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Assessment of the Effect of Sawdust along Coastal Waterways in Udu, Delta State, Nigeria

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ABSTRACT

Sawdust is popular among coastal land in the Niger Delta. This study was executed to assess the effects of sawdust on coastal land and water bodies along the Udu River, in Delta state, Nigeria, by examining and identifying the health and environmental implication on aquatic life; and also to identify the physico-chemical and heavy metals composition of the water samples within the study area. Sampling was carried out by collecting water samples weekly for a month at the point of discharge of the sawmill wastes into the river. The water samples were taken to the chemical laboratory were physico-chemical parameters namely pH, temperature, dissolved oxygen (DO), Biochemical oxygen demand (BOD), nitrates, sulphates, phosphates, total dissolved solid, turbidity, acidity and salinity were determined. The measurement of microbiological parameters; total coliform count-bacteria (MPN/100 mL) and heavy metal analysis were carried out on the water samples. Findings from this study revealed that the physico-chemical conditions as well as the microbial and heavy metal concentrations of the studied samples have been negatively affected due to sawmill activities which have resulted to pollution around the area. It was recommended that further analysis should be carried out to show the effect and extent of the pollution on the organisms present in the area.

Keywords: Coastal land, Heavy Metals, Sawdust, Biochemical Oxygen Demand, Dissolved Oxygen (DO),

INTRODUCTION

Saw dusts are visibly, small particles of wood produced through a tool or device for cutting, typically a thin blade of metal with a series of sharp teeth. Sawdust is a waste from wood and timber industry. It possesses firing capacities; it is normally used as a fuel source in thermal processes (biomass). It is also used as an insulating material [1]. The size of sawdust particles depends on the kind of wood from which the sawdust is obtained and also on the size of the saw teeth. About 10-13% of the total volume of the wood log is reduced to sawdust in milling operations. This sawdust generally depends largely on the average width of the saw kern and the thickness of the timber sawed [2].

The main chemical components of sawdust are carbon (60.8%), hydrogen (5.2%), oxygen (33.8%), and nitrogen (0.9%). Dry wood is primarily composed of cellulose, lignin, hemicelluloses, and minor amounts (5–10%) of extraneous materials [3].

Sawmill activities are popular in the coastal region of Delta State in Nigeria. Coastal areas are interface or transition areas between land and sea, including large inland lakes. In the field of compost science, sawdust has been referred to not only as a bulking agent but also as biomass material for the manufacture of woody compost [4]. The benefits of using sawdust as a woody biomass in compost manufacture are its favorable physical properties such as low apparent specific gravity (density), high porosity, high water retention, moderate water drainage, high bacteria tolerance, and biodegradability at an acceptable rate [4, 5]. Physical properties of sawdust can also be modified by combining the sawdust particles of various sizes in particular proportion [6-8]. This modification creates an ideal environment to remove moisture from sawdust waste efficiently, and also for aerobic bacteria to thrive and decompose waste effectively into carbon dioxide and water without generating odour.

Improvement in knowledge about the physical properties of sawdust signifies the first step for its rational utilization [9]. Sawdust, being essentially a ligno-cellulosic material, is not easily deteriorated but rather stable on recalcitrant in the environment, and rarely produces odor during its long-term biodegradation process [10]. Sawmill activity produces biodegradable wood waste which is dumped directly into the water bodies or is partially filtered at point source into the river, hence resulting to pollution [11-13]. Pollution of water ways by organic discharges in Nigeria is perhaps a serious threat posed to the Nigerian inland waters [14]. Sources of pollution of the inland waters of Nigeria are well known. The most notable point source arises from the dumping of untreated or partially treated sewage into the river [15] and discharge of bio-degradable wood wastes from sawmill located along the lagoon. Elijah and Elegbede [16] reported a reduction in fish diversity associated with discharge of municipal wastes and industrial pollutants into the Owhase/Ovwian River. Francis et al [17] in their study revealed that sawmill wood wastes had a negative effect on fish distribution and their communities. They further stated that at discharge areas, microbial decomposition of these wood wastes exerts high biochemical oxygen demand and creates anaerobic conditions thus, reducing water qualities.

This study is significant to the immediate population because the Owhase/Udu River is a major navigating channel to the creeks in the Niger Delta and it flows along the freshwater swamps, mangrove swamps, and along coastal sand ridges. The objective of this study is not only aimed at examining and identifying the effects of sawmills activities along Owhase /Ovwian river along Udu bridge in Warri, Delta State, but it is also to examine the health and environmental implication of sawmill activities on aquatic life. Results obtained in this study will be compared with standards from the Nigerian industrial standards such as the Standard Organization of Nigeria, the Department of Petroleum Resources and the Federal Ministry of Environment.

Study Area

The map of the study area is presented in Figure 1.

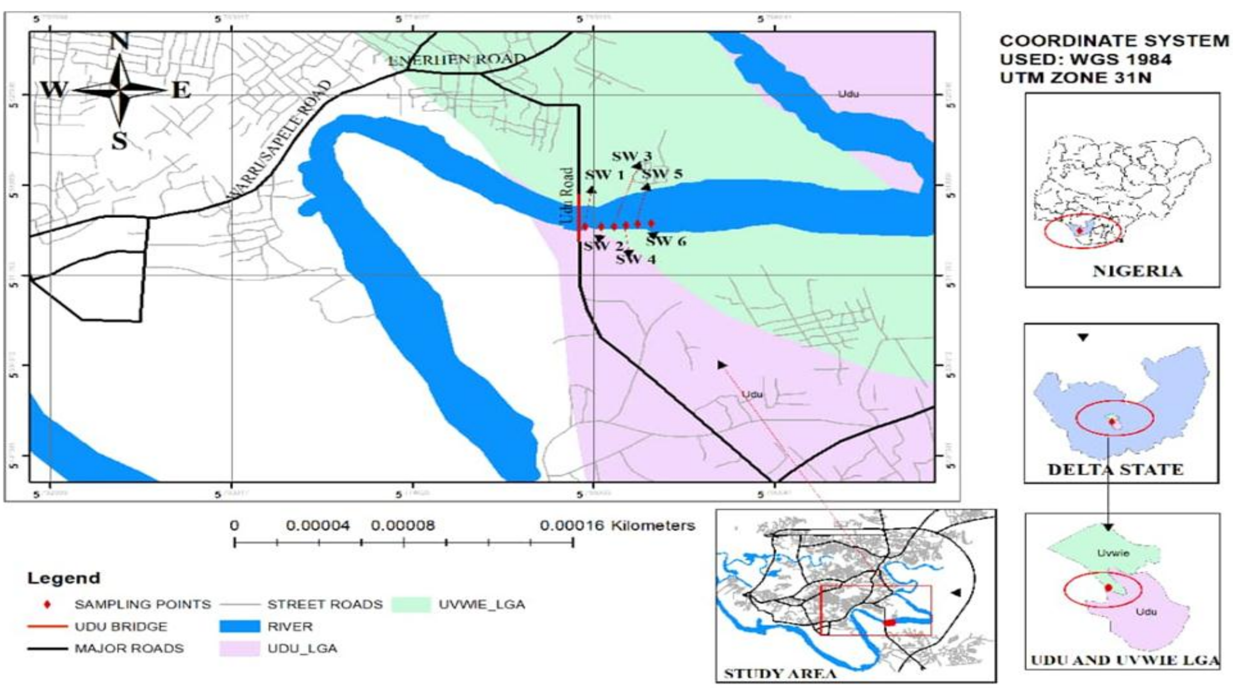

Fig. 1: A Map of Warri River showing the Study area

MATERIALS AND METHODS

Sampling

The water samples were collected weekly, between July 2021 and January 2022, at the point of discharge of the sawmill wastes into the river and at 100 m before and after the point of discharge which are the contaminated areas. The water samples were collected aseptically in one litre plastic containers. The diverse plastic containers were named fittingly with the dates of when the samples were collected. The plastic containers were put away in the cooler for time of 2–3 days after which they were taken to the Research Center for examination of physiochemical parameters and heavy metals analysis. Water samples for control experiment were collected from the Ekpan River at Uuwie local Government Area of Delta State, Nigeria.

Measurement of Physico - Chemical Parameters

pH

This is a measure of the hydrogen particle movement in a water test. The pH of common waters is a measure of the corrosive base harmony attained to by the different broken down mixes, salts and gases. The vital synthetic framework controlling pH in characteristic waters is the carbonate framework. At a given temperature, the intensity of the acidic or basic character of a solution is indicated by hydrogen ion activity. In the field and laboratory, pH is electrometrically measured using a pH meter (Model Ecosense) with a glass electrode. The APHA 4500-H+B method was utilized.

Temperature

The water temperature influences numerous advantageous uses in modern, household water supplies and amusement. The impacts of temperature on amphibian life are of most concern, nonetheless, the water quality criteria were produced to shield the touchiest oceanic living being from anxiety connected with lifted temperatures. The temperature of the samples was determined immediately after collection using a 0-100 °C thermometer by plunging the mercury-in-glass thermometer in the water samples. The thermometer was permitted to stay in the water for around 3-6 min preceding taking the readings. The qualities were recorded.

Dissolved oxygen (DO)

The APHA 4500-O C. was adopted for this study. Triplicates, portions of water samples were slowly siphoned into three separate BOD bottles. It was ensured that atmospheric oxygen was not added into the dilution water. To two of the three BOD bottles, 1 ml $MnS0_4$ solution was added, followed by 1 ml alkali-iodide-azide reagent. The pipette tips were submerged into the water sample when adding reagents. The tips well rinsed between uses. The stopper was carefully fixed to exclude air bubbles and then mixed by inverting bottle several times. When the precipitate has settled to about half the bottle volume, the stopper was carefully removed and then 1.0 ml conc. sulfuric acid was added. The cork was restored and then mixed by gentle inversion until the iodine was uniformly distributed throughout the bottle. About 203 ml of water sample was then transferred into a white 500 ml casserole dish and then titrated with 0.0250N sodium thiosulfate to a pale straw color. 1-2 ml of starch solution was added as the titration was in progress until the first disappearance of the blue color. (200 ml of original dilution water is equal to 203 ml of dilution water plus reagents).

Biochemical oxygen demand (BOD)

Water samples were placed in a 250 ml and 300 ml dark BOD bottle respectively and allowed to overflow for 5 seconds after which it was corked and wrapped with aluminum foil, kept in a BOD chamber, and incubated for 5 days at 20℃. After 5 days, the sample was fixed with $MnSO_4$ solution adding 1 ml Alkali-Iodide-Azide solution immediately and a stopper carefully to exclude air bubbles. The solution was mixed by inverting the bottle a few times and the precipitate was allowed to settle halfway in the bottle, leaving the clear supernatant. The stopper was added and mixed several times by inverting the bottle until dissolution was complete. A corresponding volume of 200 ml original sample was titrated and correction for sample loss altered by displacement with the reagent. Also, titration with 0.025 m $Na_2S_2O_3$ solution was done to a pale straw color, followed by the addition of few drops of smith solution. This was continued till the first disappearance of the blue color.

The following calculations were carried out:

For titration of 200 ml sample; 1ml 0.025M $Na_2S_20_3$: = MgDO/L If 100ml of the sample was titrated, multiply the titer value by 2.

BOD_5=DO value-DO_5 value.

Nitrates

Exactly 50 ml of wastewater sample was filtered and 1 ml of HCL solution was added and stirred thoroughly. Then it was placed in the UV Visible Spectrophotometer and the standard wavelength of 220 nm for nitrate was used to determine NO_3.

Sulphates

APHA 4500-SO42 with CFR section 40 CFR 136.3(a) method was used for the determination of Sulphate. About 20ml Buffer Solution A was added to 100ml of the sample and the resulting content was mixed. While stirring, a spoonful of barium chloride crystals was added and timing was started immediately. After 1min stirring at constant speed, the solution was poured into 10 mm cell and measured within 5 min at 425 nm.

Phosphates

The APHA 4500–P A method was used for the determination of phosphates concentration in the sample water.

Electrical conductivity (us/cm)

Electrical conductivity of water is a numerical expression of the ability of an aqueous solution to carry an electric current. This ability is a function of the presence of ions, their total concentration, mobility, valence and relative concentration in the temperature of measurement. An Electrical Conductivity Meter (HANNA) was utilized for the measurement using the (APHA 2510 40 CFR 141.121) method.

Total dissolved solid

The APHA 2540 B method was utilized for the measurement of Total Dissolved Solid in sample water using an Electrical Conductivity Meter (HANNA).

Turbidity

Turbidity was measured with the use of the turbid meter (MICROTPI product) MODEL 20008 (APHA 2130B) was used to test for the turbidity of the water samples which determines turbidity by the light scattered at an angle of 90 °C from the incident beam a 90E detection angle is considered to be the least sensitive to variations in particle size.

Acidity

The determination of acidity in water samples by titrimetry (APHA 2310 A) 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.

Salinity

The (APHA 4500-Cl- B) method was used for the determination of Saline as chloride content of the samples.

Measurement of Microbiological parameters

E. coli (MPN/100 mL): The Multiple Tube Test (APHA 9222A) was used for the determination of the E. Coli in the water samples.

Total coliform count-bacteria (MPN/100 mL)

The Multiple Tube Test (APHA 9222A) was used for the determination of the Total Coliform Count – bacteria in the study.

Analysis of Heavy Metals

Digestion of water samples took place after composite samples were prepared. About 20 mL mark was made on the beaker using a marker. Exactly 50 mL aliquot of well mixed water samples were digested in a beaker covered with a watch glass by adding 1 mL of concentrated (69-72%) HNO_3 and 2.5 mL of concentrated (30%) HCl and heated on a hot plate at 90 °C boiled until the solution reached up to the mark (20 mL). Then the beaker was removed and cooled. Each of the digested water samples was filtered through Whatman filter paper No. 42 in to a 100 mL volumetric flask and filled up to the mark with deionized water by addition of 2 mL of nitric acid to get a clear solution.

After calibration of the instrument the samples were aspirated into the FAAS instrument according to standard method (APHA, 1999). Concentrations of Fe, Zn, Pb, Cd, Cu and Cr in the extracted water sample were estimated by using FAAS Agilent Technology (Model-AT-240). Na, K, Ca and Mg were performed according to the actual DIN/EN regulations [18] with the Shimadzu atomic absorption spectrophotometer AA-7000 in a fully automatic multi element sequence. The samples were analyzed in triplicates.

RESULTS AND DISCUSSION

The results of the analysis are presented in the Tables.

Table 1: Results of physico-chemical, microbial and heavy metals analysis

Parameters	**Minimum**	**Maximum**	**Sum**	**Count**	**Mean**	**Standard Error**	**Standard Deviation**	**Sample Variance**	**Confidence Level(95.0%)**
pH	5.96	6.50	36.97	6.00	6.16	0.08	0.20	0.04	0.21
Temperature(^{0}C)	30.10	31.20	184.20	6.00	30.70	0.18	0.41	0.17	0.43
Total Dissolved Solid(mg/L)	59.63	80.27	405.41	6.00	67.568	3.72	9.11	83.00	9.56
Electrical Conductivity(uS/cm)	80.08	104.61	552.05	6.00	92.01	3.83	9.39	88.19	9.86
Turbidity(NTU)	3.82	5.37	27.18	6.00	4.53	0.22	0.55	0.30	0.58
Dissolved oxygen(mg/L)	2.00	3.10	15.20	6.00	2.53	0.18	0.44	0.20	0.46
BOD (mg/L)	2.51	4.97	23.99	6.00	4.00	0.36	0.89	0.80	0.94
Acidity(mg/L)	30.00	40.00	210.00	6.00	35.00	1.53	3.74	14.00	3.93
Sal. as Chloride(mg/L)	7.60	11.98	52.11	6.00	8.69	0.68	1.65	2.73	1.74
Nitrate (mg/L)	0.021	0.04	0.17	6.00	0.03	0.00	0.01	6.27	0.01
Sulphate (mg/L)	0.33	0.71	3.27	6.00	0.55	0.06	0.14	0.02	0.15
Phosphate (mg/L)	0.00	0.01	0.01	6.00	0.00	0.00	0.00	1.77	0.00
Lead (mg/L)	0.00	0.00	0.00	6.00	0.00	0.00	0.00	0.00	0.00
Copper (mg/L)	0.00	0.00	0.00	6.00	0.00	0.00	0.00	0.00	0.00
Nickel (mg/L)	0.00	0.20	0.63	6.00	0.11	0.03	0.07	0.01	0.07
Chromium (mg/L)	0.00	0.00	0.00	6.00	0.00	0.00	0.00	0.00	0.00
Iron (mg/L)	0.34	0.66	2.97	6.00	0.50	0.04	0.11	0.01	0.11
Zinc (mg/L)	0.00	0.01	0.01	6.00	0.00	0.00	0.01	1.06	0.01
Total Coliform Count-Bacteria (MPN/100ml)	13900.00	16000.00	93300.00	6.00	15550.00	344.24	843.21	711000.00	884.89
E. Coli (MPN/100ml)	190.00	710.00	2790.00	6.00	465	96.497	236.37	55870.00	248.05

Table 2: Results of Physico – Chemical and Microbial analysis

Parameters	**Sample Locations**						**Average**	**Standards**		
	SW1	**SW2**	**SW3**	**SW4**	**SW5**	**SW6**		**Fmenv (**E2924 V6)	**DPR**	**SON (ICS 13.060.20)**
Longitude	$05^0$30’56.2”	$05^0$30’56.2”	$05^0$30’56.1”	$05^0$30’56.5”	$05^0$30’56.9”	$05^0$30’57.2”				
Latitude	$05^0$47’04.4”	$05^0$47’08.0”	$05^0$47’ 0.7”	$05^0$47’13.3”	$05^0$47’15.9”	$05^0$47’18.9”				
pH	6.50	6.27	5.96	6.14	6.04	6.06	6.162	6.5-8.5	6.5-9.2	6.5-8.5
Temperature(^{0}C)	30.1	30.9	30.4	31.2	30.6	31.0	30.7	<30^0C	<30^0C	25^0C
Total Dissolved Solid(mg/L)	80.27	65.13	59.63	77.83	60.96	61.59	67.568	<500	<1500	<500
Electrical Conductivity(uS/cm)	104.61	94.17	80.08	100.41	85.53	87.25	92.008	<1000	NA	<1000
Turbidity(NTU)	4.95	5.37	3.82	4.25	4.34	4.45	4.53	<40	NA	5
Dissolved oxygen(mg/L)	2.00	2.10	3.10	2.40	2.90	2.70	2.533	5	<10	NA
BOD (mg/L)	4.97	4.64	2.51	4.33	3.46	4.08	3.998	NA	NA	<5
Acidity(mg/L)	36.00	30.00	32.00	34.00	38.00	40.00	35	200	NA	<400
Sal. as Chloride(mg/L)	11.98	8.50	7.63	70.60	8.15	8.25	8.685	NA	<600	<250
Nitrate (mg/L)	0.043	0.029	0.024	0.031	0.024	0.021	0.0287	10	NA	<50
Sulphate (mg/L)	0.705	0.489	0.331	0.517	0.683	0.549	0.546	200	<400	100
Phosphate (mg/L)	0.003	<0.001	<0.001	0.002	<0.001	<0.001	0.0025	<5	NA	<5
Lead (mg/L)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.05	<0.05	0.01
Copper (mg/L)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	1	<1.5	1
Nickel (mg/L)	<0.001	0.101	0.094	0.147	0.196	0.092	0.126	<0.05	NA	0.02
Chromium (mg/L)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.05	NA	<0.05
Iron (mg/L)	0.488	0.340	0.438	0.512	0.537	0.658	0.4955	<1	<1	0.3
Zinc (mg/L)	<0.001	<0.001	<0.001	<0.001	0.008	0.003	0.0055	3	<15	3
Total Coliform Count- Bacteria (MPN/100ml)	16000	15400	16000	16000	13900	16000	15550	NA	NA	0
E. Coli (MPN/100ml)	360	220	670	710	190	640	465	NA	NA	0

The creeks and lagoons of South-South Nigeria, apart from their more ecological and economic significance, serves as sink for disposal of an increasing array of waste types such as wood waste and sewage etc. [19]. In the case of study sites the major suspected source of pollution is the Saw mills, located at the bank of the Warri River along Udu bridge.

The temperature of the surface water ranged from 30.10 to 31.2 °C with an average value of 30.7 °C which is a little bit higher than the DPR and Fmenv regulatory limits of <30 °C. The slightly increased temperature may be attributed to solar radiation, faecal decomposition, and decomposition of indiscriminate dumped waste on the surface water. Also, high temperatures increase the level of turbidity and reduce the rate of light penetration. This offsets photosynthetic process of phytoplanktons in the food chain. Similarly, a high temperature increases the metabolic rate of aquatic organisms and causes a reduction in the level of dissolved oxygen. Also, the temperature values of samples were observed to be significantly different. The range of temperatures observed in this study was similar to those reported for water bodies in south western Nigeria [20].

Conductivity of water is given as the index of total ionic content which therefore indicates freshness of the water body. Conductivity at all sampling stations shows that the values were not statistically significant ($P>0.05$). Values obtained are below the Fmenv and SON regulatory limit of (<1000us/μm).

pH can drastically affect the structure and function of the ecosystem both directly and indirectly, it could lead to increase concentration of heavy metals in water from sediment [21]. From the samples analysis, it was observed that the value of pH ranged from slight acidic 5.96 to 6.50 with an average value of 6.16 which is not within the Fmenv and SON (6.5-8.5) regulatory limits for surface water. This value may be attributed to chemical substance used in wood treatment, diesel, soot and suspended particulate matter from their generators, etc. pH may affect chemical and biological processes in the water. Some organisms flourish within different ranges of pH in water. The largest variety of aquatic animals prefers a range of 6.5-8.0. pH outside this range reduces the diversity in the stream because it stresses the physiological systems of most organisms and can reduce reproduction.

Total suspended solid is the amount of particulate matter that is in the water column. High levels of suspended solid would result in a reduction in light penetration which in turn will reduce primary productivity and decrease dissolve oxygen in the water body [22]. Suspended solid recorded for this study was low. The value for TDS ranged from 59.63-80.27 mg/l with an average value of 67.57 mg/l which are within the Fmenv and SON (<500mg/l) permissible limit. However, the values of TDS may be attributed to the impact of the saw dust on the river. There was no significant difference in the suspended solid values at study station (P>0.5).

The dissolved oxygen (DO) and biochemical oxygen demand (BOD) always have an inverse relationship existing between them. It is the dissolved oxygen in water that is being depleted or utilized by the micro-organisms and hence the elevated value of biochemical oxygen demand values. It means that for a high DO, there is a less BOD and vice versa. Both dissolved oxygen and the biochemical oxygen demand showed no significant difference of the study. The low DO observed in the study could be attributed to high organic content, decayed plant and animal materials and domestic affluent. This requires large quantities of dissolved oxygen for decomposition. Biochemical oxygen demand also provides a measure of the effect of pollution on a receiving water body. The high BOD in the study showed that the water body had received an enormous level of organic pollutant. Both parameters have values below the permissible limits of BOD and DO in surface water.

Salinity as chloride ranged from 7.60-11.98 mg/l with an average value of 8.69 mg/l which are less than the SON (<250 mg/l) permissible limit. The values showed less significant difference (P>0.05).

Turbidity values ranged from 3.82 to 5.37NTU, with an average value of 4.53NTU which is below [23] permissible regulatory limits. Turbidity values also showed less significant difference (P>0.05).

The acidity value ranged from 30.00-40.00 mg/l with an average value of 35.00 mg/l which is within below the Fmenv (200 mg/l) permissible limits [24].

Nitrate index is an index derived from organic residue from plant, animals, sewage and fertilizers. Nitrate levels across samples fell within the range of 0.021 mg/l – 0.043 mg/l. Sulphate, and Phosphate (mg/l) values ranged from 0.331-0.705 and 0.002-0.003 mg/l with an average value of 0.546 and 0.0025 mg/l respectively. Nitrate, sulphate and phosphate values were all below the permissible regulatory limits for all standards.

The values for heavy metals namely Lead (Pb), Copper (Cu), Chromium (Cr), Iron (Fe), and Zinc (Zn) were relatively within national regulatory limits except Nickel (Ni) values ranging from <0.001 to 0.196 mg/l with an average value 0.105mg/l (Table 2) which is above national regulatory limits of 0.05 mg/l [25]. The availability of trace metals in water are controlled by physical and chemical interactions. These interactions are affected by factors like pH, redox potential, temperature, CO_2 level, the type and concentration of available ligands and chelating agents, as well as type and concentrations of the metal ions. Trace or heavy metals have the potential to bio-accumulate in aquatic organisms or humans from consumption of contaminated food. Effects of heavy metal contamination include reduced growth rate, cancer formation, organ damage, nervous system damage, and in extreme cases, death. Exposure to some metals, such as mercury and lead, may also cause development of autoimmunity, in which a person's immune system attacks its own cells.

The study reveals the values of Total Coliform Count (bacteria) ranging from 13900 to 16000N/100 ml with and average value of 15550 N/100 ml. This may be attributed to human faecal contamination as some of the saw mill workers lack proper sanitary toilet system. They mostly practice open defecation and indiscriminate dumping of waste into the river. Similarly, E. *coli* was also found present with values ranging from 190 to 710N/100 ml with an average value of 465N/100 ml. Both parameters showed no significant difference (P>0.05) and are above the permissible regulatory limits of (0 MPN/10 ml).

Correlation for the parameters showed that there are low positive correlations between most of the parameters such as conductivity and turbidity, conductivity and total dissolved solids, biochemical oxygen demand and acidity, nitrate and chloride, nitrate and sulphate, sulphate and phosphate, total coliform count and E. coli and iron and zinc. There are strong inverse correlations between zinc and total coliform count, dissolved oxygen and biochemical oxygen demand, dissolved oxygen and turbidity, total dissolved solids and temperature.

The results obtained in this study are in agreement with those obtained in previous studies [17, 22]. Francis et al [17] stated that the ecosystem is influenced by organic contaminants and has resulted to low diversity species.

In this study, the study area has massive deposit of wood waste with poor management practices, with no structure to reducing the impacts of sawmill wood wastes on aquatic bodies.

CONCLUSION

The results obtained from this report have revealed that physico-chemical conditions as well as the microbial concentrations have been affected due to the anthropogenic sources of pollution around the area. The major anthropogenic source however is the deposition of sawdust and other wood wastes from sawmill. This has reduced the quality of water and made it unfit for use by human and other organisms. It was observed that the river is no longer what it used to be and obviously, this pollution would continue to occur if nothing is done to reduce or even stop the main sources of pollution of this water body. It was recommended that sawdust from sawmill should not be dumped into the waterways to avoid further pollution of the waters.

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