojie[61], who reported high species diversity and abundance in their study area and associated it with non-disturbance of the lake by human activities as compared to those reported for temperate streams which are affected by agricultural activities and inert pollution[62,63]. It may also be due to Luxuriant vegetations for insects attachment and oviposition sites[64], while low values of other ecological indices is an indication of pollution in the stations could be linked with increased level of human activities[65]. It was also related to uses of agrochemicals and other activities that lead to environmental degradation which have been threatening biodiversity all over the world[66].

CONCLUSION

The present study revealed that Erelu reservoir had low nutrient input especially phosphate that is mostly responsible for eutrophication and low values of ecological indices across the stations. However, low values of ions (calcium and magnesium) showed that the reservoir is moderately polluted. Hence, the users of the reservoir should be aware that continuous anthropogenic input can lead to heavily pollution of the reservoir and may be detrimental to health status of biota and direct users.

SIGNIFICANCE STATEMENT

The study revealed the seasonal and spatial variations of physicochemical parameters and their relationship with benthic macro-invertebrates of the studied reservoir. It also revealed that the primary nutrients (phosphate and nitrate) were lower in value which tells the condition of the water body as oligotrophic during the period of this study, of which the productivity of the reservoir could be lowered. The benthic community composition of Erelu reservoir serves as the baseline information for future researchers.

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