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Assessment of potentially toxic elements contamination in soils across different land uses in a rural-urban fringe area of Edo State

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Abstract:

This work focused on the assessment of potentially toxic elements contamination in soils across different land use types in a rural-urban fringe area of Edo State. Soil samples were collected from mechanic workshop, secondary forest, block molding site, oil palm production site, fire wood processing site, cassava farm, backyard farm, cooking gas plant site and oil palm plantation respectively. The soil samples were analyzed for lead (Pb), chromium (Cr), cobalt (Co), arsenic (As), cadmium (Cd), vanadium (V) and nickel (Ni) using USEPA method 3050B. The findings indicated that the concentration levels of Co (0.16 mg/kg), As (0.14 mg/kg), and Ni (0.52 mg/kg) were higher in backyard farm, whereas Cr (0.70 mg/kg) and Cd (0.51 mg/kg) concentration levels were higher in the oil palm plantation than in the other examined land uses. The firewood processing site demonstrated higher Pb concentrations (1.80 mg/kg), and V concentrations were higher in both the backyard farm (0.12 mg/kg) and secondary forest (0.12 mg/kg). Except for Cd, contamination factor (Cf) pollution index revealed very slight contamination (< 0.1) for Pb, Co, Cr, As, V, and Ni across the investigated land uses. However, it indicated that Cd slightly contaminated cassava farm (0.17), mechanic workshop (0.20), firewood processing site (0.22), secondary forest (0.24), and cooking gas plant (0.25), severely contaminated backyard farm (1.00), and slightly polluted oil palm plantation (1.24). The study concluded that the soils were contaminated with Co, As, V, Ni, Cr, Cd, and Pb to varying levels across the land uses, with backyard farm and oil palm plantation land use types identified as Cd contamination hotspots in the rural-urban fringe area. The use of phosphorus compounds**,** lime**,** or clays is recommended as mitigation strategies against Cd contamination in the backyard farm and oil palm plantation soils.

Keywords: Pollution index, Rural-urban fringe, Soil contamination, Soil quality

1-Introduction

Environmental contamination is a severe problem in developing countries as a result of the rapidly increasing population growth, industrial and commercial development, and accelerated urbanization (Qadir et al., 2010). Soil contamination indicates the incidence of a chemical or foreign substance in concentrations beyond the normal threshold, which may be harmful to an organism or a human (Agyeman et al., 2022).

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Potentially toxic elements are also considered heavy metals due to their high toxicity, lengthy period of time and persistent bioavailability (Alloway et al., 2013). Potentially toxic elements are a significant type of contaminant that can accrue in the soils from varied sources. Following the prevalence of industrial activities, mining, fossil fuel consumption, transportation, use of agricultural inputs, etc., potentially toxic elements contamination has arisen as a serious global environmental concern during the recent past and its contents have been detected in soils at varying scales (Lima et al., 2024).

Potentially toxic elements that are generally present in soils include aluminum (Al), arsenic (As), cadmium (Cd), chromium (Cr), cobalt (Co), copper (Cu), lead (Pb), manganese (Mn), mercury (Hg), nickel (Ni), and zinc (Zn). Amongst them, As, Cd, Hg, and Pb are reported to be among the top 20 Hazardous Substances of the Agency for Toxic Substances and Disease Registry (ATSDR) and the United States Environmental Protection Agency (USEPA) (Goren et al., 2022). The incidence of extreme quantities of potentially toxic elements over allowable limits in the soil instigates toxicity to all living organisms (El-Naggar et al., 2021). Soil potentially toxic elements contamination has adverse effects, such as the contamination of ground water and soil, phytotoxicity, biotoxicity, accumulative behavior and potential human health risk (Qin et al., 2020). Consumption of plants from contaminated soils or inhalations of atmospheric polluted particles are the prime factors instrumental to potentially toxic elements exposure for the human population (Loutfy et al., 2006). When high levels of potentially toxic elements go into the soil biota, they damage the structure and function of the ecosystem and progressively depreciate soil quality, diminish soil productivity and subsequently alter human health through the food chain (Taghavi et al., 2023). However, soil contamination by potentially toxic elements of biomes and adjoining inhabited areas is often unavoidable due to leaching and wash-off (Patinha et al., 2018).

Environmental assessment with particular emphasis on soil potentially toxic elements contamination is a significant component of contemporary ecological researches. The environment and overall population are at risk from the multiplicity of potentially toxic elements in contaminated soils, particularly with regard to how rapidly the economy and society are growing (Min et al., 2018). Potentially toxic elements are one of the most investigated soil contaminants (Famuyiwa et al., 2022). However, less attention has been given to rural - urban fringe soils. Globally, researchers have undertaken a series of studies on soil contamination. Notable amongst them are: Li et al., (2025); Ribeiro et al., (2025); Lima et al., (2024); Simic et al., (2023); Albanese & Guarino et al., (2022); Gan et al., (2022); Goh et al., (2022); Zhang et al., (2022); He et al., (2015) etc. Similarly, in Nigeria, researchers such as Elemile et al., (2023); Famuyiwa et al., (2022); Olatunji & Adeyemi, (2021); Edogbo et al., (2020); Ezeofor et al., (2019); Orobator et al., (2019); Odukoya et al., (2018); Orobator et al., (2017) etc. have also carried out inquiries on soil contamination. These prior studies revealed dearth of empirical investigations on potentially toxic elements contamination of rural - urban fringe soils. Rural-urban fringe soils serves as a spatial transition zone between urban and rural areas, keeping the local milieu and biome in balance (Olatunji and Adeyemi, 2021). Nevertheless, due to increasing urbanization and population growth, potentially toxic elements concentration in soils of rural - urban fringe land uses may begin to develop.

In addition to filling the gap in research, examining potentially toxic elements contamination can allow for the identification of contamination hotspots within rural-urban fringe areas. Furthermore, Orobator et al., (2019) noted that the buildup of potentially toxic elements on anthropic soils obliges exigent and continuous attention from environmentalists. To provide an empirical understanding of potentially toxic elements contamination in soils of rural-urban fringe zones, we chose a typical rural-urban fringe area (Egbean – Iguadolor - Uhogua) in southern Edo State, Nigeria. The Egbean - Iguadolor - Uhogua fringe area illustrates the urban to rural geographical transition in terms of land use, and it is marked by various anthropogenically induced land uses (Orobator and Daniel, 2023). Different categories of land use types can result to alterations in the soil environment owing to contamination (Zuo et al., 2018). We evaluated soil contamination by potentially toxic elements across various land uses in a rural-urban fringe area of Edo State. The objectives of this research were to: (i) determine the concentration levels of Pb, Cd, Co, Cr, Ni, As, and V in soils of different rural-urban fringe land uses, (ii) ascertain the distribution of the potentially toxic elements concentration levels in soils across the rural-urban fringe land uses, and (iii) identify the status and degree of contamination by Pb, Cd, of Pb, Cd, Co, Cr, Ni, As, and V in the soils of the different rural-urban fringe land uses. The contemporary evidences from this investigation will provide baseline experiential data for soil quality and sustainability strategies, as well as significantly raise awareness for local environmental pollution assessment and monitoring in rural-urban fringe land uses. The study can help advocate for the establishment of policies and regulations to monitor soil contamination in the rural-urban areas, ensuring that contamination levels stay within acceptable thresholds. Information from this research will also be valuable in the classification of contaminated land uses, ecological quality management and provide direction for remediation, redevelopment of contaminated sites and offer vital evidence for wide-ranging rural - urban fringe environmental planning decisions.

2-Materials and Methods

2.1. Study Area

The study sites are located in a characteristic rural-urban fringe area (Egbean, Iguadolor, and Uhogua communities) in Egor Local Government Area of Southern Edo State, Nigeria. Egor Local Government Area is one of the three most densely populated Local Government Areas in Benin City, together with Oredo and Ikpoba-Okha Local Government Areas (Kelvin et al., 2015). With the expansion Benin City is currently experiencing, Egbean – Iguadolor – Uhogua areas becomes a rural-urban fringe zone. Egbean –Iguadolor- Uhogua fringe area is situated within latitudes 6° 15' 0" N - 6° 45' 0" N and longitudes 5° 15' 0" E - 5° 41' 0" E (Figure 1), and it is located in the Tropical Rainforest Belt of Nigeria. Egbean –Iguadolor- Uhogua fringe area is characterized by a Tropical climate with distinctive wet and dry seasons, averaging an annual rainfall of 2,040 mm and a mean temperature of 34°C. The topography of the rural-urban fringe area is largely flat, and the soil comprises of lateritic clay soil with a reddish-brown color, underpinned by the Benin rock formation and limestone (Orobator and Daniel, 2023). The iron-rich soils contribute to the characteristic red hue (Orobator and Odjugo, 2016). The examined land uses for the research includes: (A) Mechanic workshop, (B) Secondary forest, (C) Block molding site, (D) Oil palm production site, (E) Fire wood processing site, (F) Cassava farm, (G) Back house Farm, (H) Cooking gas plant, (I) Oil palm plantation (Figure 1). Their choice for the study is because they are the dominant land use types in the Egbean –Iguadolor- Uhogua fringe area.

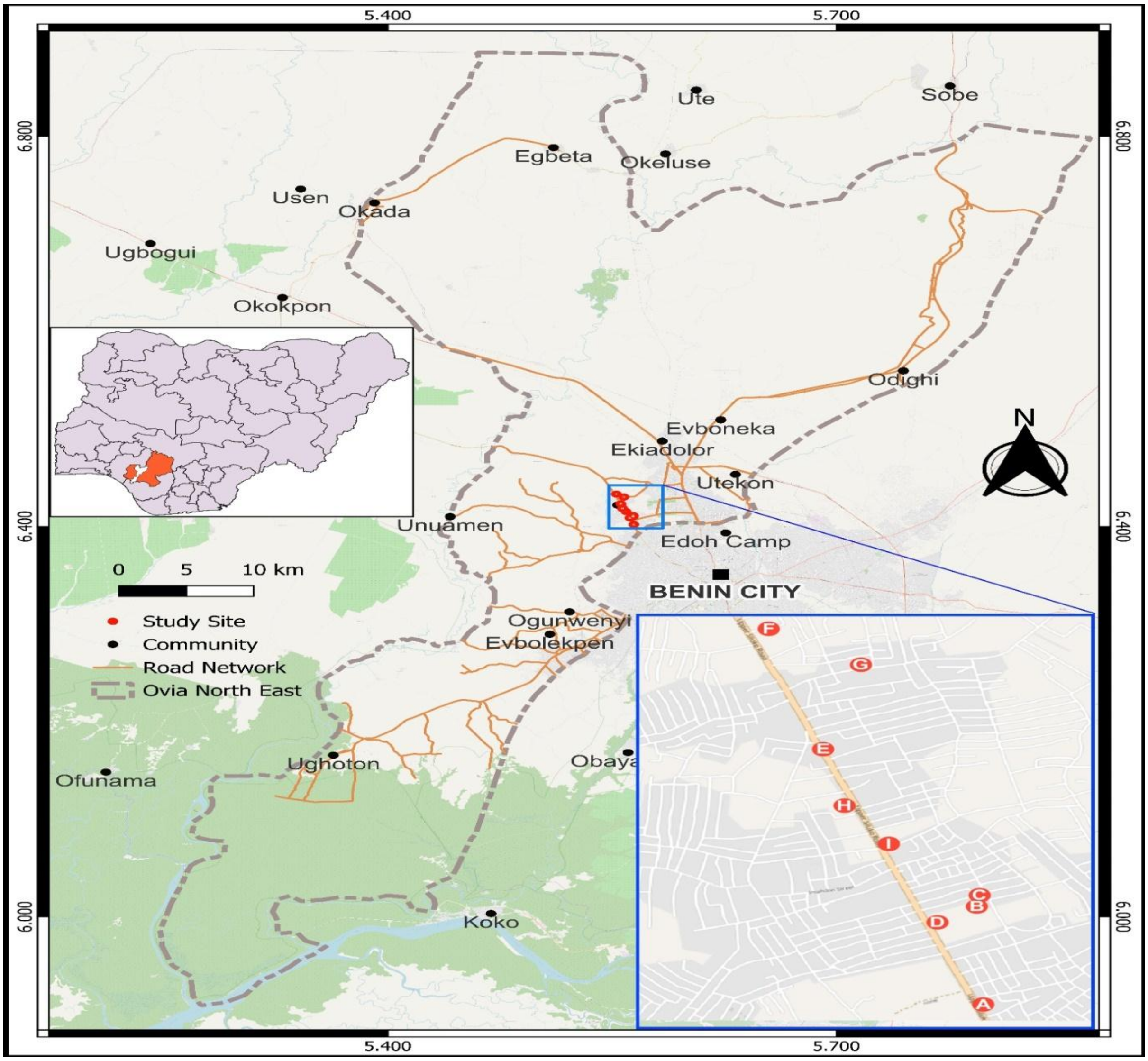

Figure 1: Location of rural-urban fringe land uses
Source: Orobator and Daniel (2023)

2.2. Soil Sampling

Soil samples were taken from mechanic workshop, secondary forest, block molding site, oil palm production site, firewood processing site, cassava farm, backyard farm, cooking gas plant, and oil palm plantation land uses respectively. The soil samples were collected at 0 -15cm (topsoil) soil depth with the aid of a soil auger. The choice of the topsoil (0 -15cm) for the investigation is because the topsoil is that part of the soil profile that is exposed and majorly affected by anthropic activities (Macedo et al., 2017). Biasioli et al., (2007) noted that for the examination of potentially toxic elements contamination in soils, the sampling methodology could be restricted to the topsoil layer. The simple random sampling technique was used to collect soil samples from the various land uses. This aided to select independent and unbiased soil samples from the investigated rural – urban fringe land uses (Wills et al., 2018).

2.3. Laboratory Analysis

The air-dried soil samples were finely ground in stainless steel, 1 g of each sample was placed in a conical flask, and a mixture of concentrated HNO_3:$HClO_4$:HF in the ratio 3:1:3 was added

(Yahaya et al., 2021). The mixtures of soils were then heated to 800 ^{o}C for 3 hrs. The digests were filtered into a 100-ml standard plastic bottle and made to 100 mL with deionized water (Lu et al., 2009). The potentially toxic elements analyzed for the study include: Lead (Pb), Cadmium (Cd), Cobalt (Co), Chromium (Cr), Nickel (Ni), Arsenic (As), and Vanadium (V). The potentially toxic elements concentrations in the soil samples were measured using AAS Spectrometer Fame Atomic Absorption Spectrophotometer **(**Varian model-AA240FS). The AAS Spectrometer Fame Atomic Absorption Spectrophotometer is an extensively used analytical method for determining the concentrations of individual elements in a soil sample (Kamanina et al., 2023).

2.4. Data Analysis

In order to achieve the objectives of the study, both descriptive statistics (charts) and soil pollution index (Contamination Factor) were adopted to analyze the data. Statistical Package for the Social Sciences (SPSS) software package was used to analyze the data descriptively. The use of charts in the study helped to show the concentration levels of Pb, Cd, Co, Cr, Ni, As, and V across the different rural-urban land uses. Additionally, the charts provided a clear indication of the distribution of Pb, Cd, Co, Cr, Ni, As, and V concentration values across the different rural-urban land uses, organizing them into specific classes (Figures 2). Soil pollution indices are valued in processing, analyzing, and transmitting raw environmental data to the public and decision-makers (Yahaya et al., 2021). They are significant in ascertaining the pollution status of the environment. The Contamination Factor (Cf) as a pollution index is used to determine the status and degree of contamination (Yahaya et al., 2021), and it was achieved for the study using the formula below:

$$Cf = C_{metal} / C_{background}$$

Where: Cf = contamination factor; C metal = concentration of pollutant in soil; C background = background value for the metal.

Ten contamination categories are recognized based on contamination factor (CF) (Yahaya et al., 2021), and these are: < 0.1 very slight contamination; 0.10–0.25, slight contamination; 0.26–0.5, moderate contamination; 0.51–0.75, severe contamination; 0.76–1.00, very severe contamination; 1.1–2.0, slight pollution; 2.1–4.0, moderate pollution; 4.1–8.0, severe pollution; 8.1–16.0, very severe pollution; and >16 excessive pollution.

3- Results and Discussion

3.1. Lead (Pb)

Pb is a highly prevalent potentially toxic element that is released in air from varied anthropogenic activities such industries using Pb composites, fossil fuels combustion, alloys, Pb mining, automobile exhaust etc. (Collin et al., 2022). The concentration levels of Pb in the different rural-urban land uses are revealed in Figure 2. The values ranged from 0.70 - 1.80 mg/kg (Figure 2), and the distribution follow this pattern; oil palm production site (0.70 mg/kg) /cassava farm (0.70 mg/kg) < mechanic workshop (0.80 mg/kg)/block molding (0.80 mg/kg) < secondary forest (0.90 mg/kg) /cooking gas plant site (0.90 mg/kg) < backyard farm (1.50 mg/kg) < oil palm plantation (1.60 mg/kg) < firewood processing (1.80 mg/kg). The higher level of Pb (1.80 mg/kg) observed in firewood processing site may be due to the effects of traffic (vehicular) pollution from the road-side. The examined firewood processing site land use has close proximity to the road, and the contributions of direct discharges from automobiles to soils at the locality are noticeable. The combustion progression from vehicles, the layer of road degradation and the particles from the road surface contribute to release pollutants into the environment (Olafisoye et al., 2016). The fumes from vehicles on the highway are major sources of Pb (Obeng-Gyasi, 2019). Explanations for Pb occurrence could be enhancement from nearness to traffic sources (Poggio et al., 2009). Traffic-associated emissions have been recognized as one of the key sources of Pb contamination in soils (Xia et al., 2011). The incidence of automobile plastics, leaded gasoline, worn-out tyres, lubricating oil, and grease are major sources of Pb in the soils of mechanic workshops (Alaekwe et al., 2019). The prevalence of palm oil mill wastes or effluents on the soils of oil palm production site may be accountable for its Pb contamination. Ogorure et al., (2024) stated that palm oil mill effluents are contributors of Pb contamination of soils.

The finding is consistent with Famuyiwa et al., (2018), who reported that roadsides soils were influenced by anthropogenic inputs that lead to Pb concentrations (32 mg/kg). Similarly, Zuo et al., (2018) observed that one of the foremost sources of Pb in varied urbanization gradients is dust accrual of traffic pollutants. However, the findings of the study is in contrast to Biasioli et al., (2007), who reported that soils in all three metropolises showed higher values of Pb (45% of Ljubljana, 43% of Torino, and 11% of Sevilla), whose most usual source, they noted is majorly vehicular traffic. Pb in soils is identified to be the key source of Pb intake by humans, and is specifically a significant route of exposure for young children (Environment Agency, 2007). High concentrations of Pb can be damaging, resulting to blood and nervous system maladies, kidney impairment, diarrhea, infertility, miscarriages, and exhaustion (Staudinger and Roth, 1998). To determine the status and degree of contamination of Pb, contamination factor indicated that all the soil samples in the rural –urban land uses were very slightly contaminated by Pb (< 0.1) (Figure 3).

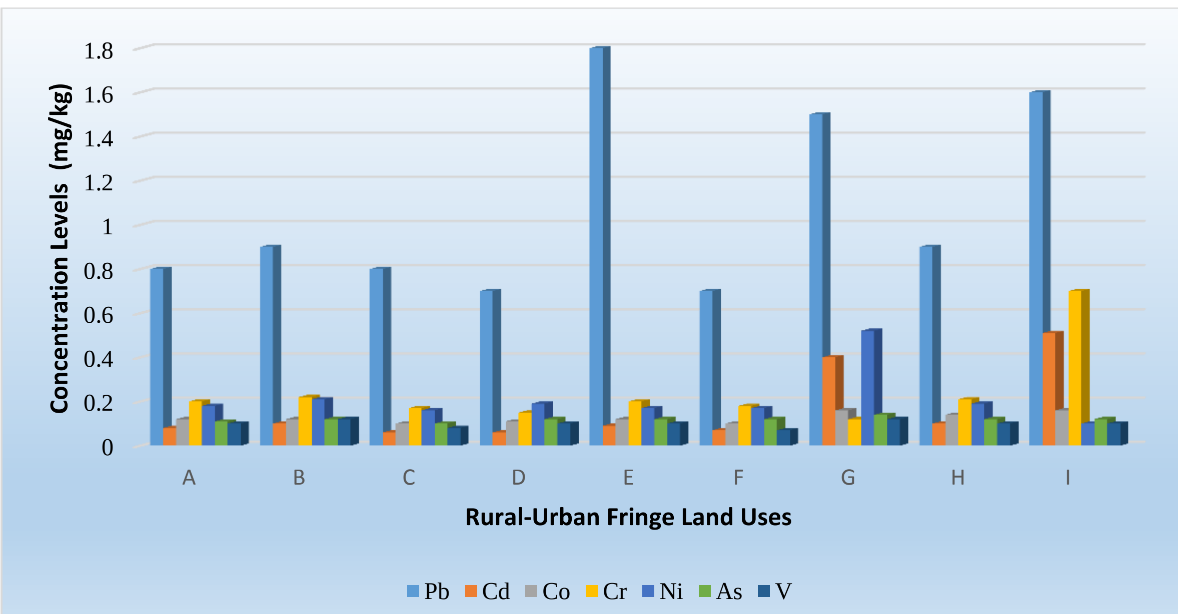

Figure 2: Potentially toxic elements concentration levels and distribution in the different rural-urban fringe land uses

Note: A- Mechanic workshop, B- Secondary forest, C -Block molding site, D- Oil palm production site, E- Firewood processing site, F- Cassava farm, G- Backyard farm, H- Cooking gas plant, I- Oil palm plantation.

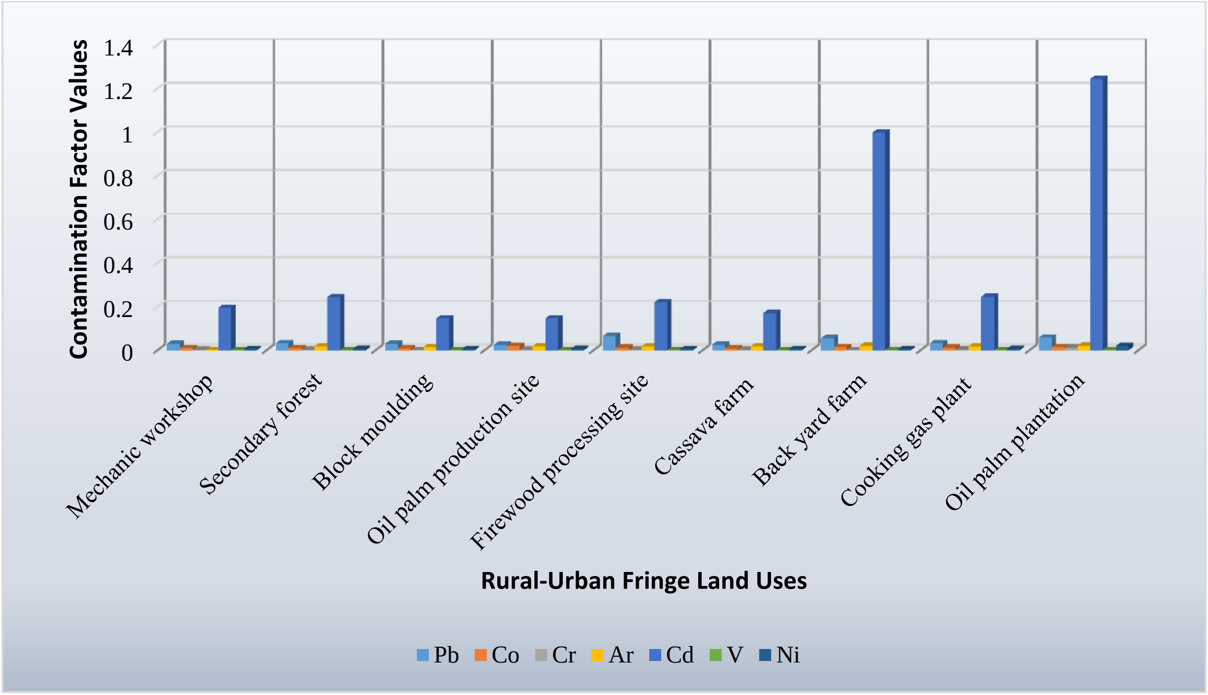

Figure 3. Contamination Factor (Cf) values of potentially toxic elements

3.2. Cobalt (Co)

Co is found in the environment along with Fe, Ni, Ag, Pb, Cu, and Mn; and is likewise found to be existing as carbonates (Mahey et al., 2020). Besides, factories that produce cement, carbide tool grinding, e-waste, polishing disc, pigment and paint; incinerators, mining activities as well as televisions (TVs), mobile batteries, computer monitors, and liquid crystal display TVs are also potential human sources of Co (Graedel et al., 2014). The concentration levels of Co in the different rural-urban land uses are revealed in Figure 2. The values ranged from 0.10 - 0.16 mg/kg (Figure 2). The order of distribution of Co as indicated in Figure 2 follow this trend; block molding site (0.10 mg/kg) /cassava farm (0.10 mg/kg) < oil palm production site (0.11mg/kg) < mechanic workshop (0.12 mg/kg) /secondary forest (0.12mg/kg)/ firewood processing site (0.12 mg/kg) < cooking gas plant (0.14 mg/kg) < backyard farm (0.16 mg/kg) /oil palm plantation (0.16 mg/kg). The higher level of Co (0.16 mg/kg) observed in backyard farm can be ascribed to the prevalence of organic manure from the droppings of poultry birds and livestock on the soils. Akhter et al., (2022) reported that due to poultry waste, press mud, and farmyard manure, Co showed more concentrations in their investigated soils. The application of solid agricultural wastes such as farm manures improves the accumulation of potentially toxic elements in soils (Ismanto et al., 2023). Excessive use of herbicides and fertilizers may account for the higher level of Co detected in oil palm plantation (Adedeji et al., 2019). The disproportionate use of pesticides and fertilizers will lead to the higher levels of potentially toxic elements in the soil (Huo et al., 2022). The application of pesticides and fertilizers may account for the detected higher concentration levels (0.16 mg/kg) of Co in oil palm plantation site. High concentrations of Co can provoke cardio toxicity in humans when exposed heavily (Linna et al., 2020). To define the status and degree of contamination of Co, contamination factor showed that all the soil samples in the rural –urban land uses were very slightly contaminated by Co (< 0.1) (Figure 3).

3.3. Chromium (Cr)

Cr is a potentially toxic element released into the environment through both natural processes and anthropogenic undertakings such as agricultural activities, metal processing, smelting, manufacturing, and, mining causing pollution and the damage of ecologies (López-Bucio et al., 2022). The concentration levels of Cr in the different rural-urban land uses are revealed in Figure 2. The values ranged from 0.12 to 0.70 mg/kg (Figure 2). Cr concentrations distribution followed the order (Figure 2); backyard farm (0.12 mg/kg) < oil palm production site (0.15 mg/kg) < block molding site (0.17 mg/kg) < cassava farm (0.18 mg/kg) < firewood processing site (0.20 mg/kg) / mechanic workshop (0.20 mg/kg) < cooking gas plant (0.21 mg/kg) < secondary forest (0.22 mg/kg) < oil palm plantation (0.70 mg/kg). The higher value of Cr (0.70 mg/kg) detected in oil palm plantation may be due to inappropriate use of agrochemicals and fertilizers (Kalpakjian et al., 2011; Olafisoye et al., 2020; Thompson-Morrison et al., 2022). The incidence of Cr in the soils of firewood processing site may be due to the fumes and fuel combustion from vehicles on the highway (Environment Agency, 2007; Sharma et al., 2021; Kerur et al., 2021). The prevalence of air conditioning coolants and engine parts are key sources of Cr in the soils of mechanic workshops (Alaekwe et al., 2019). Palm oil mill wastes are major sources of Cr contamination in the soils of oil palm production sites (Ogorure et al., 2024). The source of Cr in molding site may be linked to vehicular emissions (Olowoyo et al., 2015). This holds true for the current study, as vehicles are used to transport cement to the molding site and deliver molded blocks to customers from the site. The same applies to the cooking gas plant site. The finding of study was consistent with Olafisoye et al., (2020), who reported incidences of Cr concentrations in soils of oil palm plantations. The levels of Cr found in this study were low compared to that reported for soils in automobile workshops (Oguntimehin and Ipimoroti, 2008). This could be due to incidences of vehicle engine servicing, battery charging, body scrapping, painting of the auto-mobiles and panel beating in automobile workshops (Oloruntoba and Ogunbunmi, 2020). To ascertain the status and degree of contamination of Cr, contamination factor revealed that all the soil samples in the rural –urban land uses were very slightly contaminated by Cr (< 0.1) (Figure 3).

3.4. Arsenic (As)

As is a prevailing potentially toxic element whose place in pollution are global due to natural processes and anthropogenic activities (Hettick et al., 2015). The concentration levels of As in the different rural-urban land uses are revealed in Figure 2. The values ranged from 0.10 - 0.14 mg/kg. The distribution order of As in soils under the different land uses are as follows (Figure 2); block molding site (0.10 mg/kg) < mechanic workshop (0.11 mg/kg) < secondary forest (0.12 mg/kg) /oil palm production site (0.12 mg/kg) /firewood processing site (0.12 mg/kg) /cassava farm (0.12 mg/kg) /cooking gas plant (0.12 mg/kg) /oil palm plantation (0.12 mg/kg) < backyard farm (0.14 mg/kg). The occurrence of higher concentration level of As (0.14 mg/kg) in backyard farm may be due to the influence of domestic wastes and livestock droppings. (Kayode et al., 2021). The incidence of As in oil palm plantation soils may be ascribed to the application of pesticides and phosphate fertilizers (Environment Agency, 2007; Bhardwaj et al., 2020). The sources of As are mostly agricultural pesticides and phosphate fertilizers (Zuo et al., 2018). Similarly, Chen et al., (2022) observed that As contents were mostly found in planting areas mainly due to the application of fungicides, pesticides, and herbicides on the farmland soils. As levels observed in this study were lower than a study carried out within the vicinity of the mechanical workshop by Oloye et al., (2014). This may be due to the concentration of motor vehicles in mechanical workshops. As toxicity can cause developmental effects, neurotoxicity, and diabetes in humans (Singh et al., 2007). To determine the status and degree of contamination of As, contamination factor revealed that all the soil samples in the rural - urban land uses were very slightly contaminated (< 0.1) (Figure 3).

3.5. Cadmium (Cd)

Cd is a potentially toxic element that occurs naturally in rocks, soils, floras and faunas, and it occurs particularly in shales and clays, and sulphide mineralization (Environment Agency, 2007). The concentration levels of Cd in the different rural-urban land uses are revealed in Figure 2. The values ranged from 0.06 - 0.51 mg/kg (Figure 2). Cd is distributed in the following order (Figure 2); block molding site (0.06 mg/kg) / oil palm production site (0.06 mg/kg) < cassava farm (0.07 mg/kg) < mechanic workshop (0.08 mg/kg) < firewood processing site (0.09 mg/kg) < secondary forest (0.10 mg/kg) / cooking gas plant (0.10 mg/kg) < backyard farm (0.40 mg/kg) < oil palm plantation (0.51 mg/kg). The higher value of Cd (0.51 mg/kg) observed in oil palm plantation may be credited to the application of phosphate rock fertilizer on the soils (Environment Agency, 2007; Orobator et al., 2017; Yuan et al., 2019). The incidence of Cd in firewood processing site is related to pollutant sources along the transportation route (Zuo et al., 2018). Burning fuel and batteries are major sources of Cd in mechanic workshops (Alaekwe et al., 2019). Palm oil mill effluents contribute to Cd contamination in the soils of oil palm production sites (Ogorure et al., 2024). This study contradicted Bamgbose et al., (2000), who reported higher levels of Cd in soils of urbanized areas of Abeokuta. In humans, Cd toxicity can lead to a range of severe effects, such as renal and hepatic dysfunction, pulmonary edema and testicular damage (Gencihi et al., 2020). To ascertain the status and degree of contamination of Cd, contamination factor revealed very slight contamination (< 0.1) for block molding and oil palm production site; slight contamination (0.10–0.25) for mechanic workshop, secondary forest, firewood processing site, cassava farm and cooking gas plant; severe contamination (0.76–1.00) for backyard farm, and slight pollution (1.1–2.0) for oil palm plantation (Figure 3).

3.6. Vanadium (V)

V is an abundant potentially toxic element on earth whose main anthropogenic sources of release into the environment includes burning of fossil fuels, industries, mining, pesticide and fertilizer application and recycling of domestic waste (Imtiaz et al., 2015). The concentration levels of V in the different rural-urban land uses are revealed in Figure 2. The values ranged from 0.07 to 0.12 mg/kg. The distribution of V (Figure 2) is as follows; cassava farm (0.07 mg/kg) < block molding site (0.08 mg/kg) < mechanic workshop (0.10 mg/kg) /oil palm production site (0.10 mg/kg) /firewood processing site (0.10 mg/kg) /cooking gas plant (0.10 mg/kg) /oil palm plantation (0.10 mg/kg) < secondary forest (0.12 mg/kg) /backyard farm (0.12 mg/kg). The higher level of V detected in backyard farm (0.12 mg/kg) may be due to the prevalence of household wastes in the soils (Liu et al., 2022). In addition, incidences of V in secondary forest may be accredited to the parent material of the soils. The parent materials of soils can indicate V concentrations in soils, even in those unaffected by contamination (Guagliardi et al., 2018). Parent material, from which soils were initially derived, is the chief source of potentially toxic elements in soils (Sarwar et al., 2016). V toxicity can prompt oxidative impairment in the *brain* and develop blood brain barrier disorder and neuropathology (Rojas-Lemus et al., 2020). To determine the status and degree of V contamination, contamination factor showed that all the soil samples in the rural –urban land uses were very slightly contaminated (< 0.1) (Figure 3).

3.7. Nickel (Ni)

Ni is a potentially toxic element extensively released into the ecosystem from various anthropogenic and natural sources such as pigment manufacturing processes, wastes, alloy industries, industry wastewater, aerial deposition of pollutants, mafic and ultramafic rocks (El-Naggar et al., 2021). The concentration levels Ni in the different rural-urban land uses are revealed in Figure 2. The values ranged from 0.10 - 0.52 mg/kg (Figure 2). The order of Ni distribution in the soils of the land uses follow this pattern (Figure 2); oil palm plantation (0.10 mg/kg) < block molding site (0.16 mg/kg) < firewood processing site (0.17 mg/kg) /cassava farm (0.17 mg/kg) < mechanic workshop (0.18 mg/kg) < oil palm production site (0.19 mg/kg) /cooking gas plant (0.19 mg/kg) < secondary forest (0.21 mg/kg) < backyard farm (0.52 mg/kg). The higher level of Ni (0.52 mg/kg) observed in backyard farm may be ascribed to the effects of farming activities. Anthropogenic activities such as farming activities, smelting and mining development etc. can directly influence Ni incidence in soils (Wang & Zhang, 2007). Ni levels observed in backyard farm could be as a result of organic manure from household wastes (Oladeji, 2017). Also, the prevalence of Ni in oil palm plantation could be due to the application of fertilizers (Shrestha et al., 2021). Potentially toxic elements infiltrate the soils of farmland as well as the crops (Leng et al., 2023). This poses a significant threat to the ecological safety of farmland, as well as to crop yield and quality (Ghani et al., 2024). Palm oil mill effluents are major sources of Ni on the soils of oil palm production site (Ogorure et al., 2024). Also traffic activities are major sources of Ni (Olowoyo et al., 2015). This is true as vehicles constantly bring cement and sand to the block molding site as well take finished products from the site to the customers. This is also the situation for the cooking gas plant site. As expected, the levels of Ni observed in the present study were lower than that found in urban soils (Umoren & Onianwa, 2005). This may be due to incidences of intense degree of anthropogenic activities in the urban areas (Szynkowska et al., 2009). Ni toxicity can instigate a multiplicity of side effects on anthropoid health, such as allergy, cardiovascular and kidney diseases, lung fibrosis, lung and nasal cancer (Genchi et al., 2020). To find out the status and degree of contamination of Ni, contamination factor showed that all the soil samples in the rural –urban land uses were very slightly contaminated (< 0.1) (Figure 3).

4-Conclusions

The research examined potentially toxic elements contamination of soils in a rural-urban fringe area of Edo State. The results revealed that the soils of the land uses were contaminated with Pb, Co, Cr, As, Cd, V, and Ni. However, it indicated that backyard farm and oil palm plantation land uses were at risk with the presence of Cd in their soils. The study concluded that backyard farm and oil palm plantation land uses were the hotspots for Cd contamination in the rural-urban fringe area. We recommended the application of phytostabilizers such as phosphorus compounds, lime**,** or clays as mitigation strategies against Cd contamination in backyard farm and oil palm plantation land uses in the rural-urban fringe area. Future researches should prioritize the evaluation of potentially toxic elements contamination in the soils of emerging land uses in the rural – urban fringe area.

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