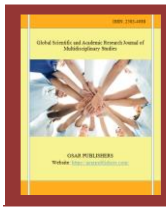

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INFLUENCE OF PHYSICOCHEMICAL PARAMETERS ON DISTRIBUTION AND ABUNDANCE OF MACRO-INVERTEBRATES FROM RIVER BENUE IN MAKURDI, BENUE STATE.

BY

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Abstract

The influence of physicochemical parameters on the distribution and abundance of macro invertebrates in River Benue was evaluated in the study. The sampling was done in three different portions of the river within a period of three (3) months. A long handed–sieve net was used to obtain the organisms in the river. The harvested macro invertebrates were identified and recorded. The physico-chemical parameters of the water were also measured and recorded during the course of the experiment. A total of 8 macro invertebrates species were observed with a total abundance of 186. The most widely distributed species was the *Pomacea caniliculata* (water snail) which was observed in all the samplings locations. The most abundant macro invertebrates however, were the *Gerris marginatus* (water striders) with an abundance of 63(33.87%). This was followed by the *Pomacea caniliculata* (water snail) 31(16.67%), *Lumbricus terrestris* (worms) 28(15.05%), the *Margaritifera margaritifera* (clams) 26(13.98%), the *Nepa cinerea* (water scorpion) 18(9.68%) and *Anisoptera* (Dragonfly Nymph) has 8(4.30%). The least abundant species was the *Hydrophilus triangularis* (water Beetles) with a relative abundance of 5(2.69%). The abundance of the macro invertebrates was observed to be dependent on the type of respective species found in the area (χ^2=57.970; df=7;p=0.000). The macro invertebrates were found to be most abundant at site B (40.3%) compare to site C (38.2%) with site A having the least (21.5%) as presented in Table 3. The Shannon-Weinner Diversity Index (H) of 1.807 with an evenness of (E) of 0.869 was observed. This showed that the macro invertebrates were evenly distributed among their respective species in the studied location.

1.0.Introduction

Most rivers in Nigeria, particularly those in urban areas are now being used for dumping both solid and liquid wastes; these high-polluting activities are now threatening the sustainability and functionality of freshwater ecosystems in Nigeria (Arimoro and Oganah, 2010). Freshwater pollution by human activities is becoming a matter of urgent concern threatening environmental productivity, sustainability, and further social-economic development in sub-Saharan Africa (Arimoro and Ikomi., 2008; Nyenje *et al*., 2010; Arimoro and Keke., 2016).

Several uses of aquatic ecosystems, includes laundry, water source for drinking, irrigation, hydropower generation as well as riparian activities on rivers' catchments such as unregulated land use and landscape alteration, have led to both biotic and physical deterioration of aquatic environment (Nyenje *et al*., 2010). Macro-invertebrate organisms are significant part of an aquatic ecosystem which are of ecological and economic importance because they maintain various levels of interaction within aquatic environment (Dobson *et al*., 2002). According to Uwem and Edet (2016) substrate is among the most important factor in the distribution of macrobenthic invertebrates, although alterations in physicochemical parameters such as temperature and salinity, and food availability also play vital role in determining the extent of distribution and abundance of macrobenthic invertebrate species in aquatic ecosystem and they play a critical role in the functioning of aquatic environment. Also, they constitute a major link in the aquatic food chain (Olomukoro *et al*., 2013).

Water quality can be defined as a measure of physical, chemical, biological, hydromorphological, and aesthetic properties of water (Giri and Qiu, 2016). The weather, altitude, position, source of pollution and time determine the changes in water parameters. Good water quality has various uses such as drinking, nature conservation, industrial, agricultural recreational, and habitat of aquatic ecosystems. However, the quality of water is rapidly declining in many areas, and this is one of the key issues that people are facing (Angweya *et al*., 2012).

In any aquatic ecosystem, the physicochemical parameters of water play an important role in determining the richness, abundance, and species composition of macroinvertebrates (Garcia *et al.*, 2008).

With increase human activities such as industrialization, urbanization, and the recent flooding of River Benue couple with other anthropogenic activities which include laundry, farming, bathing, sand excavation, and drinking along the River which is threatening the sustainability and integrity of biodiversity and water quality.

The physicochemical properties of water quality assessment give a proper indication of the status, productivity, and sustainability of a water body (Djukic *et al*., 1994). The changes in the physicochemical characteristics like temperature, transparency, and chemical elements of water such as dissolved oxygen, nitrate, and phosphate provide valuable information on the quality of the water, the source(s) of the variations, and their impacts on the functions and biodiversity of the reservoir. Physico-chemical properties of the water get varied season wise and in addition, anthropogenic activities such as agriculture, urbanization, domestic sewage, in the catchment area result in the deterioration of water quality (Verma *et al.*, 2012).

Temperature, turbidity, nutrients, hardness, alkalinity and dissolved oxygen are some of the important factors that play a vital role for the growth of living organisms in the water body. The physical and chemical characteristics of water bodies and their immediate biotypes are one of the major factors in determining the diversity, abundance, and distribution of macro-invertebrates. The water chemistry of an aquatic environment can be evaluated by the disturbance from the local surrounding land used pattern and other anthropogenic activities across the reach of the river (Edegbene *et al*., 2015).

Surface water can be polluted by industrial and municipal discharges as well as alteration to the natural environment, which may cause runoff pollutants. Both direct discharge and runoff can include human and animal wastes.

2.0. Materials and Methods

2.1 Study Area

The study area was restricted to River Benue in Makurdi town; the administrative headquarter of Benue State. The city is one of the fastest-growing urban areas in Nigeria. River Benue is one of the major rivers in Nigeria. It starts from Cameroonian mountains and flow westwards through Makurdi to meet the River Niger at Lokoja in Kogi State. The River is approximately 1,400 kilometers (870mi) long and it is almost entirely navigable during the summer months. It lies between Latitude 7^0 44″N and Longitude 8^0 31″E; and is located within the floodplain of the lower River Benue valley (Wikiedia, 2009).

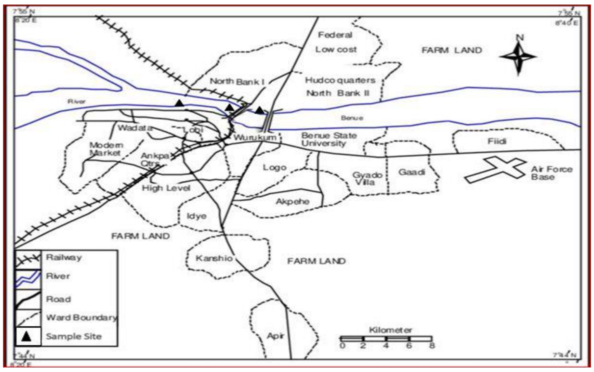

Figure 1: Map of Makurdi Showing the Sampling Sites: Wikipedia .com (2015)

2.2 Selection of Sampling Sites

Three sampling sites were identified for the research with site labeled A located at the old bridge, site B at the Wurukum Abattoir, and site C which will be after the new bridge.

2.3 Benthic Macro-Invertebrate Sampling

Samples of benthic macro-invertebrates will be collected weekly from the three sampling stations. Two random replicate of sediments will be taken from each site. Each sediment sample will be diluted with water and sieved with a 0.5mm mesh size sieve in the field (George *et al*., 2009). The residuals retained on the screens of the sieve will be washed into a shallow white tray with water for sorting. The sorted benthic macro-invertebrates will be preserved in 4% formalin in small glass jars.

The samples were transported to the laboratory of the Department of fisheries and Aquaculture Joseph Sawan Tarka University Makurdi for analysis. The preserved macro-invertebrate samples will be observed macroscopically and by using a digital Celestron® compound microscope Model #44345 and digital Celestron® cosmos dissecting microscope Model #44362. A combination of keys and guides provided will be used for identification of the macro-invertebrate species. The organisms will be counted in a counted. Pictures of the macro-invertebrates will be taken with the digital microscope and identified by referring to standard manuals, guides, keys, and textbooks

2.4 Determination of Water Quality Parameter

At each station, water samples were collected from the surface water weekly for a month using 250ml reagent bottles and one-liter plastic bottles. The samples in 250ml reagent bottles will be incubated at 20^{o}C for five days which will be used for BOD determination. Samples were analyzed in the laboratory using standard methods.

2.4.1 Turbidity

Turbidity was measured by using Sper® Scientific Turbidity Meter Model L87652. This was determined in the laboratory by taking 10ml of water sample into the glass vial using adjustable Micropipette. The sample was inserted into the well of the equipment after been cleaned and the lid closed. The test button was press and results displayed on the Liquid Crystal Display (LCD)

2.4.2 Dissolved Oxygen (DO)

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Dissolved oxygen will be determined using HANNA® dissolved oxygen (DO) meter Model HI 93246. This was done insitu by immersing the probe of the meter into the water and the reading on the LCD taken when it stabilized.

2.4.3 pH (Hydrogen ion Concentration)

Was determined using HANNA® multiparameter water tester model HI 98129. This was done by inserting the probe of the meter into the water sample and setting the mode to read pH using the MODE keypad.

2.4.4 Temperature

This was determined using HANNA® multiparameter water tester model HI 98129. This was done by inserting the probe of the meter into the water sample and setting the mode to read temperature using the MODE keypad.

2.4.5 Electrical Conductivity (EC)

Electrical Conductivity was determined by using HANNA® multiparameter water tester model HI 98129. The probe was immersed in water sample and the mode to read EC using the MODE keypad. The reading was taken after it was left to stabilize for about five (5) minutes.

2.4.6 Total Dissolved Solids (TDS)

Total Dissolved Solids (TDS) will be determined by using HANNA® multiparameter water tester model HI 98129. The probe was immersed in water sample and the mode to read TDS using the MODE keypad. The reading will be taken after left to stabilize for about five (5) minutes.

2.4.7 Nitrite

This will be determined by using Lovibond®Tintometer Model MD 600. This was determined in the laboratory by taking 10ml of water sample into the glass vial of the meter using adjustable Micropipette. Nitrite parameter was selected using the mode key. The sample was inserted into the well of the equipment after been cleaned and zeroed using the meter zero key. Remove the sample and add NitriVer powder to the sample and shake for one minute. The sample containing the powder was inserted into the well of the equipment, press test key, and the reading was displayed on the LCD.

2.4.8 Phosphate

This was determined by using Lovibond Tintometer Model MD 600. This was determined in the laboratory by taking 10ml of water sample into the glass vial of the meter using adjustable Micropipette. Select phosphate parameter using the mode key. Insert the sample into the well of the equipment after been cleaned and zero the meter using the zero key. Remove the sample and add phosphate powder to the sample and shake for one minute. Insert the sample containing the powder into the well of the equipment, press test key and the reading was displayed on the LCD.

2.4.9 Biochemical Oxygen Demand (BOD)

This was determined using methods as described by Winkler. These procedures involve the immediate determination of Dissolved Oxygen and incubation of 250ml of another sample for duration of five (5) days in the incubator. After five (5) days of incubation, the Dissolved Oxygen of the incubated sample was determined. The biochemical oxygen demand was calculated by; BOD (mg/l) = DO (before incubation) – DO (after incubation)

2.5 Data Analysis.

Data collected will be analyzed for descriptive statistics (mean and standard error of means) using Minitab 17. The data was further subjected to analysis of variance (ANOVA). Results and observations are presented in tables, figures, and plates.

3.0 Results

From the in-depth investigation, the influence of physicochemical parameters on the distribution and abundance of macroinvertebrates in River Benue was evaluated.

Table 1 below shows the abundance and distribution of macro invertebrates in River Benue, Makurdi. A total of 8 macro invertebrates species were observed with a total abundance of 186. The most widely distributed species was the *Pomacea caniliculata* (water snail) which was observed in all the samplings locations. The most abundant macro invertebrates however, were the *Gerris marginatus* (water striders) with an abundance of 63(33.87%). This was followed by the *Pomacea caniliculata* (water snail) 31(16.67%), *Lumbricus terrestris* (worms) 28(15.05%), the *Margaritifera margaritifera* (clams) 26(13.98%), the *Nepa cinerea* (water scorpion) 18(9.68%) and *Anisoptera* (Dragonfly Nymph) has 8(4.30%). The least abundant species was the *Hydrophilus triangularis* (water Beetles) with a relative abundance of 5(2.69%). The abundance of the macro invertebrates was observed to be dependent on the type of respective species found in the area (χ^2=57.970; df=7;p=0.000).

The macro invertebrates were found to be most abundant at site B (40.3%) compare to site C (38.2%) with site A having the least (21.5%) as presented in Table 3.

The Shannon-Weinner Diversity Index (H) of 1.807 with an evenness of (E) of 0.869 was observed. This showed that the macro invertebrates were evenly distributed among their respective species.

The physicochemical properties of River Benue in Makurdi, Benue State is presented in Table 2. Nine physicochemical parameters were studied which include: Temperature (26.2-26.9^{0}C), PH (5.1-6.7), TDS (23-57mg/l), Electrical conductivity(45-110s/m), Dissolved oxygen (3.7-5.1mg/l), Turbidity (28.02-62.28NTU), Nitrite (0.7-1.3), Phosphate (0.9-2.7) and BOD (0.0-0.2mg/l).

The influence of the physicochemical properties on the abundance and diversity of macro-invertebrates from River Benue was also investigated in this study using the Pearson's correlation coefficient (r).

Table 1. Abundance and Diversity of Macro-Invertebrates from lower River Benue in Makurdi, Benue State.

Macro-Invertebrates	Abundance	Relative Abundance (%)

Pomacea caniliculata(Water Snail)	31	16.67
Margaritifera margaritifera (Clams)	26	13.98
Nepa cinerea (Water Scorpion)	18	9.68
Lumbricus terrestris (Worms)	28	15.05
Argyroneta aquatic (Water Spider)	7	3.76
Anisoptera Spp. (Dragonfly Nymph)	8	4.30
Gerris marginatus (Water Striders)	63	33.87
Hydrophilus triangularis (Water Beetle)	5	2.69
Total	**186**	**100**
Shannon-Weiner Index(H)	1.807	
Evenness (E)	0.869	

X2=57.970;df=7;p=0.000

Table 2. Physicochemical Properties of River Benue in Makurdi, Benue State

Physicochemical Parameters	**Mean Value**	**Range**
Temperature (^oC)	26.60±0.3	26.20-26.90
PH	6.13±0.90	5.10-6.70
Total Dissolved Solid (mg/l)	40.33±17.01	23-57
Electrical Conductivity (s/m)	78.67±32.56	45-110
Dissolved Oxygen(mg/l)	4.33±0.71	3.1-5.1
Turbidity (NTU)	40.61±18.85	28.02-62.28
Nitrite(mg/l)	0.93±0.32	0.7-1.3
Phosphate(mg/l)	1.60±0.96	0.9-27
Biochemical Oxygen Demand (mg/l)	0.10±0.14	0.0-02

Table 3. Abundance and Distribution of Organism in relation to the different Sites

Points	**Organisms**	**Number**	**Relative abundance (%)**
A	*Pomacea candiculata*(Water Snails)	10	25
	Margaritifera margaritifera(Clams)	12	30
	Nepa cinerea(Water Scorpion)	5	12.5
	Lumbricus terrestris (Worms)	13	32.5
	Total	**40(21.5%)**	**100**
B	*Margaritifera margarititfera* (Clam)	14	18.7
	Argyronata aquatic(Water Spider)	7	9.3
	Pomacea canaliculata(Water Snails)	13	17.3
	Anisoptera(Dragonfly Nymph)	3	4
	Nepa cinerea(Water Scorpion)	8	10.7
	Gerris marginatus(Water Striders)	25	33.3
	Hydrophilus tiangularis(Water Beetles)	5	6.7
	Total	**75(40.3%)**	**100**
	Pomacea canaliculata(Water Snails)	8	11.3
C	*Gerris marginatus*(Water Striders)	38	53.5
	Nepa cinerea(Water Scorpion)	5	7.0
	Lumbricus terrestris (Worms)	15	21.2
	Anisoptera(Dragonfly Nymph)	5	7.0

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Total		**71(38.2%)**	**100**

Table 4. Physico-chemical Parameters of River Benue in relation to the different Sites

Physico-chemical Parameters	Sampling Site			FLSD –(0.05)
	A	B	C	
Temperature ^{0}C	26.80±0.10^{a}	26.20±0.10	26.67±0.06^{a}	0.410
PH	5.10±0.10^{a}	6.65±0.58^{b}	6.63±0.058^{b}	1.334
Total Dissolved Solid **(Mg/L)**	24.00±1.00^{a}	57.33±0.58^{c}	42.00±1.00^{b}	14.333
Dissolved Oxygen **(Mg/L)**	4.20±0.10^{b}	3.70±0.10^{a}	5.07±0.03^{b}	0.850
Turbidity **(NTU)**	31.55±0.01^{b}	62.27±0.01^{c}	28.17±0.01^{a}	33.111
Biochemical Oxygen Demand	0.33±0.58	0.10±0.10	0.03±0.06	NS
Nitrite	0.73±0.06^{a}	1.30±1.00^{b}	0.80±0.10^{a}	0.400
Phosphate	0.80±0.10^{a}	2.73±0.58^{c}	1.20±0.10^{b}	1.491
Electrical Conductivity**(S/m)**	45.00±1.00^{a}	111.33±1.54^{c}	81.00±1.00^{b}	29.330

Means on the same row with different superscript are statistically significant (P<0.05)

Ns = Not significant

4.0 Discussion and Conclusion

Discussion

The number of species present in a community is refers to as species richness, it is measured as the number of species per unit area of ground area (Chukwuemeka *et al.*, 2014). A total of 186 individuals from 8 species comprising the macro-invertebrate assemblage was low compared to other studies from Northern Nigeria (Emere and Nasiru, 2009; DadiMamud *et al.*, 2014). The abundance and diversity of macro-invertebrate could be due to habitat type, substrate type, and vegetation covers. Nutrient availability and nature of habitat also favour the abundance and distribution of macro-invertebrates (Keke *et al*., 2017).

Site B of River Benue had the highest family (7) richness, with a total of 75 (40.3%) macroinvertebrate populations. This could be attributed not only to the water quality but also to the pollution, Stones, vegetation, and high nutrient value at that site. Stone and vegetation habitats generally support a higher diversity of benthic macro-invertebrates compared to sandy habitats (Dallas, 2007). The lowest family richness was recorded at River Benue Site A with only three species giving a total of 40 **(21.5%).**

Sites A had among the worst water quality as determined by physicochemical parameters. The River, at this site received large volumes of abattoir effluent and other anthropogenic activities such as farming. Various scholars have used family richness in diversity ordering that is comparing the diversity between communities. These have reported significant decreases in the species richness particularly in response to toxic exposure and organic pollution (Cao *et al.*, 1996; Payne *et al*., 2005).

This study reports similar findings. For example, Site B of the River was particularly subjected to gross organic pollution. This clearly was reflected in the family richness. Sites with relatively less pollution such as Site C of the River Site had lower family richness values. However, as also demonstrated in this study, richness may not be a reliable source of diversity ordering. According to Payne *et al.,* (2005) this is because it is sensitive to small sample sizes.

Shannon-Weiner index and Simpson index are some of the mostly used indices to monitor diversity of river all around the globe. In River Ndakotsu, Lapai, Dadi-Mamud et *al.* (2014) found the Shannon index in the range between 0.376 to 0.943 which is not similar to the result of the current study which is 1.807 and evenness of 0.869. The result that shows greater than 1 indicates a fair ecosystem. Edegbene *et al* (2015) measured simpson index in municipal River, North Central Nigeria, and found in the range of 0.53- 0.69 which is far lower than the current study, that is an indicator of more diverse ecosystem.

The quality of a given water body is determined by its physical, chemical, and biological characteristics. They interact with one another to influence aquatic productivity (Keke *et al.*, 2017). The water chemistry of aquatic environment can be influenced by different sources which include natural and anthropogenic sources. Most water bodies in Nigeria have been compromised in physical, chemical, and biotic characteristic because of discharges of organic and inorganic wastes from anthropogenic activities around our freshwater bodies (Chukwuemeka *et al.*, 2014).

The physico-chemical characteristics of the River show some variations between sampling stations. All the physico-chemical parameters measured were statistically significant among sampling stations except for temperature. Temperature is one of the important environmental variables because it governs all the physical, chemical, biochemical, and biological properties of aquatic ecosystem (Chukwuemeka *et* *al.*, 2014). Temperature also regulates the physiological, behavior, and distribution of aquatic organism (Mustapha, 2008). From this study, the mean temperature ranges between 26.20 and 26.90ºC. The medium temperature obtained from this study could be as a result of sample collection time and the environmental condition at that particular time.

The DO ranged between 3.1 to 5.1 this values are lower than 7.1 to 10.4 recorded by Akpan *et al.*, (2019) which was higher than the current study. Dissolved oxygen values recorded across the stations were significantly low whe n compared with Federal Ministry of Environment limits (>6.0 mg/l). This could be caused by the consistent discharge of wastes from various anthropogenic sources into the water body. Dredging and sewage contribute to the increased loading of unwarranted toxicants into the water body. Slight increase in this parameter in station C could be attributed to limited human activities at the station. Wastes decomposition by microbe demand oxygen; this could have contributed to the reduced DO values noticeable in all the stations. Anago *et al*. (2013) stated that the decline in DO values could be due to chemical and biological oxidation processes in the water. The observed temperature is healthy for a habitat which is ranged between 26.20-26.90°c. This can be easily balanced to human body temperature and healthy to consume. The range of water temperature values obtained in the study is in accordance with the reports of Akpan and Etim (2015) for Uta Ewa Estuary.

The turbidity of any water sample is the reduction of transparency due to the presence of particulate matter such as clay or alga, finely divided organic matter, or salt, Plankton, and other microscopic organisms. In the present investigation, the turbidity range was between 28.02 NTU and 62.28 which is greater than normal and indicates a significant pollution rate. The turbidity values obtained for all the stations were higher than Federal Ministry of environment standard (<5 NTU). The observed values of turbidity across the stations could be ascribed to impact of surface runoff on these stations and the usual direct dumping of non-dissolvable wastes into the water couple with sand mining. Sand mining resulted in re-suspension of organic debris deposited at the sediment back to the water surface. The lowest turbidity values were at Site C of the River. At this point, there was less anthropogenic activities.

According to Abowei, (2011), the standard permissible limit for TDS should not be high. Water with high TDS level is unsuitable for flora and fauna to grow and taste unpleasant for drinking. The current study showed a TDS range of 23-57mg/L. High concentration of TDS in station B corresponds with the level of anthropogenic activities at this station. The elevated value in station B could be attributed to impact of surface runoff, transporting toxic substance into the station. Jonah *et al*. (2020) affirmed that increased precipitation and subsequent runoffs from the surrounding lands increased the TDS values of any water body.

The pH of a water body is also a very important character of water quality. The standard pH for fresh water to be healthy is below 8 (Asonye *et al*., 2007). The pH of River Benue ranged from 5.10-6.70. The pH values obtained varied across the stations; this could be due to the anthropogenic activities within the watershed. The values recorded fall within the recommended limits (6.5 –8.5) by FME (2011). The values of Electrical conductivity recorded in this study were within the range values reported by Akpan *et al*. (2019) for Uta Ewa Estuary and George and Atakpa (2015) for Cross River Estuary.

Biochemical oxygen demand (BOD) is one of the essential parameters usually used to assess the pollution load in water bodies (Bhatti and Latif, 2011). BOD values obtained in station B exceed the recommended value (<1.0 mg/l) by FME (2011) indicating high level of pollution and correspond with recorded values of DO. Biodegradation of wastes required a lot of DO resulted in significant increase of BOD level. The higher values recorded in this station may be linked to the high accumulation of organic and inorganic pollutants via human activities which usurp dissolved oxygen in large amounts during biodegradation. Findings coordinate with the reports of Jonah *et al.* (2019) for Ikpe Ikot Nkon River and Anyanwu *et al*. (2019) in Ossah River, Nigeria. Unpolluted water bodies have BOD values of 1.0 mg/l or less while values between 3.0mg/l and 10mg/l or more (Utang and Akpan 2012). The BOD values recorded for stations A and C was within the acceptable limit (<1.0 mg/l) by FME (2011).

River Benue with a range of phosphate of 0.9 to 2.7and nitrate of 0.7 to 1.3. Higher nitrate and phosphate values noticed in stations B may be linked to combined effects of precipitation and anthropogenic inputs. The findings are in agreement with the reports of Mandal *et al*. (2012). According to the author, higher concentration of these parameters owed to anthropogenic activities like laundering, discharge of contaminated sewage, and runoffs laden with fertilizers and pesticides. Phosphate values in all the stations in this study were within the acceptable limit (3.5mg/L) by FME (2011).

CONCLUSION

This study has established baseline data regarding the occurrence, abundance, and distribution of macro-invertebrates in the River, which can be used to evaluate the current and future biodiversity and river water quality. River Benue is found to be under minimum anthropogenic impact and is impaired in the downstream sections. The physico-chemical characteristic of the river showed some variations between sampling stations, Physico chemical parameters were statistically significant among the sampling stations ($p<0.05$). Taxonomic breakdown of macro-invertebrates from the river showed the dominance of *Gerris marginatus*, *Pomacea caniliculata*, and *Physa acuta*. These groups belong to pollution tolerant class in water body. There was a positive correlation between macroinvertebrates species and measured physicochemical parameters in the River. The survey of macro-invertebrate organisms gives an important insight into the status of the river and appends to the knowledge and understanding of the management strategies involved in biomonitoring as a significant tool in River restoration studies.

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