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LEVEL OF CONTAMINATION OF VEGETABLES FROM IRRIGATED FARMLAND IN ZARIA, NIGERIA

Samuel Yakubu[1*] and Sani Abubakar Mashi[2]
[1]Dept of Geography, Osun State University, Osogbo, Nigeria
[2]Dept of Geography, University Abuja, Nigeria

ABSTRACT

The Sustainable Development Goals (SDGs) debuted in 2015, the same year as the International Year of Soils which gave soil scientists an extraordinary opportunity to raise awareness on the fundamental role of soils in achieving SDGs and make valuable contributions to existing challenges particularly, the environmental quality of food productions that is of major concern in the world today. This paper reports the results of a study conducted to evaluate the level of contamination of vegetable farmland in Zaria, Nigeria. Five vegetable crops: cabbage, lettuce, okra, pepper and spinach grown in irrigated farm-plots under Municipal Solid Waste (MSW) application as organic fertilizer along River Galma in Zaria were used. The collected samples were rinsed with distilled water, labelled and oven dried, grinded to powder and 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). Results obtained showed variations in the metal contents. There is high concentration of Fe, Cu and Mn in the selected crops but the levels are within human safety limits while the concentration of Zn, Pb and Ni calls for urgent attention. Continuous monitoring of accumulation rates of these metals in crops and soil are therefore suggested.

Keywords: Vegetable, Heavy metal, Municipal solid waste, Contamination, Zaria

INTRODUCTION

The sustainability of any system has become major concern for the world todays. The SDGs provide clear guidelines and targets to promote sustainable food production under the ubiquitous theme of eradicating poverty. Agriculture, and consequently, soils are at the heart of the SDGs and are fundamental towards achieving them. For instance, SDG 2 (Zero hunger) is the most straightforward link that connects soils, food production, and healthy living. Nonetheless, soils fulfil a large number of functions and ecosystem services (EC, 2006) that explicitly bind them with other goals such as SDG 1 (No poverty), SDG 3 (Good health and well-being), SDG 6 (Clean water and sanitation), SDG 13 (Climate action), and SDG 15 (Life on land).

Evaluation of the level of contamination of vegetables grown irrigated farmland is perhaps the most basic decision making in order to impose appropriate nutrient management strategies (Brady and Weil, 2002). In the soil system, some of metals are indeed nutrient element and they play important roles in the metabolic pathway during the growth and development of plants when available in appreciable concentration. Accumulation of heavy metal by plant components vary according to the nature, properties, and composition of the plant. The confirmation of whether there is heavy metal accumulation in crop is only established by testing the levels in the crop.

Long term application of urban waste on cultivated fields can undoubtedly improve soil fertility and provide crop nutrient needs of farmers, but can likely lead to negative and potentially harmful changes in soil physical and chemical characteristics due to increasing toxicity (Ezeaku *et al*., 2003, Yakubu, 2014). High concentrations of these metals in soil may have adverse effects on crops, human and animal health when they are taken up by crops and transferred up the food-chain or are leached to groundwater (Kabata-Pendias, 2004). Apart from contaminating the food chain, the presence of heavy metals in urban waste can reduce crop yields (Wang *et al*., 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.

Fagbenro (2000) reported accumulation of toxic levels of heavy metals 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.

There is however every reason to be concerned about the public health implication of crops grown on municipal solid waste amended soils which could immobilize heavy metals and find their ways into human beings through the food chain processes (Silveira *et al*., 2003; Okoronkwo *et al*., 2005). Thus, the question of whether vegetables, fruits and food crops cultivated on soils to which such wastes are disposed are safe for human consumption is of great interest to public especially now that the environmental quality of food productions are of major concern. One way of ascertaining this is to evaluate the heavy metal contents since such metals are recognized as some of the most important attributes of MSW.

Since the 1990s, Zaria has been a notable hot spot for vegetable production by the growing urban population. Expansion of vegetable garden has continued along all the flood plains of the major rivers (Kubani, Saye and Galma) draining the area. Farmers in this area make use of urban solid waste after sorting to fertilize their farms because it plays vital role in sustaining soil fertility and productivity. With dumpsites becoming permanent features of urban areas in the country, the sites in some locations are being converted into cultivated fields or locations from where manure for soil amendment could be obtained. More so, with economic crisis making chemical fertilizer beyond the reach of most resource-poor farmers, this practice has been recognized as an important medium for soil organic input in the area. The aim of this study is to determine the levels concentration of the following elements: Fe, Cu, Mn, Zn, Pb and Ni in five vegetable crops grown in MSW amended soils in Zaria, Nigeria.

MATERIALS AND METHODS

Location of Sampled Sites

The study site is located approximately between latitudes 11º 04' N and 11º 05' N and longitudes 7º 43' E and 7º 44' E (see Fig. 1) at an altitude of 680m above sea level. It experiences a dry sub-humid tropical continental climate with mean annual rainfall of about 1000mm, concentrated in a wet season between April and October. The temperature is high throughout the year, with the monthly mean rising from January (21ºC) and attaining a maximum in April (29ºC). A decade mean temperature (1999 - 2008) is 26ºC (Yakubu, 2014).

The geology of the study area is Pre-Cambrian Basement Complex rocks of variable competition (FDALR, 1990). The plains attain an elevation ranging from about 550m to 740m above mean sea level (msl). The topographical nature of the area is a gentle rolling undulating landscape with residual hills of various sizes and shapes and is drained largely by three major rivers namely: Galma, Kubani and Saye. The landforms consist mainly of inselbergs, pediment landscape overlying the basement complex made up of nearly level gently undulating plains (FDALR, 1990), which are dissected by broad stream valleys. Base on the FAO classification, the soil are Ferric Luvisols, formed from basement complex rocks and quaternary deposits (Bennett, 1980). The area falls within the Guinea Savanna bioclimatic zone, therefore most of the vegetation has been degraded due to human interference such as agriculture, wood harvesting, overgrazing, and urbanization process among others.

Since the early 1970s vegetable production have been grown all year round in Zaria. Usually, water is let into cultivated fields from nearby stream or river by opening inlet channels which are closed with mud/bags filled with sand or the use of pipe to connect water directly into the farm. The main source of soil organic input in this area is the MSW, although at times, supplemented by cattle dung, poultry droppings and chemical fertilizer.

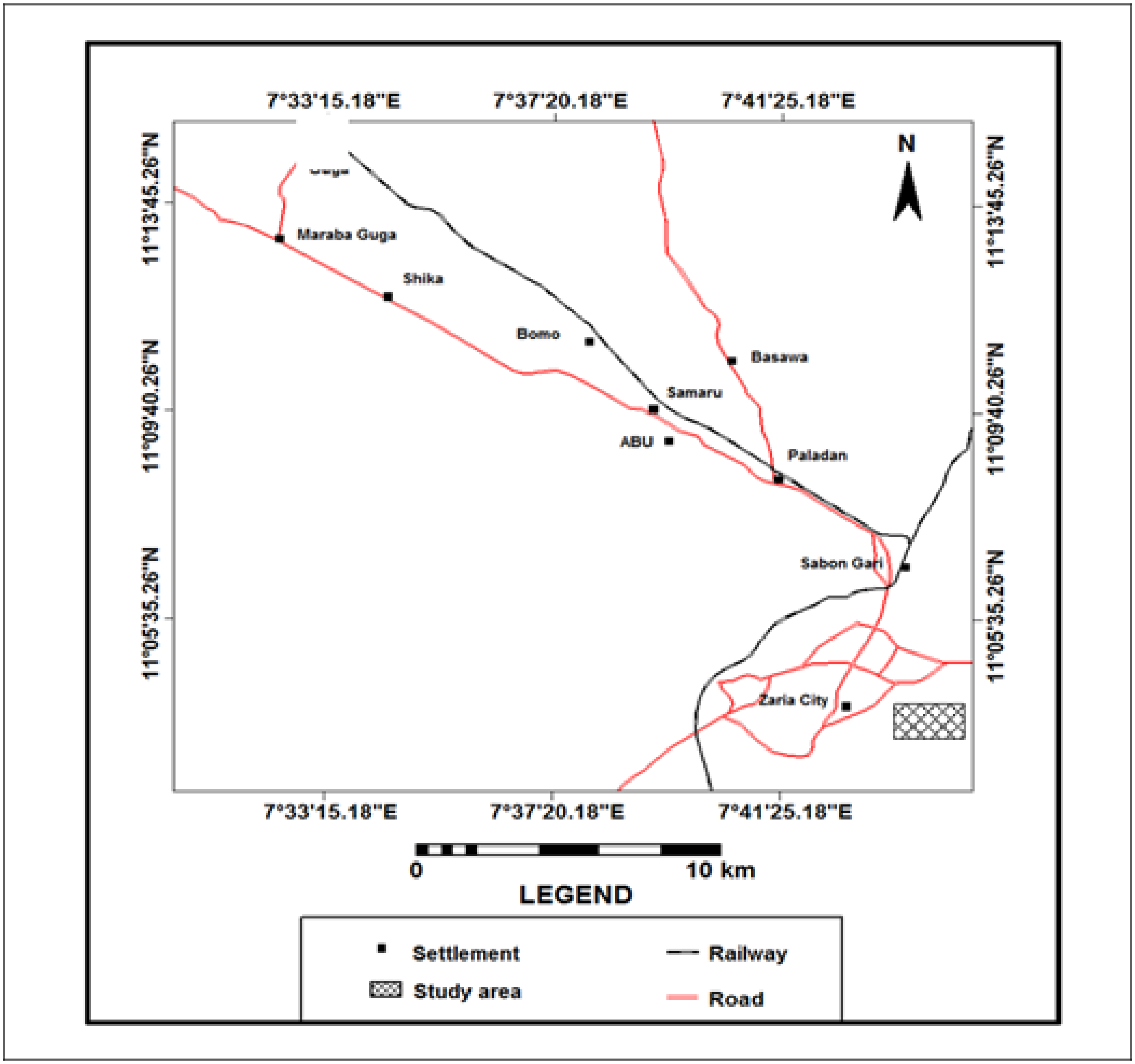

Fig 1: Map of Zaria Showing the Study Area

Crop Sampling, Preparation and Analysis

Crop samples were collected from irrigated farm plots along River Galma area of Zaria where municipal solid waste is used as organic fertilizer. The selected vegetables commonly grown in the area are: cabbage, lettuce, okra, pepper and spinach. Plant tissue analysis was required to obtain information on the health of the soil where plants draw nutrients and to explain nutrient deficiency. Since nutrients concentration in plant tissue is a reflection of available nutrient in soils, plant tissue analysis is a better measure of soil-plant interaction. The sampling guide for field crops in the savanna as reported by Agbenin (1995) was used. Collected vegetable samples were taken to laboratory immediately for treatment in order to minimize deterioration.

The collected samples were rinsed with distilled water, moisture and water droplets were removed, labelled and oven dried. After oven-dried, the samples were grinded into fine particles with agate mortar for homogeneity of particles size. The grinded samples were passed through 2mm sieve and stored in a labelled nylon for laboratory analysis of each element. The determination of the elements was done by Atomic Absorption Spectrophotometer (AAS) at Centre for Energy and Research Training (CERT), Zaria, Nigeria. Data analysis is presented in tabular form while the mean values were compared with some rating scales to determine their safety levels.

RESULTS AND DISCUSSION

Accumulation of heavy metals in the selected five vegetables crops sample is presented in Table 1.

Table 1: Results of Heavy Metal Concentration in Crops

Element (mg/kg)	Experimental Results					FAO/ WHO	Adequate Level[*1]	Critical Concentration[*2]
	Cabbage	Lettuce	Okra	pepper	Spinach			
Fe	420	562	412	411	250	48	50-250	-
Cu	10.12	5.50	6.12	13.30	11.54	30	5-20	5-64
Mn	32.45	25.60	15.82	34.37	25.20	-	20-500	100-7000
Zn	185	105	120	210	124	60	25-150	100-900
Pb	276	164	223	230	186	2	30-300	30-300
Ni	219	126	145	134	110	-	-	8-220

Source: [*1]Landon (1991) and [*2]Alloway (1990)

Iron Status

Iron is an essential micronutrient for almost all living organisms because of it plays critical role in metabolic processes such as DNA synthesis, respiration, and photosynthesis (Rout and Sahoo, 2015). The increasing order of mean Fe content in crops are: spinach (250mg/kg), 411mg/kg (pepper), okra (412mg/kg), cabbage (420mg/kg) and lettuce (562mg/kg). The status of Fe was rated high (Landon, 1991). Although the values are more than the adequate levels in crop samples, it does not appear to pose any toxicity risk. The results here are much higher than the values obtained by (Yakubu, 2014 and Uzoho, 2006) on the tissue of heavy metal concentration as affected by municipal solid waste compost application in north and south-eastern Nigeria respectively. Similarly, the value is much less than 1585 - 2417mg/kg in lettuce but greater than the value of 118mg/kg in carrot obtained by Pasquini (2002) in Jos Nigeria. 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).

Copper Status

The contents of Cu in crops (4.28 – 12.45mg/kg) fall within adequate levels given by Landon (1991) and FAO/WHO. 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, 1972). The values obtained are similar to the value of between

5.58-13.92mg/kg by Pasquini (2002) and 12.42-13.50mg/kg obtained by Yakubu (2014). On the other hand, the values are much greater than 1.7 and 12.0 mg/kg obtained by Granato *et al.* (2004) on corn grain and corn leaves respectively in soil after cessation of biosolid applications. Copper is an important micronutrient for plants and is required for lignin synthesis and acts as a constituent of ascorbic acid, oxidase, phenolase and plastocyanin (Havlin *et al*., 2010).

Manganese Status

Manganese plays an important role in oxidation and reduction processes in plants (Mousavi *et al*., 2011). The manganese content from 15.82 to 34.37mg/kg. the status of manganese is adequate (Landon, 1991) and may neither pose toxicity effect nor cause any depression in yield. Mn concentration is also low in the selected crops.

Zink Status

Zinc is essential for several biochemical processes in plants such as cytochrome and nucleotide synthesis, auxin metabolism, chlorophyll production, enzyme activation and the maintenance of membrane integrity (Havlin *et al*., 2010). Zn content in the selected crops is above FAO/WHO standards but fall within the critical concentration range of Alloway (1990). The mean values Zn are: 105mg/kg (lettuce), 120mg/kg (okra), 124mg/kg (spinach), 185mg/kg (cabbage) and 210mg/kg (pepper). This result is lower than the mean value of 214 - 242mg/kg obtained by Yakubu (2014). The status of Zn can cause toxicity effect (Landon, 1991). In addition, such high values according to Alloway (1990), may lead to reduction in crop yield.

Lead Status

Given the range of 164 to 276mg/kg of lead, the mean content in crops is very high. Its concentration in an increasing order is; lettuce < spinach < okra < pepper < cabbage. 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 - 11.58mg/kg. 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 as it poses a serious risk to human health (Turkdogan et al, 2003; Wang et al, 2003).

Nikel Status

The mean concentrations of Ni in crops samples are in an increasing order of 110mg/kg (spinach), 126mg/kg (lettuce), 134mg/kg (pepper), 145mg/kg (okra) and 219mg/kg (cabbage) respectively. The values fall within the critical concentration of 8 - 220mg/kg by Alloway (1990), which could result in 10% reduction in yield.

Using municipal solid waste as organic fertilizer in agricultural land improves soil fertility and crop productivity because the waste is rich in organic matter and serves as important nutrient for plants. However, it may increase the level of potentially harmful trace metals in both soil and crop. Harmful effects of wastes when used as organic fertilizer generally come from lack of consistency because the materials are so variable that the farmers cannot estimate the level of nutrient requirement of plants to apply while plants on the other hand vary in their up-take of heavy metals. The unique role of soils in influencing the management and use of other resources particularly, the use using municipal solid waste as organic input validates the efforts towards integrated resource management. The spotlight on sustainable practices for preserving life on earth has advocated positive influence on resource recovery from waste and ultimately, in viewing ‘waste’ as a resource (Hettiarachchi and Ardakanian, 2016). One major requirement for successful and sustainable agriculture is adequate knowledge of nutrients requirement of crops for proper growth and development.

Crops response to wastes application is highly variable and depending on the type and composition of the waste (Gramatica *et al*., 2006), crop variety and tolerance level, climatic condition, character of the receiving soil and crop and management practices. Implications of heavy metal contamination of food crops are in two folds; first, it shows that the crops which recorded high level of contamination can be key in verification of heavy metal contaminated cropping systems. Second, consumers of heavy metal contaminated vegetable are associated with potential health risks.

CONCLUSION AND RECOMMENDATION

The main objective of organic input in agricultural soils is to maximize yield and utilize waste resources with the greatest efficiency, safety and sustainability. As a common practice in the study area where direct land application of raw waste is practiced, the organic waste proved beneficial or detrimental depending upon how wisely they are used and upon waste characteristics. This is because one waste may provide valuable nutrients and improve soil productivity if applied appropriately or damage soil productivity and possibly contaminate water resource if applied inappropriately. Another waste material may benefit one cropping system and harm another, while some waste may contain some valuable nutrients but also contain high levels of heavy metals.

From this study, substantial differences in level of metal concentration were observed in each of the five vegetable samples. Metals such as Fe, Cu and Mn were present in adequate concentrations while the concentrations of Zn, Pb and Ni are high. The sustainable use and management of soils is linked to many different areas of sustainable development. Therefore, promoting proper nutrient management strategy should be adopted especially for these nutrients as they contribute to healthy soils and thus eradicating hunger, food insecurity and promote stable ecosystems. To reduce health risks in vegetable and other food crop with high heavy metal content, the crops should be thoroughly washed to remove as much soil as possible while outer leaves of leafy greens like cabbage should be removed to reduce risk.

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ABOUT THE AUTHORS Samuel Yakubu, Department of Geography, Osun State University, Osogbo, Nigeria.

Sani Abubakar Mashi, Department of Geography, University Abuja, Nigeria.