

Research paper

**An Evaluation of the As, Cd, Mn and Hg Contamination in Soils
and Plants (*Amaranthus Spinusis*) of Kaduna Metropolis
Dumpsites**

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ABSTRACT

The study assesses the qualities of contaminated soils of ten municipal waste dumpsites in Kaduna metropolis, Nigeria in 2011 and 2012. The pH of the dumpsite soils ranged from neutral to alkaline. The organic matter in the dumpsite soils during the wet season were generally lower compared to the dry. The total concentrations of As, Cd, Hg and Mn were elevated at some of the dumpsites. Metal contamination at the dumpsites follows the ranking: Mn > Hg > Cd > As. Levels of these metals in *Amaranthus spinusis* and the soils did not vary significantly across the season ($P < 0.05$). High level of contamination of these metals was recorded at Tudun Wada (TW), Rafin Guza (RG), Angwan Dosa (AD) and Angwan Shanu (AS). Transfer factor indicates that As and Hg were more accumulated in the plant (*Amaranthus spinusis*) grown on TW at the wet and dry season. The study evidently indicates high level of the selected heavy metals in the dumpsites, this calls for environmental concern since these dumpsites are invariably used as organic manures for farming.

Keywords: Heavy metals; dumpsite; soils; *Amaranthus spinusis*; contamination

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32 **1. INTRODUCTION**

33 Refuse generation, dumping and management have become a serious environmental problem
34 in many urban areas in Nigeria. The volume of waste generated in many of these urban areas
35 has been on the increase in recent times. Many human factors such as: technology,
36 industrialization, agricultural practices, transportation, education, construction trade,
37 commerce, nutrition and most importantly population increase are directly responsible for
38 increase in refuse generation in any human society (Sukop *et al.*, 1979).

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40 Although solid waste can be an asset when properly managed, it poses the greatest threat to
41 life amongst all the classes of waste since, it has the potential of polluting the terrestrial,
42 aquatic and aerial environments (Bishop, 2000).

43 Several fluxes of waste and cover materials from different sources end up at dumpsites and
44 due to the heterogeneity and complexity of wastes, these dumpsites contain a variety of
45 contaminants which can pollute the soil of the area (Sukop *et al.*, 1979). The physico-
46 chemical properties of the degraded soils at these sites are one of the important factor playing
47 roles in vegetation development (Gairola and Soni, 2010). For instance, soil structure and
48 acidity affects the absorption and accumulation of mineral elements by plants (Tresow, 1970)
49 and thus play a very important role in vegetation establishment and development at such sites

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51 Nigeria is fast becoming a dumping ground for technological waste, especially used
52 electronics and automobiles from the developed countries. It is a known fact that some of

53 these products contain hazardous metals such as lead, mercury, nickel, cadmium, copper,
54 zinc, arsenic etc. The indiscriminate dumping of damaged parts of these imported and other
55 similar locally produced materials in different forms can perturb the distribution and
56 concentration of these metals in the environment. The Nigerian Government at all levels
57 through their agencies has invested much in waste management and enforcement of sanitation
58 laws but little has been achieved so far (Ojeshiria, 1999).

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60 One of the predominant occupations in Northern Nigeria is farming (Harris, 1996). However,
61 due to the unaffordable cost of modern fertilizer, poor farmers use waste soils from dumpsites
62 as manure in many towns and villages of Northern Nigeria. This however, lead to
63 accumulation of heavy metals in plants grown on dumpsite soils or fertilized from such
64 manure which on subsequent transfer through food chain end up in man, posing potential
65 health risk.

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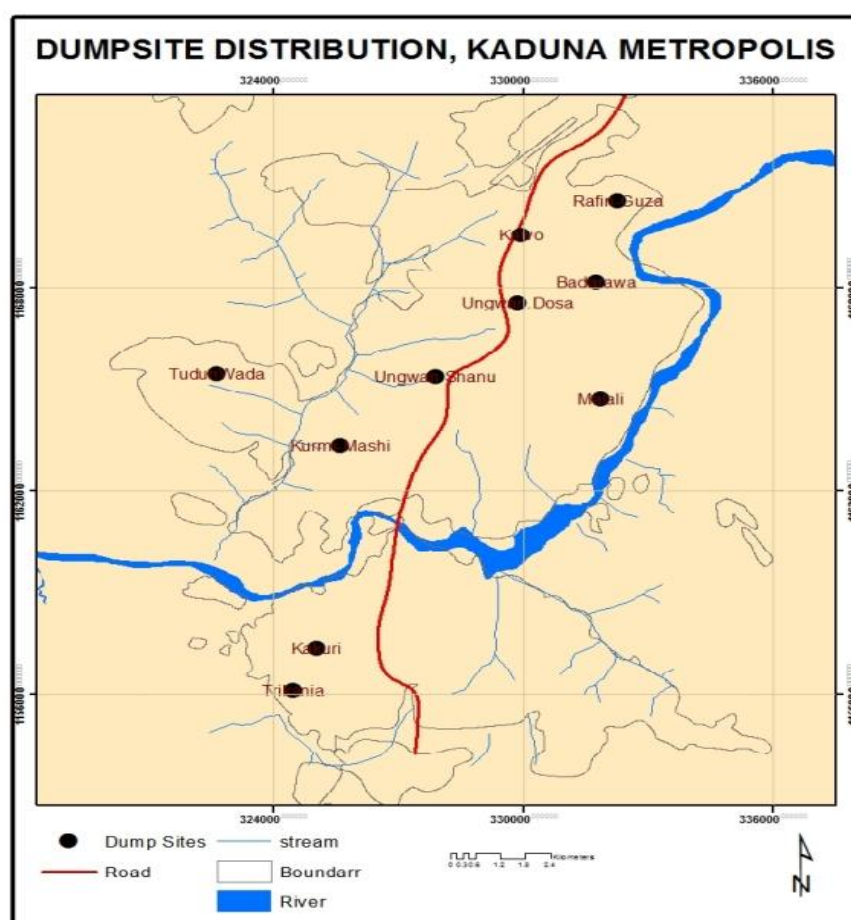
67 It is based on these facts that this study is aimed at determining the total concentration of
68 arsenic, cadmium, manganese and mercury in soils and plants of Kaduna metropolitan
69 dumpsites including the variation of the physico-chemical properties across the seasons in the
70 selected dumpsites. The significant of this work would to be provide recent and additional
71 information relevant for soil quality monitoring and assessment of the human health and
72 ecological implications associated with refuse dumpsites.

73 **2.0 MATERIALS AND METHOD**

74 **2.1 STUDY AREA**

75 The present study was performed on ten municipal waste dumpsites and a control site which
76 is 10 m away from one of the dumpsites (Badarawa) in Kaduna state. Kaduna State lies
77 between longitude 30° east and latitude 0900 and 1130° North of the equator. The State
78 occupies an area of approximately 48,473.2 square kilometres and has a population of more

79 than six million (2006 census). It falls into Guinea Savannah climate, which has distinct wet
80 and dry seasons. The ten study sites are Kawo (KW), Rafin Guza (RG), Malali (ML),
81 Angwan Dosa (AD), Badarawa (BD), Angwan Shanu (AS), Kurmum Mashi (KM), Tudun
82 Wada(TW), Trikania (TK) and Kakuri (KK) waste dumping sites (Figure 1), ranging from
83 about two to twenty- two years of existence. Figure 1 below shows the map of the ten
84 dumpsites studied.



85

86 **Figure 1: Map showing the ten study sites.**

87 **2.2 Sample Collection / Pre-treatment**

88 The ten dumpsites sampled in each location were divided into four quadrant; five plant
89 samples were collected from each quadrant in a diagonal basis following the methods of

Nuonom *et al.* (2000). The plants (*Amaranthus spinusis*) were collected in the quadrants from the dumpsites and also from the control sites. The plants were carefully uprooted and bagged in a labelled polythene bag and taken to the laboratory. The dumpsite soils were also collected from each site with the aid of a clean stainless steel spoon at 10 cm below the top soil. The soil samples were placed in labelled polythene bags and were then taken to the laboratory for treatment. The sample collection was done from August 2011 to June 2012 at three months interval, spanning rainy and dry seasons. All the samples were collected in triplicate. Soil samples from each site were homogenized in an agate mortar and air dried in a circulating air in the oven at 30°C overnight and then passed through a 2 mm sieve. The sieved soils were placed in polythene bags and ready for analysis. Plant samples were properly rinsed with tap water and then with distilled water to remove any attached soil particles, cut into smaller portions and then placed in large clean crucible where they were oven dried at 100°C for 48 hrs in order to remove moisture. The dried plant samples were grounded into fine particles using a clean acid washed agate mortar and pestle.

2.3 Physico-chemical analysis

Physico-chemical properties such as pH, electrical conductivity, moisture content, organic matter, cation exchange capacity (CEC) were analyzed. The pH and electrical conductivity were measured in a soil suspension (1:10 w/v dilution) by digital pH meter and conductivity meter respectively according to Black *et al.* (1965) and Wilcox, 1950. Moisture content and cation exchange capacity were determined by the procedures outlined by Black (1965). Organic matter was determined by the wet oxidation method of Walkey and Black (1947).

2.4 Heavy metal analysis

Total concentrations of Mn, Cd, Hg, As were analyzed in the soil samples by wet digestion according to Ogunfowokan *et al.* (2009). A 1.00 g of the soil sample was digested

in Teflon cup with 30.00 ml aqua - regia (HCl: HNO₃, 3:1) on a thermostatted hot plate at 150°C. After about 2 hrs of digestion, the Teflon cup with its content was brought down from the hot plate to simmer. Then, 5.00 ml HF was added and the mixture was heated further for 30 mins. The Teflon cup with the content was allowed to cool down to room temperature after which the content was quantitatively transferred into a 50.00 ml volumetric flask and made to the mark with distilled water. Triplicate digestion of each sample was carried out together with the blank.

The *A. spinusis* samples was digested according to Awofolu (2005), 0.50 g of dried *A. spinusis* was weighed into 100.00 ml beaker, a mixture of 5.00 ml concentrated HNO₃ and 2.00 ml HClO₄ was added and this was digested at low heat using hot plate until the content was about 2.00 ml. The digest was then allowed to cool and was filtered into a 50.00 ml standard flask. The beaker was rinsed with small portions of double distil water and then filtered into the flask. Triplicate digestion of each sample was carried out together with the blank.

3.0 RESULTS AND DISCUSSION

3.1 PHYSICO-CHEMICAL PROPERTIES OF THE SOIL

The physico-chemical properties used as indicator of the soil quality are presented in Tables 1 and 2 for wet and dry seasons respectively. Generally pH differed significantly among dumpsites and the seasons. In the wet season RG had the highest pH of 9.30 and TK had the least (7.90) while in the dry season RG and AD had the highest (9.20) and TK the least (7.55). These indicate that most of the dumpsites soils are alkaline which enhances soil fertility and plant growth. These values are in line with other studies by Bamgbose *et al.* (2000). However, compared to the control, these values on the average were significantly higher. This may be linked to the buffering effect of soil organic matter against pH change in addition to the release of basic cations during the organic matter decomposition (Mclean and

Bledsoe, 1992). At low pH, metals are more soluble in the soil solution, thus more bioavailable to plants, and hence pose severe toxicity problems in acidic than in alkaline soil (Oluyemi *et al.*, 2005). Electrical conductivity (EC) ranged from 0.010 mho/m (KM) – 0.280 mho/m (TW) in the wet season and 0.0015 mho/m (AS) – 0.093 mho/m in the dry season at AD. The electrical conductivity values were found to vary significantly across the seasons, with majority of the dumpsites recording lower values in the dry season. The relatively high EC values may be attributed to the presence of metal scraps which is one of the constituents of the refuse dumpsites (Uba *et al.*, 2008).

Table 1: Mean ($\pm$ SD) Physicochemical Parameters of Refuse waste soil (wet season)

Dump Sites	pH	Moisture Content (%)	Cation Exchange Capacity (Cmolkg ⁻¹)	Organic Matter (gkg ⁻¹)	Electrical Conductivity (mho/m)
KW	8.10 $\pm$ 0.01	88.20 $\pm$ 0.01	8.20 $\pm$ 0.20	32.70 $\pm$ 0.02	0.030 $\pm$ 0.03
RG	9.30 $\pm$ 0.02	46.00 $\pm$ 0.02	10.00 $\pm$ 0.01	29.50 $\pm$ 0.04	0.055 $\pm$ 0.06
BD	8.80 $\pm$ 0.01	84.50 $\pm$ 0.03	8.50 $\pm$ 0.02	30.70 $\pm$ 0.05	0.110 $\pm$ 0.92
AD	9.20 $\pm$ 0.01	75.10 $\pm$ 0.01	7.10 $\pm$ 0.03	22.70 $\pm$ 0.14	0.090 $\pm$ 0.03
KM	8.30 $\pm$ 0.03	68.00 $\pm$ 0.12	8.00 $\pm$ 0.01	27.10 $\pm$ 0.03	0.010 $\pm$ 0.46
AS	8.50 $\pm$ 0.03	72.08 $\pm$ 0.04	7.80 $\pm$ 0.01	20.30 $\pm$ 0.06	0.0014 $\pm$ 0.05
ML	8.60 $\pm$ 0.01	54.10 $\pm$ 0.02	7.10 $\pm$ 0.05	31.50 $\pm$ 0.07	0.055 $\pm$ 0.08
KK	8.80 $\pm$ 0.04	67.62 $\pm$ 0.03	8.60 $\pm$ 0.50	30.30 $\pm$ 0.03	0.080 $\pm$ 0.16
TK	7.90 $\pm$ 0.02	87.22 $\pm$ 0.02	7.20 $\pm$ 0.02	36.30 $\pm$ 0.33	0.112 $\pm$ 0.47
TW	8.80 $\pm$ 0.01	91.24 $\pm$ 0.02	10.40 $\pm$ 0.03	35.10 $\pm$ 0.05	0.280 $\pm$ 1.02
Control	7.30 $\pm$ 0.01	36.00 $\pm$ 0.01	6.00 $\pm$ 0.01	2.40 $\pm$ 0.01	0.015 $\pm$ 2.23

The lowest organic matter content in the wet season was recorded at AS (20.30 gkg⁻¹) and the highest at TK (36.30 gkg⁻¹) while in the dry season organic matter ranged from 20.20 gkg⁻¹ at AS - 37.20 gkg⁻¹ at TK. The significantly higher organic matter contents of the dumpsites soil

in the dry season compared to wet season could be due to the lower soil moisture contents during the dry season which retards the activities of the micro - organisms involved in the organic matter decomposition, thereby accumulating more organic matter in the dry season.

The organic matter contents of the soil plays an important role in absorption reaction in the soil, hence prevents pollutants from reaching ground water sources (Alloway and Aryes, 1995).

Cation exchange capacity in the wet season ranged from 7.10 at both AD and ML to 10.40 Cmolkg^{-1} at TW and in the dry season recorded a range of 6.90 at TK to 9.80 Cmolkg^{-1} at RG. Clay along with organic matter accounts for a great percentage of the total cation exchange sites. The soil concentrations of exchangeable bases significantly differ across the seasons and among the dumpsites as seen in this study. This may also be connected to the heterogeneous nature of wastes deposited in the dumpsites which is expected to impact differently on soil properties. In addition, the slightly higher mean values in the dry season can be attributed to leaching of cations down the profile by rainfall (Wong *et al.*, 2005).

Moisture content which is directly proportional to the water holding capacity of the soil ranged in the wet season from 46% at RG to 91.24% at TW while in the dry season the recorded range was 40.20 at RG to 81.24 at TW. These mean values as seen vary significantly between dumpsites depending on their location. The higher moisture contents in wet season explain why plants grow healthily compared to dry season.

As expected most of the parameters recorded the lowest mean values at Control which is not a dumpsite. More so, highest mean values were recorded in wet season for pH, electrical conductivity cation exchange capacity and moisture while in the dry season. organic matter recorded highest values. Also there was no remarkable difference in the mean

values of most parameters across the seasons with exception of electrical conductivity and moisture content. Correlation analysis shows that pH, electrical conductivity, cation exchange capacity and moisture content were positively correlated.

Table 2: Mean ($\pm$ SD) Physicochemical Properties of Dumpsite soil (dry season)

Dump Sites	pH	Moisture Content (%)	Cation Exchange Capacity (Cmolkg ⁻¹)	Organic Matter (gkg ⁻¹)	Electrical Conductivity (mho/m)
KW	8.00 $\pm$ 0.01	78.10 $\pm$ 0.01	8.10 $\pm$ 0.20	33.10 $\pm$ 0.02	0.035 $\pm$ 0.03
RG	9.20 $\pm$ 0.01	40.20 $\pm$ 0.02	9.80 $\pm$ 0.01	29.80 $\pm$ 0.04	0.058 $\pm$ 0.06
BD	8.70 $\pm$ 0.01	80.10 $\pm$ 0.03	8.00 $\pm$ 0.02	35.50 $\pm$ 0.05	0.115 $\pm$ 0.92
AD	9.20 $\pm$ 0.01	73.00 $\pm$ 0.01	7.00 $\pm$ 0.03	23.00 $\pm$ 0.14	0.093 $\pm$ 0.03
KM	7.90 $\pm$ 0.03	65.20 $\pm$ 0.12	7.80 $\pm$ 0.01	27.10 $\pm$ 0.03	0.010 $\pm$ 0.46
AS	8.50 $\pm$ 0.03	69.30 $\pm$ 0.04	7.80 $\pm$ 0.01	20.20 $\pm$ 0.06	0.002 $\pm$ 0.05
ML	8.40 $\pm$ 0.01	50.20 $\pm$ 0.02	7.00 $\pm$ 0.05	32.10 $\pm$ 0.07	0.056 $\pm$ 0.08
KK	8.70 $\pm$ 0.04	60.50 $\pm$ 0.03	7.50 $\pm$ 0.50	35.60 $\pm$ 0.03	0.083 $\pm$ 0.16
TK	7.55 $\pm$ 0.02	85.08 $\pm$ 0.02	6.90 $\pm$ 0.02	37.20 $\pm$ 0.33	0.112 $\pm$ 0.47
TW	8.79 $\pm$ 0.01	81.24 $\pm$ 0.02	9.50 $\pm$ 0.03	35.80 $\pm$ 0.05	0.288 $\pm$ 1.02
Control	7.30 $\pm$ 0.01	31.00 $\pm$ 0.01	6.10 $\pm$ 0.01	2.40 $\pm$ 0.01	0.014 $\pm$ 2.23

3.2 HEAVY METAL CONCENTRATIONS IN DUMPSITE SOIL (mgkg⁻¹)

The soil distribution of heavy metals is shown in the Figures 2a-2d. The Figures showed that the soil heavy metal content was significantly lower on the control site with no waste compared to the dumpsites studied. As seen in Figure 2a, arsenic content is generally low though it is higher in the dry season than the wet season. It recorded highest value (0.054) at ML and lowest (0.013) at both KM and TW in the wet season while in the dry season highest

189 value (0.51) at KK and lowest (0.001) at TK, this could be connected to the fact that
 190 residential area dumps compose less toxic waste than the industrial sites. Arsenic contents
 191 was thus extremely high at KK in the dry season, probably this is due to the nature of
 192 industrial wastes deposited.

193 In Figure 2b, manganese concentration is generally higher than all the other metals recorded.
 194 During the wet season it was lowest at AD (2.605) and highest at RG (22.88), while in the
 195 dry season, lowest value was also recorded at AD (1.005) and highest at RG (30.206). This
 196 shows that the observed concentration of Mn might have been largely due to background
 197 concentration. Dara, (1993) reported that manganese may be found in most soil since it is one
 198 of the elements in the earth crust.

199 Cadmium contents shown in Figure 2c are relatively low compared to Mn and Zn, though
 200 higher than As. There was no significant difference in cadmium contents during dry and wet
 201 season in most of the dumpsites except KW, RG, TK and TW. In wet season, TW had the
 202 lowest value (0.223) and AD had the highest (0.291), while in dry season (0.218) was the
 203 lowest value recorded at KK and 0.459 at TW. In both KM and KK it was observed that Cd
 204 contents were higher in wet than in dry season, this could be linked to the location of the
 205 dumpsites and also the nature of wastes been dumped. From the results, Cd contents may
 206 pose little or no environmental hazard on man.

207 Mercury (Figure 2d) shows least concentration in TW (0.133) and highest in AS (0.624) in
 208 the wet season, while in the dry season lowest value was recorded for BD (0.029) and the
 209 highest (0.881) for AD. In RG, AD, KM and TW there was a sharp increase in the Hg
 210 contents during the dry season, this could be probably due to the nature of the solid wastes
 211 deposited during the dry season. The trend of metal contents in the dumpsite soils studied
 212 across the season follows the order. $Mn > Hg > Cd > As$

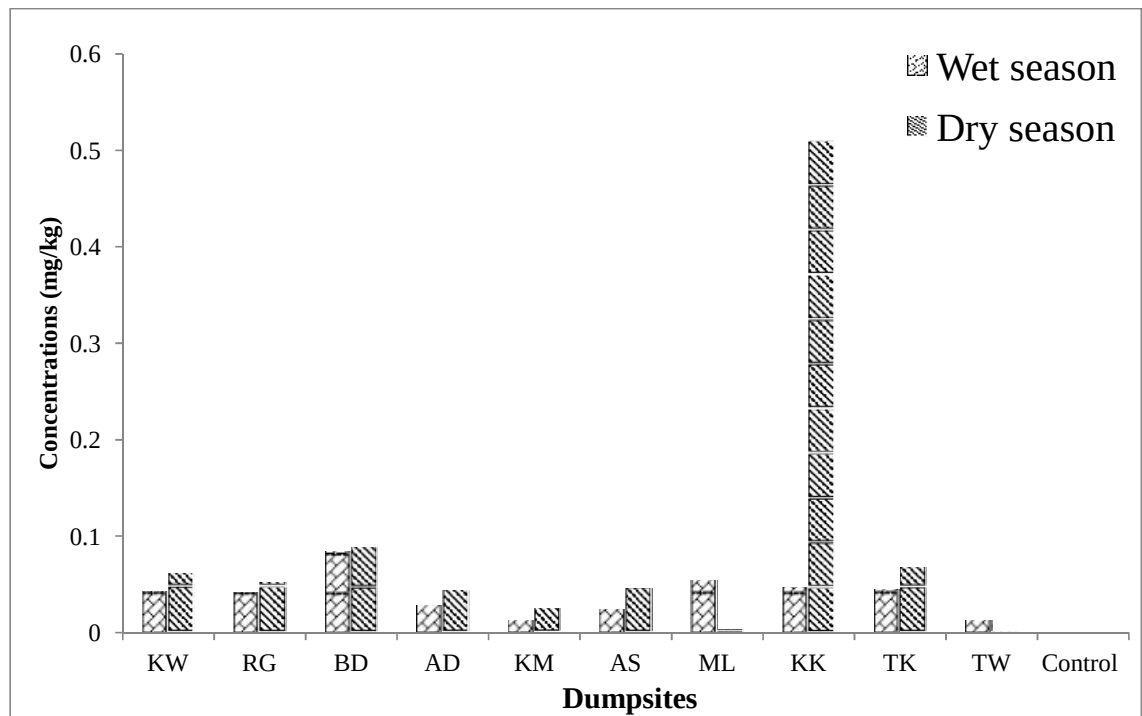


Figure 2a: Mean concentrations of As in the soil

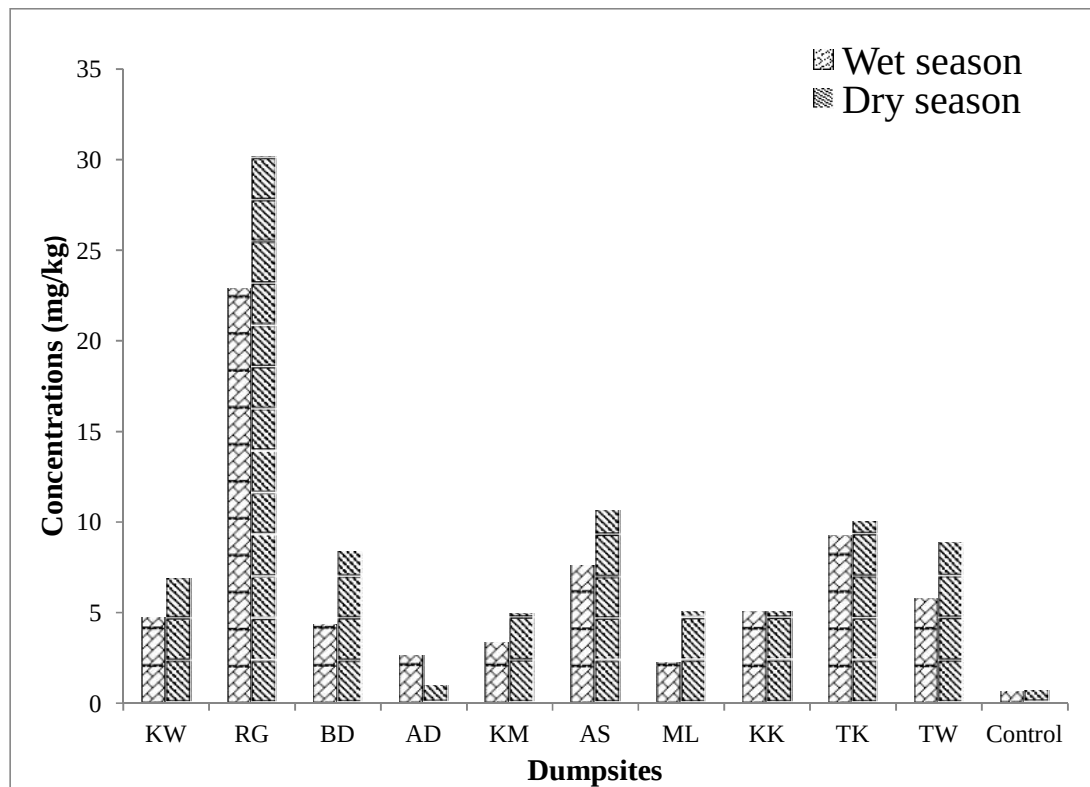


Figure 2b: Mean concentrations of Mn in the soil

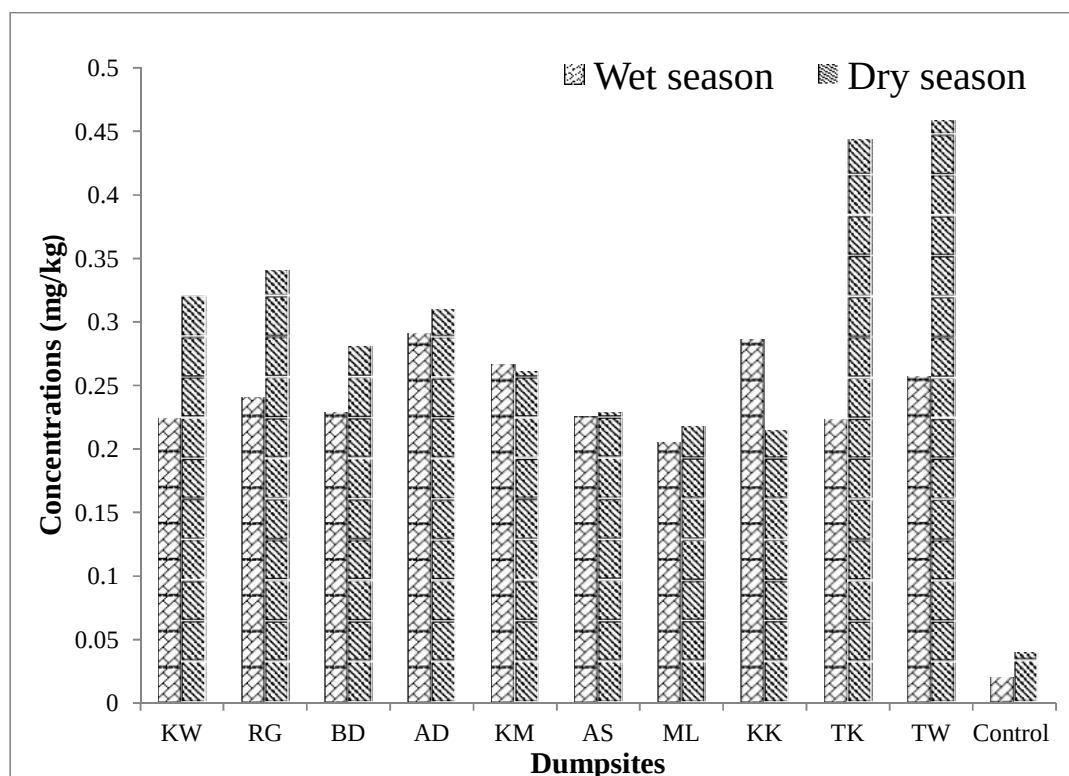


Figure 2c: Mean concentrations of Cd in the soil

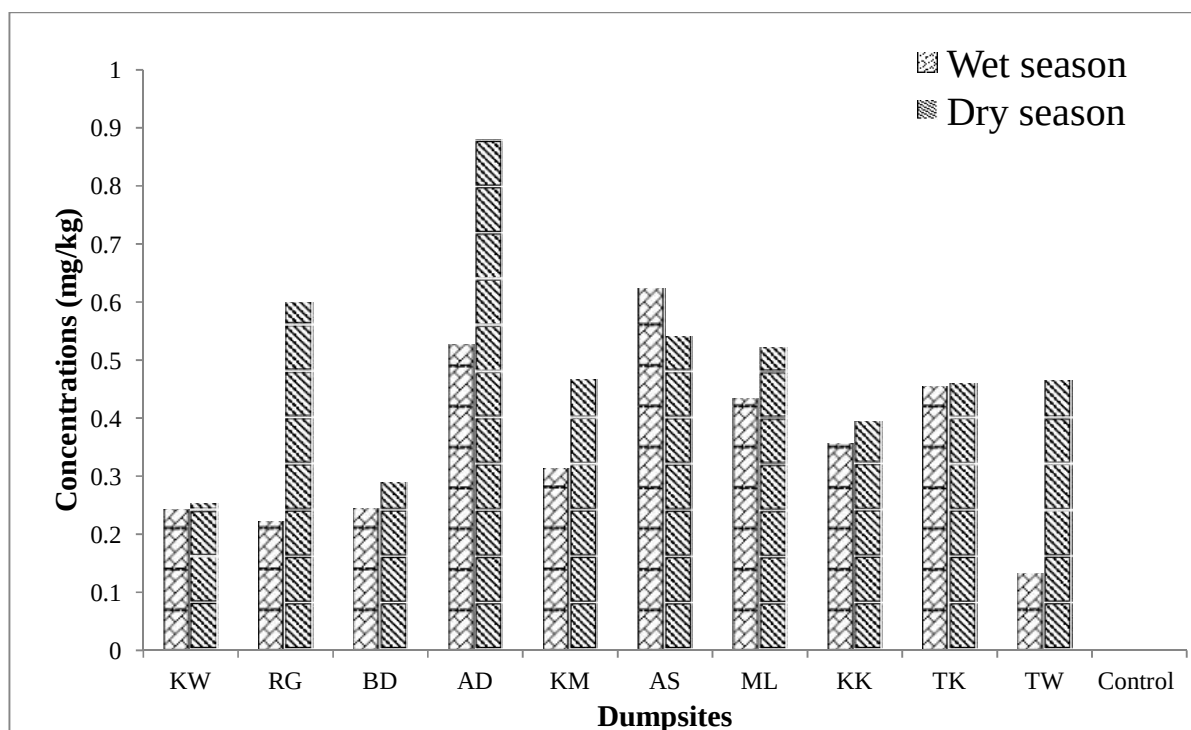


Figure 2d: Mean concentrations of Hg in the soil

3.3 HEAVY METAL CONCENTRATIONS IN *Amaranthus spinusis* (mgkg⁻¹)

Heavy metal concentrations in *Amaranthus spinusis* were found to be mostly lower than that of the soil, though in few cases *A. spinusis* recorded higher metal contents than in the soil as shown in Figures 3a-3d. Also, as expected the metal contents were mostly higher during dry season than wet season and control site metal contents were mostly below detection limit across the seasons.

Arsenic (Figure 3a) recorded lowest value at AD and KM in both wet and dry season being below detection limit, this could be due to the low arsenic content in the soil where the plants grow. Higher values were recorded for arsenic (0.037) in the wet and 0.056 for dry season both at AS. The values were found to be significantly different for wet and dry seasons, though they are within the tolerance limit and hence may pose little or no health hazard on man.

Manganese contents (Figure 3b) were the highest levels recorded among all the metals studied, the lowest value in the wet season was recorded for TW (0.167) and the highest was recorded for ML (0.690), while in the dry season, 0.288 was lowest for KM and 0.599 the highest recorded for AD. From the graph it indicates that the control site had very low values in both the wet and dry seasons, which is as expected. In addition, there was no significant difference in the values obtained for both the wet and dry seasons.

Concentrations of cadmium (Figure 3c) during the wet season was found to be lowest (0.019) in TW and highest (0.054) in BD while in dry season, lowest value was 0.051 (ML) and highest value was 0.483 (AS). These values recorded, were however seen not to be distinct across the seasons though in AS, there was a large difference, which could be due to the non-leaching of cadmium in soil and nature of solid wastes deposited in the dry season.

As seen from Figure 3d mercury contents in *A. spinusis* during the wet season ranged from 0.114 (KM) to 0.592 (RG), while in the dry season it ranged from 0.156 (KM) to 0.598 (RG). Unlike other dumpsites, ML recorded highest Hg concentration in the wet season compared to dry season; this could be attributed to dumping of higher Hg containing wastes. Mercury contents in the control were also below detection limit, indicating non-pollution of the control sites. Trend of *A. spinusis* metal contents in the dumpsites across the seasons is also given as: Mn > Hg > Cd > As.

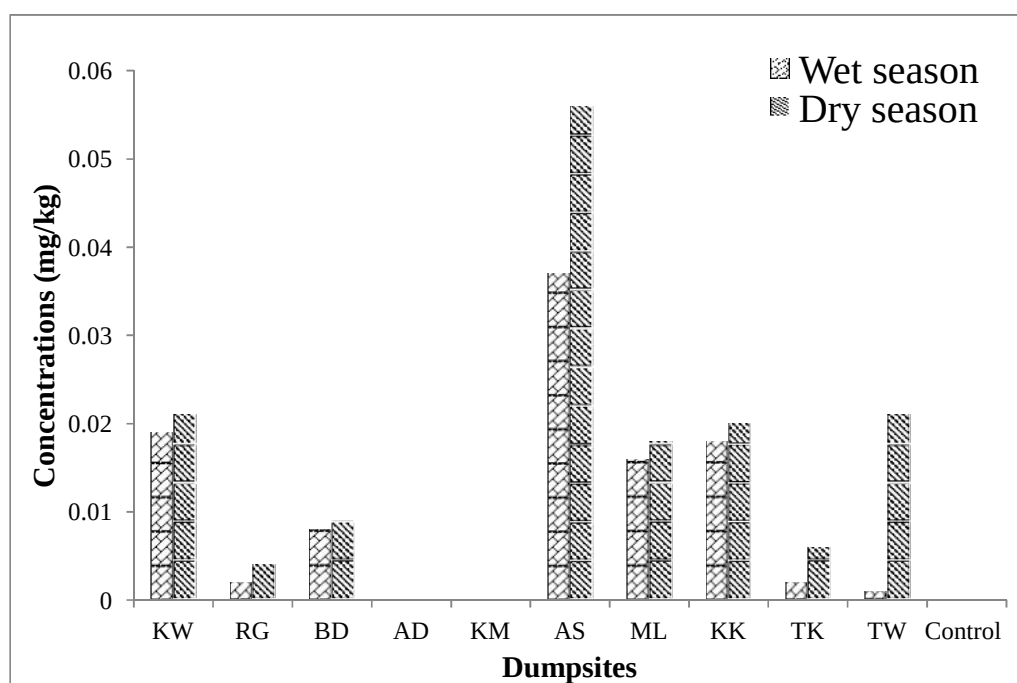


Figure 3a: Mean concentrations of As in *A. spinusis*

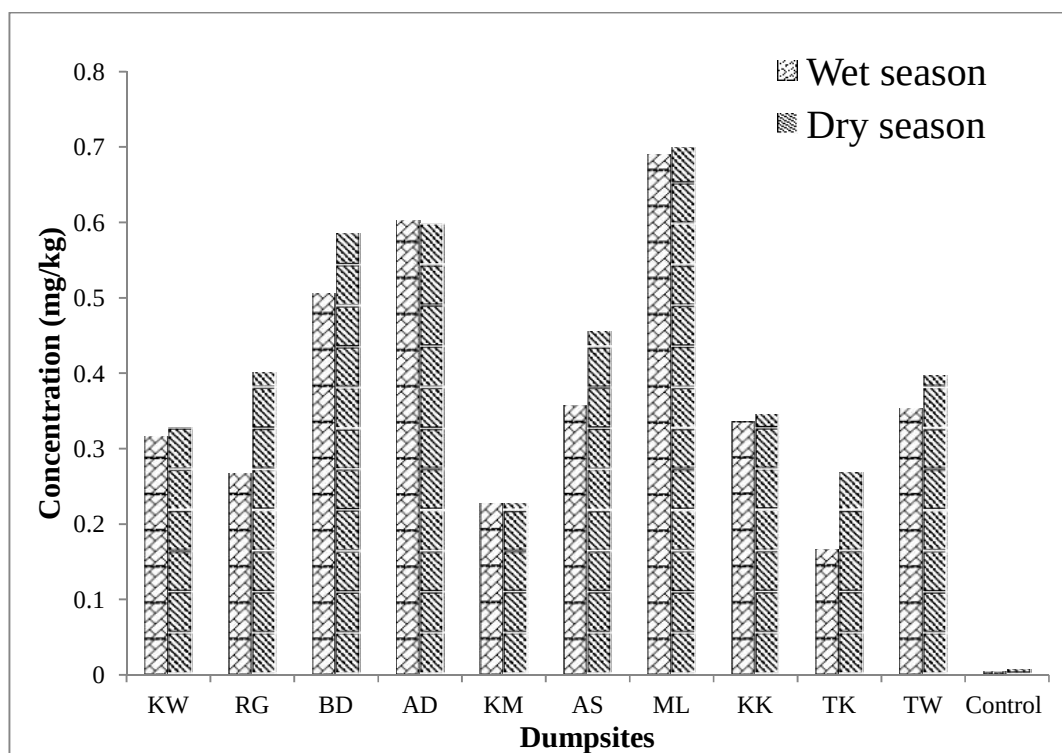


Figure 3b: Mean concentrations of Mn in *A. spinusis*

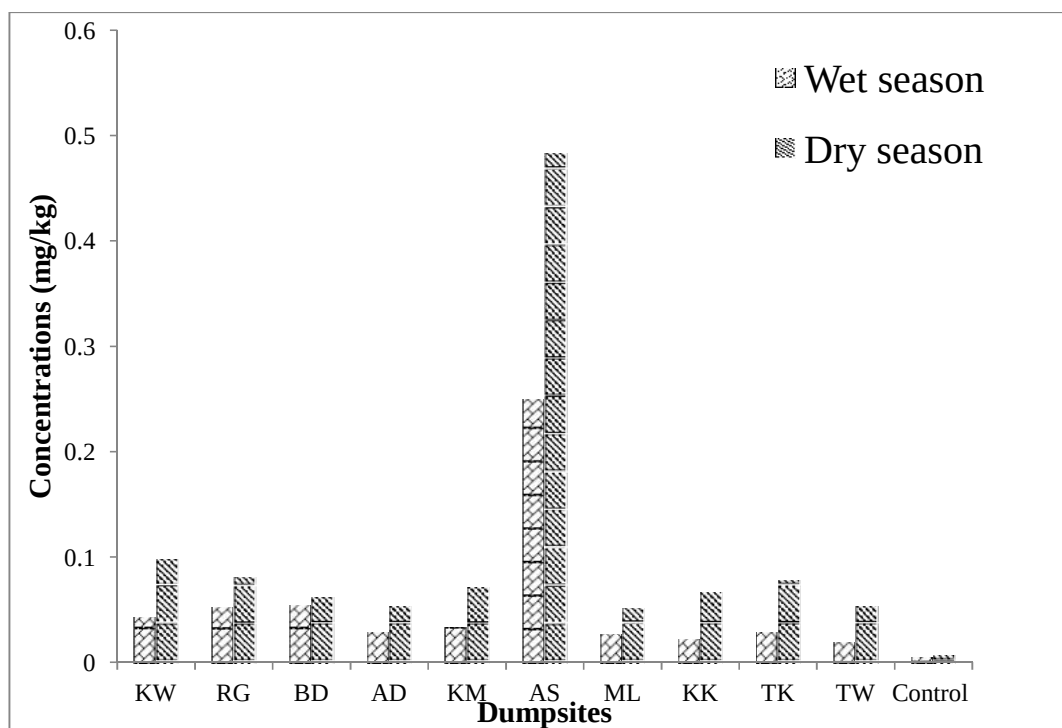


Figure 3c: Mean concentrations of Cd in *A. spinusis*

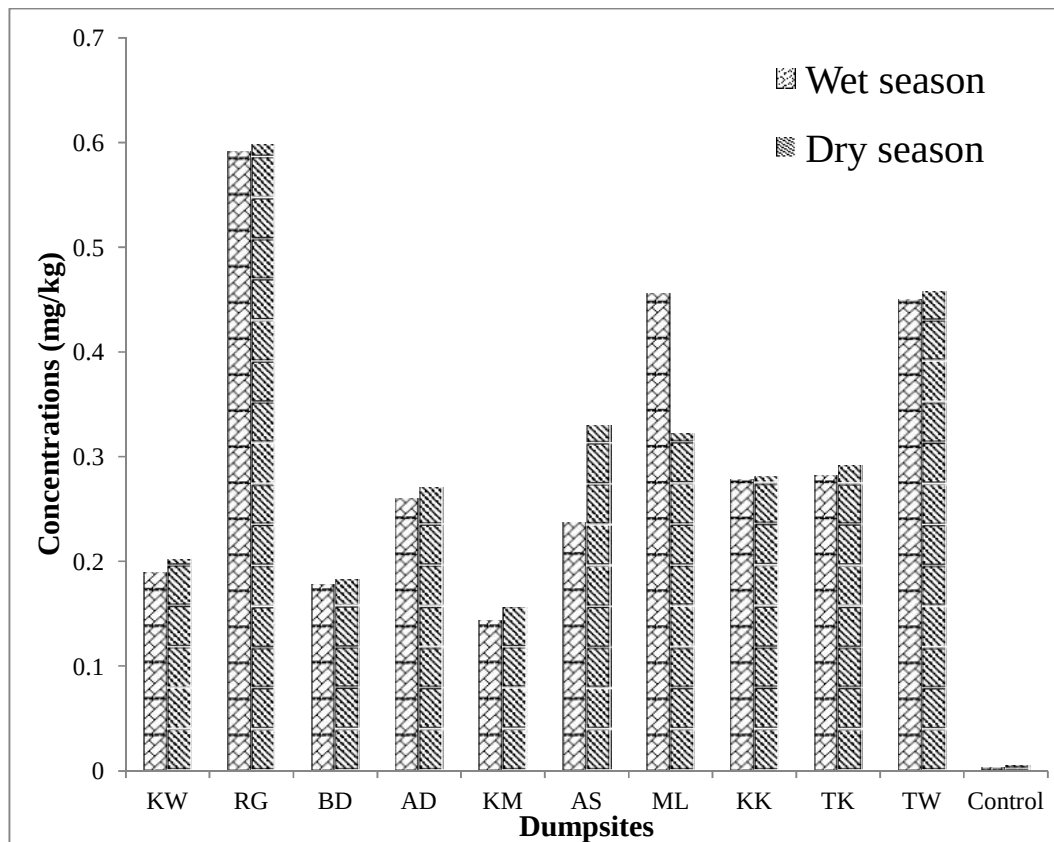


Figure 3d: Mean concentrations of Hg in *A. spinusis*

3.4 Transfer Factor of Heavy Metals

To be able to determine the contents of heavy metals contamination of the soil, an enrichment factor was computed. This was expressed as the ratio of the concentration of the metals in the plants to that of the soil (Oyedele *et al.*, 1995) as shown in Table 3 (wet season) and Table 4 (dry season). The transfer factor (TF) varied significantly among the dumpsites species of the heavy metals. Transfer factor obtained in the wet season were found to be highest for heavy metals in the following dumpsites; As, 1.54 (AS); Mn, 0.303 (ML); Cd, 1.06 (AS) and Hg, 3.38 (TW). While transfer factors during the dry season were also highest for; As, 21 (TW); Zn, Mn, 0.59 (AD); Cd, 2.1 (AS) and Hg, 0.99 (RG). These results indicated *A.spinusis* had the potential of accumulating more of Hg at TW and less of Mn at ML in the wet season while more of As is accumulated at TW and less of Mn at AD in the

274 **Table 3: Transfer Factor of Heavy Metals from Dumpsite Soil (Wet Season)**

Dumpsites	As	Mn	Cd	Hg
KW	0.441±0.0041	0.066±0.0022	0.191±0.0032	0.778±0.0057
RG	0.047±0.0071	0.011±0.0091	0.215±0.0043	2.667±0.0001
BD	0.095±0.0002	0.115±0.0041	0.235±0.0033	0.729±0.0082
AD	0	0.231±0.0061	0.099±0.0003	0.492±0.0061
KM	0	0.067±0.0021	0.123±0.0042	0.460±0.0043
AS	1.541±0.0022	0.046±0.0022	1.106±0.0055	0.379±0.0011
ML	0.296±0.0012	0.302±0.0005	0.131±0.0007	1.050±0.0084
KK	0.382±0.0034	0.066±0.0006	0.076±0.0001	0.778±0.0051
TK	0.044±0.0023	0.017±0.0004	0.125±0.0003	0.619±0.0065
TW	0.076±0.0013	0.060±0.0002	0.073±0.0005	3.383±0.0009
Control	0	0.002±0.0001	0.001±0.0031	0

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276 dry season. The transfer factor values recorded in TW for As and Hg at both wet and dry
 277 season respectively in this study is an indication of the potential of these heavy metals in the
 278 dumpsite to be transferred into the food chain through the consumption of edible plants on
 279 the site by either animals or man. Hence consumptions of these plants may cause some health
 280 implications as reported by Uba *et al.* (2008). According to Udosen *et al.* (2006) some
 281 environmental factors such as pH, exchange binding capacities and climate change might
 282 have contributed to some of the low transfer factor values in dumpsites.

283 **Table 4: Transfer Factor of Heavy Metals from Dumpsite Soil (Dry Season)**

Dumpsites	As	Mn	Cd	Hg
KW	0.344±0.0011	0.047±0.0041	0.305±0.0065	0.798±0.0091
RG	0.076±0.0021	0.013±0.0053	0.237±0.0075	0.996±0.0071
BD	0.102±0.0003	0.070±0.0006	0.220±0.0033	0.631±0.0041
AD	0	0.596±0.0066	0.170±0.0023	0.307±0.0053
KM	0	0.045±0.0076	0.272±0.0002	0.334±0.0006
AS	1.217±0.0004	0.042±0.0021	2.109±0.0008	0.609±0.0008
ML	6.000±0.0002	0.137±0.0022	0.233±0.0006	0.615±0.0005
KK	0.039±0.0008	0.068±0.0004	0.306±0.0008	0.711±0.0077
TK	0.088±0.0003	0.026±0.0003	0.175±0.0006	0.633±0.0036
TW	21.000±0.0033	0.044±0.0034	0.115±0.0031	0.984±0.0001
Control	0	0.004±0.0044	0.002±0.0011	0

284

285 **4. CONCLUSION**

286 The heavy metal concentration in the dumpsite soils of Kaduna metropolis varied to a great
 287 extent by sampling site and metal type. Among the metals analysed, Hg and Mn had the
 288 highest concentration while As was the least. Based on the findings, relatively low transfer
 289 factor were obtained, which account for the low metal contents found in the plant
 290 (*Amaranthus spinusis*) compared to metal content in soil. However, an exception was
 291 recorded in TW where transfer factor was high for Hg and As in wet and dry seasons
 292 respectively. Thus, indicating possible Hg and As contamination on consumption of such

plants by ruminants, which subsequently through food chain could pose health risk to man. Metal contents in *Amaranthus spinusis* and soil did not vary significantly in the dumpsites across the season ($P < 0.05$). The physico-chemical properties of the dumpsite soils indicate that these soils have the potential to be used as compost. However, the high levels of toxic metals in the soil is of environmental concern, and indicates that campaign on sorting of refuse for recycling purposes be after intensified.

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