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HEAVY METAL STATUS OF SOILS IMPACTED WITH PALM OIL WASTES IN ABRAKA, DELTA STATE, NIGERIA

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ABSTRACT

Waste from palm oil processing mills cause enormous environmental pollution including soil and water pollution resulting in loss of plant diversity, soil acidfication which could be due to the metal contents of the wastes. It is against this background that the current study, heavy metal status of soils impacted with palm oil waste in Abraka, Delta State, Nigeria was carried out.The study investigated the heavy metal concentrations in soils impacted by oil palm waste in Abraka, Delta state Nigeria, using Atomic Absorption Spectroscopy (AAS). Two soil samples were analysed: one from bulked oil palm waste site and a control (normal soil). Results showed elevated levels of cadmium (0.239 mg/L), lead (0.900 mg/L), iron (0.168 mg/L), zinc (0.532 mg/L), and chromium (0.025 mg/L) in soils impacted with oil palm wastes when compared with the control (unpolluted) soil that has negligible cadmium (0.000 mg/L) and lower levels of lead (1.308 mg/L), iron (0.058 mg/L), zinc (0.229 mg/L), and chromium (0.015 mg/L) respectively. The values though, falls within WHO permissible limits showed significant heavy metal contamination linked to oil palm wastes, highlighting potential environmental and health risk to the rural populace. It is recommended that palm oil wastes should be well disposed to avoid a build up of heavy metals due to their persistence and no biodegradability in ecosystems. The current study has great implications on soil conservation and environmental sustainability.

Keywords: Heavy Metal, Oil Palm Wastes, Sustainability

INTRODUCTION

Palm oil ranks among the most widely used vegetable oils globally. In Nigeria, oil palm output rose from 8.2 million metric tons in 1990 to about 9 million metric tons by 2001, positioning the country as the fifth-largest palm oil producer globally. The industry plays a key role in Nigeria's economy, as the nation remains one of the top global producers of palm oil (Adeyemi *et al*., 2017). Nevertheless, palm oil production generates considerable quantities of by-products, such as empty fruit bunches, palm kernel shells, and palm oil mill effluent (POME) (Ogbonna *et al*., 2018). If these wastes are not properly managed, they can cause environmental degradation and pose risks to human health (World Health Organization). Continuous release and uncontrolled dumping of POME has been shown to modify soil physicochemical properties over time. Palm oil cultivation and processing are also associated with various environmental impacts, including deforestation, biodiversity loss, and contamination of water bodies (Koh *et al*., 2011). Furthermore, palm oil waste often contains significant concentrations of heavy metals and other contaminants, which can contribute to soil pollution (Alloway, 2013). Pollution from heavy metals, in particular, represents a major ecological issue across many regions of the world (Egboduku *et al*., 2025). Heavy metals such as lead (Pb), cadmium (Cd), chromium (Cr), nickel (Ni), and zinc (Zn) can accumulate in soils and have toxic effects on plants, animals, and humans (Agbogidi *et al*., 2024).

Soils contaminated by heavy metals can lead to uptake by crops, introducing metals into the food chain. The contamination of soils with heavy metals can also lead to the contamination of groundwater and surface water (European Union, 2019). Heavy metals can alter microbial communities in soil, suppressing beneficial bacteria and fungi essential for nutrient cycling. Cd and Pb, in particular, reduce microbial biomass and enzyme activity. The current study has been conducted to investigate the heavy metal status of soils impacted with palm oil wastes in Abraka, Delta State, Nigeria with a view to documenting the findings and proffer possible solutions to oil palm millers, soil scientists and environmental managers.

MATERIALS AND METHODS

Study Area

Abraka, is a town in Delta state, Nigeria. It is also a home to two (2) of the main 24 urhobo kingdoms. It is mostly known as a university town and has the main campus of the Delta state University located there. Abraka is bordered to the north by Obiaruku, south by Eku, East by river Ethiope and west by Abraka inland. This study location is located between latitude 5°45' and 5°50'N and longitude 6° and 6°15E. This area is defined by total annual rainfall of about 3.098mm with mean monthly rainfall ranging from 28.8mm. The soil temperature in this area is about 28°C and soil PH ranging from 4.5-8(Achuba and Ja-anni., 2018)

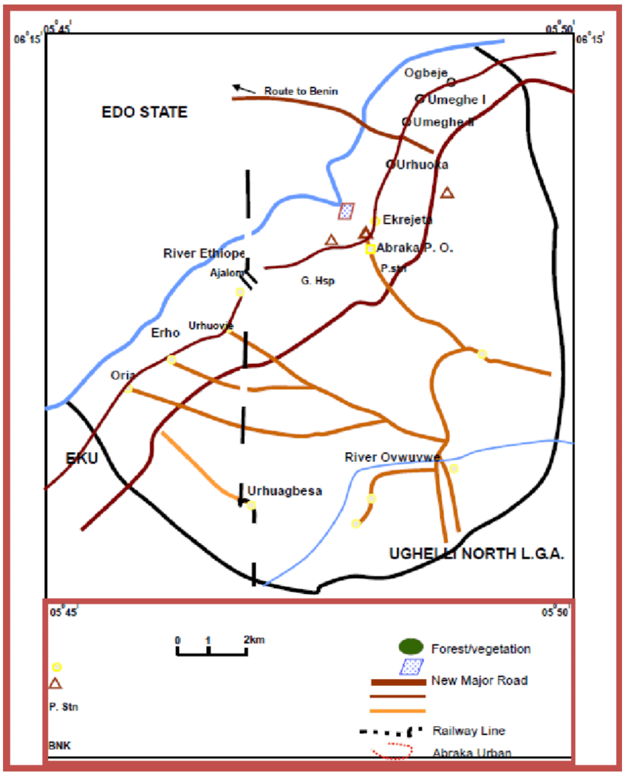

Figure 1: Map showing the study area, Abraka, Delta State
Source: Ozabo and Obaro (2016)

Sample Collection and Preparation
Soil samples were taken from palm oil waste dumpsites and bulked in Abraka, located in Ethiope East Local Government Area, Delta State, Nigeria. Soil samples were collected from five (5) carefully selected locations within the town, all of which are sites where oil palm processing activities take place. These areas where chosen specifically because they have experienced direct impact from oil palm waste, such as milling residues and by-product that affect soil quality. The five selected locations are Umeghe community, Delta State University (DELSU) Site II, Palmer road, Jehovah street, Ibani street. These location were not chosen at random but were identified due to the visible presence of oil palm processing waste, making them relevant for assessing heavy metal accumulation in impacted soils. Soil samples were collected from two categories: mixed composite soil and normal (unmixed) soil. The mixed composite soil was formed by thoroughly combining subsamples from various points within the sampling area to obtain a representative homogenized sample, while the normal soil was collected from a single undisturbed location. Samples were collected at a depth of 0-15 cm using a stainless-steel soil auger, placed in clean polyethylene bags, and transported to the laboratory.
In the laboratory, soil samples were air-dried at room temperature to constant weight and passed through a 2 mm sieve to remove stones and plant debris. The sieved samples were stored in labeled, airtight containers until analysis following the procedures of AOAC (2016).

Heavy Metals Determination
Reagents and Chemicals
All reagents used were of analytical grade. All glassware were washed with acid solution and rinsed with distilled water and dried before used. Deionized water was used throughout the experiment. For digestion, the Aqua Regia method was employed using a mixture of hydrochloric acid (HCI) and nitric acid (HNO_3) in a 3:1 ratio, as described by AOAC (2016) guidelines for trace metal analysis in environmental samples.

Sample Digestion
An accurately weighed 0.5 g portion of each prepared soil sample was transferred into a 100 mL digestion flask. To cach flask, 9 mL of concentrated hydrochloric acid (HCl) and 3 mL of concentrated nitric acid (HNO_3) were carefully added, maintaining the 3:1 Aqua Regia ratio. The mixture was allowed to stand for 15 minutes to allow initial reaction and fuming, then gently heated on a hot plate at approximately 120°C until the solution volume reduced and a clear digest was obtained. After digestion, the mixture was allowed to cool, diluted with 20 mL of deionized water, and filtered using Whatman 1 filter paper into a 50 mL volumetric flask, which was then made up to volume with deionized water. The filtrates were stored in acid-washed polyethylene bottles for subsequent analysis.

Metal Analysis
The concentrations of Zinc, Lead, Cadmium, Iron, and Chromium in the digested soil samples were determined using Atomic Absorption Spectrophotometry (AAS) with an AA320N model. The instrument was calibrated with appropriate standard solutions certified reference materials. All analyses were performed in triplicates for quality assurance. Blanks and standard solutions were analyzed concurrently to ensure analytical accuracy. Final results were expressed in milligrams per kilogram (mg/kg) on a dry weight basis. The study's adherence to AOAC Official Methods of Analysis (2016) ensures reliability, though additional sampling and analysis of surrounding areas could provide a broader context.

RESULTS AND DISCUSSION

Cadmium (Cd) was detected in Palm Oil Waste Impacted Soils (POWIS) at 0.239 mg/L, while it was absent in the control (0.000 mg/L). These values fall within the WHO/FAO permissible range of 0.01–3 mg/L. Lead (Pb) concentrations were 0.900 mg/L in POWIS and 1.308 mg/L in the control, both of which are far below the recommended safe limit of 50–300 mg/L. Iron (Fe) was present at 0.168 mg/L in POWIS and 0.058 mg/L in the control, also well below the WHO/FAO safe limit of 35,000 mg/L. Zinc (Zn) showed values of 0.532 mg/L in POWIS and 0.229 mg/L in the control, which are within the permissible range of 50–300 mg/L. Chromium (Cr) concentrations were relatively low, with 0.025 mg/L recorded in POWIS and 0.015 mg/L in the control, compared to the acceptable limit of 50–100 mg/L.

The concentration of heavy metals in palm oil waste impacted soils at Abraka is presented in Table 4. The results reveal distinct differences between the Palm Oil Waste Impacted Soil (POWIS) and the control site.

Table 1: Heavy Metal Content of Oil Palm Waste in Abraka, Delta State

S/N	Heavy Metals (mg/L)	POWIS	Control	WHO/FAO Safe Limit in Soils
1	Cadmium (Cd)	0.239	0.000	0.01–3
2	Lead (Pb)	0.900	1.308	50–300
3	Iron (Fe)	0.168	0.058	35000
4	Zinc (Zn)	0.532	0.229	50–300
5	Chromium (Cr)	0.025	0.015	50–100

Cadmium (Cd): Cd was only detected in POWIS at 0.239 mg/L, while it was absent in the control. This value still falls within the indicative soil range of 0.01–3 mg/L. The occurrence of Cd in the impacted soil likely stems from residues generated during palm oil processing, including organic waste streams, machinery lubricants, and chemical additives. Several studies in Nigeria have previously linked similar residues to cadmium enrichment in soils. Although the observed concentration is within acceptable limits, its presence is ecologically significant since continuous deposition could increase bioavailable Cd and facilitate uptake by edible plants.

Lead (Pb): Pb concentrations were unexpectedly higher in the control soil (1.308 mg/L) compared to POWIS (0.900 mg/L). Both values remain far below the permissible guideline range of 50–300 mg/L. The higher Pb level in the control site suggests contributions from other non-palm-oil-related sources such as atmospheric deposition, vehicular emissions, past industrial activities, or natural geological inputs (Agbogidi *et al*., 2023). Similar observations have been reported in other Nigerian studies, showing that Pb elevation is not always linked to palm oil waste but can arise from diffuse, non-point sources.

Chromium (Cr): Cr concentrations were slightly higher in POWIS (0.025 mg/L) compared to the control (0.015 mg/L), though both values remain well below the recommended range of 50–100 mg/L. Despite the low levels, attention is required because changes in soil pH and redox conditions around decomposing organic residues may alter the form of chromium present. In particular, under certain conditions, Cr can transform into its more toxic hexavalent form [Cr(VI)], which poses significant environmental risks (Agbogidi *et al*., 2013).

Iron (Fe): Fe showed higher concentrations in POWIS (0.168 mg/L) compared to the control (0.058 mg/L), though still much lower than the general soil guideline value of about 35,000 mg/L. The elevated Fe level in the impacted soil could be attributed to mineral mobilization during the breakdown of organic matter. Such processes may also temporarily increase soluble iron fractions and alter soil acidity, a pattern repeatedly observed in soils influenced by palm oil mill effluents (POME) (Enujeke *et al*., 2023).

Zinc (Zn): Zn levels were also higher in POWIS (0.532 mg/L) than in the control soil (0.229 mg/L), though both remain far below the guideline threshold of 50–300 mg/L. The simultaneous presence of elevated Zn and Cd is a typical marker of agro-industrial waste inputs. These metals often occur together in waste streams and may accumulate in agricultural soils if the deposition continues. Over time, this could lead to increased plant uptake and eventual bioaccumulation in the food chain. FAO (2021) has emphasized that Cd and Zn are among the trace metals most likely to bioaccumulate even at relatively low background levels in tropical environments. The study evaluated the heavy metal status of soils impacted with palm oil wastes in Abraka and observed that there is a build-up of heavy metals in soils impacted with the waste as against the control counter parts.

CONCLUSION

The higher lead (Pb) concentration in the normal soils indicates a possible pre-existing contamination source unrelated to the waste. Thus, sorting and recycling palm oil waste should be intensified to reduce the levels of these toxic metals in the affected soils. Palm oil waste should be well disposed of or if possible, treated before disposal to reduce environmental degradation, additionally, further investigation into the sources of contamination, regular monitoring of metal levels, and the adoption of soil remediation techniques (e.g., pH adjustment or phytoremediation) are recommended to mitigate long-term impacts.

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