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Evaluation of some Heavy Metals in Wetland Soil and Vegetable Sorrel *(Hibiscus sabdariffa (l.)* Cultivated in Mubi North Local Government Area, Adamawa State

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Abstract
This research aims at assessing the level of some heavy metals (Cu, Ni, Pb) contamination in wetland soil and vegetable sorrel (*Hibiscus sabdariffa*) cultivated in Mubi North Local Government Area and to ascertain the danger it may pose to human health from the consumption of the Vegetable. Soil and Vegetable (*H. sabdariffa)* samples were collected from six locations, (Digil, Muchalla, Mayo-bani, Betso, Muva and Gada) prepared using double acid extraction method and analyzed using Bulk Scientific Atomic Absorption Spectrophotometer (AAS). The concentration of heavy metals in wetland soil of the study area ranged from 5.138 to 8.160 mg/kg for Cu, 0.198 to 1.232 mg/kg for Ni and 0.153 to 0.457 mg/kg for Pb while the concentrations of heavy metals in vegetable (*H. sabdariffa*) ranged between 0.577 to 2.046 mg/kg for Cu, 0.000 to 0.015 mg/kg for Ni and 0.013 to 0.044 mg/kg for Pb. The mean heavy metals concentration obtained both for soil and vegetable in the six locations in Mubi North Local Government Area were below the permissible or recommended limits presented by the WHO/FAO (2007) Standard. The limits imply that vegetable *H. sabdariffa* is safe for consumption. Copper, Nickel and Lead are below the critical range and will have no negative effect on soil, plant and environment.

Keywords: Copper, Nickel, Lead, Roselle and wetland

Introduction

Heavy metals are generally referred to as those metals which possess specific density of more than 5 g/cm^3 and adversely affect the environment and living organisms (Järup, 2013). They, are important constituents for plants and humans, when present only in small amount. Some micronutrient elements may also be toxic to both animals and plants at high concentrations. For instance, copper (Cu), chromium (Cr), fluorine (F), molybdenum (Mo), nickel (Ni), selenium (Se) or zinc (Zn). Other trace elements such as arsenic (As), cadmium (Cd), mercury (Hg) and lead (Pb) are toxic even at small concentrations (Divrikli *et al*., 2016). Heavy metals, being persistent and non-biodegradable, can neither be removed by normal cropping nor easily leached by rain water (Khadeeja *et al.*, 2013). They may be translocated from soil to ground waters or may be taken up by plants, including agricultural crops. For this reason, the knowledge of metal-plant interactions is also important for the safety of the environment (Divrikli *et al.*, 2016). Heavy metal toxicity to living organisms can be arranged in the following order; Cu>Ni>Pb (Filipiak-Szok *et al*., 2015).

There has been increasing interest in determining heavy metal levels in public food supplied. However, their concentration in bio-available form is not necessarily proportional to the total concentration of the metal (Nwachukwu *et al.*, 2010). These activities are one of the most pressing concerns of urbanization in developing countries like Nigeria, which result in the problem of management of solid, liquid and toxic wastes. Such waste may be toxic or radioactive (Onibokun and Kumuyi, 2006 and United Nations Development Programme, UNDP, 2006). Waste management problems include heaps of uncontrolled garbage, roadsides littered with refuse, streams blocked with rubbish, prevalence of automobile workshops and service stations, inappropriately disposed toxic waste and disposal sites that constitute health hazard to residential areas (Rotich *et al.,* 2016; Ebong *et al*., 2018).

The occurrence of uncontrolled urban sewage farming is a common site in African cities which exposes consumers of such produce to poisoning from heavy metals (Ebong *et al.,* 2018). Open dumps are a source of various environmental and health hazards. The decomposition of organic materials produces methane, which may cause explosions and produce leachates, which pollute surface and ground waters. It also ruins the aesthetic quality of the land (Oyelola *et al.,* 2009). Automobile wastes include solvents, paints, hydraulic fluids, lubricants and stripped oil sludge. Other activities include battery charging, welding and soldering, automobile body works engine servicing and combustion processes (Adewole and Uchegbu, 2010; Utang *et al.,* 2013).
Soil is one of the most important component of the environment that is most undervalued, misused and abused (Gokulakrishnan and Balamurugan, 2010). Soil is equally regarded as the ultimate sink for the pollutants discharged into the environment (Shokoohi *et al.,* 2019). Most plants and animals depend on soil as a growth and development. In many instances the sustenance of life in the soil matrix is adversely affected by the presence of deleterious substances or contaminants. The contamination of soils with heavy metals or micronutrients in phytotoxic concentrations generates adverse effects not only on plants but also poses risks to human health (Murugesan *et al.,* 2008).

The consumption of contaminated vegetables constitutes an important route of heavy metal exposure to animals and humans (Sajjad *et al.,* 2019; Tsafe *et al.,* 2012). Abandoned waste dumpsites have been used extensively as fertile grounds for cultivating vegetables, though research has indicated that the vegetables are capable of accumulating high levels of heavy metals from contaminated and polluted soils. It is for this reason that this work was initiated to evaluate and assess the status of heavy metals in wetland soils and their concentrations in vegetable (*H. sabdariffa)* in Mubi north local government area of Adamawa state.

Materials and Methods

The study sites are Digil, Muchalla, Mayobani, Betso, Muva and Gada irrigation sites in Mubi North Local Government Area of Adamawa State. Mubi north is located between latitude 9^{o} 40' N and 10^{o} 30' N of the equator and longitude 13^{o} 00' E and 13^{o} 32' of the prime meridian and has an elevator of 1906 above sea level (Fig. 1). Mubi lies on the west bank of Yadzaram River a stream that flows into Lake Chad and is situated on a western flanks of Mandara Mountain. The area falls under the Sudan Savannah belt of Nigeria Vegetation. Soil samples were collected from each farm (irrigation sites) randomly taken at soil depth of 0-15 cm from three spots within the farm using soil auger. Plants were also randomly sampled in three spots within the same farm to get a representative sample.

Soil and Plant Sample Treatment and Analysis

The soil samples were spread on plates and then dried in the oven at 105^{0} C for six hours. The dried samples were grounded and sieved through 2 mm mesh sieve. Five gram each of the samples were weighed into 100 ml plastic bottle and 25 ml of extraction reagents (0.05M HCl in 0.0125M H_2SO_4) were added, shaked for 15 minutes on the orbital shaker at minimum of 180 oscillations/minute (Double acid extraction method)**.** The suspension was filtered through whatman No. 42 filter paper. The filtrate was analyzed to determine Cu, Ni, and Pb calorimetrically using (AAS) (Baker and Amacher, 1982).

Five grams of sample were weighed into 'high form' porcelain crucibles. The crucible with sample were placed into a muffle furnace and temperature was gradually increased until temperature reached 550^{0} C. The sample was ashed untill white or gray ash was observed in the crucible. The ash was dissolved by adding 2 ml of concentrated nitric acid (HNO_3) to the crucible. The dissolved ash was transferred into 100 ml volumetric flasks, shaken, filtered and diluted to volume with distilled water. The samples were analyzed using Atomic Absorption Spectrophotometer with specific lamps for heavy metals (AOAC, 2010). Data obtained were subjected to analysis of variance (ANOVA) (SAS, 2010) and means were separated using Duncan's Multiple Range Test (DMRT)

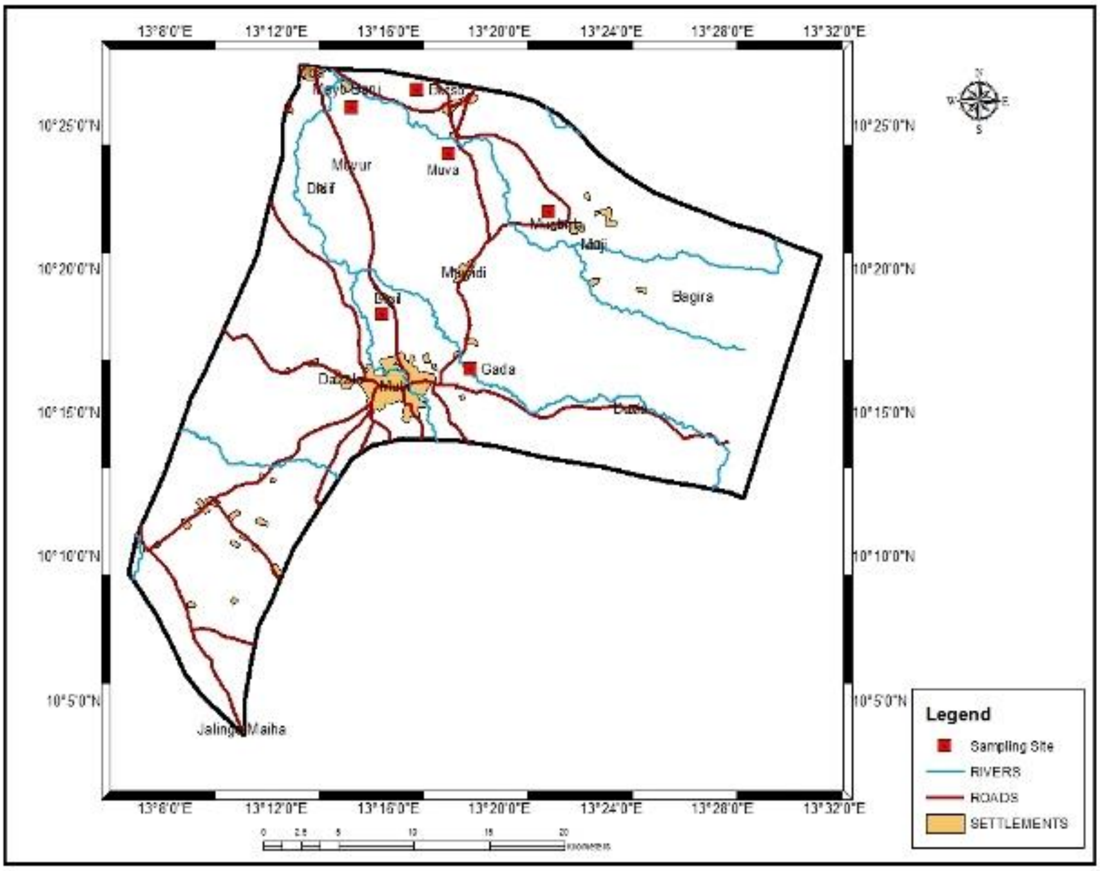

Figure 1: Map of Mubi North LGA showing soil and vegetable sampling sites

Results and Discussion

Concentration of Some Heavy Metals in Wetland Soils

The results obtained for heavy metals in agricultural soil were Copper (Cu), Nickel (Ni) and Lead (Pb) and is presented in Table 1. Concentrations of Cu (8.160 mg/kg) was significantly higher in Mayo-bani, followed by Muva, Gada, Muchalla, Betso and Digil with the corresponding value of 7.007, 6.738, 6.137, 5.135 and 5.042 mg/kg, respectively. The higher values obtained in Mayo-bani could be attributed to the use of livestock manure, pesticides and herbicides as suggested in the report of Roozbahani *et al*, 2015. For Ni, the highest value was recorded in Mayo-bani (1.232 mg/kg), which was significantly higher than at Muchalla (0.458 mg/kg), Digil (0.438 mg/kg), Muva (0.328 mg/kg) Betso (0.230 mg/kg) and the least was recorded in Gada (0.198 mg/kg) in the order of Mayo-bani>Muchalla>Digil>Muva>Betso>Gada. The highest value of Pb was obtained from Mayo-bani (0.457 mg/kg), followed by Digil (0.277 mg/kg), Betso (0.253 mg/kg), Mucalla (0.208 mg/kg), Gada (0.158 mg/kg) and lowest was in Muva with the mean value of 0.153 mg/kg (Mayo_bani>Digil>Betso>Muchalla>Muva). Thus, the concentration of Cu ranged from 5.042±0.026 to 8.160±0.005 mg/kg, Ni from 0.198±0.005 to 1.232±0.006 mg/kg and Pb from 0.158±0.004 mg/kg. Accumulation of these heavy metals at different concentrations may be attributed to natural content in the environment (Zwolak *et al*., 2019) and long time use of fertilizers and pesticides as advanced by Kumar *et al*. (2015) and Rodriquosa *et al*. (2017).

Table 1: Mean Concentration of heavy metals (mg/kg) in soil at different site in Mubi North Local Government Area.

Site	Cu (mg/kg)	Ni (mg/kg)	Pb (mg/kg)
Betso	5.135±0.005[e]	0.230±0.006[e]	0.253±0.004[c]
Digil	5.042±0.026[f]	0.438±0.007[c]	0.280±0.003[b]
Gada	6.738±0.007[c]	0.198±0.005[f]	0.158±0.004[e]
Mayo-bani	8.160±0.005[a]	1.232±0.006[a]	0.457±0.004[a]
Muchalla	6.137±0.008[d]	0.455±0.003[b]	0.208±0.007[d]
Muva	7.007±0.004[b]	0.328±0.005[d]	0.153±0.002[e]
LS	***	***	***
WHO/ FAO (2007)	40	35	10

LS=Level of Significance *n = 18*
* = Significant at 0.1% Level of probability of triplicate determination.

***Concentration Levels of Some Heavy Metals in Sorrel* (*Spinacia oleracea* (L).**

Heavy metals concentration in Roselle (*Spinacia oleracea* (L)) at different location is presented in Table 2. The analysis shows that Mayo-bani had the highest concentration of Cu (2.064 mg/kg), which is significantly higher than the values obtained at Digil (1.242 mg/kg), Gada (0.928 mg/kg), Muchalla (0.858 mg/kg) and the lowest was recorded in Muva (0.577 mg/kg). Thus Cu concentration ranged from 0.577±0.008 to 2.064±0.018 mg/kg. The value of Cu in the study area was far below the permissible limit of 40 mg/kg recommended by WHO/FAO (2007) and the concentrations vary significantly (P>0.05). The value of Nickel (Ni) obtained from all the site ranged from 0.004±0.002 to 0.015±0.00[E] mg/kg. The highest value was recoded from Mayo-bani and the lowest from Betso. The higher concentrations of these metals in vegetable in Mayo-bani coincides with their higher concentrations in the soil. These could also be attributed to anthropogenic causes as advanced by Roozbahani *et al*, 2015. The concentrations of Ni was beyond detection in Digil, Gada and Muva. The concentration of Pb ranged from 0.013±0.00[E] to 0.044±0.001 mg/kg. The highest was recorded from Mayo-bani and the lowest from Muva.

Table 2. Mean concentration of heavy metals (mg /kg) in Sorrel (*Spinacia oleracea* (L)) the different site in Mubi North Local Government Area.

Site	Cu (mg/kg)	Ni (mg/kg)	Pb (mg/kg)
Betso	0.622±0.014[e]	0.004±0.002[c]	0.014±0.001[c]
Digil	1.242±0.005[b]	0.000±0.000[d]	0.032±0.000[b]
Gada	0.928±0.007[c]	0.000±0.000[d]	0.025±0.000[c]
Mayo-bani	2. 064±0.018[a]	0.015±0.000[a]	0.044±0.001[a]
Muchalla	0.858±0.005[d]	0.012±0.000[b]	0.015±0.000[d]
Muva	0.577±0.008[f]	0.000±0.000[d]	0.013±0.000[f]
LS	***	***	***
WHO/ FAO (2007)	40	10	0.3

LS=Level of Significance
*** = Significant at 0.1% Level of probability of triplicate determination

The concentration of Cu, Ni and Pb in vegetable is a function of the concentration of same in the soil (Table 3). The strength of this relationship is more with Pb followed by Ni then Cu with corresponding R^2 of 0.6667, 0.5422 and 0.2954, respectively. Similar report was advanced by Zwolak *et al*. 2019 shows that mineral content of vegetables depends on factors such as mineral content of trace elements in the environment including the soil.

Table 3: Regressed significant correlation coefficients of heavy metals in soil and vegetable

Parameters in regression	Regression equation	R^2
Cu in soil x Cu in vegetable	y = 0.2522x - 0.5581	0.2954
Cu in soil x Ni in vegetable	y = 0.0031x - 0.0139	0.2764
Cu in soil x Pb in vegetable	y = 0.0047x - 0.0064	0.2040
Ni in soil x Ni in vegetable	y = 0.0136x - 0.0015	0.5422
Ni in soil x Pb in vegetable	y = 0.0261x + 0.0113	0.6343
Pb in soil x Pb in vegetable	y = 0.0907x + 0.001	0.6667
Cu in soil x Ni in soil	y = 0.2136x - 0.8806	0.4416
Cu in soil x Pb in soil	y = 0.0339x + 0.0355	0.1284
Ni in soil x Pb in soil	y = 0.266x + 0.1239	0.8152

Conclusion

Based on the result of the study, it is concluded that the concentration of heavy metals Copper, Nickel and Lead in soil and in the respective leafy vegetable Sorrel (*H. sabdariffa* (L) were below WHO/FAO critical limits implying they are of good quality and safe for consumption. Therefore, regular monitoring to control the accumulation of these heavy metals should be carried out.

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