Relationship between Metal levels in Dust Particulates and Tissues of Residents Living close to Dumpsite in Zaria Metropolis, Nigeria

Adamu Uzairu
Department of Chemistry, Ahmadu Bello University, Zaria, Nigeria
Email: adamuuzairu@yahoo.com

Sani Uba (Corresponding Author)
Department of Chemistry, Ahmadu Bello University, Zaria, Nigeria
Email: saniuba10@yahoo.com

Muhammad Sani Sallau
Department of Chemistry, Ahmadu Bello University, Zaria, Nigeria

Hamza Abba
Department of Chemistry, Ahmadu Bello University, Zaria, Nigeria
Email: habba@abu.edu.ng

Oluwole Joshua Okunola
National Research Institute for Chemical Technology, Zaria, Nigeria
Email: okunolaoj@gmail.com

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Abstract

The present study evaluate the relationship between the level of some metals in the particulate dust, and blood, urine, nails and hair of human exposed to metals contamination due to the dumpsites located within their residential areas. The concentrations of Zn, Pb Cu Cd and Hg are determined by Varian AA240FS Atomic Absorption Spectrometry. The results obtained revealed differences significant at $p < 0.05$ in levels of metals in dust samples across the seasons. Overall, the order of the bioavailability of these metals in the near the dumpsites followed the pattern: Cd > Zn > Pb > Hg > Cu; Hg> Zu. Cd> Cu> Pb and Zn> Hg> Cd > Pb > Cu for the dust nails and hair samples. The trend followed for the average concentrations of these metals across the sites followed the same pattern in both the urine and blood samples. Hg > Zn > Pb > Cd > Cu. The bioavailability of these metals some 300m away from the dumpsites revealed different distribution patterns Zn> Hg> Cd> Pb> Cu; Hg> Pb> Zn> Cu> Cd; Hg> Zn> Cd>Cu> Pb; Hg> Zn> Cd> Pb> Cu and Zn Cd> Cd> Pb=Hg for the dust Urine, blood, nails and hair samples respectively. The concentrations of the metals in the tissues of the residents in the dumpsites areas were higher than those recorded 300m away from the dumpsites (control sites). Moreover, one of the toxic metals, mercury was not even recorded in the tissues of the control site residents in the wet season, a clear indication of the level of pollution caused by the dumpsites.

Keywords: *Dumpsites, human tissues, dust, toxicity, heavy metals*

1.0 Introduction

Over the last three decades there has been increasing global concern over the public health impacts attributed to environmental pollution, in particular, the global burden of disease. The world Health Organization (WHO) estimates that about a quarter of the diseases facing mankind today occur due to prolonged exposure to environmental pollution. Most of these environmental related diseases are however not easily detected and may be acquired during childhood and manifested later in adulthood (UNEP, 2008)

Improper management of solid waste is one of the main causes of environmental pollution and degradation in many cites, especially in developing countries. Many of these cities lack solid waste regulations and proper disposal facilities, such waste may be infections, toxic or radioactive.

Heavy metals form artificial pollution sources are continually released into aquatic and terrestrial ecosystems and therefore the concern about the effect of anthropogenic pollution on ecosystem is growing. Contamination of meat samples with heavy metals is serious threat because of their toxicity, bioaccumulation in the food chain (Demirezen *et al*., 2006). Heavy metals are elements that are present in both natural and contaminated environments; they cause serious problems to Public health.

The elements that are of concern include lead mercury cadmium Arsenic chromium, Zinc nickel and copper. These metals may be released into the environment from metal smelting refining industries, scrap metal, plastic and rubber industries, various consumer products and from burning of waste containing these products. On release to the air, the elements travels for large distance and are deposited onto the soil, vegetation and water depending on their density. Once the metals are deposited they are not degraded and they persist into the environment for many years poisoning humans through inhalation, ingestion and skin absorption. Acute exposure to toxic metals leads to nausea, anorexia, vomiting, gastrointestinal abnormalities and dermatitis (UNEP, 2008).

Zaria metropolis is located at latitude $11^{0}3^{'}$ N and longitude $7^{o}40^{'}$E and is presently one of the most important cities in Northern Nigeria. As at 2007 census, it had a population of 1,018,827people. Like many cites in Nigeria, it faces problems of environmental sanitation such as improper disposal of refuse near residential areas, poor refuse collection and handling, etc for example, it is a common feature to find huge refuse dumpsites within residential areas and along some minor and major roads.

As many studies have shown, municipal refuse may increase heavy metal concentrations in soils and underground water (Carlson, 1976; Albores *et al*., 2006) which has effects on the host soils, crops and human health (Smith *et al*., 1996; Nyle and Ray, 1999). Thus, the environmental impacts of municipal refuse are greatly influences by their heavy metal contents.

Dumping of refuse in Zaria metropolis is unrestricted, thus, industrial, agricultural, domestic and medical wastes are strawn all over the dumping sites (UNEP, 2008).

The aim of this study therefore is to investigate the levels of Pb, Cu Cd, Zn and Hg in dust emanating from the dumpsites, waste soil, blood, urine, hair and nails of the dumpsites-residents so as to study the impact of the dumpsites on the public health.

2.0 Materials and Methods

2.1 Dumpsites Description

Soils from the ten dumpsites were collected from major settlements in Zaria metabolism. These are Samaru, Sabon Gari Tudun Wada and Zaria City. The dumpsites studied are Babban Gwani (BG), railway (RA), Alkali Jae (AJ), NT, Shafi (SH), Samaru (SA) Dandaji (DD) Kusfa (KU), Jekada Wuanikaa (JK), Prince road (PR) and a control site (CTR). Figure 1 below show the features of a dumpsite.

2.2 Sample Collection

2.2.1 Refuse Waste Soil

Samples were collected across the wet and dry seasons as follows: triplicate sample from each dumpsite were collected and composite samples were made in the laboratory. The samples were air dried and sieved (2mm sieve) then placed in polythene battles and stored in desiccators at nom temperature therefore the digestion.

2.2.2 Dust sample

Sixty six samples were collected across dry and wet (rainy) seasons between February to December 2011 from the four major settlements in Zaria Metropolis. Dust samples were collected using a plastic brush and tray (Loredo *et al.*, 2003; Yeung *et al.*, 2003) and were stored in plastic bags (Ayodele and Gaya, 1998).



Figure1: One of the sampling points at Kusfa in Zaria Metropolis

2.2.3 Tissues Samples

Blood samples (10ml) were collected from the residents of the dumpsites from February to December (2011). The blood sampels were dispensed into plain collection tubes containing EDTA to prevent coagulation and labeled appropriately. Samples were kept frozen prior to digestion (Musa *et al.*, 2011). Urine Samples were collected directly into 100ml disposable battles. The samples were then taken to the laboratory for analysis (Esimai *et al.*, 2009). Hair and nails samples were collected from various volunteered subjects residing close to the dumpsites in the age between 25 - 45years over a period of three month. Nail samples were collected in Polyethylene containers and washed in 1% solution of TritonX-100 in de-ionized water in an ultrasonic bath and on drying, the samples were then air dried and then stored in small plastic tubes (Iyengar, 1984), Hair, Samples were collected as close to the scalp as possible. (Kucera *et al.*, 1996; Ayodele *et al.*, 2009).

2.3 Samples Digestion

The collected dust samples were homogenized dried in a circulating air and then passed through a 2mm sieve. The sieved soils and dust samples were then placed in polyethene bags. 1.0g each of the dust sample was digested with 20ml of 6M acid and was filtered through acid washed Whatman 540 filter paper into a 50ml volumetric flask and was then diluted to the mark with de-ionized water (Fergusson, 1987, Ayodele and Gaya, 1998). 5.0g of the soil sample was weighed into 100ml beaker. 10ml concentrated nitric acid was added, the mixture in the beaker was covered with a watch glass and reflux for 45 minutes. The watch glass was removed and the content evaporated to dryness 5ml aqua-regia was added and the mixture was evaporated again to dryness after which 10ml 1M nitric acid was added and the suspension filtered in a 50ml volumetric flask. Triplicate digestion of each sample was carried out together with the blank. The digested samples were analyzed by the (Varian AA240FS) involving direct aspiration of the aqueous solution into an air acetylene flame (Uba *et al*., 2009). 10ml of 1% HNO_3 was added to the collected urine samples the sample was then placed in the polythene bottles, labelled and digested by the AAS technique (Esimai *et al*., 2009).

1mL of the whole blood was measured into clean test tubes and 1mL HNO_3 containing. 0.1% tritonX- 100 was added and mixed thoroughly. The test tubes were plugged with cotton wool and left on the bench over. The mixture was treated on a water bath at 100°C for 20minutes, thereafter allowed to cool, the digested blood samples was transferred the polythene bottles and the volumes made up to make with distilled water (et al 2010). The samples were then analyzed by the AAS Technique.

1.0g each of hair and nails samples was digested with 10ml concentrated $HN0_3$ and the resulting solution was evaporated to dryness and re-dissolved in 0.1M nitric acid. Trace metals concentrations were determined in the digests by flame atomic absorption spectrophotometer (Varian AA240FS) in the multi user science laboratory, Ahmadu Bello University, Zaria.

3.0 Result and Discussion

The concentrations of the metals in the dust samples across the seasons (both dry and wet) are presented in Table 1 while Figs. 1 - 5 showed the concentrations of the metals in the analysed human urine, blood, nails and hair samples respectively. The metals concentrations ranged from: Zn: 1.402(JK) - 96.904(B)mg/kg; 0.414(CTR) – 1.102mg/L(R); 0.590(R) – 4.047mg/L(D); 0.521 (JK) – 8.568mg/kg(D) and 0.774 (CTR)–14.667mg/kg(NTC): Pb:1.422(CTR)–78.754mg/kg(R); 0.066(P) – 0.183mg/L(JK); 0.009(CTR) - 0.198mg/L(S), 0.097(NTC) – 0.192mg/L (R) and BDL(CTR) – 0.298mg/L(NTC) ; Cu: 0.241(K) - 311.457mg/kg(NTC); 0.002(A)-0.056mg/L(P); 0.02(R) – 0.096mg/L (K), 0. 014(JK) - 0.0905mg/L (D); 0.0312(A) – 0.32 mg/L (P); Cd: 0.667 (NTC) – 3.744mg/kg (R), BDL(R) – 1.144mg/kg(K) and 0.149 (CTR) – 1.119mg/kg (NTC); Hg: 10.30(JK) – 27.486mg/kg(K), 2.403 (JK) – 3.187mg/L (NTC), 1.830 (K) – 3.162mg/L(A); 2.11(S) – 3.871mg/kg(R) and BDL (CTR) – 2.717mg/kg (NTC) respectively in the dry season. The concentrations of the analyzed zinc in the dumpsites dust were all below the mean concentrations of dumpsite soils and were significantly different at $p<0.05$. Furthermore, when these metals were correlated, they showed a positive correlation, this suggests their common source of pollution. High concentration of zinc was detected at sites B, CTR, and P.

The concentrations of zinc in the urine, blood, nails, hair and dust samples were highest at the NTC dumpsite although the concentration of zinc in the dust was >20mg/kg but <30mgkg^{-1}. This showed that the metal in this site is predominantly in the bioavailable phase. The order of the availability of this metal in the dust samples was:

BG> CTR > PR> RA > DD > SA > KU> JK > AJ > NTC. The lowest and highest concentrations of this metal were at sites NTC and B respectively. Furthermore, the pattern of the bioavailability of zinc in the analyzed human urine, blood, nails and hair samples were;

Urine: SA > JK > RA > AJ > NTC > DD >KU > PR> BG > CTR

Blood: DD > JK > KU > BG > NTC > CTR > SA > PR > AJ > RA

Nails: DD > NTC > CTR > PR > KU > SA > BG > AJ > RA > JK

Hair: NTC > KU > SA > RA > DD > JK > RA > PR > AJ > CTR

Overall, dust samples had the highest concentrations of all the analyzed metals, the bioavailability of the metals in the samples followed the trend: Nails > Hair > Blood > Urine. The concentrations of zinc in the nails and hair samples were significant at $p < 0.05$. Similarly, the metal was positively correlated in the blood, urine and hair samples across the sites. However, zinc was negatively correlated in the dust – nails samples. Comparing the concentrations of zinc in both the wet and dry seasons, there was a significant difference at $p < 0.05$ across the sites. This suggests that they have a common source of pollution. Furthermore, as presented in Figure II, the trend in the concentrations of lead across the sites in the dry season followed the pattern; Hair > Nails > Urine > Blood. One way ANOVA showed a significant difference in the concentrations of lead across the sites in the samples (Urine, blood, nail and hair). The concentrations of lead in different human samples (Urine, blood, nail and hair) were positively correlated. These results are in agreement with several other authors who reported varying concentrations of these metals in the hair and nails. The concentrations of zinc reported in hair, nails, blood and urine samples in this study revealed that zinc in human tissues may be playing some physiological roles (Vivoli *et al.*, 1990). This suggests that zinc in hair, hair originate from a number of sources such as the air, water and food we consume (Strain *et al.*, 1972; Mangh, 1978; Casey and Hambridge, 1980 and Ayodele and Bayero 2009).

The concentrations of copper in the analysed human tissues were significantly different at $P<0.05$ and were negatively correlated (at $P < 0.01$ and 0.05) across the seasons (wet and dry). However, positive correlation was observed between the analyzed dust and tissue samples suggesting a common source of the metal with the exception of the hair samples which was negatively correlated. One way ANOVA showed a significant difference among the different samples at $P < 0.05$. Moreover, correlation analysis showed negative correlations between zinc and lead among the fractions. In addition, there was a significant difference in the concentrations of Cd among the analyzed human samples across the sites at $P < 0.05$. This suggests that the metals have a common source. The correlation analysis among the analyzed samples for cadmium concentrations were positive with the exception of dust-nail and hair-blood which were negatively correlated.

Moreover, there was a significant difference in the concentrations of Hg across the sites and among the fraction. Thus, the source of mercury contamination across the sites and among the fraction is common. Positive correlation across the sites was observed for Hg in the blood-hair, Blood- dust and urine-hair. However, there were negative correlations in the urine and nails concentrations across the sites and seasons.

4.0 Conclusion

Hair, nails, blood and urine analysis provides medical doctors and nutritionist an additional diagnosis tool in their respective professional fields. The cosmetologists use this system to diagnose hair and skin related problems. Overall, the order of the bioavailability of these metals in the near the dumpsites followed the pattern: Cd > Zn > Pb > Hg > Cu; Hg> Zn Cd> Cu> Pb and Zn> Hg> Cd > Pb > Cu for the dust nails and hair samples. The trend followed for the average concentrations of these metals across the sites followed the same pattern in both the urine and blood samples. Hg > Zn > Pb > Cd > Cu. The bioavailability of these metals some 300m away from the dumpsites revealed different distribution patterns Zn> Hg> Cd> Pb> Cu; Hg> Pb> Zn> Cu> Cd; Hg> Zn> Cd>Cu> Pb; Hg> Zn> Cd> Pb> Cu and Zn Cd> Cd> Pb=Hg for the dust, urine, blood, nails and hair samples respectively. The concentrations of the metals in the tissues of the residents at the dumpsite areas were higher than those recorded 300m away from the dumpsites (control sites). Moreover, one of the toxic metals, mercury was not even recorded in the tissues of the control site residents in the wet season, a clear indication of the level of pollution caused by the dumpsites.

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Table 1 Concentrations of Metals ($mgkg^{-1}$) in Dust Particulates

METAL	SITE									
	AJ	BG	CTR	DD	JK	KU	SA	SH	RA	PR NT
					Dry Season					
Zn	47.00±2.25	96.90±4.60	6.95±0.33	72.69±3.45	1.40±0.07	51.21±2.43	59.34±2.82	88.66±4.21	78.75±3.74	96.25±4.57 22.26±1.06
Pb	59.90±2.85	35.04±1.67	1.42±0.07	65.35±3.10	45.76±2.17	41.84±1.99	58.73±2.79	14.01±0.67	78.26±3.72	74.27±3.53 6.02±0.29
Cd	0.96±0.05	1.15±0.06	0.61±0.03	1.54±0.07	1.38±0.07	2.49±0.12	1.51±0.07	0.96±0.05	3.74±0.18	1.35±0.06 0.66±0.03
Cu	28.63±1.36	77.12±3.66	5.79±0.28	29.51±1.40	42.38±2.013	0.24±0.01	27.39±1.30	52.01±2.47	149.50±7.1	36.58±1.74 311.50±14.79
Hg	25.69±1.22	19.20±0.91	26.05±1.24	18.95±0.90	10.30±0.49	27.49±1.31	16.91±0.80	22.00±1.05	25.31±1.20	18.21±0.87 19.70±0.94
					Rainy Season					
Zn	46.56±2.21	97.33±4.62	BDL	65.06±3.09	50.99±2.42	35.94±1.70	210.60±10.01	41.06±1.95	18.46±0.88	60.61±2.88 16.75±0.79
Pb	3.41±0.16	2.28±0.11	2.26±0.11	4.04±0.19	4.54±0.22	3.01±0.14	9.549±0.45	2.99±0.142	7.86±0.37	4.14±0.19 3.11±0.15
Cd	0.36±0.02	0.24±0.01	BDL	0.28±0.01	0.21±0.01	0.35±0.02	0.36±0.02	0.31±0.02	0.77±0.04	0.32±0.02 0.39±0.02
Cu	12.05±0.57	2.84±0.14	1.31±0.06	3.84±0.18	390.50±18.55	2.73±0.13	11.36±0.54	3.81±0.18	16.09±0.77	3.35±0.16 298.70±14.19
Hg	4.76±0.23	14.90±0.71	BDL	14.63±0.69	18.40±0.87	23.30±1.11	4.03±0.19	20.95±0.99	1.36±0.06	15.98±0.76 24.71±1.17

Concentrations were reported as mean±standard Deviation of Triplicate sample Digestion

BDL: BELOW DETECTION LIMIT

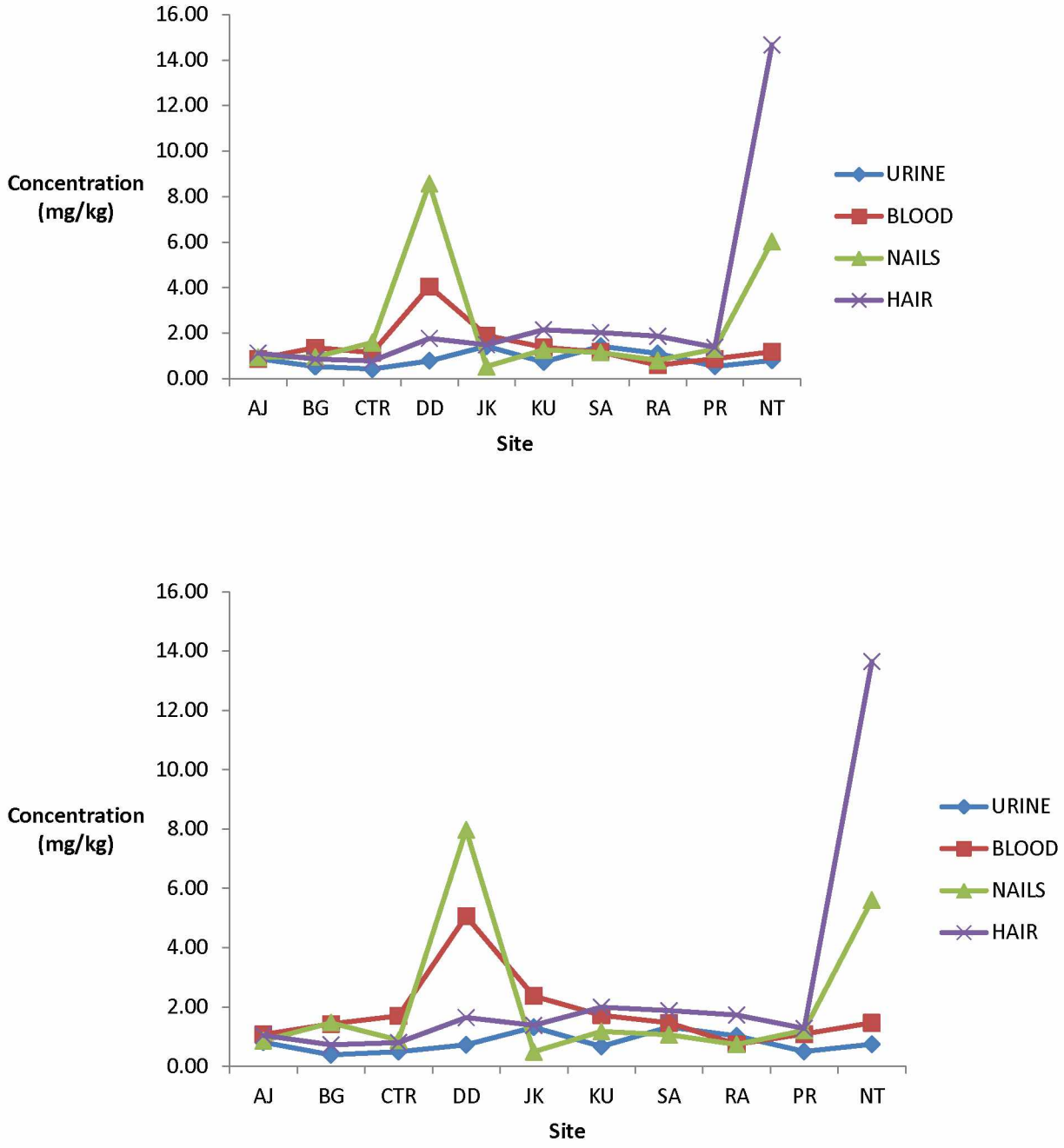


Figure 1: Concentrations of Zinc in the tissues of residents near dumpsites in both the dry and wet seasons

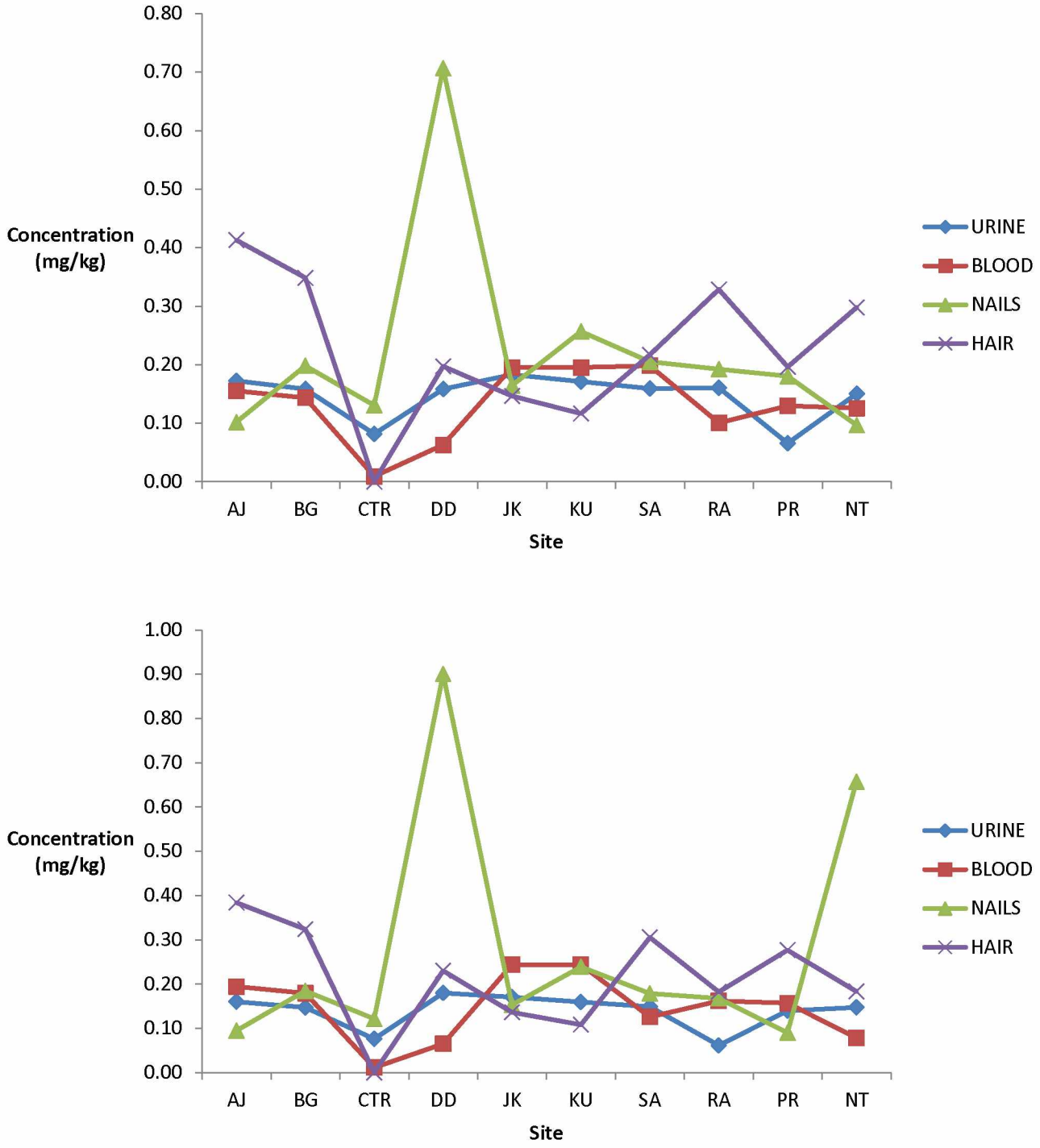


Figure 2: concentrations (mg/L) of lead in the tissues of residents near dumpsites in both the dry and wet seasons

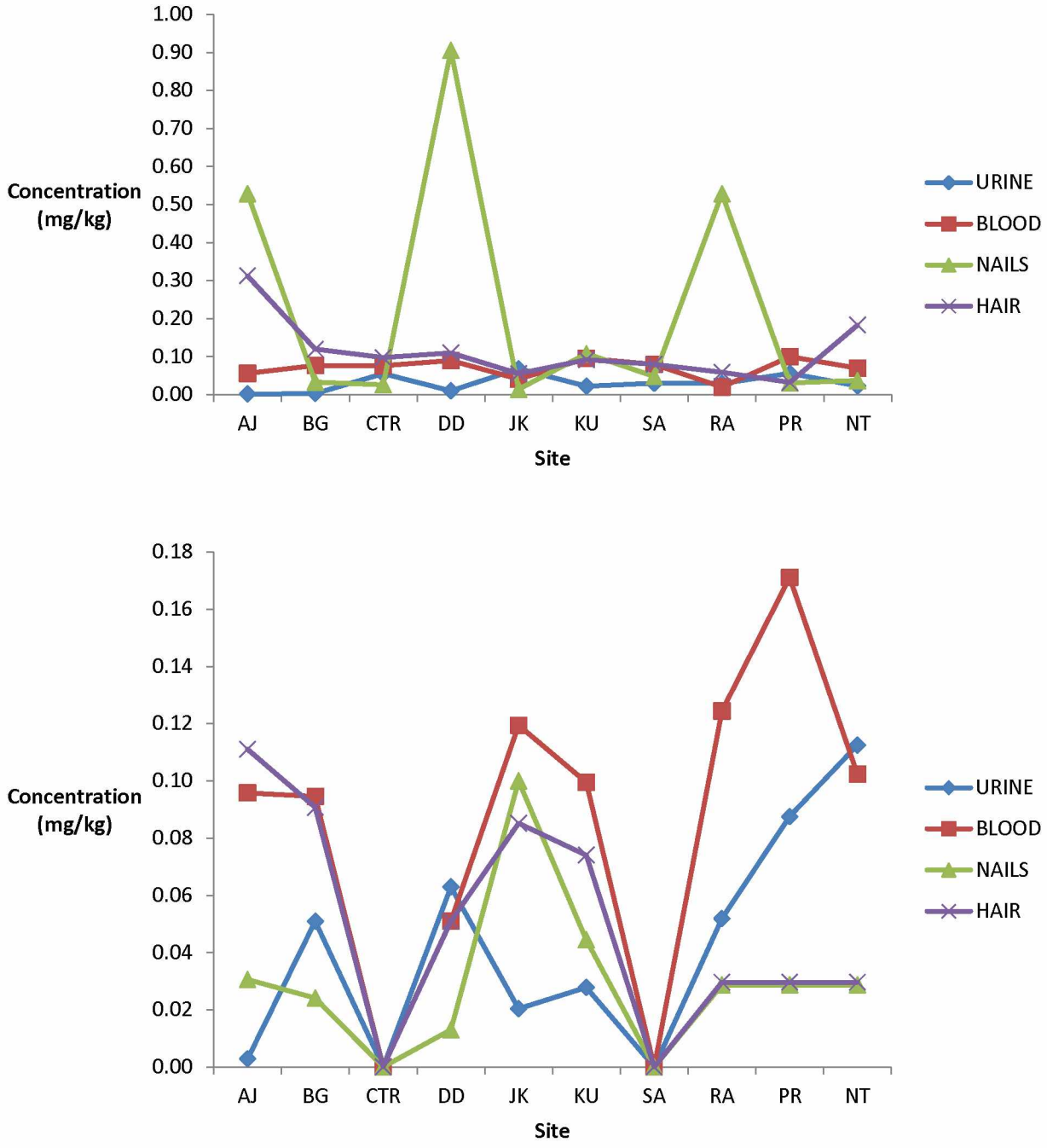


Figure 3: concentrations (mg/L) of copper in the tissues of residents near dumpsites in both the dry and wet seasons

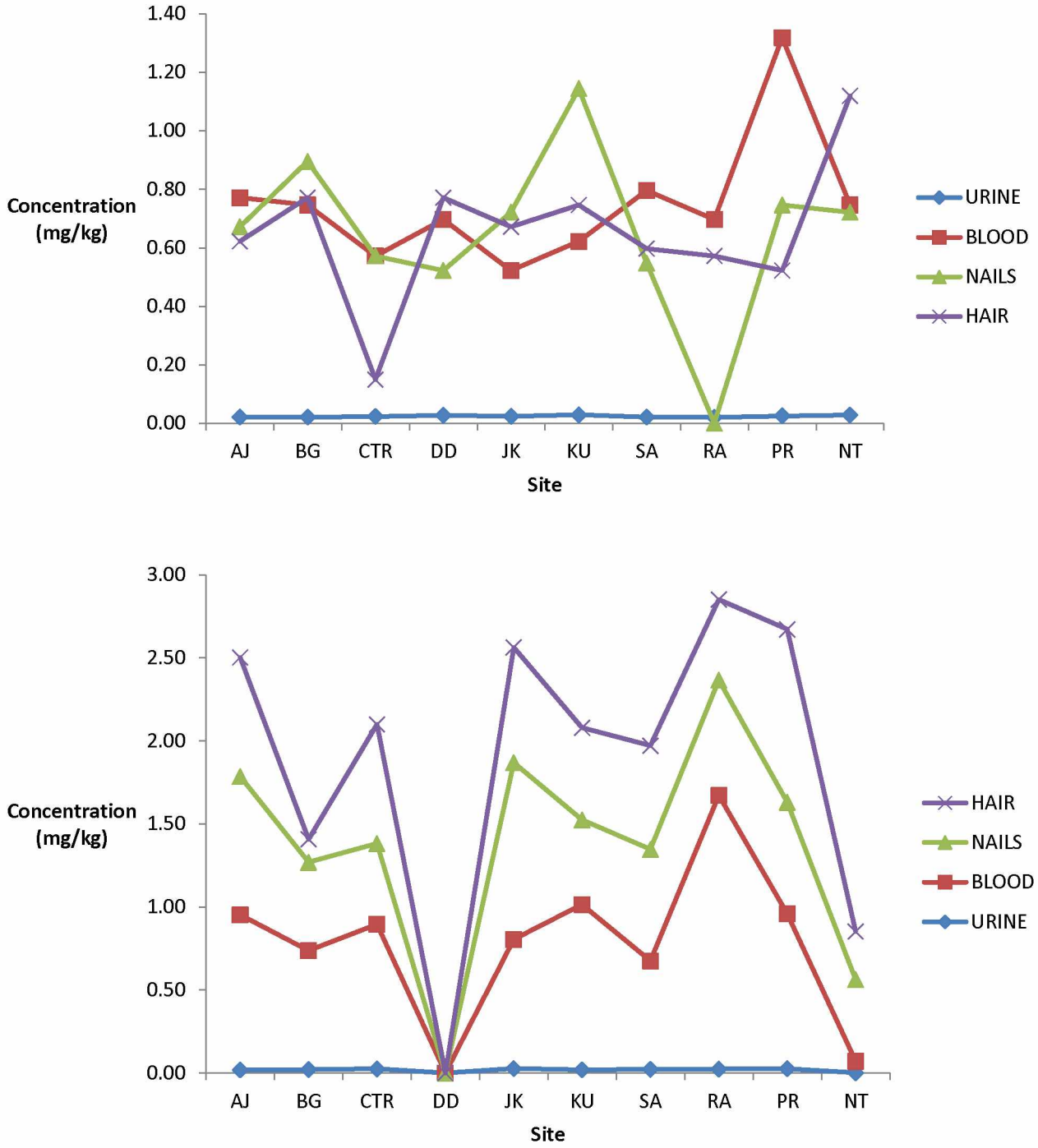


Figure 4: Concentrations (mg/L) of cadmium in the tissues of residents near dumpsites in both the dry and wet seasons

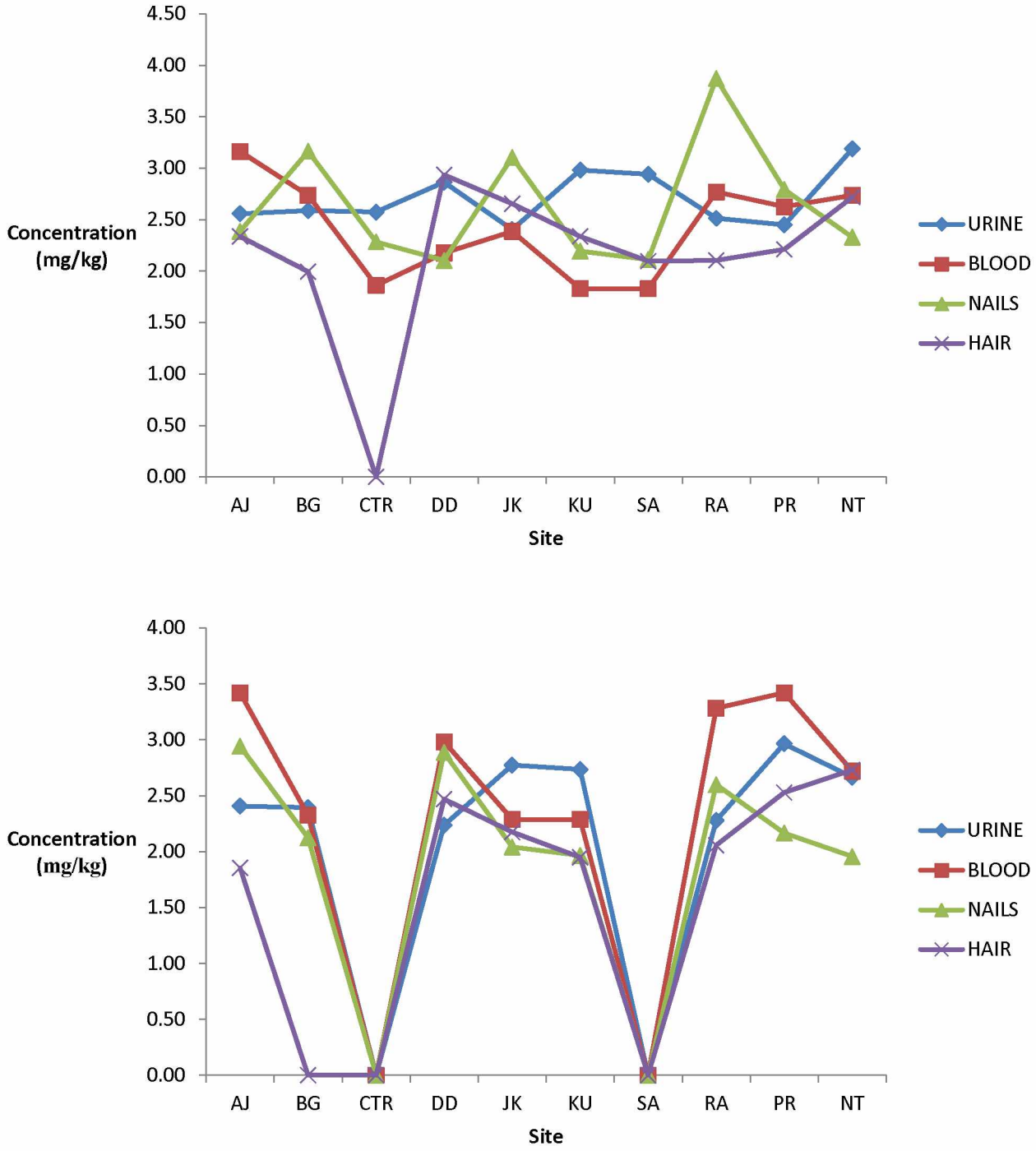


Figure 5: Concentrations (mg/L) of mercury in the tissues of residents near dumpsites in both the dry and wet seasons