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Distribution of Lead and Cadmium in Soils on Koko Seaport, Delta State, Nigeria

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ABSTRACT: Soil contamination by Lead and Cadmium is a prevalent ecological problem that requires attention because these two metals are toxic and could accumulate and translocate in soil over time, which poses a risk of entering the food chain and affecting the living organisms in the food web. The objective of this study is to evaluate the levels of Pb and Cd in soil from selected sampling locations of the Koko Seaport in Delta State, Nigeria. Five areas near Koko Seaport were investigated for the transport of these heavy metals in the soil. Statistical analysis using ANOVA and chart models was used to determine the concentration of these metals. Cadmium and lead levels that were significant were found in the studied areas. The data did not show any differences between the two metals due to the significance of the $^*p>0.05$ value. The variations showed a surge in comparisons of the amounts of cadmium in stations 2 and 3, respectively, as well as significant values for cadmium compared to lead. The outcome was directly influenced by the type and quantity of hazardous wastes present in the research area. The recommended remedial actions for these metals include soil cleansing, immobilization, and the choice of plants with hyper bio accumulation for phytoremediation methods that allow the use of genetic engineering.

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Lead is a potent neurotoxin and environmental pollutant, causing decrease in crop yield and severe threats to human health resulting from bioaccumulation and bio magnification in the food chain (Atikpo *et al.*, 2015). It is a well-known pollutant that is persistent and non-degradable in the environment (Wanjala *et al*., 2021). While many of the polluted sites have been cleaned up after decades of heavy industrial activity, many remain to be cleaned because remedial measures have often failed (Atikpo and Micheal, 2018). This is mainly attributed to the lack of information on the transport mechanism of pollutants in the subsurface medium (Hange and Awofolu, 2017). Cadmium is a by-product of Zinc and Lead-smelting, a heavy metal common in contaminated sites of hazardous wastes (Bouida *et al*., 2022). It is commonly associated with lead ores and a natural constituent of ocean. Its natural emissions could be from natural disasters like volcanic eruptions or anthropogenic sources from the consumed use of batteries, fossil fuel combustion, waste incineration and so on (Wanjala *et al*., 2021). Cadmium is released in the air through the means of transport and deposition in the ecosystem (Bouida *et al*., 2022). They travel long distance and deposits dry or wet forms to soil surfaces and water which results in elevated cadmium level in remote locations through direct application and deposition (Hange and

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Awofolu, 2017). Generally, mobility of heavy metals in soils largely depends on several factors including soil pH and Organic matter (Atikpo *et al*., 2015). Transformation processes for cadmium in soil is mediated by sorption from the desorption to water precipitation, dissolution, complexation and ion exchange, clay minerals, etc. soil with parent materials like black shales/clay tend to have higher concentration of natural cadmium (Hange and Awofolu, 2017). Cadmium binds strongly with organic matter which immobilizes the element and makes it readily available for uptake in acidic soils (Atikpo and Micheal, 2018). Cadmium and cadmium compounds have negligible vapour pressure and its association with mineral surfaces such as clay or organic materials, makes it easily released in dissolved state when sediments are dissolved (Enuneku *et al*., 2018). Previous studies show that cadmium bio accumulates in all levels of the food chain (Umeri *et al*., 2017). Deleterious effects of cadmium ranges effectively in the liver and kidneys of vertebrates. Hence, this report examines the distribution of Pb and cd in soil from the seacoast of the Koko Seaport in Delta State, Nigeria.

MATERIALS AND METHODS

Soil samples were collected from five sampling stations around Koko Seaport located on 5° 59′ 58″N and 5° 27′ 34″E Delta State, Nigeria using soil auger. The samples were thoroughly mixed in a sterile container to obtain composite soils. The sampled composite soils were collected using a polythene sealing bags. The sample location was identified with the aid of Global Positioning System (GPS 73-Garmin) while readings were recorded. The samples were transported and analyzed in a standard laboratory with the aid of conical flask, hot plate, measuring cylinder, pipette, a round bottom flask and Atomic absorption spectrometer (AAS).

Each sample was prepared by weighing 2.0g of air dried soil sample in 250ml round bottom flask and 20ml of distilled water with 1.0ml of concentrated nitric acid was added, including 5.0ml of concentrated hydrochloric acid. This mixture was swirled and placed on a heating mantle until the volume reduced to 5ml-10ml and then, allowed to cool, thereafter, filtered. Distilled water was added to the filtrate to 20ml and then, the digested sample was sent to PG instrument- AA500 Spectrometer for determination of Pb at a wavelength of 283.3*nm* and cd at a wavelength of 228.8*nm* respectively under strict quality control precautions.

Statistical analysis was carried out using Statistical Package for Social Sciences (SPSS) to determine the coefficient of variation (CV), One-way Analysis of Variance (ANOVA) and Standard error (SE). Modal chart was used for comparisons and variations.

Coefficient of variation (CV): This was used to displayed the ratio of the extent of variability in relation to the mean.

$$CV = \frac{SD}{\bar{x}} x100 \qquad (1)$$

ANOVA was to test if there was going to be a significant difference between both heavy metals.

The t-test is given as:

$$t = X - \frac{\mu}{SE} \qquad (2)$$

Where x = sample mean; μ = population mean; SE = Standard error of mean

Standard error is given as:

$$\mathrm{SE} = \frac{\sigma}{\sqrt{n}} \qquad (3)$$

Where SE is Standard error, σ is sample standard deviation and n is the number of samples.

RESULTS AND DISCUSSION

The results of the experiment showed a strong correlation between the presence and concentration of lead and cadmium in the area. The sampled concentration across sites in the Nigerian port of Koko was clearly indicated in the table 1. Activities conducted at the ports and its surroundings reflect the production of source materials with a high concentration of these components. Due to the direct exposure caused by the disposal of hazardous waste nearby, the soil was vulnerable to high concentrations of toxic metals (Umeri *et al*., 2017). According to Table 1, Cadmium had a mean concentration of 4.3836 mg/kg, followed by Lead, which had a mean concentration of 4.1058 mg/kg.

Table 1: t-test analysis of cadmium and lead in Koko Seaport, Delta State, Nigeria

Metals	Units	mean	Variance	Standard error	Coefficient of variation	T-test
Cd	m/kg	4.3836	0.8971	0.423	20.4649	2.776
Pb	m/k	.058	0.51	0.32	12.42	

*t-calculated is less than $t_{critical}$ ($t_{0.05(2),4}$) *p>0.05- significant*

Cadmium also had a higher variance, standard error, and coefficient of variation than Lead throughout the sampled stations. The (Ho) Null was established since the estimated t-test between the two metals revealed no significance.

From figure 1, there were slightly significant variations of cadmium and lead, though not so pronounced that cadmium had low concentrations than lead at point sample 1 compared to Lead, because these metals converted to oxides and condensed as fine particulates on the soil, revealing the type of concentration of these metals emitted at sufficient time from both air and vapour streams. Lead and Cadmium concentrations in Point Samples 2 and 3 were greater than those in Point Sample 1. The quantity of cadmium was slightly lower than that of lead at point samples 4 and 5 compared to Figure 2. High quantities can be found at sample points 2 and 3 according to the comparison from Figure 2.

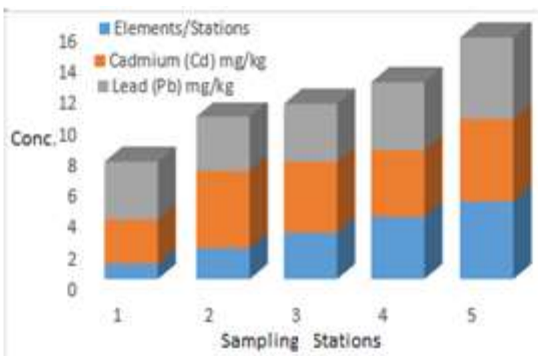

Fig 1: Variations of heavy metals at sampling points in Koko seaport, Delta State, Nigeria

In contrast, sediments with high concentrations of heavy metals, particularly cadmium and lead, have a variety of negative ecological and health effects and have emerged as one of the most significant ecological issues with serious health implications (Atikpo *et al*., 2015). The most prevalent heavy metals at hazardous sites are lead (Pb), chromium (Cr), arsenic (As), zinc (Zn), cadmium (Cd), copper (Cu), and mercury (Hg). These metals have the ability to significantly reduce crop production, biomagnify and bioaccumulate in the food chain, as well as contaminate surface and ground water sources (Atikpo and Micheal, 2018).

Iron has the widest variation in concentration with concentration of heavy metals in order of abundance, according to mean variations of persistent hazardous chemicals containing metals in koko sediments, fish, and periwrinkle. fe>pb>mn>zn>ni>cu>co>cd however, high cadmium levels have been observed in koko soil, and Enuneku *et al*., (2018) have found that particle size is an important factor in controlling the levels of heavy metals. This is because fine particles have a high capacity to adsorb soluble heavy metals and deposit them at the bottom of sediments.

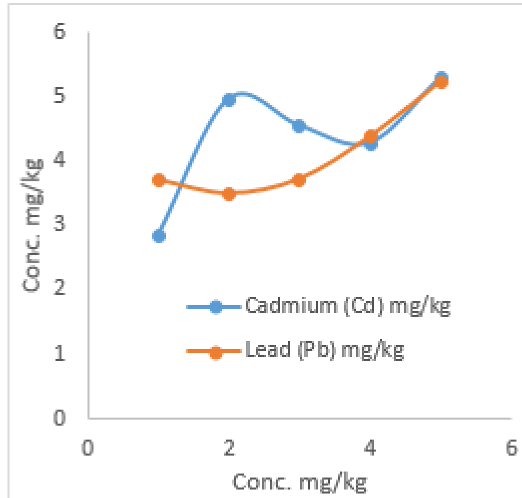

Fig 2: Comparison between cadmium and Lead heavy metals

Conclusion: The study found that the deposition of hazardous wastes of organic origin was the main cause of the significant concentrations and variation in Pb and Cd metal analysis along the Koko ports borders. These substances fall within a category to dictate factors that could influence the choice of any remediation technique for best possible solution.

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