
HEAVY METAL ACCUMULATION IN LEAVES OF SELECTED MEDICINAL PLANTS GROWING ON DUMPSITES IN RIVERS STATE, NIGERIA

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Abstract

Dumpsites can serve as sources of environmental contaminants that may be taken up by plants growing within or around waste-disposal areas. This study evaluated the concentrations of lead (Pb), cadmium (Cd), and chromium (Cr) in the leaves of three medicinally relevant plant species *Amaranthus spinosus* L., *Cleome rutidosperma* DC., and *Luffa cylindrical* M. Roem. growing at Ogoloma Dumpsite in Okrika Local Government Area and the Ignatius Ajuru University of Education (IAUOE) Dumpsite in Obio-Akpor Local Government Area, Rivers State, Nigeria. Mature leaves were collected from each dumpsite and from corresponding control locations approximately 100 m away. Plant specimens were authenticated by a taxonomist, and heavy metals were determined by flame atomic absorption spectrophotometry following acid digestion adapted from USEPA Method 3050B. The results showed clear differences among plant species and locations. Leaf Pb ranged from 0.43 ± 0.02 to 10.26 ± 0.07 mg/kg, Cd from 0.05 ± 0.00 to 0.97 ± 0.01 mg/kg, and Cr from 0.44 ± 0.02 to 6.79 ± 0.04 mg/kg. The highest concentrations of all three metals were recorded in *A. spinosus* at Ogoloma Dumpsite. Across species, dumpsite samples generally contained higher concentrations than their corresponding controls. These findings demonstrate that plants established on the studied dumpsites can accumulate Pb, Cd, and Cr in leaf tissues. Because the study did not include dietary exposure parameters or a formal health-risk model, the results indicate contamination and potential exposure concern rather than a quantified human-health risk. Routine monitoring of dumpsite vegetation and avoidance of using plants collected from contaminated waste sites for medicinal or food purposes are therefore warranted.

Keywords: *Amaranthus spinosus*; *Cleome rutidosperma*; *Luffa cylindrica*; lead; cadmium; chromium; medicinal plants; dumpsites; Rivers State.

1. Introduction

Uncontrolled or poorly managed dumpsites are important potential sources of environmental contamination because municipal, commercial and industrial wastes may contain metallic contaminants that persist in soil and can enter biological systems. Recent investigations in Port Harcourt and other Nigerian cities have documented heavy-metal contamination in dumpsite soils and associated vegetation, demonstrating that waste-disposal areas can affect surrounding terrestrial food and plant systems (Okechukwu *et al.*, 2024; Olagbemiro *et al.*, 2025).

Plants growing on contaminated sites may absorb metals through the root system and may also receive atmospheric deposition on above-ground tissues. The magnitude of accumulation depends on plant species, metal bioavailability, soil properties, and physiological characteristics. Evidence from Nigerian dumpsites has shown transfer of metals from contaminated substrates into edible or medicinally relevant plant tissues (Uka *et al.*, 2013; Omada *et al.*, 2024).

Medicinal plants require particular attention because contamination of plant material can introduce an additional exposure pathway for people who use herbal preparations. Studies from Nigeria have reported heavy metals in medicinal plants and herbs collected from contaminated or market environments, with some investigations identifying concentrations that warrant continued monitoring (Sulaiman *et al.*, 2024; Orji, 2024). A recent study of *Stylochaeton hypogaeus* in Senegal likewise emphasized the importance of monitoring heavymetal concentrations in medicinal plants because of repeated or prolonged consumption (Diouf *et al.*, 2025).

The present study focused on three plants occurring naturally or semi-naturally around two dumpsites in Rivers State: *Amaranthus spinosus* L. (Amaranthaceae), *Cleome rutidosperma* DC. (Cleomaceae), and *Luffa cylindrica* M.Roem. (Cucurbitaceae). The study compared leaf concentrations of Pb, Cd and Cr between dumpsite locations and nearby control locations. The specific objectives were to determine the concentrations of Pb, Cd and Cr in the leaves of the selected plants and to compare their accumulation patterns across study locations.

The study is relevant to environmental monitoring in the Niger Delta, where urbanization and mixed waste disposal occur alongside widespread use of plants for food, traditional medicine and other purposes. The work also provides baseline plant-tissue data for the selected locations and species.

2. Materials and Methods

2.1 Study area and sampling locations

The study was conducted at two dumpsites in Rivers State, Nigeria: Ogoloma Dumpsite in Okrika Local Government Area and the Ignatius Ajuru University of Education (IAUOE) Dumpsite in Rumuloumeni, Obio-Akpor Local Government Area. The sites receive mixed waste. Mature, healthy leaves of the three selected plant species were collected from each dumpsite and corresponding control locations approximately 100 m away. Diseased leaves were excluded. At least 20 mature leaves were collected per species at each sampling location, placed in clean labelled polythene bags, and transported to the laboratory.

Location	Status	Approx. latitude	Approx. longitude
Ogoloma Dumpsite	Dumpsite	4°44'6.70" N	7°5'2.32" E
IAUOE Dumpsite	Dumpsite	4°48'23.48" N	6°56'23.48" E
Ogoloma Control	Control	4°44'13.08" N	7°5'3.44" E
IAUOE Control	Control	4°48'24.75" N	6°56'21.11" E

Note: Coordinates above are indicative of the general locality; exact coordinates of each composite sampling point were determined on-site using a handheld GPS receiver (Garmin eTrex 22x) and recorded in the field log.

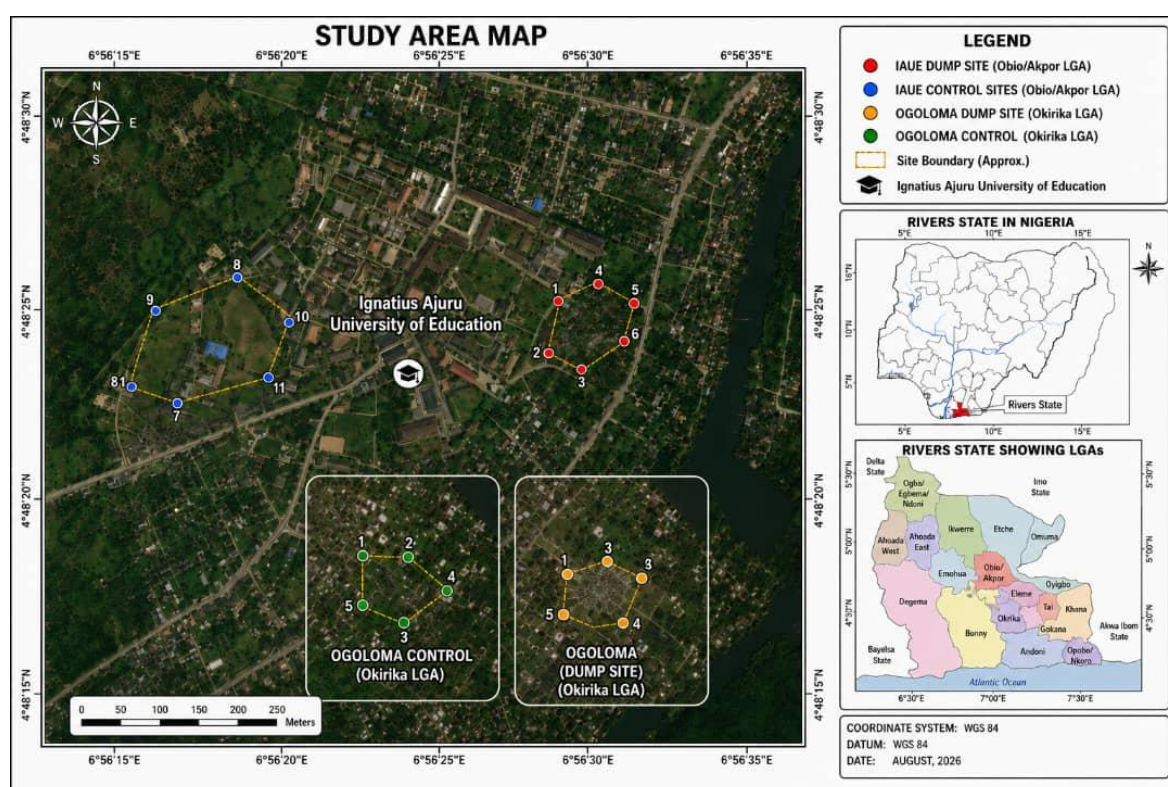


Figure 1. Study-area map showing the sampling stations for Ogoloma and IAUOE.

2.2 Plant identification and sample preparation

The plant specimens were authenticated by a taxonomist in the Department of Plant Science and Biotechnology, Rivers State University. Collected leaves were handled separately by species and location. The supplied study document reports oven-drying and powdering of plant material before digestion.

2.3 Acid digestion and determination of heavy metals

Three metals of environmental and toxicological interest Pb, Cd and Cr were quantified. Oven-dried powdered leaf samples (3 g) were weighed into conical flasks and digested with 5 mL of a tri-acid mixture ($\text{H}_2\text{SO}_4:\text{HNO}_3:\text{HClO}_4$, 40:40:20) in a fume cupboard until white fumes appeared. The digest was cooled, filtered into a 100-mL volumetric flask and made to volume with metal-free distilled water. Concentrations were determined using a flame atomic absorption spectrophotometer (Solar Thermo Elemental AAS, Model S4-71096) fitted with

element-specific hollow-cathode lamps. Calibration standards of 0, 0.5, 1.0, 2.0, 4.0 and 8.0 mg/L were used, and calibration curves with $r^2 \geq 0.995$ were accepted. Samples were aspirated in triplicate. The procedure was described in the supplied study as adapted from USEPA Method 3050B (U.S. EPA, 1996).

Metal concentration was calculated as: Metal concentration (mg/kg) = $(C \times V) / W$, where C is the concentration in the digest (mg/L), V is the final digest volume (L), and W is the mass of sample digested (kg).

2.4 Statistical presentation

All quantitative data generated from the heavy metals analyses were subjected to descriptive statistical analysis, including mean and standard deviation, using the Statistical Package for the Social Sciences (SPSS), version 25. The significant differences among plant species and locations were recorded as $p < 0.001$ and provides least significant difference (LSD) values for mean separation at $p < 0.05$.

3. Results

3.1 Lead concentration in leaves

Leaf Pb concentrations differed among plant species and locations. In each species, concentrations at the two dumpsites were higher than those at the corresponding controls. The maximum value was 10.26 ± 0.07 mg/kg in *A. spinosus* at Ogoloma Dumpsite, while the minimum was 0.43 ± 0.02 mg/kg in *C. rutidosperma* at Ogoloma Control. At IAUOE Dumpsite, *A. spinosus* also recorded the highest Pb concentration among the three species (8.11 ± 0.03 mg/kg).

Plant species	IAUOE Dumpsite	IAUOE Control	Ogoloma Dumpsite	Ogoloma Control	LSD
<i>A. spinosus</i>	8.11 ± 0.03^b	0.99 ± 0.02^c	10.26 ± 0.07^a	0.59 ± 0.00^d	0.084
<i>C. rutidosperma</i>	6.23 ± 0.13^b	0.71 ± 0.01^c	7.98 ± 0.02^a	0.43 ± 0.02^d	0.119
<i>L. cylindrica</i>	6.75 ± 0.03^b	0.80 ± 0.01^c	8.37 ± 0.05^a	0.49 ± 0.01^d	0.060

Table 2. Lead concentration (mg/kg) in leaves of selected plants across study locations. Values are mean $\pm$ SD. Different superscript letters within a row indicate significant differences at $P < 0.05$ (LSD).

3.2 Cadmium concentration in leaves

Cadmium concentrations also varied by species and location. The highest Cd concentration was observed in *A. spinosus* at Ogoloma Dumpsite (0.97 ± 0.01 mg/kg), followed by *L. cylindrica* (0.84 ± 0.01 mg/kg) and *C. rutidosperma* (0.73 ± 0.01 mg/kg) at the same site. The lowest concentrations (0.05 ± 0.00 mg/kg) occurred in *C. rutidosperma* and *L. cylindrica* at IAUOE Control.

Plant species	IAUOE Dumpsite	IAUOE Control	Ogoloma Dumpsite	Ogoloma Control	LSD
<i>A. spinosus</i>	0.74 ± 0.02 ^b	0.07 ± 0.00 ^d	0.97 ± 0.01 ^a	0.46 ± 0.01 ^c	0.020
<i>C. rutidosperma</i>	0.58 ± 0.00 ^b	0.05 ± 0.00 ^d	0.73 ± 0.01 ^a	0.34 ± 0.02 ^c	0.020
<i>L. cylindrica</i>	0.63 ± 0.01 ^b	0.05 ± 0.00 ^d	0.84 ± 0.01 ^a	0.39 ± 0.01 ^c	0.012

Table 3. Cadmium concentration (mg/kg) in leaves of selected plants across study locations. Values are mean ± SD. Different superscript letters within a row indicate significant differences at $P < 0.05$ (LSD).

3.3 Chromium concentration in leaves

Chromium showed a pattern similar to Pb and Cd. The highest Cr concentration was recorded in *A. spinosus* at Ogoloma Dumpsite (6.79 ± 0.04 mg/kg), followed by *L. cylindrica* (5.58 ± 0.06 mg/kg) and *C. rutidosperma* (5.22 ± 0.08 mg/kg). The lowest value was 0.44 ± 0.02 mg/kg in *C. rutidosperma* at Ogoloma Control.

Plant species	IAUOE Dumpsite	IAUOE Control	Ogoloma Dumpsite	Ogoloma Control	LSD
<i>A. spinosus</i>	5.31 ± 0.10 ^b	0.72 ± 0.03 ^c	6.79 ± 0.04 ^a	0.59 ± 0.01 ^c	0.103
<i>C. rutidosperma</i>	4.12 ± 0.09 ^b	0.55 ± 0.04 ^c	5.22 ± 0.08 ^a	0.44 ± 0.02 ^c	0.119
<i>L. cylindrica</i>	4.46 ± 0.09 ^b	0.62 ± 0.02 ^c	5.58 ± 0.06 ^a	0.50 ± 0.01 ^c	0.103

Table 4. Chromium concentration (mg/kg) in leaves of selected plants across study locations. Values are mean ± SD. Different superscript letters within a row indicate significant differences at $P < 0.05$ (LSD).

3.4 Comparative accumulation pattern

Across the three species, the approximate mean concentrations at the dumpsites were higher than at the controls. At IAUOE, the three-species means were 7.03 mg/kg Pb, 0.65 mg/kg Cd and 4.63 mg/kg Cr, compared with 0.83, 0.057 and 0.63 mg/kg, respectively, at IAUOE Control. At Ogoloma, the corresponding dumpsite means were 8.87 mg/kg Pb, 0.85 mg/kg Cd and 5.86 mg/kg Cr, compared with 0.50, 0.40 and 0.51 mg/kg at Ogoloma Control. These descriptive means reinforce the site-related accumulation pattern observed in the individual species.

Discussion

The principal finding of this study was the consistently greater accumulation of Pb, Cd and Cr in leaves collected from the two dumpsites compared with the corresponding control locations. This pattern is biologically plausible because mixed-waste dumpsites can act as sources of metal inputs to surrounding soil, and plants established on contaminated substrates

can subsequently acquire and translocate metals into above-ground tissues. Studies in Port Harcourt have documented heavy-metal contamination of active dumpsite soils, while studies elsewhere in Nigeria have demonstrated transfer of metals from contaminated dumpsite environments into plant tissues (Okechukwu *et al.* , 2024; Omada *et al.* , 2024).

Lead was the most prominent contaminant in the present leaf dataset, with the maximum concentration occurring in *A. spinosus* at Ogoloma Dumpsite. The magnitude of the difference between dumpsite and control samples was substantial. For example, the Ogoloma-dumpsite value in *A. spinosus* was approximately 17.4 times its Ogoloma-Control value. Comparable evidence of Pb accumulation in plants associated with waste sites has been reported in Nigeria. Uka *et al.* (2013) found Pb accumulation in *Amaranthus hybridus* grown on waste dumpsites in southeastern Nigeria and concluded that dumpsite-grown vegetables could accumulate metals from contaminated environments.

Cadmium displayed the same general site pattern but at lower absolute concentrations than Pb. The highest Cd value occurred in *A. spinosus* at Ogoloma Dumpsite. The three species also differed in their capacity to accumulate Cd, with *A. spinosus* generally showing the highest values. Differences among species may reflect variation in uptake, sequestration and translocation processes. Similar interspecific variation has been documented in medicinal and other plants exposed to metal-contaminated environments (Sulaiman *et al.* , 2024; Diouf *et al.*, 2025).

Chromium concentrations were higher at the dumpsites than controls, again with *A. spinosus* recording the highest value at Ogoloma. Recent Nigerian studies have reported Cr in plants growing around dumpsites and emphasized the need to consider plant uptake alongside soil contamination (Olagbemiro *et al.*, 2025; Omada *et al.*, 2024). The present results extend this evidence to the three plant species and two locations examined in Rivers State.

The consistently high concentrations observed at Ogoloma relative to the controls may reflect differences in the intensity, composition or duration of waste deposition between the study locations. However, the present dataset does not include soil-metal concentrations, soil physicochemical properties, metal speciation, or source-apportionment data. Therefore, the specific mechanisms responsible for the difference between Ogoloma and IAUOE cannot be established from the current results alone.

The findings are relevant to medicinal-plant safety. Recent work in Nigeria has shown that medicinal plants and herbs can contain measurable concentrations of toxic metals, and researchers have emphasized continued monitoring because repeated consumption may create an exposure pathway (Orji, 2024; Sulaiman *et al.*, 2024). Importantly, the present study measured metal concentrations in leaves but did not estimate estimated daily intake, hazard quotient, hazard index or cancer risk. Such risk calculations require additional parameters, including consumption rate, body weight, exposure frequency and duration, reference doses and, where applicable, cancer slope factors. Consequently, the present findings should be interpreted as evidence of environmental contamination and plant accumulation rather than as a numerical human-health risk assessment.

Conclusion

The study demonstrates that leaves of *Amaranthus spinosus*, *Cleome rutidosperma* and *Luffa cylindrica* growing at the investigated Ogoloma and IAUOE dumpsites contained Pb, Cd and Cr at higher concentrations than corresponding control samples. Ogoloma Dumpsite generally showed the highest values, and *A. spinosus* recorded the highest concentration of

each of the three metals among the selected species. The findings provide baseline evidence of plant-tissue metal accumulation in two dumpsite environments in Rivers State. Because these plants may have food or medicinal relevance, their collection and use from contaminated waste-disposal areas should be approached cautiously. The study does not, however, provide a formal quantitative human-health risk estimate.

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