PHYSICOCHEMICAL AND MICROBIOLOGICAL STUDY OF ABA RIVER ABIA STATE, NIGERIA

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ABSTRACT

Physicochemical and microbiological analyses of water samples from Aba River in Abia state were conducted in order to ascertain their compliance with standards for domestic consumption. Water samples collected from three sampling points were analyzed and compared with World Health Organization (2004) and Nigerian standard for drinking water quality (2007). Results showed that Dissolved oxygen, Ammonia, Total suspended solids, Iron, Electrical conductivity and Turbidity exceeded World Health Organization (WHO) standard and Nigerian Standard for Drinking Water Quality (NSDWQ), while the remaining parameters fall within WHO and NSDWQ standards. The test of significance conducted equally showed that there was no statistical variation in physicochemical parameters between the samples as evidenced by p > 0.05. Also, none of the water samples complied with microbiological standards. Heterotrophic counts ranged from 2.93 ±0.02 × 10^7 to 2.96 ± 0.02 × 10^7 ,Vibrio cholera count ranged from 2.00 ± 0.06 x 10^3 to 2.10 ± 0.04 x 10^3cfu /ml, Salmonella shigella count were in the range of 1.66 ± 0.04 × 10^4 to 2.15 ± 0.43 × 10^4cfu/ml, Escherichia coli count ranged from 2.12 ± 0.38 × 10^3 to 2.83 ± 0.33 × 10^3cfu, Salmonella shigella count were in the range of 1.66 ± 0.04 × 10^4 to 2.15 ± 0.43 × 10^4cfu /ml while Fungal count ranged from 1.35 ± 0.68 × 10^8 to 2.25 ± 0.23 × 10^6 cfu /ml.These findings revealed that Aba River is polluted and unfit for both drinking and other domestic purposes.

***KEYWORDS**: Physicochemical, Microbiological, Study, Aba River*

1.0 INTRODUCTION

Despite major efforts that have been made over recent years to clean up the environment, pollution remains a major problem and poses continuing risks to health. The problems are industrial emissions, poor sanitation, inadequate waste management, contaminated water supplies and exposures to indoor air pollution from biomass fuels which affect large numbers of people. Even in developed countries, however, environmental pollution persists, most especially amongst poorer sectors of society (Samet *et al*., 2000; Sexton and Adgate, 2000).

Human activities including industrialization and agricultural practices contribute immensely in no small measure to the degradation of the environment which adversely affects water bodies (Owa, 2013). The importance of water for sustenance of life cannot be overemphasized. It is important therefore, to note that depletion of this commodity either through contamination, or careless use results in serious consequences (Owa, 2013). Water is considered polluted if some substances or conditions are present to such a degree that it cannot be used for a specific purpose. Water pollution is the presence of excessive amounts of hazards (pollutants) in water in such a way that it is no longer suitable for drinking, bathing, cooking or otherwise (Olaniran,1995). The introduction of pollutants or contaminants into the environment refers to pollution. It is caused by industrial and commercial sectors, agricultural practices, everyday human activities and most notably, models of transportation.

For instance, heavy metal contamination in rivers is a major water quality issue in many fast growing cities. This is because improvements in water and sanitation infrastructure have not kept pace with population growth and urbanization in most developing countries (Mintz and Baier, 2000). Metals enter rivers and lakes from a variety of sources, such as rocks and soils directly exposed to surface waters, decomposing dead organic matter, and from man's activities, including the discharge of various treated and untreated liquid wastes into the water body (Olayinka, 2004).

A further special feature of toxic metals is that they are not biodegradable. Instead, they undergo biogeochemical cycle with substantially different residence times in the various spheres and compartments of the environment. Within this cycle they will be taken up also by man, predominantly from food and drinking water. In this respect, toxic metals constitute a particular risk.

Deliberate discharge, spillage (e.g. from storage, during transport, or during processing and usage) leakage and runoff (e.g. of agricultural chemicals) are all important terms

of aqueous pollutants. Landfilll sites may thus be responsible for emissions of a wide range of pollutants, via different pathways, especially when these sites are inadequately sealed or poorly maintained. Among various pollutions, water pollution, is a vital threat to human health, and also the most remarkable issue for sustainable development. Niemi *et al.* (1990) reported that human activities mainly impact surface water quality through effluent discharges, use of agricultural chemicals, in addition to the increased exploitation of water resources.

This research work is therefore aimed at investigating the physicochemical and microbiological properties of Aba River for domestic use for the inhabitants of the area.

2.0 MATERIALS AND METHOD

2.1 The study area

The study area is Aba in Aba North local government area of Abia state in south eastern Nigeria. It is the commercial nerve city of Abia State and it lies within coordinates Longitude 7º 19'E to 23'E and latitude 5º 10'N. Aba River is a tributary of Imo River and is the major river passing through Aba town. The River flows through the Azumiri River down to the Atlantic Ocean and the land mass of the area is about 198km^2. It is located close to the industrial and commercial city of Aba.The map of the study area is shown in Fig. 1.

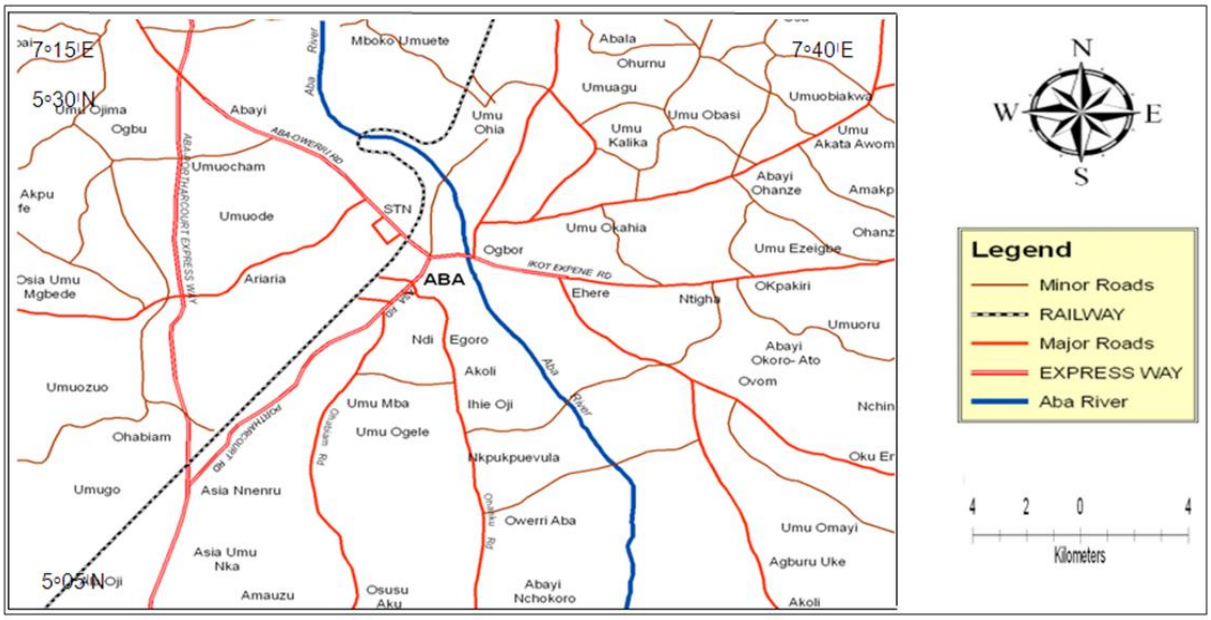

Figure 1. Map showing the location of the study area (Source: NGSA, 2004)

2.2. Climate and Vegetation of the study Area

The area lies within the tropical rainforest area. It has an average rainfall of about 2285 mm. Rainfall is experienced between March to November with a relative humidity of 80% and mean annual temperature of 27 ºC. The area experiences flooded terrain during rainy season owing to poor drainage system. The dry season ranges between November to March within the area and is often characterized by windy weather, with little or no rainfall. The maximum temperature occurs in the area around December while the minimum temperature is observed in February due to harmattan season.

2.3 Data requirements and sources

This research was based mainly on primary and secondary sources of data sets. The primary sources of data were obtained from observations, carefully conducted laboratory experiments as well as analyses of microbiological and physicochemical parameters of water samples collected from the River. The secondary sources consist of information obtained from published works from the World Health Organization (WHO) and Nigerian Standard for Drinking Water Quality (NSDWQ).

2.4 Samples collection and treatment

Water samples were collected by connecting a bottle to ropes, both of which were previously washed with detergent and rinsed 3 times with the sample before it was filled. A

small air space was allowed in the bottle to allow mixing of sample at the time of the analysis. Grab samples were collected from well mixed section of the River (main stream) at a depth of 0.3 m in accordance with Khadse (2010). The rope was lowered to immerse the bottle in the water to fill it. Once the bottle was full, it was pulled out of the River and closed firmly and labelled properly.

The samples were collected at three (3) different points at a considerable distant apart across the width of the River to ensure homogeneity and proper representation of the water. The first sample was taken from the point of discharge of effluent flow into the River labelled A, while the second sample was collected at 200 m from the point of discharge of effluent flow into the River (Abattoir) labelled B. The third sample was also collected at 400 m from Abattoir (Mechanic workshop) labeled C.

Temperature and pH were measured in situ, using a temperature probe and portable pH meter, Cyberscan pH 300 series, respectively. All the samples were collected in duplicates, making a total of 6 samples. They were covered with sterilized closures and transported to National, Soil, Water and Plant Laboratory Umuahia Abia State in an icebox at 4^{o}C for analyses (WHO, 2003; Greenberg *et al.,* 1995).

2.4 Parameters of interest

2.4.1 Physical parameters

The physical parameters studied included; Turbidity, electrical conductivity and temperature.

2.4.2 Chemical parameters

The chemical parameters studied included; Dissolved oxygen, Biochemical oxygen demand, Chemical oxygen demand, Total hardness, Nitrate, Ammonia, Sulphate, Phosphate, Chloride, Potassium, Calcium, Magnesium, Manganese, Iron, Lead, Cadmium, Nickel, Copper, Cobalt, Mercury, Alkalinity, pH, Total dissolved solids, and Total suspended solids.

All physicochemical parameters were analyzed in accordance with standard methods (APHA, 1992; DPR, 2000; WHO, 1984). Turbidity was measured with a HACH 2100 P Turbidimeter. The dissolved oxygen was measured using dissolved oxygen (DO) meter (Model oxi 197). Total dissolved solids and suspended solids were measured gravimetrically after drying in an oven to a constant weight at 105^{o}C. Ammonia was analyzed using a comparator (HANNA) while alkalinity was determined by strong acid titration method. Conductivity was measured with Cybersan 510 conductivity meter.

2.4.3 Microbiological Parameters

The microbiological parameters tested included*; Escherichi a coli, Vibro cholera* count, Total heterotrophic bacteria count, *Salmonella-shigella* count and Fungal count.

The total heterotrophic bacteria in the water samples were obtained using the spread plate method. Dilutions of 10-1 to 10-4 of the samples were prepared in 0.1% buffered peptone water (oxoid) and 0.1ml aliquots of each dilution was inoculated onto the surface of dried nutrient agar plate in triplicates and incubated at 37ºC for 24 hours. Petri-dishes from dilutions containing between 30 and 300 discrete colonies were counted and the result expressed as colony forming unit per milliliter (Krieg and Holt, 1994). Faecal *coliform* was enumerated by multiple tube fermentation tests as described by APHA (2005*). Escherichia Coli* count was obtained using the three tube assay of the Most Probable Number (MPN) technique. Escherichia coli were isolated by inoculating the sample in Bismuth green bile broth. Enteric bacteria isolated on respective selective or differential media were identified on the basis of their colonial, morphological and Biochemical properties.

Salmonella and Shigella species were isolated using Salmonella/Shigella agar (SSA). The media was prepared following the manufacturer's directive and 0.1ml aliquot of ach water sample was transferred onto the surface of a dried sterilized SSA plates. The plates were inoculated in triplicates and incubated at 37^{0}C for 24 to 48 hours. Pure cultures were obtained through sub-culturing and the colonies were identified using standard procedures (Cheesbrough, 2002).

Thiosulphate citrate bile salt (TCBS) agar was used to screen for the presence of *Vibrio species*. The media was prepared according to manufacturer's directive, poured into sterilized Petri dishes and allowed to solidify. Then, 0.1ml of each water sample was transferred onto the dried TCBS agar plates in triplicates using a 1ml pipette and spread evenly with a hockey stick. The plates were incubated at 35^{0}C for 24 to 48 hours. Thereafter, yellow colonies were counted and identified following standard procedures (Cheesbrough, 2002).

3.0 RESULTS AND DISCUSSION

3.1 Results

The results of the physico-chemical and microbiological analysis of water samples from Aba River in Aba North Local government Area of Abia State together with WHO and FEPA standards are presented in Tables 1 and 2, respectively. While the single factor, ANOVA results for physiochemical analysis are shown Table 3.

Table 1: Physicochemical Analysis of Water samples

S/N Parameters	Sample A	Sample B	Sample C	WHO(2004)	NSDWQ(2007)
1.Total dissolved solids	114.40	121.00	128.05	1000	500
2. pH	5.81	5.92	5.10	6.5-8.0	6.5.8.5
3.. Dissolved oxygen(mg/l)	13.42	10.88	7.61	7.5	-
4.BOD (mg/l)	2.62		1.48	10.0	-
5.COD (mg/l)	3.10	2.58 3.12	3.14	255	-
6. Total hardness(mg/l)	5.51	4.41	3.31	500	150
7.Nitrate(mg/l)	2.11	1.19	0.91	50	50
8.Ammonia(mg/l)	12.41	16.11	20.6	1.0	-
9.Alkalinity(mg/l)	37.00	38.00	39.00	100-200	-
10.Sulphate(mg/l)	105.75	108.40	110.60	250	100
11.Mercury	ND	ND	ND	0.001	0.001
12.Phosphate(mg/l)	0.017	0.010	0.003	5.0	-
13.Potassium(mg/l)	0.12	0.03	0.004	42-45	-
14.Calcium(mg/l)	5.15	6.80	3.12	75-200	-
15 .Magnesium(mg/l)	0.02	0.004	0.005	50-150	-
16.Manganese(mg/l)	0.14	0.16	0.18	0.4	0.2
17.Iron(mg/l)	10.58	26.07	38.07	0.3	0.3
18.Lead(mg/l)	ND	ND	ND	0.01	0.01
19.Cadmium(mg/l)	ND	ND	ND	0.003	0.003
20.Nickel(mg/l)	0.02	0.01	0.01	0.02	0.02
21.Total suspended Solids	80.00	91.00	101.00	10	-
22.Copper(mg/l)	0.008	0.008	0.008	2.0	1.0
23. Zinc(mg/l)	2.94	1.42	1.22	3.-5	3.0

24.Electrical conductivity(Ns/cm)	375	314	254	1000	1000
25.Turbidity(NTU)	3.50	3.11	3.0	5	5
26.Temperature(ºC)	27.3	28.6	29.9	27-28	Ambient

ND=Not Detected

Table 2: The Mean Count of Micro-organisms isolated from the Water Samples

THBC (cfu/ml)	VCC (cfu/ml)	SSC (cfu/ml)	ECC (cfu/ml)	FC (cfu/ml)
A. $2.93 \pm 0.02 \times 10^7$	$2.00 \pm 0.06 \times 10^3$	$2.15 \pm 0.43 \times 10^4$	$2.83 \pm 0.33 \times 10^3$	$1.50 \pm 0.53 \times 10^6$
B. $2.94 \pm 0.01 \times 10^7$	$2.10 \pm 0.04 \times 10^3$	$1.80 \pm 0.08 \times 10^4$	$2.73 \pm 0.23 \times 10^3$	$2.25 \pm 0.23 \times 10^6$
C. $2.96 \pm 0.02 \times 10^7$	$2.02 \pm 0.04 \times 10^3$	$1.66 \pm 0.06 \times 10^4$	$2.12 \pm 0.38 \times 10^3$	$1.35 \pm 0.68 \times 10^6$

Note:

THBC:Total heterotrophic bacteria count,VCC:Vibrio cholera count,

SSC: *Salmonella-shigella* count, ECC: Escherichia *coli* count, FC: Fungal count.

Table 3: ANOVA; Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Column 1	28	876.933	31.31903571	5608.279684
Column 2	28	852.84	30.45857143	4283.038522
Column 3	28	820.328	29.29742857	3282.569192

ANOVA

Source of Variation	*SS*	*Df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	57.63843831	2	28.81921915	0.006562805	0.993459211	3.109310548
Within Groups	355694.9598	81	4391.295799			
Total	355752.5982	83				

3.2 Discussion

3.2.1 Physicochemical Properties

The results of the physicochemical analysis (Table 1) showed that the pH, Biochemical oxygen demand, Chemical oxygen demand, Total hardness, Sulphate, Phosphate, Chloride, Potassium, Calcium, Magnesium, Manganese, Nickel, Total dissolved solids, copper, Zinc, Alkalinity Electrical conductivity and Turbidity fall within WHO and NSDWQ permissible limits while Dissolved oxygen, Ammonia, Total suspended solids, Iron and temperature exceeded the permissible limits set by WHO and NSDWQ.

pH: The pH is a measure of acidity or alkalinity of a solution. The pH range from 0 – 14. A pH of less than 7 in water sample signifies acidity of the water while a pH of more than 7 signifies that the water is alkaline. A water sample with pH of 7 on the other hand signifies neutrality of the water sample. The values of pH in the present study ranged from 5.10-5.92(Table 1) which implies that the water samples are acidic. The acidic nature of the water could be as a result of acidic metabolites. The result of water in alkaline state tends to be better than acidic water owing to the fact that minerals such as calcium can be absorbed by the body up to 30% easier from water than from food. Healthy minerals are got in alkaline water while toxins such as mercury can be absorbed from acidic water (Wynn *et al.,* 2009).

Dissolved Oxygen

Dissolved oxygen refers to the amount of oxygen dissolved in water. Oxygen finds its way into the water as a result of diffusion from the surrounding air as a waste product of photosynthesis through aeration (Kumar and Puri, 2012). In the present study, dissolved oxygen values ranged between 7.61-13.42 mg/l (Table 1).Hence, the values exceeded the permissible limits of 7.5mg/l set by WHO .The high values of dissolved oxygen could be as a result of water movement at the air-water interface increasing the surface available for oxygen absorption in surface water. This in turn brings about an increase in pollution load of the River. This finding is in agreement with similar study by Ugwu et al. (2016).

Ammonia

Ammonia in the environment emanates from metabolic, agricultural and industrial processes. The presence of Ammonia in water indicates possible sewage, bacterial, and animal waste pollution. The values of ammonia in the present study ranged from 12.41mg/l to 20.60mg/l.

The permissible limit of ammonia concentration for groundwater and surface water are usually below 1 mg/litre. Hence, the values exceeded the permissible limit set by WHO for domestic water use. The high level of ammonia in the samples could be attributed to the decay of organic waste discharged in the River which in turn increased the pollution load.

Total Suspended Solids

These are organic and inorganic solid materials which are suspended in water. It is an indicator of water pollution. Total suspended solids in the samples were in the range of 80mg/l to 101mg/l. The values exceeded the permissible limits for WHO. The high value of total suspended solids could be as a result of direct discharge of effluents into the River which increased the pollution load of the River.

Iron

Iron is known as the fourth most abundant element in the earth's crust. Owing to its prevalent nature in the earth's crust, it reaches higher concentrations in sediments and water than other trace metals. Deficiency of iron causes fatigue and anaemia in humans. However, excess quantity of it in water brings about deposits of sediments. In the present study, the values of iron ranged from 10.58mg/l to 38.07mg/l. These values exceeded WHO and NSDWQ standards of 0.3mg/l.

Temperature

Temperature is an important parameter in water chemistry owing to its effect on water. At higher temperatures, the rate of chemical reactions increases. From the analysis, sample A fall within the permissible limits of WHO and NSDWQ while samples B and C exceeded the limits. This could be attributed to increased nutrient load emanating from industrial discharge.

3.2.2 Microbiological Properties

The results of the microorganisms isolated from the water samples are shown in Table 2.

Total heterotrophic count

The total heterotrophic count ranged from $2.93 \pm 0.02 \times 10^7$ to $2.96 \pm 0.02 \times 10^7$ cfu/ml. The water samples from mechanic workshop recorded the highest level of count $2.96 \pm 0.02 \times 10^7$ cfu/ml whereas; the water samples from effluent discharge point had the least bacterial count of $2.93 \pm 0.02 \times 10^7$ cfu/ml. The water samples from 200m downstream of the River had bacterial count of $2.94 \pm 0.01 \times 10^7$ cfu/ml (Table 2). The heterotrophic bacteria counts of all the samples were generally high in the sense that they exceeded the standard permissible limit of 1.0×10^2 cfu/ml stipulated for drinking water (WHO, 2004).

The results of the present study are in conformity with similar researches by other researchers who found out that the sources of heterotrophic bacteria present in water are from

runoffs, pasture, sewage, other unhygienic practices as well as animal and human wastes (Edema et al., 2001; Ibe and Okplenye, 2005; Kiman-Murage and Ngindu, 2007).

Runoffs, sewage, agricultural wastes are usually high in organic matter and nutrients, and could cause increase in the microbial flora of the water bodies thereby resulting in high heterotrophic bacteria counts (Obire and Aguda, 2004).

***Vibrio Cholerae* Count**

Vibrio cholera count of water samples ranged from 2.00 ± 0.06 x 10^3 to 2.10 ± 0.04 x 10^3cfu /ml with sample A having the lowest value of 2.00 ± 0.06 x 10^3 cfu/ml while sample C had 2.02 ± 0.04 x 10^3cfu/ml. All the water samples in the present study exceeded WHO recommended limits of (0cfu/100ml) for domestic water supply.

***Salmonella Shigella* Count**

Salmonella shigella count of the samples were in the range of 1.66 ± 0.04 × 10^4 to 2.15 ± 0.43 × 10^4 cfu /ml. Sample A had the highest Salmonella shigella count of 2.15 ± 0.43 × 10^4 cfu /ml. All the water samples in the present study exceeded WHO recommended limits of (0cfu/100ml) for Salmonella shigella in water used for domestic purposes.

***Escherichia Coli* Count**

Escherichia coli is an indicator of faecal pollution in water samples. It is an example of faecal coliform. *Faecal coliform* bacteria refer to a collection of relatively harmful microbes which live in the intestines of cold and warm blooded animals usually in large numbers. The presence of *faecal coliform* bacteria in water is an indicator that it is polluted with faecal material from either man or animal. The *Escherichia coli* count of the samples were in the range of 2.12 ± 0.38 × 10^3 to 2.83 ± 0.33 × 10^3 cfu /ml with sample A having the highest value of 2.83 ± 0.33 × 10^3 cfu /ml while sample C had the least value of 2.12 ± 0.38 × 10^3 cfu /ml. All the water samples in the present study exceeded WHO recommended limits of limits of (0cfu/100ml) for *E. coli* concentration in water used for domestic purposes.

***Fungal* Count**

Fungal count was in the range of 1.35 ± 0.68 × 10^8 to 2.25 ± 0.23 × 10^6 cfu /ml. All the samples studied are polluted as evidenced by its non-conformity with WHO standards.

3.3 Test of Significance

The results of physiochemical analysis obtained were subjected to statistical analysis using Analysis of Variance (ANOVA).The result of one way ANOVA (Table 2) showed that there was no statistical variation of physicochemical parameters between the upstream, mid-stream and downstream as evidenced by p>0.05(Table 3). This implies that the all the samples both upstream, midstream and downstream have the same physicochemical properties statistically. Hence, the degree of pollution of the river is independent of the place and method of collection.

4.0 CONCLUSION AND RECOMMENDATION

The results of the physicochemical parameters of water samples collected from Aba River in Abia state showed that the pH, Biochemical oxygen demand, Chemical oxygen demand, Total hardness, Sulphate, Phosphate, Chloride, Potassium, Calcium, Magnesium, Manganese, Nickel, Total dissolved solids, copper, Zinc, Alkalinity Electrical conductivity and Turbidity fall within WHO and NSDWQ permissible limits while Dissolved oxygen, Ammonia, Total suspended solids, Iron and temperature exceeded the permissible limits set by WHO and NSDWQ.

On the other hand, the results of all the microbiological parameters of the water samples studied exceeded WHO/NSDWQ permissible limits for domestic water use.

The test of significance on the physiochemical parameters using ANOVA single factor indicated that there was no significant difference between sample A, sample B and sample C. The results obtained from the water samples therefore signify Aba River is polluted and not fit for domestic purposes.

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