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The Impact of Rice Milling Activities on the Quality of Soil

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Abstract:- Rice is a very popular commodity amongst Nigerian families, however the demand for rice is on the rise daily, hence an increase in rice milling activities across the country. This study is aimed at determining the impact of rice milling activities on soil quality. The samples were gotten from Auchi, Anambra and Kogi State. The samples were digested and analysed using a varian 220 atomic absorption spectrometer (AAS). Physicochemical properties showed the ph of the soil, ranging from 6.7 -9.84, temperature 29.1^{o}C – 30^{o}C and electrical conductivity of soil ranged from 1.3(µS/cm)-88.2(µS/cm). The available nutrients in the soil revealed the highest values for nitrogen to be 52.2779 (mg/kg), and phosphorus to be 296.421 (mg/kg), while the highest value for potassium was 188.315 (mg/kg). Conclusively, The rice mill operations was seen to affect the soil quality parameters, due to the release of effluents on the soil, resulting in an increase in the heavy metal concentrations in the soil and decrease in the available nutrients. Accumulative geo-index revealed that Auchi is moderately polluted with cadmium and Anambra is highly polluted with zinc.

***Keywords**:- Rice Mills, Soil Nutrients, Heavy Metals, Accumulative geo-index, Anthropogenic Metals.*

I. INTRODUCTION

For a huge fraction of human the population in Nigeria, environmental degradation refers to changes in the physical environment. This view has totally ignored the existence of the rapidly increasing levels of toxic chemicals in soil (Odoh*et al.*, 2014). With the intensive use of the land due to population pressure and absence of any definite management system, the productivity of the soil has been adversely affected (Nwite, 2015). This effect on productivity arises from direct soil contamination. Soils may become contaminated by the accumulation of heavy metals and metalloids through emissions from the rapidly expanding industrial areas, mine tailings, disposal of high metal wastes, leaded gasoline and paints, land application of fertilizers, animal manures, sewage sludge, pesticides, wastewater irrigation, coal combustion residues, spillage of petrochemicals, and atmospheric deposition (Zhang, Liu and Haung, 2010).

Continuous soil contamination from human activities results in the rapid depletion of plant nutrients, resulting in limitations to crop production. Agricultural productivity of soils is hindered by soil fertility constraints and deteriorating nutrient status (Olatunji and Ayuba, 2011). Many interrelated factors, both natural and managerial cause soil fertility decline. This decline in soil fertility may occur through leaching, crop removal and soil erosion (Njoku, Uguru and Mbah, 2017).

For instance, rice dust is a solid waste common in rice mill centre and hundreds of tones are been produced every day. This rice dusts constitute a very serious problem if not handled and adequately removed. The rice husk is been disposed, to the land very close to the milling centre. These over grown heaps of rice dust always cause environmental nuisance and contribute to the loss of nutrients to runoff water, and this reduces the soil quality since these soil nutrients are not recycled (Njoku, Nwali and Igwe, 2017). Aside nutrient reduction, the physical properties of soil is also adversely affected. According to Chude, Malgwi, Amapo and Ano(2011) soil physical properties are the main factors that are affecting the use of soil because for agriculture to succeed or fail it depends on the physical properties of the soil, since physical properties are more difficult to change than chemical properties. While the government is basically fixed devoted to primary health care, environment contamination from toxins which induce chronic effects with similar symptoms to communicable diseases have been neglected. These toxins come from trace metals. The ambient concentrations of these trace metals in the various environmental compartments are comparable to and often exceed the levels now being found to cause health problems in the developed countries (Odoh*et al.,* 2014). The presence of toxic metals in soil can severely inhibit the biodegradation of organic contaminants. these metals in soil may pose risks and hazards to humans and the ecosystem through: direct ingestion or contact with contaminated soil, the food chain (soil-plant-human or soil-plant-animal-human), drinking of contaminated ground water, reduction in food quality (safety and marketability) via phytotoxicity, reduction in land usability for agricultural production causing food insecurity, and land tenure problems (Wauna and Okieimen, 2011).

The environmental impact of an industry is not determined by the size of the operation but by the lack of any controls on the toxic wastes being released to the environment. Many of such industries like rice mill carryout operations with toxic wastes that may affect the physical and chemical properties in Soil. Unfortunately, many of the available soils within or near rice mill industry are being cultivated by farmers particularly with fruits, vegetables and other crops like maize, ground-nuts, cassava, cocoa-yam and yam (Odoh*et al.*, 2014). This affects their entire farmer operation through reduced production. Hence, as a result of this, it is important to ascertain the impact of rice milling activities on soil quality.

II. MATERIALS AND METHODS

This research work investigated the impact of rice milling activities on soil quality in accordance with the method adopted by Njoku *et al.*, (2017). The research was conducted through analysis of soil samples close to and away from the study area to ascertain pollution impacts.

A. Sample Collection

Soil samples were collected from three observational points in three different states (Edo, Kogi and Anambra), using a soil auger at depth of 0 – 20cm (top soil) at a distance of 1m and 10m away from study area where rice mill processing is conducted. A control soil sample was also obtained from a different location with no processing activities. Each obtained sample was air-dried, sieved with a 2mm sieve and stored in labeled polythene bags for a week and used for chemical analysis. The three obtained samples were labeled OA, OB, OC (denoting; Observation point A, B and Control).

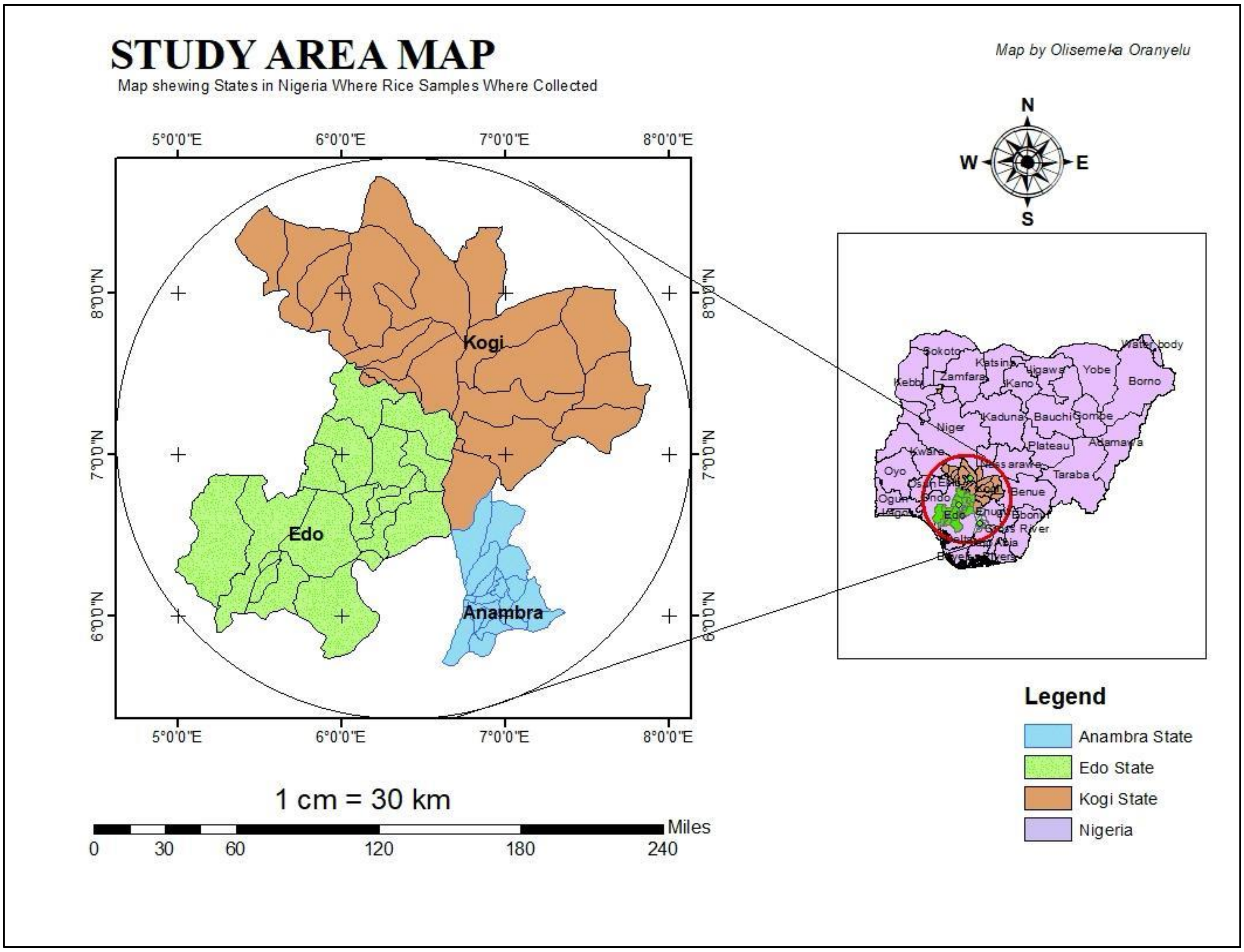

Fig 1: Study Area Map

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B. Laboratory Analysis

The soil samples were analyzed for physical and chemical parameters. The physical parameters will include temperature while, chemical parameters will include Soil pH, Electrical Conductivity, total nitrogen, available phosphorus and available potassium. Laboratory analysis of trace metals were also investigated. These trace metals include, Zinc, Cadmium and Lead contents in soil.

C. Determination of Soil pH and Temperature

The pH and temperature were determined using pH meter (with incorporated thermometer probe). The pH meter was calibrated using pH buffer solutions. The pH meter was plugged to an electric source and turned on. The pH and temperature probes were then inserted into the buffer source 4, allowed to stabilized and calibrated using the calibration button. The same procedure was repeated for buffer 7 and 10 respectively to complete the calibration process. 5gof representative soil samples were weighed and measured into a beaker containing 10ml of deionized water. The mixture was stirred and kept for 30 minutes before the pH and temperature probe were inserted to determine the soil pH and temperature.

D. Determination of Soil Total Nitrogen

5g of air dried and sieved soil sample was weighed into a 500mL macro-Kjedahl flask, with 20mL of distilled water added and swirled for a few minutes before been allowed to stand for 30minutes. 1 tablet of mecury catalyst, 10g of K_2SO_4, and 30mL of concentrated $H_2SO_4$was then added together through an automatic pipette. The flask was then heated at low temperature to allow digestion. When the water has been removed and frothing ceased, heating was continued until the digest is clear. The flask was again allowed to cool and 100mL of water added slowly to the flask. The digest was transferred into another flask. 50ml of H_3BO_3 indicator solution was added to a 500ml Erlenmeyer flask which is then placed under the condenser of the distillation apparatus. The Kjedahl flask was attached to the distillation apparatus with 150ml of 10M NaOH poured in through the distillation flask by opening the funnel stopcock and distillation commenced. 150ml of distillate was then collected and titrated with 0.01M standard HCl using a 25ml burette.

$$\text{Nitrogen}(\%) = \frac{\text{TitrevaluexMolarityofHClx 14}}{\text{WtofSoilused}} \text{x } 100 \qquad (1)$$

E. Determination of Soil Heavy Metal Content

All representative soil samples were allowed to pass through a 2mm sieve prior to analysis.2.0g of 2mm sieved air-dried soil was weighed into a 300cm^3 conical flask and 1ml of concentrated $HCLO_4$, 3ml of HNO_3 and 1ml of concentrated HF was added to the soil in a conical flask under a fume hood. The flask containing the sample was heated until a dense white fume appears and heating was continued for half a minute afterwards. The flask was allowed to cool and then 40-50ml of distilled water was added. The solution was allowed to cool completely and the solution filtered completely with a wash bottle into a pyrex volumetric flask. The flask was made up to mark with distilled water and again filtered with a whatman No.42 filter paper. The soil extract and standard solution were aspirated into the air-acetylene flame of varian 220 Atomic Absorption Spectrometer to determine concentrations of heavy metals.

III. RESULTS AND DISCUSSION

Laboratory results from soil quality parameters analyzed on soil samples obtained from rice mill operation centres are represented as shown below;

Table 1: Result of Physicochemical Parameters of Soil Samples

Locations	**Distance**	**pH**	**Temperature (^{O}C)**	**Electrical Conductivity (µS/cm)**
Auchi (OA)	1m	6.7	30	2.8
Auchi (OB)	10m	7.19	30.3	5.2
Auchi (OC)	Control	7.99	29.4	67.2
Anambra (OA)	1m	6.82	30.1	1.3
Anambra (OB)	10m	6.79	31.4	13.4
Anambra (OC)	Control	9.84	30.8	88.2
Kogi (OA)	1m	7.57	29.1	64.7
Kogi (OB)	10m	7.77	29.4	72.6
Kogi (OC)	Control	7.93	30	78.7

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Table 2: Result of Available Nutrient in Soil Samples

Locations	Distance	Total Nitrogen (mg/kg)	Total Phosphorus (mg/kg)	Total Potassium (mg/kg)
Auchi (OA)	1m	6.88	54.682	96.11
Auchi (OB)	10m	9.815	50.077	84.653
Auchi (OC)	Control	36.256	116.567	131.724
Anambra (OA)	1m	19.021	198.046	143.127
Anambra (OB)	10m	43.34	257.083	163.205
Anambra (OC)	Control	4.653	34.166	62.835
Kogi (OA)	1m	52.277	296.421	188.315
Kogi (OB)	10m	5.902	41.864	75.548
Kogi (OC)	Control	12.246	74.017	124.91

Table 3: Result of Heavy Metals Concentrations in Soil Samples

Locations	Distance	Lead	Cadmium	Zinc
Auchi (OA)	1m	<0.001	0.001	0.281
Auchi (OB)	10m	<0.001	0.003	1.167
Auchi (OC)	Control	<0.001	<0.001	2.683
Anambra (OA)	1m	1.2	<0.001	4.129
Anambra (OB)	10m	<0.001	<0.001	5.825
Anambra (OC)	Control	1.925	0.005	0.504
Kogi (OA)	1m	<0.001	<0.001	10.991
Kogi (OB)	10m	<0.001	0.002	9.782
Kogi (OC)	Control	<0.001	<0.001	8.919

Table 4a: Average Result of Geo-Accumulation Index of Soil Samples

Locations	Lead	Cadmium	Zinc	I-Geo Lead	I-Geo Cadmium	I-Geo Zinc
Auchi	0.001	0.002	0.724	-0.58	0.42	-2.5
Anambra	0.6	0.001	4.977	-2.26	-2.9	2.7
Kogi	0.001	0.0015	10.387	-0.58	0	-0.4

Table 4b: Seven Classes of Geo-accumulation Index

Class	Value of Soil Quality
<0	Unpolluted
0-1	Unpolluted to moderately polluted
1-2	Moderately polluted
2-3	Moderately polluted to highly polluted
3-4	Highly polluted
4-5	Highly polluted to very highly polluted
>5	very Highly polluted

Sources:Pam *et al.*, (2013)

Table 5: Average Result of Anthropogenic Metals

Locations	Lead	Cadmium	Zinc	Anthropogenic Metals (%)		
Auchi	0.001	0.002	0.724	0	50	0
Anambra	0.6	0.001	4.977	0	0	90
Kogi	0.001	0.0015	10.387	0	33.3	14

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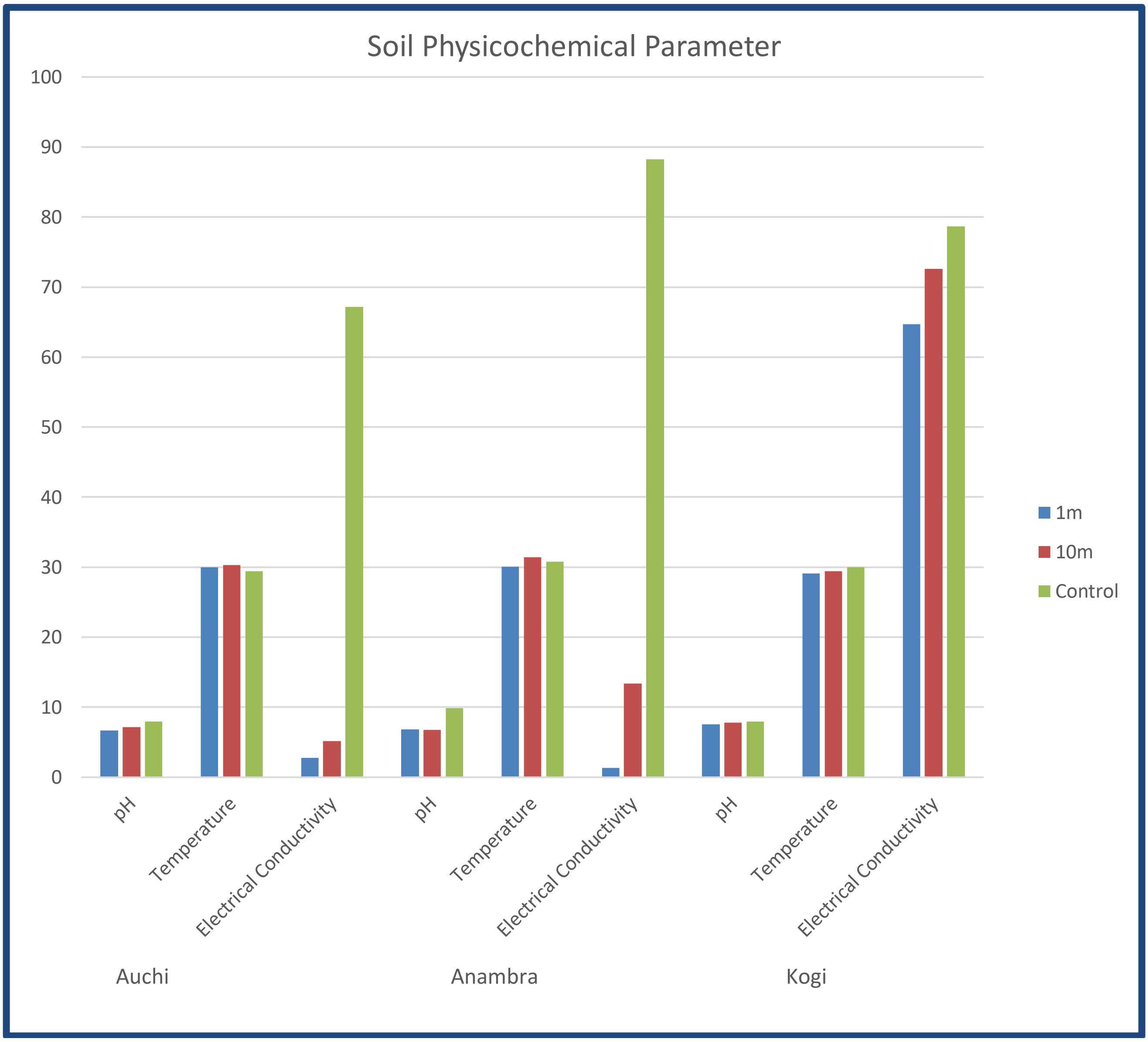

Fig. 2: Physicochemical Assessment of Soil Samples

According to Candemir and Gülser (2011) the application of different agricultural wastes to soil, especially tea waste, decreased soil pH values in different textured soils. In other cases of agricultural waste CO_2 released into soil atmosphere due to decomposition of organic wastes can be converted into carbonic acid (H_2CO_3) by reacting with water (H_2O) and decreasing soil pH. The result obtained from this study followed a decreasing trend as show by laboratory report. The closer the distance to the waste, the greater its decrease in pH value. This report is supported by Demir and Gulser (2015) with a decreasing trend of 7.66, 7.74 and 7.72, respectively in pH values on soil samples. other attributed parameter may include effluents released from rice mill operation plants during parboiling process of paddy. Sabapathy, Devaraj and Kathivel (2017) observed that these effluents are acidic and this may be a contributing factor to the reduction in soil pH.Temperature change however occurs due to geographical location and fluctuates based on weather conditions. Electrical conductivity of soil is the ability of soil water to carry electrical current. It is an electrolytic process that takes place through water filled pores and it is mainly used as an indicator of soil salinity which is important for crop growth and soil microbial activity. The electrical conductivity values obtained from this study reveals that soil samples obtained at distance of 1m to soil mill operational site shows lower electrical conductivity value and increases with increased distances. This is because excessive water logging of soil may have caused salts to be dissolved out of soil pores. This water may result from effluent discharged close to study area over the years. Statistical analysis reveals that no significant difference exists between physicochemical parameters obtained at different study areas which reveals that similar activity occurs.

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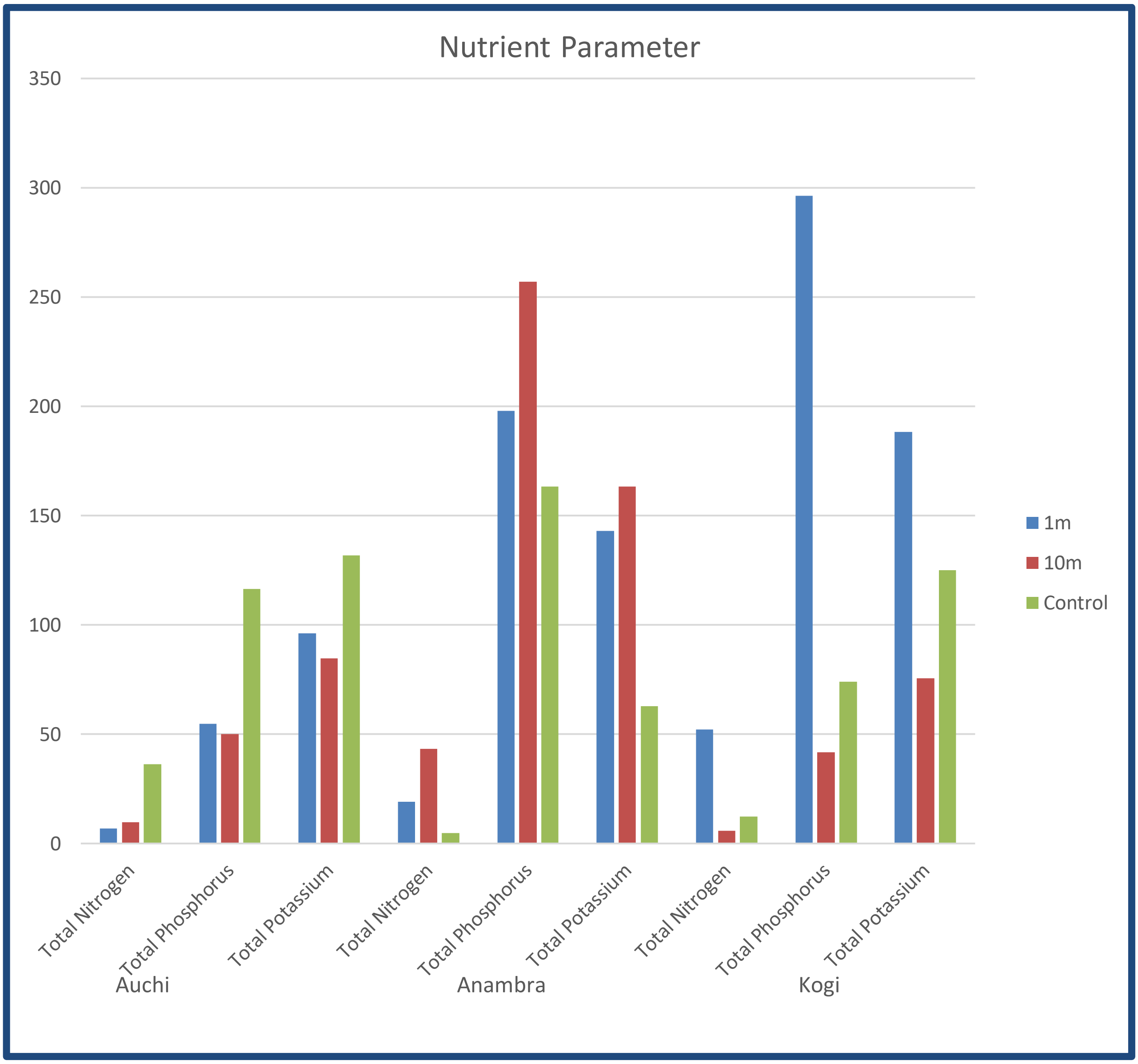

Fig.3: Nutrient Availability of Soil Samples

Available nitrogen in soil is mainly affected by the availability of metals in soil. Soil sample obtained at Auchi indicated low amount of total nitrogen at 1m distance to study point. Also, nitrogen increase was observed as greater distance from study point which indicates that rice mill operation activity influences available nitrogen in soil. This is confirmed by Njoku *et al.,* (2017)which reported that soil around a rice mill industry has nitrogen deficiency which may be caused by human activities. However, in other study areas such as Anambra and Kogi, nitrogen contents were observed to increase and this could be due to rice mill waste dumped on soil which may have resulted in increase in soil nutrient. This is because of the nitrogen content in soil.

The primary role of phosphate in plant is to store and transfer energy produced by photosynthesis. In soil, available phosphorus can be affected by soil pH especially at a pH greater than 7. This is because, phosphate can be involved in a fixation reaction with calcium in soil to form insoluble dicalcium phosphate. Result for this study reveals that phosphate availability in Anambra and Kogi is affected by soil pH with increasing pH indicating reduction in amount of total phosphorus. Comparison with control indicates that the amount of available was more for study area which shows that rice mill waste contributes to phosphorus availability. However, findings from analysis of soil from Auchi shows that the rice mine activity causes a reduction to amount of total phosphorus which may be affected by the microbial use in remediation of soil contaminants. this finding is in line with study by Njoku *et al.,* (2017) which reveals increasing amount of phosphorus with increasing distance from rice mill industry.

Potassium content in soil same similar to findings for phosphorus which follows an increasing trend with decreasing distance for Auchi and decreasing trend with increasing distance for Anambra and Kogi. Nwite and Azuka (2019) showed a similar trend as reported for Anambra and Kogi over a variation of distance from 50m - 200m.

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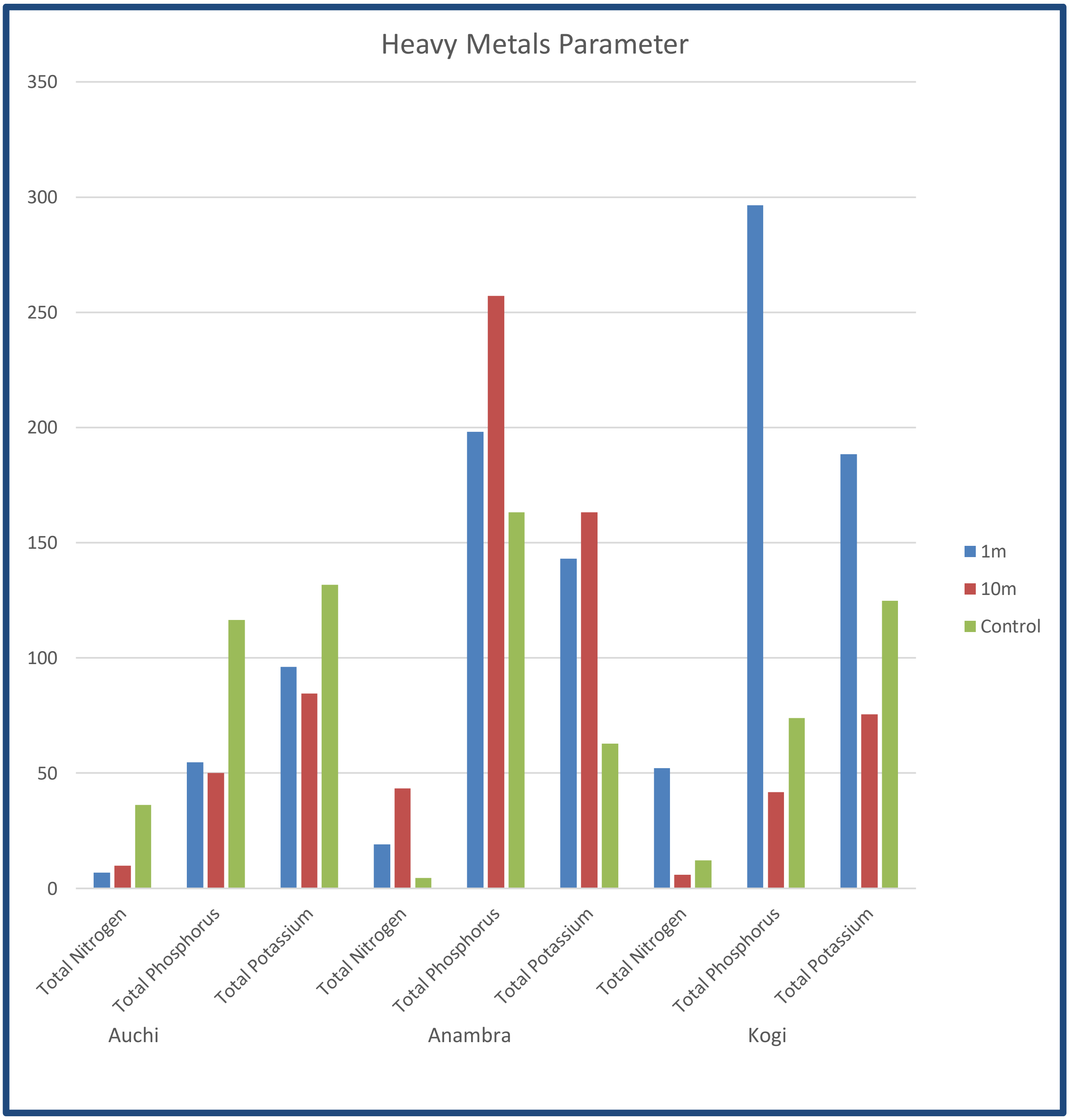

Fig.4: Heavy Metals in Soil Samples

According to Odoh*et al.*,(2014) the degrees of heavy metals pollution in rice mill industrial soils which is determined by its enrichment factors were also high. The trace heavy metal concentrations of the top soil samples show that the soils contain sufficient amounts of Pb, Zn, Cd, Cr, Cu and Co. According to them, the high level of zinc in the top soils of the study area could be attributed to emission sources from the factory while cadmium may be derived from the mechanical abrasion of vehicles and also associated with tyre wear. In soil samples analyzed at rice mill industry in Auchi, they were presence of zinc at 1m distance and control and presence of zinc and cadmium at 1om distance of the study point. The presence of cadmium can be attributed to mechanical abrasion of vehicles and also associated with tyre wear as described by Odoh*et al.*,(2014). This resulted in a 50% in amount of cadmium content in relations to the control. In Anambra, there were observed presence of lead and zinc in soil samples. the presence of lead can be attributed to production process of rice requiring a substantial amount of energy supplied by burning of coal and fossil fuel as well as other activities requiring the lead present materials which can be spread through by rain. In control locations cadmium and lead was observed to be higher in concentration and this can be attributed to high traffic in the area and other anthropogenic activities resulting in the use of petroleum products.

In Kogi, rice mill operations can be said to have contributed to a 33.3% and 14% rise in amount of cadmium and zinc when compared with control locations.

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IV. CONCLUSION

Rice mill operations can be observed to have affected soil quality parameters should the release of effluents and other industrial activities which resulted in an increase in concentrations of heavy metals and decrease in soil available nutrients. It can therefore be concluded from rice mill operations result in the release of effluents and waste with alters soil pH and conductivity and therefore leads to fixation of total nitrogen, phosphorus and potassium in some study areas. In other areas where pH was not affected, significant increase was observed in nutrients. It can also be concluded for heavy metals that industrial activities contributions to increase in concentrations with accumulative geo-index indicating that Auchi is moderately polluted with cadmium and Anambra is highly polluted with zinc.

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