

## **EFFECTS OF MUNICIPAL SOLID WASTE (MSW) APPLICATION ON VEGETABLE METAL CONCENTRATIONS**

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### **Abstract**

This study was conducted to examine the effects of untreated municipal solid waste used as organic input on crops' heavy metal concentrations and to estimate whether accumulation of heavy metals in the vegetables would impact on human nutrition or health hazards. Three vegetable crops: cabbage, spinach and tomato grown in selected irrigation farm-plots along River Kubani flood plain in Zaria, Nigeria were used. The collected samples were rinsed with distilled water, labeled and oven dried at a temperature of 700C for 48 hours, grinded to powder, sieved with 2mm sieve, for elemental analysis. The crop samples were analyzed for: Fe, Cu, Mn, Zn, Pb and Ni by Atomic Absorption Spectrophotometer (AAS). The results however revealed that the application of untreated waste has increased the concentrations of Fe, Mn, Pb and Ni in the selected crops above the WHO/FAO. The only exception was the concentration of Cu. The concentrations of Mn, Pb and Ni call for urgent attention. Continuous monitoring of accumulating rates of metals in crops and soil and clean-up procedure either by the use of bioremediation, particularly phytoremediation or reclaimed of land by top soiling with uncontaminated soils are suggested.

**Keywords:** *Municipal solid waste, Vegetables, Heavy metals, Environmental pollution*

### **Background to the study**

In the soil system, metals play important roles in the metabolic pathway during the growth and development of plants, when available in appreciable concentration. Accumulations of heavy metal by each plant component vary according to their nature, properties, and climate of a particular plant. The confirmation of whether there is heavy metal accumulation in crop can only be established by testing the levels in the crop.

The study area (Zaria) has been a notable hot spot for vegetable gardening since Nigeria's oil boom of the 1970s, which was accompanied by increased demand for vegetable produce by the growing urban population. Among the important factors which stimulated this are the favourable markets, the cool harmattan session in the region, high degree of accessibility by road, rail, and pool of prospective labour force (Yakubu et al; 2006). Since the 1990s, expansion of vegetables garden has continued along all the flood plains of the major Rivers (Kubani and Galma) draining the area. Besides relying on waste water that flow freely in the rivers, the farmers make use of untreated urban solid waste to fertilize their farms which play vital role in sustaining soil fertility and productivity. Environmental pollution is the main cause of heavy metal contamination in foodchain. These metals may reach and contaminant plants, vegetables, fruits and canned foodst through air, water, and soil during cultivation (Hussain et al., 1995) and also during industrial processing and packaging (Tsoumbaris and Tsoukali-Papadopoulou, 1994). Depending on the

environmental conditions and the rate which heavy metals are added to the soils, the elements can be leached through the soil profile, and consequently, contaminate groundwater. Crops grown on municipal solid waste amended soils showed responses which vary from nutrient deficiency to poor crop yield due to nutrient immobilization (Erickson et al; 1999) have been reported to occur. These heavy metals may enter the body through food, water and air. Once they enter the body, they compete with and displace the essential minerals such as Cu, Zn, Mg and Ca and interfere with organ system function (Raskin et al; 1994). Fagbenro, (2000) reported accumulation of toxic levels such as Pb, Cd, Ni, and Cr in crops grown on municipal solid waste amended soils while Warman and Rodd (1999) on the other hand noticed that crops grown on municipal solid waste amended soils hardly accumulate heavy metals beyond critical recommended safety levels.

In India, a research conducted at New Delhi on vegetables eating up vegetarians showed the presence of deadly heavy metals in vegetable samples (The Hindus, 2003). Somasundaram, (2003) studied heavy metal content of plant species of sewage-irrigated area of Coimbatore, Darnatake where leafy vegetables were found with very high heavy metal contamination including: Cd, Zn, Cu, Mn and Pb. Similarly, Bempah (2012) investigated the magnitude of heavy metals present in some Ghanaian medicinal herbs/plants available in local markets and obtained results which showed the predominance of Cd in almost all the analysed parts of the samples followed by Zn, Cu, As and Hg. The levels of Cd, Cu, and Ni in vegetables from industrial and residential areas of Lagos was studied by Yusuf et al; (2002) which revealed higher levels in industrial areas than those of residential areas due to pollution. The objective of this study is to determine the concentration of heavy metal (Fe, Cu, Mn, Zn, Pb, Ni) in three vegetable crops (cabbage, spinach and tomato) grown in municipal solid waste amended soils in Zaria area, northern Nigeria.

## **Materials and Method**

### **Location of Sampled Sites**

The study site is located approximately between latitudes 11°04'N and 11°05'N and longitudes 7°43'E and 7°44'E at an altitude of 680m above sea level. The geology of the area is mainly older and younger laterite plinthite with patches of Biotite gneiss (Wright and McCury 1970). It experiences a dry-sub humid tropical continental climate with mean annual rainfall of about 800mm, concentrated in a wet season between April and October (Yakubu, 2009). The temperature is high throughout the year, with the monthly mean rising from January (21°C) and attaining a maximum in April (29°C). A decade mean annual temperature (1999-2008) is 26°C (Yakubu, 2009).

### **Crop Sampling, Preparation and Analysis**

Crop samples were collected from some irrigation farm plots along river Kubani. The selected crops are cabbage, spinach and tomato. The collected samples were rinsed with distilled water gently; moisture and water droplets were removed; labeled and oven dried at a temperature of 70°C for 48 hours. After oven dried, the samples were grinded, to powder, sieved with 2mm sieve, labeled and stored in a polythene bag and prepared for elemental analysis. Determination of the elements was done by Atomic Absorption Spectrophotometer (AAS) at Centre for Energy and Research Training (CERT), Zaria. Data analysis was performed by presenting data in table and comparing their mean values with some rating scales to determine their safety levels.

## **Results and Discussion**

Accumulation of heavy metals in vegetables crops as a function of concentration is presented in Table 1.

**Table 1:** Heavy metal concentration in crops, FAO/WHO and ratings scale for foliar Examination of Micro-nutrients in crops by Landon (1991) and Alloway (1990)

Element	Cabbage	Spinach	Tomato	FAO/WHO	Adequate levels <sup>a</sup>	Critical Concentrations <sup>(1)</sup> <sup>b</sup>
Fe (mg/kg)	409	500	438	48	50-250	-
Cu (mg/kg)	12.42	13.30	13.50	30	5-20	5-64
Mn (mg/kg)	38.20	42.40	39.10	-	20-500	100-7000
Zn (mg/kg)	214	242	230	60	25-150	100-900
Pb (mg/kg)	160	286	162	2	30-300	30-300
Ni (mg/kg)	116	105	158	-	-	8-220

**Source:** FAO/WHO, 1976, aLandon (1991); balloway (1990)

Means values likely to cause a 10% depression in yield. Below the adequate levels, are the deficiency levels, which above it, is an excessive level that may likely cause toxicity effects.

**Iron status:** The mean Fe content in crops ranged from 409-620 mg/kg and its status was rated high (FAO/WHO, 1976, Landon, 1999 and Alloway, 1990). Although the values are more than the adequate levels in crop samples, it does not appear to pose any toxicity risk. The values are spinach (500) mg/kg, tomato (438 mg/kg) and cabbage (409 mg/kg) respectively. The results here are much higher than the values obtained by (Uzoho, 2006) on the tissue of heavy metal concentration as affected by municipal solid waste compost application in southeastern Nigeria. Similarly the values is much less than 1585- 2417 mg/kg in lettuce but greater than the value of 118 mg/kg in carrot obtained (Pasquini, 2002) in Jos Nigeria.

**Copper status:** The contents of Cu in crops (12.42 – 13.50mg/kg) fall within adequate levels (Landon, 1999). The values obtained are similar to the value of between 5.58-13.92mg/kg by (Pasquini, 2002). On the other hand, the values are much greater than 1.7 and 12.0 mg/kg obtained by Granato (2004) on corn grain and corn leaves respectively in soil after cessation of biosolid applications.

**Manganese status:** With a range of 25.60-39.10mg/kg, the status of Mn is adequate (Landon, 1999) and may neither pose toxicity effect nor cause any depression in yield.

**Zink status:** Zn content in the crops ranged from 214 mg/kg (cabbage), to 242 mg/kg (spinach). The status of Zn is more than adequate level and can cause toxicity effect (Landon, 1999). In addition such high values may lead to reduction in crop yield (Alloway, 1990).

**Lead status:** The mean Pb content in crops is very high. Its concentration in an increasing order is cabbage <tomato < spinach. The concentrations of Pb in all crops fall within normal range for plants (Alloway, 1990). The mean Pb concentrations for all the crops fall below the limit for leafy vegetables and other vegetables. Pasquini, (2002) obtained the values of 5.88-11.58 mg/kg.

**Nickel status:** The mean concentrations of Ni in crops samples are in descending order of 158, 132, and 105mg/kg-1 in; tomato, cabbage and spinach respectively. The values fall within the critical concentration of 8-220 mg/kg-1 of (Alloway, 1990), which could result in 10% reduction in yield. Fe concentrations in all the samples are high because plant leaves tend to have high Fe content as earlier observed. More so, it shows that Zn, Cu and Mn content in the soil does not interfere with the translocation of Fe in the plants (Russell, 1973). Cu concentrations in the crops were low. Other plant nutrients might have influenced Cu content in the crops such as phosphate, which reduces Cu concentrations in roots and leaves (Lucas and Knezek, 1973).

Mn concentrations were also low in the selected crops. This can also be attributed to high pH as well as Zn and Fe interference, although, plant response to high levels of Mn varies (Sillanpaa, 1972). The high content of Pb, for instance, might have resulted from surface contamination of the leaves by soil Pb. This means that people feeding on the vegetables might possibly suffer the hazardous effect of this pollutant in the long run, for instance, lead intake has been reported in cases of damages to kidney and central nervous system (Van Ash and Ciarletta, 1993). Heavy metals present in urban waste can contaminate the food chain and reduce crop yields (Wang, et al;2003). The consumption of plants containing high levels of heavy metals might pose a serious risk to human health (Turkdogan et al; 2003). Blacket et al; (1990) showed that waste irrigation water of vegetables caused helminthic infection and typhoid fever to people that ate such vegetables. Further harmful effects of solid wastes when used as organic fertilizers is the general lack of consistency because the materials are so variable, that the farmers cannot estimate what level of nutrient to apply. Plants parts on the other hand vary in their tendency to uptake and accumulate heavy metals.

Crops response to wastes application is highly variable and depending on the type of waste, crop variety and tolerance level, climate, soil type and management systems. Long term application of organic wastes can however significantly increase heavy metal concentration in the soils and consequently to crops. These metals can be toxic to plant or their levels in plant tissue might become harmful to the health of humans and animals that feed on the crops. The implications of heavy metal contamination of food crops are of two folds; firstly it implies that the crops which recorded high heavy metal content can be key in verification of heavy metal contaminated cropping systems. Secondly consumers of heavy metal contaminated food crops are associated with potential health risks. This is why environmental pollution by heavy metals even at low concentrations and the long- term cumulative health effects that go with it is of major health concerns all over the world.

### **Conclusion**

Heavy metals are environmental hazardous and many developed and developing countries have been continuing to monitor the trends of its concentrations in food, herbal medicines and other biota. In this study, substantial differences in heavy metal values were observed in each of the crop samples. It is worthy of note that all metals with the exception of Cu were above WHO permissive levels. But the high concentrations of Zn, Pb and Ni in crop samples are of much concern.

### **The following recommendations are suggested;**

- i. Clean-up procedure could be embarked on to reduce the heavy metal concentrations of Pb and Ni in the soil either by the use of bioremediation, particularly phytoremediation or the land can be reclaimed by top soiling with uncontaminated soils from off site to a depth that would minimize uptake of heavy metals by vegetables.
- ii. To reduce health risks in soils with high heavy metal content, food crops should be thoroughly washed to remove as much soil as possible. Outer leaves of leafy greens should be removed and root crops should be peeled to further reduce risk.
- iii. Although heavy metals in crop samples may not pose immediate risk to human health, a yearly monitoring program for heavy metals in food crops and other herbal products is a necessity.

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