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Levels of Selected Heavy Metals and Physicochemical Parameters in Soils and Watermelon Samples from Mainok Farmland, Kaga L.G.A, Borno State, Nigeria

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ABSTRACT

The study was conducted to determine the concentrations of some heavy metals (Cd, Pb, Cu, Ni, Mn, Fe, Zn and Co); and Ions (NO_3^-, NO_2^-, PO_4^{-3}, SO_4^{-2}, K^+, Na^+, Ca^{2+} and Mg^{2+}); in seed, pulp, leaves, stem and root of watermelon varieties (sugar baby and crimson sweet) and soil at different depth (0-10 cm, 10-20 cm and 20-30 cm from Mainok in Kaga local government area. All parameters were analyzed using standard analytical tools (Atomic Absorption and UV visible smart spectrophotometer). The result also showed that iron has the highest concentration in all the samples analysed, while lead showed the least concentration in watermelon pulp from Minok agricultural location in all the samples analyzed. The levels of the heavy metals were found to increase significantly ($p<0.\ 05$) to depth of 30 cm. The concentrations of all the parameters analyzed were below the threshold limits set by W.H.O. Thus, the soil of Mainok, Kaga Local Government Area of Borno State may not impact pose immediate health hazard to the general populace via consumption of watermelons from the study area.

Keywords: Borno; Heavy Metals; Ions; Mainok; Nigeria, Watermelon

INTRODUCTION

Watermelon (*Citrullus lunatus*), an annual plant of the *Cucurbitaceae* family, is one of the most cultivated and consumed crops in the world (Huh *et al.*, 2008). The global consumption of watermelon is greater than any other cucurbit with China leading in its production followed by Turkey, United States, Iran and Republic of Korea (Huh *et al.,* 2008). There are over 1,200 varieties of watermelons worldwide with wide variety of watermelons being cultivated in Africa (Zohary and Hopf, 2000). Several of these varieties have been recommended and they include Sugar-baby, Crimson Sweet (Zebra), Charleston Grey, Chilean black, Congo, Fairfax and Tom Watson (Tindall, 1983).

Watermelon is an important fruit which is highly nutritious and has clinical value. It is majorly consumed especially in the hot weather due to its high levels of water and sugar which can help to reduce the risk of dehydration in the body (Oyinloye *et al.*, 2021). It has been reported that watermelon has ability to reduce the formation of kidney stones and bone loss due to aging. Watermelon contains amino acids and beta carotene which reduces the risk of heart disorders. Naturally watermelons contain large amount of coloring substance lycopene which protects infection of urinary and mouth tumors. The cotyledons of watermelons contain suitable quantities of metals like Na, Mg, P, K, Ca, Mn, Fe, Cu and Zn that is necessary for body development and metabolic process of living organisms (Gwana *et al*., 2014).

Metals are substances which are good conductors of heat and electricity and can be changed into different forms and wires. Heavy metals are the type of metals which possess high toxicity and density ($>5g/cm^3$). Suitable quantity of metals is required for both plants and animals for their survival. Intake of high quantity of heavy metals can lead to severe diseases or abnormalities (Jaishankar *et al.*, 2014). The main task for researchers and nutritionists is to analyse toxic metals in various consumable products including fruits, vegetables, medicinal plants, meat and water. For healthy diet, it is necessary to monitor concentration of toxic metals in fruits and vegetables. Minerals are needed in a suitable quantity for metabolism and growth of body and are crucial in production of vitamins, minerals and fibres (Salvatore *et al*., 2009). Naturally metals are found in earth crust while contamination of food occurs due to human activities such as; use of chemical sprays, contaminated water, mining, fertilizers and industrial wastes (Lugwisha and Othman, 2014). Khan *et al*. (2019) reported the contamination of watermelons and vegetables due to the exposure of these food products to heavy metals. The use of fertilizer, pesticide, herbicides and other organic manure in control of weeds and to supply nutrients to the soil to improve crop yields has led to increase in pollutants level in soil, fruits and other plant materials.

The intake of heavy metals can be detrimental the health of both humans and animals. Thus, reported carcinogenic effects generated by continuous consumption of fruits and vegetables accumulated with heavy metals such as Cd and Pb are known. There are existing scientific reports associating heavy metals to gastrointestinal cancer (Tricopoulas, 1997; Turkdogan *et al.,* 2002), and cancer of the pancreas, urinary bladder or prostate (Waalkes and Rehm, 1994).

Kaga Local Government Area of Borno State is known for farming activities. The major occupation of the people in the local government areas is farming. They make use of fertilizer and organic manure in improving crop yield, and this has led to increase in accumulation of heavy metals and other pollutants in the soil and other plant materials. Heavy metals accumulation in soils is of concern in agricultural production due to the adverse effects on food quality, crop growth (Akan *et al*., 2013) and environmental health. Plant species have a variety of capacities in removing and accumulating heavy metals. There are reports indicating that some plant species may accumulate specific heavy metals (Santamaria, 2006). The uptake of metals from the soil depends on different factors, such as their soluble content in it, soil pH, plant species, fertilizers, and soil type (Yusuf and Oluwole, 2009). Hence, the need to evaluate the presence of these heavy metals and ions in the soil and watermelon samples cultivated in Kaga Local Government Area of Borno State.

MATERIALS AND METHODS

Sample Location and Sampling

Sampling Area

Mainok is a village in Kaga Local Government Area located in Borno State, Nigeria. It has its headquarter in the town of Benisheikh. It is located at about 72 Km North of Borno State Capital. It has an area of 2,700 km² and a population of 90,015 at the 2006 census. It is one of the sixteen LGAs that constitute the Borno Emirate, a traditional state located in Borno State, Nigeria. The major occupation of people in this area is farming.

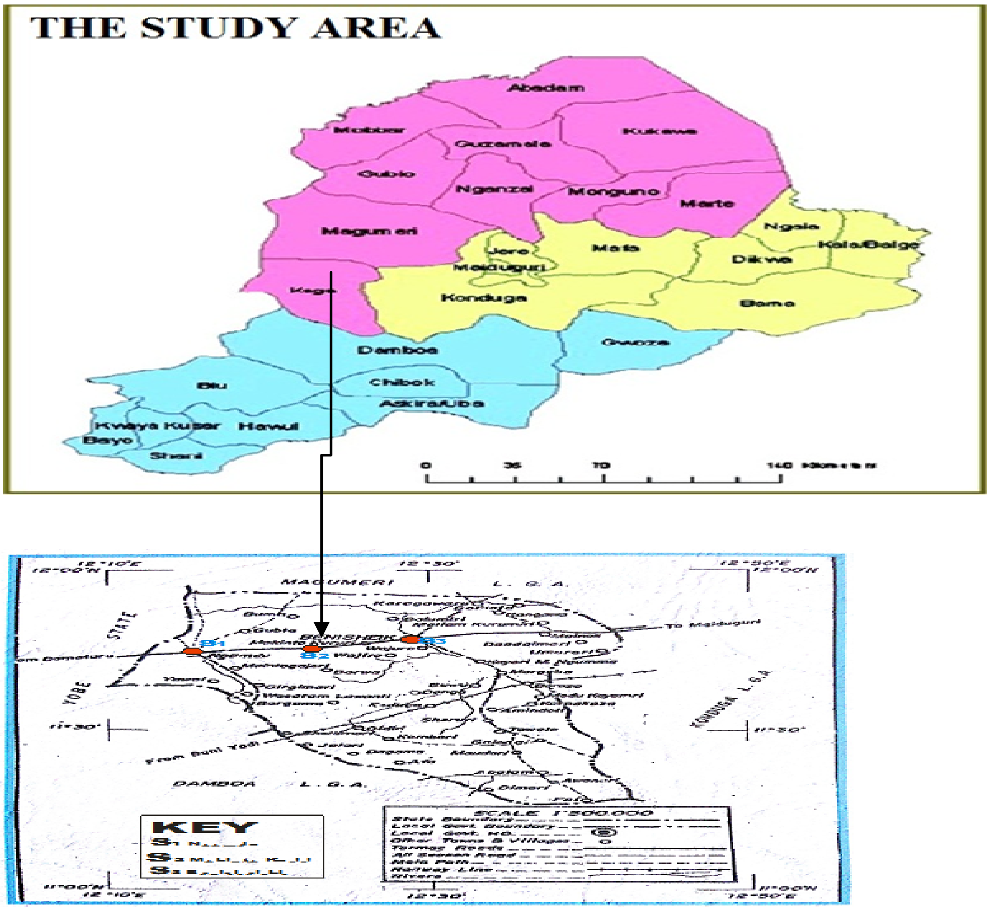

Figure 1: Map of Borno State showing Mainok Sampling Area

Sample Collection

Soil samples at depth (0-10 cm, 10-20 cm and 20-30 cm) were collected from the agricultural location. Five points were identified 200 meters away from each other at the sampling location. Soil samples collected from these points were pulled together to form a representative sample. Soil samples from elevated, non-residential, non-farmland location were collected as control. Fresh leaves, stem, root and a total of 108 fresh, ripe fruits of two different varieties of water-melon (crimson and sugar baby) were collected from Mainok agricultural location of Kaga Local Government Areas of Borno State, Nigeria. At the sample location, samples were collected once, weekly for the period of three months. Watermelon and soil samples were put in clean polythene bags, labelled with identification numbers and transported to chemistry research laboratory, University of Maiduguri for preparation and analysis.

Digestion of Soil Samples

Two grammes (2 g) of the soil samples were weighed into acid washed glass beaker. Soil samples were digested by the addition of 20mL of aqua regia (HCl and HNO_3, ratio 3:1) and 10mL of 30% hydrogen peroxide (H_2O_2). The hydrogen peroxide (H_2O_2) was added in small portions to avoid any possible overflow leading to loss of material from the beaker. The beakers were covered with watch glass, and heated over a hot plate at 90^oC for two hours. The beaker wall and watch glass were washed with distilled water and the solutions were filtered out to separate the insoluble solid from the supernatant liquid. The volumes were adjusted to $100cm^3$ with distilled water (Radojevic and Bashkin, 1999).

Digestion of Watermelon Samples

The watermelon samples were weighed to determine the fresh weight and dried in an oven at 110°C for 72 hr to determine their dry weight. The dry samples were crushed in a mortar and the resulting powder digested by weighing one grams (1 g) of oven-dried ground and sieve (<1 mm) into an acid-washed porcelain crucible and placed in a muffle furnace for four hours at 500°C. The crucibles were removed from the furnace and cooled. 10 mL of 6 M hydrochloric acid (HCl) was added covered and heated on a steam bath for 15 minutes. Another 1 mL nitric acid (HNO_3) was added and evaporated to dryness by continuous heating for 1 hr to dehydrate silica and completely digest organic compounds. Finally, 5 mL of 6 M HCl and 10mL of water were added and the mixture was heated on a steam bath to complete dissolution. The mixture was cooled and filtered through a Whatman filter paper up to the mark in a 100 mL volumetric flask with distilled water (Schirado *et al.*, 2012).

Elemental Analysis of Samples

Determination of Cu, Zn, Co, Mn, Fe, Cd, Ni and Pb were made directly using Perkin-Elmer Analyst 300 Atomic Absorption Spectrophotometer.

Determination of pH, EC, Organic Carbon and Ions

The pH, electrical conductivity and ions (nitrite and nitrate, sulphate, sodium, potassium, calcium and magnesium ions were analysed using the method described by Radojevic and Bashkin (1999).

Data Handling

Data collected were subjected to one-way analysis of variance (ANOVA) to assess whether heavy metals and ions varied significantly between watermelon and soil samples. Probability less than 0. 05 ($P < 0.05$) were considered statistically significant. All statistical calculations were performed using Graphpad Prism (2016) for windows. Results were presented in mean ± standard deviation.

RESULTS

Concentration of Some Heavy Metals and Ions in Two Watermelon (Sugar baby and Crimson sweet) and Soil Samples from Mainok

Table 1 presents mean concentration of heavy metals in soil sample from Mainok agricultural farm location, Kaga Local Government area, Borno State. The results revealed that concentrations of heavy metals differ with depth in the order of 0-10 cm < 10-20 cm < 20-30 cm. Iron showed the highest concentration in depth profile of 20-30 cm. The highest concentration of zinc was 0. 82 ± 0. 17 µg/g at depth of 20-30 cm and the least concentration of lead was 0. 04 ± 0. 01 µg/g at depth profile 0-10 cm. The overall total concentrations of heavy metals determined were in the following order; Zn >Fe > Cu > Ni >Mn> Co > Cd >Pb.

Table 2 presents the mean value of some physicochemical parameters in the soil samples from Mainok agricultural location, Kaga Local Government area, Borno State. The result revealed that pH values were 6.40 ± 0.56, 5.62 ± 0.49 and 5.34 ± 0.52 at the depths of 0-10cm, 10-20 and 20-30cm respectively, which indicates that the soil is acidic. The soil samples had moderate level of organic matter ranging between 16.30 ± 2.45 to 1.68 ± 0.09 (%). This implies that the soil samples were rich in humus and indicate soil is very fertile. Organic carbon ranges between 0.23 ± 0.11 to 0.91 ± 0.20 (%). The electrical conductivity ranging between 34. 05 ± 3. 61 µS/cm to 51.85 ± 4.61 µS/cm which indicate the total soluble salt in the soil. It shows that soil sample have moderate salinity effect.

Table 3 presents the mean concentration of anion and cation in soil samples from Mainok

agricultural farm location, Kaga Local Government Area, Borno State. The results revealed that the concentration of ions in soil differ with depth in the order 0-10 cm < 10-20 cm < 20-30 cm. The result of the ions analyzed showed that sodium has the highest concentration. The concentration of sodium was 84.60 ± 0.25 µg/g at depth profile 20-30 cm while potassium showed the least concentration of 0.24 ± 0.10 µg/g at depth profile 0-10 cm. The order of concentration of ions were $Na^{+} > Ca^{2+} > Mg^{2+} > SO_4^{2-} > NO_3^{-} > NO_2^{-} > PO_4^{-} > K^{+}$.

Table 1: Mean Concentration of Heavy Metals (μg/g) in Soil Sample at Varying Depth from Mainok Agricultural Location.

Depth	Cd	Pb	Cu	Ni	Mn	Fe	Zn	Co
0-10 cm	$0.10^a \pm 0.02$	$0.04^a \pm 0.01$	$0.24^a \pm 0.03$	$0.17^a \pm 0.08$	$0.17^a \pm 0.09$	$0.43^a \pm 0.13$	$0.28^a \pm 0.02$	$0.14^a \pm 0.06$
10-20 cm	$0.12^b \pm 0.03$	$0.05^b \pm 0.01$	$0.45^b \pm 0.04$	$0.37^b \pm 0.03$	$0.26^b \pm 0.06$	$0.69^b \pm 0.25$	$0.34^b \pm 0.08$	$0.20^b \pm 0.09$
20-30 cm	$0.14^c \pm 0.03$	$0.08^c \pm 0.03$	$0.56^c \pm 0.04$	$0.55^c \pm 0.04$	$0.24^c \pm 0.08$	$0.69^c \pm 0.25$	$0.82^c \pm 0.17$	$0.43^c \pm 0.26$
Control								
0-10 cm	$0.06^a \pm 0.02$	$0.03^a \pm 0.01$	$0.05^a \pm 0.01$	$0.12^a \pm 0.01$	$0.16^a \pm 0.05$	$0.54^a \pm 0.05$	$0.41^a \pm 0.06$	$0.10^a \pm 0.09$
10-20 cm	$0.10^b \pm 0.03$	$0.04^b \pm 0.01$	$0.15^b \pm 0.02$	$0.14^b \pm 0.04$	$0.21^b \pm 0.06$	$0.58^b \pm 0.08$	$0.48^b \pm 0.03$	$0.10^b \pm 0.06$
20-30 cm	$0.13^c \pm 0.01$	$0.17^c \pm 0.02$	$0.19^c \pm 0.02$	$0.19^c \pm 0.04$	$0.36^c \pm 0.05$	$0.23^c \pm 0.04$	$0.64^c \pm 0.09$	$0.24^c \pm 0.05$
WHO (1999)	0. 2	0. 3	40	10	10	20	50	10

Values presented are in Mean ± SD. Within the column, paired mean with different alphabets are statistically significant ($p < 0.05$).
Key: SD = Standard deviation

Table 2: Mean value of some Physicochemical Parameters in Soil Sample at varying Depth from Mainok Agricultural Location.

Depth	pH	OC (%)	OM (%)	EC (μS/cm)
0-10 cm	$6.40^a \pm 0.56$	$0.23^a \pm 0.11$	$16.30^a \pm 2.45$	$44.05^a \pm 3.61$
10-20 cm	$5.67^b \pm 0.49$	$0.73^b \pm 0.08$	$2.58^b \pm 0.09$	$74.25^b \pm 3.88$
20-30 cm	$5.34^c \pm 0.52$	$0.91^c \pm 0.20$	$1.68^c \pm 0.09$	$99.85^c \pm 4.61$
Control				
0-10 cm	$6.32^a \pm 0.11$	$0.15^a \pm 0.02$	$0.10^a \pm 0.07$	$17.27^a \pm 5.96$
10-20 cm	$6.50^b \pm 0.19$	$0.16^b \pm 0.09$	$0.14^b \pm 0.06$	$31.23^b \pm 9.65$
20-30 cm	$6.70^c \pm 0.26$	$0.19^c \pm 0.08$	$1.18^c \pm 0.81$	$80.64^c \pm 2.06$

Values presented are in mean ± SD. Within the column, paired mean with different alphabets is statistically significant ($p < 0.05$).
Key: SD Standard deviation, OM Organic Matter, OC Organic Carbon, EC Electrical Conductivity

Table 3: Concentration Mean of Cation and Anion (μg/g) in Soil Sample at varying Depth from Mainok Agricultural Location.

Depth	NO_3^-	NO_2^-	SO_4^{2-}	PO_4	K^+	Ca^{2+}	Na^+	Mg^{2+}
0-10 cm	$2.49^a \pm 0.44$	$1.36^a \pm 0.33$	$3.23^a \pm 0.59$	$1.42^a \pm 0.20$	$0.12^a \pm 0.10$	$55.51^a \pm 5.96$	$72.22^a \pm 0.08$	$21.71^a \pm 5.50$
10-20 cm	$3.63^b \pm 1.19$	$1.55^b \pm 0.38$	$4.76^b \pm 0.51$	$1.64^b \pm 0.34$	$0.24^b \pm 0.08$	$59.98^b \pm 4.06$	$73.26^b \pm 0.11$	$23.87^b \pm 5.58$
20-30 cm	$4.13^c \pm 1.07$	$2.62^c \pm 0.65$	$5.55^c \pm 0.94$	$2.09^c \pm 1.00$	$0.42^c \pm 0.11$	$68.84^c \pm 5.71$	$84.60^c \pm 0.25$	$26.05^c \pm 5.33$
Control								
0-10 cm	$0.19^a \pm 0.04$	$0.13^a \pm 0.04$	$0.13^a \pm 0.05$	$0.19^a \pm 0.21$	$0.10^a \pm 0.01$	$2.59^a \pm 1.32$	$0.11^a \pm 0.06$	$4.90^a \pm 3.37$
10-20 cm	$1.09^b \pm 0.16$	$0.42^b \pm 0.56$	$0.75^b \pm 0.12$	$0.70^b \pm 0.61$	$0.12^b \pm 0.02$	$12.36^b \pm 6.90$	$0.11^b \pm 0.07$	$11.35^b \pm 6.78$
20-30 cm	$1.20^c \pm 0.63$	$1.23^c \pm 0.95$	$1.93^c \pm 0.17$	$0.81^c \pm 0.61$	$0.14^c \pm 0.03$	$14.82^c \pm 1.27$	$0.12^c \pm 0.08$	$13.29^c \pm 1.86$

Values presented are in mean ± SD. Within the column, paired mean with different alphabets are statistically significant ($p < 0.05$).
Key = SD = Standard deviation

Figure 1 and 2 presents the mean concentration of heavy metals in different parts of sugar baby and crimson sweet samples from Mainok agricultural location, Kaga local government area, Borno State. In the sugar baby sample analyzed iron has the highest concentration. The concentration of iron 0.84 ± 0.18 µg/g was higher in the leaves and least in the stem of 0.05± 0.04 µg/g. Lead showed the least concentration of 0.02 ± 0.01 µg/g in pulp. The order of metal concentration in sugar baby sample were Fe > Cd > Ni >Mn> Co > Zn > Cu >Pb. The order of concentration in sugar baby sample were Root < Stem < Seed < Pulp < Leaf. In crimson sweet sample iron showed the highest concentration of 0.85 ± 0.21 µg/g in leaves and the least concentration in pulp of 0.16 ± 0.02 µg/g. Lead showed the least concentration of 0.02 ± 0.01 µg/g in pulp analyzed. The order of concentration of metals were Fe > Co > Zn >Mn> Ni > Cd > Cu >Pb. The order of concentration of heavy metals in crimson sweet sample were Leaf > Stem > Root > Seed > Pulp.

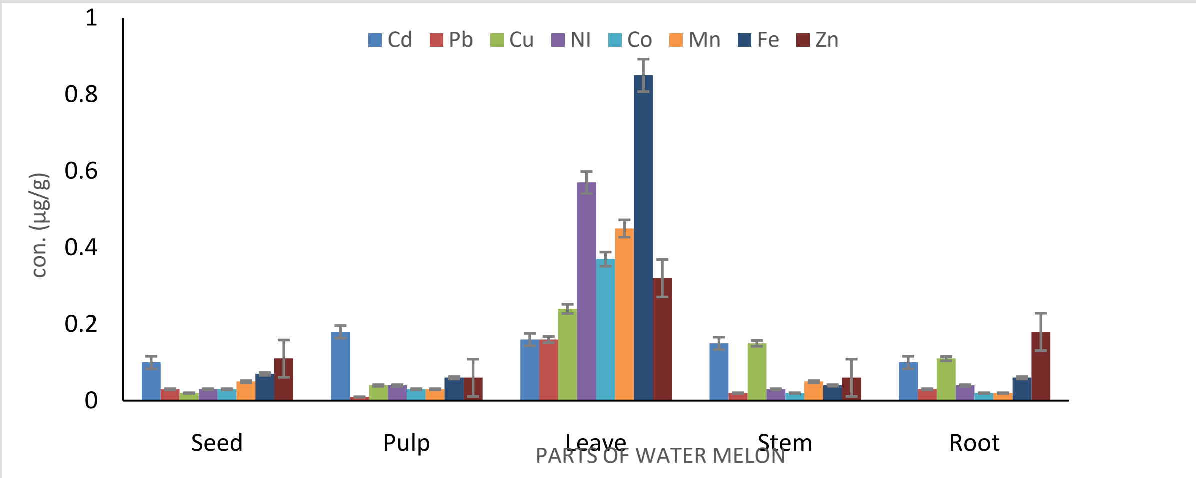

Figure1: Mean Concentration of Heavy Metals (µg/g) in Different Parts of Watermelon Samples(sugarbaby) from MainokAgricultural Location

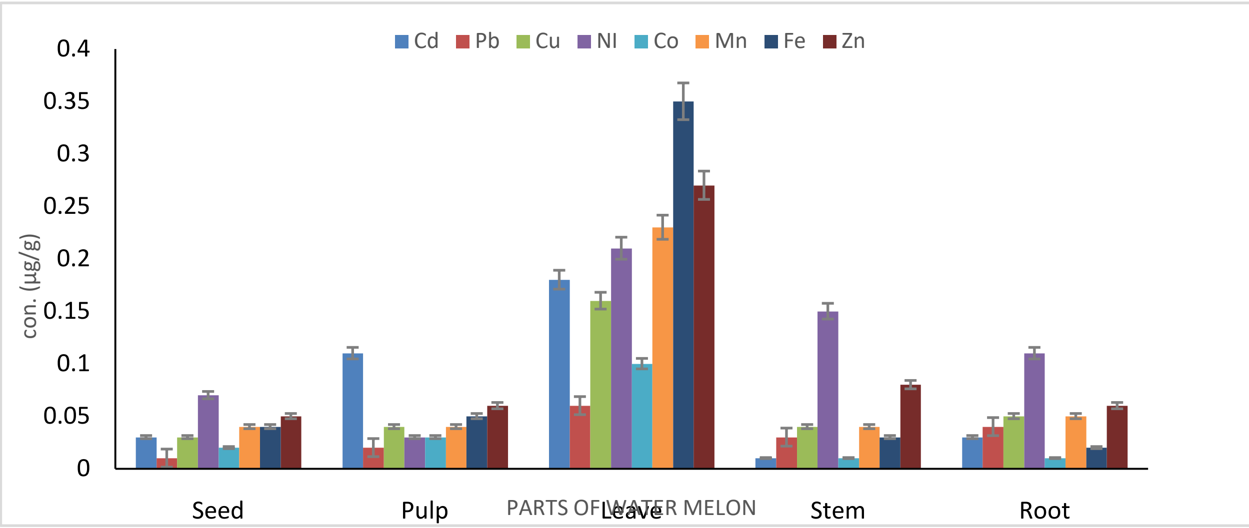

Figure 2: Mean Concentration of Heavy Metals (µg/g) in Different Parts of Watermelon Samples (crimson sweet) from Mainok Agricultural Location

Figure 3 and 4 presents mean concentration of anion and cation in watermelon samples (sugar baby and crimson sweet) from Mainok agricultural location, Kaga local government area, Borno State. The result revealed that in sugar baby sample sodium showed the highest concentration. The concentration of sodium 66.80 ± 20.11 µg/g was highest in the leaves and least in the seed of 24.76 ±8.13 µg/g. Phosphate showed the least concentration of 1. 01 ± 0. 10 µg/g in seed sample analyzed. The order of concentration of ions were Na^{+}> K^{+}> Ca^{2+}> Mg^{2+}> NO_3> SO_4^{2-}> NO_2^{-}> PO_4^{-}.

In crimson sweet sample sodium showed the highest concentration of 56.41 ± 2.14 µg/g in leaves and least concentration in the root of 23.25 ±

3.15 µg/g. Phosphate showed the least concentration of 1.01 ± 0.11 µg/g in crimson sweet root sample analyzed. The order of concentration of ions concentration were Na^{+}> K^{+}> Ca^{2+}> Mg^{2+}> NO_3^{-}> SO_4^{2-}> NO_2^{-}> PO_4^{-}. The order of concentration in all samples analyzed were Leaf > Pulp > Stem > Seed > Root.

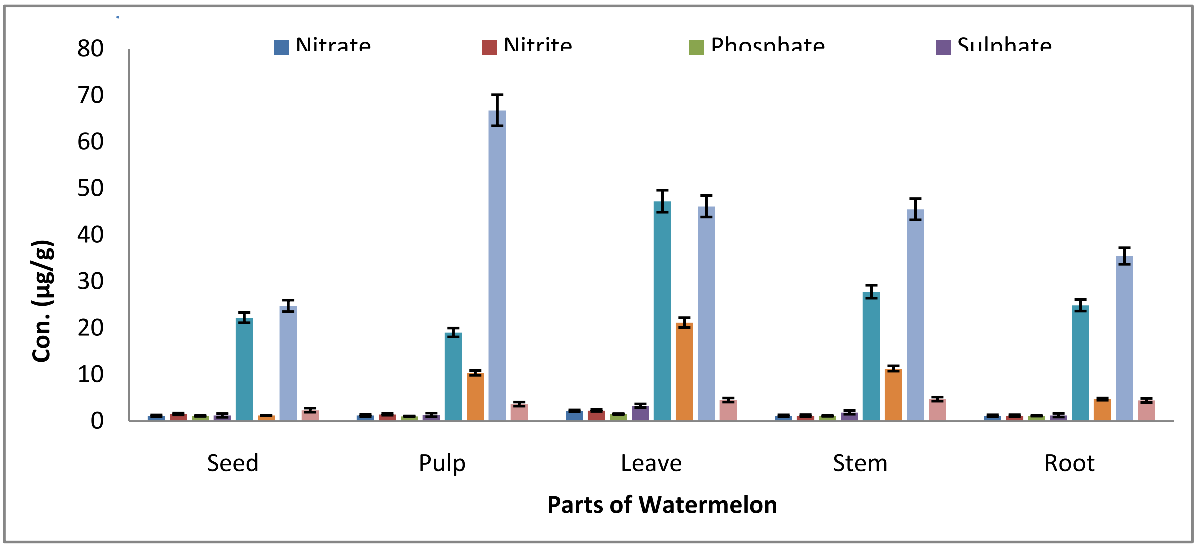

Figure 3: Mean Concentration of Ions (µg/g) in Different Parts of Watermelon Sample (sugar baby) from Mainok Agricultural Location

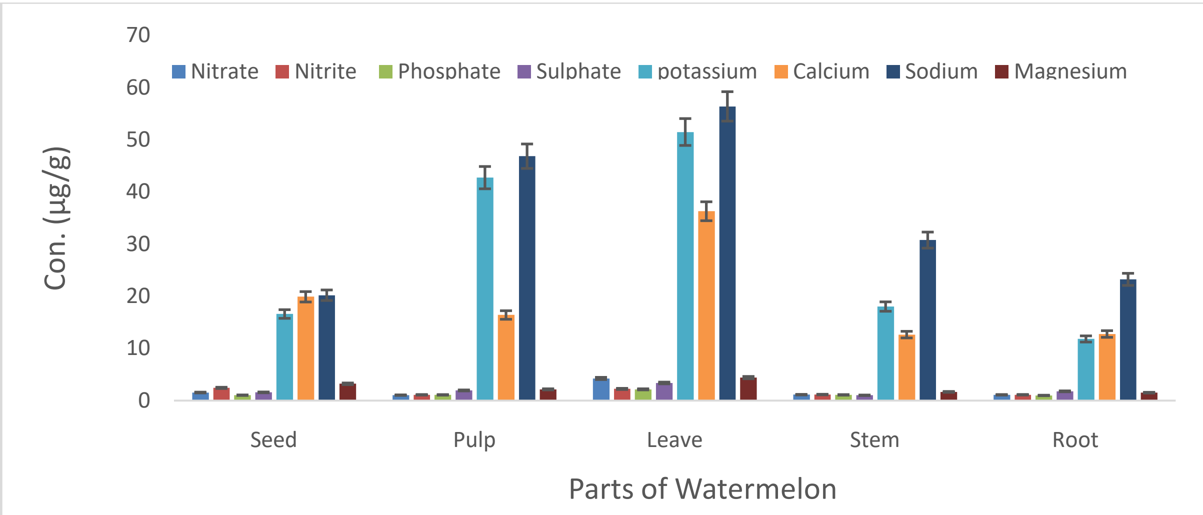

Figure 4: Mean Concentration of Ions (µg/g) in Different Parts of Watermelon Samples (crimson sweet) from Mainok Agricultural Location.

DISCUSSION

This study revealed the presence of some chemical pollutants which can be detrimental to human health. The concentration of lead increases significantly with depth from 0-10 cm, 10-20 cm and 20-30 cm. Among the different parts of watermelon samples, lead is highest in leaves and least in pulp. The concentrations of lead in watermelon are in the order: sugar baby > crimson sweet respectively.

The concentration of cadmium increases significantly ($P>0.05$) with depth from 0-10 cm, 10-20 cm and 20-30 cm. One-way ANOVA showed that the concentration of cadmium is statistically significant at ($P<0.05$). The result of this study also showed that cadmium concentration is found to be highest in leaves of sugar baby plant and least in pulp. The trend of cadmium concentration in samples analyzed were Leaf > Stem > Root > Seed > Pulp. The result showed that the concentrations of cadmium were lower than the WHO (1996) safe limit of 0. 2mg/kg. Cadmium is of particular concern for both plants and animals, as it accumulates more in the leaf, which can be 10-500 times higher than in plants grown in non-polluted environments. The ability of plants to absorb this metal depends on the concentration of Cd of the soil where the plant is grown, and the plants ability to accumulate and translocate. It is also affected by pH, temperature and redox potential, as well as by concentrations of other elements and soil organic matter (Sanita and

Gabbrielli, 1999). Taylor *et al.*(2007) reported that cadmium is a mobile element which is absorbed by roots and transported to stem where it is uniformly distributed to other part of the plant.

Iron is an essential element in human and play a vital role in the formation of haemoglobin, oxygen and electron transport in human body (Perneger *et al.,* 2014). The results of this study revealed that the concentration of iron increases significantly with depth from 0-10 cm, 10-20 cm and 20-30 cm. Among the different parts of watermelon samples analysed, iron was highest in crimson sweet leaf and least in sugar baby root sample. The concentrations of iron in watermelon samples were in the order: crimson sweet > sugar baby respectively. The iron content of the soil and watermelon samples are lower than permissible limit set by WHO (1999) of 20mg/kg so the levels of iron obtained in this study indicated that the watermelon sample is safe for consumption. Statistically, there is a significant difference (p < 0. 05) in levels of iron in soil and watermelon sample analyzed.

The results of this study revealed that concentration of copper in soil increases significantly with depth from 0-10 cm, 10-20 cm and 20-30 cm. Based on the analysis of copper in different parts of two watermelon samples it was observed that crimson sweet leaf had the highest concentration, while the least was observed in sugar baby seed. The concentrations of copper obtained in this study are lower than the permissible limit of 10mg/kg set by WHO (1999). One-way ANOVA showed that there is significant difference (P<0. 05) in the level of copper in soil and watermelon.

The concentration of cobalt in the soil sample increases significantly to a depth from 0-10 cm, 10-20 cm and 20-30 cm. The result of this study also showed that cobalt is highest in sugar baby plant leaf and least in crimson sweet plant pulp. The results are lower than the permissible limit set by WHO (1999) of 10mg/kg. One-way ANOVA revealed that there is a significant different (p<0. 05) in level of cobalt in soil and watermelon samples analyzed.

Manganese is an important plant micronutrient and is required by plants in greatest quantity. Manganese is used in plant as a major contributor to various biological system including photosynthesis, respiration and nitrogen assimilation. The uptake of manganese by humans mainly takes place through food. Excessive manganese concentration in plant tissues can alter various processes, such as enzyme activity, absorption, translocation and utilization of other mineral elements (Salah *et al.,* 2011). The results of this study revealed that concentration of manganese increases significantly to a depth of 20-30 cm. The result of this study also revealed that manganese is highest in sugar baby plant leaf and least in pulp sample. The results are lower than the permissible limit set by WHO (2001). One-way ANOVA revealed that there is a significant difference (p<0. 05) in level of manganese in soil and watermelon samples analyzed.

Nickel is an essential element for plants, but excessive nickel levels in the soil can result in toxicity to plant. Plant can take up nickel through the roots by both diffusion and active transport mechanism (Sharma *et al*., 2009). The concentration of nickel in crimson sweet sample is in the order of leave > stem > root >seed > pulp. That is, the highest concentration was observed in the leave while the pulp showed a least concentration of accumulation. Similarly, sugar baby showed accumulation in the order of leave > root > pulp >stem >seed highest accumulation of in the leave and the lowest in the seed, all the concentration observed were within the threshold limit of WHO (2001). The result of this study also showed a significant different (p<0. 05) in level of nickel in soil and watermelon sample analyzed. A previous study by Orisakwe*et al*. (2012) has also shown the presence of nickel and other heavy metals in fruit sold in Warri South Eastern Nigeria

Zinc is an essential trace metal that despite having no redox activity is particularly involved in many vital physiological events in plants. Fruits growing on heavy metals contaminated soil can accumulate high concentration of zinc and causes serious health risk to consumers (Ladipo and Doherty, 2011). The result of this study revealed that the concentration of zinc increases significantly with depth from 0-10 cm, 10-20 cm and 20-30 cm. The results of this study also revealed the level of zinc in watermelon samples. Zinc showed the highest concentration in crimson sweet leaf and the least concentration of zinc was showed in crimson sweet pulp. Deficiency of zinc can also result from inadequate dietary intake, impaired absorption, excessive excretion or inherited defects in zinc metabolism (Aggett and Harries, 1979). The concentrations of zinc reported in this study are lower than the permissible limit of 50mg/kg set by WHO (1999).

CONCLUSION

The results obtained in this study showed that the soil of the study location was observed to be slightly acidic which may have effect on watermelon grown in Mainok, KagaLocal Government Area of Borno State. The concentrations of heavy metals and ions were found to be higher in leaves and low in pulp and a significant (P<0. 05) difference in levels of heavy metals and ions in soil, root, stem, leaves, pulp and seed of watermelon samples analyzed, but however all the analytes were lower than the WHO (2001) standard. Therefore, consumptions of these watermelons have no health effect on human.

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