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Survey of Zooplanktondiversity and Abundance and Its Relationship with Physicochemical Parameters in River Kashimbila Takum, Taraba State, Nigeria

***B. Usman[1], M. S. Bingari[1], D. D. Peter[1], S. Vandi[1]**
1. Department of Biological Sciences, Taraba State University, P. M. B 1165, Jalingo Taraba State, Nigeria
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ABSTRACT: *Zooplankton diversity and abundance and its relationship with physico-chemical parameters in River Kashimbila was carried out for a period of eight (8) months from August, 2016 to March, 2017.Physico-chemical parameters were determined, the identification and abundance of zooplankton were also determined. A total of twenty-one (21) species of zooplankton were reported, which was dominated by Ciliophora (34.61%), followed by Rotifera (32.92%) and the least being Cnidaria (0.02%). Shannon Weinner diversity index ranged from 1.40 -2.72, Margalef Index from 2.37 – 2.72 and evenness from 0.45 – 0.60. The data revealed that there was a significant difference among number of species and species count at (P<0.05) between raining and dry season. Zooplankton diversity and abundance were influenced by seasons and sites while species composition varied significantly with season at (P<0.05). Based on the zooplankton diversity and abundance, the rivers hold high possible impact on fish production.*

KEY WORDS: zooplankton, abundance, diversity, river Kashimbila

INTRODUCTION

Nutrient enrichment is another impact of anthropogenic processes altering aquatic systems. It has been recognized that anthropogenic nutrient loading can lead to undesired algal blooms, fish death, and loss of zooplankton diversity. Aquatic habitats also experience natural nutrient pulses during spring run-off turnover and rainstorms. Thus nutrient pulses tend to be a major environmental factor influencing aquatic communities. Lakes that have different levels of primary productivity are characterized by different zooplankton assemblages. Species composition is expected to change in response to increasing nutrient levels and productivity and the diversity will also change when the initial system level was relatively low. (Leibold*et al.*, 1997 and Carpenter*et al.*,1998) The study is designed to determine diversity and abundance of zooplankton and it relationship to physicochemical parameters and seasonal variation.

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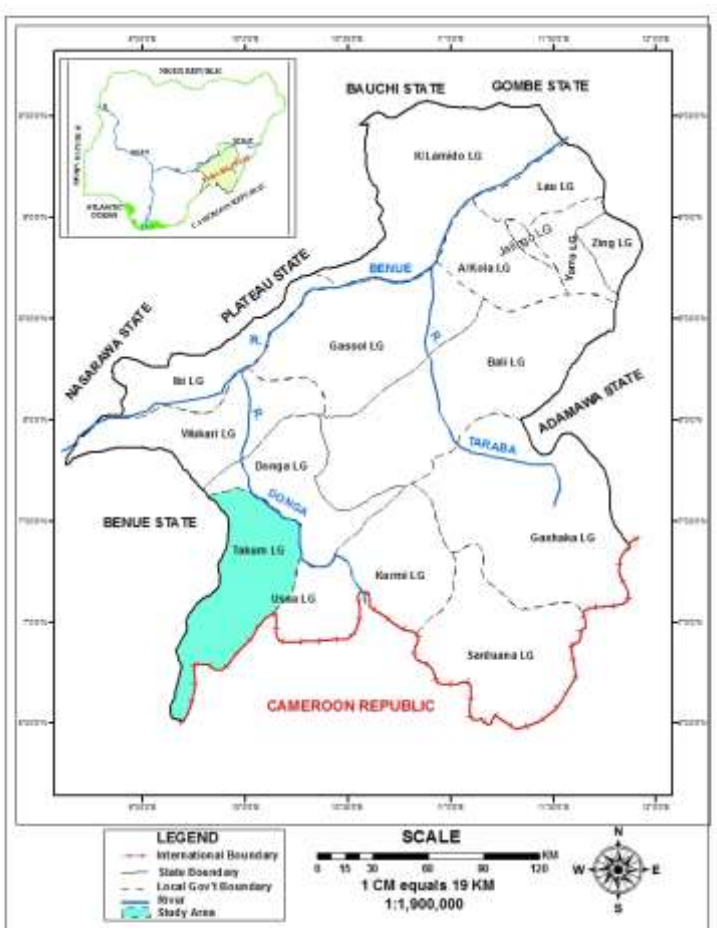
MATERIALS AND METHODS

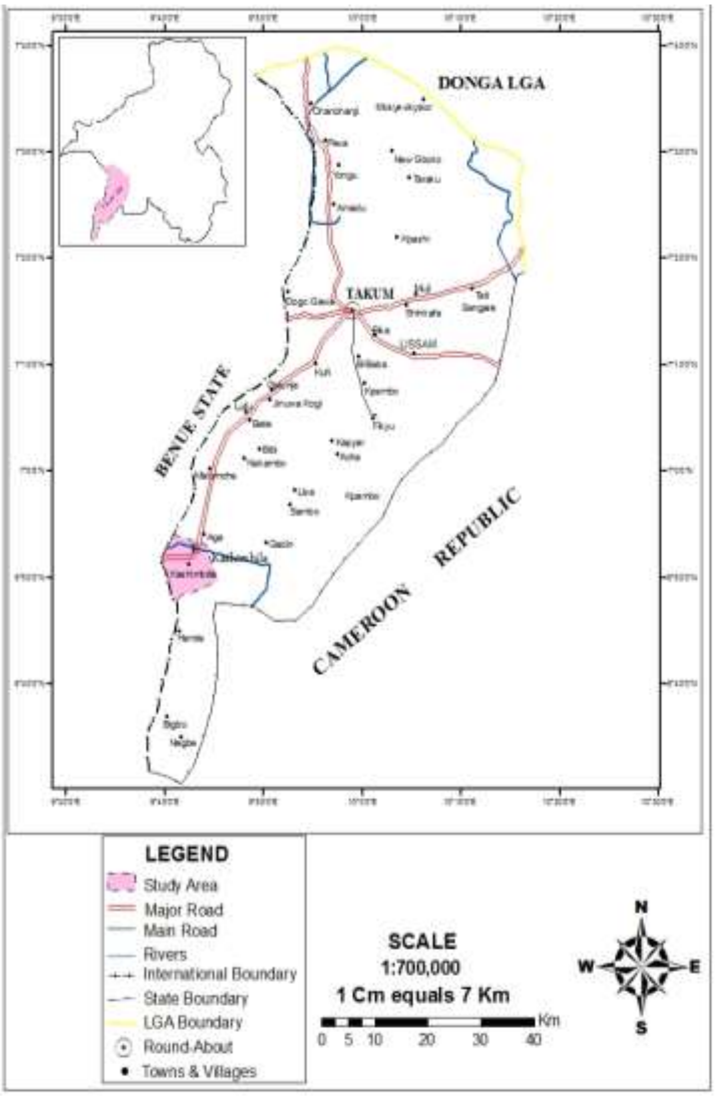
Study Area

The dam is located in Taraba State, in the Guinea savannah zone of Northeastern Nigeria. It consists of undulating landscape dotted with a few mountainous features and few scattered trees along the river, on the Latitude 06^{o} 52′N and Longitude 09^{0} 45′E which is between the towns of Kashimbila and Gamovo in Takum. The area has two distinct seasons (wet and dry). The rainy season period lasts from May to October while the dry season lasts from November to April.

The ethnic tribes in Takum are Jukun, Chamba, Kuteb, Ichen, Hausa, Tiv. They are predominantly farmers therefore cultivate crops like: cassava, guinea corn, maize, millet, groundnut, soyabean, benniseed, rice, melon, and other vegetable crops and some migrant Fulani who rear animals along the river. The Kashimbila Dam is 50km south west of Takum (Oruonye, 2015). The river took its source from the Bamenda highlands in northwesternCameroon. The dam is 35m high and is to serve as a buffer against flood from Lake Nyos, Cameroon.



Taraba State Showing the Study Area



Takum Local Government Area showing Study Site

Sample Site

The samples were collected in three stations namely: Station A before the dam where fishing activities, farming, bathing and washing of clothes occur; Station B where the dam is built and Station C downstream of the dam where irrigation, farming and cattle rearing occur.

Sample Collection and Handling

Samples were collected monthly for eight (8) months (August – March, 2016).

From each station using plankton net of 55µm mesh size by hauling the sampler horizontally a distance of five (5) meters according to the method of Anene (2003). The resultant concentrated plankton samples were transferred into a plastic container and were fixed using 4% formalin and three drops of Lugol's solution (Boney, 1983). The samples were transported to the laboratory in an ice box. Identification and enumeration of zooplankton were carried out in the Laboratory with a sedge-wick rafter-counting chamber by the use of Olympus binocular Microscope (APHA, 2005).

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Physico-chemical Parameters Analysis:
The following physicochemical parameters were determined on site: pH, Temperature, Dissolved Oxygen, Conductivity and Transparency by the use of HM Digital pH meter (Model PH80), pocket thermometer, Ex Stik II DO meter (DO600) Conductivity Tester (EC scan 40) and Secchi disc respectively. Water for determination of chemical parameters such as ammonia, alkalinity and free carbon dioxide were taken to the laboratory for analysis.
Plankton diversity and abundance and its relationship with the physico-chemical environment in the three stations of the Kashimbila dam were compared using ANOVA.

The individuals were counted from sample pipetted out using binocular microscope and relative abundance was estimated in accordance with keys provided by the standard work of Botes (2003) and Umar *et al.* (2013). The specific diversity calculation was based on the Shannon and Wiener index and Species Richness Index (D) according to Margalef (1958).
Shannon Weiner Diversity Index (H) of plankton species within the different sites was determined using: $H^1 = \Sigma$ (Pi)(Log_n P) (Magauran, 1988).
Where H^1 = Index of species diversity, Pi = Proportional of total sample belonging to ith species and i = number of species.
Margalef index is by $D = (S - 1)/Log_eN$
Where: D = Species richness index,S = Number of species in the sample and N = Number of individuals in the samples.

Species Evenesson the other handwas determined by the equation: E = H/lnS
Where:H= Shannon and Weiner's Index and S= Number of species in samples (Pielou, 1966).

RESULTS

Twenty one (21) species of zooplankton were identified, distributed across. Twelve (12) phyla: Arthropoda, Nematoda, Amoebozoa, Cladocera, Copepoda, Coleoptera, Ciliophora, Diptera, Heterichida, Macroinvertebrate, Cnidria and Rotifera. Macroinvertebrate (n = 8) was the most dominant in terms of number of species followed by Ciliophora (n = 3) then the others Arthropoda, Nematoda, Amoebazoa, Cladocera, Copepoda, Coleoptera, Diptera, Heterichida, Cnidaria and Rotifera recorded (n = 1) each.

In terms of abundance, Ciliophora (34.61%) was the most dominant, followed by Rotifera (32.92%) then Copepoda (19.66%) and the least was Cnidaria (0.02%).In terms of species abundance, *Brachionussp*(1459.33)of the phylum Rotifera was the most dominant species followed by*Diaptomussp* (871.67)of Copepoda, for Ciliophora, *Vorticellasp* (833.33) was the most dominant followed by *Stylonychiasp* (616.67) and the least was *paramecium* (84.33).
Under Macro-invertebrate, Mayfly nymph (130.33) was the dominant, followed by Damselfly nymph (119) and the least was Alderfly nymph (2.67). Others recorded one each: Diptera had *Polypedilum* (120.33), Amoebazoa, *Amoeba* (75), Cladocera*Daphnia* (37.33),Heterichida, *Stentor* (81.00), Arthropoda,water mite(±7.67),Nematoda, *Ascarislumbricoides* (3.67) and Coleoptera, water beetle(5.33)Cnidaria, Hydra (0.67.Range of Values recorded for Shannon Weinner Index, Magarlef Index and Pielou diversity Index at sites were (1.4 -1.86) (2.37; 2.72; 2.53,) and (0.55; 0.60;0.45) respectively (Table 1).

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Table 1: Zooplankton Species Composition, occurrence and mean abundance in River Kashimbila

S/N	Z ooplankton Taxa/Species	Site A	Site B	Site C	Total	Percentage (%)	Mean A
Arthropoda	*Water mite*	+	-	+	+	0.17	7.67
Nematoda (Roundworm)	*Ascarislumbricoides*	+	+	-	+	0.08	3.67
Amoebozoa	*Amoeba*	+	-	-	+	1.69	75
Cladocera	*Daphnia*	+	+	+	+	0.84	37.33
Copepoda	*Diaptomus*	+	+	+	+	19.66	871.67
Coleoptera	Water beetle	+	+	+	+	0.08	3.33
Ciliophora	*Paramecium*	+	+	-	+	1.90	84.33
	Stylonychia	+	+	-	+	13.91	616.67
	Vorticella	+	+	+	+	18.80	833.33
Diptera	*Polypedilum*	+	+	+	+	2.71	120.33
Heterichida	*Stentor*	+	+	+	+	0.61	81
Macroinvertebrate	Mayfly nymph	+	+	+	+	2.94	130.33
	Mosquito larva	+	+	+	+	0.35	15.67
	Damselfly nymph	+	+	+	+	2.68	119
	Blackfly	+	-	-	+	0.14	6
	Dragonfly nymph	+	-	+	+	0.13	5.67
	Alderfly nymph	+	-	-	+	0.06	2.67
	Stonefly nymph	+	-	+	+	0.18	8
	Water beetle	-	-	+	+	0.12	5.33
Cnidaria	*Hydra*	-	-	+	+	0.02	0.67
Rotifera	*Brachionus*	+	+	+	+	32.92	1459.33
	Total	19	13	15	21	100.00	
	Shannon Weinner index	**1.71**	**1.86**	**1.4**	**13299**	**100.00%**	
	Margalef Index	**2.37**	**2.72**	**2.53**			
	Pielou Index	**0.55**	**0.6**	**0.45**			

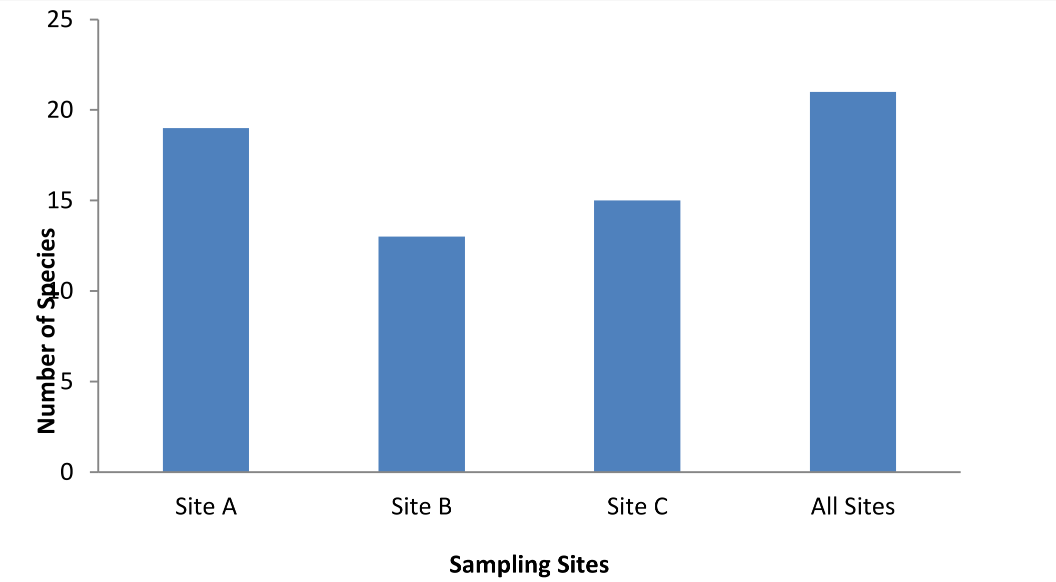

Figure 1. Number of Species recorded for different sites

Figure 1: Zooplankton species based on sites

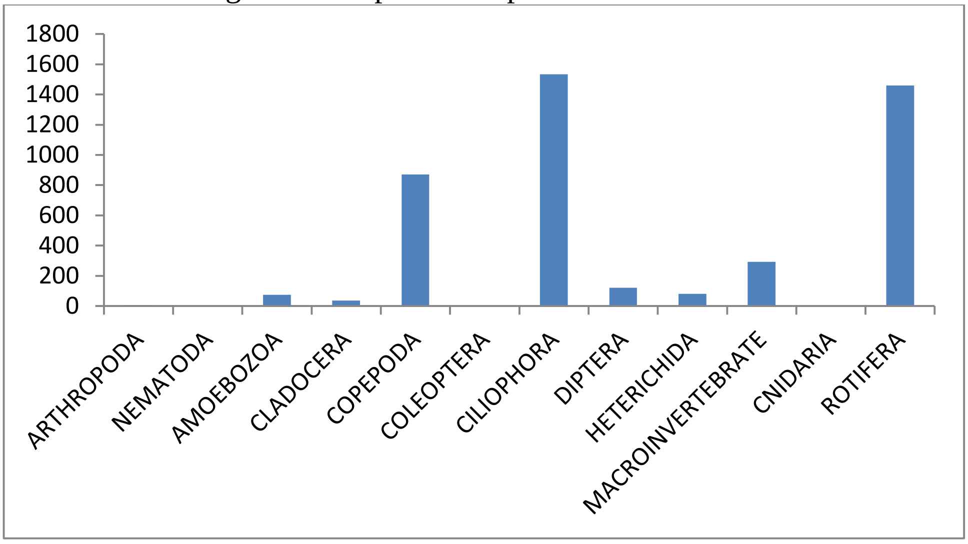

Figure 2: Zooplankton taxa in River Kashimbila.

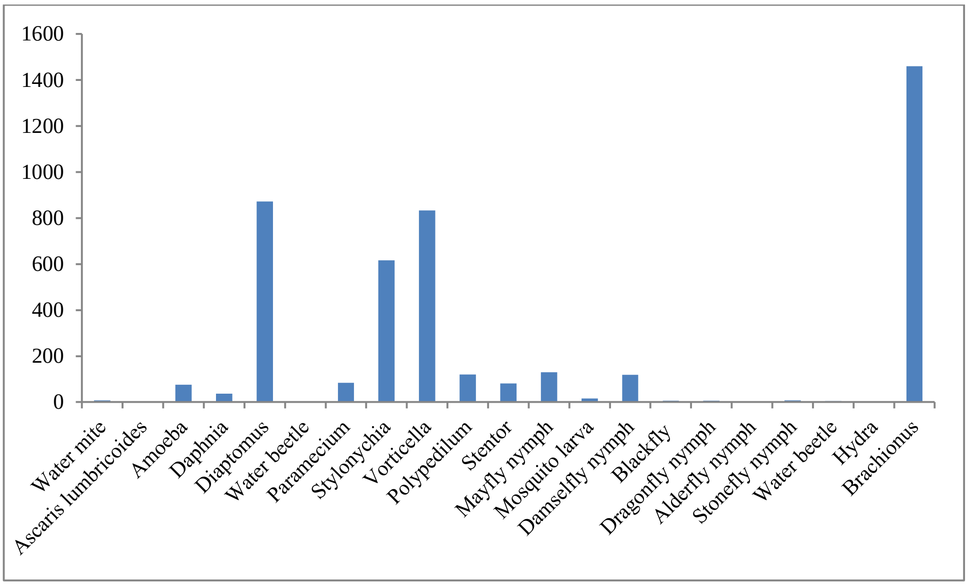

Figure 3: Abundance zooplankton species in River Kashimbila.

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Table 2: physicochemical parameters for sites.

Site	Means of Physicochemicals							
	Alkalinity (mg/l)	Ammonia (mg/l)	CO_2 (mg/l)	D.O (mg/l)	pH	Temperature (°C)	Transparency (NTU)	Conductivity µS/cm
A	566.3[a]	0.0203[a]	4.02[a]	3.9625[a]	6.2275[a]	25.375[a]	0.9050[a]	504.79 [a]
B	571.8[a]	0.0320[a]	5.20 [a]	3.7875[a]	5.9187[a]	25.625[a]	0.3900[b]	438.84 [a]
C	689.6[a]	0.0339[a]	9.24[a]	3.8250[a]	5.9012[a]	25.625[a]	0.7300[ab]	429.63 [a]
WHO	-	-	-	5.00	6.5 - 8.5	25	5.00	50-1500
USEPA	-	-	-	-	6.5 - 8.5	-	-	300
SE±	86.02	7.359	4.054	0.2087	0.2062	0.5428	0.1654	52.561

*abcd values with the same letters in the column did not differ significantly at P<0.05*WHO: World Health Organization (2006) *USEPA: United States Environmental Protection Agency (2017)

Table 3: Physicochemical parameters for the Months of August 2016 to March 2017.

Months	Means of Physicochemical parameters for months							
	Alk (Mg/l)	Ammo (mg/l)	CO_2 (mg/l)	D.O (mg/l)	pH	Temp °C	Trans (NTU)	Conductivity µS/cm)
August	283.7 [d]	0.016[b]	0.0012[b]	4.0667[ab]	5.5900 [b]	23.000 [c]	0.2400 [c]	502.00[ab]
Sept	743.3[bc]	0.026[b]	0.0235 [a]	4.1333[ab]	5.8367[ab]	25.667[bc]	0.2567[ab]	677.20 [a]
Oct	400.0 [cd]	0.023[b]	0.0011 [b]	2.9000 [d]	5.8333[ab]	24.667[bc]	0.4867[ab]	360.00 [b]
Nov	406.7 [cd]	0.027[b]	0.0018 [b]	2.5800 [d]	5.5000 [b]	24.000 [c]	0.6100[ab]	476.00[ab]
Dec	506.7 [cd]	0.026[b]	0.0015 [b]	5.6000[bc]	6.4000[ab]	24.000 [c]	1.0667[ab]	310.00 [b]
Jan	596.7 [cd]	0.029[b]	0.0054[ab]	4.8333 [a]	6.6667 [a]	28.000[a]	0.6533[ab]	340.99[ab]
Feb	886.7[ab]	0.065[a]	0.0089[ab]	4.0333[ab]	6.3667[ab]	27.000[ab]	1.0967 [a]	497.50[ab]
Mar	1050.0 [a]	0.0097[b]	0.0060[ab]	4.2667[ab]	5.9333[ab]	28.000 [a]	0.9900[ab]	497.50[ab]
WHO	-	-		5.00	6.5-8.5	25	5.00	50-1500
USEPA	-	-	-	-	6.5-8.5	-	-	300
SE±	140.80	0.0120	0.621	0.3408	0.3367	0.8864	0.2702	85.831

*abcd values with the same letters in the column did not differ significantly at P<0.05
*WHO: World Health Organization (2006) *USEPA: United States Environmental Protection Agency (2017)

DISCUSSION

Species composition and Abundance based on sites and Months

Ciliophora (34.61%) was the most abundant phylum followed by Rotifera (32.92%) and the Copepoda (19.66%). The abundance of these phyla could be due to availability of nutrient that is type of phytoplankton available and seasonal effects. This agreed with FAO (2006) on abundance of zooplankton due to variation in types of phytoplankton available, seasonal effects and difference in study area.

High zooplankton diversity and richness was observed in site B (0.6) and the least in site A and C respectively based on the result obtained from Shannon Weinner diversity index. Site A and C are characterized with high anthropogenic activities (cattle rearing, farming, fishing, dumping of refuse in the river) and run-off, which might have reduced richness and diversity of zooplankton.

The Pielou`s species evenness records with mean values ranging from 0.45 to 0.60 revealed that the distribution of species in this river were not even. This result agreed with the report of Jaji *et al.* (2007). However, Antai and Joseph (2015) recorded equitability in the zooplankton communities in Great Kwa River; this could be due to different period of sample collections, nutrient availability and seasonal effect on zooplankton abundance
The higher abundanceof zooplankton in dry season over raining season could be due to the effects of scouring activity and habitat destructionof higher river flow that usually inhibits plankton development in the river.The abundance, quality of life and species richness are said to be influenced by current velocity as stated by Crayton and Sommerfields (1979) in tributaries of Colorado Rivers. In the same vain, the higher abundance of plankton during the dry season could be attributed to bright sunshine and habit stability.

Species Composition and Abundance of Plankton in Relation to Physico-chemical Parameters.

The means of physicochemical did not differ for the three (3) sites except for transparency, where there was significant ($P<0.05$) differences between sites A (0.9050) and B (0.3900). This is due to human activities such as logging, transportation of farm produce, fishing, laundry, irrigation and bathing which have added to the turbidity experienced in sites A and B. The results obtained indicate that the range of values were above WHO measured standard of 5NTU but fell within range of FAO irrigation water quality guideline value of 35 NTU. Therefore, the present study suggests that the water is not safe for drinking but could be used for irrigation purposes (WHO, 2006 and Ayers and Wescot, 1985).

The physicochemical parameters based on months (Table 3) revealed that alkalinity was dominant in the month of March but least in August. It means alkalinity increase with decrease in quantity of water; it could be as a result of the carbonate rich soil and rock and anthropogenic activities. Alkalinity also neutralizes high concentration of acid; regulate pH range so as not to be lethal to aquatic life. The acceptable limit of alkalinity is 200 mg/l and in the absence of alternate water source, alkalinity of up to 600 mg/l is acceptable for drinking (Patil*et al.*, 2012). Alkaline was also found to favour zooplankton growth and abundance in the river, as seen from the direct relationship with pH.Byars (1960) reported that zooplankton prefers alkaline waters.

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The relatively low ammonia concentrations from August to January may be attributed to high biological activities as thepresence of nitrogen stimulates zooplankton communities. This agrees with Turano *et al*.(2008)on high affinityammonium uptake by Cyanobacteria. The presence of ammonia could be an indication of pollution and direct contamination by agricultural fertilizers. Ammonia is typically found in natural waters at concentrations less than 0.1 mg/L;(Waite and Dufour2003). It therefore, suggested that pollution level of ammonia in the water was very low and can support aquatic life as it ranged from 0.0097mg/l – 0.065mg/l. Free carbon dioxide was significantly high in September (0.0235), this could be due to respiration, and the free CO_2 released during respiration reacts with water, producing carbonic acid (H_2CO_3). It could become more acidic which some species of plankton might not survive it.

In the present study there was low concentration of dissolved oxygen in the months of October and November, which could be due torun-offs from farm fields and this affects the growth of many aquatic lives.

The high concentration of pH in the months of August – November was due to lack of high alkalinity concentration which is effective as a buffer to fluctuating of pH which might be caused by introduction of waste water and other metabolic processes.Tanimu*et al*. (2011) reported that alkalinity concentration is an effective buffer for pH. Thus, the pH range obtained in this study was from 5.50 - 6.66 which was not higher than the recommended level of 6.5 - 8.5 but within the range which is good for drinking water (WHO, 2006). Fluctuations of pH affect reproduction and cause death in many aquatic organisms (Boyd, 1979). The change of pH could be due to the inflow of chemical from the dam construction site, disposal of domestic and farm wastes, run-off from agricultural fields and cattle dung. This agrees with Abel (1996) whoreported that even though the pH of 5–9 is not directly harmful to aquatic life, such changes can make many common pollutants more toxic.Satpathy*et al.* (2009) also recorded that pH of water also depends upon relative contents of free CO_2, carbonates, bicarbonates and calcium. The water tends to be more alkaline when it possesses carbonates, but lesser alkaline when it supports more bicarbonates, free CO_2 and calcium.

The mean temperature range of the present study was between 23- 28^{o}Cfor months while mean square for sites was 25.625^{o}C therefore, it is good for plankton production. Therefore, water temperature increases the rate of molting, brooding and reproduction in water (Wetzel, 1983). The temperature in the month of March ranged between 28-30^{o}Cwhich favoured high reproduction plankton. This agrees with the different species that showed varied tolerances to increases or reductions in temperature ranges, and particularly sensitive individuals are eliminated by them (Andrulewicz*et al*., 2008; Tunowski, 2009).On the contrary,the temperature obtained for three sites are within the natural background level of 22-30°C for water in the tropics (Stumm and Morgan, 1981) but slightly above the limit of 25°C allowed for WHO drinking water standard.

The turbidity in August (0.2400) was significantly higher than other months, this could be due to the high velocity of water transporting debris or suspended particles, but the water became more transparent (less turbid) from December to March therefore, there was relatively equal reception of sun light and this could be the reason for the abundance of zooplankton in the dry season. Increase in water turbidity, increases water temperature because suspended particles absorb more heat. This in turn reduces the concentration of dissolved oxygen because warm water holds less dissolved oxygen than cold water (Abubakar, 2006). Suspended materials can clog fish gills reducing resistance to disease, lowers growth rates and affects egg and larva development (Sterling, 1985). However, the water may not be safe for drinking as the values obtained exceeded the WHO standard for drinking water (5NTU) but could be used for irrigation as the values obtained in the present study is within the range FAO recommended 35 NTU (Nephelometric Turbidity Unit) guidelines for irrigation.

Conductivity (µs/cm) is referred to as ability of liquid to transmit heat, electrical charges and also the measurement of ionic strength. Conductivity measurement of this present study ranged from 310 – 677.20 µS/cm and the analysis of variance showed significant difference between the months. However, most streams conductivity range between 50 to 1500 µS/cm. Freshwater streams ideally should have conductivity between 150 to 500 µS/cm to support diverse aquatic life(Abowei, 2010). The high values in August and September were (502.00 and 677.20) which could be due to high contamination from domestic activities such as bathing, washing, deposit of refuse and agricultural run-off and could also be the reason for low percentage abundance of the zooplankton within these months.

CONCLUSIONS

The present study revealed that Ciliophora was the most dominant and diversity, abundance and distribution of species were greatly influenced by season and sites as well as the physico-chemical parameters.

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