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Physicochemical Properties of Soil Exposed to Saw Dust and Timber Processing Activities in Port Harcourt, Rivers State, Nigeria

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Abstract

Studies have highlighted the modification of the microbiology of soils exposed to timber processing waste, but there is limited data on the geochemistry. This study assessed the soils at Marine Base, Mile 3, and the Iloabuchi timber markets in Port Harcourt, River State, Nigeria exposed to saw dust and timber processing activities, to evaluate for their physicochemical characteristics, polyaromatic hydrocarbon (PAH) levels and heavy metals concentrations. The soil samples were randomly taken from different depths (0-10, 15-30, and 30-50 cm) at four cardinal points from the sampling locations. The pH values recorded in the control site were found to range from 3.43-4.7. The sampling sites, exhibited a wider range of pH values. Marine base had a pH range of 3.69-5.50, Mile 3 had a range of 4.49-6.22, and Iloabuchi had the highest pH range of 6.62-7.82. The conductivity values varied between the control site and the sampling sites. The control site had conductivity values ranging from 63-93 µS/cm. The highest conductivity value was observed in the Iloabuchi site, with the range 1621-1767 µS/Cm. The control recorded the highest bulk density of 2.56 g/cm³ and porosity (81.00 g/cm³) compared with the study samples. The highest values of phosphate, sulphate and nitrate in soil were obtained at Iloabuchi site (12.59 mg/kg, 488.4 mg/kg and 18.47 mg/kg respectively) in the sub and top soil, these values are significantly ($P< 0.05$) higher than the corresponding values in control (0.05 mg/kg, 10.03 mg/kg and 6.4 mg/kg). The order of concentrations of the heavy metals was typically: Co > Mn > As > Ni > Cd > Zn. The order is attributed to several factors such as variations in the geological composition of the soil and industrial activities in the vicinity. The values indicate pollution in these areas. The study also revealed that 16 polyaromatic hydrocarbons (PAHs) were present in measurable, variable, and detectable quantities in the soil samples from the three sawmilling sites. The metal concentrations found in the study may not be a significant risk to human health, though there is a possibility of accumulation over time leading to potential environmental issues in the future. Therefore, continuous evaluation and monitoring of sawmill activities and their surroundings are recommended to prevent harmful effects from excessive pollutants.

Keywords: Heavy metals, human health risk, physicochemical, polyaromatic hydrocarbons, saw dust, timber

Introduction

Man's actions have caused significant soil contamination around the planet, thereby affecting the soil's makeup. The persistence of these effects results in human health risks [1]. Heavy metals, petroleum hydrocarbons, agricultural herbicides, insecticides, and decomposing organic debris are just a few of the contaminants that often pollute soil. The physical and chemical characteristics of the soil and its surroundings can be changed by these pollutants. Human activities, such as waste management in cities and industries, agricultural fertilizers, mining, and metal smelting, are among the factors that contribute to soil contamination, modification of its natural structure and biological composition [2].

The physicochemical characteristics of soil have a significant role in the growth and production of agricultural products. Understanding the soil quality through examining specific physicochemical characteristics reveals the impact of certain processes on the ecosystem. pH, texture, organic carbon, organic matter, electrical conductivity, wetness, and soil density are some of the physical and chemical characteristics of soil that may change as a result of anthropogenic activity and hence have an impact on human well-being [1]. The physicochemical characteristics of the soil, such as pH, cation exchange capacity (CEC), soil texture, and organic matter are influenced by a number of variables, such as; altitude, parent rocks, flora, and human activity. The best range for soil pH, which has an impact on the availability of nutrients, is between pH 5 and 7 [3]. A number of variables, including organic matter, clay type and quantity, pH, the current redox conditions, and routes, affect the ability of elements present in soils to be mobilized, immobilized, and redistributed [4]. Rivers State harbors a large wood industry that supplies domestic and international markets. Sawmilling is concentrated in urban centers including Port Harcourt with registered mills [5]. This raises waste management concerns as sawdust pollutes surrounding lands and waterways. Regular dumping modifies the physicochemistry and pollutant load of receiving soils significantly [6]. Comprehensive data on soil attributes changes around Port Harcourt sawmills is needed to devise effective remediation and regulate sawmilling practices.

Therefore, this study assessed the physicochemical properties and heavy metal contamination levels in soils exposed to sawdust around three major sawmilling sites in Port Harcourt, Rivers State.

Materials and Methods

Sampling and Study Area Description

The study was conducted in Marine Base, Mile 3 Timber Market, and Iloabuchi, all located in Port Harcourt, Rivers State, Nigeria. Mile 3 Timber Market and Iloabuchi are situated in Diobu, a densely populated business district, while Marine Base is a neighborhood near the NEPA and Fisherman Trade areas. The sawmill at Mile 3 is located at a latitude of 4°48'24"N and a longitude of 6°59'36"E (Figure 1), while the sawmill at Iloabuchi is positioned at a latitude of 4°47'22"N and a longitude of 6°59'17"E. The Marine Base site is situated in Port Harcourt at a latitude of 4°77'05"N and a longitude of 7°02'35"E.

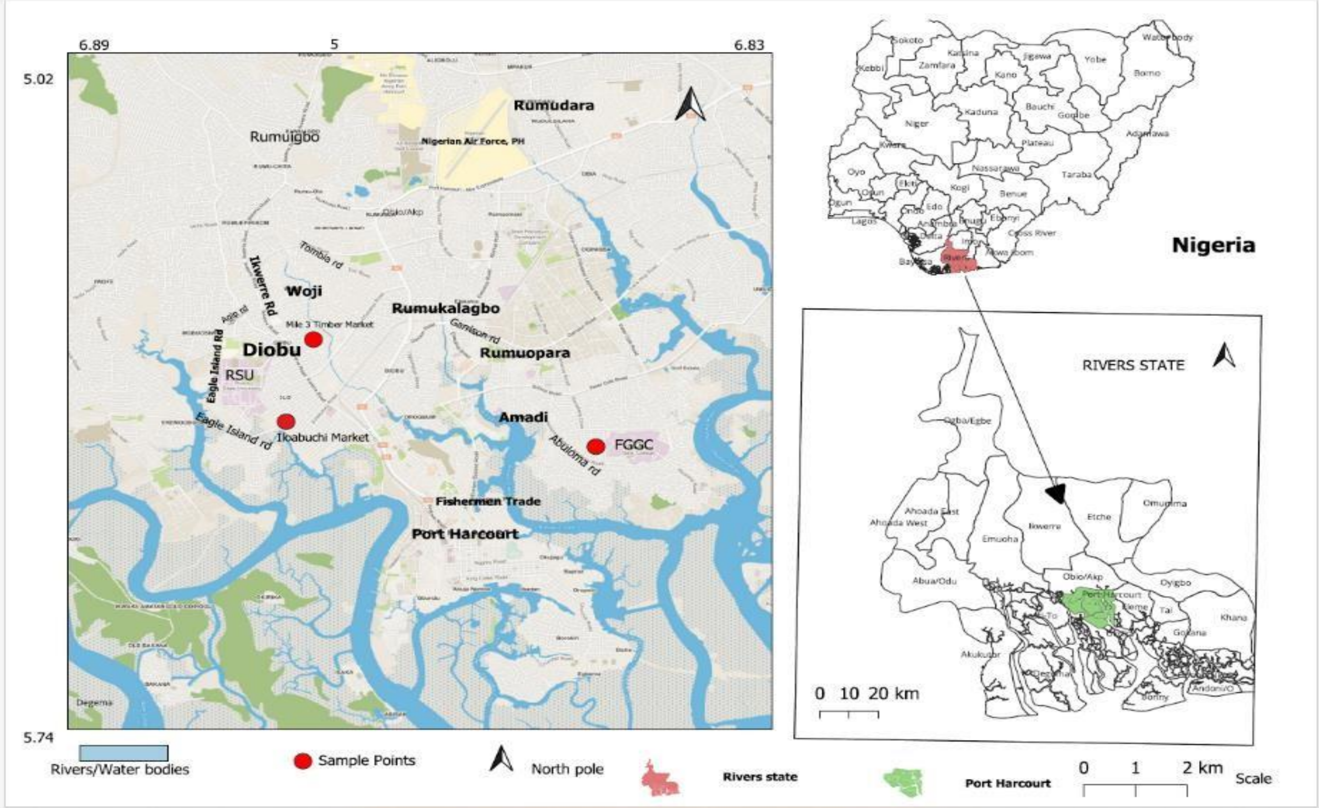

Figure 1: Map of Study Area Showing Sample Locations

Sample Collection and Preparation

The soil sampling sites at each location were divided into four sections for testing. Using a soil auger, soil samples were taken from the chosen locations at depths of 0–15 cm, 15–30 cm, and 30–60 cm for topsoil, subsoil, and low soil, respectively. The soil samples were a collection of three sub-samples from each of the four sites. After sampling, the equipment was cleaned with soap and distilled water, the soil samples were packed in well labeled air tight polythene bags, and glass bottles for heavy metals and PAHs test respectively were taken to the laboratory for processing and analysis, according to the methods given by earlier researchers [6]. The samples were stored in a cool location to prevent the decomposition of organic matter. Afterward, the samples were air dried for a period of 48 hours. To eliminate debris, gravel, and other materials, the samples were sieved using a 2 mm mesh before analysis.

Determination of the Physicochemical Properties of the Soil

Determination of pH

Soil pH was determined potentiometrically in a slurry system using an electronic pH meter according to American Society of Testing and Method (ASTM) (1995). The pH meter was calibrated over the appropriate range using standard buffers. 10 g of each sample was weighed into a beaker and 10 ml of distilled water was added into it and stirred; the value displayed was read directly as the pH of the sample.

Determination of Electrical Conductivity

Soil electrical conductivity was determined potentiometrically by weighing 10 g of soil sample in a beaker, followed by addition of 50 ml of distilled water. A conductivity meter (HI 98303 Hanna conductivity meter (Romania) was dipped into it and the value was recorded as done by [7].

Determination of Soil Bulk Density and Porosity

An undisturbed flat horizontal surface in the soil was prepared with a spade. A steel ring was gently hammered into the soil. The ring was excavated without disturbing or loosening the soil it contained. It was carefully removed with the soil intact. Excess soil was removed from the outside of the ring. Soil sample was poured into a plastic bag according to a method earlier reported [8].

The following was done to get the bulk density and soil porosity:

Soil volume = ring volume (1)

To determine the soil volume, the volume of the ring was calculated by measuring its height using a ruler in centimeters and halving the diameter to get the radius. The ring volume in cubic centimeters was calculated using the formula:

Ring volume = 3.14 x r^2 x ring height (2)

To calculate the weight of the soil without moisture; the first step was to weigh an ovenproof container in grams (W1). Then, the soil sample was taken out from the plastic bag and transferred to the container. The container, along with the soil, was then dried in a conventional oven at 105 °C for 2 hours. After that, the container with the dried soil was weighed again (W2). To calculate the weight of the dry soil in grams, the difference between W2 and W1 was calculated as shown in equation 3.

Dry soil weight = W2 – W1 (3)

Bulk density (g/cm^3) = Dry soil weight (g)/ Soil volume (cm3)

The soil porosity, which represents the percentage of the soil that contains pores, was calculated using the formula Soil Porosity = (1 - (Bulk Density ÷ Particle Density)) x 100 (4)

The particle density is the density of the mineral particles in the soil, which is assumed to be 2.65 grams per cubic centimeter. The soil porosity calculation involved subtracting the bulk density of the soil from the particle density, dividing the result by the particle density, and then multiplying the quotient by 100. The higher the soil porosity, the more pores there are in the soil for water and air to move through.

Determination of Soil Nitrate

The extracted samples, 2 ml of the extracted samples were introduced into different test tubes, followed by the addition of 2 ml of concentrated H_2SO_4. The mixture was allowed to cool. A 0.2 ml amount of brucine was added to the solution, heated for 15 mins and analyzed using a UV spectrophotometer (Hach DR6000, USA) at wavelength of 410 nm [24].

Determination of Phosphate

The extracted sample (25 ml) was introduced into different test tubes, followed by the addition of 1 ml of Ammonium molybdate. Then two (2) drops of stannous chloride was added and the mixture was allowed to stay for days to allow a color change and the absorbance was taken at the wavelength of 690 nm [25].

Determination of Sulphate

An extracting solution was first prepared. 5 g of the air-dried soil sample was weighed into a conical flask, 25 ml of the extracting solution was added and shook for 30 mins and then filtered with filter paper. 5 ml conditioning reagent was added and mixed, after which a spoon of BaCl2 crystals was added. The absorbance of the solution was taken with UV-spectrophotometer and sulphate concentration was taken from the calibration graph [26]

Determination of Heavy Metal Levels

To extract the elements from the dried soil samples, a digestion process was performed. A dried soil sample weighing 0.5 g was mixed with 20 mL of freshly prepared aqua regia (HNO_3: HCl, 1:3 ratio). The mixture was allowed to stand overnight and then placed in a digestion block for approximately 30 minutes. After cooling, the mixture was filtered into a 50 mL volumetric flask using distilled water [9]. To ensure accurate analysis, a 1:100 dilution of the filtrate was performed by adding 1 mL of the filtrate to 99 mL of deionized water. The resulting dilution was analyzed for the presence of heavy metals using a Perkin-Elmer Analyst 300, USA, atomic absorption spectrophotometer (AAS). The concentrations obtained from the AAS were multiplied by the dilution factor of 100 to determine the actual concentrations of heavy metals in the soil samples.

Polyaromatic Hydrocarbon Determination

Soil and sediment extraction was carried out by the following process:

Extraction solvent containing acetone and methanol in a ratio of 3:1 was prepared. 10 g aliquot of well-mixed sample was measured into a solvent-rinsed beaker. Wet samples were properly dried with anhydrous sodium sulphate until particles were loose. 20 to 50 ml of the solvent was measured and mixed with the samples. This was placed in the sonicator and sonicated for about 5-10 minutes at 700 oC. The extract was filtered through a glass funnel with glass wool and anhydrous sodium sulphate. The extract was also transferred to a Teflon-lined screw-cap vial for PAH analysis using a GC–MS system (Agilent 7890A GC coupled to a 5977B MSD, USA). The instrument was calibrated before analysis.

Results and Discussion

Soil Physicochemical Properties

Soil pH

Soil pH varied significantly across sawmilling sites and depths, generally decreasing from top to lower samples as shown in figure 2. pH ranged from strongly acidic for Marine base and Mile 3 topsoil to moderately alkaline for Iloabuchi subsoil. This is attributed to pollution of the areas and organic matter quality. Acidic residues like sawdust decrease pH while alkaline wood ash increases pH values. Similar observation has been reported [1].

Soil Electrical Conductivity

Spatial variations in electrical conductivity (EC) reflected salt and nutrient concentrations across sawmilling soils (Figure 3). Iloabuchi topsoil recorded the highest EC of 1767 µS/cm, followed by Mile 3 (448.66 µS/cm) and Marine base (370.67 µS/cm) at lower soils. This is attributed to leaching and accumulation of soluble ions, available cations and anions from organic wastes deposited over time.

Soil Bulk Density and Porosity

Bulk density was lowest in Marine base (0.36- 0.37 g/cm3), followed by Mile 3 (0.38-0.39 g/cm3). This is attributed to the inputs from organic matter in sawdust (Figure 4-5). Conversely, Iloabuchi topsoil recorded the highest bulk density of 1.47 g/cm^3.

Total porosity decreased across soil depths in Marine base (63.25-37.95%) and Mile 3 (56.25-37.9%) but increased in Iloabuchi (17.6-36.1%). These variations may be derived from differences in soil characteristics and sawdust pollution levels across sites.

Soil Nutrient Status

Nutrient levels fluctuated within and across sawmilling sites, generally increasing in topsoils and lower depths (Figure 6-8). NO3- concentrations exceeded 16.73 ppm in some soils while available phosphorus and sulphate levels ranged between 0.02-12 ppm and 5.4-488.4 ppm respectively. The high level of nutrients is attributed to organic matter deposits from saw dust, which mineralized over time.

Discussion

The physicochemical properties of the soil samples collected from the three sawmilling sites and the control site showed variations both within and between the different locations. This could be attributed to differences in pollution levels as well as soil factors across the study areas.

pH levels varied considerably, generally decreasing with depth (Figure 1-3). This aligns with findings of [10]. They observed initial pH rise, followed by decline upon addition of organic wastes like sawdust to soils over time. Similarly, soil pH fluctuations have been linked to residual alkalinity release and organic matter oxidation reactions occurring during residue breakdown [11,12]. The findings of this study are in contrast to reports on the pH variations of soil obtained from sawmill conducted by Obike-Martins et al. [13]. The pH of the sawmill soil sample was acidic at a depth of 0-15 m.

Spatial variations in electrical conductivity across sawmilling soils reflect changes in ionic composition influenced by sawmill waste dispersion and drainage patterns over time. Marine base and Mile 3 EC increased in low soils (370.67, 448.66 µS/cm), indicating salt and nutrient accumulation at depth. Similar observation has been made [13]. Iloabuchi top- soil recorded the highest EC (1767 µS/cm) against sub-low soils (1621-1650 µS/cm). This reflects the predominant waste loading at the surface. The influence of pollutant leaching with drainage is evident from EC fluctuations between horizons and is attributed to organic matter deposition. Earlier researchers gave similar report [14]. The values from the sample sites surpassed that from the control site, indicating anthropic pollution.

Bulk density and porosity patterns aligned with literature, denoting inverse relationships between organic matter and bulk density as well as direct links between porosity, waste inputs and decomposition activity. Similar report has been made [15]. Variations in these properties influence soil structural properties, aeration, water dynamics and biology.

Excessive nutrients emerged from mineralization of sawdust organic matter accumulated over decades, as reported previously [16, 17]. Analysis of major anions showed variations across sawmilling sites and soil depths. Nitrate ranged from 9.83-18.47 ppm with concentrations increasing underneath dumps over time. Highest values occurred in Marine base subsoil and Iloabuchi topsoil. Mile 3 low soil exceeded 16.73 ppm nitrate. Similar variation has been made [18]. Sulphate level differed, with top-soil concentrations peaking at 288.42-488.40 ppm in Iloabuchi and Marine base respectively. This may be due to leaching from near waste sources. Mile 3 low soil had a value of 254.90 ppm. This surpassed the surpassed the control level. Sawdust and timber processing wastes have been reported to be rich in organic sulphur [19].

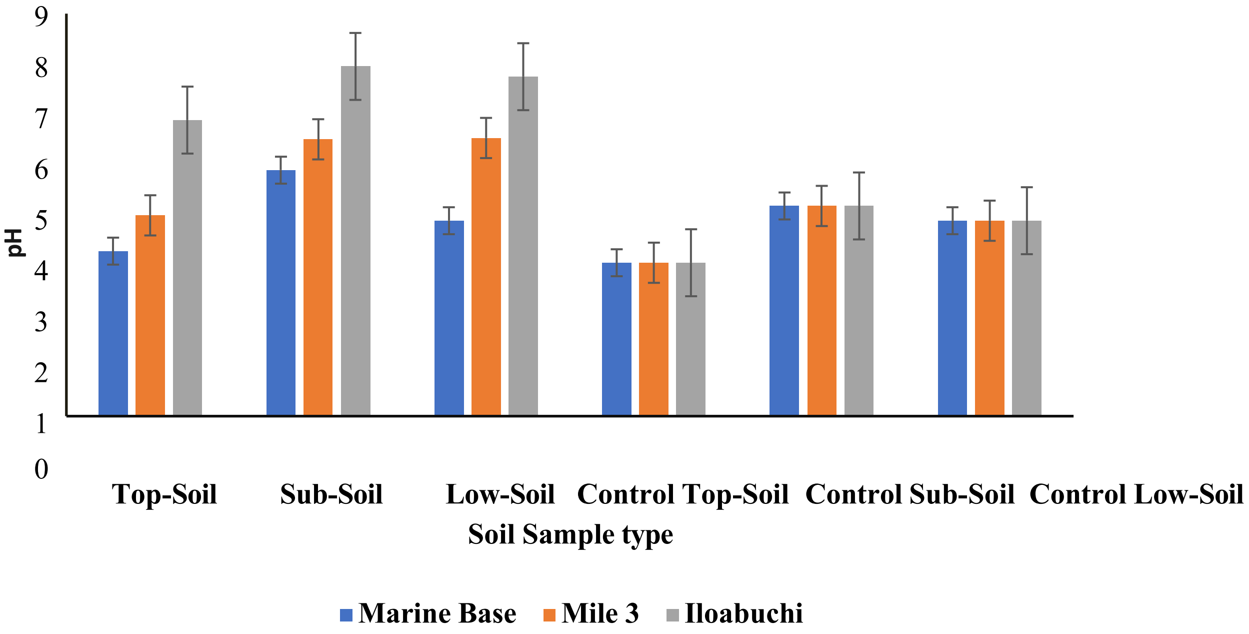

Figure 2 : pH Levels of Different Soil Sample Types from Marine Base, Mile 3, and Iloabuchi Compared to Control Samples

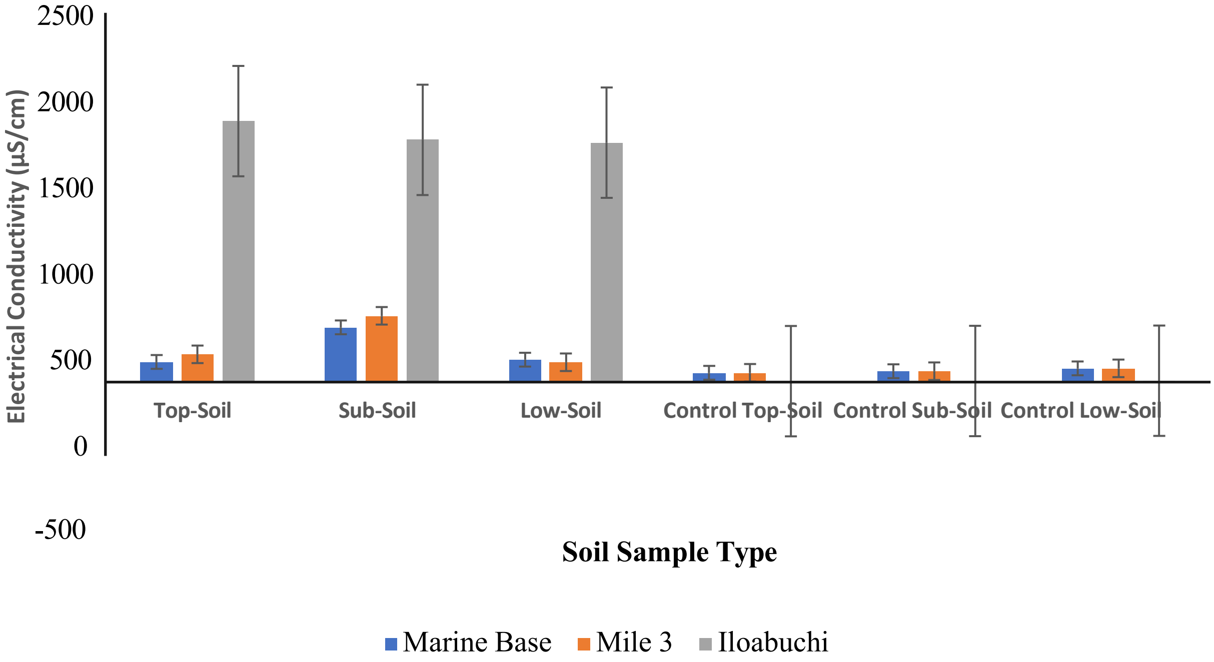

Figure 3: Electrical Conductivity Levels of Different Soil Sample Types from Marine Base, Mile 3, and Iloabuchi Sawmills Compared to Control Samples

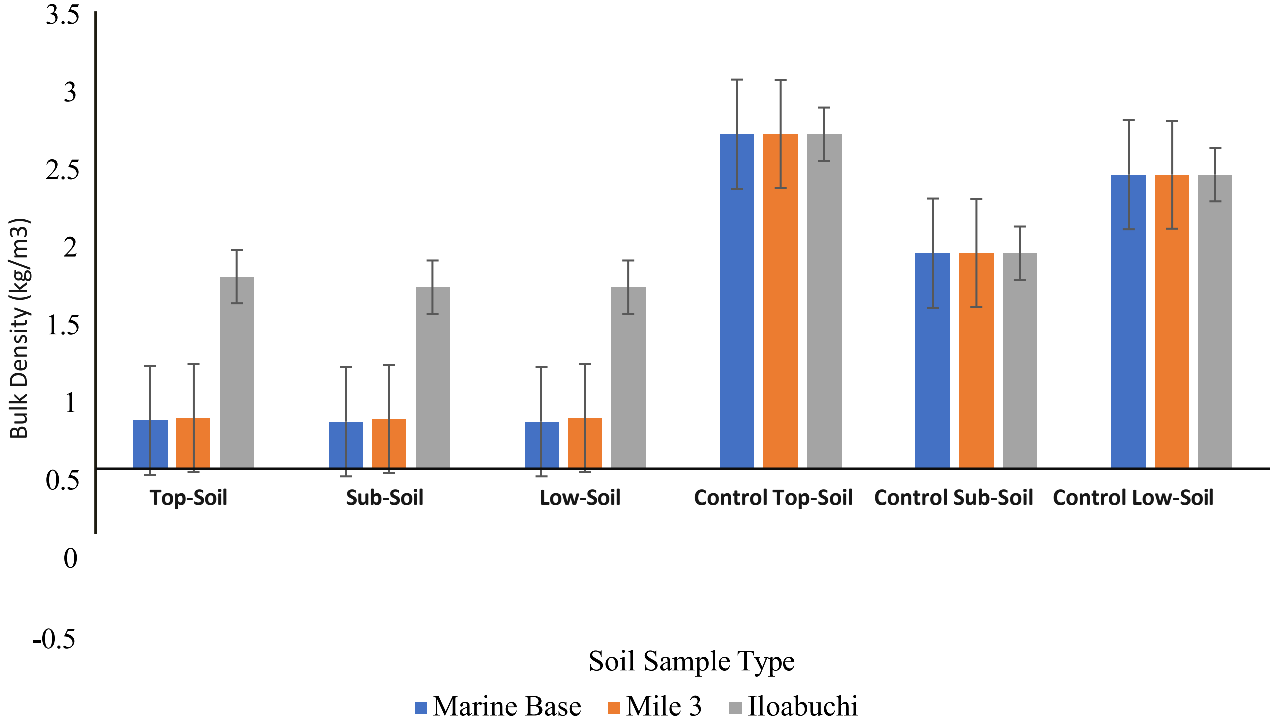

Figure 4: Bulk Density Levels of Different Soil Sample Types from Marine Base, Mile 3, and Iloabuchi Sawmills Compared to Control Samples

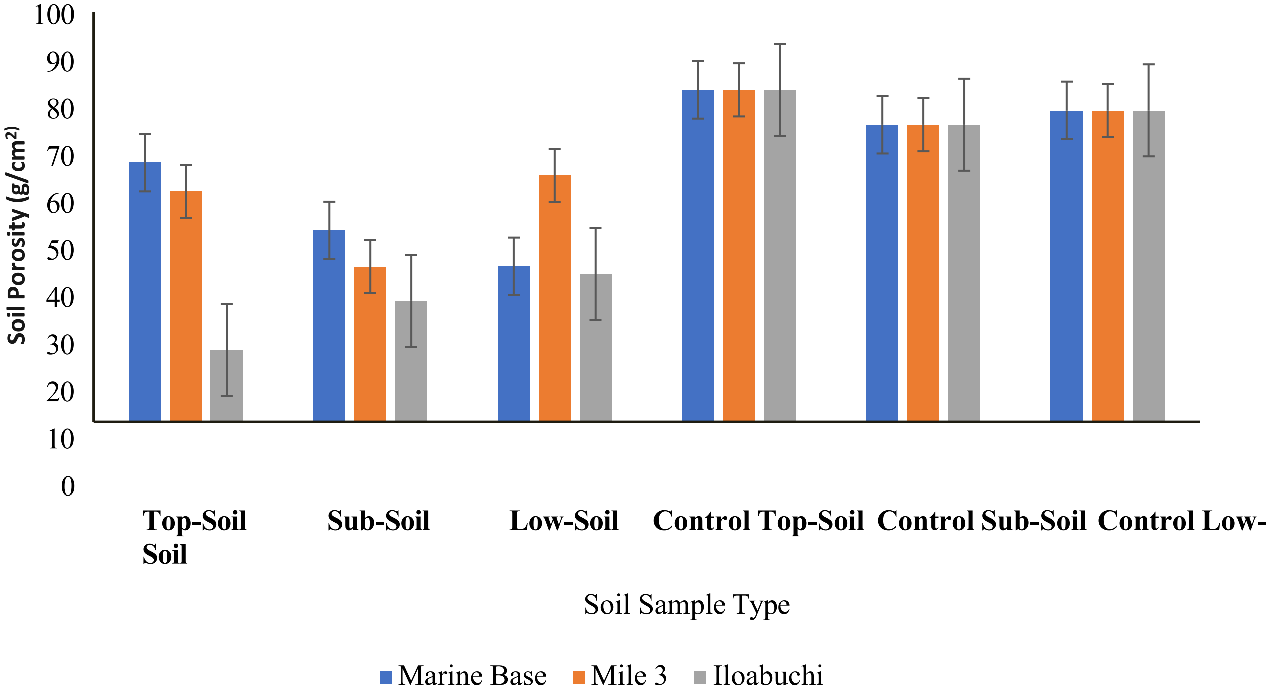

Figure 5: Soil Porosity Levels of Different Soil Sample Types from Marine Base, Mile 3, and Iloabuchi Sawmills Compared to Control Samples

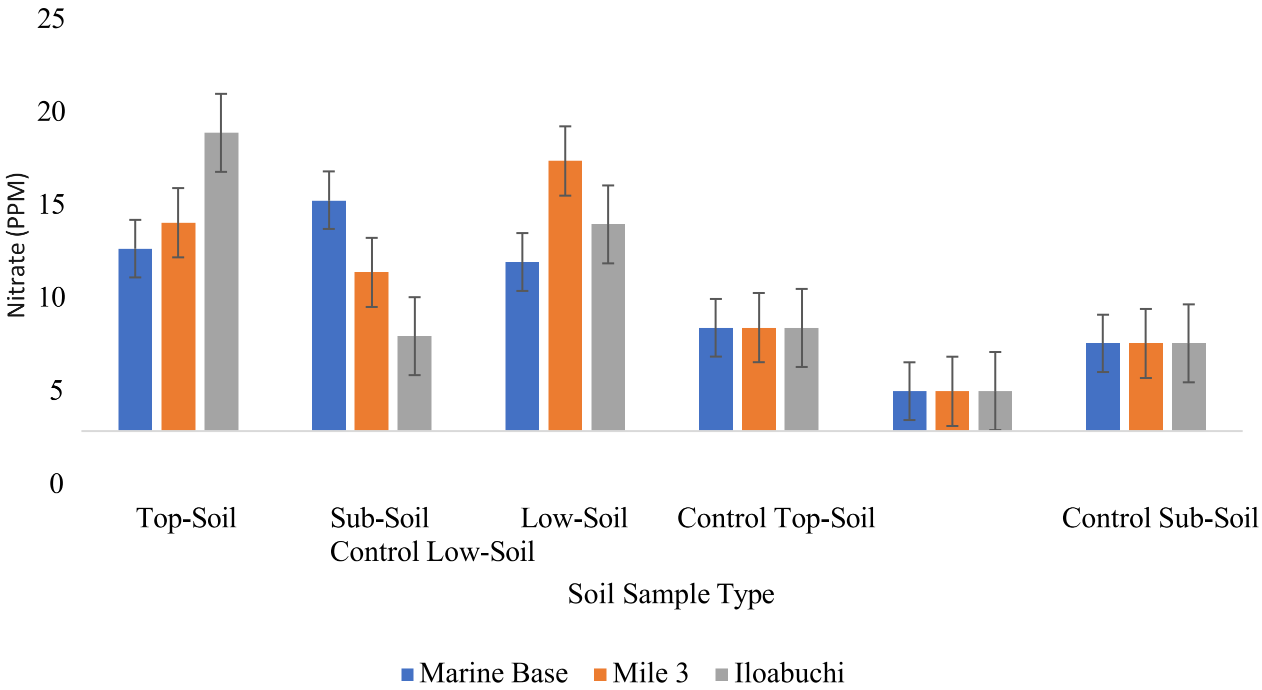

Figure 6: Nitrate Concentration of Different Soil Sample Types from Marine Base, Mile 3, and Iloabuchi Sawmills Compared to Control Samples

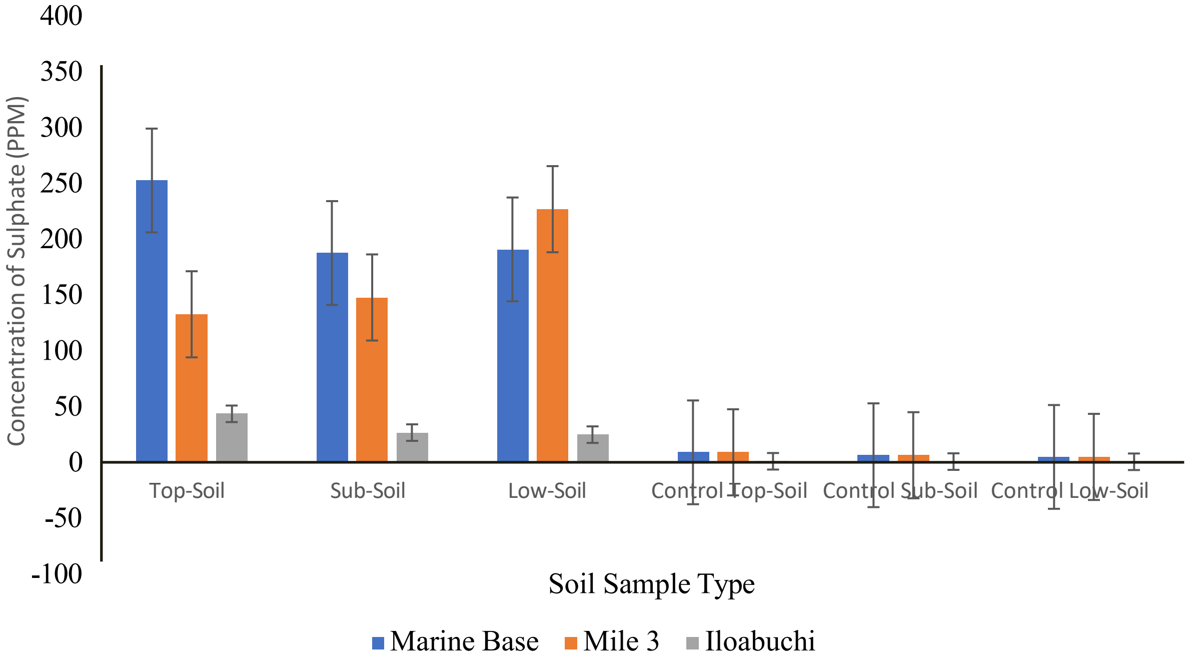

Figure 7: Sulphate Concentration of Different Soil Sample Types from Marine Base, Mile 3, and Iloabuchi Sawmills Compared to Control Samples

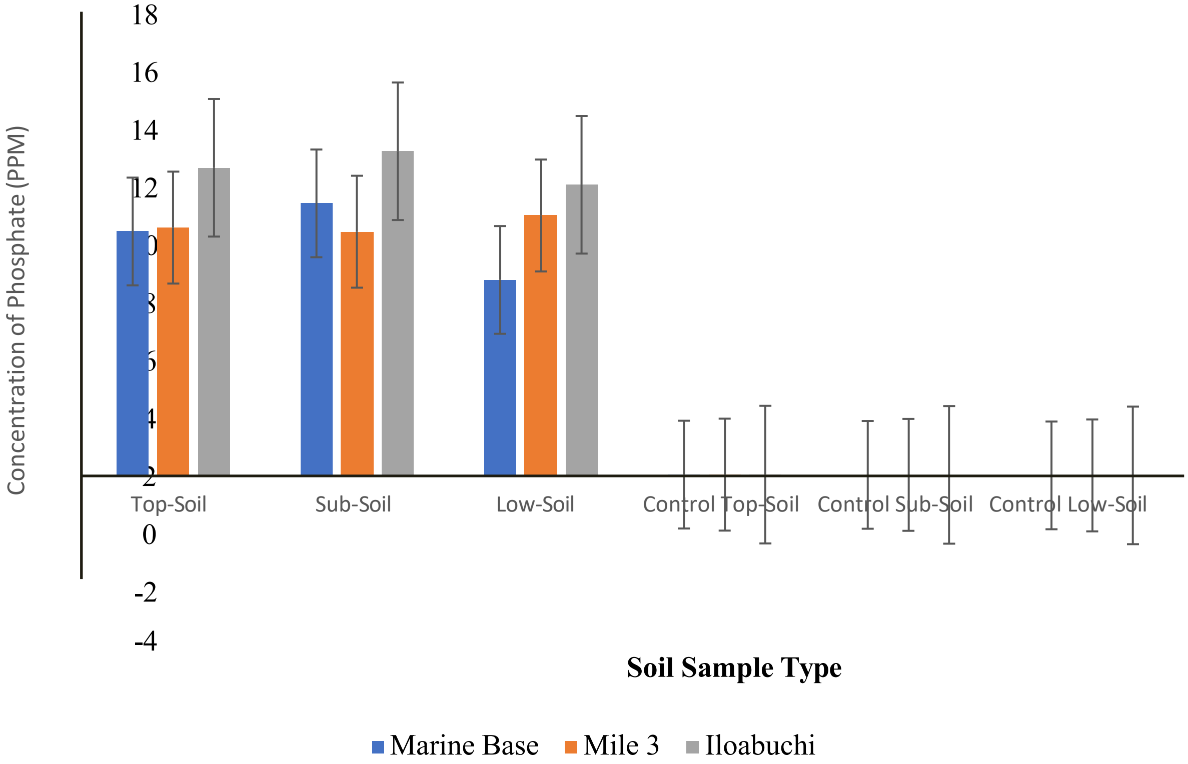

Figure 8: Phosphate Concentration of Different Soil Sample Types from Marine Base, Mile 3, and Iloabuchi Sawmills Compared to Control Samples.

Heavy Metals

Heavy metal analysis revealed significant contamination in soils from sawmilling activities (Table 1). Most heavy metal levels, except for Zn and Ni, exceeded both control values and WHO standards across the study areas. Arsenic (As), manganese (Mn), cobalt (Co), and cadmium (Cd) were particularly elevated, indicating substantial pollution.

Arsenic levels ranged from 68.45 mg/kg to 162.15 mg/g, with the highest concentration in Mile 3 subsoil, surpassing the control (74.00 mg/g). This far exceeds the WHO permissible limit for soils (20 mg/g). Nickel concentrations, while lower compared to other metals, peaked at 45.00 mg/g in Marine Base subsoil, remaining within the WHO standard of 35 mg/g.

Cobalt exhibited alarmingly high concentrations, with values reaching 386.87 mg/g in Marine Base topsoil and 534.77 mg/g in Iloabuchi subsoil, compared to the WHO standard of 0.1 mg/g. Similarly, manganese levels were elevated, ranging from 92.98 mg/kg to 436.43 mg/g, with the highest levels observed in Iloabuchi topsoil, well below the WHO standard of 3000 mg/g.

Cadmium concentrations were significantly above acceptable limits, with levels up to 318.10 mg/g in Iloabuchi subsoil, exceeding the WHO standard of 0.8 mg/g by a wide margin. Zinc concentrations varied, ranging from below detectable limits (BDL) in some samples to a maximum of 169.00 mg/g in Iloabuchi low soil. While higher than the control (183.20 mg/g), zinc levels generally stayed within the WHO standard of 300 mg/g.

The control site exhibited significantly lower background levels, emphasizing the role of anthropogenic pollution from sawmilling activities. The accumulation of heavy metals in the topsoil is linked to surface waste deposition, while their decrease with depth reflects subsurface dissolution and leaching processes.

Table 1: **Heavy Metal Concentration (mg/g) in the Different Sawmilling Site**

Heavy metals	Marine Base			Mile 3			Iloabuchi			Control			WHO (1996)
	Top Soil	**Sub Soil**	**Low Soil**	**Top Soil**	**Sub Soil**	**Low Soil**	**Top Soil**	**Sub Soil**	**Low Soil**	**Top Soil**	**Sub Soil**	**Low Soil**	
Ni	24.00±0.00	45.00±0.00	25.5±0.00	25.70±7.35	8.00±16.33	BDL	2.90±0.00	4.3±0.00	16.1±4.53	27.01±1.05	153.00±3.02	97.00±3.00	35
As	156.53±2.84	68.45±6.76	141.07±3.51	152.1±22.89	68.68±3.10	162.15±45.84	135.07±23.10	138.80±25.25	42.70±2.83	88.00±0.1	74.00±2.43	137.30±0.5	-
Co	386.87±15.27	276.03±17.17	298.53±53.66	91.82±7.50	98.30±43.69	132.17±23.15	363.80±16.80	534.77±20.07	286.95±12.52	121.00±1.01	91.12±2.01	86.15±5.00	0.1
Mn	161.03±15.53	149.9±15.40	92.98±3.80	127.60±23.19	230.43±21.28	120.4±22.19	436.43±31.68	131.80±25.78	224.0±10.75	81.00±3.00	102.00±4.01	95.05±4.00	3000
Cd	ND	90.3±0.00	ND	183.40±0.00	148.10±3.82	BDL	69.53±5.35	318.10±0.00	223.4±11.46	59.01±2.00	53.00±3.05	59.04±3.00	0.8
Zn	BDL	17.70±0.00	4.00±0.00	9.25±0.50	BDL	3.80±2.26	33.07±8.51	75.00±2.61	169.00±10.00	149.00±8.15	206.00±3.01	183.20±5.00	50

Key: Values are represented as mean±Std

Polyaromatic Hydrocarbons

Sawmill soils showed higher concentrations of polycyclic aromatic hydrocarbons (PAHs) compared to the control soil as shown in Table 2.

Marine Base and Mile 3 sawmill soils had the highest mean PAH concentrations, followed by Iloabuchi soil. Naphthalene and three-ring PAHs like acenaphthene and fluorene were found in relatively higher concentrations, especially in Marine Base and Mile 3 soils. Heavier five-ring and six-ring PAHs were detected in Marine Base low soil and subsoil. Total PAH concentrations ranged from 2.86 to 42.59 mg/kg in sawmill soils and were negligible in the control soil.

Previous research has found higher polyaromatic hydrocarbons (PAHs) concentration in topsoil layers that decrease with depth due to preferential sorption and variation in biodegradation patterns depending on molecular structure [20]. This aligns with the observed pollution patterns across soil depths in this study. The PAH levels were also higher in sawmilling soils compared to the control. This may be due to anthropogenic emissions from wood processing superseding natural sources as the dominant influence on local PAH burdens, consistent with literature [21]. Additionally, the high organic matter content of sawmilling topsoils, especially at Iloabuchi site, enhances PAH sequestration through sorption as reported earlier [22]. Sawdust acts as a carrier facilitating PAH redistribution within soils through dry cracking or mechanical disturbances, a process shown to borne PAH transportation [22]. This introduces and spreads residues detrimental to biota and humans amongst sawmilling vicinity soils. Therefore, sawdust pollution represents a risk factor for PAHs contamination of surrounding lands needing remediation.

Table 2: Polyaromatic Hydrocarbon Concentration (mg/kg) in the Different Sawmilling Site

PAHs		**Marine Base**			**Mile 3**			**Iloabuchi**			**Control**			**Total**
		Top Soil	**Sub Soil**	**Low Soil**	**Top Soil**	**Sub Soil**	**Low Soil**	**Top Soil**	**Sub Soil**	**Low Soil**	**Top Soil**	**Sub Soil**	**Low Soil**	
Two ring	Naphthalene	0.01	0.12	0.05	0.01	0.12	0.05	0.03	0.01	0.02	ND	ND	ND	0.42
Three ring	Acenaphthylene	8.12	10.53	9.05	0	1.34	0	0	0	0	ND	ND	ND	29.04
	Fluorene	2.71	0	2.71	3.32	0.4	0	0	0.27	0	ND	ND	ND	9.41
	Acenaphthene	1.95	1.93	1.94	2.02	0.29	1.93	1.93	0.21	1.55	0.02	0.01	ND	13.75
	Phenanthrene	0	0	0	0	0	2.18	2.15	0	1.75	ND	ND	0.01	6.08
	Anthracene	0	0	0	0	0	2.53	2.49	0.25	2.03	ND	ND	ND	7.30
Four Ring	Fluoranthene	2.78	2.79	2.78	2.78	0.42	2.78	2.81	0.28	2.22	ND	0.01	0.01	19.64
	Pyrene	2.6	0	2.58	2.56	0.39	2.56	2.57	0.26	2.05	ND	ND	ND	15.57
	Benzo(a)anthracene	2.87	2.88	0	2.87	0.43	2.87	2.87	0.29	2.29	ND	0.02	ND	17.37
	Chrysene	1.84	1.85	0	1.84	0.28	1.84	1.85	0.18	1.47	ND	ND	ND	11.15
Five Ring	Benzo (b) fluoranthene	3.95	0	3.93	3.93	0.59	3.92	0	0.39	3.14	0.01	ND	ND	19.85
	Benzo (k) fluoranthene	3.47	0	3.45	3.44	0.52	3.44	0	0.34	2.75	ND	ND	ND	17.41
	Benzo[a]pyrene	0	0	3.84	3.84	0.58	3.84	0	0.38	3.07	ND	0.02	ND	15.55
	Dibenz(a,h)anthracene	0	4.12	4.17	4.13	0.62	4.17	0	0	3.34	ND	ND	ND	20.55
Six Ring	Indeno[1,2,3-c,d]pyrene	4.42	0	4.46	4.41	0	0	4.42	0	0	ND	ND	ND	17.71
	Benzo[g,h,i]perylene	3.58	3.57	3.63	3.57	0.54	3.59	3.57	0	2.87	ND	ND	0.01	24.92
	Mean±SD	2.31±2.23	1.61±2.83	2.60±2.47	2.34±1.63	0.39±0.35	2.14±1.50	1.41±1.48	0.19±0.15	1.71±1.2	ND	ND	0.01±0.01	15.36±7.25
	Total	38.3	27.79	42.59	38.72	6.52	35.7	24.69	2.86	28.55	ND	ND	0.02	245.72

Key; Values are represented as mean±SD.

Conclusion

From the results obtained in the study, it is evident that the continuous dumping of sawmill waste has substantial impact on the physical and chemical characteristics of the soil. Deposition of sawdust gave noticeable alterations in the soil's bulk density and porosity. It also affected the chemical composition of the soil, as indicated by the increase in electrical conductivity compared to the control samples. pH decreased with depth across the sample sites.

Nutrients in the soil differed significantly between the sawmilling locations and the control area, with the soil samples from the various sawmilling sites containing higher values. For heavy metal concentrations, Marine base site had a higher concentration order of Co > Mn > As > Ni > Cd > Zn, while the Mile 3 site showed Mn > As > Co > Cd > Ni > Zn. At the Iloabuchi site, the concentration order was Co > Mn > As > Cd > Zn > Ni. The presence of Co and Mn in the soils at the sawmilling sites indicates significant pollution levels.

Sixteen (16) different Polycyclic Aromatic Hydrocarbons (PAHs) in variable amounts across the soils from the three sawmilling sites were detected showing the impact of timber processing activities on soil contamination**.**

Conflict of Interest

The authors declare that there is no conflict of interest.

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