academicJournals

Vol. 6(8), pp. 271-279, August 2014
DOI: 10.5897/JENE2014.0460
Article Number: 71BD15147564
ISSN 2006-9847

http://www.academicjournals.org/JENE

Journal of Ecology and the Natural Environment

Full Length Research Paper

Macro invertebrates fauna group and their relationship with environmental variables in River Benue at Makurdi, Benue State, Nigeria

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Received 10 July, 2014; Accepted 31 July, 2014

Indiscriminate dumping of wastes into rivers without control measures is widely practiced in the developing nations of the World as it is observed in River Benue at Makurdi. To ascertain the health status and integrity of River Benue at Makurdi, water samples and sediments were collected monthly from five different locations on the shoreline of the river for a period of two years (July 2011-June 2013). The physico-chemical quality of the water samples were examined using standard methods. The sediments were examined for the presence and absence of macro benthic fauna. The mean values were generally within the WHO and the Nigerian Standard for Drinking Water Quality accepted maximum limit except for colour and turbidity. The result of ANOVA for all the parameters was significant during the seasons (P<0.05), except for total dissolved solids (TDS), total suspended solids (TSS) and temperature (P>0.05). Across the locations temperature, bicarbonate, nitrate, sulphate, phosphate and copper were not significant (ANOVA, P>0.05). The result of the sediments showed that a total of 4,451 macro benthic fauna individuals comprising of 4 phyla and 21 taxa were obtained. Among this benthic fauna group, Athropoda had the highest population of 90.15%, Annelid 4.74%, Mollusca 3.39% and Platyhelminthes 1.7%. A significant relationship at some instances was noticed between benthic fauna group and some environmental variables indicating relationship between benthos and hydrochemistry of River Benue. It is recommended that the discharge of effluents and other waste into the River Benue should be controlled and enforced.

Key words: River Benue, physico-chemical, macro benthic fauna, relationship.

INTRODUCTION

The health of the ecosystem is determined by the taxa-nomic composition of the community as well as its diversity (Idowu and Ugwumba, 2005). Benthic macro fauna are those organisms that live on or inside the deposit at the bottom of a water body (Barnes and Hughes, 1988; Idowu and Ugwumba, 2005). They are used to detect changes in the natural environment, monitor the presence of pollution and its effect on the ecosystem in which organisms' lives and, to monitor the progress of environmental cleanup (Otway and Gray, 1996;

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Nkwoji et al., 2010). They are used in testing water bodies for the presence of contaminants (Nkwojiet al., 2010). Studies have shown that there is entwining relationship between surface water quality and macro invertebrate diversity (Teferiet al., 2013). The physico-chemical parameters of lakes, ponds and rivers have considerable effect on the aquatic life. These parameters determine the productivity of a water body. Thus, a change in the physico-chemical aspect of a water body brings about a corresponding change in the relative composition and abundance of the organisms in that water (Adeyemiet al., 2009). All the same chemical and physical measurements used in evaluating water quality provide data that primarily reflect conditions that exists when the water sample was taken (Ikomiet al., 2005; Muralidharan et al., 2010). However, physico-chemical and biomonitoring are not mutually exclusive, an optimal limnological study involve both approach (Muralidharan et al., 2010). This is because the biological community gives an indication of past conditions as well as the current situation of the aquatic ecosystem (Nkwojiet al., 2010). Therefore, any negative effect caused by pollution in the community structure can in turn affect trophic relationship (Sharma and Chowdhary, 2011). An additional advantage of macro invertebrates' bio indicators is that they integrate stream conditions related to the flow and chemical characteristics as well as the cumulative impact of multiple potential contaminants (Yagowet al., 2006). Biological assessment is therefore a useful alternative for assessing the ecolo-gical quality of aquatic ecosystems since biological communities integrate the environmental effects of water chemistry, in addition to the physical and geo-morphological characteristic of rivers and lakes (Stevenson and Pan, 1999). As rural and urban communities in Nigeria and Makurdi in particular continue to rely on surface water sources and shallow wells for their water needs, it is important to know the quality of the water they use as a means of advancing their health in the face of grinding poverty (Akaahan et al., 2010). Apart from this, the water quality is also determination for the well-being of the fisheries resources which is of paramount importance. This research is aimed at complementing the previous work done on the quality of Nigerian inland waters of which River Benue is prominent for the sustenance of its flora and fauna composition as well as the benthic fauna in particular.

MATERIALS AND METHODS

Study area

The River Benue with its source from the Cameroonian mountains flows westwards into Nigeria. It is the second largest river in Nigeria and measures approximately 310,000 Ha. It is about 1.488 km in length with alluvia fertile flood plains on either banks (Welcomme, 1986). The Benue River flows through Makurdi and confluence with River Niger at Lokoja, the capital of Kogi state, Nigeria. Makurdi is the capital city of Benue state is located on Latitude 7°41' N and Longitude 8° 28' E. The size of the River Benue within Makurdi and major settlement runs through is approximately 671 m (Udo, 1981).

The rainfall seasons at Makurdi produces a river regime of peak flows from August to early October and low flow from December to April. The rainy season which last for seven months (April to October) has a mean annual rainfall ranging from 1200-2000 mm (Nyagba, 1995). High temperature values averaging 28-33°C are recorded in Makurdi throughout the year, most notable from March to April. Harmattan winds are accompanied with cooling effects mostly during the nights of December and January (Nyagba, 1995). All the same, the periodic dust plumes associated with this time of the year may encourage surface water pollution (Nyagba, 1995). Five stations were selected along the river course at Makurdi, Benue State for this study as follows(Figure 1):Site I(N07°^{0} 43.663'E008° 35.427'): it is located behind Coca Cola PLC plant along Gboko road and it is approximate 1.5 km away from Site II. Site II (N07°43.615' E008° 35.300'): it is located directly behind Benue Brewery Plc along at Kilometer 5 along Gboko road. This site is impacted by the brewery effluents generated from the factory into the river.Site III (N07°43.649' E008° 35.302'): this site is located behind Mikap Nigeria Ltd, a rice processing factory along Gboko road. It is approximately 1 km away from Site II and 2.5 km away from Site I. This site receives effluents from the rice mill into the river. Site IV (N07°44.076' E008° 32.840'): this site is located behind Wurukum abattoir close the new bridge across the river.Abattoir waste is washed directly into this site. Farming and sand dredging also take place at this site on routine bases. Site V (N07°44.789'E008° 30.624'): This site is located behind Wadata market along the river water course at Makurdi. Wastes from the heap refuse dumpsite behind the market are leached directly into the river.

Water sample collection and analysis

Water samples for physico-chemical analysis were collected at five different points from each of the five sampling locations. Fortnightly, routine sampling was conducted between 8:00 am and 12:00 noon on each sampling day. The water samples for biochemical oxygen demand analysis were collected in dark bottles of 1,500 ml capacity at the depth of 20 cm, while 1,500 mL (1.5 L) containers were used for collection of water samples for otherphysico-chemical parameters. Usually sampling bottles and containers were rinsed three times with river water at each sampling site before sample collection. The water sampler was rinsed for about six times at each sampling site before the collection of the samples. Each sample container was treated according to the analysis to be carried out on it on the field before they were transported to the laboratory. Surface water temperature, TDS, conductivity, pH, and DO were determined *in situ* on the field, while copper, nitrate, chloride, bicarbonate, sulphate, phosphate, TSS, turbidity, colour, BOD and COD were examined in the laboratory using standard methods (APHA, 1999).

Benthic fauna sample collection and analysis

Three successful hauls of benthic samples were taken from each station using a van Veen grab ($0.1m^2$) from an anchored boat with an out-board engine of 25 HP during the 24 months study period. The two shovels of the grab were held open by a small bar. The grab was then lowered into the river bed at the sampling sites. When the grab reaches the bottom of the river, the bar was automatically released. The two shovels of the grab sampler were closed tightly with sand and mud captured in it. The content of the grab were emptied into a polythene bags, labeled properly and taken to the laboratory for sorting and analysis. In the laboratory, the samples were sieved in order to remove fine sediments and any other extraneous material. Each of the sediment sample collected was washed three times in the laboratory through three sets of

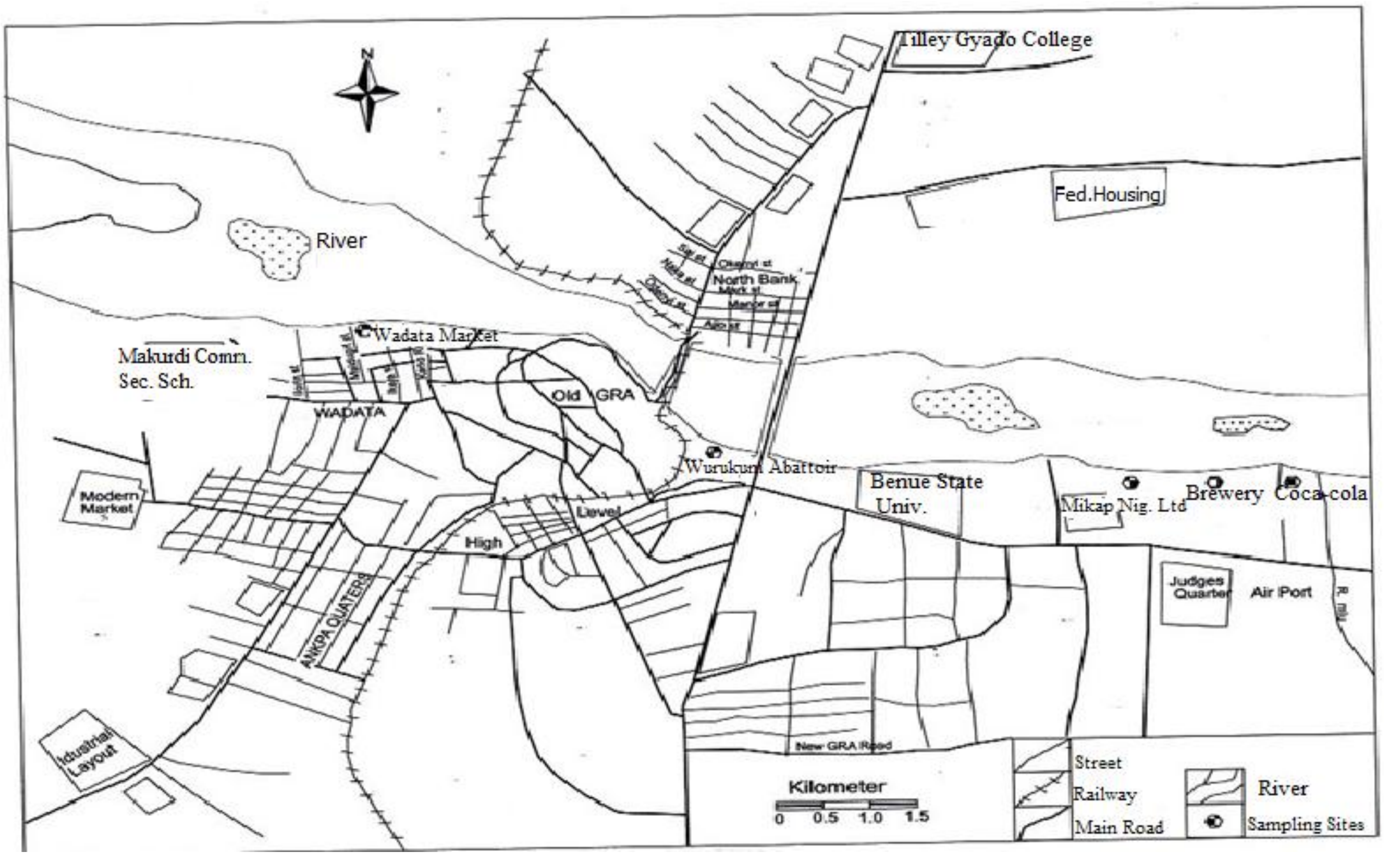

Figure 1. Map of Makurdi town showing sample site (Source: Ministry of Lands and Survey).

sieves, 1st 2 mm, then 1mm and finally 0.5mm mesh size sieves to collect the macro benthos in them (Esenowo and Ugwumba, 2010). The retained macro benthos were poured into bottles and labeled properly. The benthic fauna samples were then fixed with 4% formaldehyde. The washed and preserved sediments with benthic invertebrates were poured into a white enamel tray and sorted out. The sorting was made effective by adding moderate volume of water into container to improve visibility (George et al., 2009). Large benthic fauna were picked out using forceps while the smaller ones were pipetted out. The preserved animals were identified under light and stero dissecting microscope and counted. The identification was carried out using keys by Day (1967), Pennak (1978), Water and Rivers Commission, (2001) and Merrit and Cummins (1996).

Data analysis

Microsoft excel 2007 was used for graphical illustrations. Means and standard deviation were determined using SPSS version 20.ANOVA was determined to test the significant difference among meansof water quality parameters across stations and between seasons. Multiple linear correlation analysis was carried out on the water quality parameters and benthos to verify if there is any significant relationship between the water quality and benthic fauna composition of River Benue at the study sites.

RESULTS

The result presented in Table 1 is the mean and standard Deviation concentration of physico-chemical parameters in River Benue at Makurdi. The result showed that there was a significant difference in the mean concentration of the physico-chemical parameters across all the station (ANOVA -$P<0.05$) except for surface water temperature, bicarbonate ion, nitrate, sulphate, phosphate and copper that did not vary significantly across the stations (ANOVA-$P>0.05$). However across the station and season, there was significant difference between season and stations for COD and nitrate only.

Figure 2 shows the composition benthic fauna group along River Benue water course at Makurdi. The result indicates that the phylum Arthropoda recorded the highest population among other phyla across the locations during the period of this research. At Coca Cola, there was a slight difference between annelids, Mollusca and Platyhelminthes as was observed at the other four stations in Rivers Benue during the 24 months study period. The result presented in Table 2 indicates that correlation was significant between Arthropoda and turbidity, Platyhelminthes and turbidity, Arthropoda and bicarbonate, DO and Arthropoda; DO and Mollusca, DO and Platyhelminthes, copper and Arthropoda, copper and Mollusca, copper and platyhelminthes only at Coca-cola (Station I) location during the period of this study.

Data presented in Table 3 is the correlation between benthic fauna and physicochemical parameters was

Table 1. Mean concentration of physico-chemical parameters of River Benue at Makurdi.

Parameter	Unit	Sample station codes				
		I	II	III	IV	V
Conductivity	µS/cm	64.69±36.97	124.79±125.52	139.59±215.05	63.95±30.94	70.97±48.57
pH		6.95±0.86	6.90±0.74	6.49±0.87	6.46±0.84	6.33±0.59
TDS	mg/L	35.05±18.18	67.15±68.79	69.14±106.56	28.29±11.69	34.89±27.97
TSS	mg/L	41.00±25.42	87.56±57.39	87.09±91.17	52.17±51.58	44.25±49.75
Colour	TCU	244.54±128.53	393.01±175.73	344.28±157.89	208.07±113.63	192.60±143.79
Turbidity	NTU	46.89±26.66	91.38±56.54	83.47±65.83	49.12±47.22	44.53±44.28
Temperature	^{0}C	28.09±1.97	28.69±1.89	28.96±1.83	28.96±2.11	28.99±1.63
Bicarbonate	mg/L	122.52±57.20	185.61±126.59	182.69±178.63	121.98±59.13	126.66±69.85
Chloride	mg/L	145.19±109.98	173.07±71.27	169.72±82.86	117.44±59.46	138.56±83.32
Nitrate	mg/L	2.79±4.38	3.66±3.08	3.67±5.22	3.76±5.22	2.23±3.14
Sulphate	mg/L	10.95±15.84	16.40±18.98	17.24±15.21	12.55±11.84	10.41±9.84
Phosphate	mg/L	1.21±1.94	1.20±0.81	1.47±2.07	1.25±2.49	0.92±1.11
Copper	mg/L	0.16±0.27	0.31±0.34	0.24±0.28	0.12±0.27	0.11±0.09
DO	mg/L	4.47±2.18	3.28±2.30	3.09±1.71	4.37±2.41	4.42±2.57
BOD	mg/L	1.95±1.35	1.28±0.92	1.21±0.53	1.74±1.38	2.18±1.75
COD	mg/L	4.43±2.91	2.89±2.27	3.16±2.74	4.15±3.23	4.80±4.21

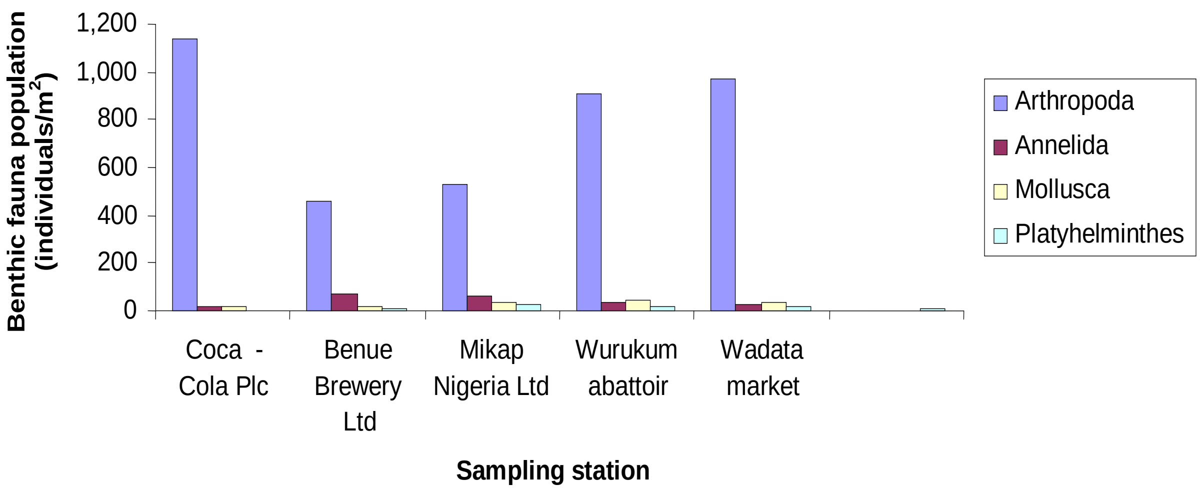

Figure 2. Benthic Fauna group population in River Benue at Makurdi.

deter-mined at Benue Brewery PLC (Station II) and significant with conductivity and Platyhelminthes, phosphate and Arthropoda and copper and Platyhelminthes only. The result in Table 4 showed that at Mikap Nigeria Ltd (Station III), correlation was significant between TDS and Annelida, TDS and Mollusca DO and Annelida, DO and Platyhelminthes only during the period of this study.

The result of correlation analysis between physic-chemical parameters and benthic fauna presented in Table 5 were significant between pH and Annelida, turbidity and Arthropoda, turbidity and Annelida, bicarbonate and Annelida and copper and Annelida at Wurukum abattoir (Station IV).

Table 6 shows the result of the correlation between physico-chemical parameters at Wadata market (StationV) location of River Benue at Makurdi. The result showed that correlation was significant between TSS and Mollusca, turbidity and Arthropoda, turbidity and Mollusca, bicarbonate and Annelida, sulphate and Mollusca, phosphate and Annelida, and copper and Platyhelminthes only, during the period of this research.

During this present investigation, turbidity was determined to correlate negatively with Arthropoda and Platyhelminthes benthic fauna group at Coca-colalocation. Similarly, turbidity was observed to correlate negatively with Arthropoda and positively with Annelida

Table 2. Correlation between environmental variables and Benthic fauna Group at Station I.

Parameter	Arthropoda		Annelida		Mollusca		Platyhelminthes		Sample
	P≤0.01	P≤0.05	P≤0.01	P≤0.05	P≤0.01	P≤0.05	P≤0.01	P≤0.05	size(N)
Conductivity	−0.18	0.39	−0.33	0.11	−0.26	0.21	0.02	0.92	24
pH	0.24	0.26	0.05	0.83	−0.07	0.76	0.16	0.45	24
TDS	−0.07	0.76	−0.28	0.21	−0.19	0.35	0.03	0.87	24
TSS	−0.08	0.71	0.17	0.43	0.05	0.83	0.11	0.59	24
Colour	−0.25	0.24	0.05	0.80	−0.14	0.50	0.19	0.38	24
Turbidity	−0.43**	0.04	0.01	0.96	−0.16	0.44	−0.43**	0.03	24
Temperature	−0.04	0.85	−0.34	0.10	−0.14	0.52	−0.14	0.52	24
Bicarbonate	0.46**	0.02	−0.09	0.66	0.12	0.56	0.37	0.07	24
Chloride	0.15	0.48	0.18	0.38	0.05	0.82	−0.17	0.41	24
DO	−0.57**	0.004	−0.19	0.37	−0.004**	0.98	−0.56**	0.005	24
BOD	−0.39	0.06	−0.21	0.33	0.007	0.75	−0.35	0.09	24
COD	−0.41	0.05	−0.15	0.48	−0.15	0.49	−0.38	0.07	24
Nitrate	−0.27	0.19	0.22	0.31	−0.16	0.45	−0.21	0.33	24
Sulphate	−0.21	0.32	−0.01	0.96	−0.06	0.79	−0.36	0.08	24
Phosphate	0.26	0.22	0.29	0.17	0.16	0.44	−0.05	0.83	24
Copper	0.02	0.47*	0.19	0.36	0.54**	0.007	0.03	0.44*	24

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

Table 3. Correlation between environmental variables and Benthic fauna Group at Station II.

Parameter	Arthropoda		Annelida		Mollusca		Platyhelminthes		Sample
	P≤0.01	P≤0.05	P≤0.01	P≤0.05	P≤0.01	P≤0.05	P≤0.01	P≤0.05	size(N)
Conductivity	−0.36	0.08	0.21	0.24	0.67	0.04	0.61**	0.001	24
pH	−0.13	0.54	0.25	0.23	0.03	0.88	0.23	0.28	24
TDS	0.29	0.17	−0.27	0.20	0.27	0.21	0.59**	0.003	24
TSS	−0.13	0.53	−0.03	0.91	0.06	0.76	0.04	0.42*	24
Colour	0.22	0.29	−0.05	0.81	0.24	0.26	0.05	0.41*	24
Turbidity	0.00	0.99	−0.21	0.31	−0.02	0.92	0.33	0.11	24
Temperature	0.38	0.07	0.06	0.78	0.08	0.72	0.37	0.71	24
Bicarbonate	0.36	0.09	−0.14	0.51	0.15	0.47	0.13	0.55	24
Chloride	0.05	0.83	0.28	0.19	0.11	0.60	0.05	0.83	24
DO	−0.32	0.12	0.08	0.71	−0.15	0.48	−0.23	0.29	24
BOD	−0.27	0.21	0.08	0.72	0.02	0.92	−0.12	0.58	24
COD	−0.22	−0.11	0.11	0.62	0.04	0.84	−0.09	0.66	24
Nitrate	−0.16	0.44	−0.18	0.40	0.03	0.89	−0.14	0.50	24
Sulphate	−0.15	0.46	0.13	0.53	−0.04	0.85	0.43	0.87	24
Phosphate	0.04	0.43*	0.39	0.18	0.99	0.001	0.87	0.03	24
Copper	0.59	0.12	0.82	0.05	0.22	0.30	0.04	0.43*	24

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

at Wurukum abattoir. At Wadata market location, turbidity was determined to correlate positively with Arthropoda and Mollusca during the 24 months study period. The negative significant correlation of benthic fauna group observed at Coca-cola and Wurukum abattoir might be due to the unidentified interactions of certain factors operating at these areas.The locations where no significant correlations were observed may be attributed to the fact that at these locations, the environmental factors were interacting with the benthic community. The finding of this work agrees with the work of Ishaq and Khan (2013) that reported a negative significant relationship between turbidity and benthic fauna groups in River Yamun. Significant positive correlations were

Table 4. Correlation between environmental variables and Benthic fauna Group at Station III.

Parameter	Arthropoda		Annelida		Mollusca		Platyhelminthes		Sample size(N)
	P≤0.01	P≤0.05	P≤0.01	P≤0.05	P≤0.01	P≤0.05	P≤0.01	P≤0.05	
Conductivity	−0.24	0.25	0.08	0.70	−0.13	0.54	0.11	0.62	24
pH	−0.16	0.46	0.09	0.71	0.19	0.36	0.08	0.70	24
TDS	−0.12	0.57	0.77**	0.56	0.80**	0.84	0.40	0.05	24
TSS	0.18	0.40	0.12	0.52	0.22	0.30	0.09	0.67	24
Colour	0.09	0.68	0.06	0.79	0.29	0.17	0.11	0.60	24
Turbidity	−0.11	0.61	−0.26	0.21	0.05	0.81	0.11	0.59	24
Temperature	−0.23	0.28	0.07	0.74	−0.21	0.31	0.12	0.57	24
Bicarbonate	0.13	0.54	0.39	0.05	−0.01	0.96	0.32	0.13	24
Chloride	0.36	0.08	0.21	0.22	0.31	0.14	0.07	0.76	24
DO	−0.31	0.13	0.02	−0.48*	−0.09	0.65	0.13	0.43*	24
BOD	−0.04	0.82	−0.32	0.12	0.05	0.81	−0.21	0.32	24
COD	−0.01	0.95	−0.17	0.42	0.03	0.88	−0.13	0.53	24
Nitrate	−0.05	0.81	−0.08	0.69	0.21	0.33	−0.05	0.81	24
Sulphate	−0.15	0.48	−0.27	0.19	−0.11	0.62	−0.18	0.40	24
Phosphate	0.08	0.71	−0.10	0.63	0.03	0.88	0.10	0.64	24
Copper	0.22	0.31	0.30	0.15	0.27	0.19	0.30	0.15	24

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

Table 5. Correlation between environmental variables and Benthic fauna Group at Station IV.

Parameter	Arthropoda		Annelida		Mollusca		Platyhelminthes		Sample Size(N)
	P≤0.01	P≤0.05	P≤0.01	P≤0.05	P≤0.01	P≤0.05	P≤0.01	P≤0.05	
Conductivity	0.19	0.36	0.33	0.11	0.16	0.44	0.11	0.60	24
pH	0.12	0.57	0.05	0.41*	0.21	0.33	0.21	0.33	24
TDS	0.11	0.61	0.19	0.37	0.08	0.69	−0.26	0.22	24
TSS	−0.26	0.21	0.30	0.15	−0.06	0.77	0.30	0.15	24
Colour	−0.12	0.57	−0.27	−0.19	−0.02	0.93	0.05	0.80	24
Turbidity	0.04	−0.43*	0.04	0.41*	0.18	0.41	0.18	0.41	24
Temperature	0.02	0.91	−0.05	0.80	0.09	0.69	−0.20	0.35	24
Bicarbonate	0.05	0.83	0.02	0.47*	0.04	0.87	0.07	0.74	24
Chloride	0.24	0.26	0.29	0.16	0.17	0.42	0.09	0.76	24
DO	0.03	0.89	0.20	0.34	0.36	0.08	0.06	0.79	24
BOD	−0.05	−0.82	−0.03	0.89	−0.12	0.55	0.05	0.82	24
COD	0.08	0.69	0.07	0.75	0.08	0.72	0.05	0.80	24
Nitrate	−0.32	0.13	0.22	0.29	0.13	0.55	−0.04	0.84	24
Sulphate	−0.17	0.42	0.33	0.12	−0.11	0.58	−0.20	0.30	24
Phosphate	0.11	0.62	0.35	0.09	0.31	0.13	0.06	0.78	24
Copper	0.34	0.10	0.13	0.50*	0.24	0.26	0.03	0.88	24

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

noticed between bicarbonate and Arthropoda benthic fauna and Annelida at Coca-cola and Wurukum abattoir, respectively, during the present study. This result disagrees with the result of an earlier study that reported a negative significant correlation between bicarbonate and Annelida and Mollusca (Sharma and Chowdhary, 2011). However, this finding agrees with the result of a study in River Tawi India that reported positive significant correlations between bicarbonate and Arthropoda and Annelida (Mohan et al., 2013). Correlation coefficient for DO was found to be negative with Arthropoda, Mollusca and Platyhelminthes at Coca-cola during the present study. A similar result was obtained at Mikap Nigeria Ltd location where DO correlated negatively with Annelida and positively with Platyhelminthes.However significant correlation in DO was not observed in the surface

Table 6. Correlation between environmental variables and Benthic fauna Group at Station V.

Parameter	Arthropoda		Annelida		Mollusca		Platyhelminthes		Sample Size(N)
	P≤0.01	P≤0.05	P≤0.01	P≤0.05	P≤0.01	P≤0.05	P≤0.01	P≤0.05	
Conductivity	−0.19	0.36	−0.03	0.88	0.12	0.56	0.02	0.93	24
pH	−0.03	0.88	0.03	0.89	0.20	0.35	0.21	0.33	24
TDS	−0.19	0.38	−0.18	0.41	0.06	0.77	0.19	0.37	24
TSS	−0.25	0.24	−0.37	0.08	0.04	0.43*	−0.04	0.85	24
Colour	−0.08	0.72	−0.32	0.13	−0.30	0.15	0.03	0.87	24
Turbidity	0.02	0.46*	−0.26	0.21	0.56**	0.05	0.12	0.58	24
Temperature	−0.05	0.80	−0.06	0.79	−0.07	0.76	0.19	0.38	24
Bicarbonate	−0.11	0.61	0.04	0.42*	−0.14	0.51	0.18	0.41	24
Chloride	0.07	0.76	0.06	0.79	0.40	0.05	−0.01	0.95	24
DO	−0.22	0.29	−0.05	0.79	−0.14	0.53	−0.03	0.89	24
BOD	0.02	0.91	0.05	0.81	0.04	0.86	−0.007	−0.97	24
COD	−0.01	0.95	0.04	0.36	0.09	0.68	−0.05	0.94	24
Nitrate	−0.28	0.17	0.12	0.56	0.36	0.08	−0.05	0.83	24
Sulphate	−0.08	0.69	0.07	0.75	0.03	−0.44*	−0.11	0.60	24
Phosphate	0.14	0.52	0.01	0.50*	0.23	0.25	−0.27	0.21	24
Copper	−0.13	0.53	0.01	0.96	0.97	0.007	0.01	0.49*	24

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

waters at Benue brewery, Wurukum abattoir and Wadata market locations. This may be due factors contributing to the correlation of DO and benthic fauna. The result of this study disagrees with the result of an earlier study in Himalayan River that did not show any significant correlation between DO and Annelida, Arthropoda, and Mollusca (Sharma and Chowdhary, 2011). All the same, this result agrees with the findings ofan earlier study that reported positive and negative significant correlations between DO and benthic fauna (Mohan et al., 2013). Similarly, Chowdhary et al. (2013) reported a significant correlation between DO and Arthropoda, Mollusca and Annelida across the study stations in River Tawi within the vicinity of Jammu city India. This result is in agreement with the findings of this present investigation. A significant positive correlation was noticed between copper and Arthropoda, Mollusca and Platyhelminthes at Coca-cola locations during this study. A similar result was observed at Wurukum abattoir location where copper positively correlated with Annelida. All the same, no significant correlation was observed at Benue Brewery; Mikap Nigeria Ltd and Wadata market. This would be that other factors and not copper is impacting on the benthic fauna at these locations. Across the locations except at Benue Brewery, there was a positive correlation between conductivity and Platyhelminthes benthic fauna in River Benue. This result may be due other factors responsible for the benthic fauna group population, as a result of lack of correlations between benthic fauna and conductivity at these locations. This result disagrees with the result of an earlier study that showed a positive significant correlation between conductivity and Arthropoda (Ishaq and Khan, 2013).A strong positive significant correlation was observed between total dissolved solids (TDS) and Platyhelminthes at Benue Brewery. Similarly, strong positive significant correlation was noticed between TDS and Annelida and Mollusca at Mikap Nigeria Ltd. No significant correlation was observed between TDS and benthic fauna at the other three locations. The lack of significant correlations between TDS and benthic fauna at these locations may be attributed to other unidentified factors interacting with benthic fauna at these locations and not TDS. This finding disagrees with the result of a study that showed a negative significant correlation between TDS and Arthropoda (Ishaq and Khan, 2013).A positive significant correlation was observed between total suspended solids (TSS) and Platyhelminthes and between TSS and Mollusca respectively at Benue brewery and Wadata market locations of River Benue during this study. All the other locations did not record a significant relationship with TSS and benthic fauna group. Ishaq and Khan (2013) reported a significant negative correlation between TSS and Arthropoda in their study that disagrees with the result of this research. Bilotta and Brazier (2008) reported that an elevated TSS in surface waters is associated with benthic drift. This is evident in the positive correlation between TSS and benthic fauna during the course of this study. The colour of the waters was observed to positively correlate significantly with Platyhelminthes at Benue brewery location only, throughout the study period. There was no significant correlation at all the other locations. The poor colour of effluents discharged into the river Benue at this location may be responsible for the significant relationship.

Phosphate during this present investigation was observed to positively correlate significantly with Arthropoda at Benue Brewery and Annelida at Wadata market. This result disagrees with the finding of studies that reported negative significant correlation between phosphate and benthic fauna in Rivers (Ishaq and Khan, 2013; Mohanet al., 2013). Correlation coefficient for pH was observed to be positively significant with Annelida at Wurukum abattoir only throughout the 24 months period of this research. However, such a clear tendency in correlations of pH and benthic locations at River Benue was not noticed in the other locations. The significant correlation showed that the pH of the water was interacting with Annelida at Wadata market. This result disagrees with the finding of a study that reported pH not to be significantly correlating with any benthic group in River Tawi India (Sharma and Chowdhary, 2013). All the same, the findings of this research agree with the result of an earlier study that reported a significant positive correlation between pH and Annelida in a River system in India (Mohan et al., 2013). Throughout the period of this research, sulphate was observed to be negatively correlated with Mollusca at Wadata market. This assertion agrees with the report of a study that showed a negative significant correlation between sulphate and Mollusca (Mohan et al., 2013).

However, during this present study, surface water temperature, chloride, biochemical oxygen demand (BOD), chemical oxygen demand (COD) and nitrate did not correlate significantly with any of the benthic fauna group throughout the study period. All the same, other studies reported significant correlation between surface water temperature, nitrate, chloride, BOD, COD and benthic fauna group (Ishaq and Khan, 2013; Mohan et al., 2013). The result of this study agrees with the findings of an earlier study that reported no significant correlation between chloride and benthic fauna group (Annelida, Arthropoda and Mollusca) in Himalayan River India (Sharma and Chowdhary, 2011). The lack of significant correlation between surface water temperature, chloride, nitrate, BOD, COD and benthic fauna during this study may be due to other environmental variables interacting with the benthic fauna groups.

Conclusion

Correlation studies of benthic fauna diversity with environmental variables revealed that relationship between benthic fauna and physico-chemical parameters are highly complex and mostly controlled by unidentified interaction of different factors.All the groups (Arthropoda, Annelida, Mollusca and Platyhelminths) of benthic fauna were noticed to correlate positively with certain Environmental parameters, while other benthic fauna correlated negatively with environmental parameters. However no correlation was observed between the environmental parameters and Annelida at Stations I and II throughout the period. Similarly, Mollusca did not correlate with any environmental parameter at Stations II and IV during the study period. More so, Platyhelmiths did not show any correlation with any of the environmental parameters during the time of the study. Those that were negatively correlated may be utilized as indicator species or groups for identifying the ecological status of the River Benue. However, there was no significant correlation between benthic fauna and surface water temperature, chloride, BOD, COD and nitrate throughout the period of this study. The result of this study showed that, River Benue at Makurdi is polluted along its course. This poses a health risk to humans who rely on the river as the primary source of domestic water supply without adequate treatment and the aquatic biota.

Conflict of Interests

The author(s) have not declared any conflict of interests.

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