Nigerian Research Journal of Chemical Sciences **(ISSN: 2682-6054)**
Volume 9, Issue 1, 2021

POLLUTION ASSESSMENT OF SOIL AND PLANTS GROWN AROUND THE VICINITY OF SOME DUMPSITES IN KADUNA- NIGERIA

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ABSTRACT

The aim of this research is to assess the quality of the dump soil and plants grown around the vicinity of some dumpsites in Kaduna South Local Government Area in Nigeria. Soil and plant samples were collected within the vicinities of four dumpsites and a control site. The soil and plant samples were analyzed for five heavy metals (Cd, Cu, Ni, Pb and Fe) using Atomic Absorption Spectroscopy (AAS). The heavy metal concentrations of the dumpsites soils were, Cd: 185.83 - 86.98 mg/kg, Cu: 220.50 - 89.42 mg/kg, Ni: 40.52 – 22.43 mg/kg, Pb: 250.90 - 180.75 mg/kg, and Fe: 70.22 - 40.94 mg/kg, while the of heavy metal concentrations in sugar cane (stem) were, Cd: 45.23 - 18.80 mg/kg, Cu: 120.11 - 89.42 mg/kg, Ni: 25.22 – 8.34 mg/kg, Pb: 70.77 - 45.26 mg/kg and Fe: 58.33 – 15.22 mg/kg. The concentrations observed for the studied metals in the sugar cane stem and in the dump soil exceeded the accepted safety limits. The study showed that ingestion of plants produced on these sites could pose health risk to human.

Keywords: Dumpsites; heavy metals; pollution; plants; soils

INTRODUCTION

Pollution is the introduction into the environment of substance or energy predisposed to cause threat to human health, harm to living resources and ecological system damage to structures or amenity or interference with legitimate uses of the environment. Pollution releases unwanted materials into the environment, which affect the natural sequence of the environment [1].

A pollutant is any material that is introduced into the environment that causes injury to the health of the environment, including life forms present in it, appliances installed in it and reduces the aesthetic quality of the environment [2].

Rapid population growth and urbanization in Kaduna South metropolis have led to the generation of enormous quantities of solid wastes and consequential environmental degradation. Thus the level of heavy metals in both soils and plants grown on or around the dump sites are expected to be elevated beyond the threshold levels. It is imperative to understand that domestic, industrial, and agricultural activities contribute to the heavy metal loading of the soil and plants grown around the soil dump sites. The determinations of the heavy metal uptake since these metals are taken up by plants and from here enter into the food chain where they may cause health hazards and the pollution indices of the dump soils will help to determine the level of pollution loading [3].

Although metals such as Cu and Zn are essential trace metals in view of their valuable role for metabolic activities in organisms, other metals like Cd, Pb, Ni and Hg exhibit high toxicity even at trace levels. However, the synergy of plant and soil are enormous because the soil directly affects the plant compositions. The dumping of refuse affects the nutritional value of crops grown on that particular soil [3]. Heavy metals could enter the aquatic environment from both natural and anthropogenic sources. Natural sources include weathering of minerals and soils [4]. Anthropogenic inputs are mainly from industrial effluents, domestic effluents, rural and urban storm water runoff and spoil heaps [5].

Studies have shown that municipal refuse may increase heavy metal concentration in soil and underground water [6, 7]. This may have effects on the host soils, crops and human health [8]. Thus, the environmental impacts of municipal refuse are greatly influenced by their heavy metal contents. The concentrations of heavy metals are steadily increasing which is adduced to industrialization [9]. Therefore, the aim of this research was to ascertain the level of soil pollution at Nasarawa, Trikania, Gonigora and Sabo dump sites and their relationship to the heavy metal contents of sugar cane grown around the vicinity of the dumpsites. The objective of the study was to assess the level of pollution in soil and sugar cane (stem) ability to accumulate Cd, Pb, Cr, Ni and Fe as it can pose health risk to consumers of the plant.

MATERIALS AND METHODS

Study Area

This research covered four sites in Kaduna South Local Government, Nigeria. The sites were: Nassarawa (NS), Sabo (SB), Gonigora (GN) and Trikania (TK). The dumpsites are situated around residential areas and farm lands within the metropolis.

Kaduna South is occupying the central portion of Kaduna State, Nigeria with location matrix of Latitude 10.52 °N and Longitude 7.44 °E. Annual temperature varies between 29 to 38.6 °C. Kaduna is an administrative, industrial, a veritable commercial center and a functional urban area. As at 1991 census, it had a population of 993,600 [10].

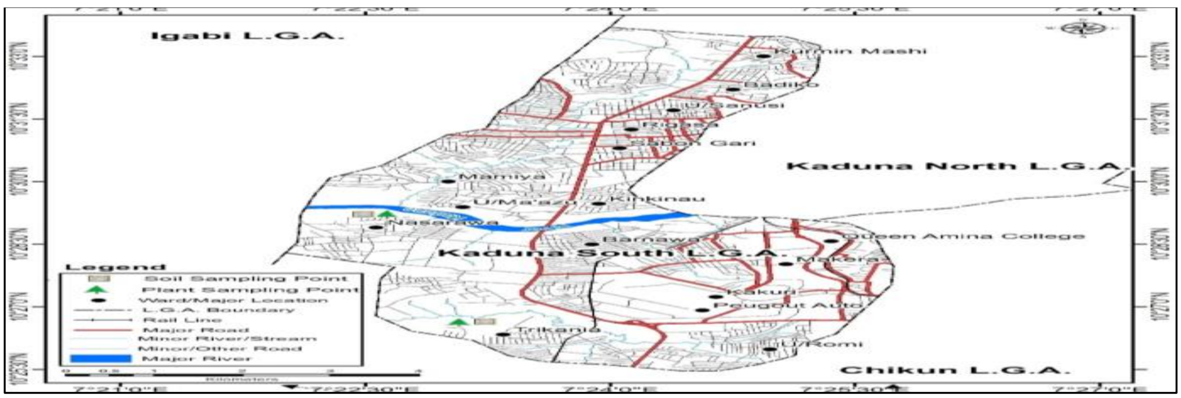

Figure 1: Map of Kaduna South Showing Sample Locations

Sample Collection

The soil surface was cleared with a hand trowel before the samples were collected using a stainless steel spoon. After every collection, the hand trowel and spoon were washed with distilled water. The number of sampling points depended on the size of dumping site and the four dumpsites were each divided into four (4) quadrants. Soil samples were taken from the soils of each quadrant at 0 – 15 cm depth and were mixed properly to give a composite sample mixture in a plastic container rinsed with distilled water and HNO_3 to avoid sample contamination. The sample was labeled in plastic container for laboratory analysis. Sample was immediately transported to the laboratory for processing and preservation and the sampling was carried out between October and December, 2019 [11].

The sugar cane plant was collected from a nearby farmland within 2 m to 5 m of each dumpsite and the plant sample was divided into eight quadrants and the whole plants were uprooted from each quadrant in a diagonal basis [11]. The plant samples were bagged in paper bags and transported to the laboratory for pretreatment and subsequent analysis. A control site (non-contaminated site) which was about 2 km distance where no activities involving disposal of metal containing materials was selected [6].

Sample Pre-Treatment

The plant samples of sugar cane was washed with tap water and thereafter rinsed with distilled water and sliced into uniform size (2 mm) to facilitate drying. It was dried in an oven at 100 ºC for 24 hr; until they became brittle and crisp [11]. This is to prevent growth of micro-organisms and care was taken in other to avoid contamination. The soil sample from each site was homogenized and air dried in at 30 ºC to a constant weight and passed through 2 mm sieve.

HEAVY METAL ANALYSIS

The samples collected were digested for heavy metal analysis as reported in previous studies [12]. Soil samples (1 g) of each sample was digested in Teflon cups with 30 cm^3 aqua-regia (HCl: HNO_3, 3:1) on a thermostat hot-plate at 150 ºC. After 2 hours of digestion, the Teflon cup with its content was removed from the hot-plate to simmer. Then, 5 cm^3 HF was added to the cup and heated further for 30 min. The Teflon cup with the content was allowed to cool down to room temperature and filtered. The filtrate was quantitatively transferred into 50 cm^3 volumetric flask and made up to mark with deionized water. A blank determination was carried out using the procedure described above. Cd, Cu, Pb, Ni and Fe concentrations were determined using Atomic absorption spectroscopy (AAS). The total heavy metal content in soil and plants was determined using Variant spectra Atomic Absorption Spectrophotometer (Agilent Technology 240 model) equipped with a digital readout system at Federal Ministry of Agriculture, Gonigora, Kaduna Research Centre, Nigeria.

The dried plant samples were pulverized using mortar and pestle. The plant samples (5 g) were placed in beaker, 3 cm^3 of hydrogen peroxide and 75 cm^3 of 0.5 M of HCl were added. The content was heated gently at a low temperature on a hot plate for 2 hr after which it was filtered into a 50 cm^3 standard flask and two 5 cm^3 portions of distilled water were used to rinse the beaker and the contents filtered into the 50 cm^3 flask. The filtrate was allowed to cool to room temperature before dilution was made to the mark and the content mixed thoroughly by shaking. The digestion was carried out in triplicate for both samples and blanks [12].

Quality Assurance

The validity of the extraction procedure, the precision and accuracy of the Atomic absorption spectrophotometer was tested by spiking experiments. Validation of the technique was conducted on the digested plant and soil samples. This was done by spiking the pre-digested samples with multi-element standard solution (5 mg/L of Cd, Cu, Ni, Pb and Fe) as reported in previous studies [13]. The digest was run on AAS equipment and the concentrations of metals in the spiked and un-spiked samples were used to calculate the percentage recovery in order to validate the method. The percentage recoveries for the soil samples varied between 85.26% - 96.83% while for the plant samples, the percentage recoveries varied between 81.63% - 92.08%. From the results, acceptable recoveries were obtained in all cases which validated the efficiency of the AAS.

Table 1: Percentage recovery of heavy metals in soil and plant sample

Metals	Soil Sample (%)	Plant Sample (%)
Cd	88.00	85.00
Cu	90.00	81.63
Ni	96.83	92.00
Pb	85.26	85.00
Fe	89.00	86.00

RESULTS AND DISCUSSION

The mean concentration values of metals in soil samples are presented on Figures 1- 5 while the ranges in sugar cane samples are shown on figures 6-10, with a concentrations of Ni (25- 12 mg/kg), Fe (38 -13 mg/kg), Pb (70 -45 mg/kg), Cu (50 -38 mg/kg) and Cd (45 -18 mg/kg) and the mean concentrations values in soil samples were Ni (135- 22 mg/kg), Fe (140 -55 mg/kg), Pb (250 -180 mg/kg), Cu (235 -89 mg/kg) and Cd (185 -86 mg/kg). The control values were 0.02 mg/kg, 0.00 mg/kg, 15.00 mg/kg, 17.00 mg/kg and 10.00 mg/kg for Ni, Fe, Pb, Cu, and Cd respectively in control soil samples.

The mean levels of Ni, Pb, Cd, Cu and Fe in all the figures showed that the soil and plant metals contents were significantly lower in the control site (5.00 mg/kg, 2.00 mg/kg 5.00 mg/kg, 6.00 mg/kg and 9.00 mg/kg for Ni, Fe, Pb, Cu, and Cd respectively in sugar cane samples) compared to the study areas.

The concentration ranges of Cd, Cu and Pb in sugar cane in this research are higher than the concentration ranges of Cd, Cu and Pb investigated by Clifford *et al* .[6] and Ogunfowakan *et al.* [12] in *Zea Mays* and *Amaranthus retroflexus* respectively which were higher than the concentration as reported in the previous studies for vegetables samples [7].

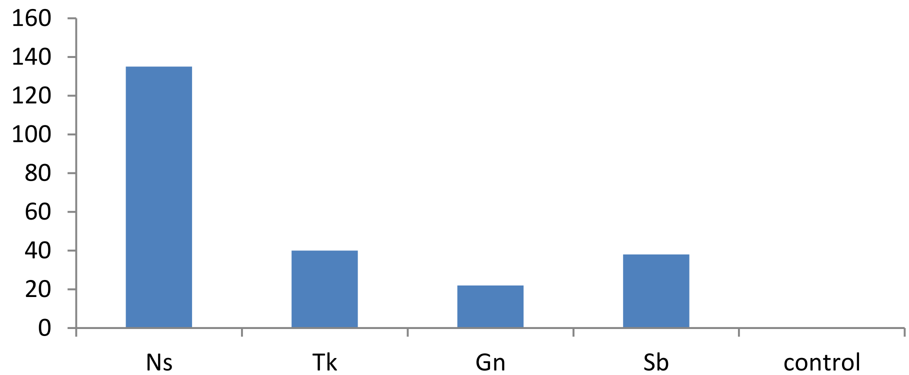

Figure 1: Mean Ni Concentrations in the dumpsites soils

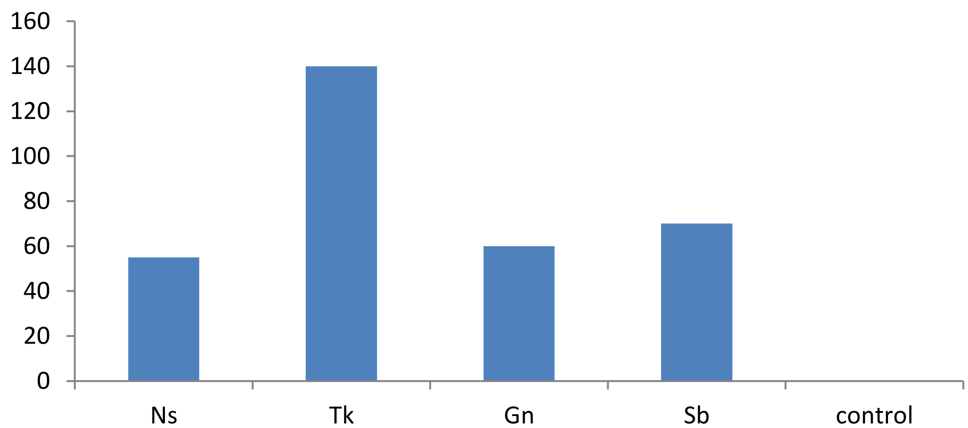

Figure 2: Mean Fe Concentrations in the dumpsites soils

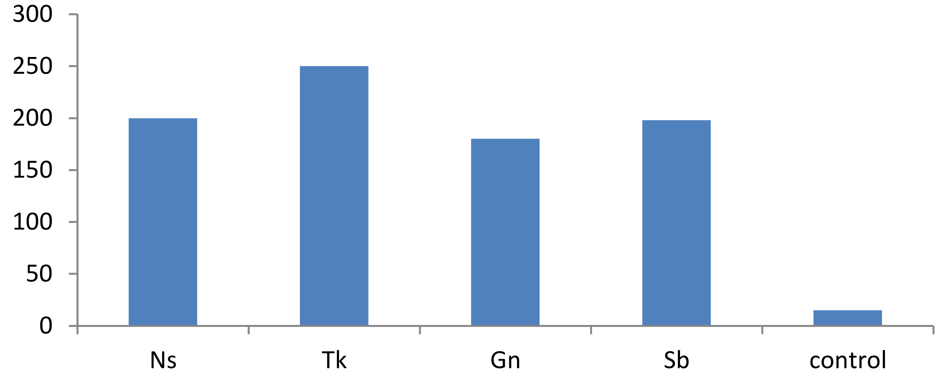

Figure 3: Mean Pb Concentrations in the dumpsites soils

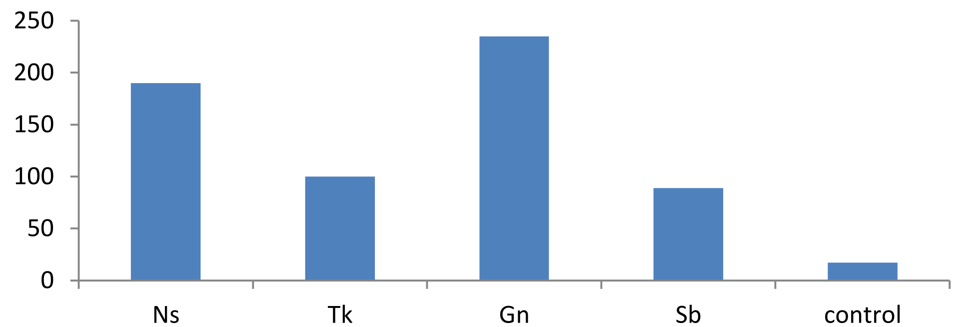

Figure 4: Mean Cu Concentrations in the dumpsites soils

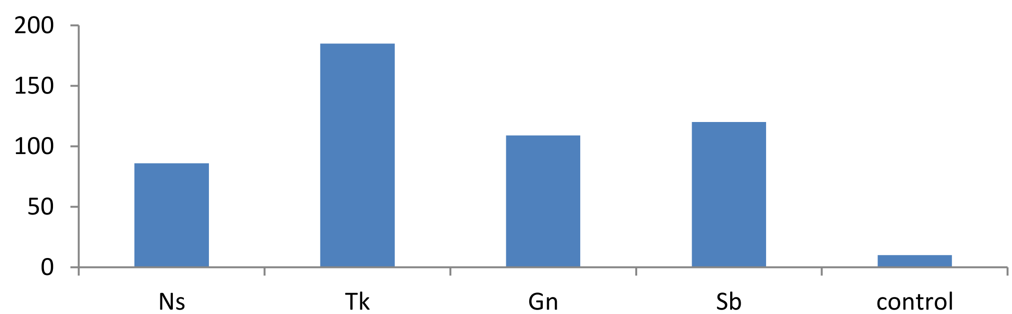

Figure 5: Mean Cd Concentrations in the dumpsites soils

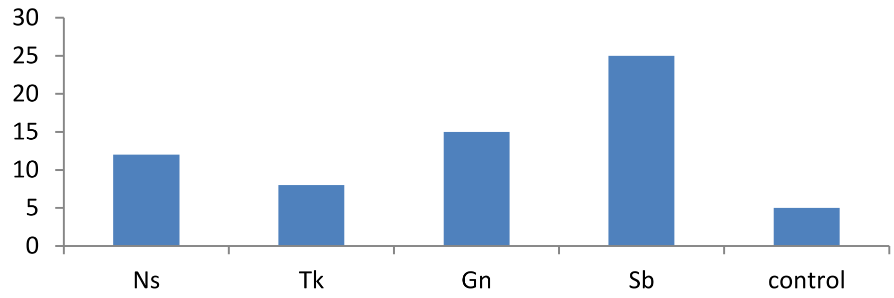

Figure 6: Mean Ni Concentrations in Sugar Cane

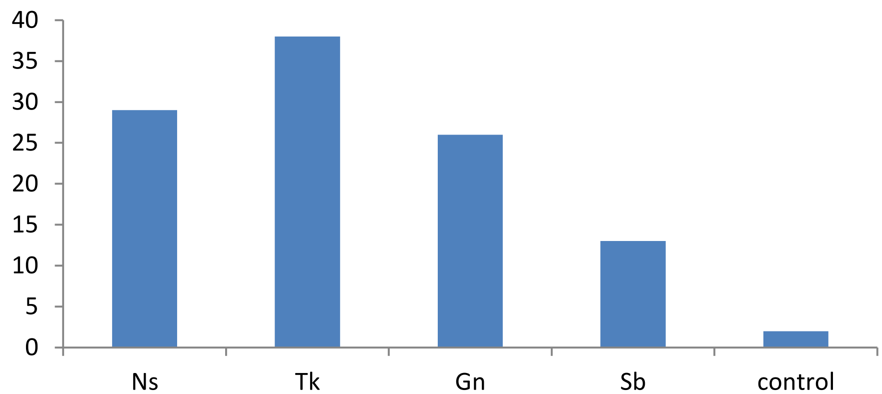

Figure 7: Mean Fe Concentrations in Sugar Cane

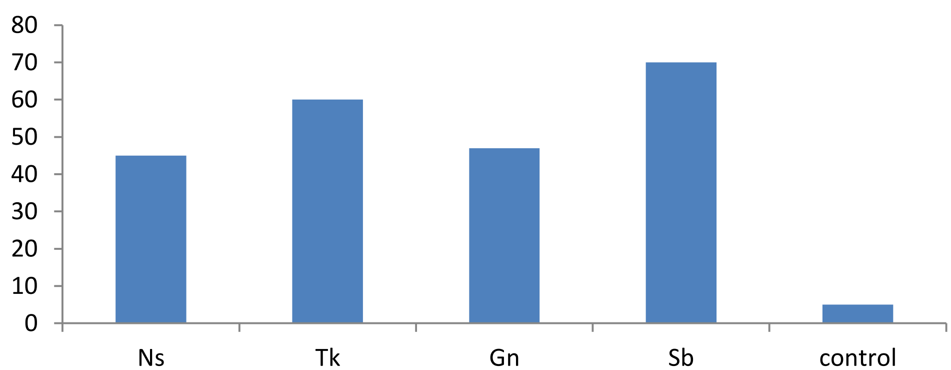

Figure 8: Mean Pb Concentrations in Sugar Cane

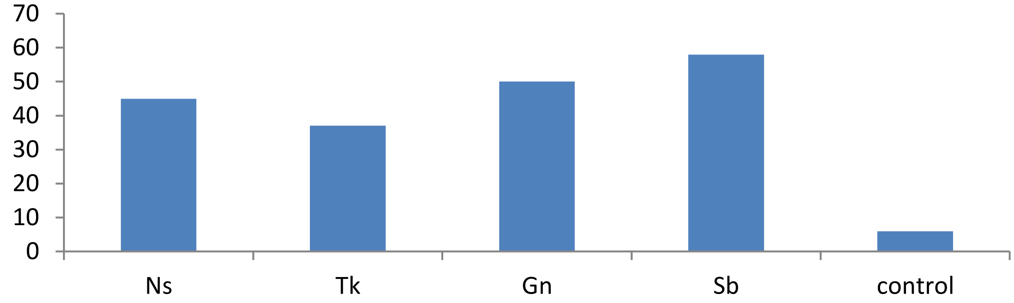

Figure 9: Mean Cu Concentrations in Sugar Cane

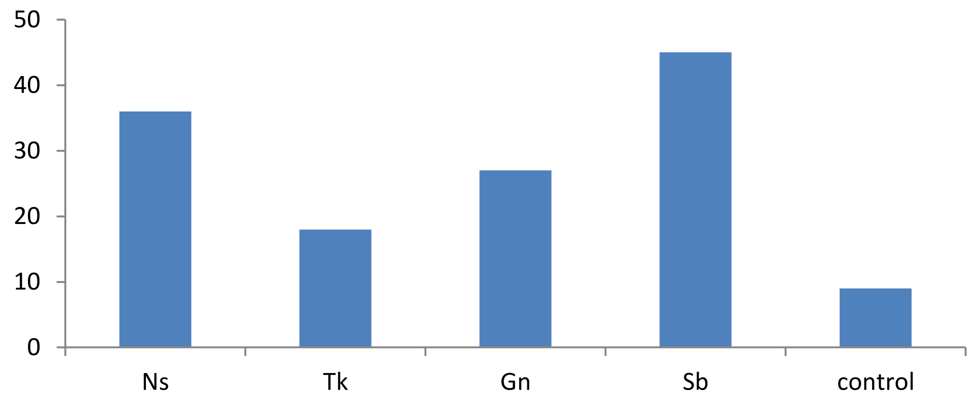

Figure 10: Mean Cd Concentrations in Sugar Cane

The concentrations of Cd, Fe, Ni, Cr and Cu sugar cane were above the permissible limits [14-17] as the intake of sugar cane from these dumpsites may pose potential human risk, especially to people living around this area.

The concentrations of Cd, Pb, Ni and Fe in the dumpsites soils and plants were above the standard limits for the above named metals as reported in the previous studies [14-17]. These high concentrations of cadmium at the study areas could be linked to waste disposed from industries, mechanic workshop, and market.

The mean value obtained by Obasi *et al* [7], Uba *et al* [18] and others were lower than the concentrations reported in this work [19, 20]. From the results, the level of heavy metal contents may pose environmental hazard to man. Human activity can also contribute to increased heavy metals level as a result of urban-industrial activity or agricultural practices [20- 21].

CONCLUSION

The results of the investigation from this study have shown that soil and plants sampled within the vicinity of some dumpsites in Kaduna indicated higher heavy metals comparative to the control site. The high concentrations of heavy metals could be credited to anthropogenic sources such as spent batteries, paints and plastics at the dumpsites. Sources of these heavy metals in the soils could be due to automobiles, coloured polythene bags, discarded plastic materials, empty paint containers and electronic waste.

RECOMMENDATIONS

It is recommended that study of other toxic metals be carried out across the seasons and at various depths in more dumpsites in the metropolis, so as to obtain a thorough and broad database for elucidating the environmental impact and health risk of the heavy metals in the dumpsites of Kaduna South Local Government Area, Nigeria. The dumpsites were shown to directly contribute to the pollution of the soils and plants in Kaduna South metropolis and the fact that it is an illegal. As such, dumping should be stopped and the sites properly closed.

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