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Zooplankton Community Response To Deteriorating Water Quality In Tungan Kawo (Wushishi Dam), North Central, Nigeria

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***Abstract:** Physicochemical variables and zooplankton were collected monthly for five months in three sites in Wushishi Dam, Niger State. The study was undertaken to look at the community response of zooplankton to some water quality variables. Dissolved oxygen (DO) showed a range of 1.9-3.0 mg/l while BOD was in the range of 1.0 – 6.0mg/l. There was significant difference ($p<0.05$) in DO, BOD and pH recorded among the months and sites. Temperature and transparency showed no significant difference ($p>0.05$). Four zooplankton orders were recorded namely; Cladocera, Copepoda, Calanoida and Rotifera, consisting of 2471 number of species. The Canonical correspondence analysis revealed a fairly strong connection between some zooplankton species distribution/abundance and some measured water quality parameters (BOD_5, Transparency, Turbidity and pH). Some of the zooplankton like Megacyclops viridis, Leptodiaptomus minutus, Leptodiaptomus ashlandi, Harpacticoida sp. in February, March and June (sites 2 and 3) were strongly associated with BOD_5 and Turbidity. Ceriodaphnia cornuta site 3 (February, March, April and June) is a lover of pH while Cyclops scutiser is weakly associated with conductivity. From the environmental variables data, it shows that the water body is gradually deteriorating which may be occasioned by high degree of human influences. The zooplankton abundance and composition showed a sparse distribution, which called for urgent measures to curb the menace posed by these pollutional processes going on in the dam.*

***Keywords:** Physicochemical variables, Megacyclops viridis, Pollution, BOD_5, Wushishi Dam, Niger State, Nigeria.*

I. INTRODUCTION

Aquatic pollution is becoming a serious issue of water management in Nigeria and other part of Africa, especially in urban and semi urban cities. Many water bodies in urban and semi urban areas of Nigeria have been used for disposals of both solid wastes and waste waters, usually untreated, and are thus adversely polluted. This high pollution status threatens and, in many cases, has already altered the ecological balance of most water bodies in Nigeria (Zabbey and Hart, 2006). Recently, there have been increased campaign on the use of aquatic biota in assessing the quality of water bodies in Africa, Nigeria not an exception (Arimoro and Oganah 2009 and Edegbene and Arimoro 2012).

Zooplankton community structure, composition and diversity are important parameter for assessing the quality of water bodies. In an ecological system, zooplankton assemblage usually influences the flow of energy through a given food chain, nutrient cycling and community population dynamics within an ecosystem (Mustapha, 2009). Typical zooplankton composition of dams and other water bodies is mainly laden with rotifera, copepoda and cladocera (Rocha *et al*. 1999). In line with this assertion; Shekhar *et al.* (2008) assessed the zooplankton species richness, diversity and evenness to predict the state of three perennial ponds in India. A total of 47 species of taxa were recorded in three sampling sites. Their compositions were 24 rotifers, 9 copepods, 8 cladocerans, 4 ostracods and 2 protozoans.

Lately, zooplankton studies in some parts of Nigeria have received a great attention. Some of these studies includes that of Ogbeibu and Edutie (2002), Okogwu and Ugwumba (2006), Mustapha (2009) and Arimoro and Ogannah (2009), just to mention but a few. Contrarily, there are little or no studies on Wushishi Dam which is the study area of this present research. In this regard, this study might be the pioneering work on the zooplankton community structure of

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the said dam. This work intended to add to the growing pool of data set as regard zooplankton studies in Nigeria and Niger State in particular. Hence, the study attempted to look at the community response of zooplankton to some water quality variables in the said water body.

II. MATERIALS AND METHODS

STUDY AREA AND SAMPLING SITE

The Tungan Kawo Dam (Wushishi Dam) is built across the flood plains River Ubandawaki and Bankogi. It is located at about 7.5 km from Wushishi town in Wushishi Local Government Area of Niger State (Fig. 1). The dam is located on the interception of longitude 6°9'E and latitude 9°48'N of the equator. Tungan Kawo Dam and irrigation project is one of the multi-purpose projects embarked upon by the Niger River Basin Development as a solution to the frequent flooding of valuable agricultural land in the project area by River Ubandawaki and Bankogi. The dam has been subjected to varied degree of anthropogenic activities occasioned by refuse dump, domestic activities, irrigation processes among others.

The area shows two distinct seasons i.e. a rainy and dry season. The rainy season is Between April to October with a peak rainfall occurring in September and dry season between November to March. The normal rainfall range-between 1200 mm and 1300 mm. Cattle fecal wastes are found around the premises as cattle visit the dam to drink water, subsistence fishing activities are also carried out on the Dam.

SAMPLING OF WATER QUALITY VARIABLES

Water samples were collected monthly over a period of 5 months between February and June 2014 for laboratory analysis. Subsurface water temperatures, transparency, conductivity, turbidity, dissolved oxygen, biochemical oxygen demand, pH, water depth and flow velocity were measured. A mercury-in-glass thermometer was used for measuring temperature. A HANNA HI 9828 multi-probe metre manufactured by HANNA instruments was used for measuring values of DO, Conductivity and pH according to APHA (1998) methods. Transparency was measured using secchi disc. Water samples were collected in 1-l plastic acid washed bottles and transported to the laboratory in a cooler box containing ice. In the laboratory, water samples were analysed for BOD_5 (APHA (1998).

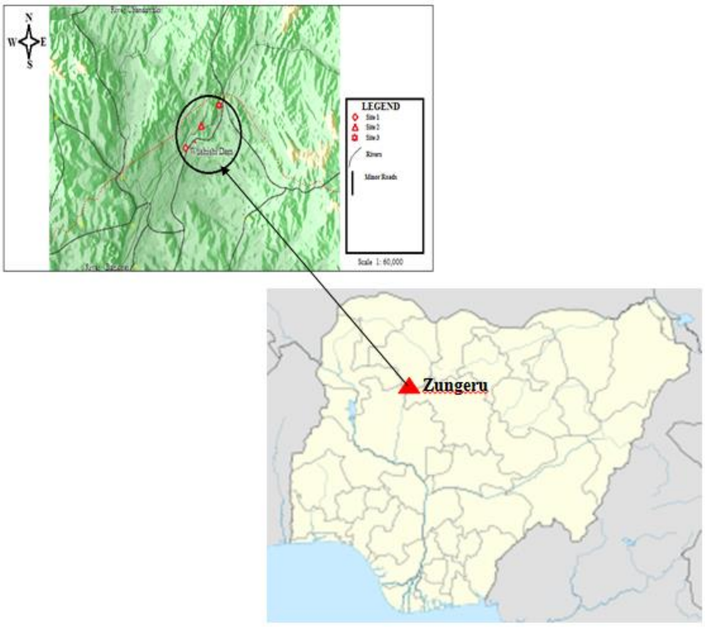

Figure 1: Map of Nigeria inserts Niger State showing the study area and sampling sites.

ZOOPLANKTON COLLECTION

Zooplankton was sampled quantitively in the mid channel at all sites. Vertical hauls were taken using plankton townet of mesh size 80µm (172 meshes/inch) (Edmondson and Winberg 1971). The samples were preserved in 4% buffered formalin solution and transported back to the laboratory of the Department of Biological Sciences, Federal University of Technology, Minna, Nigeria for further analysis. Taxonomic identification was conducted under a microscope at a magnification of 40X and 100X. Zooplankton organisms were identified to the species level according to [Pennak 1978 and Shiel 1995) and abundance estimated.

DATA ANALYSIS

The mean and standard deviation of means of the physico-chemical parameters of the study stations were determined by descriptive statistics using Microsoft Excel program. Community attributes were compared using repeated measures analysis of variance (ANOVA). Fixed-effect ANOVA were performed using dates as repeated on log (x+1) transformed data. Canonical correspondence analysis (CCA) was used to evaluate relationships between zooplankton communities and environmental variables with STATISTICA version 9.0. Zooplankton data was presented on a table using Microsoft Excel.

III. RESULTS

Table 1 shows the variations in the physicochemical parameters in Wushishi Dam. Dissolved Oxygen (DO) was highest in station 1 with a mean value of 2.60± 0.248 mg/l while station 3 had the lowest (1.95±0.05 mg/L). There was no significant difference ($p > 0.05$) in DO recorded between the months and sites. DO range from 1.8 to 3.0 mg/L in the three stations studied. There were no significance differences in biological Oxygen Demand (BOD) and pH between months and among the sites studied ($p > 0.05$). There were significant difference ($p < 0.05$) in temperature and transparency among the months and sites studied.

Conductivity value ranged between 22.4 and 23.4 µS/cm, with the highest mean value of 22.85 ± 0.1555 µS/cm was recorded in station 1 while stations 2 and 3 had the same mean value of 22.83 µS/cm. There was significance difference in conductivity among the months ($p < 0.05$) but statistically not significant among sites ($p > 0.05$).

COMPOSITION AND ABUNDANCE OF ZOOPLANKTON IN RELATION TO STUDY SITES AND SOME WATER QUALITY VARIABLES IN WUSHISHI DAM

Four (4) zooplankton orders were recorded during the course of this study. The orders were cladocera, copepoda, calanoida and rotifera (Table 2). They were represented by 5, 4, 3 and 1 species respectively. Rotifera was the least represented order with *Brachiounus salcatus*. Generally, a total of thirteen (13) species of zooplankton was recorded in the study area. A total of 2471 individuals of zooplankton were recorded in the entire study period. Station 2 had the highest number of zooplankton of 1823 individuals followed by station 3 with 512 individuals, then 136 individuals in station 1. *Megacyclops viridis* had the highest individuals among the three (3) stations studied with 806 individuals in station 2, followed by *Ceriodaphnia reticulata* with 515 individuals in station 2. *Megacyclops viridis* and *Ceriodphnia cornuta* had 192 individuals each in station 3. *Leptodisptomus minutus* and *Brachionus fulcatus* were absent in station 1 and 3 respectively while *Harpacticoida* sp. was absent in station 1. Generally, *Brachionus fulcatus* was sparingly present in the study area with only 4 individuals in station 2. Also, *Eucyclops elegance* was sparsely distributed in the study area with 1, 8 and 3 individuals in stations 1, 2 and 3 respectively. *Moina macrura* was densely populated in the study area with 22, 134 and 97 individuals respectively in stations 1, 2 and 3. Again, *Cyclops scutiser* had the highest occurrence in station 2 with 116 individuals, then 9 and 50 individuals in station 2, 1 and 3. *Simocephalus expinosus* had 49 individuals in station 2, then 9 in station 3 while station 1 was only represented by 5 individuals. *Leptodiaptomus ashlandi* had the lowest representatives in station 1, with 3 individuals while the highest was in station 2 with 58 individuals, then 10 individuals in station 3. *Leptodiaptomus coloradensis* was represented by 9, 67 and 21 individuals in stations 1, 2 and 3 respectively. *Daphnia longiremus* had 5, 7 and 27 individuals respectively in stations 1, 2 and 3.

The canonical correspondence analysis (CCA) ordination plot for sites, environmental variables and species is shown in Figure 2. The CCA ordination showed a fairly good relationship between some zooplankton species distribution and some measured environmental variables (BOD_5, Transparency, Turbidity and pH). The strongest factors were BOD, Transparency and Turbidity while pH was the weakest among the variables that showed good relationship with the zooplankton composition. DO was negatively correlated with Conductivity, Temperature and pH.

Some of the zooplankton like *Megacyclops viridis, Leptodiaptomus minutus, Leptodiaptomus ashlandi, Harpacticoida* sp. in February, March and June (sites 2 and 3) were strongly associated with BOD_5 and Turbidity. *Ceriodaphnia cornuta* site 3 (February, March, April and June) is a lover of pH while *Cyclops scutiser* is weakly associated with conductivity. Monte carlo permutation test revealed that there were no significant differences in axes 1 and ($p>0.05$). 65.21% of the CCA was described by axis 1 while axis 2 described 21.0%.

Parameter	Site 1	Site 2	Site 3	Months F- value	Months P- value	Sites F- value	Sites P- value
Dissolved oxygen (mg/L)	2.60 ± 0.248 (1.90 - 3.0)	2.53 ± 0.125 (2.2 - 2.8)	1.95 ± 0.05 (1.8 - 2.0)	0.257	*P*>0.05	3.578	*P*>0.05
Biochemical oxygen demand (mg/L)	7.25 ± 1.93 (2.0 – 11)	3.25 ± 1.109 (1.0 – 6.0)	3.75 ± 1.109 (1.0 – 6.0)	2.950	*P*>0.05	3.80	*P*>0.05
pH	7.3 ± 0.095 (7.0 – 7.4)	6.8 + 0.108 (6.5 – 7.0)	7.0 + 0.129 (6.7 – 7.3)	1.216	*P*>0.05	4.904	*P*>0.05
Temperature (°C)	27.0 + 2.483 (21 – 32)	27.25 ± 2.840 (21 – 33)	27.25 ± 2.955 (20 – 33)	218.4	*P*<.0.05	0.2	*P*<0.05
Transparency (cm)	8.0 ± 1.472 (4.0 – 11)	24.5 ± 2.723 (17 – 30)	22.0 ± 3.162 (14 – 28)	7.038	*P*<0.05	36.50	*P*<0.05
Conductivity (µS/cm)	22.85 ± 0.1555 (22.5 – 23.2)	22.83 ± 0.232 (22.4 – 23.4)	22.83 ± 0.132 (22.6 – 23.1)	11.60	*P*<0.05	0.089	*P*>0.05

Note: Values are means ± standard error. Minimum and maximum values in parenthesis. The F – values indicate ANOVA and P – value indicating the level of probability

Table 1: Environmental variables measured at the study sites of Wushishi Dam, Niger State (February to June, 2013)

Order	Taxa	Codes	Sites 1	Sites 2	Sites 3
Cladocera	*Ceriodaphnia reticulata*	Cerr	37	515	97
	Ceriodaphnia cornuta	Cerc	3	10	192
	Simocephalus expinosus	Sime	5	49	9
	Moina macrura	Moic	22	134	97
	Daphnia longiremus	Dapl	5	7	27
Copepoda	*Megacyclops viridis*	Megv	42	806	192
	Cyclops scutiser	Cycs	9	116	50
	Eucyclops elegance	Euce	1	8	7
	Harpacticoida sp.	Hars	0	13	1
Calanoida	*Leptodiaptomus ashlandi*	Lepa	3	58	10
	Leptodiaptomus coloradensis	Lepc	9	67	21
	Leptodiaptomus minutus	Lepm	0	36	0
Rotifera	*Brachionus fulcatus*	Braf	0	4	0
Total			**136**	**1823**	**512**

Table 2: Composition and abundance of zooplankton in relation to study sites in Wushishi Dam

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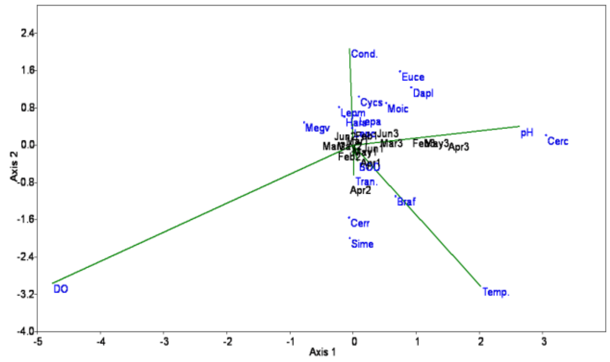

Figure 2: Canonical correspondence analysis (CCA) ordination for sites and environmental variables zooplankton species code in Table 2, (Monthly codes are Fe, February; Ma, March; Ap, April; My, May; Ju, June. Sites are 1, 2 and 3)

IV. DISCUSSION

The dissolved oxygen (DO) concentration of sites sampled showed that it was poorly aerated. This DO (1.95 – 2.60 mg/L) result of the present study is in contrast with earlier reports by Edegbene and Arimoro (2012) in River Owan, Southern Nigeria and Edgebene *et al.*, (2012) in River Atakpo, Niger Delta Area of Nigeria who reported a relatively aerated sites of their study station. The permissible DO limit for aerated water body by World Health Organization is 5.0 – 6.0 mg/L (Oluyemi *et al.* 2010). The poor dissolved oxygen recorded in this study might be attributed to various anthropogenic activities around the water body such as defaecation, washing and indiscriminate refuse dump by the immediate riparian communities, among others.

Biological oxygen demand (BOD) values indicated the extent of organic pollution in water quality (Jonnalagadda and Mhere, 2001). At site 1, the BOD value ranged between 2.0 and 11mg/L which was the highest with a mean value of 7.25mg/L showed the extent of stress this particular station is undergoing presently as the acceptable BOD limit for portable drinking water is 0 - 6.0 mg/L, though some of the sites conform with this accepted limit.

The pH values in this study ranged from slightly acidic to slightly alkaline. The pH values are within the permissible limit of standard organization of Nigeria (6.5 – 8.5) for fresh water bodies. This value range is in line with earlier report by Edegbene and Arimoro (2104), who recorded a value range of 6.1 – 7.6 of pH in Owan River, Niger Delta, Nigeria. Transparency value of this present study ranged from 4.0–30cm. The relative poor nature of transparency of this present study area could be attributed to the perturbed nature of the water, probably as a result of influx of human wastes from the riparian zone to the water body. Earlier reports by Edegbene *et al.* (2012) in Atakpo River in the Southern part of Nigeria conform favourably with the recorded transparency value in this study. That study earlier implicated low transparency in water bodies to the unregulated human influences along the banks or shores of water bodies.

The four (4) orders of zooplankton recorded in this study is in line with earlier work by Mustapha, (2009), who recorded three order of zooplankton in a reservoir in Offa, Nigeria. This showed that these groups of zooplankton are common in the North Central region of Nigeria, because Offa and Tunga Kowa are both in North Central Nigeria. The observed rotifera being least abundant species during the entire study is contrary to the reports of Mustapha (2009) who reported the dominance of rotifera (*Brachionus* sp.) in Ogun reservoir in Offa. Also, earlier reports by Akin-Orioda (2003) and Mustapha and Omotosho (2006), shows that the order Rotifera and the genus *Brachionus* is the most dominant zooplankton group in Nigeria aquatic ecosystems. They attributed the high population density of the rotifers is attributed to their parthenogenetic reproductive patterns and short developmental rate under favourable conditions (Pouriot *et al.* 1997), their morphological (Wetzel, 2001) and their ability to feed on different food type. The sparse distribution of *Brachionus fulcatus* in this present study indicated a non eutrophic (i.e. poor nutrient) nature of the dam, from personal observation because the dam is becoming stressed from the physicochemical parameters analyzed. Furthermore, Rocha *et al.* (1999) has asserted that high organic matter or nutrient in a water body increases the abundance of *Brachionus*.

The observed number of species of cladocera and copepoda in this study do not conform favourably with the results of Mustapha (2009) who reported low abundances of Cladocerans and Copepods. Also, elsewhere, in South Africa, Martin and Cyrus (1994) in Lake Cubhu, reported low abundance of these two genera. In line with this, is the work of Akin-Oriola (2003) in Ona Rivers, who documented low abundance of the two genera. Furthermore, Mustapha (2009) recorded predominance of *Daphnia* among the Cladocerans sampled in a reservoir in Offa. That study attributed this observation to the large body size of the *Daphnia* which enables it to graze on large quantities and diverse forms of phytoplankton. The study reported that *Daphnia* population is due to effective grazing on rotifers. Contrarily, from this study the population of rotifers was just four (4), which showed that the Daphnia might not have much food to feed on, hence its reduction in the population when compared to the remaining species of Cladocerans (*Ceriodaphnia reticulata*, *C. cornuta*, *Simocephalus expinosus* and *Moina macrura*) which were very much present in high numbers.

The CCA indicated that zooplankton organisms responded fairly positively to some environmental variables. Turbidity and BOD were found to be major factor affecting the distribution of zooplankton. Earlier research has found BOD as an important factor determining the abundance of zooplankton (Pandey and Verma, 2004; Okogwu and Ugwumba, 2006). As a confirmation to the fact that abundance of zooplankton may be related to some environmental variable, can be seen in the positive correlation of *Megacylops viridis* with BOD. In this present study more *M. viridis* were sampled in site 2 and 3. From this, it can be inferred that *M. viridis* can be used as bioindicator, because of its abundance in area with high BOD concentration. Also, *Ceriodaphnia reticulata*, *Ceriodiaphnia cornuata* and *Cyclops scutiser* were also associated with a high degree of pollution as revealed by CCA ordinance. This also lends credence to the perturbed nature of site 2 and 3 due to the level of pollutional processes going on in this sites.

The presence of *Cyclops scutiser* in a relatively high numbers is a good omen, because, it has been documented by earlier researchers to have medical usefulness (Mustapha, 2009). *Cyclops* abundance in water bodies has been reported to have medical significance in Africa aquatic system (Mustapha, 2009). Again, the absence of the Rotifera (*Brachionus fulcatus*) in station 1 and 3 and it low abundance in station 2, is an indication that the Rotifer (*Brachionus fulcatus*) could be used as bioindicator of water quality. Arimoro and Oganah (2009) have earlier reported the sensitivity of some species of Rotifera and Crustacean to pollution in River Orogodo, Niger Delta, Nigeria. Though, this is just a suggestion, because the absence of a particular species or group from a river may not be indicative of pollution because not all reaches in a water body are suitable for all organisms.

V. CONCLUSION

A detailed research is recommended to further prove this study, most especially on the use of zooplankton as bioindicators of water quality in Wushishi Dam. *Ceriodaphnia cornuta* which was found to be lover of increased pH value should be studied further to ascertain the cause of its correlation to increased pH, as this can be a major breakthrough in using this species of zooplankton in determining the acidity and alkalinity status of water bodies. Again, an analysis of nutrient parameters (nitrate, sulphate and phosphate) should be conducted to determine their usefulness to the abundance of Rotifera in this study area and other water bodies in Nigeria, because *Brachionus fulcatus* which is the least abundant species in the entire study is said to thrive more in a nutrient rich environment and its usefulness as bioindicator of water quality.

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