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Assessment of Some Physicochemical and Microbial Properties of Sawdust Polluted Creek

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ABSTRACT
This study is carried out to assess some physicochemical and microbial properties of sawdust polluted creek of Owhase, in Udu local government area of Delta State, Nigeria. The water samples were collected for both dry and wet seasons, covering a total period of four (4) months. Water samples were analyzed for pH, temperature, electrical conductivity (EC), total dissolved solid (TDS), turbidity, total suspended solids (TDS), acidity, dissolved oxygen (DO), Biochemical oxygen demand (BOD), chemical oxygen demand (COD), Salinity as chloride, nitrate, sulphate, phosphates, cations (Ca, Mg, Na and K), total coliform count-bacteria. Finding from this study revealed that the Owhase creek is contaminated with sawmill activities and such pollutants are beyond the tolerant limit of the Federal Ministry of Environment, Department of Petroleum Resources, and Standard Organization of Nigeria. Hence, there is need for collaboration among government agencies, communities and industry stakeholders to review anthropogenic and industrial activities around the region in order to effectively combat creek pollution.

Keywords: Creek, Microbial, Physicochemical, Pollution, Sawdust

INTRODUCTION

Owhase community is a unique community known for its wood processing plant that terminates to the open creek. A creek is a narrow, sheltered waterway, especially an inlet in a shoreline or channel. It is widely contaminated with pollutants and it is a concerning environmental issue that can have serious consequences for both the ecosystem and human health (Mmolawa, *et. al.*, 2011; Irerhievwie and Akpoghelie, 2015; Okoh, *et. al.*, 2015). Along the coast line are several anthropogenic and mini industrial activities that terminate on the water body, hence altering the physico-chemical properties of the aquatic. Pollution in creeks can come from various sources, including industrial discharge, agricultural runoff, urban storm water runoff, and improper waste disposal (Akpoghelie, *et. al.*, 2021). Common pollutants found in contaminated creeks include: Chemical Pollutants - these can include heavy metals (e.g lead, mercury, cadmium); pesticides, herbicides, and industrial chemicals. According to (Wu and Zhang, 2010; Okoh, *et. al.*, 2015; Akpoghelie, *et. al.*, 2015; Ali, *et. al.*, 2005), these substances can have toxic effects on aquatic life and can accumulate in the food chain; Nutrient Pollution - excessive nutrients like nitrogen and phosphorus from fertilizers and sewage can lead to water quality problems such as algal blooms, which deplete oxygen and harm aquatic ecosystems; Sediment - erosion from construction sites, agriculture, or deforestation can lead to excess sediment in creeks, clouding the water and burying aquatic habitats; Pathogens - contaminated creeks may contain harmful bacteria, viruses, and other pathogens from sewage and animal waste, posing risks to human health if the water is used for recreation or drinking; Plastic Pollution - Plastic debris, including micro plastics, can enter creeks and rivers and have a detrimental impact on aquatic life; Oil and Hydrocarbons - Spills or runoff from roads and parking lots can introduce oil and other hydrocarbons into creeks, which can be toxic to aquatic organisms (Okoh, *et. al.*, 2015; Akpoghelie, *et. al.*, 2015; Ali, *et. al.*, 2005). The contamination of creeks can lead to a range of negative consequences, including harm to aquatic life (Ali, *et. al.*, 2005), water quality degradation, loss of biodiversity, human health risks and economic Impact (Audu and Lawal, 2005; Darko, *et al.*, 2022). This review of existing knowledge on water pollution due to sawmilling and wood waste generation in Nigeria aims to establish a relationship between the production of wood materials in the sawmill and deterioration of the environment with a focus on surface water

qualities in particular. The objective of this study is to review the effects of sawmill activities around Owhase creek and to proffer ways to mitigate surface water pollution.

MATERIALS AND METHODS

Collection of Water Samples

The water samples were collected for both dry and wet seasons, covering a total period of four (4) months. The wet season sampling was carried out in May and July, while the dry season sampling was carried out in October and December. These samples were collected at the point of discharge of the sawmill wastes into the river (known as Point Source – PS), and also at 100m before the point of discharge (known as Upstream Sample – US), and 100m after the point of discharge (known as Downstream Sample – DS). The control samples were collected at about 1km away from the study area. All the samples collected were geo-referenced using Global Positioning System (GPS). The samples for physicochemical parameters were collected into 2 litres pre-sterilized bottles. The sampler wore rubber gloves sprayed with ethanol. The sampler held the bottom of the sample container with the open end of the sample bottle directly facing the river and submerged at the water surface. While taking the water samples, the river was ensured not disturbed. In-situ analysis like pH, temperature, total dissolved solid, electrical conductivity, dissolved oxygen and turbidity were carried out on the field, while other physiochemical and microbiological parameters analysis of the water sample were determined in the laboratory in accordance with Standard Test Methods. The filled water sample bottles were preserved in an icepack, and were transported to the laboratory for other analysis. The water sample bottles were inverted many times to thoroughly mixed and were split to fill several smaller 250 cm^3 Nalgene, wide mouth screw capped sterilized bottles aseptically prior to analysis.

Physicochemical and Microbial Analyses

pH

The pH of the sample water was measured with a Fisher Scientific AB15 pH meter (Pittsburgh, PA) in accordance with Standard Method 4500-H + (APHA, 2017). Sample water was poured into a small clean beaker from the 250 cm^3 sample bottle after inverting several times. The pH meter was calibrated before use with 4, 7, and 10 pH buffers. The pH probe was then placed in the sample and the value read from the digital readout of the calibrated pH meter.

Temperature

The temperature was determined using electrometric Hanna Temperature Meter. 50cm3 of water sample was poured into 100cm^3 plastic beaker, the meter was powered-on and the probe of the meter was inserted into the sample for the reading.

Electrical Conductivity

An Electrical Conductivity Meter (HANNA) was utilized for the measurement using APHA 2510 B method.

Total Dissolved Solid

Total dissolved solids (TDS) were determined using a Pre-calibrated Extech Instrument, following the method of APHA 2510B. The meter probe was dipped into the sample and left for about 3 minutes for equilibration before the reading was recorded. TDS was reported in mg/l.

Turbidity (NTU)

The turbidity was measured using a Hach Model 2100N Laboratory Turbidimeter (Loveland) and in accordance with Standard Method APHA 2130B. Sample water from each site was poured into a clean, oiled turbidity vial after the sample bottle had been inverted several times. The turbidity vial was filled to the white line, gently inverted several times, and placed into the turbidimeter (making sure to align the white arrow on the sample cell to the white line on the turbidimeter). A measurement was obtained by waiting 15 seconds, watching the digital readout on the turbidimeter for 30 seconds and determinizing an average reading. Two replicate measurements were recorded for each sample.

Total Suspended Solids

Total Suspended Solid was determined using filtration technique (APHA 208D). The millipore filter paper was weighed as *X* mg. The TSS filtration assembly was in place, and the millipore filter paper was properly placed. The filter paper was held tight with the aid of the clamp. Then, the water sample was vigorously shaken, and 250 cm^3 of the water sample was measured, and transferred into the filtration flask. Then, the filtration commenced with the aid of filtration pump, after which filter paper was carefully removed and put in the oven for drying for about 30 minutes. It was transferred straight into a desiccator, and the filter paper plus the recovered solid was weighed as *Y* mg. Thus, it was calculated using equation (1):

$$TSS\ (mg/l) = \frac{(Y - X)\ x\ 1000}{Vol.of\ Sample} \qquad (1)$$

Acidity

The determination of acidity in water samples by titrimetry (ASTM D1067) was used. Acidity of water is its quantitative capacity to react with a strong base to a designated pH. Hydrogen ions present in a sample as a result of dissociation or hydrolysis of solutes react with additions of

standard alkali. Acidity thus depends on the end point pH or indicator use.

Dissolved Oxygen (DO)

Dissolved Oxygen was determined using the Winkler method. A standard DO bottle was used. The bottle was filled with water sample making sure that bubbles were not trapped. 2cm^3 of $MnSO_4.5H_2O$ was added and 2cm^3 of alkaline-iodide solution was also added. It was thoroughly mixed by rotating and inverting the bottle several times. The precipitate was allowed to settle, then 1cm3 of sulphuric acid was added, and gently mixed. Then, 100cm^3 of the sample solution was measured into the conical flask and 2cm^3 of starch indicator was added, and titrated against 0.0125N of NaS_2O_3. $5H_2O$. The end point was carefully observed and recorded by colour change from straw yellow to colourless. Thus, it was calculated using equation (2):

$$DO\ (mg/l) = \frac{8.0\ x\ vol.of\ titrant\ x\ 0.0125\ x\ 1000}{Vol.of\ Sample} \quad (2)$$

Biochemical Oxygen Demand (BOD)

The determination of Biological Oxygen Demand (BOD5) (APHA 5210B) involves the measurement of the dissolved oxygen used by microorganism in the biochemical oxidation of organic matter in the water or waste water. The test is vital because it determines the approximate quantity of oxygen that will be required to biologically stabilize the organic matter content present. The sample to be analyzed is diluted in a BOD dilution water and kept in the dark at a temperature of 20 ^oC for five days at the end of which the dissolved oxygen left is determined and the BOD calculated from the initial BOD and the final BOD of the diluted sample taken into cognizance the dilution factor of the sample.

Chemical Oxygen Demand (COD)

Chemical Oxygen Demand (COD) was determined using Open Reflux Method (APHA 508). After 0.4g Hg_2SO_4 was placed in a 250cm^3 conical flask, 20cm^3 of the water sample was added, followed by 10cm^3 of 0.25N $K_2Cr_2O_7$ solution and 20cm^3 of Conc. H_2SO_4 containing Ag_2SO_4. The mixture then undergoes gentle shaken for a period of 10minutes. Then, the mixture was refluxed for about 2hrs, cooled after which 100cm^3 of distilled H_2O was added and then allowed cooled to room temperature. The excess dichromate was titrated with standard $Fe(NH_4)_2(SO_4)_2$ using 2-3 drops of Ferroin indicator and the COD is calculated as in equation (3).

$$COD(mg/l) = \frac{(a-b)c\ x\ 8.000}{Vol.of\ Sample} \quad (3)$$

Where; a = cm^3 Fe $(NH_4)_2(SO_4)^2$ used for blank (distilled H_2O)

b = cm^3 Fe $(NH_4)_2$ $(SO_4)^2$ used for sample

c = Normality of Fe $(NH_4)^2$ $(SO_4)^2$

Salinity as Chloride

Salinity refers to the total amount of soluble salts dissolved in a kilogram of water collectively. The burette was filled with 0.01 N $AgNO_3$, solution. Few drops of 5% potassium chromate solution were added to 10 cm^3 of the water sample in a conical flask. The water samples were titrated against the $AgNO_3$, solution and a brick red colour indicating the end point for the titration. The Titration continues until the concordant values are obtained and the outcome recorded as equation (4).

$$Chloride(Cl^-) = \frac{35.5\ x\ C_b\ x\ V_b\ x\ 1000}{Vol.of\ sample} \quad (4)$$

Where: C_b = Concentration of $AgNO_3$ (Normality)

V_b = Volume of $AgNO_3$ (Consumed)

Nitrate

The brucine method for nitrate determination in water (ASTM D 3867) was used to determine the nitrate concentrations. 50.0cm^3 of filtered water sample was measured into an evaporating dish, and evaporated to dryness. After cooling, 1.0cm^3 phenol disulphonic acid was added. The content of the evaporating dish was transferred into 50cm^3 volumetric flask with 25-35cm^3 of distilled water. 4.0cm^3 of ammonium hydroxide was added to develop the yellow colour, and diluted to a volume with distilled water. The blank was also carried out. Then, the yellow colour of the sample against the reagent blank was measured with a spectrophotometer at 410nm. Then, the concentration of Nitrate-Nitrogen was observed from the calibration graph.

Sulphate

Sulphate in the water sample was determined using the gravimetric Method with Ignition of residue principle. 250 cm^3 of the water samples were added into a conical flask and the acidity adjusted with HCl from 4.5 to 5 using a pH meter or the orange colour of methyl red indicator. Then additional 1 to 2cm^3 HCl was added and heat to allow to boil while stirring gently, barium chloride solution was slowly added until precipitation appear to be completed. Then add about 2 cm^3 in excess. The precipitate was placed along with filter paper in a crucible after finding its empty weight and dry it. The crucible was placed in a muffle furnace and ignite at 800°C for 1 hour before cooling in a desiccator and weighed. To find the weight of the barium sulphate precipitate, the precipitate was digested at 80°C to 90°C preferably at night but for not less than 2 hours. And then, the content was filtered into the flask through an ashless filter paper. The precipitate was washed

with small portion of warm distilled water until the washing is free of chloride as indicated by testing with silver nitrate-nitric acid reagent.

Phosphates

The APHA 425C method was used for the determination of phosphates concentration in the sample water. 40cm^3 of sample was poured into 50-cm^3 volumetric flask. 40cm^3 of distilled water as a blank was also poured into another flask. 8cm$_3$ of mixed reducing agent was added to both flasks, and diluted to 50cm^3 with distilled water. It was mixed and allowed to stand for ten minutes. The absorbance of the sample at 880nm was measured and recorded. From the calibration graph, the number of microgrammes of phosphate equivalent to the optical density of the test and blank solutions was read. Thus, the amount of phosphate in the sample was calculated. The result was expressed as milligrammes of phosphate as P, per litre of sample.

Cations (Ca, Mg, Na and K)

The cations in water samples were analyzed using AAS Method (APHA 301). 100cm3 of sample was treated with 25cm^3 of neutral 1.0N CH_3COONH_4. It was stirred for 15 minutes and filtered. Calcium (Ca), Magnesium (Mg), Sodium (Na) and Potassium (K) were determined from the filtrate by Atomic Absorption Spectrophotometer.

Total Coliform Count- Bacteria

The presence of total coliform organism was determined in water samples using Most Probable Number (Multiple Test-Tube –APHA 9222A) Method. Mac Conkey broth was prepared following manufacturer's prescription. Autoclave was used to sterilize the medium, apparatus and other materials for 15 minutes at 121^{0}C. Then, the sterilized coliform bottles were orderly arranged in 3 sets of 5 bottles each. Thereafter, 9cm^3 of the prepared broth was dispensed in each bottle. Then, the serial dilution was made from 1cm^3 of the sample into 9cm^3 of sterilized distilled water, and dispensed into each set of the bottles with 1cm^3, 0.1cm^3 and 0.01cm^3 dilution strength. It was mixed by gentle agitation. Then, the durham tubes were inverted and inserted into the solution bottles and properly covered. The sample solution bottles were incubated at 370C for 24 hours, after which colour change was observed, and recorded using Standard MPN Mc Crady's Statistical table.

Feacal Coliform Bacteria (E. Coli)

Once the fecal coliforms were counted and recorded, the filter membrane was aseptically transferred from the Petri dishes containing m-FC to identically labeled Petri dishes containing nutrient agar with MUG. The transfer was done by lifting the membrane on the m-FC plate by the edge with flamed forceps and lowering the paper into the new Petri dish on top of the nutrient agar with MUG, making sure no air bubbles were under the filter paper. The location of each of the fecal coliforms was then marked on the cover of each Petri dish. This was done so that the fecal coliform and background colonies could be differentiated when counting the E. coli colonies, as all colonies take on a beige appearance after incubation on nutrient agar with MUG. Following the membrane transfer, the Petri-dishes were placed upside-down into a 35ºC incubator for 4 hours ± 20 minutes. The Petri dishes were then taken out of the (Westbury, New York) was held over the Petri dish. The number of colonies that fluoresced under the light were counted and recorded as E. coli. Once all of the counts were recorded, the plates were autoclaved in a biohazard bag and disposed of.

RESULTS AND DISCUSSIONS

Temperature (ºC)

Figure 1 shows the graphical representation of temperature recorded at the study areas. The study revealed that water temperature greatly depends on ambient conditions and amount of heat absorbed by the water body. The atmospheric temperatures of Udu River for both wet and dry seasons had mean values of 26.00^{0}C and 28.90^{0}C (for Point Source), 26.25^{0}C and 28.80^{0}C (Downstream), 26.15^{0}C and 28.80^{0}C (Upstream), while control had 26.00^{0}C and 28.65^{0}C for wet and dry seasons respectively. The temperature had standard deviation values of 2.05, 1.80, 1.87 and 1.87 for PS, DS, US and Control respectively. The recorded temperatures were due to the climatic weather condition at different sampling seasons (Taofeek, *et. al*., 2012; Mtunzi, *et. al.*, 2015; Akpoghelie, 2017). According to (Agbaire, *et. al*., 2016), temperature higher than 15ºC facilitates the development of microorganisms and at the same time intensifies the organoleptic parameters such as odour, taste and so, activates chemical reactions.

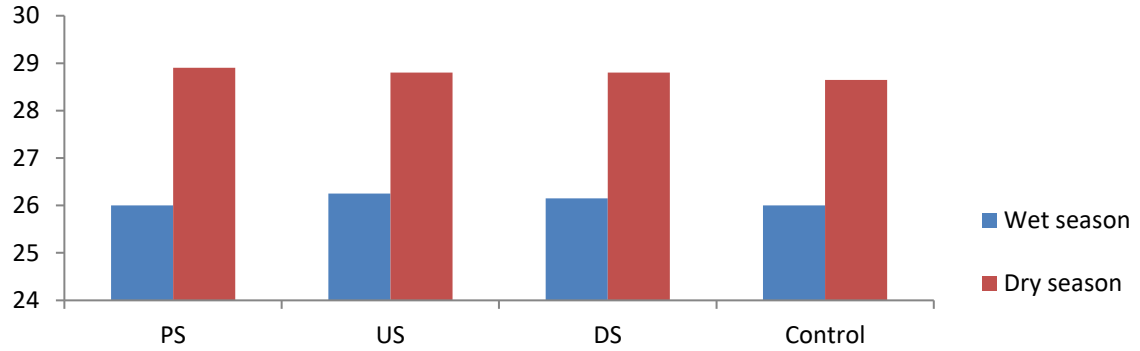

Figure 1: Seasonal Temperature of the study areas in comparison with the Control

Hydrogen Ion Concentration (pH)

It is the concentration of hydrogen ion in the water. The pH value of water denotes the reciprocal of log of hydrogen ion concentration, and is determined with the aid of a potentiometer or pH meter. pH is an indicator of the existence of biological life as most of them thrive in a quite narrow and critical pH range (Agbaire, *et. al*., 2016). The pH of water affects the solubility of many toxic and nutritive chemicals. As acidity increases, most metals become more water soluble and toxic (Ali, 2010). For this study, the ±atmospheric temperatures of Udu river for both wet and dry seasons had mean values of 8.30 and 7.06 (for Point Source), 8.17 and 6.85 (Downstream), 7.93 and 6.51 (Upstream), while control had 7.55 and 6.33 for wet and dry seasons respectively. Meanwhile, the pH recorded standard deviation of 0.88, 0.93, 1.00 and 0.86 for PS, DS, US and Control, therefore having no significant impact. The surface water of the study areas was alkaline, while the control was found to be slightly acidic. According to (Prescott, *et. al*., 2002), the alkaline water always supports the optimal growth of microorganisms particularly bacteria. Figure 2 shows the graphical representation of pH of the study areas.

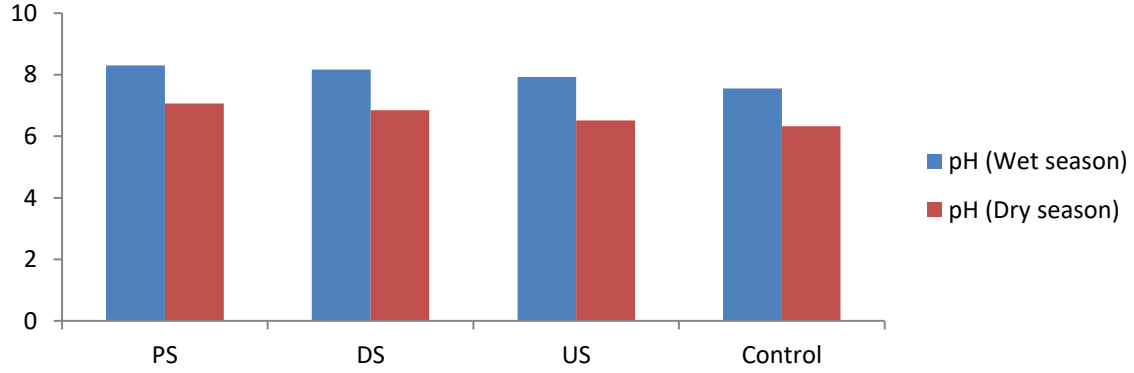

Figure 2: Surface water pH of the study area in comparison with the Control

Total Dissolved Solid and Electrical Conductivity

Electrical Conductivity is the ability of an aqueous solution to carry an electric current and it is related to the concentration of ionized substances in water (USEPA, 2014). As revealed in Fig.3, the total dissolved solid (TDS) of Udu river at different sampling points showed the mean values of 58.43±0.20 mg/l and 78.88±0.11mg/l (wet and dry season) and 55.06±0.21mg/l and 74.41±0.22mg/l (wet and dry season) for Downstream; 42.55±0.13mg/l and 58.85±0.14mg/l (wet and dry season) for Upstream; while the Control had mean values of 50.80±0.12mg/l and 68.61±0.11mg/l (wet and dry season). Similarly, the EC had mean values of 105.17±0.21µS/cm and 141.98±0.22µS/cm (wet and dry season) for Point Source; 99.10±0.11µS/cm and 133.93±0.13µS/cm (wet and dry season) for Downstream; 76.59±0.14µS/cm and 105.93±0.13mg/l (wet and dry season) for Upstream; while the Control had mean values of 91.44±0.22µS/cm and 123.50±0.22µS/cm (wet and dry season). Figure 3 shows the graphical representation of the TDS and EC of the study areas.

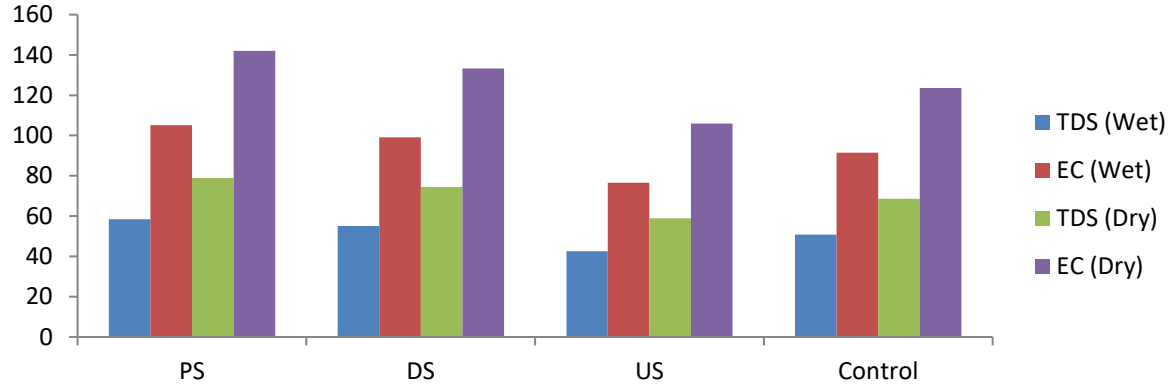

Figure 3: seasonal TDS and EC of Samples in comparison with Control

Turbidity and TSS

The American Public Health Association (World Bank, 2020; Giusti, 2009) defines turbidity as "the optical property of a water sample that causes light to be scattered and absorbed rather than transmitted in straight lines through the sample". In other words, it is how cloudy the water is. Turbidity is an important factor in mixing and transport of nutrients and waste product in water. Some organisms depend entirely on these processes for survival. From fig 4, the turbidity recorded mean values of 77.82±0.11 NTU, 65.09±0.12 NTU and 35.09±0.11 NTU for PS, DS and US during the wet season, while the dry season had 44.11±0.21NTU, 31.75±0.19 NTU, and 13.50 ±0.20NTU for PS, DS and US respectively. Meanwhile the Control sample had a mean value of 26.55±0.11 NTU for wet season and 7.74±0.11 NTU for dry season. Also, the SD values were 23.83±0.13, 23.58±0.12 and 15.27±0.11 for PS, DS and US, while the control had SD value of 13.30±0.25. This variation clearly shows that the water is turbid during the wet season and less turbid during the dry season, and more turbid in the study area than the control area. The high values recorded for the wet season was a pointer to the high nutrients which also stimulates the indigenous microbes to rapidly multiply (Orji and Ayogu, 2018). If turbidity is largely due to organic particles, dissolved oxygen depletion may occur in the water body (Guo-bing, 2013). Higher turbidity levels are often associated with higher levels of 33 disease-causing microorganisms such as viruses, parasites and some bacteria. These organisms can cause symptoms such as nausea, cramps, diarrhea, and associated headaches. Figure 4 showed the graphical representation of the turbidity level of the samples. Total Suspended Solid is the total amount of remained particles which are undissolved in water. This, however, is directly proportional to the turbidity levels of such water samples. Figure 4 revealed that the TSS of the study area had mean values of 97.50±0.18mg/l and 60.50±0.11mg/l (PS – wet and dry season); 75.50±0.12mg/l and 39.50±0.11mg/l (DS – wet and dry season); 45.00±0.12mg/l and 18.50±0.20mg/l (US – wet and dry season); and 38.00±0.20mg/l and 11.0±0.180mg/l (Control – wet and dry season). Figure 4 showed the graphical representation of Turbidity and TSS of the samples.

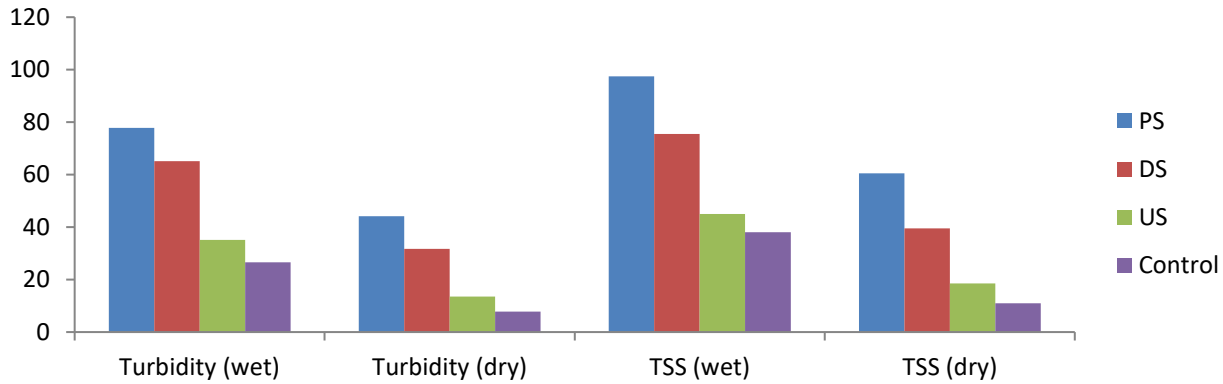

Figure 4: Seasonal Turbidity and TSS of the Samples in Comparison with the Control

Dissolved Oxygen (mg/l)

The Dissolved Oxygen which is the amount of oxygen present in the water sample at a particular time (Okoh, *et. al.*, 2015). DO is an important parameter in understanding ecosystem health as this is essential for the metabolism of aerobic organisms. For this study, the surface water recorded a mean DO value of 2.45±0.20mg/l, 3.00±0.22mg/l and 5.35±0.21mg/l (wet season), while

1.30±0.12mg/l; 2.05±0.12mg/l and 4.70±0.12mg/l (dry season) for Point Source, Downstream and upstream respectively. The control had mean values of 5.70±0.11mg/l and 4.95±0.11mg/l for wet and dry seasons respectively. The DO of the PS and DS were detected to be low, and DO below 2 mg/l will put aquatic biota in stress and eventual death. The high organic matter content into the aquatic environment can result in the depletion of oxygen in water thereby killing the aquatic organisms, as reported by (Diya'uddeen, 2012). According to the report of (USEPA, 2014), one of the adverse effects of pollution of a water body is a decrease in dissolved oxygen (DO). Decrease in dissolved oxygen is a positive indicator of water pollution. The primary reason for depletion of DO is the proliferation of oxygen-demanding aerobic bacteria. Figure.6 shows the graphical representation of DO present in study samples.

Biochemical Oxygen Demand (BOD)

The Biochemical Oxygen Demand (BOD), which is an empirical measure of the relative oxygen requirement of wastewaters, effluents and polluted waters, is a test for the amount of oxygen utilized during a specific incubation period, usually 5 days, for the biochemical degradation of organic material as well as the amount of oxygen used to oxidize inorganic material. Meanwhile, as shown in Figure 5, the Surface water samples had BOD mean values of 12.25±0.11mg/l; 9.60±0.11mg/l and 3.05±0.12mg/l (wet season), while 23.19±0.20mg/l, 17.54±0.17mg/l and 3.75±0.18mg/l (dry season) for Point Source, Downstream and upstream respectively. The control had mean values of 2.70±0.31mg/l and 3.30±0.27mg/l for wet and dry seasons respectively. BOD concentration is a pollution indicator that reveals level of organic compounds in a wastewater (Ogbogu, and Akinya, 2002). According to (Irerhievwie and Akpoghelie, 2015; Ogbogu, and Akinya, 2002) the greater the BOD, the greater is the degree of pollution. Figure 5. shows the graphical representation of BOD amount in surface water samples.

Chemical Oxygen Demand (COD)

The chemical oxygen demand (COD) is used as a measure of the oxygen equivalent of the organic matter content of water that is susceptible to oxidation by a strong chemical oxidant (Okoh *et al*., 2015). COD which is empirically related to BOD, organic carbon or organic material is a useful tool for monitoring and control of waters, either in industry or from polluted sources. This study shows a relatively moderate level of COD in groundwater, and high in the leachates (Irerhievwie and Akpoghelie, 2015; Ogbogu, and Akinya, 2002). The samples had mean COD values of 27.21±0.23mg/l, 21.32±0.22mg/l and 7.44±0.22mg/l (wet season), while 51.54±0.22mg/l, 38.97±0.25mg/l and 9.15±0.23mg/l (dry season) for Point Source, Downstream and upstream respectively. The control had mean values of 6.28±0.32mg/l and 7.68±0.33±0.25mg/l for wet and dry seasons respectively. Meanwhile, PS and DS were observed to be far higher than DS and the Control, therefore signifying some levels of pollution. Excessive level of BOD and COD in wastewater released into water bodies will reduce the level of dissolved oxygen, and low levels of dissolved oxygen can induce fish kills and reduce reproduction rates in aquatic life (Nwajei and Iwegbue, 2007; Okunola *et. al*., 2007). The graphical representation of level of COD in samples is presented in Figure 5.

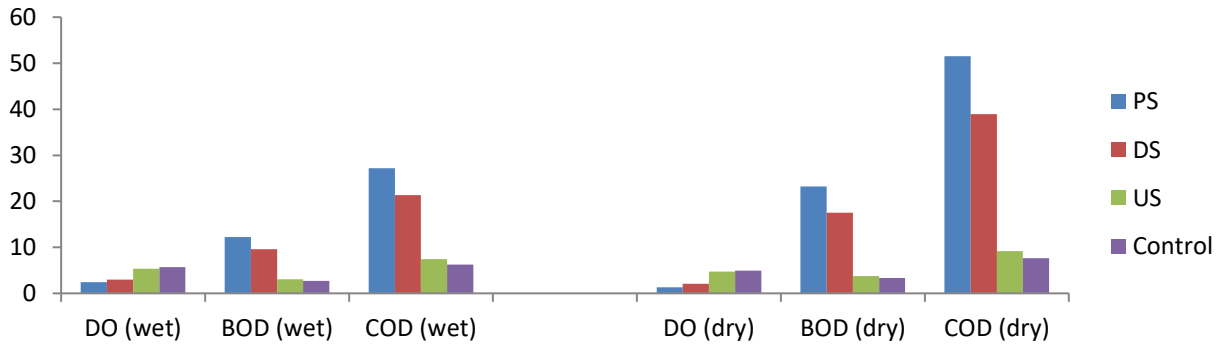

Figure 5: DO, BOD and COD of the study areas in comparison with the Control

Cations

Sodium, Potassium, Calcium and Magnesium are alkaline-earth metals in solution, and they are major cations, and form part of the nutrients. Mineral deposits constitute a primary source of calcium in water (Irerhievwie, *et. al*., 2015). As shown in Figure 6**,** the water from the study areas (PS, DS and US) had mean values of

6.63±0.12mg/l, 5.74±0.21mg/l and 3.63±0.21mg/l for Sodium (wet season), while dry season had mean values of 8.95±0.30mg/l, 7.76±0.21mg/l and 5.03±0.23mg/l. The Control had mean values of 4.13±0.22mg/l and 5.57±0.21mg/l (wet and dry seasons) for Sodium. Meanwhile, The Potassium of the study areas (PS, DS and US) had mean values of 3.04±0.11mg/l, 2.65±0.15mg/l and 1.60±0.20mg/l, with the control value of 1.91±0.15mg/l (wet season), 4.10±0.22mg/l, 3.58±0.22mg/l and 2.22±0.22mg/l, with the control value of 2.58±0.11mg/l (dry season). The dry season had Magnesium mean values of 2.40±0.12mg/l, 1.88±0.12mg/l and 1.59±0.17mg/l for PS, DS and US, with the control mean value of 2.03±0.12mg/l. Fig 6 shows the graphical representation of cations in water samples of the study areas.

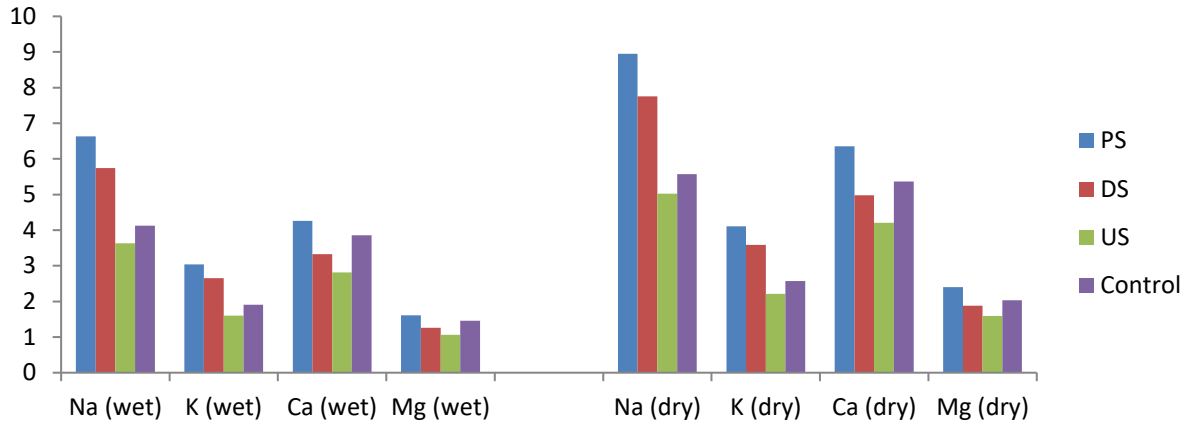

Figure 6: representation of Cations of Surface water of the Study Areas in comparison with Control

Microbial Studies

Micro-organisms are living catalysts that enable a vast number of chemical processes to occur in water and soil (Khan and Scullion, 2000; Gurung, *et. al*., 2009). A majority of the important chemical reactions that take place in water, particularly those involving organic matter and oxidation-reduction processes, occur through bacterial intermediaries. Micro-organisms are responsible for the formation of many sediment and mineral deposits. More so, presence of pathogenic micro-organisms in the environment is detrimental to health (An *et al*., 2007). Figure 7 showed the total bacteria coliform counts for surface water samples of the study areas. The results revealed that study areas had mean TCC values of 775.00 MPN/100cm^3, 580.0 MPN/100cm^3 and 215.00 MPN/100cm^3 (wet season) and 1365.00 MPN/100cm^3, 980.00 MPN/100cm^3 and 395.00 MPN/100cm^3 (dry season) for PS, DS and US. The control had mean value of 100.00MPN/100cm^3 and 165.00MPN/100cm^3 (wet and dry seasons). Similarly, fecal coliform counts (FCC) had mean values of 90.00MPN/100cm^3, 55.0MPN/100cm^3 and ND (wet season) and 190.00MPN/100cm^3, 125.00MPN/100cm^3 and ND (dry season) for PS, DS and US. The control had no detection (ND) for both wet and dry seasons. Meanwhile, the absence of Feacal Coliform (*E. coli*) in the control area was an indication that the control water was not contaminated by fecal materials. The graphical representation of total coliform count (TCC) and Feacal Coliform Count (FCC) in the surface water samples are shown in Figure 7.

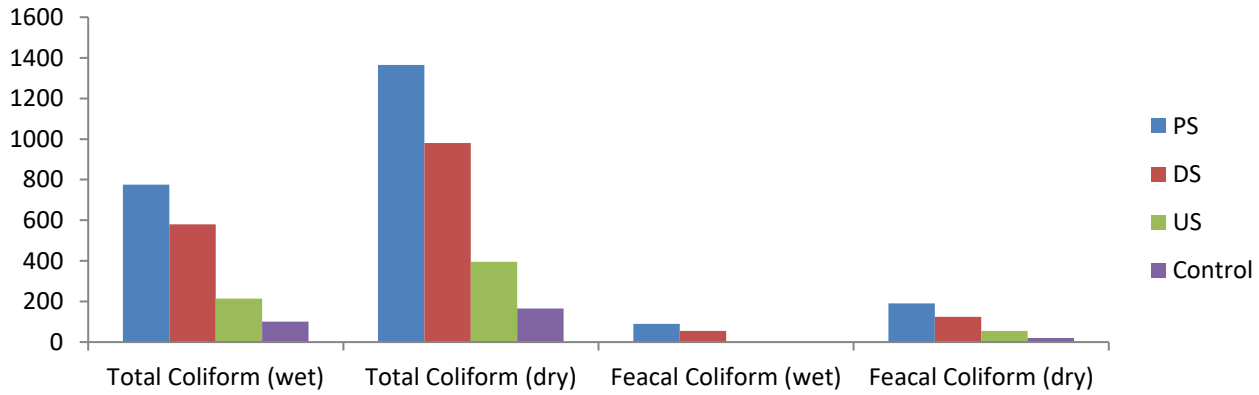

Figure 7: Microbial Load (TCC and FCC) of Samples in comparison with the control

CONCLUSION

After the various assessments of the effects of sawmill activities on the study area, it can be concluded that the Owhase creek contains pollutants that are beyond the Federal Ministry of Environment, Department of Petroleum Resources, and Standard Organization of Nigeria limits. This study further revealed that creek contamination can be addressed through the combination of regulatory measures, pollution prevention, and cleanup efforts. This may include Regulations - enforcing laws and regulations to limit the discharge of pollutants into water bodies; Best Management Practices (BMPs) - Implementing BMPs in agriculture, construction, and urban planning to reduce runoff and pollution; wastewater treatment - upgrading wastewater treatment plants to remove pollutants effectively; erosion control - implementing erosion control measures to prevent sediment runoff; community education - educating the public about proper disposal of waste, chemicals, and the importance of protecting water quality; monitoring and remediation - regularly monitoring water quality and taking action to clean up polluted areas. Hence, it's crucial to address creek contamination to protect the environment and public health and ensure the long-term sustainability of aquatic ecosystem.

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