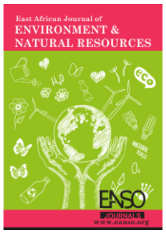

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Original Article

THE STUDY OF PHYTOPLANKTON AND LIMNOLOGICAL VARIABLES AS WATER QUALITY INDICATORS OF RIVER RIMA, SOKOTO, NIGERIA

Muhammad Ibrahim Magami[1], *Musa Tanko Muhammad*[2],
Adamu Abdullahi[3], *Muhammad Sokoto Rabiatu*[4] *& Ibrahim Ibafidon Madinat*[5]

[1]Usmanu Danfodiyo University, P.M.B 2346, Sokoto State, Nigeria, ibrahim.magami@udusok.edu.ng.
[2]Sokoto State University, P.M.B 2134, Sokoto State, Nigeria, muhammad.musatanko@ssu.edu.ng.
[3]Sokoto State University, P.M.B 2134, Sokoto State, Nigeria, adamgad83@gmail.com.
[4]Sokoto State University, P.M.B 2134, Sokoto State, Nigeria, rabiatumuhammad1@gmail.com.
[5]Federal College of Education (Technical) Gusau, Zamfara State, Nigeria, madinat01ibrahim@gmail.com.

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ABSTRACT

Water quality is neither a static condition of a system nor can it be defined by the measurement of only one parameter rather, it is variable in both time and space hence it requires routine monitoring to detect the fertile pattern and changes over time. Water quality in the present study was measured using various methods. The biological analysis (i.e., phytoplankton communities) was carried out with the support of the interpretation of the results obtained from the physicochemical analysis of the water. The climatic factors such as the temperature fluctuated from 18.500c to 23.500c to 20.500c then 23.500c respectively from January to April. Phytoplankton composition, Chlorophyceae was the highest with 8 species and 6870mg/l in total, followed by Bacillariophyceae with 4 species and 2310mg/l in number then Cyanophyceae with 3 species and 1920mg/l in number. In general, the overall average phytoplankton abundance in the study area was 11,100cells/l. On the other hand, the phytoplankton abundance was low in the first two months as a consequence of relatively low temperatures, even though nutrient levels, especially nitrate levels were high during this period. Phytoplankton reflects water quality through changes in its community structure, patterns of distribution and the proportion of sensitive species. Water quality was evaluated using water quality index, which was 55.05 for January, 46.43 for February, 54.58 for March, and 48.16 for April. The average for limnological variables was taken and used to evaluate the water quality, and the result was 50.45. There were no high nutrient concentrations measured during the study period nor was there any dominance of harmful phytoplankton species.

INTRODUCTION

Water is vital to the existence of all living organisms, but this valued resource is increasingly being threatened by the growth of human population and demand for more water of high quality for domestic purposes and economic activities (Carr & Neary, 2006). Water abstraction for domestic use, agricultural production, mining, industrial production, power generation, and forestry practices can lead to deterioration in water quality and quantity that impact not only the aquatic ecosystem but also availability of safe water for human consumption (Carr & Neary, 2006).

In aquatic environments, biotic and abiotic environmental factors have important effects on phytoplankton succession and abundance. Therefore, evaluation of water quality using physicochemical properties can give clear picture reflecting on the composite influence of different water parameters. Water quality index (WQI) is also useful for classification of water and can give a clear indication of water health status. Finally, the species composition of the phytoplankton community is another efficient bio-indicator of water quality (Shashi *et al.*, 2008).

The quality of any surface or groundwater is a function of either or both natural influences and human activities. Without human influences, water quality will be determined by weathering bedrock minerals, the atmospheric processes of evapotranspiration and deposition of dust and salt by the wind. Natural leaching of organic matter and nutrients from the soil, hydrological factors that lead to runoff and through biological processes within the aquatic environment that affect the physical and chemical composition of water considerably affect water quality (Carr & Neary, 2006).

Water quality is neither a static condition of a system nor can it be defined by measuring only one parameter (WHO, 2003). Rather, it is variable in both time and space hence requires routine monitoring to detect a fertile pattern and changes over time. Some variables provide a general indication of water pollution, whereas others enable the direct tracking of pollution structures (WHO, 2003). Plankton can be either small plant or animal form in freshwater bodies that cannot swim against the current. There are of two forms, namely phytoplankton and zooplankton (Halegraff, 1993).

According to Halegraff (1993), the term phytoplankton encompasses the entire photoautotrophic microorganism in aquatic food webs; phytoplankton serves as a base of aquatic food webs providing an essential ecological function for all aquatic life. However, unlike terrestrial communities where most autotrophs are a plant, phytoplankton as a diverse group incorporating protistan eukaryotes and both *eubacterial* and prokaryotes (Halegraff, 1993). The most important groups of phytoplankton in terms of number include diatoms, cyanobacteria, dinoflagellates, although many groups of algae are represented (Halegraff, 1993). Evaluation of water quality using water quality indices of River Rima is not well documented; therefore, this paper aimed to evaluate the water quality of River Rima since it serves as the main source of income to the inhabitant of that area.

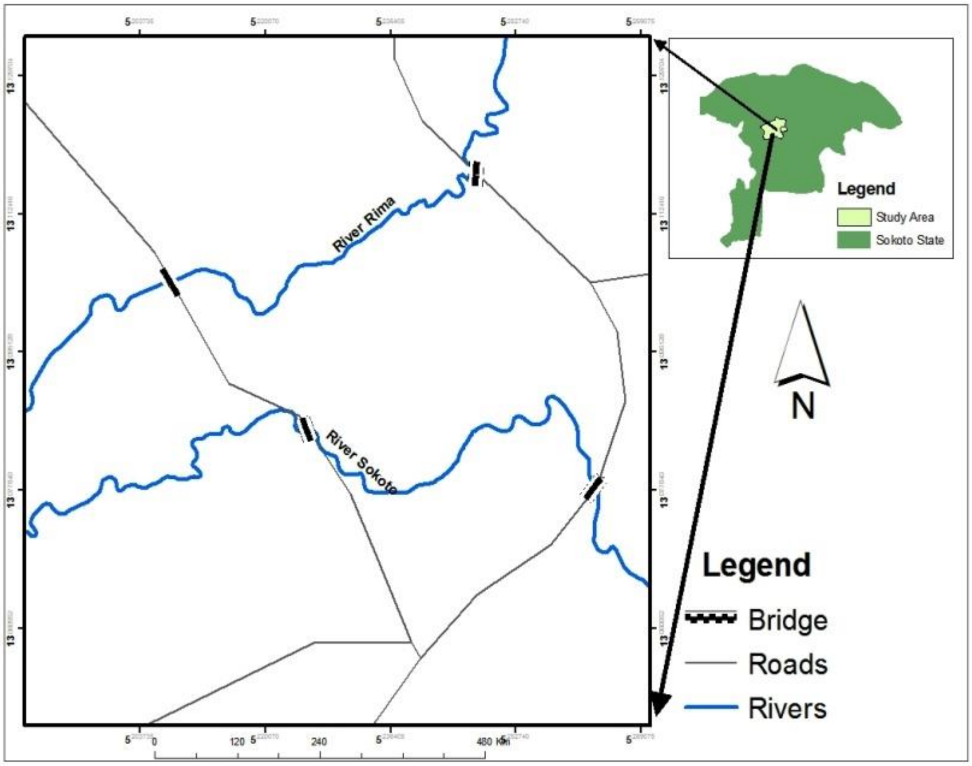
METHODOLOGY

The Study Area

River Rima is located at altitude 803, within Latitude 13° 6.241N, and Longitude 5° 12.357E. The River originates from Goulbi de Maradi River in the Niger Republic, it runs southwest and joins River Sokoto in Sokoto and continues south to join Niger River (Akani and Luiselli, 2002).

The River is surrounded by *fadama* (wetland). The direction of flow of the river is east to west with vegetation consisting of grasses and trees such as *Azadirachta indica* and *Acacia* species which are dominant. Farming, irrigation, and fishing are routine activities around the river (Akani and Luiselli, 2002).

Figure 1: Map Showing River Rima in Sokoto State, Nigeria



Sample Collection

Water samples were collected in plastic bottles from January to April. Two samples were collected from each month for phytoplankton and physiochemical analysis. The phytoplankton samples were immediately fixed with 4% formaldehyde for laboratory analysis. Temperature, transparency was determined *in situ* while, the following parameters were determined in the laboratory; pH, dissolved oxygen, dissolved inorganic nitrogen, and phosphate all were according to standard methods described by APHA (1989).

Phytoplankton Count and Identification

Logo's solution was added into the sample collected and left for 24 hours for sedimentation. Then decanted by using 50mm in centrifuge machine then inserted into the counting chamber and viewed under the microscope to determine the number and species of phytoplankton been trapped, each species identified was counted and recorded (Lund & Cander-Lund, 1995).

Determination of Physicochemical Variables

This temperature parameter was determined using sensitive mercury thermometer; depth was measured using a mushroom string of 2g by lowering the string into the water until it reaches the bottom of the river. While transparency was measured using Secchi disc of 25cm in diameter by disappearance and reappearance method using the expression Transparency = $\frac{D_1+D_2}{2}$. pH was measured using a pH meter. Salinity was measured using titration method by with following equation Mg/l:

$$\frac{100 \times concentration of silvernitrate \times titrevalue}{\text{volume of sample (50ml)}}$$

Dissolved oxygen (DO) was measured using titration method, Nitrate (NO_3) was measured using Kjeldahl distillation method, phosphate (PO_4) was determined using spectrometer at 660 nn/wavelength using the following equation to calculate PO_4 in Mg/l:

$$\frac{Absorbance \times conversion factor(0.61) \times dilution factor(25\ which is constant)}{\text{atomic weight of phosphate (30.95)}}$$

Water Quality Determination using the Water Quality Index

The formula for calculating Water Quality Index:

$WQI = Eq_1 w_1$

where q = water quality rating = $100 \times \frac{V_a - V_i}{V_s - V_i}$,

V_a = actual value in sample,

V_i = Ideal value (0 for all parameters except pH and DO, which is 7.0 and 14.6 respectively)

V_s = Standard value

If q_1 = O (absence of pollutant)

> 100 = pollutants above standard

w_1 = weight assigned to parameters$w = \frac{K}{Sn}$

$$K = \frac{1}{\frac{1}{V_1} + \frac{1}{V_3} + \frac{1}{V_3}}$$

Sn= standard value

V=value in each sample for each parameter (Swamee and Tyagi, 2007)

Analysis of variance (ANOVA) was used to compare the monthly means whether they are statistically significant, the means are presented

RESULTS

Physicochemical Parameters of River Rima

The monthly means of limnological variables of River Rima from January to April are shown in *Table 1*. Water temperature did not show much fluctuation (18.5 to 23.5◦C). The lowest values were recorded in January (18.5) and the highest in February and April (23.5◦C). Salinities were uniform throughout the period of study and exhibited only a narrow variation with a maximum difference of 1.05mg/l. The pH varied over a very narrow range from 7.25-7.90mg/l on the river during the sampling period. The dissolved oxygen concentration ranges from 4.15 mg/ l to 6.05 mg/ l. As far as nutrients are concerned, values were generally significantly higher on station A. Nitrate, ammonium, and phosphate ranged from 1.10-1.30mg/l, 0.50-0.70mg/l, 0.14-0.26mg/l respectively (Table 1).

Table 1: Physiochemical Parameters from January to April of River Rima and River Sokoto

Variables	**January**	**February**	**March**	**April**
Temp.	18.5±0.50	23.5±0.50	20.5±0.50	23.5±0.50
Transparency	0.27±0.00	0.23±0.35	0.27±0.00	0.32±0.05
Depth	2.65±0.15	2.65±0.15	2.65±0.15	2.65±0.15
DO	6.05±0.15	4.15±0.05	5.15±0.25	5.45±0.15
Salinity	1.05±0.05	0.65±0.15	0.50±0.00	0.65±0.05
pH	7.25±0.05	7.90±0.10	7.55±0.25	7.25±0.15
NH_4	0.60±0.00	0.50±0.10	0.70±0.10	0.60±0.10
PO_4	0.26±0.00	0.18±0.01	0.14±0.00	0.14±0.01
NO_3	1.10±0.10	1.00±0.00	1.30±0.10	1.20±0.10

Water Quality Index from January to April of River Rima

The result of water quality index for January to April was calculated using the mean of each variable, Standard value for each variable (25^{0}c for temperature, 6.5-8.5 for pH, 5.0mg/l for dissolved oxygen, 50mg/l for nitrate, 0.5 for ammonium and 0.5 for phosphate according to standards for surface water directives).Weight age was calculated for each variable (0.006, 0.02, 0.03, 0.003, 0.3 and 0.3 for temperature, pH, dissolved oxygen, nitrate, ammonium and phosphate respectively. The quality rating which was also calculated for each variable, as shown in *Table 2*.

Table 2: Average Water Quality Index from January to April 2015 of River Rima

Variable	Observed value	Standard value	Weight	Quality Rating	WQI
Temp.	21.5	25	0.006	86	0.52
pH	7.3	6.5 – 8.5	0.02	20	0.4
DO	5.9	5.0	0.03	90.63	2.72
NO_3	12	50	0.003	2.4	0.007
NH_4	0.6	0.5	0.3	120	36
PO_4	0.18	0.5	0.3	36	10.8
Total			**0.659**		**50.45**

The results for water quality were 55.05 for January, 46.43 for February, 54.58 for March and 48.16 for April (Table 3). Overall water quality was calculated using means of all the variables from January to April, the weight age and quality rating was 50.45 (*Table 2*).

Table 3: Water Quality Using Water Quality Index for January to April 2015 of River Rima

Variable	January	February	March	April
Temp	0.44	0.56	0.49	0.56
pH	0.33	1.2	0.73	0.33
DO	2.67	3.26	2.95	2.86
NO_3	0.007	0.006	0.008	0.007
NH_4	36	30	42	36
PO_4	15.6	11.4	8.4	8.4
TWQI	**55.05**	**46.43**	**54.58**	**48.16**

Phytoplankton Community Structure and Composition

From the analysed data, visible change in phytoplankton community with regard to numerical abundance was evident in the river. A total of 11,100cells/l of phytoplankton was found through the analysis of the samples collected from the two stations from January to April. Chlorophyceae made up the highest while Cyanophyceae were the lowest. The most diverse species was Chlorophyceae with eight species, followed by Bacillariophyceae with four species and Cyanophyceae with three species (*Table 4& 5*). A high diversity of species was recorded in station A from March to April. Chlorophyceae was highest (61.89%) with following species *Staurastrum rotula*, *Scenedesmus quadricauda*, *Hormidium guttatum*, *Volvox* sp., *Selenastrum* sp., *Chlorella ellipsoidea*, *Akistrodesmus* sp., *Closterium kuetzingi*. Bacillariophyceae (20.81%) were second most abundant with following species *Diatomella*, *Navicula mutica*, *Nitzschia*, *Synedra ulnariaceae*.They were followed by Cyanophyceae (17.3%) with the following species *Aphanocapsa elachista*, *Lyngbya limnetica*, *Chlorogloea microcystoides* (*Table 6*).The biological index was used to analyse the phytoplankton community, number, and composition.

Table 4: Taxonomic composition of phytoplankton groups of River Rima in January and February

Groups	Members	Cell/L		Percentage		Mean	
		Jan	***Feb***	***Jan***	***Feb***	***Jan***	***Feb***
Chlorophyceae	*Staurastrum rotula*	270	130	48.2	39.4	27	13
	Scenedesmus quadricauda	40	20	7.1	6.1	4	2
	Hormidium guttatum	40	30	7.1	9.1	4	3
	Volvox sp.	-	20	-	6.1	-	2
	Selenastrum sp.	10	-	1.8	-	1	-
	Chlorella ellipsoidea	160	50	28.6	15.2	1.60	5
Bacillariophyceae	*Diatomella*	20	30	3.6	9.1	2	3
	Synedra ulnariaceae	-	40	-	12.1	-	4
	Nitzschia	10	10	1.8	1.8	1	1
Cyanophyceae	*Aphanocapsa elachista*	10	10	1.8	3	1	1
Total		**560**	**330**	**100**	**100**		

Table 5: Taxonomic composition of phytoplankton groups of River Rima in March and April

Groups	Members	Cell/L		Percentage		Mean	
		Mar	***Apr***	***Mar***	***Apr***	***Mar***	***Apr***
Chlorophyceae	*Chlorella ellipsoidea*	2,000	2600	51.3	41	166.67	260
	Selenastrum sp.	100	100	2.6	1.59	8.3	10
	Scenedesmus quadricauda	100	100	2.6	1.59	8.3	10
	Staurastrum rotula	100	100	2.6	1.59	8.3	10
	Ankistrodesmus sp.	200	400	5.1	6.35	16.67	40
	Volvox sp.	100	100	2.6	1.59	8.3	10
	Selenastrum .sp		100		1.59		10
Bacillariophyceae	*Diatomella*	300	1600	7.7	25.4	25	160
	Navicula mutica	100	100	2.6	1.59	8.3	10

	Nitzschia	100		2.6		8.3	
Cyanophyceae	*Aphanocapsa elachista*	400	1100	10.3	17.46	33.33	110
	Lyngbya limnetica	200		5.1		16.67	
	Chlorogloea microcystoides	200		5.1		16.67	
Total		**3900**	**6300**	**100**	**100**		

Table 6: Specie Diversity Index of River Rima from January to April

Class	Species Diversity	Total Number	Percentage (%)
Chlorophyceae	8	6870	61.89
Bacillariophyceae	4	2310	20.81
Cyanophyceae	3	1920	17.3
Total		**11,100**	**100**

DISCUSSION

Water quality in the present study was measured using various physical, chemical, and biological methods. The biological analysis (phytoplankton communities) was carried out in support of the interpretation of the results obtained from the physicochemical analysis of the water.

The physical factors such as the temperature fluctuated from 18.50^0c to 23.50^0c to 20.50^0cthen 23.50^0c respectively from January to April. Temperature values recorded during the study period was similar with the values found by Bagalwa *et al*. (2014) in Ishasha River, East Africa, which further revealed that, cloud cover and wind speed were by far to influence climatic factors of the temperature in the region; this in turn also applies to river Rima. Transparency fluctuated from 0.27cm to 0.24cm, 0.27cm,and 0.32cm respectively from January to April. The higher dry season Secchi-disc transparency mean value compared to that of the rainy season could be due to the absence of floodwater, surface run-offs and settling effect of suspended materials that followed the cessation of rainfall; Kamdirim (1990) reported similar observations. Depth taken was 2.65meters, salinity fluctuated from 1.05mg/l to 0.65mg/l, 0.50mg/l and 0.65mg/irrespectively from January to April while pH also fluctuated from 7.25 to 7.90, 7.55 and 7.25 respectively from January to April. DO fluctuated from 6.05mg/l to 4.15mg/l, 5.15mg/l and 5.45 milligrams per litre respectively from January to April. DO showed high values (> 5 mgl-1) in the stations indicating that it was within the permissible limits for aquatic lives. These findings could be compared with high oxygen at the upstream sites in Ishasha River (Mbalassa et al. 2014); the river crosses along savannah grassland area, and receives a direct sunlight which is known to influence the increase of photosynthesis rate, photosynthesis rate combining with the water turbulence, could be among factors contributing to the higher oxygen content (Boyd,1998).

Nutrient concentrations at River Rima in terms of nitrate, ammonia, and phosphate concentrations varied in the ranges 1.0–1.4 mg/l, 0.4–0.8mg/l, 0.13–0.26 mg/irrespectively. Findings by Ibrahim *et al*. (2009) reported that high dry season means values of phosphate phosphorus (PO_4-P) in Kontagora reservoir, which could be due to the concentration of reduced water volume which differs from that of River Rima. Nitrate-nitrogen ($N0_3$-N) concentration during the rainy season could be due to surface run-offs as well as the decomposition of organic matter similar observations were made for Dokowa Mine Lake by Ufodike *et al*. (2001).

Water quality was evaluated using water quality index, which was 55.05 for January, 46.43 for February, 54.58 for March, and 48.16 for April. The average for limnological variables was taken and used to evaluate the water quality, and the result was 50.45.Classification of water quality index is done as excellent (index range >80-100), good (index range >60-80), moderate (index range >40-60), bad (index range >20-60) and very bad (index range >0-20) by Swamee and Tyagi, (2007).

For phytoplankton composition, Chlorophyceae was the highest with eight species and 6,870mg/l in total, followed by Bacillariophyceae with four species and 2,310mg/l in number then Cyanophyceae with three species and 1,920mg/l in number. In general, the overall average phytoplankton abundance in the study area was 11,100cells/l. On the other hand, the phytoplankton abundance was low in the first two months as a consequence of relatively low temperatures, even though nutrient levels, especially nitrate levels, were high during this period. However, the increase in phytoplankton abundance in March and April was also typically nutrient-limited in River Rima. Species diversity of 3 to 4 indicates unpolluted aquatic ecosystem while in polluted water species diversity is usually less than one (Wilhm, 1970). Presence of Chlorophyceae indicates high nutrient level, freshwater situation, and moderate water pollution, Bacillariophyceae indicates a moderate level of nutrients, Cyanophyceae indicates moderate organic pollution as shown in findings of Iyagbe lagoon by Onyema (2006) but also shows the presence of other species because of high rainfall distribution in the area.

Neither high nutrient concentrations nor was there any dominance of harmful phytoplankton species measured during the study period. Three species of phytoplankton (Chlorophyceae, Bacillariophyceae, and Cyanophyceae) were dominant, which indicates an unpolluted aquatic ecosystem. It can be concluded that the index based on WQI is currently more suitable than the phytoplankton species index for assessing the quality of the water.

RECOMMENDATIONS

There is a need to carry out further analysis of the river for a long period to obtain detail information about the river. A good management system is necessary to reduce the risk of water pollution, which may likely evolve due to farming and other human activities within and around the river.

REFERENCES

APHA (1989). *Standard Methods for the Examination of Water and Wastewater*, 17th edition. Washington, DC: American Publication Health Association (APHA).

Akani, G.C., and Luiselli, l. (2002). Amphibian faunal diversity and conservation status in theNiger Delta

Basin (Southern Nigeria): an update. Frog log, 2002(51): 9 – 11.

Bagalwa, M., Yalire, M., Balole, E., and Karume, K. (2014). A Preliminary Assessment of Physico-Chemical and Bacteriological Characteristics of Lake Edward and Majors Tributaries Rivers, Democratic Republic of Congo. *Scholars Academic Journal of Biosciences (SAJB*), 2(3): 236-245.

Boyd, C.E. (1998). *Water Quality for Pond Aquaculture*. Research and development Series No43. ICAAE. Auburn, Alabama: Auburn University.

GESAMP (1988). *Report of the Eighteenth Session, Paris 11 – 15 April 1988*. GESAMP Report and Studies No. 33. Paris, France: United Nations Education, Scientific and Cultural Organization.

Halegraff, G.M. (1993). A Review of Harmful Algal Blooms and their Apparent Global Increase. *Phycologia*, 32(2):79-99.

Ibrahim, B., Auta, J., & Balogun, J. (2009). An assessment of the physicochemical parameters of Kontagora reservoir, Niger state, Nigeria. *Bayero Journal of Pure and Applied Sciences*, *2*(1), 64-69.

Kamdirim, E.C. (1990). Periodicity and succession of phytoplankton in an upland and lowland impoundment in Plateau State Nigeria. *Unpublished PhD thesis*. University of Jos, Nigeria. Pp484

Lund, J.W.G., and Cander-Lund, H. (1995) Freshwater Algae. Their Microscopic World Explored, *Biopress Limited*., England, UK; pp 360.

Mbalassa, M., Bagalwa, J. J. M., Nshombo, M., & Kateyo, M. E. (2014). Assessment of physicochemical parameters in relation with fish ecology in Ishasha River and Lake Edward, Albertine Rift Valley, East Africa. *International Journal of Current Microbiology and Applied Sciences*, *3*(6), 230-244.

Onyema, I.C (2006). Phytoplankton Bio-indicators of Water Quality Situations in the Iyagbe Lagoon, South western Nigeria. Acta SATECH 4(2): 93-107.

Reynolds, C.S. (1997). Vegetation Processes in the Pelagic. A model for Ecosystem Theory. Excellence in ecology, Ecology Institute, Oldendorf/Luhe, Germany, 1-371

Shashi, S. T.R., Kiran, B.R., Puttaiah, E.T., Shivaraj, Y. and Mahadanvan, K.M. (2008). Phytoplankton an Index of Water Quality with Reference to Industrial Pollution. *Journal of Environment Biology*, 29(2): 233-236.

Swamee, D.K. and Tyagi, A. (2007). Improved method for aggregation of Water Quality Sub indices. *Journal of Environmental Engineering*, 133:220-225.

Ufodike, E.B.C., Kwanasie, A.S. and Chude, L.A. (2001). On-set of rain and its destabilising effect on aquatic physicochemical parameters. *Journal of Aquatic Sciences*, 16(2) 91-94.

Carr, G. M. & Neary, J. P. (2006). Water Quality for Ecosystem and Human Health Management. Ontario, CA: United Nations Environment Programme Global Environment Monitoring System (GEMS)/Water Programme. Retrieved from http://wedocs.unep.org/bitstream/handle/20.500.11822/12217/water_quality_human_health.pdf?sequence=1&isAllowed=y.

WHO. (2003). Emerging issues in water and infective diseases. Geneva, Switzerland: (World Health Organization. Retrieved from http://www.who.int/water_sanitation_health/emerging/emerging.pdf.

Wilhm, J.L. (1970). Range of Diversity Index in Benthic Macroinvertebrate Pollutions. *Journal of Water Pollution Control Federation*. 42:221-224.