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The Impact of Human Water Exploitation on Physico-Chemical Characteristic of Mmubete River in the Niger Delta, Nigeria

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ABSTRACT

The physico-chemical properties of water samples from five sampling stations at Mmubete River were monitored for a period of two months with the aim of determining its suitability for human consumption. The establishment of the five study stations was based on flow pattern and the activities at each sampling station. The stations are: upstream and point of minimal pollution. 200m downstream and spot used for sand dredging. 400m downstream and point for car wash. 600m downstream and point of direct discharge of abattoir wastes and 800m downstream and point of manual dredging and close to where slaughtered animals are washed. The study investigated the presence of Coliforms and other physico-chemical characteristics defining the suitability of the water for drinking according to World Health Organization standard for drinking water. Results were compared with World Health Organization limit for safe drinking water. The variation in some physico-chemical parameters appears to be closely related to the activities at the sampling stations. The results showed higher levels of turbidity (97.5 NTU); Biological oxygen demand was 102 mg/l, Total Coliform was 846 CFU/100ml. These higher levels were attributed to human activities taking place in the river. The level of dissolved oxygen at the five stations was very low with an average of 0.9 mg/l and this can be a potential risk to fish and other aquatic organisms. The values of some physico-chemical parameters were above the acceptable limit which suggests possible negative consequences of water pollution and poses risk to human health and therefore not suitable for human consumption without treatment.

Keywords: *Mmubete River, Physicochemical Characteristics, Water Exploitation*

1. INTRODUCTION

There is scarce supply of clean water by the government to households in semi urban towns, such as Eleme in the outskirt of Port Harcourt in Nigeria. As a result people use the rivers for their water supply. The characteristics of any water body could be an indication of its pollution level [1]. Generally, the presence of disease causing organisms in water supply can cause serious health problems. The problem of water pollution and need to characterize water quality of a river especially when used for domestic purposes has been investigated by other authors [2, 3]. In addition, the importance of downstream use (mainly drinking, fishing) has been recognized as important in determining the amount and concentration of pollutants allowable in any receiving water body [3, 4]. This need has necessitated this study due to the use of the Mmubete River which is mainly for drinking and fishing purposes.

The Mmubete River is in Eleme local government area of Rivers State, Nigeria. The Niger Delta is located in the Atlantic Coast of Southern Nigeria with a coastline of about 450km which ends at Imo River entrance. The Mmubete River can be described as a black freshwater. It runs through some semi-urban communities like Alesa, Agbonchia and Eleme communities in Eleme Local Government Area. The river drains through some swamps and empties into the Woji creek in the upper Bonny River estuary [5]. Kadafa [6] in his paper described Nigeria as having two large Rivers, the River Niger-Benue and the Chad River. He further described several rivers as channeling directly into the Atlantic Ocean while all other flowing waters flow into the Chad basin or into the lower Niger to the sea eventually.

Urbanization and industrialization in Port Harcourt (the economic hub of Niger Delta) have contributed to a high cost of living and so people tend to move to semi-urban areas where housing is more affordable. However, lack of portable water is one of the challenges faced by the local residents in such areas.Indiscriminate dumping of domestic waste into rivers is a common practice among residents of semi urban towns in the Niger Delta region [1]. This arises due to lack of any effective and efficient waste management system. The Mmubete River is one of such water bodies that receive effluent. Also, lack of drainage systems in semi-urban areas and local communities has favored surface runoff and discharge of untreated waters into rivers [7]. The authors reported that most rivers in the Niger Delta region are used for multi-purposes due to lack of adequate water supply. The communities use the same water source for both drinking and bathing. Most times, the public latrines are sited on the river bank and such practice contaminates and pollutes the river. Sometimes, the same river used for domestic needs are also used for other unwholesome activities such as sand dredging and discharge route for abattoir wastes. Odeyemi and Ogunseitan [8] identified the problems of water pollution in the Niger Delta region as originating from both fecal and petrochemical sources. Water pollution has affected the traditional economies of the people from the region such as declining productivity in commercial fishing.

As a result of this trend, subsistence fishing is gradually taking over.

Daramola [9] studied the physical, chemical and bacteriological characteristics of borehole water samples in Odo-oro Ekiti, Nigeria and reported the water as odourless, slightly acidic and has no taste. He concluded that though the physical and chemical characteristics conform with the WHO specification, the high bacteria count is beyond the limit making the water unacceptable as a potable water unless special water treatments is carried out [9]. Based on the concentrations of the physico-chemical parameters, Gideon et al [10] found that the Okura River is potable. This water also has some presence of anions such as nitrate and sulphate which indicated the presence of some unwanted substances in the river [10]. Several other researchers [11-19] have carried out similar studies to investigate the quality of water in different regions. To date, there is no data on the influence of human activities such as dredging and slaughtering on the Mmubete River.

Dredging of sand and slaughtering of livestock are the most prominent businesses done at the Mmubete River. Therefore, there is need for constant monitoring of the river due to human activities in and around it. This study, therefore aims at bridging this gap by monitoring the physio-chemical properties of Mmubete River in order to assess the impact of human water exploitation on the water quality and the likely health implications of such water to the users.

2. MATERIALS AND METHODS

2.1 Description of the study area

Eleme is located in Rivers State of South-eastern Nigeria. It is around 25km due East of Port Harcourt, the capital city of Rivers State. On the South-eastern Nigerian map, Eleme can be found between the coordinates 7E and 8E, 4N and 5N. Investigation of the physical, chemical and bacteriological characteristics of water samples were done for a better understanding of the pollution situation and characteristics of the river. Five sampling stations were established with a spacing of about 200m between each sampling station in the study area. The study stations were based on flow pattern and the activity at each sampling station. The sampling stations are: Upstream and point of no or minimal pollution; 200m downstream and point of dredging; 400m downstream and point of car wash; 600m downstream and point of direct discharge of abattoir wastes; and 800m downstream and point of manual dredging and close to where slaughtered animals are washed.

2.2 Sample collection and tests

Samples were collected between October (wet season) and November (dry season), 2009 from the 5 sampling stations. This was done three times in a month. These two months mark the end of rainy season and start of dry season in Nigeria respectively. The sampling depth was about 10cm and plastic bottles were used to collect water samples for physico-chemical analysis and dark stoppered biological oxygen demand (BOD) bottles were used for BOD samples. The physiochemical parameters were determined using standard methods adapted for the examination of water and wastewater [21]. The instruments used were calibrated according to the manufacturer's specification. The parameters measured were: pH, total dissolved solids (TDS), turbidity, five day biological oxygen demand (BOD_5), temperature, dissolved oxygen (DO) and fecal Coliform.

The pH was measured in situ with the use of a portable pH meter (model DSPH-1 BUS). The pH level for the samples were determined in situ, the meter was calibrated prior to use with buffer solutions of pH 4, 7 and 10 of known calibration standard. The probe of the meter was dipped into the sample at all the flow stations and values obtained as displayed on the screen of the equipment. TDS were determined using Conductivity/TDS meter (model Cyberscan Con 20). TDS in the effluent samples were measured with the use of the meter which was calibrated prior to use with distilled water and a set of calibration standards according to manufacturer's specification. The probe of the meter was dipped into the sample and TDS values obtained as displayed on the screen.

Turbidity was determined by using a turbidity meter (HACH model 2100P) with a range of 0–800NTU. The Biochemical Oxygen Demand (BOD_5) was determined in accordance with APHA 5210B. Dissolved oxygen was measured at the start and end of incubation period. Samples were incubated at 20^{o}C for five days in the dark. The BOD was computed from the difference between initial and final DO. This was carried out using the Winker's Titrimetry/Dilution Method

Ambient surface water temperature and DO was measured in situ using a mercury-in-glass thermometer and HACH DO meter respectively. For the ambient surface water temperature, the bulb of the thermometer was dipped approximately 10cm below the water surface for measurement of the water temperature. The probe was rinsed with distilled water and calibrated accordingly. Total hardness levels of the samples were determined by titration with standard EDTA as titrant and Erichrome Black T as indicator. The standard Most Probable Number (MPN) was used for the estimation of the fecal Coliform present in the water sample [20]. A single strength MacConkey Broth (Difco) medium was prepared according to the manufacturer's instruction by dissolving 35g of MacConkey Broth powder in 1litre of distilled water in a conical flask. The mixture was stirred and heated slightly to dissolve. Nine milliliter (9ml) of the mixture was dispensed into some test tubes, each containing inverted Durham tubes. The test tubes were shaken to fill the Durham tubes with broth, in order to ensure that no gas bubbles was trapped. The test tubes were covered with cotton wool and then, aluminum foil. They were left in the autoclave for 15 minutes at a temperature of 121^{o}C. On cooling, they were aseptically inoculated at different dilution factors; 1 in 10 and 1 in 100 dilutions of the stock sample, using sterile pipettes. Each of these dilutions was inoculated into 5 replicate tubes for the entire five stations and the tubes were incubated at 37^{o}C for 24hours, after which the number of positive results identified, and the Most Probable Number (MPN) of Coliform organisms in 100ml of the sample computed with reference to McCrady's probability table. The positive test shows the production of acid (detected by a change in color from reddish purple to yellow) and gas collected by the presence of air bubbles in the Durham tubes.

Four physico- chemical parameters and three biological parameters were determined from the five sites over a two-seasons, raining (October) and Dry (November). Table 1 summarizes the acceptable limits of WHO standards for all the parameters tested.

Table 1: WHO Standard for safe limits of the measured parameters [21]

Parameter	WHO Standard
pH	7.0 – 8.5
Temperature(°C)	No specification
TDS(mg/L)	500mg/ℓ
DO(mg/L)	3.0 - 7.0mg/ℓ
Turbidity(NTU)	10NTU
BOD_5 (mg/L)	0
Total Coliform (CFU/100ml)	0

3.1 pH and temperature

pH ***(Potential d'Hydrogene)*** is an important indicator of the water quality in any aquatic environment. usually Generally referred to as the measure of the concentration of hydrogen ions in the water. This measurement indicates the acidity or alkalinity of the water and affects both biological and chemical reactions such as solubility and metal toxicity. pH values of below 7, 7 and above 7 indicate acidity, neutrality and alkalinity respectively. The pH of unpolluted streams is neutral or slightly alkaline. The pH at upstream was 7 in October. At 200m DS the pH reduces to 6 as acidic and remained within the same range up to 600m DS, while a pH of 6.4 was recorded at the 800m DS. As the dry season set in, the pH at the upstream reduces to 6.7. The same trend was recorded from 200m DS to 800m DS. In general the upstream pH for both seasons are higher when compared to the downstream values recorded, perhaps as a result of minimal pollution at this point Figure 1. In general the pH of the different sampling stations falls within 6 except at the upstream area. Thisis a concern given the river serves as drinking water supply to the local residents as well as being used for domestic purposes. The measured temperature is a reflection of the sampling seasons. Temperature affects movement of gases in water as higher temperature results in the decrease of solubility of oxygen and vice visa. When a river is low in dissolved oxygen it will affect fishes and other aquatic life. The temperature of the river in wet season was lower than the temperature at the beginning of the dry season as shown in Figure 2. The range of temperature for October was 25.6^{0}C to 26.8^{0}C, while that of November was 27.9^{0}C to 29^{0}C. The average annual temperatures of 31°C for dry season have been reported [1], probably due to the intensity of heat in the region during the dry season.

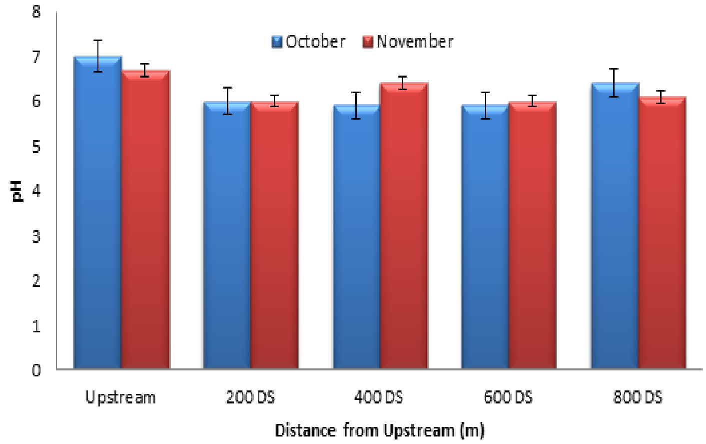

Figure 1: Effect of pollution on pH of the River

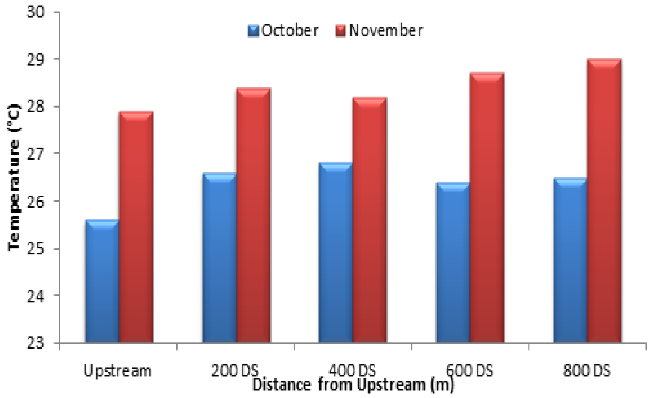

Figure 2: Effect of pollution on temperature within the sampling stations

3.2 Turbidity and TDS

High levels of total dissolved solids affects biological life in aquatic system because of increase in biological oxygen demand which depletes the dissolved oxygen. As observed in the present study, the turbidity was high and ranges from 21.1 to 97.5 NTU in comparison to WHO safe limits for drinking water of 10NTU (Figure 3). The high levels of turbidity observed in the Mmubete River could also affect fish and other aquatic life due to obstruction of light [1]. This will result to declining fish production. In addition, if the local farmers rely on fish for their source of protein then it becomes a health concern. Declining fish production will indirectly lower their income and invariably affect their traditional means of livelihood. The levels of TDS were in the range of 9 to 99.2 mg/L. Figure 4 shows that the TDS upstream was much lower than the other four locations downstream which give an idea of the pollutant load of the River. The high TDS for all the sampling stations during the dry season can be linked to low tide in the dry season and this could influence the water level and perhaps result to low dilution. However, high tide is experienced during rainy season, and could lead to more dilution of dissolved matters.

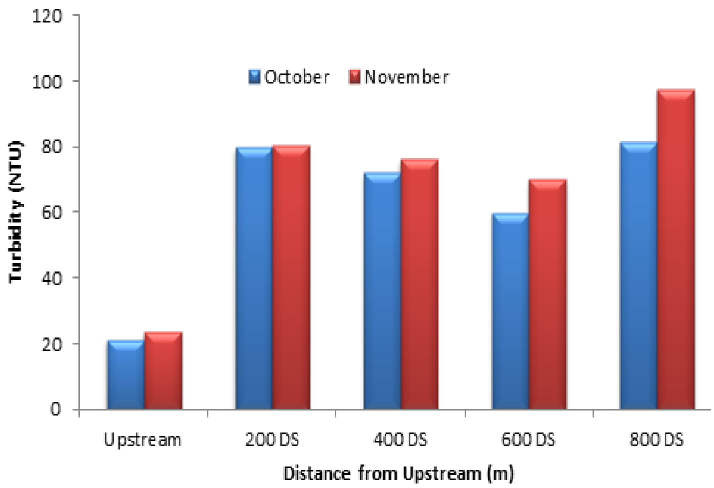

Figure 3: Effect of pollution on Turbidity of the River

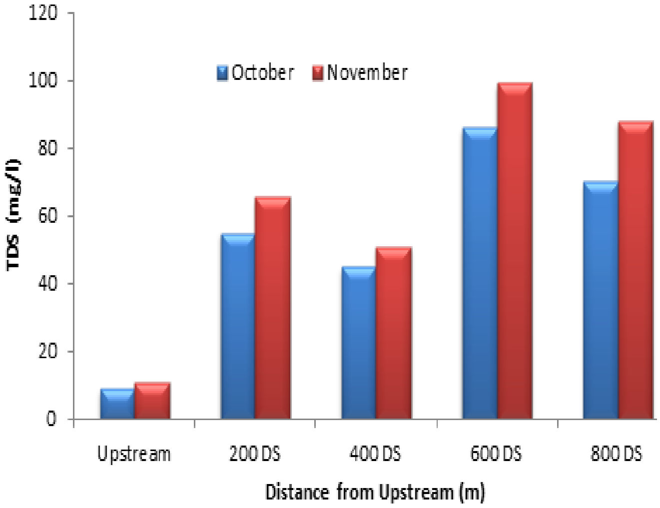

Figure 4: Effect of pollution on TDS of the River

3.3 BOD$_5$ and DO

BOD is an indication of organic pollutant in the River and therefore affects water quality. The presence of biodegradable materials in water body can be related to the availability of dissolved oxygen because oxygen is needed for the breakdown of these biodegradables. Though, there is no given standard on the preference of water quality assessment indices, dissolved oxygen and biological oxygen demand is among the common indices used. The BOD$_5$ recorded for all the stations ranged from 52.4 to 102mg/L which is very high when compared with WHO safe limits for drinking water of 0 mg/L. The BOD$_5$ value at 800m DS in the month of November was the highest (102 mg/L) and was due to slaughtering and washing of animals. These activities released highly biodegradable materials into the river.

BOD$_5$ has been used as an alternative measurement in determining the degree of organic pollution of water [3, 22]. The current WHO recommendation for cleanliness of a stream has used BOD$_5$ as a measure on the basis that 0 mg/l is considered very clean; 2mg/l is clean, 3mg/l fairly clean, 5mg/l doubtful and 10mg/l bad. The results show that Mmubete River is not clean for drinking.

The high BOD (Figure 5) would have contributed to the very low DO (Figure_6) observed during the two months of sampling in all the stations. The DO ranged from 0.18 mg/L to 1.8 mg/L against WHO limit of 7mg/L. This suggests that human activities downstream of the Mmubete River greatly influenced the water quality of the river. The low DO could also be unsafe for the survival of fish and other aquatic organisms as it is far below the 5 mg/L required for the survival of fish [1]. The traditional economy of the local people in the region is fish farming. It is expected that, any drop in fish productivity will affect their income and standard of living.

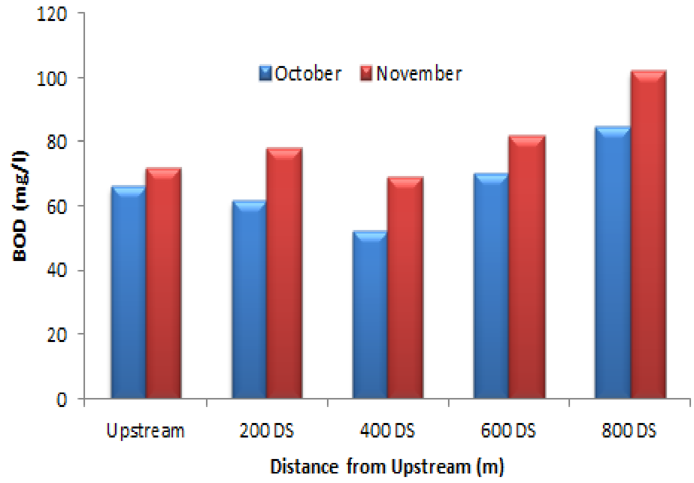

Figure 5: Effect of pollution on BOD of the River

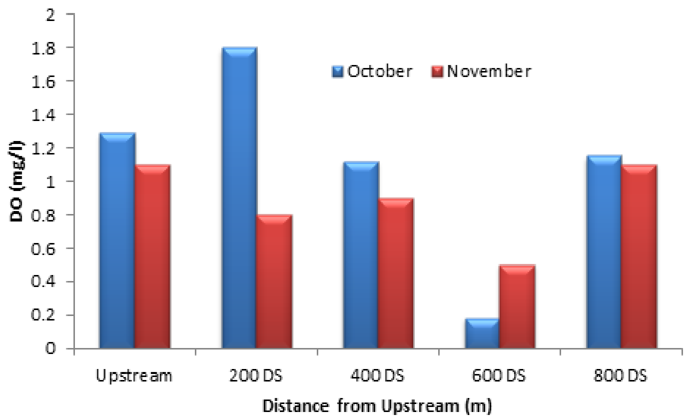

Figure 6: Effect of pollution on DO of the River

3.4 Total Coliforms

The result of the Total Coliforms shows that there was a rapid increase in the presence of Coliform from upstream to 800m DS. Figure 7 shows that Total Coliforms were highest in November at 600m DS and 800m DS with values of 846 CFU/100ml and 794 CFU/100ml respectively as against the WHO safe limit of zero Coliforms [22]. This is not far from expectations as the two areas are used for discharge of abattoir wastes and washing of slaughtered animals. The presence of Coliform has a number of negative implications on human health. Fecal Coliform has been implicated in water related diseases such as typhoid fever, diarrhea and dysentery [7]. Fecal Coliform in water body indicates recent contamination by human or animal faeces. It is believed that pathogenic microorganisms will be present in the water body due to such pollution. Presence of fecal Coliform affects humans' more than aquatic organisms. In their investigation on the water

quality of a different river in the Niger Delta region observed fecal Coliform in the three sampling zones to be higher than the acceptable limits and attributed the presence of fecal Coliforms to fecal pollution caused mainly by inadequate/poor waste management common in the region.
Occurrence of Coliforms is key issues in relation to quality of drinking water. Usually the Coliforms inhabit the gastrointestinal region and by itself do not necessarily spell much trouble. However, they could be passed out with pathogens and so their presence is an indication that pathogens (disease causing organisms) could as well be present. Given the Mmubete River does not undergo any form of water treatment before consumption, makes it more worrisome so the need for treatment to improve the water quality of the river cannot be overemphasized.

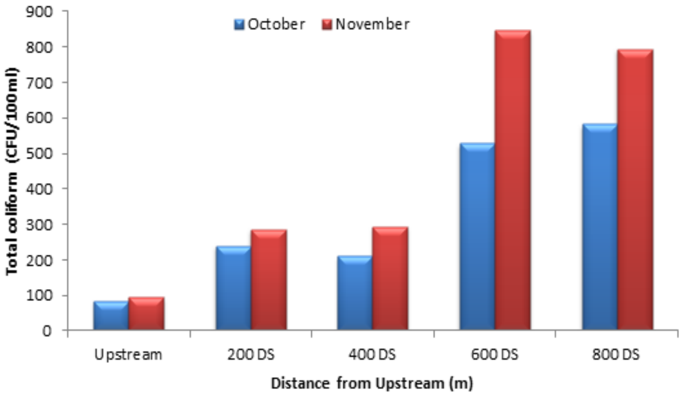

Figure 7. Effect of pollution on total Coliform count of the River

4. CONCLUSIONS

The physico-chemical parameters of Mmubete River were evaluated from approximately 800m from the upstream towards downstream waters. The Results show that temperature, TDS, turbidity, BOD_5 and total Coliforms were higher in the month of November than in the month of October. This variation might be as a result of dilution effect on the pollutants as October marks the last month in wet season and November marks the beginning of dry season. Izonfuo and Bariweni [1] reported similar results from their investigation on physico-chemical parameters of the Epic Creek in the Niger Delta region of Nigeria and stated that the mean values of some physico-chemical parameters were higher in the dry season than in the rainy season. The values of the physiochemical parameters do not fall within the good-quality range. It can be concluded from the results that the indiscriminate human activities in the Mmubete River have significant effect on the water quality and therefore not safe for human consumption. The study could help the government in making right judgment with respect to pollution control.

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