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ASSESSING THE EFFECTS OF FLOODING ON SOILS QUALITY IN SOME PARTS OF LOKOJA KOGI STATE, NIGERIA

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Abstract
Water and soil quality in Kogi state are examined in this study. Soil samples were taken from two sampling sites and one control site. The soil samples' pH, lead, moisture, iron, copper, zinc, phosphate, and other physicochemical properties were measured using standard laboratory methods. The result was examined using standard methods to determine how floods affected soil quality. Floodplain soil quality was significantly lower than in non-flooded areas. At 95% confidence (p0.05), this was scientifically proven. Using a p-value of 0.05, soil properties were considerably lower in flood zones than controlled sites. The study found that floodplains had poorer soil quality than non-flooded areas. Thus, to preserve floodplains' natural quality, the government and other institutions should avoid further flooding.

Key Words: *Flood, physiochemical properties, Soil, Environment, Lokoja*

Introduction

Floods are environmental hazards caused by both climate and human activity. Man's relationship with the environment is best shown by the deluge. They occur in both developed and developing countries and often cause catastrophic loss of life and property, suffering, difficulty, disease, and hunger. Catchment floods loosen soil, which rains and discharge wash away. Overbank discharge defines floods (Morganstein and Ursano, 2020).

Soil particles separate and move due to shear stress from overland flow. Detached material settles when the flow's carrying capacity is exceeded (Nilsson, 2018). Inundation disrupts soil physiochemistry and often ruins entire harvests, resulting in a food shortage. In times of food scarcity, feeding people is hard.

Flooded soils are anaerobic, which kills microorganisms. The soil's free oxygen usually diminishes within a few days after a flood (Liu *et al*., 2021). Flooding helps preserve key eco-system processes and biodiversity in a variety of natural systems, despite its significant environmental impacts. A flood brings organic materials, minerals, and other vital resources from rivers and oceans to land, making it more fertile, productive, and prosperous.

Therefore, inundation circumstances arise when rainfall exceeds the usual amount for a site oriole (Mensah and Ahadzie, Divine Kwaku, 2020). This state can be caused by natural (heavy rainfall, dam collapse, clogged rivers) or man-made (building structures on natural waterways, urbanisation, deforestation, etc.) factors (Mfon et al., 2022). Flooding often kills people and destroys property. Additionally, it has long-term psychological effects (Glago, 2021).

Flash flooding is common in Nigeria from May to September during the rainy season. Torrential rains in Nigeria, nearby Cameroon, and Niger from July to September 2021 increased overflowing water reservoirs, causing officials to open dams (Lamingo dam and Lagdo dam in Cameroon's Northern sector) (Ajanaku, 2022). As a result, riverbanks and infrastructure were damaged, property was destroyed, farm animals killed, and flash floods occurred in various places. From July through September 2021, heavy rainfall overflowed reservoirs. As of November 5, 2021, 600 people have died and almost 1,300,000 have been displaced by Nigeria's worst floods in four decades (Onukwue, 2021). Flooding has been reported in 32 of Nigeria's 36 provinces. Flooding was particularly severe in Adamawa, Taraba, Delta, Anambra, Lagos, Edo, Niger, Cross-River, Bayelsa, Rivers, Plateau, Benue, and Kogi states. Flood devastation and its negative effects on agricultural soils, which lower soil quality, necessitate this research. Floods' effects on soil quality indicators in agricultural fields around Lokoja, Kogi state, will be assessed in this study.

Research Hypotheses

$H_{01.}$ The quality of the top soil characteristics of the sampled soil in flood-prone areas and at the control location is not statistically significantly different.

H_{02}. There is no significant difference between the subsoil quality values of soil samples collected from flood-prone areas and soil samples collected from the control point.

Study Location

Lokoja, which serves as the state capital, is situated in Kogi state. 7° 45′ north of the equator and 6° 41′ east of the Greenwich Meridian. The Niger River defines the western boundary of this area. The flat terrain is 107 metres below sea level and features frequent undulations. According to the 2006 census, the geographical area is 3,180 km^2 and the population is 195,258. The average daily temperature is approximately 23.2°C. It enjoys year-round sunshine and comfortable temperatures due to its tropical climate. The Guinea Savannah, also known as parkland savannah, is the most common variety of vegetation in Lokoja. Long grasses and scattered trees distinguish both varieties (Adedibu *et al*., 2022).

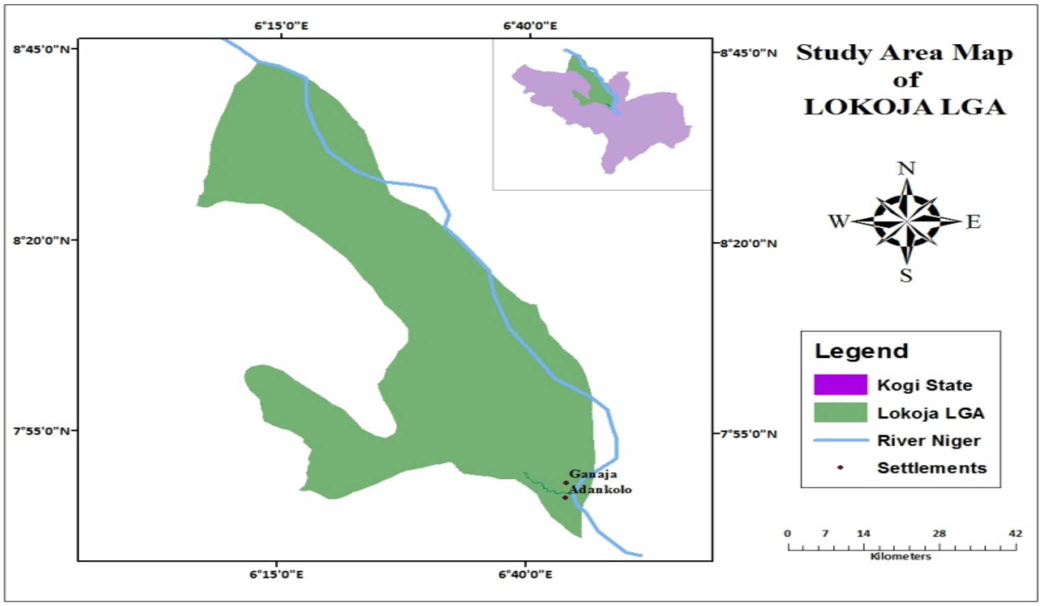

Fig. 1: Map of Lokoja Showing Study Areas

Methodology

For this study, primary and secondary materials were used. This inquiry requires soil samples from Lokoja's Ganaja and Adankolo localities. To assess their physicochemical properties, these soil samples were collected along floodplains under controlled conditions. 20 soil samples were gathered from 15m-by-15m plots in flood-prone areas and controlled sites in the research zone using a soil auger. Topsoil and subsurface samples were 0–30cm and 30–60cm deep, respectively. Samples were taken at each junction of each test plot's grid lines. Three surface and three deep soil samples were taken from each allotment. The research findings will be matched against FME standards. Environmental regulations are made and enforced by it. Conservation and environmental management are the plan's objectives.

After collecting soil samples from two flood-prone areas and one control point, they were carefully packaged and displayed. Physical, chemical, and heavy metal soil samples were collected in clean polythene containers for laboratory analysis. The findings were bar charted. Hypotheses were tested using two-way ANOVA.

Results and Discussion

Soil Physical Properties

Soil pH

The pH levels of all floodplain soils (including topsoil and subsoil) ranged from 7.6 to 8.3, with an average value of 7.95 + 0.35 indicating the soil was mildly acidic. The average pH of the control site is 8.4 +0.33, ranging from 8.3 to 8.5. These results differ from those of Mfon *et al*. (2022) and Ebuzoeme (2015), but agree with those of Talbot *et al*. (2018) and Sugianto *et al*. (2022). The decrease in pH levels that follows flooding demonstrates that floods have an effect on floodplains. Consequently, the soil becomes more acidic. When organic acid is fermented in highly saturated soil, the pH level of the soil decreases. With increasing alkalinity, the pH of acidic soils increases, while the pH of alkaline soils falls. The soil's pH is a significant determinant of which elements are available for plant absorption (Neina, 2019). Based on these PH levels, soil acidity has no effect on its nutrient composition.

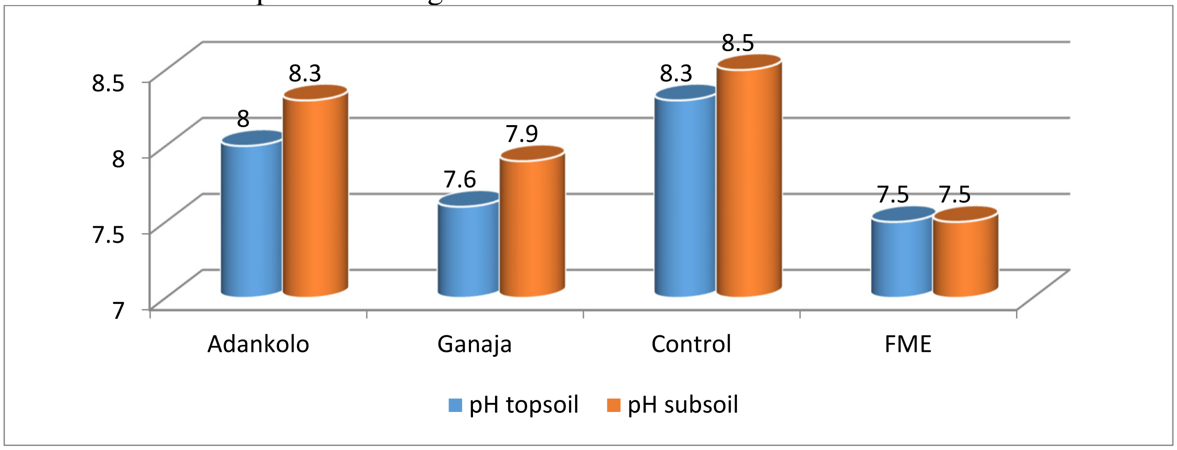

Fig. 2: Soil pH of the study site

Temperature

The average temperature of the studied soils (including the topsoil and the subsoil) in the floodplain ranged from 31.5 to 32.0ºC, with a mean of 31.75. This temperature is compared to that of the control point, which ranged from 31.4 to 31.9ºC, with an average of 31.65ºC.

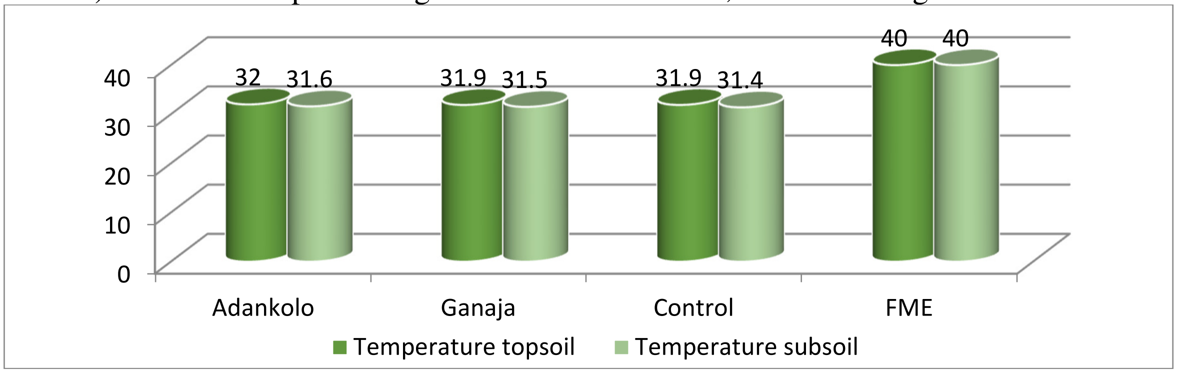

Fig. 3: Soil Temperature of the study site

Soil Porosity

The porosity of the floodplain site (topsoil and subsurface) varies from 38.3 to 46.66, with a mean value of 43.09 + 0.33, whereas the porosity of the control site varies from 41.66 to 47.00, with a mean value of 44.33. There is a wide spectrum of possible soil porosities. The porosity of free soil can reach approximately 50%, while the porosity of compact soil can reach approximately 30%. The statistics indicate that the controlled and floodplain porosity values are comparable.

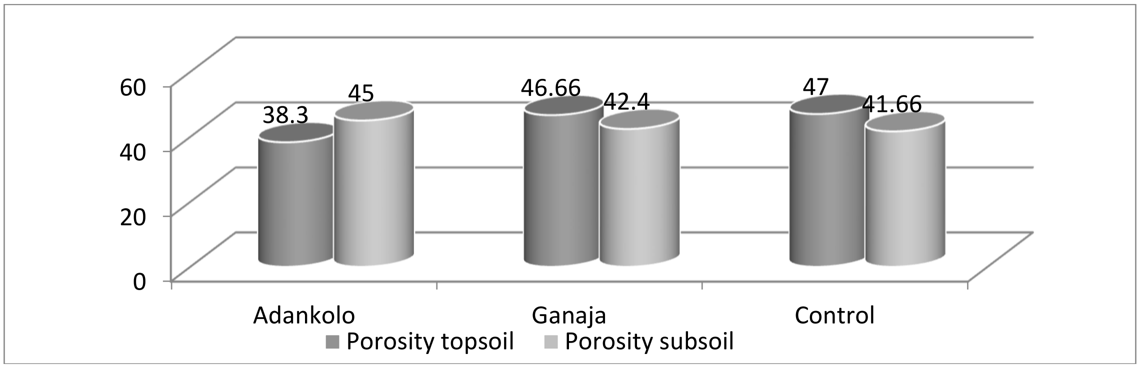

Fig. 4: Porosity of the study site.

Soil Moisture

The moisture content of the topsoil and subsoil at separate sites in the flood plain varied from 1.011 to 8.77, with a mean value of 4.25 + 0.33, and from 1.01 to 1.15, with a mean value of 1.08. The absorption capacity of the soil, as well as the flow rates of rivers, streams, and coastal areas, all influences the susceptibility of an area to inundation. Heavy or persistent precipitation could lead to flooding. Confirming the conclusion, a creek overflows onto adjacent land. This suggests that flooding in the Adankolo region will be substantially more severe than flooding in the Ganaja region, as the result obtained in the Adankolo floodplain area is relatively high, whereas the result obtained in Ganaja is comparable to the control.

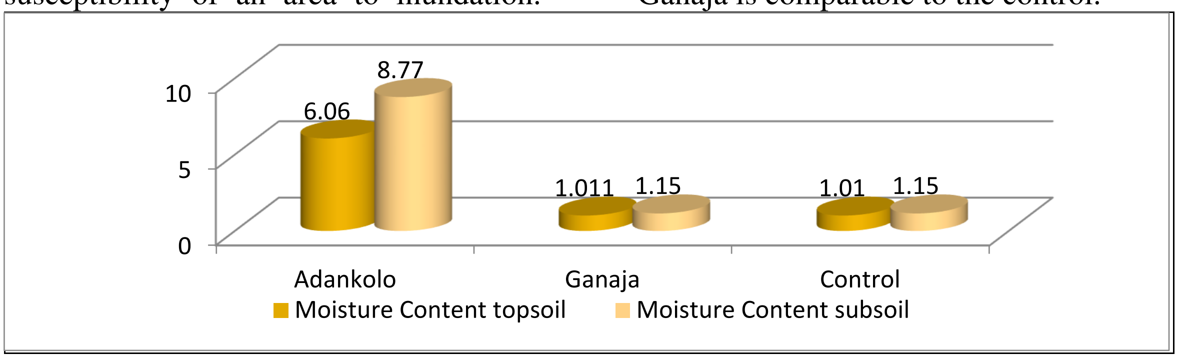

Fig. 5: Moisture of the study site

Bulk Density

The flood plain site's bulk density (topsoil and subsoil) ranged from 0.476 to 0.580, with a mean value of 0.519 + 0.33, whereas the control site's bulk density ranged from 0.3750 to 0.498, with a mean value of 0.4365. This site of erosion had a greater bulk density than the control site, which was a fallow field. This, according to Gürsoy (2021), makes it more difficult for plant roots to penetrate the soil, resulting in decreased infiltration, increased overland flow, and, ultimately, soil erosion.

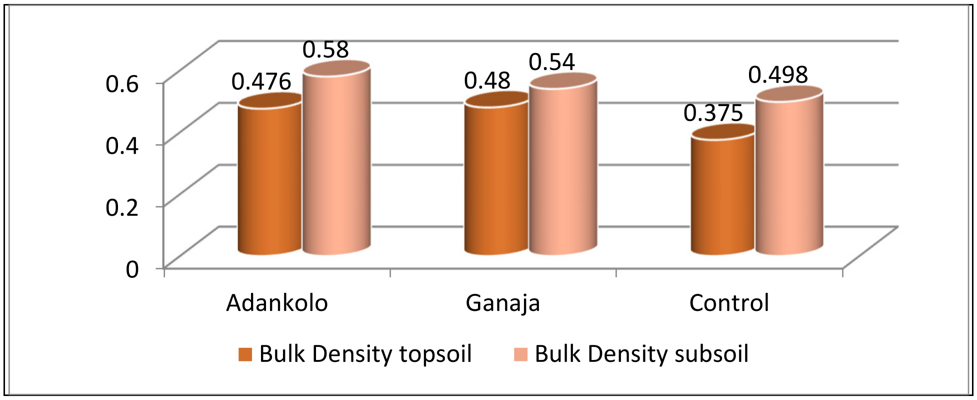

Fig. 6: Bulk Density of the study site

Soil Chemical Properties

Phosphate

Compared to the control site, where phosphate levels range from 57.5 to 81.0 with a mean value of 69.25, topsoil and subsurface phosphate levels at the flood plain site range from 7.6 to 55.1 with a mean value of 20.60 + 0.33. A phosphorus deficiency could lead to phosphorus deficiency. Even when phosphorus is present, plants may find it difficult to assimilate it if the soil is acidic. The fact that the control site has a high phosphate concentration while the floodplain has a low phosphate concentration indicates that the phosphate content of the soil in the research location was washed away by flooding.

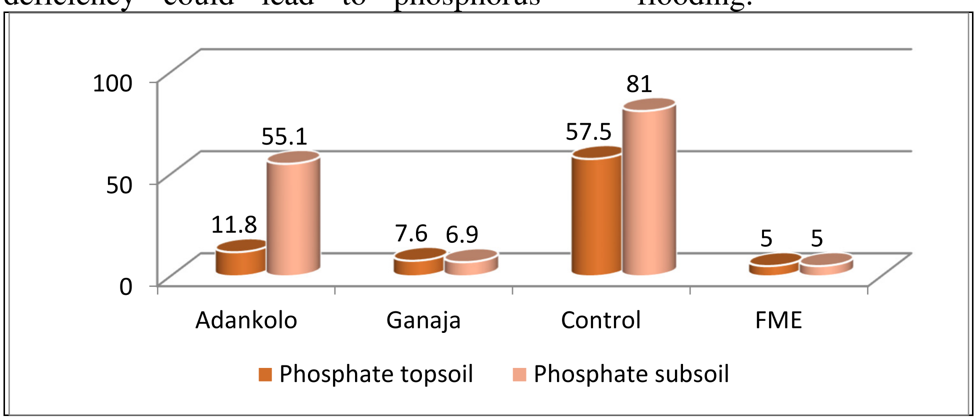

Fig. 7: Phosphate of the study site

Nitrate

The range of total nitrogen (TN) concentrations in the topsoil and subsoil of the four flood plain locations was 0.207 to 0.393. Nitrate values range between 0 and 0.39.5 mg/L. While the nitrate level at the controlled site ranges from 19.97 to 28.0, with an average of 24.58, and from 15.23 to 20.75, with an average of 17.99, the phosphorus level at the variable floodplain site (topsoil and subsurface) ranges from 0.279 to 0.497, with an average of 0.279. Phosphorus concentration in the floodplain varies significantly. Although comparable results were recorded for the control site and the floodplain, the concentration of nitrite at the control site is higher than that of the floodplain.

Nitrate violates this regulation (Kaden *et al.*, 2021). During floods, the quantity of ammonium in the earth increases due to a significant decrease in (aerobic) nitrification processes and a net increase in ammonification (Grzyb *et al.,* 2021). Nitrate concentration is an essential indicator of soil fertility, quality, and yield.

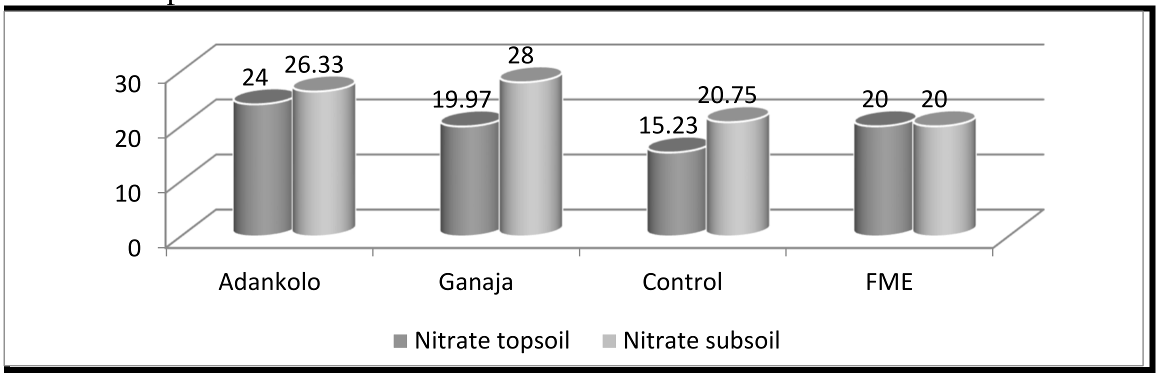

Fig. 9: Nitrate for study site

Chloride

Topsoil and subsoil chloride concentrations range from 25.2 to 51.0, with a mean value of 37.8, and from 30.5 to 33.4, with a mean value of 31.98, at the flood plain site. Following both a little and huge flood, the nutritional content of the soil changed. Soil nutrient content often rose as flooding depth and duration were reduced. Because flooding has reduced nutrient availability in the soil at the research site, the low levels of chloride in soil samples from both floodplain sites confirm this result.

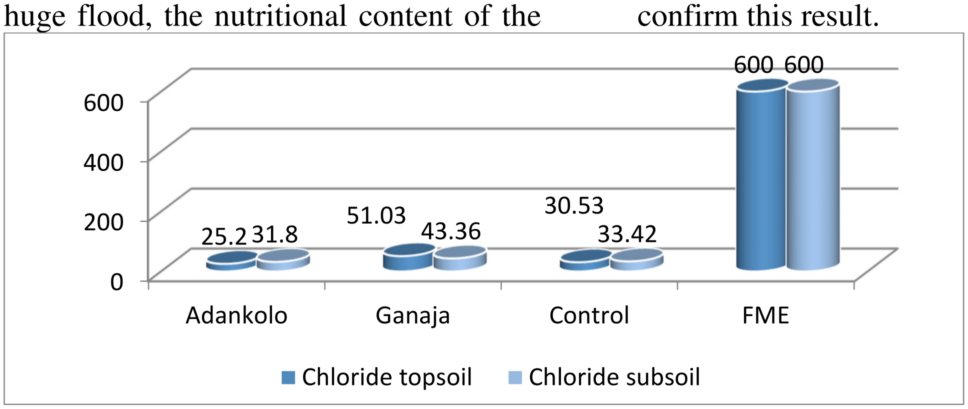

Fig. 10: Chloride of the study site

Sulphate

Topsoil and subsoil sulphate concentrations at the flood plain site range from 9.8 to 65.3, with an average of 34.02, compared to 10.3 to 11.8 and 11.05% at the control site.

Wet conditions result in the formation of acid sulphate soils, which may be soils, detritus, or organic substrates (such as peat). Pyrite is the most frequently discovered iron sulphide mineral in these ground waters. It is acceptable to disregard naturally occurring acid sulphate soils below the water table. The detection and evaluation of soil sulphate acidity, Soil sulphides react with oxygen to form sulfuric acid until the soil is excavated up, exposed to air, or the water table is lowered. The high levels of sulphate in the floodplain can be attributed to the frequent wet conditions in the study area, specifically Christel *et al*. (2019).

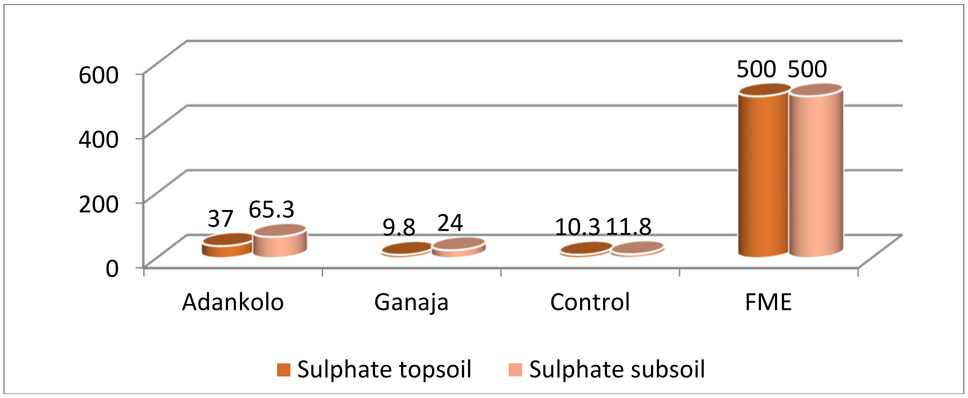

Fig. 11: Sulphate of the study site

Magnesium

The average magnesium content of the flood plain (including topsoil and subsurface) is 34.24, which is comparable to the average magnesium content of the control site. According to the data, the soil in the study area has a low magnesium concentration compared to the amount recommended by the Federal Ministry of the Environment. Low magnesium concentrations in the floodplain zone after a major flood may be the result of dissolution and dilution, as mineral nutrients are more soluble during a flood. During a catastrophic deluge, it stands to reason that more soil nutrients will be leached away.

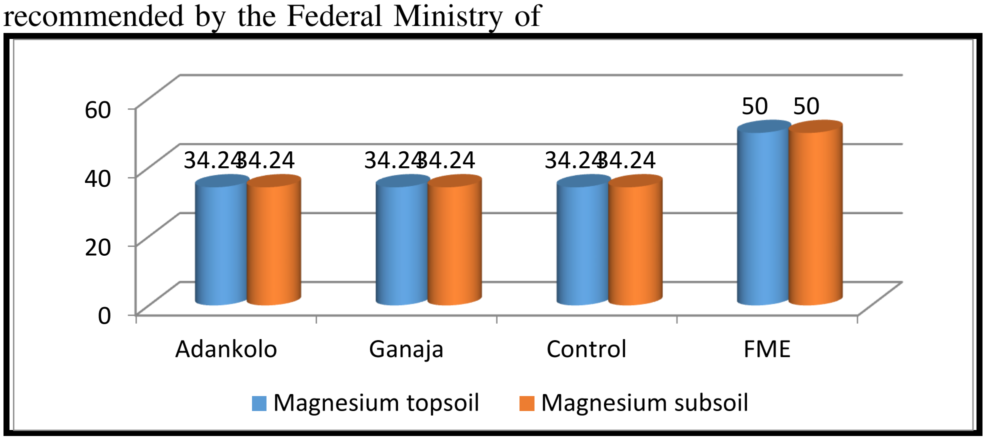

Fig. 12: Magnesium for study site

Aluminum

Al in the topsoil and subsoil of the flood plain site ranges from 0.320 to 0.834 on average, with a value of 0.544, while in the control site it ranges from 0.612 to 0.834 on average, with a value of 0.723.

Consequently, the inundation plain has less aluminum. The rate at which organic matter decomposes is one of the factors that may contribute to low soil aluminum levels during periods of substantial inundation. Organic matter decomposes, releasing nutrients that had been confined within the substance (Schoonover and Crimmins, 2015). After floods, the soil's oxygen content decreases (Liu *et al.*, 2021).

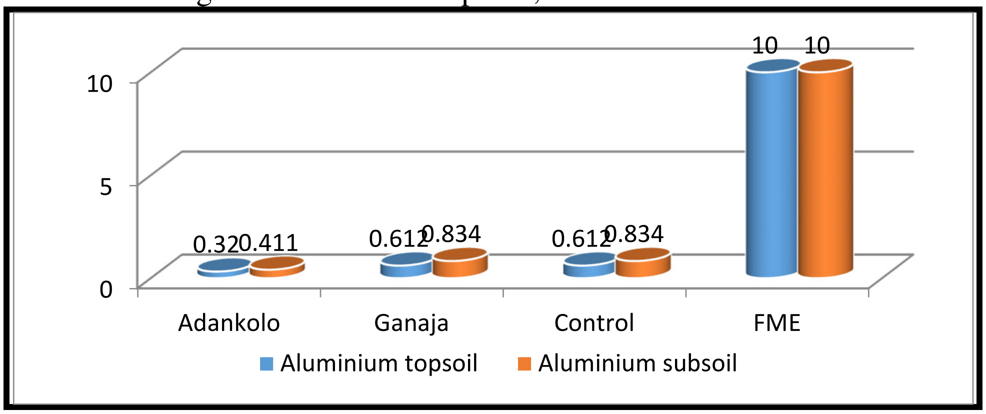

Fig. 13: Aluminum of the study site

Total Organic Carbon

The controlled site value ranges between 5.48 and 6.55, with an average of 6.015, whereas the floodplain organic carbon content ranges between 2.50 and 6.55, with an average of 4.28. There are comparable numbers provided. TOC is used to measure organic matter in soils, sediments, and water (Avramidis, Nikolaou, and Bekiari, 2015). Organic acids and biological activity have a substantial impact on the contribution of TOC to acidity. Due to the fact that the flood swept away the majority of the soil's organic material, including organic acids and humus, the only sources of organic carbon content, a slight decrease in total organic carbon was likely detected in the flood-affected region. Given the significance of organic carbon in stimulating microbial respiration and activity, a decrease in soil organic matter may have a negative impact on soil quality and fertility. The soil's "total organic carbon" (TOC) is known as "organic carbon." As living and extinct microbes, soil biota, root exudates, and other organic waste decompose the soil's organic carbon content rises.

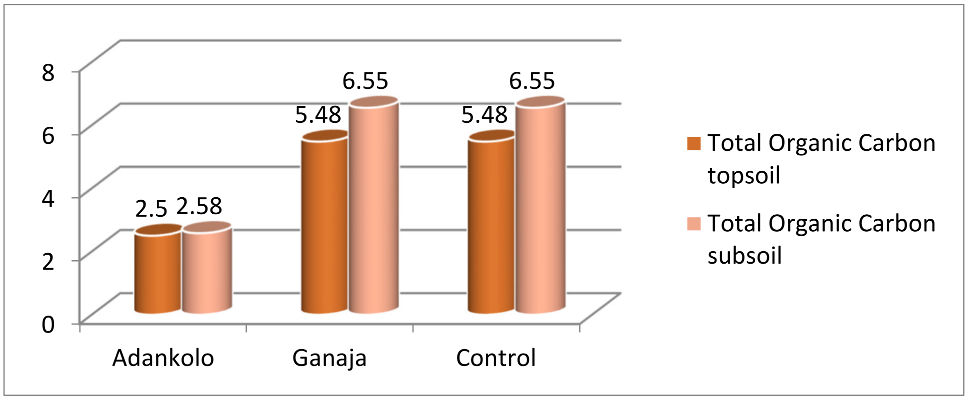

Fig. 14: Total Organic Carbon of the study sites

Calcium

The calcium concentration of the site's topsoil and subsoil ranges from 68.48 to 85.6, with an average of 76.0. In contrast, the mean calcium concentration varies from 68.48 to 68.48 in the control area. The collected data indicates that the calcium concentration is substantially below the federal standard imposed by the Department of the Environment. As flooding increases the solubility of mineral elements, dissolution and dilution may contribute to low calcium concentrations in the floodplain zone after a significant flood (Kelly *et al*., 2020). During a significant flood, when water permeates the soil and flushes away dissolved compounds via leaching, it is normal to anticipate a larger loss of soil nutrients. The dissociation of NO3- from HNO3 enhances cation leakage (from nitrification), according to reports. As a consequence of the region's prolonged and intense flooding, Adankolo may have lost additional soil nutrients due to leaching.

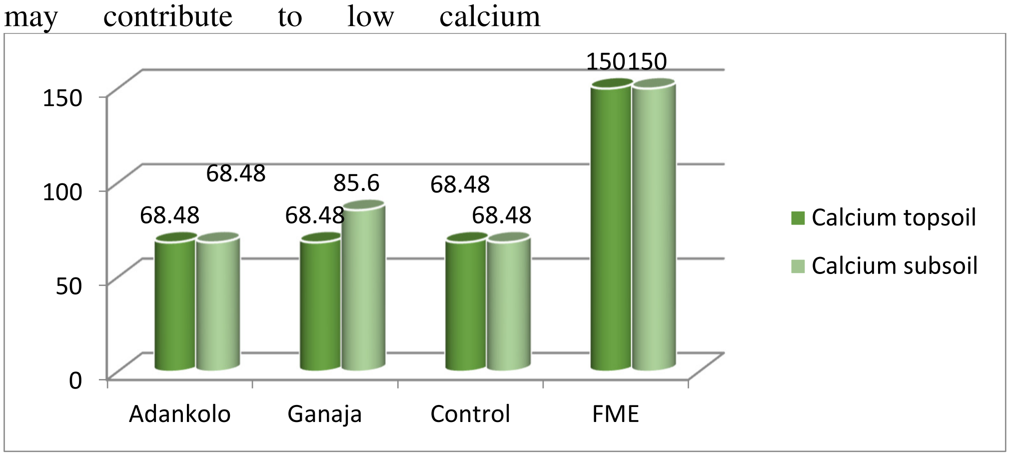

Fig. 15: Calcium for study site

Heavy Metals

Lead

While the lead content of the control site (containing topsoil and subsoil) ranges from 0.098 to 0.250, with a mean of 0.16675, the flood plain site varies from 0.098 to 0.250. The results demonstrate that the floodplain location has higher lead than the control site. Lead levels in floodplains may have increased due to nutrients carried from erosion regions and dumped there, making floodplains more fruitful and productive than arable land. Flooding causes food shortages because crops are drowned or choked, while floodplains are fertilised by the addition of nutrients that were previously inadequate. Soffar (2016) made the same discovery.

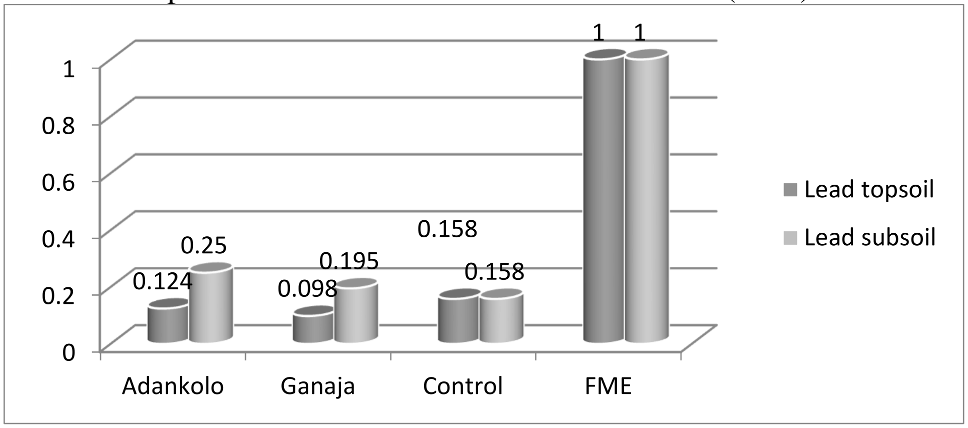

Fig. 16: Lead of the study site

Iron

The flood plain site's iron concentration ranges from 1.214 to 2.100, with an average of 1.675, whereas the control site's iron content ranges from 1.875 to 2.030, with an average of 1.9525. Iron and other inorganic leachable elements are typically found in ash residues and C&D debris. Because of the variability of solid waste, only broad generalizations about the association between floods and leach ate quality are attainable (Nyandwaro, 2017). Because the dumpsite contains a variety of trash, including construction detritus, demolition rubble, and domestic garbage, the elevated iron level at the test site is most likely the result of waste water seeping from several sources. Despite the fact that plants cannot use the bulk of its forms, iron is the fourth most common element in soil.

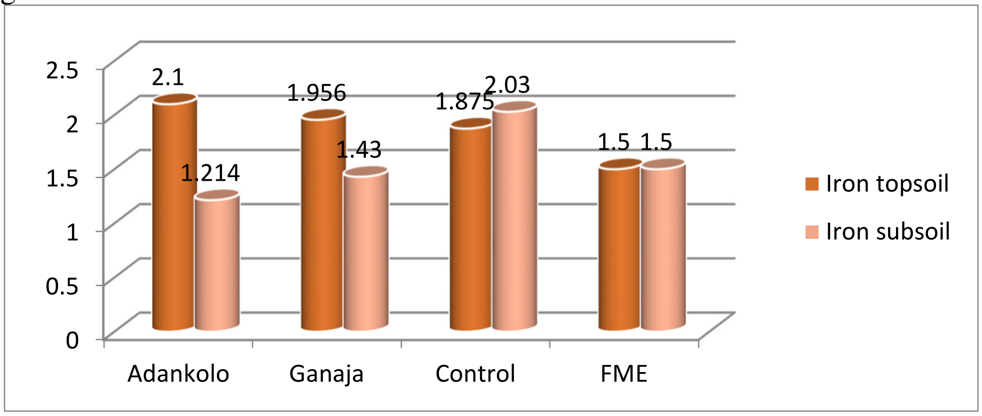

Fig. 17: Iron of the study site

Copper

Copper concentrations in the topsoil and subsoil of the flood plain site range from 0.148 to 2.167, with a mean of 0.931, whereas they range from 5.00 to 5.084, with a mean of 5.042, at the control site. Adankolo's floodplains may be more fruitful and productive than adjacent arable land due to nutrients transported from erosion zones and deposited there, which may account for the area's higher copper content. Timmis and Ramos (2021) found that floodplains become more fertile by adding nutrients that are lacking in the soils, even when flooding cause food shortages due to crop loss from water and suffocation.

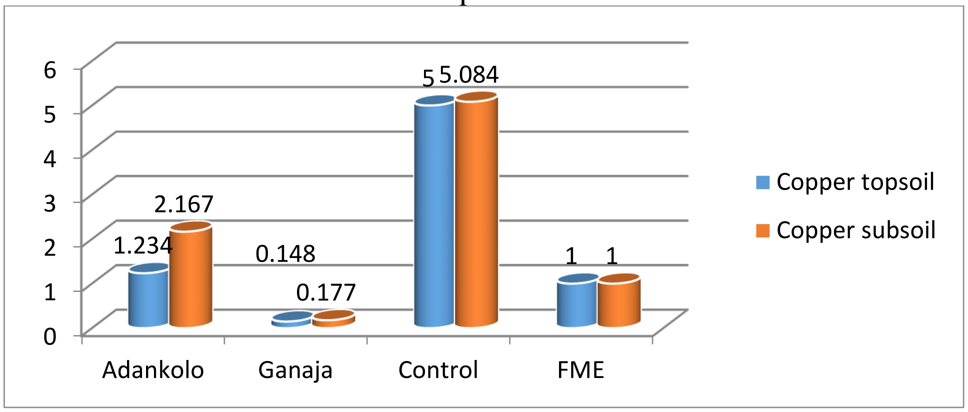

Fig. 18: Copper of the study site

Cadmium

Cadmium concentrations in the topsoil and subsoil of the flood plain site fluctuate substantially, on average, from 0.331 to 1.299, whereas at the control site they fluctuate more gradually, on average, from 0.55 to 0.631, for a value of 0.5905. The results revealed that the Ganaja soil contained significantly more cadmium than the reference site. Given that cadmium is produced during the smelting of lighter metals such as zinc, lead, and copper, it stands to reason that fluctuations in the concentrations of these elements will have an equal and contrary effect on the cadmium concentration at any given location. The data indicate that the control point contains a significant quantity of copper and zinc, which has led to an increase in cadmium concentration.

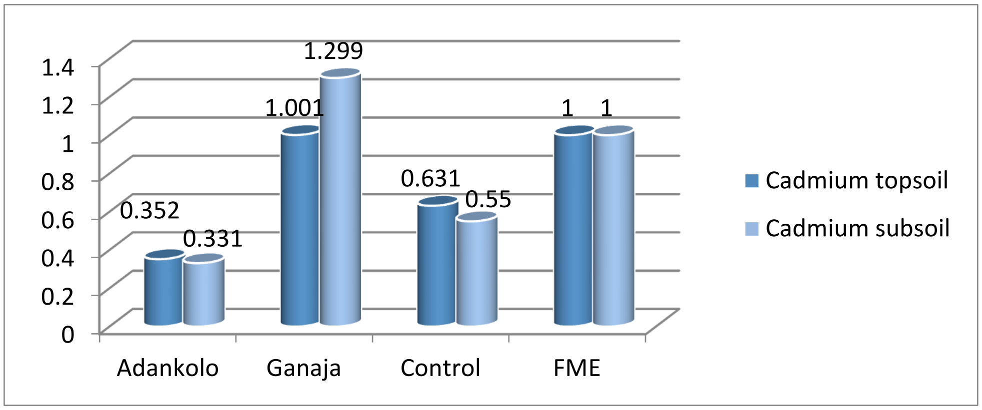

Fig. 19: Cadmium of the study site

Zinc

The zinc content of the flood plain site's topsoil and subsoil ranged from 0.356 to 0.758, while the control site's zinc content ranged from 0.716 to 0.908, making the control site zinc-richer than the flood plain site. Comparing the zinc concentrations at the sample site and the control site, the control site had a higher zinc concentration. Zinc has been shown to be essential for the functioning of numerous enzyme systems; however, excessive zinc consumption, whether from natural or synthetic sources, may be detrimental to human health (Briffa *et al.*, 2020).

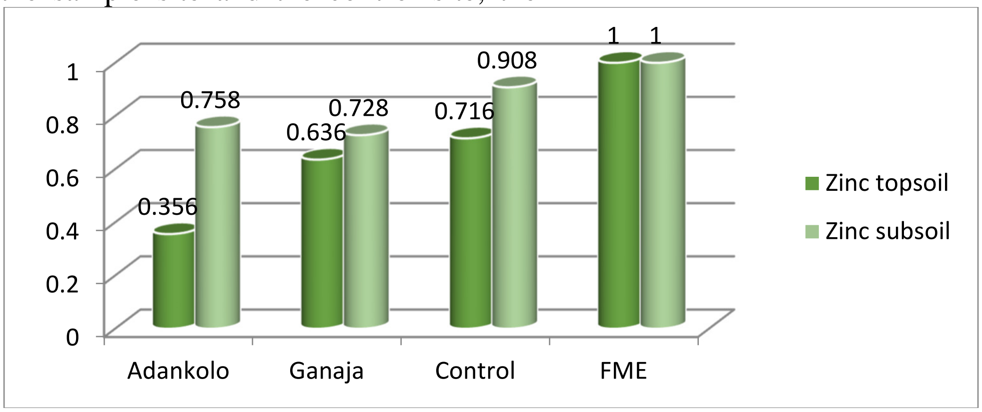

Fig. 20: Zinc for study site

Manganese

The average manganese concentrations in the flood plain site's topsoil and subsoil range from 0.503 to 0.935, whereas they are normally in the 0.803 to 0.835 range in the control site. Manganese concentrations were compared at the sampling site and a control site, and the results show that manganese concentrations are higher at the erosion site. The mining and smelting of manganese-containing iron ores is the world's leading source of manganese pollution (Matveeva *et al*., 2022).

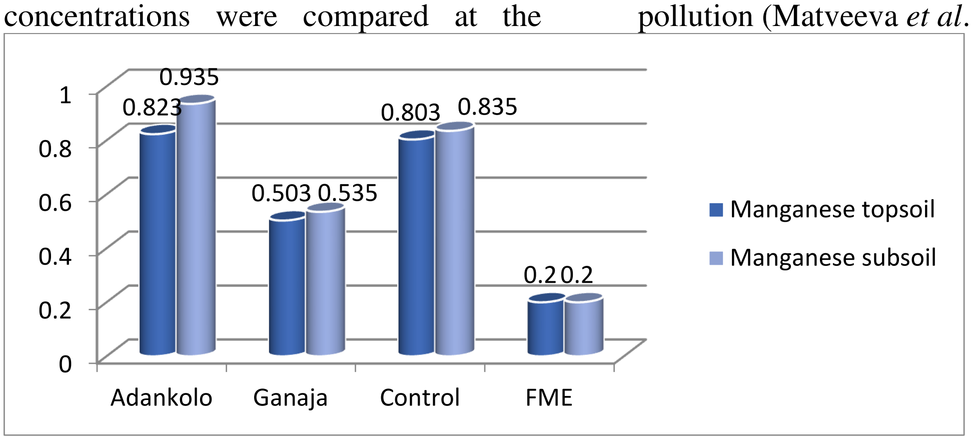

Fig. 21: Manganese of the study site

Determination of significant variation in the values of physiochemical properties of sampled soils of floodplains and controlled sites

$H_{01.}$ The quality of the top soil characteristics of the sampled soil in flood-prone areas and at the control location is not statistically significantly different.

Table 1: Test of Hypothesis one

ANOVA: Single Factor

Summary

Groups	*Count*	*Sum*	*Average*	*Variance*
Control top soil	20	320.461	16.02305	455.8297
Ganaja top soil	20	289.412	14.4706	427.3857
Adankolo top soil	20	293.662	14.6831	361.8135

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	28.33816	2	14.16908	0.034142	0.966454	3.158843
Within Groups	23655.55	57	415.0096			
Total	23683.89	59				

The studies revealed an F-value of 3.1588, whereas the table value was 0.0966 at a significance level of 0.05. If the projected value of 3.1588 is greater than the table value of 0.966, there is a statistically significant relationship between the top soil properties of the soil samples from flood-prone areas and the control site.

H_{02}. There is no significant difference between the subsoil quality values of soil samples collected from flood-prone areas and soil samples collected from the control point.

Table 2: Test of Hypothesis two

ANOVA: Single Factor

Summary

Groups	*Count*	*Sum*	*Average*	*Variance*
Control Subsoil	20	350.344	17.5172	570.7126
Ganaja Subsoil	20	318.557	15.92785	506.8741
Adankolo Subsoil	20	384.539	19.22695	560.9187

ANOVA

Source of Variation	*SS*	*Df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	108.8889	2	54.44446	0.099684	0.90528	3.168843
Within Groups	31131.6	57	546.1684			
Total	31240.49	59				

The determined F-value in this study is 3.1688, with a significance level of 0.05, while the similar value from the table is 0.0996. Because 3.1688 is greater than 0.996 in the table, there is a significant relationship between the sub-soil property values of the soil samples taken from flood-prone regions and the control site.

Conclusion and Recommendation

According to studies, floods dramatically alter soil parameters, reducing soil quality in floodplains compared to controlled settings with equivalent characteristics. In flood-affected areas, soil moisture, bulk density, nitrate, sulphate, lead, cadmium, and calcium increased by 62%. The floodplains had far lower pH, porosity, phosphate, nitrite, chloride, magnesium, aluminum, total organic carbon, iron, copper, zinc, and manganese than the control zones. In flood-prone areas, the control site and soil parameter values differ significantly. According to the investigation, Adankolo and Ganaja soil samples were severely affected by the flood.

The government and other relevant organizations should prevent further flooding of floodplains and protect the natural quality of these farmlands from the degrading and destructive effects of such a severe flood, according to the study. Farm discharge and subsurface drainage generate downstream floods in vulnerable areas, therefore agricultural land use can lower flood risk. If vegetation is to grow here, drainage and aeration must be promoted and slow-draining zones avoided. Organic materials like leaf compost, pink bark, and peat moss increase soil porosity. Finally, develop hardy plant seedlings.

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