Assessment of pawpaw, tomato and cocoyam grown in dump sites in Ogbomoso metropolis, Nigeria for heavy metals.

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ABSTRACT:

Urban backyard crop production is confronted with heavy metal soil pollution, the soil being mostly abandoned refuse dumpsites. This research is designed to investigate the impact of heavy metal soil pollution on pawpaw, tomato and cocoyam grown in dump sites in Ogbomoso metropolitan. Three heavy metal dump sites and one non-dump site were selected as sampling locations. Leaves, stems, roots, and fruits of the test crops were collected randomly from all the sites. The samples were enveloped, labelled and taken to the laboratory for analysis. Soil samples were also taken at the three locations per site with core sampler at 15cm depth and were put in labelled polythene bags and taken to the laboratory for analysis. Wet digestion was used and the concentration of heavy metals (Pb, Cd, Mn, Cu, and Cr) were determined using atomic absorption spectrophotometric analysis. Soil pH, , and organic matter percentages were also determined. The results showed that all the crops were able to accumulate heavy metals to appreciable proportion in their organs. The transfer ratios recorded for pawpaw, tomato and cocoyam leaves were respectively Pb (0.76)>Cd (0.7)> Mn (0.65)> Cu (0.41) >Cr (0.10); Mn (1.19)>Pb (0.51) > Cd (0.48)> Cu (o.44)>Cr (0.05), and Mn (2.99)> Pb (0.85)> Cd (0.80)> u (0.13)>Cr (0.10). The extracted heavy metals got from the stem of the test crop were in the order of transfer ratio: Mn (2.49)> Pb (0.73)> Cd (0.70)> Cr (0.11)> Cu (0.08); Mn (1.24)> Pb (0.5)> Cd (0.49)> Cu (0.06)> Cr (0.05) and Mn (2.91)> Pb (0.98)> Cd (0.88)> Cu (0.14)> Cr (0.11) for pawpaw, tomato and cocoyam respectively. The roots of the respective crops also contained the heavy metals despite the quantity transferred to the other organs. The trends observed were Mn (2.46)> Pb (0.69)> Cd (0.66)> Cr (0.12)> Cu (0.10); Mn (1.29)>Pb (0.48)> Cd (0.46)> Cu (0.05)> Cu (0.01) and Mn (3.0)> Pb (1.05)> Cd (0.93)>Cr (0.15)> Cu (0.13) for the test crop respectively. The directly consumed parts of the crops were able to retain these heavy metals in their tissues. The following respective trends were observed for pawpaw, tomato fruits and cocoyam corm: Mn (1.60)> Pb (0.67) > Cd (0.69)> Cu (0.11) = Cr (0.11); Mn (1.23)> Pb (0.54)> Cd (0.49)> Cr (0.16)> Cu (0.05) and Mn (3.10) Pb (1.05)> Cd (0.93)> Cr (0.17)> Cu (0.14). All these metal concentrations were high compared with international standards, and it was found out that they were on the high side.

Keywords: cocoyam, dump site, heavy metals, pawpaw, tomato, transfer ratio

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INTRODUCTION

Most abandoned and living waste dumpsites in many towns and villages in Nigeria attract people as fertile ground for cultivating varieties of crops. Plants growing on municipal dumpsites soil accumulated higher concentrations of metals than those on rural dumpsites (*Amusan, et al., 2005*). The plants take up heavy metals either as mobile ions presents in the soils solution through the root (*Davies, 1983*) or through foliar absorption. The uptake of the metals by crops results in the accumulation of these metals in plant tissues. This is known to be influenced by the metal species, plant species, and plant age and plant parts (*Juste and Mench, 1992 and Amusan et. al., 2005*).

Reports showed that Iron (Fe) and Zinc (Zn) have higher concentration in the leaves of *Carica papaya* and *Talinum triangulare*, and other metals recorded higher concentration in the roots (*Mkpenie, et. al., 2006*). These cultivated plants take up these metal ions either as mobile ions in the soil solution through their roots (*Weiting, 1988)* or through their leaves thereby making them unfit for human consumption (*Strobrawa and Lorence, 2008*). In small concentrations, the traces of heavy metals in plants and animals are not toxic (*De Vries, et., al., 2007*) but lead (Pb), Cadmium (Cd) and Mercury (Hg) are exceptions as they are toxic even in very low concentration (*Galas-Gorchev, 1991*).

Exposure to heavy metals is normally chronic due to food chain transfer. Acute poisoning from heavy metals is rare through ingestion or dermal contact, but is possible. 'Itai-itai' disease, an epidemic of bone fractures in Japan from gross cadmium contamination of rice stocks, has recently been shown to happen in more subtle fashion among a general community living in an area of relatively modest cadmium contamination (Staessen, *et al.,* 1999). Long term exposure of cadmium in human and animals is associated with renal malfunction, increase blood pressure, bone defects (Osteomalacia), lung diseases particularly cancer (ATSDR, 1997). Lead poisoning is associated with mental lapse in children, high blood pressure, arm and leg pains, nausea and vomiting. Low-level exposure to chromium can irritate the skin and cause ulceration while long term exposure causes kidney and liver damage and causes damages to circulatory and nerve tissue (Culboard, et. al., 1983). Chromium is also a carcinogen, particularly of the lungs through inhalation. Manganese has recently become a metal of global concern because of the introduction of methylcyclopentadienyl manganese tricarbonyl (MMT) as a gasoline additive. Proponents of the use of MMT have claimed that the known link between occupational manganese exposure and the development of a Parkinson's disease-like syndrome of tremor, postural instability, gait disorder, and cognitive disorder has no implications for the relatively low levels of manganese exposure that would ensue from its use in gasoline. However, this argument is starkly reminiscent of the rationale given for adding lead to gasoline, and what little research that exists from which one can infer the toxicity potential of manganese at low –levels of exposure is not particularly comforting (Lyzincki et, al., 1999).

Based on these facts about metal toxicity, there is the need to critically assess the heavy metal absorption of pawpaw, tomato and cocoyam plants growing commonly at dumpsites in towns, for people utilize these plants for direct and indirect consumption as food and local herbs.

MATERIALS AND METHODS

Three dumpsites A (Olukoko General), B (Ode-Loba) and C (Oke Ado Akintola) in Ogbomoso, Oyo State, Nigeria were selected as sampling sites while samples collected from Ladoke Akintola University Teaching and Research farm (LAUTECH FARM) Ogbomoso, Nigeria, served as control (uncontaminated) site. Leaves, stems and roots of pawpaw, tomato and cocoyam were collected at all the sites. Soil samples were also collected in polythene bags with core sampler *in situ* at 15cm depth (three spots per site). The soil samples from each site were mixed together thoroughly, composite samples were taken and labeled. The soil and the plant samples were then taken to the laboratory at the Institute of Agricultural Research and Training (I. A. R. & T.) Moor Plantation, Ibadan, Oyo State, Nigeria for heavy metal analysis.

The plant samples were washed with deionised water and dried inside oven at $68 \pm 2^{o}C$ until it gives constant weight for 48 hours. Dried plant samples were powdered using hammer mill incorporated with 2mm sieve. 2g of the powdered samples were put into crucible and ashed inside furnace at $580^{o}C$. The ash was then washed into 100ml volumetric flask using wet digestion solution of 10ml concentrated perchloric and nitric acid (1:1) and made up to volume with deionised water. Soil samples were sieved with 2mm sieve after drying. 2g soil sample was put into digestion tube and wet digestion procedure was followed (ref.). Total metal contents of the plants and soil digests were determined by atomic absorption spectrophotometer. Organic carbon, and organic matter percentages and pH, of the soil samples were also determined in the laboratory.

RESULTS AND DISCUSSION

Site B has the highest percentage organic matter (12.85) and has the lowest soil chromium (0.29mg/kg) compared with site A and C with 0.40mg/kg and 0.46mg/kg (Table 1) chromium respectively. Pawpaw leaf retained higher amount of Pb, Cd and Mn from dumpsite B while Cr and Cu were highest at site C. Metals from control site are generally lower in concentration than all the dumpsites. The transfer ratio (percentage absorption in relation to total soil metal) of metals in the leaf indicated the trend Pb (0.76) > Cd (0.7) > Mn (0.65) > Cu (0.41) > Cr (0.10) (Table 2). Thus, lead was observed here to be more abundant in pawpaw leaf when related to soil total lead.

The concentrations of the five metals from the three sites followed the same trend Mn > Cd > Pb > Cu > Cr in the leaf, stem, root and fruit of tomato. However, in term of transfer ratio, lead was highly accumulated than cadmium (Table 2). Thus tomato leaf contained highest amount of manganese and lower amount of chromium. Metals from the control site were lower than those from dumpsite.

Metal concentration in the leaf of cocoyam followed the trend Mn > Cd > Cu > Pb > Cr. But the trend in terms transfer ratio is Mn > Pb > Cd > Cu > Cr (Table 2). The concentrations of the metals in the leaf of cocoyam from the control site are lower compared with that from the dumpsites.

The same trend was followed by pawpaw stem in terms of the amount of lead, cadmium and manganese retained but chromium did not vary as such from the three dumpsites. Chromium was not detected in pawpaw stem from the control site.

Manganese happened to be excessively accumulated in the stem and roots of pawpaw from all the three dumpsites. Thus the transfer ratio followed a different trend from that of the leaf viz: Mn (249.2) >Pb (0.73) > Cd (0.70) > Cr (0.11) > Cu (0.08) (Table 3).

Tomato stem accumulated metals from the three sites in the same trend as the leaf although the amount of manganese accumulated was higher than in the leaf and copper was lower in the stem than the leaf (Table 3). Stem contained lower concentrations of all the metals from the control site. Cocoyam stem absorbed metals from the dumpsites with the trend Mn > Cd > Pb > Cu > Cr while the percentage of total soil metals followed the same trend as cocoyam leaf.

The accumulation of each metal in the roots of pawpaw did not vary as such in the three sites. Manganese was however found to be the highest absorbed metal in all the sites including the control. The transfer ratio of each metal was of the same sequence as that of the stem although the ratio varied slightly (Table 4).

The percentage concentration in relation to soil total followed the same trend for the leaf and stem. Chromium was not differently absorbed by the root of tomato when compared with leaf and stem. Chromium was not detected in the root of tomato from the control site. Root absorbed the highest percentage of Mn compared to other organs considered in this study (Table 4).

Table 1: Metal ion concentrations in soil from contaminated (waste dumps) and control sites in Ogbomoso metropolis.

Sample site	Soil pH	%OM	Pb	Cd	Cr	Cu	Mn
SS-control.	6.64	12.76	0.01	0.01	nd	0.14	0.16
SSA	7.52	18.27	0.34	0.48	0.40	2.14	0.36
SSB	6.63	22.15	0.55	0.68	0.29	4.28	0.45
SSC	7.02	19.79	0.38	0.52	0.46	2.36	0.42

Data are in mg/kg dry weight.

Nd= not detected.

Table 2: Metal concentrations in pawpaw, tomato and cocoyam leaves.

Metal	PA	PB	PC	Pco	TR	TA	TB	TC	Tco	TR	CA	CB	CC	Cco	TR
Pb	0.24	0.40	0.32	0.03	**0.76**	0.20	0.23	0.22	0.03	**0.51**	0.24	0.47	0.31	0.10	**0.85**
Cd	0.31	0.47	0.40	0.01	**0.70**	0.28	0.27	0.26	0.01	**0.48**	0.32	0.55	0.47	0.06	**0.80**
Cr	0.04	0.03	0.05	0.01	**0.10**	0.02	0.02	0.02	0.01	**0.05**	0.03	0.02	0.06	0.02	**0.10**
Mn	0.12	1.18	1.26	0.10	**0.65**	0.64	0.48	0.34	0.12	**1.19**	0.77	1.34	1.57	0.16	**2.99**
Cu	0.26	0.32	0.22	0.12	**0.41**	0.18	0.18	0.18	0.12	**0.44**	0.29	0.53	0.34	0.13	**0.13**

Data are in mg/kg dry weight.

PA=Pawpaw , Pco= control, TA=Tomato, Tco= control, CA= Cocoyam, A,B,C,= sites.

TR= Transfer ratio

Table 3: Metal concentrations in pawpaw, tomato and cocoyam stems.

Metal	PA	PB	PC	Pco	TR	TA	TB	TC	Tco	TR	CA	CB	CC	Cco	TR
Pb	0.26	0.37	0.30	0.02	**0.73**	0.21	0.21	0.21	0.02	**0.50**	0.30	0.53	0.42	0.06	**0.98**
Cd	0.32	0.44	0.41	0.01	**0.70**	0.26	0.28	0.28	0.02	**0.49**	0.33	0.63	0.51	0.03	**0.88**
Cr	0.05	0.04	0.04	Nd	**0.11**	0.03	0.02	0.01	0.01	**0.05**	0.02	0.03	0.08	0.01	**0.11**
Mn	0.82	1.12	1.30	0.12	**2.49**	0.60	0.61	0.32	0.13	**1.24**	0.69	1.29	1.60	0.14	**2.91**
Cu	0.24	0.26	0.20	0.13	**0.08**	0.16	0.17	0.16	0.13	**0.06**	0.33	0.51	0.40	0.14	**0.14**

Data are in mg/kg dry weight.

PA=Pawpaw, Pco= control, TA=Tomato, Tco= control, CA= Cocoyam, A, B, , =sites.

TR= Transfer ratio

Table 4: Metal concentrations in, pawpaw, tomato and cocoyam roots.

Metal	PA	PB	PC	Pco	TR	TA	TB	TC	Tco	TR	CA	CB	CC	Cco	TR
Pb	0.18	0.35	0.35	0.04	**0.69**	0.16	0.20	0.25	0.02	**0.48**	0.32	0.61	0.40	0.04	**1.05**
Cd	0.26	0.42	0.42	0.02	**0.66**	0.21	0.26	0.31	0.01	**0.46**	0.36	0.68	0.52	0.06	**0.93**
Cr	0.06	0.02	0.06	nd	**0.12**	0.02	0.03	0.03	Nd	**0.01**	0.03	0.04	0.10	0.02	**0.15**
Mn	0.86	0.92	1.24	0.14	**2.46**	0.57	0.65	0.37	0.12	**1.29**	0.82	1.32	1.55	0.16	**3.00**
Cu	0.31	0.30	0.25	0.10	**0.10**	0.14	0.16	0.17	0.14	**0.05**	0.27	0.48	0.42	0.14	**0.13**

Data are in mg/kg dry weight.

PA=Pawpaw , Pco= control, TA=Tomato, Tco= control, CA= Cocoyam, A,B,C,= sites.

TR= Transfer ratio Of cocoyam accumulated metals in the same trend but the percentage of total soil metal is slightly different as Mn > Pb > Cd > Cr > Cu.

Pawpaw fruit from site B and C contained similar and higher amount of cadmium than site A. Manganese was highest in pawpaw fruit from site B followed by site A with site C containing the lowest. From Table 5, Mn (1.06) > Cd (0.69) > Pb (0.67) Cr (0.113) > Cu (0.105) was the trend, which when compare with the leaf, root and stem differ. Pb was highest in the leaf, root, stem and fruit, Mn was highest with Cd occupying second position in leaf and fruit and third in stem and root. Cu was only higher than chromium in the leaf but chromium was higher in concentration in root, stem and fruit than copper. Pawpaw leaf accumulated the highest percentage of total soil copper. Mn was highly absorbed by pawpaw stem, root and fruit but least absorbed by leaf. Other metals Pb, Cd, Cr and copper were absorbed at almost the same rate by all the organs.

Tomato fruit from site A accumulated the metals in the trend Mn > Cd > Pb > Cr > Cu, while the trend was the same in site A and B and with the leaf, stem and root (Table 5). Interestingly, tomato fruit absorbed the highest percentage of the total soil Pb, Cd and Cr. Chromium was not detected in the fruit of tomato from the control site.

Tomato root absorbed the highest percentage of total soil Mn while the leaf accumulated the highest percentage of total soil copper. Cocoyam corm and root were similar in terms of the trend in metal concentration accumulated and the total soil metal percentages. Pb, Cd and Cr were highest in concentration in both the root and corm of cocoyam.

Table 5: Metal concentrations in tomato and pawpaw fruits and cocoyam corms.

Metal	**PA**	**PB**	**PC**	**Pco**	**TR**	**TA**	**TB**	**TC**	**Tco**	**TR**	**CA**	**CB**	**CC**	**Cco**	**TR**
Pb	0.22	0.31	0.32	0.10	**0.69**	0.18	0.22	0.28	0.02	**0.53**	0.33	0.60	0.40	0.03	**1.05**
Cd	0.27	0.45	0.44	0.04	**0.69**	0.24	0.26	0.32	0.01	**0.49**	0.34	0.66	0.56	0.04	**0.93**
Cr	0.05	0.03	0.05	0.01	**0.11**	0.14	0.02	0.02	Nd	**0.16**	0.02	0.05	0.12	0.02	**0.17**
Mn	0.54	0.88	0.18	0.10	**1.06**	0.48	0.68	0.35	0.11	**1.23**	0.79	1.40	1.62	0.17	**3.10**
Cu	0.33	0.33	0.26	0.11	**0.11**	0.12	0.17	0.16	0.14	**0.05**	0.32	0.46	0.45	0.14	**0.14**

Data are in mg/kg dry weight.

PA= Pawpaw , Pco= control, TA=Tomato, Tco= control, CA= Cocoyam, A,B,C,=sites.

TR= Transfer ratio

Active organic matter is effective in reducing the availability of chromium. (USDA, 2000). Metal uptake by plants is dependent on soil acidity (pH)- the higher the acidity the more soluble and mobile the metal become, and the more likely they are to be taken up and accumulated in plants. At pH 6 or lower, cationogenic metals such as Cd, Zn, Ni, Pb, Co, and similar substances are more mobile while anionogenic metals such as Cr (iv), As, Mo, and similar substances are immobile (Eastern Research Group, 2001) . The level of metal in the soil may have an impact on the rate of metal accumulation in a plant. In short, different organs of pawpaw varied in their ability to accumulate different metals in their tissues.

At high pH, most cationic metals are less available to plant, being less soluble and therefore less likely to be incorporated in their tissues and ingested by humans. There will be more metals in the soil than in the plant tissue at high pH. Lead from soils tends to concentrate in root vegetables (e.g. onion) (Ward and Savage, 1994), and leafy green vegetables (e.g. spinach). Once metal ions have entered the root, they can either be stored or exported to the shoot through the xylem after crossing the impermeable casparian strip that separates endodermis from epidermis. Metal chelate complexes like Cd-citrate may facilitate this movement suggesting the role of phytochelatins in transport of metal pollutants. Nicotianamine has been shown to be general heavy metal transporter in the phloem.

Individuals will absorb more lead in their food if their diets are deficient in calcium, iron, or zinc (Mahaffey, 1990). Low-level lead exposure in children less than five years of age (with blood levels in the 5-25µg/dL range) results in deficits in intellectual development as manifested by lost intelligent quotient points (Banks, et al, 1997).Thus, in the U.S., the Centers for Disease (CD) lowered the allowable amount of lead in a child's blood from 25 to 10µg/dL, and recommended universal blood lead screening of all children between the ages of six months and five years (Centers for disease control, 1991). For adults, blood lead levels in the range of 7-40µg/dL have been linked with evidence of toxicity such as neurobehavioral decrements (Schwartz et al, 2001) and renal impairments (Kim et al, 1996).

Cadmium concentrations was high in most plant organ assessed in this study, even sometimes higher than lead. It reaches variable concentrations in different organs of different species of such as oats, soybean, corn, and tomato which accumulate more cadmium in root than in aerial parts of the plants. Conversely, lettuce, carrot, and potato accumulate more in leaves. Soybean accumulates more in the seeds than in the leaves (Sauebeck, 1991; Kabata-Pendias, 1992).

In this study, cocoyam corm and tomato fruits from the dump sites accumulated highest amount of Pb, Cd and Cr. The health implication of this fact can be devastating in that most urban backyard farms are on abandoned dump sites. There is an urgent need to start educating the general public about metal toxicity and their media of exposure so that the number of seemingly incurable or otherwise terminal diseases which are products of acute and chronic metal toxicity can be drastically reduced.

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