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EFFECT OF MECHANIC AND REFUSE DUMPING ACTIVITIES ON THE LEVELS OF SOME HEAVY METALS IN *Musa cavendishi, Amaranthus hybridus* and *Zea mays.*

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ABSTRACT
The effect of mechanic and refuse dumping activities on the concentration of Zn, Fe, Mn, Cu and Pb in the fruits of *Musa Cavendishi*, edible parts of *Amaranthus hybridus* and seeds of *Zea mays* from Keteren-Gwari Minna, Nigeria was studied. The heavy metals were determined with an Atomic Absorption Spectrophotometer (Model 990 - P.G. Instruments Ltd., U.K.) Copper was consistently higher in all the samples downstream. Lead was high in all samples from farms close to site of activities. While *Zea mays* recorded a higher concentration of Zn, Fe and Mn in farms close to dumping and mechanic activities. The levels of Zn, Fe and Mn in the samples ranged from 25.30 to 97.00mg/kg; 32.50 to 495.80mg/kg and 2.50 to 182.80mg/kg respectively. The study revealed that the activities at the site affected the concentration of Zn, Fe, Mn and Pb in some samples. Levels of lead ranged from 5.00mg/kg in *Amaranthus hybridus* to 37.00mg/kg in *M. cavendishi* which was higher than allowable limits in diet. Introduction of used batteries and scrap metals to the surrounding and stream used for irrigation could be responsible for the high levels of metals recorded in samples from farms close to site of activities. While the high level of copper observed downstream can be attributed to the mobility of the metals or their compounds into the soil which reduced the level of Zn in the Zn:Cu balance and makes copper available for absorption by the plants. This study can be used to assess the impact of mechanic and dumping activities on plants and the consumption of such plants by humans. Statistical comparison (ANOVA) at 95% confidence interval revealed significant difference between the levels of metal ions within most samples.

KEYWORDS: Mechanic Site, Heavy Metals, Refuse Dumping, AAS

INTRODUCTION

Food is any substance which contains essential nutrients, such as carbohydrates, fats, proteins, vitamins, or minerals, and is ingested and assimilated by an organism to produce energy, stimulate growth, and maintain life, (Anonymous, 2011:http://en.wikipedia.org/wiki/Food Retrieved 2011-10-03)

People obtained food from hunting, farming, ranching and fishing, known as agriculture. With increasing concern in agribusiness over multinational corporations owning to the world food supply through patents on genetically modified food, there has been a growing trend toward sustainable agricultural practices recently. This approach, partly fuelled by consumer demand, encourages biodiversity, local self-reliance and organic farming methods (Anonymous:http://faostat.fao.org. Retrieved 2010).

Almost all foods are of plant or animal origin. Cereal grain is a stable food that provides more food energy worldwide than any other type of crop. Maize, wheat and together account for 87% of all grain production worldwide, (Anonymous, 2011:http://en.wikipedia.org/wiki/Food Retrieved 2011-10-03)

Vegetables and fruits constitute an important part of the diet since they contain fibre, proteins, vitamins, minerals as well as trace elements.

The contamination of the environment through waste disposal and other human activities such as mechanic activities, alter the natural balance of the soil as they introduce some minerals into soils and by implication food grown on such soils. Therefore, food plants grown on such soils may pose serious health hazard. For example, Cu, Cd and Pb in fruits and vegetables were related to high prevalence of upper gastrointestinal cancer (Sanyaolu, *et al*, 2011). It has also been reported that nearly half of the mean ingestion of lead, cadmium and mercury is from fruits, vegetables and cereals,(Adefila *et al*, 2010)

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Some metals such as Ca, Na, Mg and K are required in large quantities by the body tissues, while others including Zn, Mn, Co and Cu are required by the body tissues in trace amounts due to their involvement in certain physiological processes. (Merrill *et al.*, 2001; Onianwa *et al.*, 2001; Ako and Salihu, 2004). For example, Magnesium is involved in the activation enzymes involved in DNA and RNA synthesis, glycolysis, intracellular mineral transport, nerve impulse generation and cell membrane electrical potential. It is also important in the synthesis of protein, regulation of the levels of Ca, Co, Zn, K, Vitamin D and other nutrients in the body system. In plants it is the core content of chlorophyll in plant tissue (Ako and Salihu, 2004; Merrill *et al.*, 2001; Casas and Sordo, 2006).

Deficiency of magnesium in humans results in muscular weakness, mental derangement and nausea (Merrill *et al.*, 2001).

Zinc plays an important role in enzyme stimulation (stimulates about 100 enzymes), quick healing of wounds and growth and development during pregnancy. It also helps in maintaining senses of taste and smell. (Donaldson, 1982; Macrae *et al.*, 1997; Onianwa *et al.*, 2001)

The manifestations of zinc deficiency in humans included behavioural alteration and central nervous system changes, such as depression, psychosis, night blindness etc. Other signs are rough skin, loss of scalp, facial and body hairs, impaired wound healing and reduced immunity, (Pasad, 1990; Macrae *et al.*, 1997, Merrill *et al.*, 2001; Onianwa *et al.*, 2001).

Iron is a vital component of haemoglobin. It is responsible for oxygen transport and storage as well as oxidative metabolism and cellular growth. The deficiency of iron results in anaemia, mucosal and epithelial abnormalities, defect in immunity, skeletal muscle dysfunction and behavioural and neurological abnormalities. Other effects of deficiency are listlessness and fatigue (Macrae *et al.*, 1997; Merrill *et al.*, 2001; Ako and Salihu, 2004).

Calcium plays a role in coagulation of blood. It is used for building of bones and teeth. The deficiency of calcium in young animals and humans results in rickets, a condition where satisfactory bone formation cannot occur (Ako and Salihu, 2004).

Copper is essential for enzymes required for heart function, bone formation, energy metabolism, nerve transmission, elastin synthesis, pigmentation of skin, normal hair growth and red blood cell production (Johnson, 1997; Macrae *et al.*, 1997; Merrill *et al.*, 2001; Onianwa *et a.l*, 2001).

Signs of deficiency of Cu in humans such as brain, heart, bone and blood disorders are explained by decreases in copper metallo-enzymes (Macrae *et al.*, 1997; Onianwa *et al.*, 2001)

In plants photosynthesis is the most important role of Mn, particularly in photosynthetic oxygen evolution. It is also a constituent or an activator of enzymes that catalyze the synthesis of proteins, carbohydrates and lipids as well as cell division and extension, particularly in the roots, (Marschner, 1995).

In humans Manganese activates the enzymes responsible for the utilization of several key nutrients including biotin, thiamin, ascorbic acid and choline.

In addition, manganese activates the enzymes known as glycolsyltranserferases and xylosyltransferases, which are important in the formation of bone. It is also a constituent of the metalloenzymes such as Arginase, the enzyme in the liver responsible for creating urea, a component of urine; Glutamine synthetase, which is involved in the synthesis of glutamine, Phosphoenolpyruvate decarboxylase, an enzyme that participates in the metabolism of blood sugar and Manganese-dependent superoxide dismutase, an enzyme with antioxidant activity that protects tissues from the damaging effects of free radicals. It is found exclusively inside the body's mitochondria (oxygen-based energy factories inside most of our cells) (Institute of Medicine, 2000)

Lead poisoning in children can affect almost every part of their system. It can result in convulsion, encephalopathy, osteoporosis, reduced IQ, learning disabilities, attention deficit, muscle and joint pain, irritability and lack of concentration (Macrae, *et al.*, 1997; Merrill *et al.*, 2001; Casas and Sordo, 2006).

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MATERIALS AND METHODS

Sampling and sample preparation

Fresh samples of matured seeds of *Zea mays*, fruits of *Musa cavendishi* and the edible parts of *Amaranthus hybridus* were collected into polyethylene bags from three different farms located upstream, at site, and downstream of the dump site in Keteren-Gwari Minna, Nigeria. Locations for sampling were chosen with respect to the direction of flow of the tributary of River Suka (northwest to southeast), the bank of which mechanic activities and refuse are dumped and which also serves as a source of water for irrigating the farms. Northwest of the site were farms "upstream", "downstream" referred to farms southeast of the site while farms close to the mechanic shades and other activities were those "at site". Sampling was done 100 metres upstream, at site and 1kilometres downstream. Sampling was done on six locations on each farm.

The samples were washed in the laboratory under running tap water and rinsed with distilled water. The *M. carvendishi* fruits were allowed to soften for a few days before peeling with hands, the edible soft portions of the *Amaranthus hybridus* and seeds of *Zea mays* were remove with hands. The *Musa cavendishi* and *Amaranthus hybridus* samples were separately chopped with an aluminium knife. The samples were dried in a Gallenkamp moisture extraction oven regulated at 85^0C, on white sheets of cardboard paper. The oven-dried samples were micronized with the aid of the porcelain mortar and pestle and then packed in air tight transparent polyethylene bags and stored in a large brown screw cap sample bottle for further analysis, (Ako and Salihu, 2004).

Methods

2g of the micronized sample was weighed into a 100 cm^3 acid washed beaker. 25 cm^3 aqua-regia and 5 cm^3 of 30% hydrogen peroxide (H_2O_2) were added. The mixture was digested at 80 ^{0}C for 1 hour. After cooling, the digest was filtered with a Whatman No. 42 filter paper into a 100 cm^3 volumetric flask and made up to the mark with de-ionized water and store in refrigerator pending analysis. This was repeated for all samples. A blank was prepared similarly.

Levels of copper, iron, zinc, manganese and lead were determined with the aid of the Atomic Absorption Spectrophotometer (Model 990 - P.G. Instruments Ltd., U.K.)

Statistical Analysis

The data was subjected to ANOVA statistical analysis using MINITAB 14 at 95% confidence level and Turkey's multiple comparisons.

RESULTS AND DISCUSSION

Table 1: Mean Concentration (mg/kg dry weight) of Heavy Metals in *M. cavendishi* Flesh and Peel.

		Heavy Metals			
Samples	Zn	Fe	Mn	Cu	Pb
U-BF	41.00±7.07	46.50±53.03	^{b}5.50±0.71	0.25±0.35	ND
A-BF	34.00±4.60	61.75±37.83	10.75±1.06	ND	11.50±0.35
D-BF	28.50±2.12	56.25±18.74	^{b}5.50±0.71	0.50±1.41	ND
U-BP	41.95±7.00	^{a}218.50±Nd	21.75±1.06	^{d}3.75±0.35	ND
A-BP	71.75±5.30	^{a}201.25±88.74	^{c}29.00±2.83	^{d}2.75±3.89	17.50±3.54
D-BP	89.75±10.25	^{a}201.75±35.70	^{c}27.50±2.12	4.75±0.39	37. 0±31.82

U-BF = Flesh upstream; A-BF = flesh Onsite; D-BF = Flesh Downstream
U-BP = Peel upstream; A-BP = Peel Onsite; D-BP = Peel Downstream
a, b,c, d = no significant difference; ND = Not Detectable

Table 2: Mean metal concentrations (mg/kg dry weight) in *Amaranthus hybridus* at the sites

		Heavy Metals			
Samples	Zn	Fe	Mn	Cu	Pb
U-A	70.25±10.96	^{e}412.00±96.87	45.50±0.71	7.75±0.35	ND
A-A	97.0±1.41	495.80±54.09	50.25±1.06	^{f}10.25±1.06	15.00±10.60
D-A	ND	^{e}419.75±45.50	182.80±3.89	^{f}11.25±1.06	5.00±3.54

U-A = Amaranthus Upstream; A-A = Amaranthus Asite; D-A = Amaranthus Downstream
e, f = no significant difference; ND = Not Detectable

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Table 3: Mean metal concentrations (mg/kg dry weight) in *Zea mays* at the sites

Samples	Heavy Metals				
	Zn	Fe	Mn	Cu	Pb
U-Z	25.30±0.96	32.50±17.08	^{g}2.50±1.40	4.75±0.25	ND
A-Z	43.50±9.19	141.50±100.10	6.00±0.01	3.25±0.35	15.00±10.60
D-Z	34.30±1.06	42.50±37.48	^{g}3.50±1.41	6.75±0.35	ND

U-A = Zea mays upstream; A-Z = Zea mays Atsite; D-Z = Zea mays Downstream
g = no significant difference; ND = Not Detectable

The results of the analysis are presented in Tables 1-3. A broad view of the result showed a variation in the concentration of metal ions in all sample in the farms. Copper was consistently higher in all the samples downstream. Lead was high in the farms close to site of activity. While *Zea mays* recorded a higher concentration of Zn, Fe and Mn also in farms close to dumping and mechanic activities.

Zinc content range from 28.50 to 89.50 mg/kg in the flesh and peel of M. *cavendishi* respectively downstream. In general metal concentration was higher in samples exposed (leaves or peels) compare to seeds or fleshy parts. The high levels of metals recorded close to site of activity could be due to introduction of used batteries, scrap metals and other household wastes to the surrounding and stream used for irrigation. While the level of copper observed downstream could be due to mobility of the metals or their compounds into the soil which reduced the level of Zn in the Zn:Cu balance making copper available for absorption by the plants, (Spectrum Analytic Inc, 2012). Other contributing factors, especially on leafy or peel of fruit samples, are topical application by splashing contaminated water during irrigation; this can cause adsorption of the metals to the surface of the sample and secondly, the involvement of the metals in photosynthesis and other cellular activities in the plants.
In *Zea mays* Zn ranged from 25.30 to 43.50 mg/kg but was not detectable in *A. hybridus* downstream. Generally Zn is lower in *Zea mays* compare to other samples. This observation further proves its involvement with copper in photosynthesis and production of chlorophyll in plants, Spectrum Analytic Inc, (2012). Also topical application of contaminated water used for irrigation could contribute to the observation. Compare to Adefila *et al*, (2010), the concentration of Zn were higher. The maximum permissible level of Zn is 20mg/kg in food samples as recommended by WHO (Adefila, *et al.* 2010; Codex Alimentarius Commission, 2001), this is small compared to the result of this research.

Iron content ranged from 46.50mg/kg in the flesh of *M. cavendishi* to 218.50mg/kg in the peel; *A. hybridus* recorded a range of 412.00 to 495.80mg/kg while a range of 32.50 to 141.50mg/kg was observed in *Zea mays.* Generally, *A. hybridus* recorded highest level of iron.

Mn range from 45.50 to 180.80mg/kg in *A. hybridus* and 21.75 to 29.00 mg/kg in *M. cavendishi* peel. Other samples showed value of Mn ranging between 2.50 to 10.75mg/kg. Compare to the other samples, the content of Mn was higher in *A. hybridus* and tailed by *M. carvendishi* peel. This could be due to its involvement in photosynthesis apart from contamination through water used for irrigation and other factors.

Copper was beyond detectable limit in *M. cavendishi* flesh at site. It values ranged from 0.25 to 4.75mg/kg in *M. cavendishi* samples, 7. 75 to 11.25mg/kg in *A. hybridus* and 3.25 to 6.75mg/kg in *Zea mays.* Values were higher downstream in all the samples. This could suggest that the presence of heavy metals like Mn and Zn may interfere with the absorption of copper. Again the high levels of copper observed downstream could be due to the mobility of the metals or their compounds into the soil, which distorts the Zn:Cu balance by reducing Zn level, therefore making copper available for absorption by the plants. Also, organic matter readily and tightly complexed with copper. The result seems to suggest low organic matter content in the soil downstream which increased copper availability. (Ako and Salihu, 2004; Spectrum Analytic Inc, 2012). Apart from the Zn:Cu balance, research have indicated low response of some vegetables to Cu toxicity since more copper are accumulated in roots and stems rather than the leafy parts, this can account for the low levels of copper observed in some sample analysed (Singh, *et al.*, 2012; Reichman, 2002; Spectrum Analytic Inc, 2012). The presence of lead in some samples which exceeded the safety limits of Codex Alimentarious Commission, (2001), is a source of concern. The concentration of lead ranged from 5.00mg/kg in A. *hybridus* to 37.00mg/kg in *M. cavendishi* peel. Lead was higher at the site of activity for all samples. This is can be attributed to external sources such as water used for irrigation which may contain the salts of the element from used car batteries and other materials dumped on the site.

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Statistical analysis, (ANOVA) using MINITAB 14 and Turkey's family error rate at 95% confidence level, indicated only the level Mn was not significantly difference between samples of M. *cavendishi* flesh (upstream and downstream) and *Zea mays* at site. While other samples showed no significance difference only within samples as shown in the Tables 1-3 of results. The level of Zn was significantly different between and within some samples.

CONCLUSION

Copper was consistently higher in all the samples downstream. This seems to agree with Adefila, *et al.* (2010) that the presence of some ions affects the uptake of others by plants. The result also agree with Spectrum Analytic Inc, (2012) on the Zn:Cu balance which showed that low level of zinc increases the absorption of copper by some plants. The high amount of copper and zinc in the peel of M. *cavendishi* and A. *hybridus* compare to *Zea mays* seeds further prove their involvement in photosynthesis and production of chlorophyll in plants. Lead was high in all the farms close to site of activity. While *Zea mays* also recorded a higher concentration of Zn, Fe and Mn in farms close to dumping and mechanic activities. Fe was particularly higher in concentration than other heavy metals. These observations can be linked to the mechanic and dumping activities which introduce these metals or their compounds to the surrounding. The heavy metals analysed Pb and Zn exceeded the maximum limit of 0.2mg/kg and 20mg/kg allowed in food reported by Codex Alimentarius Commission, (2001) and Adefila *et al.* (2010).

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