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Assessment of Water Quality and Degradation in Relation to Anthropogenic Activities: A Case Study of River Benue, Jimeta-Yola, Adamawa State, Nigeria

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ABSTRACT

The paper assesses the water quality of the River Benue in Jimeta and in relation to human activities. The study assesses three different stations and conducted several interviews, observations and laboratory procedures to assess physiochemical properties of the water. Assessing water quality involved collecting water samples from each of the three sampling units. Laboratory test were further conducted which included PH and coliform tests. Secondary data was used to investigate the concentration of heavy metals and other physiochemical properties. Activities were observed and recorded in each of the units; interviews were also carried out to attain general data on the activities in each of the units. Water quality in each of the three sections was assessed successfully. None of the three sampling units had water sample that is permissible for drinking or any related process that involves ingestion of the water. To be more specific, results showed that although water sample from Jimeta dumpsite was neutral, it exhibits the property of high concentration of metals and coliforms. The paper concludes that water sample from Jimeta dumpsite has the highest level of contamination. Nevertheless, activities were more intense at the Jimeta Bridge compared to the other two sites. However, it is recommended that the Adamawa State Government and related organizations should integrate quality management with the quantity of water within a comprehensive, decentralized and participatory management system and also conduct a risk assessment in order to advance possible solutions to associated risks.

Keywords: *Assessment, water quality and degradation, anthropogenic, River Benue*

INTRODUCTION

The Environment plays an important role in the life of individuals including both plants and animals and therefore keeping the environment in a good shape is an obligation for the present generation. For that reason, it is fundamental so as to take care of our environs and assist nature retain ecological equilibrium accordingly so as to offer to the approaching generations the environment as we found it, if not any better. During the current earlier period there has been a bunch of harm to the ecology. Soil, water and air have been unhygienic and there appears to be no important conclusion to it. Water, which is an essential component of life has been over exploited and degraded over the years due to several factors of which human activities contributed the most. Most importantly rivers, lakes and other water bodies have been polluted

to the point that they don't support the life of organisms living in them. Industrial pollution, chemical fertilizers from runoffs and polluted water from households are few among many. The scientific development and quick industrialization has taken its charge. Construction of dams, use of water for agricultural and industrial purposes and climate change has caused extensive depletion of natural water bodies. It is being thought by most people that water is constantly going to be available because it is in abundance in many parts of the world. But it has been proven that although water is sometimes considered as a renewable energy source, it can be completely depleted even faster than it is being replenished resulting to droughts. Also, climate change contributes most to the reduction of water quantity which further results to drying up of lakes and rivers.

Statement of problem

In Nigeria, as in most developing countries, water quality is generally deteriorating, especially aroundurban areas. Population growth, and industrial expansion are generally not managed by appropriate standards and enforcement of infrastructures such as sewer systems and water treatment plants is not done (Meybeck et al. 1989). Quality of river is modified mainly through human activities; such include discharge of domestic waste from households in the river, deposition of agricultural waste such as organic matter, carbon, nitrogen and phosphorus compounds, dumping of industrial waste such as trace elements and complex organic compounds. Recently, high concentration of zinc was observed in one of the tributary streams of Ogun Riveraround the Midgal industry. Zinc concentration rose from 0.3 mg/l to 7.4 mg/l in just three months, which is almost five times higher than the permissible level in drinking water. Activities around the river bank such as washing of vehicles, grazing, bathing and other human related events contribute to the decrease in water quality. Increase in atmospheric temperature and altered weather patterns have contributed a lot to water scarcity over the years. Precisely, water is highly evaporated primarily due to global warming that is caused by formation of greenhouse gases. Other activities that result to depletion of river water include; irrigation, industrial use, domestic use and abstaining from considering alternative sources.

Aim and objectives

The study to be conducted aims to investigate various forms and sources of degradation and depletion of river Benue as a result of human activities. Specific objectives are:

- To conduct a PH and coliform test in order to assess water quality

- To assess the physical properties of the water (color, coagulating particles, turbidity, hardness)
- To investigate the major activities that that result to degradation and depletion of the water
- To provide possible solutions and recommendations that will improve the state of the water

Hypothesis

- Water sample taken from the area where human activities are persistent will contain more contaminants than the sample from the area where there is less activity.
- The water from the river will be experiencing more degradation than depletion as a result of human activities.

Study Area

Adamawa is a state located in northeastern Nigeriawith a land mass of 36,917km2 and it is inhabited with3, 737,223 people. The state was established in 1991 and it is well known for its variety of tribes. Yola (Jimeta) is the capital of adamawa and is located between Longitudes 12° 26' E and Latitude 9° 16' N along the banks of River Benue, it also has an estimated population of 600,000 people. The state covers the Sahel region of the country and normally experiences two main seasons which are the dry and wet. This region also experiences low rainfall and humidity, but temperature is usually extremely high resulting to high evaporation rate. Jimeta is a town in adamawa state which lies on the south bank of the Benue River, and on the highway between Zing and Girei. Jimeta was united withYola in 1935 by the Fulani administration. The town became a major point of transporting goods through river Benue in yola. During rainy season when the water level is high, boats transport goods like groundnut oil, mats and slippers to places like Cameroon and chad. River Benue which was formally known as the river Chadda is the longest tributary of river Niger. The length of the river has been estimated to be1400 km (870ml) and it covers some areas of west Africa including the Adamawa Plateau of northern Cameroon, the town of Garoua and Lagdo Reservoir, Nigeria south of the Mandara mountains, Jimeta, Ibi, Makurdi, Lokoja, Gongola River, Mayo Kébbi, Logone River, part of the Lake Chad, Taraba River and River Katsina Ala.

Figure 1: Map showing the River Benue drainage basin

The paper focuses on three different areas of the river in Jimeta, Adamawa State. These include Jimeta Bridge, Adamawa State Water Board and Adamawa Major Dumpsite. These three different parts of the river have different characteristics and activities and therefore the nature of the water varies. The Jimeta bridge area is known to be the major point of transporting goods to neighboring countries such as Cameroon and chad, other activities includes irrigation and fishing. The Adamawa State Water Board treats water from the river Benue and supplies it to different part of Jimeta. Lastly, the dumpsite area is usually dry during summer and filled up during raining season. During dry season, the area is used as a major dumping site in Jimeta. Nevertheless, streams of the river water can still be found during dry season that is less extensive.

A Brief Literature review

Water (H2O) is the most abundant compound on earth and it makes up the earths water bodies including streams, oceans, lakes, river and aquifers. Water is commonly referred to as a universal solvent covers 70% of the earth's surface and makes up 55% to 78% of the human body (Hoffmann, 2004). Unless affected by a foreign substance or an element, water is

known to be colorless, odorless and tasteless.

The unique properties exhibited by water makes it vital for the survival of all living organisms on earth from the early stages of life to more developed stages. With water availability, life has become easier for humans to explore and develop their environment and also to satisfy their basic needs. Water is used by humans for various purposes including, irrigation, industrial purposes, domestic use, and source of energy, transportation, recreational and environmental activities. Water on earth is broadly classified into two different categories which are ocean water and fresh water, ocean water covers 71% of the earth surface while freshwater accounts for only 2.5% (Hoffmann, 2004). Ocean water is characterized to be salty in nature and therefore humans depend less on it compared to freshwater that has less than 1% salinity (Jackson, 2006). Earths freshwater which is unevenly distributed makes up the streams, lakes, rivers, glaciers, aquifers etc. Of these sources, only river water is generally valuable although small percent of it makes up the total freshwater on earth. Since the past four decades, settlements have faced consistent challenges caused by droughts, water pollution and water quality degradation (Navjot S. Sodhi, 2004). Increase in population density, economic growth and industrial development have resulted to the increase in river water demand, as well as several forms of water quality deterioration (Chun et al., 2001; Wong and Wong, 2003).Rivers have been known to be the most important source of freshwater for our ancestors and yet present evolving human activities are still dependent upon them. River water is used in various aspects of human life including agriculture, Industry, transportation, aquaculture, public water supply etc. However, large chunks of waste from industries, untreated sewage and agricultural lands can end up in the rivers, which may result to water quality deterioration (Ravindra, 2003).Urban rivers are more prone to pollution mainly due to their exposure to many pollution sources like domestic wastewater discharge points, industrial effluent discharge points, and solid-waste disposal sites. Where urban agriculture is practiced, agricultural lands are an additional source of pollution to urban rivers (Kaseva, 2005). Degradation of urbanrivers in industrialized nations have special concerns because of poor pollution control, inappropriate activities, lack of regulations and compensation and the mentality of not taking responsibility of environmental protection. Another factor that contributes to the high level of urban river degradation is the population density in urban areas which results to more dependence on the river. The most common form of river water degradation in developing

countries is eutrophication, which is referred to as the presence of excess nutrients in the river as a result of discharge from industries, agricultural lands and other urban sources of waste. Eutrophication boosts the growth of algae which increases bacterial activity. The end product of this which is hypoxia is the most threatening to the survival of living organisms in the water.

MATERIALS AND METHODS

The paper investigates forms of degradation and depletion of water from River Benue required both laboratory analysis of water samples and assessment of activities that influence the water quality. Assessing the water quality and the influence of human activities involved visiting three different sites of the river in Jimeta which were; Adamawa state water board (AWB), Jimeta Bridge (JB) and a major dumpsite in Jimeta (DJ). The target populations required to assess the human activities that influence the river water degradation and depletion were individuals that had permanent jobs at the river banks, those that transport goods to neighboring countries and the employees of Adamawa state Water Board. A total of 5 individuals that fitted the category of the target population were involved in the study. At each site, water sample was taken and few people were interviewed around the areas. With the help of the Geology lab technician (Josiah Samuel) at the American University of Nigeria (AUN), some information was attained with the aid of observing activities that were going on. The samples that were taken were further analyzed at the biology lab of AUN; analysis included assessing properties of the water which were pH level, water color, coalition of particles and coli form count tests. In summary, the study investigates activities that affect the river water quality and assessed the physical and chemical properties of the water samples from different locations. Assessing water quality was conducted to see if the activities going on around the river contribute to the river degradation and depletion. However, factors such as climate change that are not direct human activities were excluded as part of the determinants. Different areas were selected to understand the correlation of human activities and the water quality. To be more precise, selecting siteswere based on different extents of human activities that have impact on the water both negatively and positively.

Data Collection

Two different sites that were involved in the study were directly observed to note the various activities that were going on, these werethe Jimeta Bridge (JB) and the Jimeta major dumpsite (DJ). A checklist was used to record the activities and how they affect the river. At the Adamawa state Water Board, a

tour round the facility was taken with the guidance of an intern (Suleiman), this involved explanation of how the river water is manipulated and the mechanical processes involved. Four individuals were interviewed to attain more detailed analysis of activities that affect the river. All the four respondents were the supervisors of different activities, 2 were from the Jimeta Bridge area and 1 from each of the other two areas. Due to the different activities in the three locations, questions for the interview varied for each respondent. Results from similar studies conducted to assess the water quality were used to attain some data. Some of them included concentration of heavy metals and physiochemical properties for the three different sampling stations.

Laboratory Analysis

Coliform tests were conducted to check for any form of fecal contamination in the water sample, the test was done by providing a suitable environment for the microorganisms to develop and form colonies, thereby becoming visible for further analysis. Materials that were used included: Beakers, eosin methylene blue agar, distilled water, river water samples, laboratory plates, pipette, incubator, autoclave machine, forceps, Membrane filter, Hydrion papers, ethanol, syringe and gloves.

PH Test

PH of water samples was tested separately in order to assess the level of acidity or alkalinity of the water. This was done using two different procedures which were Hydrion paper PH test and the PH sensor technique.

Analysis of physical properties

This was a simple procedure that did not require the use of any technical equipment. Physical properties that were observed included color of water samples, particles in present in water samples, odor of water samples and water clarity assessment. All of these were done by just observing physically.

RESULT AND ANALYSIS

Table1: Results from PH test

WATER SAMPLE	PH VALUE (PH sensor)	PH VALUE (Hydrion paper)
JB	8.90	9.00
AWB	6.24	6.47
DJ	7.36	7.00

Source: Field work at River Benue, Jimeta

Table2: Results from coliform test

WATER SAMPLE	COLIFORM COUNT
JB	50+
AWB	10+
DJ	200+
NOTE: Specific bacteria coli form was Escherichia Coli, others include PseudomonasAeruginosa	

Source: Field work at River Benue, Jimeta

Name of site	Availability of river water at site	Description of activities	Pollutants at site	Effect of activity on the river	Preventive measures at site
Jimeta bridge	Always available although water level varies with climatic conditions	Vehicle washing, intensive fishing, exporting of groundnut oil and mats, grazing, urine and feces deposition	Detergent, petrol and diesel from vehicle parts, groundnut oil, petrol from boats, potash, urine and feces	Potash used for vehicle washing contributes to intensive fishing, pollution of the river with diesel, petrol and groundnut oil.	Police stations and custom services are available but not effective in terms of degradation control
Adamawa state water board	Always available although water level varies with climatic conditions	River water excavation, purification of river water, maize cultivation	Fertilizer and manure from agricultural activities, Chemicals used for water purification	Possible deposition of excess nutrients from fertilizer. Deposition of metals and other chemicals in the river	None observed
Jimeta dumpsite	Not available during dry season but during rainy season, water covers all dumpsite.	Vegetable planting, dumping of waste	Nitrate and phosphorus from fertilizer, pollutants from dumpsite	Eutrophication of river tributaries. Burning in dumpsite may produce toxic chemicals which may affect organisms in the river.	None observed

Table 3: Data from direct observation

Source: Field work at River Benue, Jimeta

Table 4: Physiochemical properties of JB, AWB and DJ

Parameters	**Sample sites**		
	JB	**AWB**	**DJ**
Temperature (^{0}c)	17.9 ± 1.5	21.8 ± 2.1	28.0 ± 0.9
Conductivity	204.4± 8.4	239.0± 7.4	1326.0±67.2
Dissolved oxygen	14.7±0.4	14.9±3.5	13.6±1.3
Nitrate (mg/kg)	10.7±0.4	16.8±0.9	55.84±1.2
Total suspended solids	942.0±1.8	222.9± 31.8	1061.0±70.0

Table 5: Concentration of heavy metals in JB, AWB and DJ

Heavy Metals	**Concentration in 3 sampling stations**		
	JB	**AWB**	**DJ**
Fe	0.065±0.07	0.12±0.1	0.326±0.1
Zn	0.067±0.02	0.0002±0.001	0.119±0.06
Mn	0.023±0.004	0.0004±0.0002	0.089±0.05
Cu	0.005±0.002	0.0008±0.0001	0.056±0.023
Cd	0.004±0.00	0.0005±0.0001	Nil
Cr	0.027±0.02	0.0006±0.0001	0.026±0.001
Pb	0.0007±0.0001	0.0023±0.000	0.0002±0.00

DISCUSSION

Among the three sections of the river that were studied, Jimeta Bridge was assessed to have the most intense activities along the river banks which included washing of vehicles using potash, detergents and soaps, feces deposition, transporting of goods etc. As it is seen in table 3, Potash used for vehicle washing contributes to intensive fishing; there is also pollution of the river with diesel and petrol usually from vehicle parts and the boat engines.Activities at the Adamawa State water board have the least effect on the river because most of the activities are carried out within the facility and not along the river banks. However, workers plant crops such as maize and fertilizers are used; this may result to deposition of excess nitrates into the river. Lastly, anthropogenic activities at the DJ sampling station include dumping of waste and cultivation of vegetables. Considering the fact that water is usually not available during the dry season, degradation of the river water is determined by the amount of rain that falls. To be more precise, the area has to be filled up with water to cover up the whole dumpsite and deposit the waste to other sections of the river.

Looking at the coliform count which is an important aspect of water quality assessment, a simple agar technique

was used to check if coliforms were present in the water samples. Based on the results, all three water samples produced coliforms after the test. However, not all coliforms are considered to be pathogenic but a previous research that was conducted by Dr. Tyndall from the American University of Nigeria showed that *Escherichia Coli* and *Pseudomonas aeruginosa* were present in water sample taken from the Jimeta Bridge. The presence of *Escherichia Coli* in JB water sample shows that there is fecal contamination of the water. This microorganism can be responsible for causing diarrheal diseases in people that ingest the water. *Pseudomonas aeruginosa* can result to severe blood infections especially in people with a weak immune system; it can also result to pneumonia. On the other hand, coliforms from the other two sites (DJ and AWB) cannot be concluded to be pathogenic. However, coliform count was highest in the DJ water sample with 200+ counts while AWB had the lowest with just 10+ counts. This shows that water at Jimeta dump site is highly contaminated compared to the other areas; this was expected because the fact that the area is covered with waste materials from the dumpsite makes the water prone to contamination. The JB water sample which produced 50+ coliform counts shows that there is less contamination of the water compared to the DJ water sample but is more contaminated than that of AWB. This was also expected because the Jimeta Bridge had more activities around the area than the Adamawa State Water Board. The level of acidity and basicity in the water samples were assessed using a PH sensor and the Hydrion paper technique. Two different techniques were used to test the PH of the samples so as to ensure the accuracy of the figures. Results show that the water from Jimeta Bridge is slightly basic, that of Adamawa State Water Board is acidic and that of Jimeta dumpsite was a neutral. The average PH of JB sample was 9; this may be due to activities that involved the use of soap around the area. To be more precise, soap is primarily made of Sodium Hydroxide which is basic in nature. The water sample from the Adamawa state water board had an average PH of 6; this could possibly be due to excess deposition of acidic chemicals during the purification process. Lastly, the DJ sample exhibits a neutral PH property as it is shown in the results section. The availability of water must have affected the PH because water sample was taken during the dry season. In other words, pollutants from the dumpsite did not affect the little water that was available because there was no rain to move the pollutants to where the water was. Nevertheless, this may vary depending on the magnitude of rainfall.

The mean concentrations of physicochemical quality parameters of

the three samples as shown in table 4 indicated elevated levels of turbidity and total suspended solids probably due to flooding and anthropogenic activities. Nitrate concentrations at in all the three sampling units are also elevated above maximum permissible limit set out by WHO Standard. Table 2 presents the mean concentration of heavy metals recorded at each of the three sampling stations. The ranges of Fe recorded are (0.065 – 0.326mg/l) with station JB the lowest and DJ the highest. Sources of Fe that areobvious in river water might be from weathering processes of soil formation, municipal drain water, leachate from refuse dump sites which are discharged into river water bodies. Zn is one of the most common elements in the earth crust that are found in various component of air, soil, food and water in the environment which plays active role in the enzymatic reaction. The range of Zn in this study is 0.0002 – 0.119mg/l with sample DJ recording the maximum value while sample AWB the least. The mean Zn concentration of (0.263mg/l) was relatively low compared to the standard limits of 5.0mg/l (FME) and 3.0mg/l (WHO) for drinking water (Emeshili and Egboh, 2007). Mn is one of the essential nutrient elements required for the growth and wellbeing of plants and animals. Water body containing excessive level of Mn may impair objectionable staining properties on cloth washing operations. Mean concentration of Mn in the water samples was 0.037mg/l with DJ having the highest value and AWB the least. The value recorded in this work is below the maximum permissible limit set out by the WHO. Generally, most of the metals that were examined in all the three stations are present in permissible quantity when compared to the standards proposed by the WHO and FME. However, it was reported from a similar research that the occurrence of high levels of concentration of Cd, Cu, Cr and Pb at seven other sampling units is a source of serious concern to public health using the river water. Also results from similar studies show that heavy metals concentrations in the river water are in the following trend, Mn > Zn > Cu > Fe > Cd > Cr > Pb. Public sensitization of the water users is required in orderto protect and safeguard public health.

Table 6: Comparison of results from all the sampling units Highest>Average>Least

Factors to be compared	Sampling units		
	Jimeta bridge	**Adamawa state water board**	**Jimeta dumpsite**
Intensity of activities	Highest	Least	Average
Coliform count	Average (50+)	Least (10+)	Highest (200+)
PH level	Highest (basic)	Least (acidic)	Average (neutral)
Concentration of heavy metals	Average	Least	Highest
NOTE: The table is showing a general overview but specific factors such as concentration of each metal may vary in each sampling unit. Other physiochemical properties also vary in each sampling unit, however result from Jimeta dumpsite showed the highest temperature, conductivity, nitrate concentration and total suspended particles.			

CONCLUSION AND RECOMMENDATIONS

The general water quality of the whole of River Benue cannot be concluded to be poor or excellent because the river extends to a reasonable number of states in the country and therefore three sampling stations from Jimeta cannot be used to conclude. Nevertheless, water quality in each of the three sections was assessed successfully. None of the three sampling units had water sample that is permissible for drinking or any related process that involves ingestion of the water. Also, the presence of pseudomonas aeruginosa in the water sample from Jimeta Bridge shows that infections can occur through dermal absorption. The result does not support the first hypothesis which states that water sample taken from the area where human activities are persistent will contain more contaminants than the sample from the area where there is less activity. The result which opposes this statement shows that Jimeta bridge area has more anthropogenic activities but Jimeta dumpsite has more contaminants. Looking at the second hypothesis which states that water from the river will be experiencing more degradation than depletion as a result of human activities, the results for this study doesn't show any form of depletion in all the three areas. Climate change was the major factor that contributes to the change in water level which is not directly linked with the activities around all the three areas. Generally, water quality in all the three sampling units was poor with DJ

sample being the poorest in quality. Although some contaminants were present in low concentrations and below the permissible limits proposed by the WHO and FME, these areas are highly vulnerable to degradation from anthropogenic activities. Therefore, the paper recommends that the Adamawa state government and related agencies should implement the following:

- Integrate quality management with the quantity of water within a comprehensive, decentralized and participatory management system
- Conduct a risk assessment and investigate the possible solutions of associated risks
- Inform the primary dominants of the affected areas on the potential outcomes of their activities
- Specific to Jimeta dumpsite, the waste management agency of the state should find alternative sources of waste disposal

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