Fundamental Journal of Applied Sciences
Vol. 1, Issue 1, 2016, Pages 1-18
This paper is available online at http://www.frdint.com/
Published online February 18, 2016

ANALYSES OF pH, DISSOLVED OXYGEN AND TURBIDITY OF AQUATIC ECOSYSTEMS AT BORI, GOKANA, OKIRIKA, TAI AND ELEME AREAS OF RIVERS STATE, NIGERIA

U. D. ENYIDI[1, 2,*] and P. I. AGI[1]

[1]Department of Animal Biology and Environmental Biology
University of Port Harcourt
Rivers State, Nigeria

[2]Department of Fisheries and Aquatic Resources Management
Michael Okpara University of Agriculture Umudike
Umuahia, Abia State, Nigeria
e-mail: enyidiuche@yahoo.com

Abstract

A survey on the status of pH, dissolved oxygen content, turbidity and bottom substrate of aquatic ecosystems in Bori, Gokana, Okirika, Tai and Eleme areas of Rivers State, Nigeria was made in this paper. A total of sixteen (16) streams, thirteen (13) lakes and ponds and nine (9) rivers, generating fifty three (53) loci sites were surveyed. Sampling started in the first week of January and ended at the end of March. The sampling period was chosen to forestall effects of runoffs from rains and erosions that could alter pristine environmental results. Some samples were analyzed immediately on the site and in the lab (pH and turbidity) while others (dissolved oxygen, bottom substrate) were fixed and analyzed in the laboratory. Generally the sampled sites had low pH, low dissolved

Keywords and phrases: acid water, toxicity, physic-chemical parameters, freshwater, pH.

[*]Corresponding author

Received March 16, 2015

oxygen and low turbidity. The average pH values per ecosystem were; streams, 5.29 ± 0.03, ranging from 4.7-6.4; rivers, 5.13 ± 0.08, ranging from 4.8-5.6; lakes and ponds, 5.80 ± 0.02, ranging from 4.9-7.65. Average dissolved oxygen values were; for streams, 3.86 ± 0.02, ranging from 1.34-6.63 mg/l; rivers, 3.99 ± 0.02, ranging from 2.0-6.7 mg/l; and ponds and lakes, 3.86 ± 0.02, ranging from 2.02-5.3 mg/l. Average turbidity values per ecosystem were as follows; streams, 5.69 ± 0.03, ranging from 1.5-18.9 NTU; rivers, 5.29 ± 0.02, ranging from 1.05-16 NTU; and lakes and ponds, 4.52 ± 0.03, ranging from 2.0-6.7 NTU. There were no aquatic macrophytes found during research period. Fish stock were scanty and only very few tilapia were found around Bori. The bottom substrate was either clay, sandy or mixed and no aquatic snails were found. The hyper acidic nature of the ecosystem coupled with low dissolved oxygen and turbidity seems to be responsible for absence of aquatic snails and macrophytes in the study area.

1. Introduction

Physico-chemical status of aquatic ecosystems to large extent determines the prevalence and biodiversity of aquatic assemblages like autotrophs, saprophytic microorganisms and facultative detritivorous fauna [1, 2, 3]. Acidification of natural water can be caused by natural means or anthropogenic means. Acidification can be as result of precipitation of acid rains, sulphuric dioxide and nitrogen oxides and combustion of fossil fuel. These gases get mixed up with water forming sulfuric acid and nitric acid precipitation. The falling of the acid precipitation as acid rain forms strong solution causes disruption in sensory system of aquatic organisms rendering them susceptible to dangers and eventually death [4]. Acidification has led to decline in population of communities and extinction of some fish species in Europe and North America [5]. Acidification influences community composition and trophic levels thereby affecting ecosystem stability [6, 7]. It has been noted that at pH 5.0 gastropods, leeches and mollusks were no longer observed in their aquatic habitats [8]. Similarly low fish stock has been noted in acidified water pH 5.5, due to poor larval growth and recruitment [9, 10]. The effects of acidification on population and community structure starts from impairment of hatching of eggs and subsequently poor recruitment of year class [11]. Low pH decreases microbial activities and populations of detritivores leading to lower decomposition rate lower detritivores activities [12]. Lower detritivore activities leads to decrease in palatability of decaying materials to shredders and scrappers in aquatic ecosystem. Oxygen content of water also contributes in small measure to species distribution and abundance in aquatic ecosystems [13, 14]. The occurrence of many species of ostracods in lake Golkoy, Bolu, Turkey is affected by redox potential, dissolved oxygen and temperature fluctuations [13]. The effects of dissolved oxygen on aquatic snail vary per species. Gastropods and sphaerrids example Pisidium sp. are usually not found in lakes with pH less than 6.0 [15]. Physiologically hyperacidity of aquatic ecosystem interferes with shell formation in gastropods. Low pH increases the effects of heavy metals on aquatic organisms [16]. Acidification of aquatic environment leads to deposition of toxic metals like aluminum and magnesium which causes death of micro and macro organisms [14, 17]. Turbidity has been known to determine prevalence of some mollusks like Bullinusglobosus which occurs in highly turbid water [2].

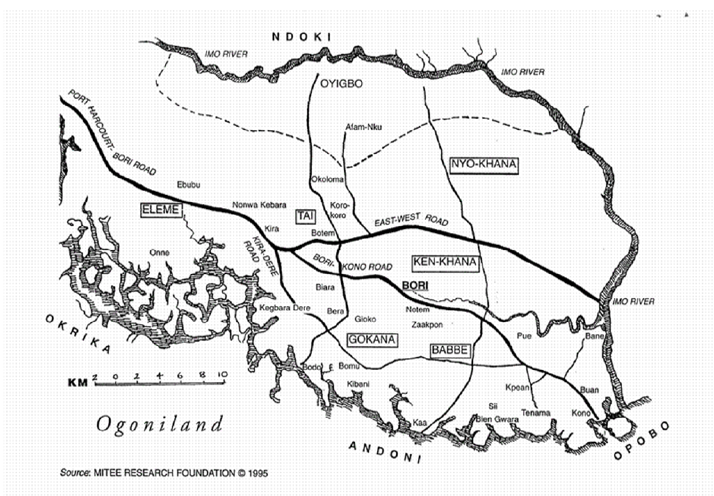
This research is aimed at analyzing the status of pH, dissolved oxygen, and turbidity of aquatic ecosystems at Bori, Gokana, Okirika, Tai and Eleme local areas of Rivers State, Nigeria. These are towns within four local government areas of the state. This paper also studied the prevalence of aquatic organisms in the study area in relation to water chemistry.

2. Geography of Study Area

The study area Bori, Gokana, Okirika, Tai and Eleme are large towns which are parts of four separate but close local government areas of Rivers State, Nigeria. They lie within 40°50°N and 70°35°E of Rivers State, Nigeria (Figure 1a). The study area is bounded in the west by Cross River State Nigeria, in the north by Imo State, Nigeria, in the east by another local government Degema local government area of Rivers State and in the south by Atlantic Ocean (Figures 1 and 2). The soil component and aquatic substrate of study area is a mixture of sand, alluvium, clay and some humus in village areas. Topographically study area is low land devoid of hill. This study was done in interior parts of Ogoni land with permit from village chiefs. Study area is home to series of oil drilling companies. Gas flaring by some oil producing companies goes in some parts of the study areas. Study area is also part of Ogoni land known for oil restiveness. The sturdy area map is shown in Figure 1b and Figure 2. Figure 2 shows the roads and locations of the sites in dotted black.

Map of Study area

(a)



(b)

Figure 1.

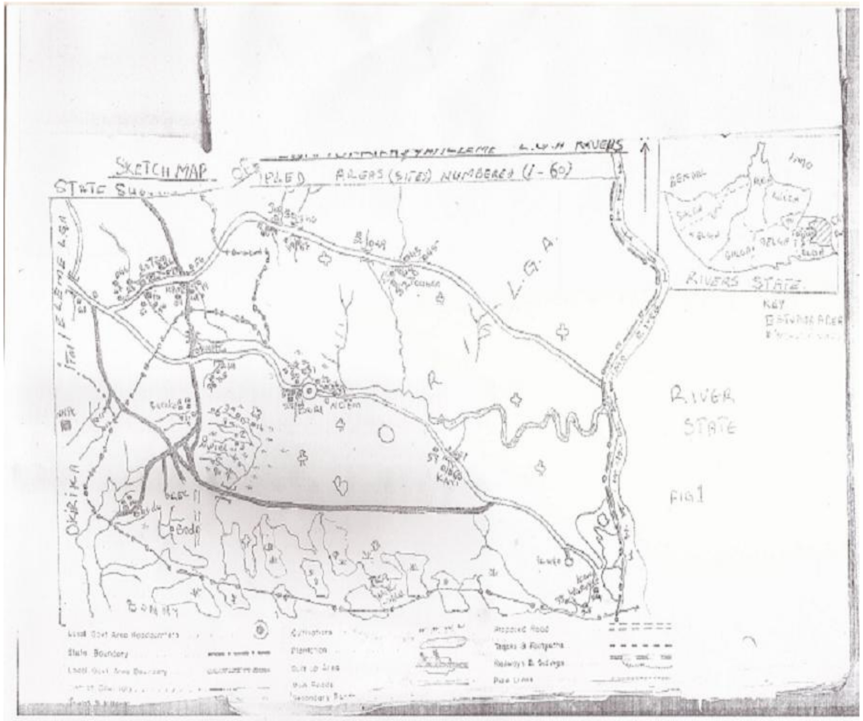


Figure 2.

3. Materials and Methods

Sampling

Sampling covered a total of sixteen (16) streams, thirteen (13) lakes and ponds and nine (9) rivers, that generated a total of fifty three (53) loci surveyed sites. Sampling started in January and ended at the end of March making three months of study. Sampling period was chosen to be within dry seasons so as to avoid flooding periods. Water collection was done with colored bottles and blue colored plastic containers. The amber colored bottles were used in obtaining water for oxygen analyses. Scoop net was used in probing for substrate and organisms at the bottom of water bodies and on riparian and emergent and submerged vegetation's. Substrate and organisms probing were done near the bank of the water bodies and in the middle and banks.

Dissolved Oxygen

Oxygen was measured by Wrinkler titrimetric methods to ensure accuracy. Amber colored bottles of 250 ml capacity were used in collecting water from sites. Water was fixed on the sites and specific cares were taken to avoid air bubbles while fixing the water. Fixing of water was done by pipetting 2 ml of 40% manganous chloride (Wrinkler I) into the amber bottle. The pipette was gently lowered into the water column down to the bottom and released to avoid air bubbles. Then into the same water was pipetted 2 ml of alkalinated potassium iodide (KOH/KI) which is (Wrinkler II). The addition of Wrinkler II created precipitates and bottles were inverted four times and kept in cool container.

$$\mathrm{Mn}^{2-} + 2\mathrm{K}^{-} + 2\mathrm{OH}^{-} \rightarrow \mathrm{Mn(OH)}_2 + 2\mathrm{KICl}_2.$$

1- $\mathrm{Mn}^{2-} + 2\mathrm{OH}^{-} \rightarrow \mathrm{Mn(OH)}_2$,

2- $2\mathrm{Mn(OH)}_2 + 1/2\,\mathrm{O} + \mathrm{H_2O} \rightarrow 2\mathrm{MnO(OH)}_2$ Oxidation of Mn (II) to Mn (III),

3- $2\mathrm{Mn(OH)}_3 + 2\mathrm{I}^{-}6\mathrm{H}^{+} \rightarrow 2\mathrm{Mn}^{+2} + \mathrm{I}_2 + 6\mathrm{H_2O}$.

In the presence of dissolved oxygen a brownish precipitate results confirming reaction between oxygen and manganous hydroxide

$$2\mathrm{Mn(OH)}_2 + \mathrm{O}_2 \rightarrow 2\mathrm{MnO(OH)}_2.$$

Acidification of fixed samples

Acidification of fixed water samples was done by adding 2 ml of conc. sulfuric acid to fixed water sample. The sulfuric acid was allowed to run down the neck of bottle containing fixed water sample. Acidification dissolves the precipitates forming a solution. The kinetics of the reaction was improved by inverting or jerking bottle several times. The addition of sulfuric acid results in liberation of iodine. The quantity of iodine released is stoichiometrically same as the dissolved oxygen content of the water. Iodine solution turns the solution brownish yellow.

$$\mathrm{Mn(OH)}_2 + 2\mathrm{H_2SO_4} \rightarrow \mathrm{Mn(SO_4)}_2 + 3\mathrm{H_2O},$$

$$\mathrm{Mn(SO_4)}_2 + 2\mathrm{KI} \rightarrow \mathrm{MnSO_4} + \mathrm{K_2SO_4} + \mathrm{I}_2.$$

Titration

The acidified water was titrated against $0.01\,\mathrm{N}$ sodium thiosulphate. About $25\,\mathrm{ml}$ of acidified water was put into $250\,\mathrm{ml}$ glass conical flask. The indicator used in titration was 1% starch solution. Starch solution was freshly prepared from freshly made starch corn starch. Addition of starch solution to fixed water sample resulted in blue black color showing presence of iodine starch complex. The blue black solution was titrated to a critical colorless point and volume of titrant was recorded. Three titrations were performed and average recorded. The DO_2 is read off.

$$2Na_2S_2O_3 + I_2 \rightarrow Na_2S_4O_6 + 2NaI.$$

pH Measurement

The pH of sample water was measured in two ways. Sample water was measured using litmus paper at the site. The sampled water was brought back to site and pH was measured again at site temperature using a pH meter. Results were compared and harmonized to be exact.

Turbidity

Turbidity measurements were done using turbidometer and reported in Nephalometric turbidity unit (NTU). Turbidometer was first standardized with distilled water of turbidity 0 NTU. Raw sample water were poured into provided tube and inserted into inlet chamber of a turbidometer. Turbidometer estimates light scattering of suspended (turbid) particles in water. Turbidity values were expressed in NTU.

4. Results

(A) Streams

(1) pH

The pH results for streams ranged from 4.7 taken from site 57 at Sorgho (bottom substrate muddy) to 6.4 ± 0.06 taken from site 54 at Botem (bottom substrate sandy). Only two sites had pH values up to 6.0, which are sites 46 at Botem, pH 6.1 ± 0.02 and site 54 at Botem, pH 6.4 ± 0.06 (Table 1). Among all the stream sites analyzed 98% had pH ≤ 5.3, rest of the stream sites had pH ≤ 4.6 or ≤ 6.4. Results show hyperacidity of streams located in the study area. The results of the experiments on pH values of streams are tabulated in Table 1.

(2) Dissolved Oxygen (DO_2)

The dissolved oxygen content of the streams ranged from 1.34 ± 0.02 mgl^{-1} measured from site 27 at Kpite to 7.3 ± 0.02 mgl^{-1} taken from site 31 at Bori (Table 1). Site 27 was a stream located in the interior populated village of study area. Villagers use the streams for many domestic purposes like bathing, fermenting cassava, washing plates and utensils and drinking in some places. The whole length of the streams is used for different purposes. Site 31 was a stream at Bori along the road. People frequent the sites majorly to fetching water used in washing motor bikes. Site is not located in built up areas. The average DO_2 of the streams was 3.86 ± 0.02 mgl^{-1}.

(3) Turbidity

The turbidity levels measured in the streams at study area ranged from 1.5 ± 0.03 NTU to 18.9 ± 0.02 NTU (Table 1). The least turbidity values was taken from site stream sites, 1 and 2 located in Boa, Nwoel Gokanain Bori local government area of Rivers State, Nigeria. The substrate was fine sand and site was used for drinking water by the farming community. The maximum NTU was taken from site 7 a stream in Nwoel Gokana. Bottom substrate was sand and mud, water was covered with aquatic plant Pistiastratoides. There were twenty two (22) sited surveyed in this research out of which only 4 sites had turbidity values > 10 NTU. These are stream sites 7 turbidity (18.9 ± 0.02), site 16 at Petaoo (17 ± 0.02), site 46 at Botem $(16 \pm 0.07$ NTU$)$ and site 5 turbidity $(12 \pm 0.01$ NTU$)$ (Table 1).

(B) Rivers

(1) pH

There were low pH values analyzed for rivers in the study area. The pH values of the rivers ranged from 4.8 ± 0.03 to 5.65 ± 0.02. (Table 2). The lowest pH values were taken from river site 53 at Sorgho with bottom substrate black mud mixed with little sand. The highest pH value was 5.65 ± 0.02 taken from site 23 at Botem. This river was characterized in some sections by emergent vegetation and was stagnant. Average pH value for rivers was 5.13 ± 0.08. There were only four (4) out of fifteen (15) sampled rivers with $\text{pH} \geq 5.6$, the rest were more acidic in nature. Generally low pH was measured in all sampled rivers (Table 2).

(2) Dissolved Oxygen $(\mathbf{DO_2})$

The average dissolved oxygen content of the rivers was $3.99 \pm 0.05\,\text{mg/l}$. Dissolved oxygen values ranged from $2.54 \pm 0.06\,\text{mg/l}$ to $6.7 \pm 0.07\,\text{mg/l}$. The lowest DO_2 was taken from site 52 at Taabaa and had sandy bottom substrate. The river was used for domestic purposes by villagers. The highest DO_2 value was taken from site 22 at Botem also with sandy substrate, the river was used for mainly bathing and as drinking water. There were generally low DO_2 in all sampled river sites. There were 15 sampled rivers sites and only 5 had DO_2 greater than $4.0\,\text{mg/l}$ (Table 2).

(3) Turbidity

The turbidity of sampled river sites is recorded in Table 2. The average turbidity value of the rivers was $5.2 \pm 0.4\,\text{NTU}$. The minimum turbidity value was $1.05 \pm 0.01\,\text{NTU}$ that was taken from river site 55 at Taabaa (Table 2). This river is a tributary of Imo river en route the Atlantic Ocean, the bottom substrate is sandy. The maximum turbidity value recorded was $16 \pm 0.04\,\text{NTU}$ and this was analyzed from river site 52 at Taabaa, the bottom substrate was black and sandy and very dirty. The turbidity measurements of the rivers were generally low. There were only three (3) sites that had turbidity values greater than $6.5\,\text{NTU}$. These are site 59 at Kpite $(12 \pm 0.01\,\text{NTU})$ with several over hanging toilets that drops into the water in some sections. Villagers used same water after few $(4\text{-}5\,\text{m})$ meters away for other domestic purposes (a common site in study area), site 50 at Taabaa $(15 \pm 0.01\,\text{NTU})$ bottom substrate was black sand and site 52 at Taabaa $(16 \pm 0.04\,\text{NTU})$. Most of the river sites had turbidity values less than 6. There were generally low turbidity values analyzed for the river sites.

(c) Lakes and ponds

(1) pH

The average pH value of the lakes and ponds was 5.80 ± 0.02. The pH values for lakes and ponds were generally acidic. The highest pH value was 7.65 ± 0.02 taken from site 18 at Balako. This site had sandy bottom substrate and is used by villagers for domestic purposes. The least pH value was 4.9 ± 0.01 taken from site 40 at Sorgho. The bottom substrate was muddy. Only four (4) sites out of sixteen (16) sites had pH value > 6.0, the rest were all less more acidic, these were sites 13, pH $6.8 \pm 0.0.2$; site 17 pH 6.5 ± 0.01; site 18 pH 7.65 ± 0.02; site 20 pH 6.7 ± 0.03.

(2) Dissolved Oxygen (DO_2)

The average dissolved oxygen for the ponds and lakes was $3.86 \pm 0.02\,mgl^{-1}$. The lowest dissolved oxygen value was $2.02 \pm 0.01\,mgl^{-1}$ taken from site 6 at Petaao. The substrate of this site was muddy. The highest DO_2 value was $5.37 \pm 0.02\,mgl^{-1}$ taken from site 18 at Barako with sandy substrate and emergent riparian vegetation and floating plants. There was generally low dissolved oxygen taken from the ponds and lakes sites. Only three sites had DO_2 values $> 5.0\,mgl^{-1}$, these are sites 42, DO_2 $5.2 \pm 0.03\,mgl^{-1}$; site 21, DO_2 $5.15 \pm 0.03\,mgl^{-1}$ and site 18 DO_2 $5.37 \pm 0.02\,mgl^{-1}$ at Nwoel Gokana. There were generally low DO_2 values for the lakes and pond. 50% of the sites had DO_2 $< 2.0\,mgl^{-1}$.

(3) Turbidity

The turbidity values for the ponds and lakes ranged from 2 ± 0.01 NTU (turbidity minimum, *T*min) to 16 ± 0.02 NTU (turbidity maximum, *T*max). The *T*min value was taken from site 9 at Lalunu, bottom substrate was sandy. The value for *T*max was taken from site 60 at Kani, bottom substrate was black mud and some sand. The average turbidity measurement for ponds and lakes was 4.52 ± 0.03 NTU.

A total of 16 ponds and lakes were surveyed but only 2 had turbidity > 6.0 NTU (Table 3); these are lake site 51 at Botem, turbidity 16 ± 0.02 NTU; site 20 at Barako Gokana, turbidity 6.7 ± 0.01. Generally turbidity measurements for lakes and ponds were low.

5. Prevalence of Aquatic Organisms

There was probing and net scooping of at the bottom substrate and riparian and submerged vegetation of the water bodies. The study sites were also devoid of aquatic snails and similar macrophytes throughout the research periods. Moreover, oral interrogation of villagers also revealed that aquatic snail and shell fish were not prevalent in study area. There were, however, scanty population of tilapia and small clariids at interior parts of Bori. During the study, we met a boy farmer fishing with hook and line. Interviews of villagers also proved that surveyed communities were not fishing communities, hence crop farming was rampant.

6. Discussions

The sampled sites were generally acidic and acidification of sampled aquatic ecosystems could be as a result of anthropogenic activities. The study area is home to oil companies engaged in oil exploration and drilling activities. Gas flaring takes place constantly in study area. Burning of fossil fuel releases sulfur dioxide (SO_2), and nitrogen oxides (NO_x) into the atmosphere, the gases released mixes with water forming sulfuric acids and nitric acids [18, 19, 20]. Bush burning takes place in study area especially within farming months of March (at onset of rains). Bush burning had been noted to increase acidity of water in southern Norway [21]. The low pH of study area water may have accounted for the poor biodiversity of organisms. The average acidification levels of 5.2 for streams, 5.13 for rivers and 5.4 for ponds and lakes, showed very low acidity level of all aquatic ecosystem sampled. The acidic nature of the aquatic habitats may have accounted for the poor fishery resources of sampled areas hence most villagers took to crop farming. The fish population of Europe and Northern America was noted to have declined as a result of acid water [5]. This is in line with previous findings, [4] noted that at acidification levels of 6.0 fish alarm cues are impaired and this lead to greater vulnerability and mortality. High acidification therefore alters population dynamics of aquatic organisms in the study areas. Similarly [22] noted that acidified water alters relative abundance of organisms and undergoes chemical and biological changes due to dual effects of deposition of H^+ ion in water and effects on the soil and vegetation. Benthic macro invertebrates like snails have been known to disappear when pH drops to 5.3-5.2 [23, 24]. However, [25] working in western Nigeria, [15, 26, 27] in Norway and [28] in USA, noted that snails were very sensitive to pH and never found when pH drops 6.0. These findings are in line with this research and could have accounted for absence of aquatic snails and other macro invertebrates in the sampled areas.

Acidification of sampled areas reduces the biodegradation and bioactivities. The disappearance of aquatic organisms like snails and other macro invertebrates could be due to low food availability in acid water. Decomposition rate and bioactivities of detritivores is reduced in acid water [1, 3], this makes lesser food available to macrophytes. High acidity of water in sampled area must have had compound deleterious effects the aquatic ecosystem. Similarly [29] noted that processing rate of litters from riparian vegetation are highly reduced under acid conditions making it hard for shredders and other organisms that feed and depend on them to exist. This may have as well accounted to absence of aquatic macrophytes in the study area. It has been noted series of aquatic invertebrates like mollusks, crustaceans, barnacles and insects reduce in population or become entirely extinct when streams pH falls below 5.7 [30, 23, 24]. Similarly, the prevalence of ostracods in lake Golkoy, Turkey has been associated with mostly affected by dissolved oxygen and redox potential [12].

Low dissolved oxygen causes further high biological oxygen demand and high oxygen budget. Snails and aquatic organism are dependent on oxygen and the low pH could have as well contributed to low DO_2. [28] working in USA noted 64% reduction in oxygen uptake by snails at pH of 4. Consequently absence of snails in the study area could also be caused by low dissolved oxygen content of the aquatic habitats. The villagers ferment cassava and wash in different sections of the water bodies leading to low dissolved oxygen. It is unhealthy to construct toilets on top of wooden platform above municipal water sources like rivers streams or lakes. Such behaviors can lead to enrichment and disruption of aquatic ecosystem balance, eutrophication and high BOD. The lack of bioactivities in acid water we analyzed in this synthesis and low DO_2 could have contributed to low turbidity of the aquatic ecosystem studied. Turbidity results from silts or fine particulate matter or planktons hence, low pH decrease activities of shredders and scrappers which produce fine particulate matters. The absence of scrappers and shredders in study area could as well have contributed to low turbidity in the study area. In a previous experiment, [3] noted that acid water resists production of fine particulate matter. The presence of fine particulate matter in water bodies increases the turbidity.

The physic-chemical nature of the ecosystems seems to be based under the effects of anthropogenic factor. Gas flaring in the survey area could have been source of the hyperacidity of research area. The hyperacidity together with other factors like low DO_2 and turbidity then resulted in the low biodiversity in study area. More researches should be done in the study area to ascertain other likely effects of the chemical nature of water in study area.

Table 1. Variations of pH, $DO_2 (mg/l)$, Turbidity (NTU) of streams surveyed for three months at Bori, Gokana, Tai, Eleme and Okirika areas of Rivers State, Nigeria

serial no	site	pH	DO_2	Turbidity
1	1	5.20 ± 0.01	3.36 ± 0.03	1.50 ± 0.04
2	2	5.00 ± 0.03	3.50 ± 0.02	1.50 ± 0.03
3	3	5.10 ± 0.01	2.68 ± 0.01	2.00 ± 0.03
4	4	5.30 ± 0.04	2.91 ± 0.01	8.00 ± 0.02
5	5	5.50 ± 0.02	3.60 ± 0.02	12.0 ± 0.01
6	7	5.70 ± 0.01	3.58 ± 0.01	18.9 ± 0.02
7	16	4.90 ± 0.06	3.81 ± 0.03	17.0 ± 0.02
8	26	5.15 ± 0.03	3.36 ± 0.02	5.00 ± 0.04
9	27	5.53 ± 0.05	1.34 ± 0.02	4.80 ± 0.01
10	28	5.50 ± 0.01	3.36 ± 0.01	4.50 ± 0.01
11	30	4.80 ± 0.01	2.20 ± 0.05	2.60 ± 0.03

12	31	5.19 ± 0.05	7.30 ± 0.02	4.20 ± 0.02
13	34	5.00 ± 0.06	3.14 ± 0.04	3.50 ± 0.03
14	35	5.54 ± 0.02	4.48 ± 0.02	2.50 ± 0.03
15	36	5.20 ± 0.05	4.27 ± 0.01	4.00 ± 0.02
16	37	4.90 ± 0.04	3.14 ± 0.03	3.32 ± 0.01
17	38	5.20 ± 0.02	6.27 ± 0.04	3.40 ± 0.02
18	39	5.10 ± 0.01	3.20 ± 0.02	5.00 ± 0.04
19	41	5.49 ± 0.05	4.50 ± 0.01	1.50 ± 0.04
20	46	6.10 ± 0.02	5.61 ± 0.02	16.0 ± 0.07
21	54	6.40 ± 0.06	4.20 ± 0.02	2.50 ± 0.03
22	57	4.79 ± 0.01	5.21 ± 0.01	1.50 ± 0.05
Means		5.29 ± 0.03	3.86 ± 0.02	5.69 ± 0.03

Table 2. Variations of pH, DO_2(mg/l), Turbidity (NTU) of river surveyed for three months at Bori, Gokana, Tai, Eleme and Okirika areas of Rivers State, Nigeria

serial no	site	pH	DO_2	Turbidity
1	10	5.50 ± 0.02	4.03 ± 0.03	2.90 ± 0.02
2	15	5.20 ± 0.01	4.00 ± 0.02	2.90 ± 0.03
3	19	5.50 ± 0.04	3.14 ± 0.04	6.50 ± 0.02
4	21	5.24 ± 0.02	2.00 ± 0.01	3.20 ± 0.01
5	22	4.90 ± 0.01	6.75 ± 0.02	1.80 ± 0.02
6	23	5.65 ± 0.02	6.72 ± 0.04	2.00 ± 0.01
7	43	5.05 ± 0.04	4.20 ± 0.02	2.50 ± 0.03
8	44	4.85 ± 0.03	3.45 ± 0.03	2.00 ± 0.03
9	48	5.10 ± 0.03	3.20 ± 0.01	4.00 ± 0.02
10	49	5.00 ± 0.02	4.25 ± 0.02	2.80 ± 0.02
11	50	5.02 ± 0.01	5.20 ± 0.03	15.0 ± 0.01
12	52	4.85 ± 0.03	2.54 ± 0.02	16.0 ± 0.04
13	53	4.80 ± 0.03	3.52 ± 0.04	4.80 ± 0.02

14	55	4.90 ± 0.01	3.20 ± 0.03	1.05 ± 0.01
15	59	5.50 ± 0.04	3.70 ± 0.04	12.0 ± 0.01
Means		5.13 ± 0.08	3.99 ± 0.02	5.29 ± 0.02

Table 3. Variations of pH, DO_2(mg/l), Turbidity (NTU) of lakes and ponds surveyed for three months at Bori, Gokana, Tai, Eleme and Okirika areas of Rivers State, Nigeria

serial no	site	pH	DO_2	Turbidity
1	6	5.10 ± 0.03	2.02 ± 0.01	5.00 ± 0.03
2	8	5.10 ± 0.02	3.36 ± 0.04	2.50 ± 0.03
3	9	5.00 ± 0.01	3.50 ± 0.02	2.00 ± 0.01
4	13	6.80 ± 0.02	3.14 ± 0.03	3.00 ± 0.03
5	17	6.50 ± 0.01	3.12 ± 0.01	3.50 ± 0.01
6	18	7.65 ± 0.02	5.37 ± 0.02	3.00 ± 0.02
7	20	6.70 ± 0.03	4.03 ± 0.03	6.70 ± 0.01
8	29	5.43 ± 0.01	5.15 ± 0.03	3.00 ± 0.03
9	32	5.60 ± 0.04	4.70 ± 0.02	3.80 ± 0.03
10	40	4.90 ± 0.01	2.30 ± 0.01	2.80 ± 0.04
11	42	6.40 ± 0.03	5.20 ± 0.03	3.20 ± 0.01
12	45	5.10 ± 0.02	4.10 ± 0.01	5.00 ± 0.02
13	47	5.90 ± 0.03	4.80 ± 0.02	2.90 ± 0.01
14	51	5.90 ± 0.01	4.20 ± 0.02	5.00 ± 0.02
15	58	5.52 ± 0.03	3.30 ± 0.01	16.0 ± 0.02
16	60	5.30 ± 0.04	3.60 ± 0.03	5.00 ± 0.01
Means		5.80 ± 0.02	3.86 ± 0.02	4.52 ± 0.03

References

[1] V. N. Okwuosa, Studies on the ecology and distribution of schistosomes vectors and other snail fauna in the south western states of Nigeria, Nigerian J. Parasitology 3(1) (1982), 78-86.

[2] V. G. F. Smith, Distribution of snails of veterinary importance in an organically polluted water course in Nigeria, Annals of Tropical Medicine and Parasitology 76 (5) (1982), 539-546.

[3] C. J. Kok and A. Van der Velde, Decomposition and macroinvertebrate colonization of aquatic and terrestrial leave material in alkaline and acid still water, Fresh Water Biology 31 (1994), 65-75.

[4] A. O. Leduc, P. L. Munday, G. E. Brown and M. C. Ferrari, Effects of acidification on olfactory-mediated behavior in freshwater and marine ecosystems, a synthesis, Philos. Trans. R. Soc. Lond. B. Biol. Sci. 368 (2013), 20120447.

[5] J. P. Baker, D. P. Bernard, S.W. Christensen, M. J. Sale, J. Freda, K. Heltcher, D. Marmorek, L. Rowe, P. Scanlon, G. Sutter, W. Warren-Hicks and P. Welbourn, Biological effects of changes in surface water acid-base chemistry, NAPAP Report No. 13, National Acid Precipitation Assessment Program, Acidic Deposition: State of the Science and Technology, J. P. Baker, ed., NAPAP, Oak Ridge, TN, Vol. II, 1990, pp. 381.

[6] J. Fott, M. Blazo, E. Stuchlik and O. Strunecky, Phytoplankton in three Tatra Mountain lakes of different acidification status, J. Limnology 58(2) (1999), 107.

[7] A. Locke and W. G. Sprules, Effects of Lake acidification and recovery on the stability of zooplankton food webs, Ecology 75 (1994), 498.

[8] J. M. Eilers, G. L. Lien and R. G. Berg, Aquatic organisms in acid environment: a literature review, WISC Rep. Natural Resources, Technical Bulletin 150, 1984, pp. 18.

[9] L. Norrgren and E. Degerman, Effects of different water qualities on the early development of Atlantic salmon and brown trout exposed in situ, Ambio 22 (1993), 213-218.

[10] B. O. Rosseland, I. Sevaldrud, D. Svalastog and I. P. M. Muniz, Studies on freshwater fish populations- Effects of acidification on reproduction, population structure, growth and food selection, Proceedings of the International Conference on the Ecological Impact of Acid Precipitation, D. Drablos and A. Tollan, eds., SNSF Project, Oslo, Norway, 1980, pp. 3336-337.

[11] P. L. Brezonik, J. G. Eaton, T. M. Frost, P. J. Garrison, T. K. Kratz, C. E. Mach, J. H. McCormick, J. A. Perry, W. A. Rose, C. J. Sampson, B. C. L. Shelley, W. A. Swenson, and K. E. Webster, Experimental acidification of Little Rock Lake, Wisconsin:

chemical and biological changes over the pH range 6.1 to 4.7, Canadian J. Fisheries and Aquatic Sciences 50 (1993), 1101-1121.

[12] C. J. Kok, W. Haverkamp and H. A. Van der Aa, Influence of pH on the growth and leaf-maceration ability of fungi involved in the decomposition of floating leaves of Nymphae alba in acid water, J. General Microbiology 138 (1992), 103-108.

[13] O. Kulkoyluoglu, Ecology and phenology of fresh water ostracods in lake Golkoy (Bolu, Turkey), Aquatic Ecology 39(3) (2005), 295-304.

[14] R. Fox, Physico-chemical parameters along longitudinal and transverse transect, Laboratory exercise for limnology, Biology 415, Lander University, Green Wood SC, PG, 2003, pp. 1-121.

[15] J. Okland and K. A. Okland, pH level and food organisms for fish: Studies of 1,000 lakes in Norway, Ecological Impact of Acid Precipitation, D. Drablos and A. Tollan, eds., Proceedings of the International Conference on the Ecological Impact of Acid Precipitation, SNSF Project, Oslo, Norway, 1980, pp. 326-327.

[16] B. P. Baldigo and G. B. Lawrence, Effects of stream acidification and habitat on fish population of a North American river, Aquatic Sciences 63 (2001), 196-222.

[17] R. S. E. W. Leuven, G. Van der Velde and H. L. M. Kersten, Interrelations between pH and other physic-chemical factors of Dutch waters, Archiv. EurHydrobiologie 126 (1992), 27-57.

[18] D. L. Findlay and S. E. M. Kasian, Phytoplankton communities of lakes experimentally acidified with sulfuric and nitric acids, Canadian J. Fisheries and Aquatic Sciences 47 (1990), 1378.

[19] S. J. Smith, S. Conception, R. Andres and J. Lurz, Historical sulphur dioxide emissions 1850-2000: methods and results, Department of Space Studies, University of North Dakota, Pacific Northwest National Laboratory, 2004, p. 14.

[20] T. A. Clair, I. F. Dennis, R. Vet and G. Weyhenmeyer, Water chemistry and dissolved organic carbon trends in lakes from Canada’s Atlantic Provinces, norecovery from acidification measured after 25 years of lake monitoring, Canadian J. Fisheries and Aquatic Sciences 68 (2011), 663-674.

[21] E. Lydersen, R. Høgberget, E. C. Moreno, Ø. A. Garmo and C. P. Hagen, The effects of wildfire on the water chemistry of dilute, acidic lakes in southern Norway, Biogeochemistry DOI 10.1007/s10533-014-9951, 2013.

[22] J. Kalff, Limnology, Prentice-Hall, Inc., Upper Saddle River, NJ, 2002.

[23] M. Furse, D. Hering and O. Moog et al., The STAR project context, objectives and approaches, Hydrobiologia 3 (2006), 566.

[24] A. K. Schartau, S. J. Moe, L. Sandin, B. MacFarland and G. G. Raddum, Macroinvertebrate indicators of Lake Acidification: analysis of monitoring data from UK, Norway and Sweden, Aquatic Ecology 42l (2008), 293.

[25] F. M. A. Ukoli, An Introduction to Parasitology in Tropical Africa, John Willey and Sons Publishers Ltd, 1984.

[26] J. Økland, Factors regulating the distribution of fresh-water snails (Gastropoda) in Norway, Malacologia 24 (1983), 277-288.

[27] J. Økland, Effects of acidic water on freshwater snails: results from a study of 1000 lakes throughout Norway, Environmental Pollution 78(1-3) (1992), 127-30.

[28] D. W. Sutcliffe and A. G. Hildrew, Invertebrate communities in acid streams, Acid Toxicity and Aquatic Animals, R. Morris, E. W. Taylor, D. J. A. Brown, J. A. Brown, eds., Cambridge University Press, Great Britain, 1989, pp. 13-29.

[29] V. Felten and F. Guerold, Short-term physiological responses to a severe acid stress in three macroinvertebrate species, a comparative study, Chemosphere 63 (2006), 1427-1435.

[30] B. R. Lewis, I. Juttner, B. Reynolds and S. J. Ormerod, Comparative assessment of stream acidity using diatoms and macroinvertebrates, implications for river management and conservation, Aquat. Conserv.: Marine and. Freshwater Ecosystem 17 (2007), 502-519.