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Physico-Chemical Parameters and Zooplankton Commmunity of Pindiga Pond, Gombe State, Nigeria

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Abstract

The Abundance and Distribution of zooplankton and relationship with physico-chemical parameters of Pindiga pond in Akko LGA, Gombe state was determined. Four sampling stations (A – D) were selected on the pond and the sampling was conducted weekly for a period of four (4) months (from July to October 2021). Zooplankton samples were collected using plankton net of 55µm mesh size by hauling horizontally for five meter. The collected samples were preserved in 4% formalin and 3 drops of lugols iodine solution and transported to the Biological Sciences laboratory of Federal University of Kashere for counting and identification using taxonomic keys. Physico-chemical properties were measured (Temperature using mercury-in-Glass thermometer, Transparency using Secchi disc, p^H, Total dissolved solute and conductivity using conductivity meter, Dissolved oxygen and Biological Oxygen Demand using Dissolved oxygen meter and Heavy metals using Atomic Absorption Spectrophotometer). Shannon Weiner diversity and Margalef richness indices was employed for estimation of abundance and distribution. Results of the physico-chemical characteristics showed the ranges of Water temperature, Transparency, Water pH, Total Dissolved Solid, Conductivity, Dissolved Oxygen, Biochemical Oxygen Demand, Magnesium and Iron were 28.9-29.0^{0}C, 0.48- 0.80m, 6.8-6.5, 702- 714mg/L, 1667- 1675 µS/cm, 3.3- 5.0mg/L, 1.5- 3.5mg/L, 3.80- 4.1mg/L and 1.63- 1.75 mg/L respectively. A total of 436 individuals of zooplankton species comprising of 24 genera among the four zooplankton taxa of *Cladocera*, *Copepoda*, *Rotifera* and *Ostracoda* were recorded during the study period. Outcome of the investigation reveals that physicochemical properties were within the range value recommended for most tropical water bodies according to standard recommendation of NESREA and so, the pond is suitable to sustain the accretion; continued existence and growth of aquatic organisms predominantly fish. Therefore, there is need to maintain its ecological integrity through sustainable use of its other resources.

Keywords: Zooplankton taxa, Temperature, Dissolved oxygen, Pindiga pond.

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Introduction

Water requirements in all living organisms are on sharp and constant increase daily, but the source of drinking water remains a crucial issue, as all water resources is facing serious crisis as a result of urbanization and industrialization (Bibbi *et al*., 2016). Pollution of water always occurs when there is adjustment in the physical, chemical or biological condition in the environment which affects the value of human life together

with other fauna and flora (Ojitiku *et al*., 2018).

Zooplankton are myriads of diverse floating and drifting animals with limited power of locomotion, which are essential components of water food web, as they always play a vital role in the productivity of freshwater ecosystems. They are also prone to changing ecosystem; as a result, they are perfect indicator organisms to pollution (Ikhuoriah *et al*., 2015). Zooplanktons are important aquatic organisms which are found in all aquatic habitats, and they play key role in transfer of energy (Siddique and Kale, 2018). Zooplanktons make up essential foodstuff to other aquatic macro invertebrates in the higher trophic levels depending on the nature of their feeding habits (Erondu and Solomon, 2017). They feed on phytoplankton and facilitate the conversion of plant material into animal tissue and in turn constitute the basic food for higher animals including fishes, particularly their larvae. The zooplankton occurrence and distribution influence pelagic fishery potentials. The fishes mostly breed in areas where the planktonic organisms are plenty so that their young ones could get sufficient food for survival and growth. Zooplankton shows inconsistency in the species composition and abundance as a result of change in numerous physico-chemical characteristics of the water (Azuka *et al*., 2018).

Zooplankton study is very important in determination of water quality and the productivity of aquatic ecosystem despite the abundant study of planktons in Gombe State water bodies, however, the information on zooplankton abundance and distribution in Pindiga pond is not well documented based on the available literatures consulted even though this pond is one of the major source of drinking water for humans and livestock and other agricultural activities within the area; thus the essence of this research to investigate the abundance and distribution of zooplankton present in the pond which will serve as baseline information for further studies.

Materials and Methods

Study Area:

Pindiga pond is a tropical freshwater located along Tumu road in Pindiga town of Akko LGA, Gombe State (Fig. 1). The pond lies between latitude 10.13'15^{0}N and longitude 11.11'19^{0}E. It is situated at elevation of 523 meters above the sea level. The pond primarily serves as a source of water for domestic uses to the community.

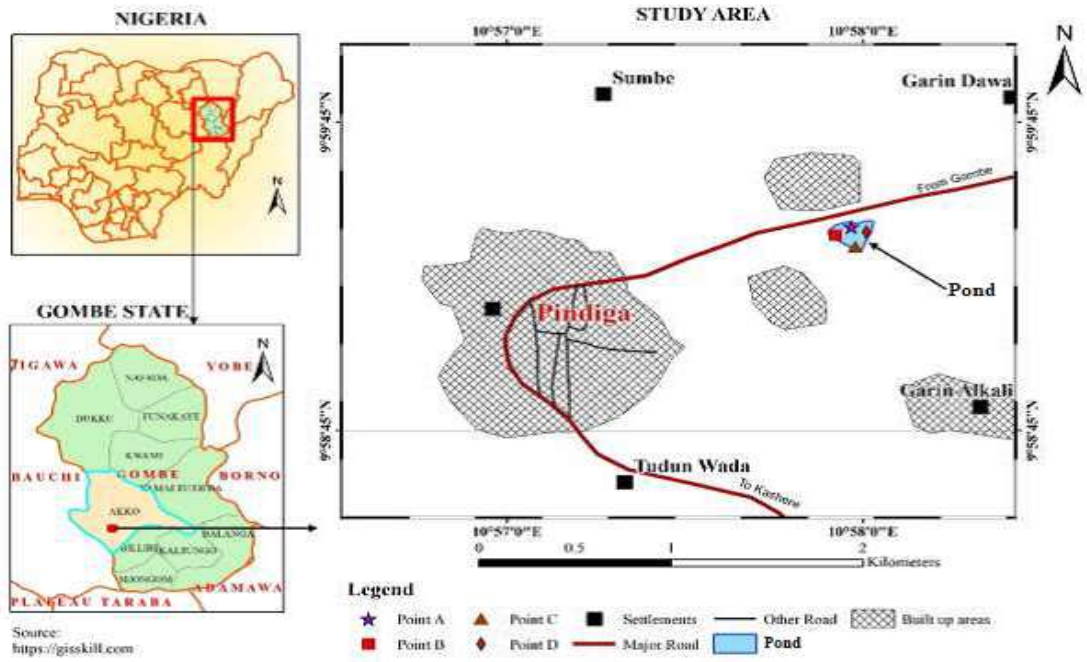

Fig 1: Map of the Study Area showing the Sampling sites.

Sampling Stations

Zooplankton abundance and distribution of Pindiga pond, Gombe State were evaluated. Four sampling stations (A, B, C, and D) with distance of 500 meter apart were selected randomly and replicated samples were collected at each point throughout the study period. Water samples were collected from four different locations on the pond and mean values of the four stations were worked out and recorded. The sampling was conducted fortnightly between July and October, 2021. Sampling was done between 8.00am and 10.00am.

Zooplankton Sampling

The zooplankton samples were collected using 55 µm Hydrobios plankton net for 16weeks. The plankton net was dragged horizontally for approximately over a distance of about 5 meter of the water body per station and filtered samples were transferred into 100ml plastic bottle and preserved in 4% buffered formaldehyde then transported to the Federal University of Kashere Biology laboratory for analysis. The samples were collected in triplicates from each station.

Zooplankton Laboratory identification

One drop of the preserved zooplankton sample was put on clean glass slide and examined at ×400 magnification of Olympus binocular microscope. The zooplankton was identified using applicable standard zooplankton keys of (Petersen, (2018) and Phan *et al., (*2015) and counted.

Measurement of physicochemical parameters

Water temperature was determined in situ by dipping mercury in glass thermometer into the water at each station for about 1- 2 minutes and readings were recorded (APHA, 2005). pH was measured using Hanna pH meter (Model H199107). The tip of the pH meter was immersed into the 100ml beaker containing water sample for 2-3 minutes and readings were recorded according to APHA, (2005). Electrical conductivity was measured with Hanna conductivity meter (Model EC 215). The water samples was drawn in a wide mouthed beaker and the tip of the conductivity meter was dipped into a beaker for a period of 2-3 minute to permit constant reading (APHA, 2005).Total dissolved solid was determined with Hanna TDS meter microprocessor (Model H215). The water samples were drawn in a 100ml beaker and the tip of the TDS meter was dipped into a beaker for a period of 2-3 minute to permit constant reading (APHA, 2005).Turbidity was measured with Black-white secchi disc. This was done by gradually lowering the Secchi disc at respective sampling points. The depths at which it disappears in the water (X1) and reappears (X2) were noted and estimated as the average of points of disappearance and reappearance (APHA, 2005). Hanna dissolved oxygen microprocessor (Model HI 98186) was used to measure the dissolved oxygen. Sample of the water was collected in 100ml beaker; the electrode of dissolved oxygen microprocessor was dipped into the beaker that contains the sample water for about 2-3 minutes. The reading was recorded in mg/l (APHA, 2005). Hanna dissolved oxygen microprocessor (Model HI 98186) was used to determine the biochemical oxygen demand, 100ml part of the sample collected was incubated for five days in dark cupboard at room temperature and dissolved oxygen was determined after five days of incubation. The difference between the initial value of dissolved oxygen and the value after five days of incubation was used as value of biochemical oxygen demand in the water sample (APHA, 2005). The analysis of heavy metals and other elements was done using Atomic Absorption Spectrophotometer (Model 7100), according to the method of APHA (1995).

Indices for Species diversity and taxa richness

Simpson's biodiversity index was employed to determine the zooplankton species diversity of the samples in Pindiga pond. Simpson's equation is given by:

$$D = \frac{[ni(ni-1)]}{[N(N-1)]}$$

Where:

ni= the number of individuals in i_{th} genera and

N = the total number of individual

i = Number of genera.

Genera Richness Index (d) was employed according to the method used by Margalef (1958) to examine the community structure. The equation applied is given below:

$$D1 = \frac{(S-1)}{(LogeN)}$$

Where:

D1=Genera richness index

S=Number of genera in a population

N= Total number of individuals in S genera.

Statistical Analysis

The Zooplankton abundance and distribution were analyzed and presented using Excel Microsoft Software version 2021. Correlation analysis was also carried out.

Results

The results of the physic-chemical properties were presented in Table 1. The ranges of water temperature of 28.8^0C – 29.0^0C was recorded with stations C & D respectively while pH was 6.5 – 6.8 with stations D & A respectively. The dissolved oxygen recorded ranges from 3.3 – 5.0mg/L with stations A & B respectively; Biochemical oxygen demand (1.5 – 3.5mg/L) with stations C & B respectively and Total Dissolved solid ranges from 702 – 714mg/L with stations C & A respectively. Electrical conductivity of 1667 – 1675 µs/cm^3 was recorded. Water transparency recorded ranged from 0.49 – 0.58m; Magnesium recorded was 3.8 – 4.1mg/L while Iron was 1.63 – 1.75mg/L.

A total of 434 individuals' of zooplankton species in 24 genera among four zooplankton taxa of *Cladocera*, *Copepoda*, *Rotifera* and *Ostracoda* were recorded during the study period (Table 2). The Copepods (164 individuals) were the most abundant zooplankton taxon comprising 14 genus. The subsequent one was the taxa *Rotifera*. *Cladocera* was the second to the last taxa in terms of abundance and then followed by the taxa *Ostracoda* which has the least abundant zooplankton in the study area.

A total of 139 individuals made of 23 genera, 71 individuals made of 22 genera, 79 individuals made of 22 genera and 117 individual made of 23 genera were recorded at Stations A, B, C and D respectively (Figure 1).

The results of the relationship between physic-chemical properties and planktonic fauna showed there was significant correlation between zooplankton abundance and some physico-chemical properties as shown in Table 4.

The Simpson's Species diversity index for the three zooplankton taxa of *Cladocera*, *Copepoda*, *Rotifera* and *Ostracoda* were presented in Table 3 with taxa *Copepoda* having highest Simpson values and taxa *Ostracoda* lowest values, while the Margalef index of genera richness of *Cladocera*, *Copepoda*, *Rotifera* and *Ostracoda* were presented in Table 3 with taxa *Copepoda* having highest MargaleF values and taxa *Ostracoda* lowest values.

The relationship between the abundance and growth of the zooplanktons in the four sampling stations with the physic- chemical parameters of the pond were presented in Table 4 below

Table 1: Mean results of physicochemical parameters of the different sampled stations of Pindiga pond during the study period.

PARAMETERS	STATIONS			
	A	**B**	**C**	**D**
Temperature (ºC)	28.9±2.10^{b}	29.0±1.15^{a}	28.8±2.00^{c}	29.0±3.10^{a}
pH	6.8±1.10^{a}	6.7±0.70^{b}	6.7±1.15^{b}	6.5±2.00^{c}
D.O (mg/L)	3.3±1.00^{c}	5.0±1.10^{a}	4.7±1.00^{b}	3.3±1.15^{c}
B.O.D(mg/L)	1.5±0.50^{c}	3.5±0.60^{a}	1.5±0.40^{c}	2.3±0.50^{b}
T.D.S(mg/L)	714±10.40^{a}	702±15.20^{c}	702±10.50^{c}	712±20.10^{b}
Conductivity(µs/cm^{3})	1667±20.10^{c}	1669±30.15^{b}	1675±25.10^{a}	1667±20.15^{c}
Transparency (m)	0.58±0.60^{a}	0.56±1.00^{b}	0.49±0.80^{c}	0.56±1.00^{b}
Mg^{+}(mg/L)	4.0±1.20^{b}	4.1±0.70^{a}	3.8±0.80^{c}	3.81±1.00^{c}
Cu(mg/L)	ND	ND	ND	ND
Fe^{+}(mg/L)	1.63±0.40^{b}	1.74±0.20^{b}	1.75±0.10^{a}	1.75±0.25^{a}
Zn(mg/L)	ND	ND	ND	ND

****a,b,c means with different superscripts shows significant differences (p<0.05) in the physico-chemical properties across different sampling stations of the pond.**

Table 2: The abundance and distribution of zooplankton sampled from four different stations in Pindiga pond during the study.

Zooplankton taxa	STATIONS				Total
	A	**B**	**C**	**D**	
Cladocera					
Bosmina sp.	2	6	3	1	12
Daphnia sp.	8	3	7	4	22
Moina sp.	11	6	4	12	33
Macrothrix sp.	10	2	4	8	24
Simocephalus sp.	11	4	7	5	27
Copepoda					
Tropocyclops sp.	17	5	7	13	42
Macrocyclops sp.	14	7	14	4	39
Acanthocyclops sp.	1	1	3	4	9
Diacyclops sp.	1	1	0	2	4
Mesocyclops sp.	7	1	2	8	18
Limnocalanus sp.	1	2	2	1	6
Leptodiapthamus sp.	2	4	5	2	13
Senecella sp.	5	2	1	5	13
Paracyclops sp.	7	3	4	6	20
Rotifera					
Asplanchna sp.	14	5	5	24	48
Brachionus sp.	4	3	5	8	20
Keratella sp.	1	1	2	2	6

Hexarthra sp.	1	2	3	3	9
Polyarthra sp.	8	5	4	1	18
Rotaria sp.	5	2	8	4	19
Trichocerca sp.	10	4	7	1	22
Synchaeta sp.	2	2	1	1	6
Ostracoda					
Hemicypris sp.	1	0	0	1	2
Stenocypros sp.	0	0	2	0	2
Grand Total	**143**	**71**	**100**	**120**	**434**
Abundance (%)	**32.95**	**16.36**	**23.04**	**27.65**	**100**

Table 3: Simpson and Margalef index of zooplankton species abundance in Pindiga pond

Zooplankton taxa	Station A	Station B	Station C	Station D	Total (%)	Simpson_1-D	MargaleF
Cladocera	42	21	25	30	118 (27.2%)	0.05214	1.9260
Copepod	55	26	38	45	164 (37.8%)	0.09937	4.0116
Rotifera	45	24	35	44	148 (34.1%)	0.08925	3.1768
Ostracoda	1	0	2	1	4 (0.9%)	0.00124	0.1523
Total	143	71	100	120	434		
Genera number	23	22	22	23			
Abundance (%)	32.95	16.36	23.04	27.65	100		

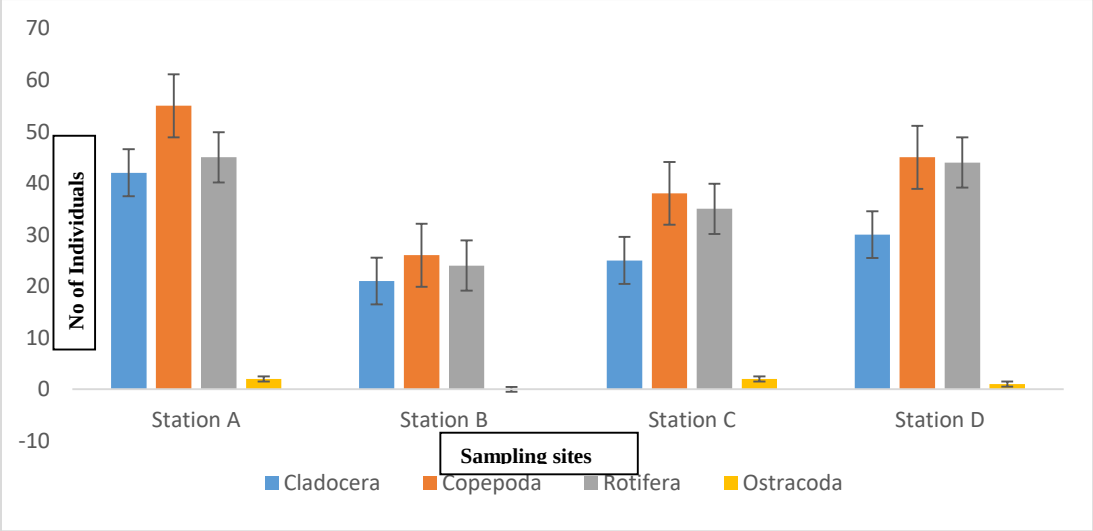

Figure 1: Percentage composition of the major zooplankton taxa (*Copepoda, Cladocera, Rotifera* and *Ostracoda*) among the four sampling stations during the study period.

****a,b,c means with different superscripts shows significant differences ($p<0.05$) among the four different taxa of zooplanktons across different sampling stations of the pond.**

Table 4: Correlation matrix showing relationship between Zooplankton taxa and Physico-chemical characteristics in Pindiga pond.

Properties	Temp	pH	EC	TDS	Tran	DO	BOD	Mg+	Fe+	Cop	Rotf	Clado	Ostra
Temp.	**0.96**												
pH	-0.12	-0.25											
EC	**0.737**	**0.592**	0.223										
TDS	**0.741**	**0.597**	0.216	1									
Transp.	0.128	0.112	**0.519**	0.109	0.101								
DO	**0.854**	**0.856**	0.237	**0.613**	**0.618**	0.181							
BOD	**0.791**	**0.738**	0.017	**0.658**	**-0.66**	0.055	**0.795**						
Mg+	0.248	0.040	**0.797**	**0.584**	**0.578**	-0.323	-0.015	-0.279					
Fe+	0.266	**0.517**	**0.667**	**0.088**	-0.009	0.360	**0.351**	0.510	**0.556**				
Copepod	**0.768**	**0.553**	-0.4	0.305	-0.128	**0.813**	**0.675**	0.32	0.45	**0.755**			
Rotifera	**0.589**	**0.658**	0.211	0.305	0.311	-0.438	**0.554**	0.118	0.412	**0.53**	**0.514**		
Cladocera	**0.774**	0.295	**0.587**	**0.591**	0.01	**0.85**	**0.735**	0.402	0.115	0.120	**0.642**	**0.866**	
Ostracod	**0.550**	0.450	0.20	0.101	0.001	**0.510**	**0.570**	0.201	0.230	0.441	**0.540**	**0.568**	1

Bold font indicated that correlation is significant at ($p<0.05$)

Discussion

The ranges of water temperature (28.9±2.10-29.0±3.10^{0}C) recorded in Pindiga pond with station D recording the highest temperature was higher than the range reported by Usman and Yerima, (2017) in Ajiwa reservoir, Katsina State and slightly lower than the ranges reported by Abubakar *et al.*, (2015) of 30^{0}C conducted in Dadin Kowa dam, Gombe State; Saidu *et al.,* (2016) conducted in Balanga dam. The difference could be as a result of differences in location, altitude and other factors such as cloud cover, vegetation and level of penetration of sunlight which will result to adequate eutrophication of the pond.

The pH ranges (6.5±2.00 - 6.8±1.10) recorded during the study period was within the standard limit recommended by NESREA which also agrees with the findings of Abed *et al*., (2022) and Majeed *et al*., (2021) in research conducted on Tigris River water quality in Northern Baghdad and lower than the ranges reported by Abubakar *et al.,* (2015) conducted in a research carried out on Dadin kowa dam; Usman and Yerima, (2017) conducted in Ajiwa river, Katsina State; Azuka *et al.,* (2018) conducted at Ikpoba river and the differences could be attributed to the amount of decomposition and inflow of inorganic nutrient into the water bodies.

Dissolved oxygen (3.3±1.00-5.0±1.10mg/L) recorded during the study period was similar to the ranges reported by Otene *et al.*, (2019) in a research conducted at Okamini Stream, Port Harcourt; Isah *et al*., (2018) at Dadin kowa dam and slightly lower than the ranges reported by Rashad *et al*., (2020) in a research conducted on Nile water in a selected area of Egypt. The differences observed could be as a result of differences in temperature and solubility of gases. Therefore, the dissolved oxygen of Pindiga pond is within the required range of good water quality according to the standards of NESREA and hence, facilitates the survival, growth and reproduction of aquatic organisms.

Biochemical oxygen demand range of 1.5±0.40-3.5±0.60mg/L recorded during the study period was similar to the ranges reported by Isah *et al.,* (2018) conducted in Dadin kowa dam, Gombe State and Abed *et*

al., (2022) and Majeed *et al*., (2021) in research conducted on Tigris River water quality in Northern Baghdad. BOD literally means indirect estimate of organic matter of the pond.

Total dissolved solid recorded in Pindiga pond was higher than the Total dissolved solid range reported in a research conducted by and Isah *et al.,* (2018) in Dadin Kowa dam, Gombe State and lower than the range reported by Umar *et al.,* (2017) conducted in Kashimbila river, Takum, Taraba State. The differences observed could be attributed to the nature of the water body and variation caused by the topography. Total dissolved solids consist of organic and inorganic substances dissolved and washed into the lakes by runoffs which plays an essential role in the survival, growth and reproduction of aquatic organisms (Umar *et al*., 2014).

The range mean value of Conductivity in Pindiga Lake was similar than the range reported by Umar *et al.,* (2017) conducted in Kashimbila river, Takum, Taraba State and higher than the electrical conductivity range reported by Abed *et al*., (2022) and Majeed *et al*., (2021) in research conducted on Tigris River water quality in Northern Baghdad. The differences might be to the level of inflow of ions into the water body and variation caused by the topography.

Transparency range recorded in Pindiga pond was similar to the range reported by Umar *et al.,* (2017) conducted in Kashimbila river, Takum, Taraba State and higher than the range reported by Isah *et al.,* (2018) conducted in Dadin Kowa reservoir, Gombe State. The transparency of the pond corresponds with the result of the total dissolved solid which encourages growth and survival of the aquatic organisms.

Magnesium ranged between (3.8±0.80 - 4.1±0.70mg/L) which is far below the standard recommendations of NESREA is lower than the range reported by Umar *et al.,* (2014) conducted in Kashimbila river, Takum, Taraba State and Abed *et al*., (2022) and Majeed *et al*., (2021) in research conducted on Tigris River water quality in Northern Baghdad.. The variation could be attributed to the nature of the water body as a close system and variation caused by the topography. The presence of nutrients and plant biomass formation in water body exhibit a complex dynamic relationship in tropical aquatic ecosystem due to various physico-chemical and biological characteristic.

Iron ranges between which is above the standard recommendations of NESREA is lower was similar than the range reported by Abubakar *et al.,* (2015) conducted in Dadin Kowa reservoir, Gombe State, Isah *et al.,* (2018) conducted in Dadin kowa Dam, Gombe State.

The most abundance of Copepoda could be attributed to the dependent on availability of sufficient nutrients and favorable temperature (Rashad *et al.,* 2020) and their acclimatization to altering ecological condition and capability to bear up varying ecological hassle (Majeed *et al.,* 2021). Subsequently, the abundance and richness of taxon Rotifera would be attributed to their capability to undergo upright movement, which lessens competition through niche exploitation and food utilization. Rotifers have widely been used as biological indicators in studies due to their sensitivity to various levels of water quality characteristics. Then Cladocera was second to the last taxa in terms of abundance then followed by the taxa Ostracoda which has the least abundant zooplankton in the study area which could be attributed to the competition for food with other herbivores, depth of the pond and other climatic conditions of the pond contrary to the statement of Abed *et al*., (2022) who reported that Cladocera are the most abundant zooplankton in freshwater.

Significant correlation was observed between zooplankton abundance and some physico-chemical properties in this study suggesting that the favourable conditions of the physic-chemical parameters of the pond results in abundance of the zooplanktons to thrive and survive which is in agreement with the findings of Ewa *et al.,* (2017) who also reported significant correlation between the occurrence of zooplanktons and some physicochemical characteristics in coastal Vistula lagoon. Majeed *et al.,* (2021) also reported that

different environmental factors, affecting the characteristics of water have enormous impact upon the growth and abundance of zooplankton. Increase in temperature in Pindiga pond showed negative strong correlation between the abundance of zooplankton while increase in the amount of dissolved oxygen in the pond showed strong correlation the abundance of zooplankton as agreed to the findings of Umar *et al,* (2017) who reported that increase in temperature significantly reduces the zooplankton abundance while increase in dissolved oxygen increase the abundance of zooplankton in a field research conducted at Kashimbila river, Takum, Taraba state. Usman and Yerima, (2017) also reported in a field research conducted on ecological investigation of zooplankton abundance in Ajiwa reservoir, Katsina State, Nigeria, that increase in Dissolved oxygen lead to the increase in abundance of zooplankton as investigated, also Ewa et al., (2017) reported that increase in temperature mostly decrease the number of species present in a tropical rain forest river in Niger Delta, Nigeria, similarly Abed *et al*., (2022) reported in a field research conducted that the abundance of zooplankton increased with the increase in dissolved oxygen and decrease significantly with increases in temperature.

Conclusion

The result of the research showed that physicochemical properties were within the range value suggested for most tropical water bodies according to NESREA except for Mg^{+} and Fe^{2+} and zooplankton abundance and distribution observed in this study was very impressive and made Pindiga pond a very productive ecosystem and exceedingly potential for broaden ecological studies. Consequently, the lake is suitable to sustain the accretion; continued existence and growth of aquatic organisms predominantly fish and so adequate steps should be taken to maintain and protect the pond from pollution.

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