



## Research Article

# Assessment of Some Chemical Pollutants in Soil and Watermelon Samples Cultivated in Benisheikh, Borno State, Nigeria

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### ARTICLE INFO:

#### Keyword:

Water melon,  
Heavy Metals,  
Electrical Conductivity,  
Organic Carbon,  
Organic Matter

### ABSTRACT

The study was conducted to determine the concentration of heavy metals (Cd, Pb, Cu, Ni, Mn, Fe, Zn and Co); ions ( $\text{NO}_3^-$ ,  $\text{NO}_2^-$ ,  $\text{PO}_4^{3-}$ ,  $\text{SO}_4^{2-}$ ,  $\text{K}^+$ ,  $\text{Na}^+$ ,  $\text{Ca}^{2+}$  and  $\text{Mg}^{2+}$ ); in seed, pulp, leaves, stem and root of watermelon (sugar baby and crimson sweet) and physical parameters (pH, Electrical Conductivity, Organic Carbon and Organic Matter) in soil at different depth (0-10cm, 10-20cm and 20-30cm from Benisheikh, Kaga LGA, Borno State, for the period of three months. Atomic Absorption and UV visible spectrophotometer were used to analyse the samples obtained for this study. The results of this study showed that the pH of the soil samples ranges from  $4.30 \pm 0.15$  to  $6.40 \pm 0.56$ , revealing that the soils were slightly acidic. Organic carbon values ranges between  $0.23 \pm 0.11$ - $1.55 \pm 0.10$  % and organic matter values ranges between  $16.30 \pm 2.45$ - $4.15 \pm 0.25$  %. Organic carbon and organic matter showed the lowest. The concentration  $0.86 \pm 0.12$   $\mu\text{g/g}$  of iron is the highest in the leaves and least in the stem ( $0.13 \pm 0.02$   $\mu\text{g/g}$ ). Lead showed the least concentration of  $0.02 \pm 0.01$   $\mu\text{g/g}$  in pulp. The levels of Heavy metals increased significantly ( $p < 0.05$ ) based on depth. The ions, calcium and potassium showed the highest concentration in leaves with values  $57.14 \pm 0.02$   $\mu\text{g/g}$  and  $52.22 \pm 0.04$   $\mu\text{g/g}$  while nitrite, phosphate and sulphate showed the lowest concentration in pulp and seed samples analyzed. The concentration of all the parameters analyzed was below the threshold limits set by World Health Organization. Thus, watermelon samples from Benisheikh may not constitute possible health hazard.

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## INTRODUCTION

Watermelons are member of the Cucurbitaceae family of gourds plants, which is classified as *Citrullus lantus*. It is related to the cucumber, squash and pumpkin (Maynard, 2001). The plant is commonly used as a fruit, used as sweetner to enhance our everyday meals. Watermelon is used as a vegetable in counties like China, where it is stir-fried, stewed and often pickled. Pickled watermelon rind is also widespread in Russia (WFO, 2023). Watermelon constitutes an important part of the diet of human being, since they contain carbohydrates, minerals, proteins, as well as vitamins and heavy metals.

Heavy metals are one of a range of important types of contaminants that can be found on the surface and in the tissue of fresh vegetables (Usman *et al.*, 2016). Significant number of elements, such as lead (Pb), cadmium (Cd), nickel (Ni), cobalt (Co), chromium (Cr), Copper (Cu) and Selenium (Se) (IV) can be harmful to plants and humans even at quite low concentrations (Usman and Kolo, 2015). Soil pollution is caused by misuse of the soil, such as poor agricultural practices, disposal of industrial and urban wastes, etc. (Usman *et al.*, 2015). Soil is also polluted through application of chemical fertilizers (like phosphate and Zn fertilizers), and herbicides (Demirezen and Aksoy, 2004). Heavy metal 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. So 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). The accumulation of heavy metals in soils and plants is a rising concern due to the potential human health risks it poses. The

contamination of food chain by such metals is one of the important pathways for the entry of these toxic pollutants into the body of the human. Heavy metal accumulation in plants depends on plant species, and the efficiency of different plants in absorbing metals is evaluated by either plant uptake or soil-to plant transfer factors of the metals (Covelo *et al.*, 2010). Vegetables cultivated in wastewater-irrigated soils take up heavy metals in large enough quantities to cause potential health risks to the consumers. In order to assess the health risks, it is necessary to identify the potential of a source to introduce risk agents into the environment, estimate the amount of risk agents that come into contact with the human-environment (Khan *et al.*, 2008). Human activities which include mining, ultimate disposal of treated and untreated waste discharges effluents containing toxic metals as well as metal chelates from different industries. More so, indiscriminate use of heavy metal-containing fertilizers and pesticides in agriculture resulted in deterioration of water quality rendering serious environmental problems posing threat on human beings. However, some of the metals for example Cu, Fe, Mn, Ni and Zn are essential as micronutrients for life processes in plants and microorganisms, while many other metals like Cd, Cr and Pb have no known physiological activity (Kar *et al.*, 2007).

Borno is a state in North-Eastern Nigeria, which was formed in 1976. It state is predominated by the Kanuri people, with other smaller ethnic groups which include Lamang, Babur, Marghi and Kibaku who are also found in the southern part of the state.

Kaga is a Local Government Area of Borno State, Nigeria, with it's headquarter is in Benisheikh. It is located in the Northern part of Borno State about 72km away. It has an area of 2, 700 km<sup>2</sup> 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

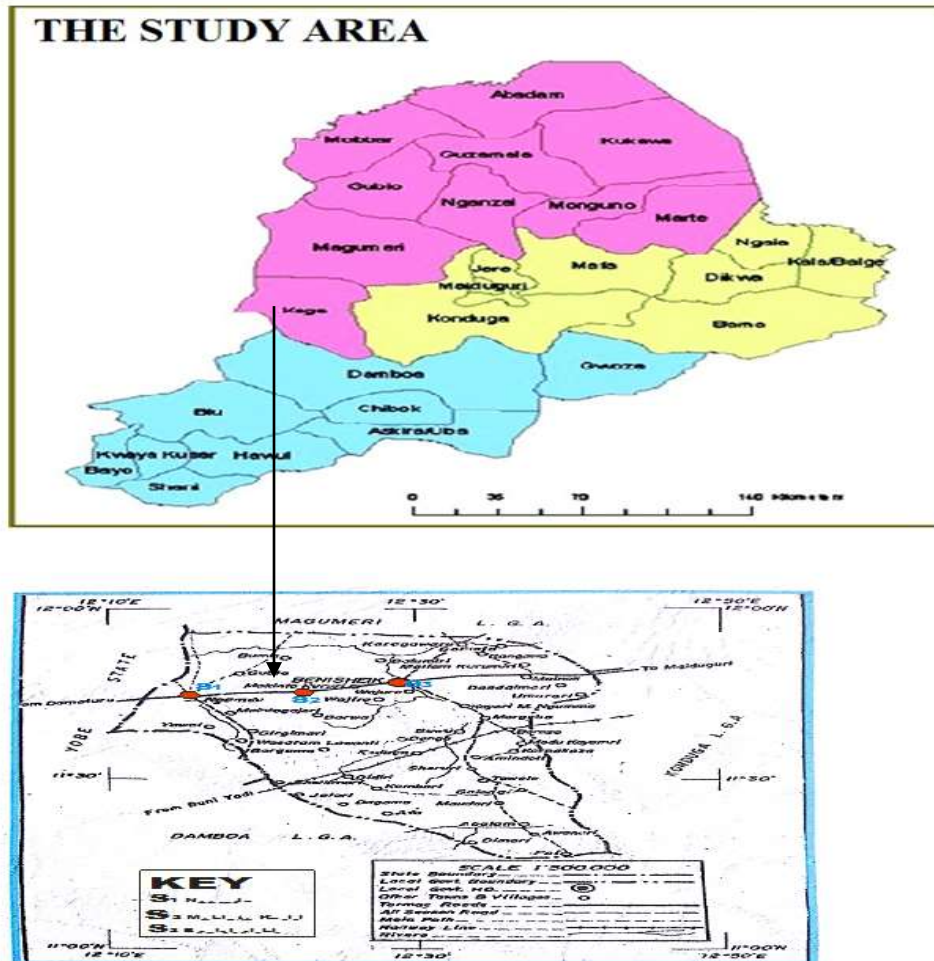
located in Borno State, Nigeria. The major occupation of people in this area is farming. The objectives of this study are to determine the concentration of some heavy metals (Cd, Pb, Ni, Cu, Zn, Co, Fe and Mn), some physical parameters (Electrical conductivity, Organic carbon, Organic matter and pH) in soil and watermelon samples; and some ions [Sulphate (SO<sub>4</sub>), Nitrate (NO<sub>3</sub><sup>-</sup>), Nitrite (NO<sub>2</sub><sup>-</sup>), Potassium

(K<sup>+</sup>), Calcium (Ca<sup>2+</sup>), Sodium (Na<sup>+</sup>) and Magnesium (Mg<sup>2+</sup>)] in soil, root, stem, leaves, pulp and seed of watermelon samples.

**MATERIALS AND METHODS**

**Sampling Area**

The area considered for this study is Benisheikh (Figure 1), the headquarters of Kaga LGA, Borno State.



**Figure 1:** Map of Borno State Showing the study area, Benisheikh

### Sample Collection

Soil at depth (0-10 cm, 10-20 cm and 20-30 cm) was collected from Benisheikh agricultural location. At the sampling location, five points were identified 200 meters away from each other. Soil samples collected from these points were pooled 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, ripped fruits of two different varieties of watermelon (Crimson and Sugar-baby) were considered for this study. Samples were collected for the period of three months, (September, October and November 2021). Watermelon and soil samples were collected from sampling site and put in clean polythene bags, labelled and transported to Postgraduate Research laboratory, Department of Pure and Applied Chemistry, University of Maiduguri for preparation and analysis.

### Digestion of Soil Samples

Two grammes (2 g) each of the soil samples were weighed into acid washed glass beaker and were digested by the addition of 20mL of aqua regia (mixture of HCl and HNO<sub>3</sub>, ratio 3:1) and 10mL of 30 % hydrogen peroxide (H<sub>2</sub>O<sub>2</sub>). The hydrogen peroxide (H<sub>2</sub>O<sub>2</sub>) was added in little portions. The beakers containing the mixture were covered with watch glass and heated over a hot plate at 90°C for two hours. The beaker wall and watch glass were washed with distilled water and the samples were filtered out to separate the insoluble solid from the supernatant liquid. The volumes were adjusted to 100mL with distilled water (Akan *et al.*, 2013).

### Digestion of Watermelon Samples

The fresh watermelon samples were weighed to determine the fresh weight and dried in an oven at 110°C for 72hr to determine their dry weight. The dried samples were crushed in a mortar using a pestle and were digested by weighing one grams (1 g) of the pulverized samples and sieved (<1 mm) into an acid-washed porcelain

crucible, which was then placed in a muffle furnace and heated for 4hrs at 500°C. The crucibles were removed from the furnace and cooled. Ten (10) mL of 6 M hydrochloric acid (HCl) each were added, covered and heated on a steam bath for 15 minutes. Nitric acid (HNO<sub>3</sub>) [1 mL] each were added and evaporated to dryness by continuous heating for one hour 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 Whatmann filter paper up to mark with distilled water (Radojevic and Bashkin, 1999).

### Elemental Analysis of Samples

Determination of the concentration levels of Cu, Zn, Co, Mn, Fe, Cd, Ni and Pb was carried out directly on each final solution using Atomic Absorption Spectroscopy (Perkin-Elmer Analyst 300)

### Determination of pH

Ten grams (10.0 g) of air-dried soil sample of each sampling site was weighed into a 50 cm<sup>3</sup> beaker and 20 cm<sup>3</sup> distilled or de-ionized water was added. The mixture was then allowed to stand for 30 minutes with occasional stirring with glass rod, after which the electrodes of a pre-calibrated pH meter were inserted into the partly settled suspension of each soil sample and the pH of the soil was taken (Hendershot *et al.*, 2008).

### Determination of Electrical Conductivity

Ten grams (10 g) of air-dried soil samples of each collection was weighed into a plastic container and 20 cm<sup>3</sup> de-ionized water was added, so that the soil to water ratio was 1:2, the mixture was then stirred several times for about 30 minutes. Then the suspensions of each soil were allowed to stand for 30 minutes undisturbed. The electrodes of the conductivity meter were then inserted into the settled suspension and the electrical conductivity of the soil recorded in  $\mu\text{Scm}^{-1}$ . The electrical

conductivity meter was calibrated using 0.1M KCl before use and the conductivity read (Bamgbose *et al.*, 2005).

#### **Determination of Organic Carbon and Organic Matter**

One gram (1.0 g) soil samples were weighed in triplicates into 250 cm<sup>3</sup> conical flask. Thereafter, 10 cm<sup>3</sup> of 0.02 mol/dm<sup>3</sup> K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> was pipetted into each flask and swirled gently to disperse the soil, followed by addition of 20 cm<sup>3</sup> concentrated H<sub>2</sub>SO<sub>4</sub>. The flask was then swirled gently until soil and reagents were thoroughly mixed. The mixture was then allowed to settle for 30 minutes on a glass plate. Then 100 cm<sup>3</sup> distilled water was added with four drops of ferroin indicator. This was titrated with 0.25 mol/dm<sup>3</sup> ammonium ferrous sulphate. Blank titration was similarly carried out. The percentage organic carbon is given by the equation.

Where  $f$  = correction factor

$m$  = Concentration of ferrous sulphate.

Then % organic matter in soil = % organic carbon (Walkey and Black, 1934).

#### **Determination of Nitrite and Nitrate**

One gramme (1.0 g) each of soil samples were transferred in a 25 mL beaker and extracted with 3 mL portions of 0.5% NaCO<sub>3</sub> solution. The extracts were filtered using Whatman no. 41 filter papers. The filtrates were collected and diluted to 25 mL. Appropriate aliquots of 1-2 mL of the solution was transferred in to a 10 mL calibrated flask and analyzed using standard procedure. To these samples known amounts of nitrite and nitrate sample were added and analyzed for nitrite and nitrate (Santamaria *et al.*, 2008).

#### **Determination of Phosphate**

One gramme (1 g) each of the ground and sieved samples was weighed into acid-washed porcelain crucibles. The crucibles were labeled and 5 ml of (20%) magnesium acetate were added and evaporated to dryness. The crucibles were then transferred into a furnace and the

temperature was raised to 500°C. The samples were ashed for 4 hrs, removed and cooled in desiccators until required for analysis (Salim *et al.*, 2009).

#### **Determination of Sulphate**

Five grammes (5 mL) of Mg(NO<sub>3</sub>)<sub>2</sub> solutions were added to each of the ground and sieved samples in the crucibles. These were then heated to 180°C on a hot plate. The heating process was allowed to continue until the colour of the samples changed from brown to yellow. The samples were then transferred to the furnace at a temperature of 500°C for four hours. Magnesium nitrate was added to prevent loss of sulphur. The contents of each crucible were carefully transferred to different evaporating basins. 10 mL of concentrated HCl were added to each of them and covered with watch glasses. They were boiled on a steam bath for 3 minutes. On cooling, 10 mL of distilled water were added to each of the basins and the contents of each were filtered into 50 mL volumetric flasks and the volumes made up to the marks with distilled water. Sulphate was determined using smart spectro spectrophotometer (Rowell, 1994).

#### **Determination of Sodium and Potassium**

The determination was by flame photometric method and the concentration of potassium and sodium was directly found from the standard curved. The amount of potassium ion and sodium ions in the sample was calculated (Radojevic and Bashkin, 1999).

#### **Determination of Calcium and Magnesium**

Ten (10) mL of extract was pipetted into a clean 25 mL conical flask and 100 mL of distilled water was added. 10 drops each of potassium cyanide (KCN) and ammonium hydroxide (NH<sub>4</sub>OH) were also added followed by 10% sodium hydroxide (NaOH) to raise the pH to 12 or slightly higher. Then the solution was titrated (Sauve *et al.*, 2000).

#### **Data Handling**

Data collected were subjected to one-way analysis of variance (ANOVA) to assess

whether heavy metal and ions varied significantly between watermelon and soil samples. Probability values 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  $\pm$  standard deviation.

## RESULTS

### Mean Concentration of Heavy Metals in Soil Sample from Benishiekh Agricultural Location, Kaga Local Government Area, Borno State

Table 1 Present the mean concentration of heavy metals in soil samples from Benishiekh agricultural location. Kaga Local Government area, Borno State. The results revealed that concentration 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 20-30 cm. The highest concentration of iron was  $2.05 \pm 0.40$   $\mu\text{g/g}$  at depth profile 20-30 cm and the least concentration was showed by cadmium  $0.09 \pm 0.02$   $\mu\text{g/g}$  at depth profile 0-10 cm. The concentrations of heavy metals are in the following order  $\text{Fe} > \text{Zn} > \text{Mn} > \text{Cu} > \text{Pb} > \text{Co} > \text{Ni} > \text{Cd}$ .

### Mean Values of Some Physical Parameters in Soil Samples from Benishiekh Agricultural Location

Table 2 present mean values of some physical parameters in soil samples from Benishiekh agricultural location. The result revealed that soils' pHs were slightly acidic ranging from  $5.04 \pm 0.05$  to  $5.20 \pm 0.16$  to  $4.30 \pm 0.15$ . The soil sample have moderate level of organic matter ranging between  $4.15 \pm 0.25$  to  $2.79 \pm 0.24$  to  $1.56 \pm 0.29$  (%). This implies that soil sample was rich in humus and indicate soil is very fertile. Organic carbon ranges between  $1.55 \pm 0.10$  to  $0.68 \pm 0.26$  (%). The electrical conductivity ranges between  $71.08 \pm 19.94$  to  $138.11 \pm 63.87$   $\mu\text{s/cm}$ , which indicate that the total soluble salt in the soil. It shows that soil sample have moderate salinity effect.

### Mean concentration of anion and cation in soil sample from Benishiekh agricultural location, Kaga local government area, Borno State

Table present mean concentration of anion and cation in soil sample from Benishiekh agricultural location, Kaga local government area, Borno State. The result 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 calcium has the highest concentration. The concentration of calcium was  $58.47 \pm 0.07$   $\mu\text{g/g}$  at depth 20-30 cm while potassium showed the least concentration of  $0.20 \pm 0.02$   $\mu\text{g/g}$  at depth profile 0-10 cm. The order of concentration of ions were  $\text{Ca}^{2+} > \text{Mg}^{2+} > \text{SO}_4^{2-} > \text{NO}_3^- > \text{NO}_2^- > \text{Na}^+ > \text{K}^+$ .

Figure 2 and 3 present mean concentration of heavy metals in different parts of watermelon sample (sugar baby and crimson sweet) from Benishiekh agricultural location, Kaga local government area, Borno State. In sugar baby sample analyzed iron showed the highest concentration. The concentration of iron  $1.34 \pm 0.10$   $\mu\text{g/g}$  was higher in the leaves and least in the pulp of  $0.15 \pm 0.01$   $\mu\text{g/g}$ . Zinc showed the least concentration of  $0.12 \pm 0.03$   $\mu\text{g/g}$  in pulp. The order of metals concentration in sugar baby sample were  $\text{Fe} > \text{Mn} > \text{Co} > \text{Ni} > \text{Cd} > \text{Cu} > \text{Pb} > \text{Zn}$ . The order of concentration in sugar baby sample were Pulp < Root < Seed < Stem < Leaf. In crimson sweet sample iron has the highest concentration. The concentration of iron  $0.86 \pm 0.12$   $\mu\text{g/g}$  is highest in the leaves and least in the stem of  $0.13 \pm 0.02$   $\mu\text{g/g}$ . Lead showed the least concentration of  $0.02 \pm 0.01$   $\mu\text{g/g}$  in pulp. The order of metals concentration in crimson sweet sample were  $\text{Fe} > \text{Mn} > \text{Ni} > \text{Zn} > \text{Co} > \text{Cu} > \text{Cd} > \text{Pb}$ . The order of concentration in crimson sweet sample were Leaf > Pulp > Seed > Root > Stem.

**Table 1:** Mean Concentration of Heavy Metals ( $\mu\text{g/g}$ ) in Soil Sample at varying Depth from Benishiekh Agricultural Location

Depth	Cd	Pb	Cu	Ni	Mn	Fe	Zn	Co
0-10 cm	$0.09^a \pm 0.02$	$0.12^a \pm 0.01$	$0.15^a \pm 0.02$	$0.14^a \pm 0.01$	$0.40^a \pm 0.10$	$1.59^a \pm 0.22$	$0.89^a \pm 0.13$	$0.19^a \pm 0.01$
10-20 cm	$0.10^b \pm 0.02$	$0.13^b \pm 0.02$	$0.26^b \pm 0.03$	$0.17^b \pm 0.03$	$0.31^b \pm 0.12$	$1.42^b \pm 0.54$	$1.70^b \pm 0.98$	$0.25^b \pm 0.07$
20-30 cm	$0.12^c \pm 0.02$	$0.34^c \pm 0.01$	$0.46^c \pm 0.02$	$0.25^c \pm 0.03$	$0.82^c \pm 0.19$	$2.05^c \pm 0.40$	$1.78^c \pm 1.17$	$0.29^c \pm 0.07$
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	$0.10^b \pm 0.04$	$0.04^b \pm 0.01$	$0.15^b \pm 0.02$	$0.14^b \pm 0.04$	$0.21^b \pm 0.06$	$0.58^b \pm 0.08$	$0.48^b \pm 0.03$	$0.10^b \pm 0.06$
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	0.2	0.3	40	10	10	20	50	10

Values presented are mean  $\pm$  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 Physical Parameters in Soil Sample at varying Depth from Benishiekh Agricultural Location.

Depth	pH	OC (%)	OM (%)	EC ( $\mu\text{s}/\text{cm}$ )
0-10 cm	5.04 <sup>a</sup> ± 0.05	0.68 <sup>a</sup> ± 0.26	1.56 <sup>a</sup> ± 0.29	71.08 <sup>a</sup> ± 19.94
10-20 cm	5.20 <sup>b</sup> ± 0.16	0.60 <sup>b</sup> ± 0.16	2.79 <sup>b</sup> ± 0.24	98.48 <sup>b</sup> ± 32.73
20-30 cm	4.30 <sup>c</sup> ± 0.15	1.55 <sup>c</sup> ± 0.10	4.15 <sup>c</sup> ± 0.25	138.81 <sup>c</sup> ± 63.87
Control				
0-10 cm	6.32 <sup>a</sup> ± 0.11	0.15 <sup>a</sup> ± 0.02	0.10 <sup>a</sup> ± 0.07	17.27 <sup>a</sup> ± 5.96
10-20 cm	6.50 <sup>b</sup> ± 0.19	0.16 <sup>b</sup> ± 0.09	0.14 <sup>b</sup> ± 0.06	31.23 <sup>b</sup> ± 9.65
20-30 cm	6.70 <sup>c</sup> ± 0.26	0.19 <sup>c</sup> ± 0.08	1.18 <sup>c</sup> ± 0.81	80.64 <sup>c</sup> ± 2.06

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

Key:

SD Standard deviation

pH Hydrogen Concentration

OM Organic Matter

OC Organic Carbon

EC Electrical Conductivity

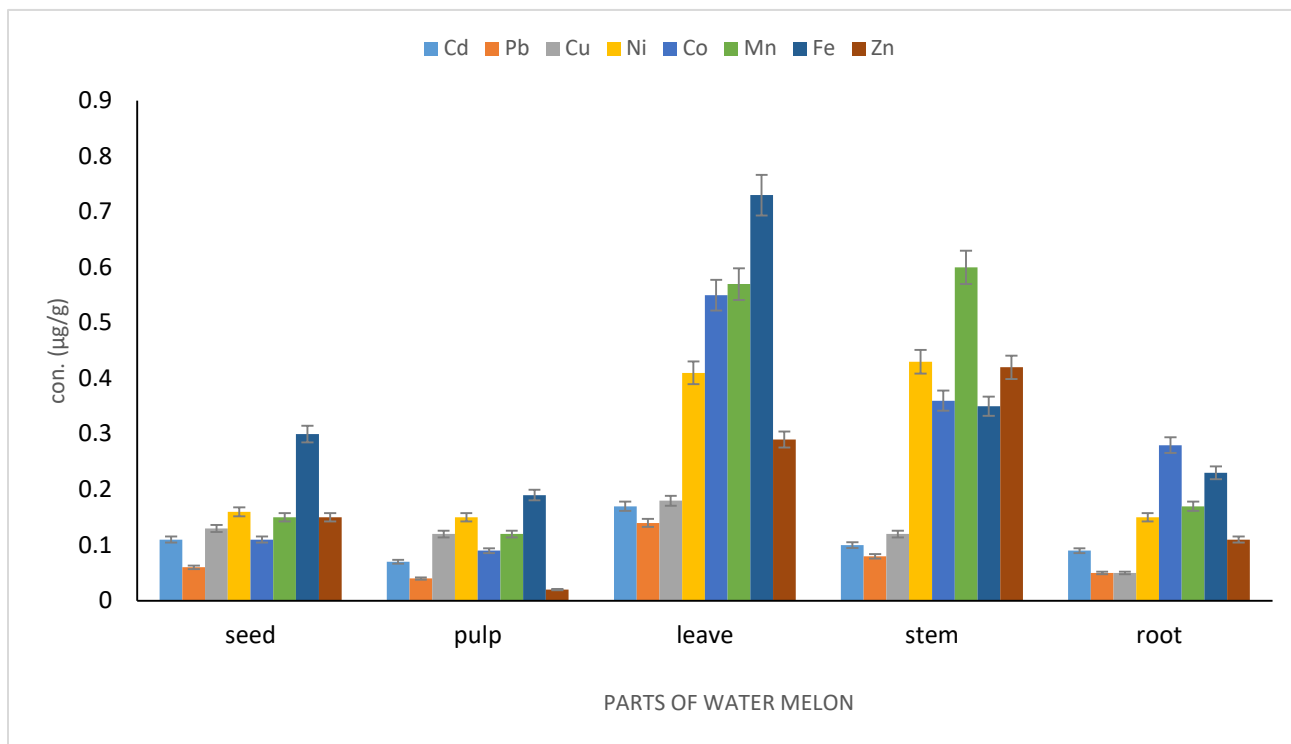


**Table 3:** Concentration Mean of Cation and Anion ( $\mu\text{g/g}$ ) in Soil Sample at varying Depth from Benishiekh Agricultural Location

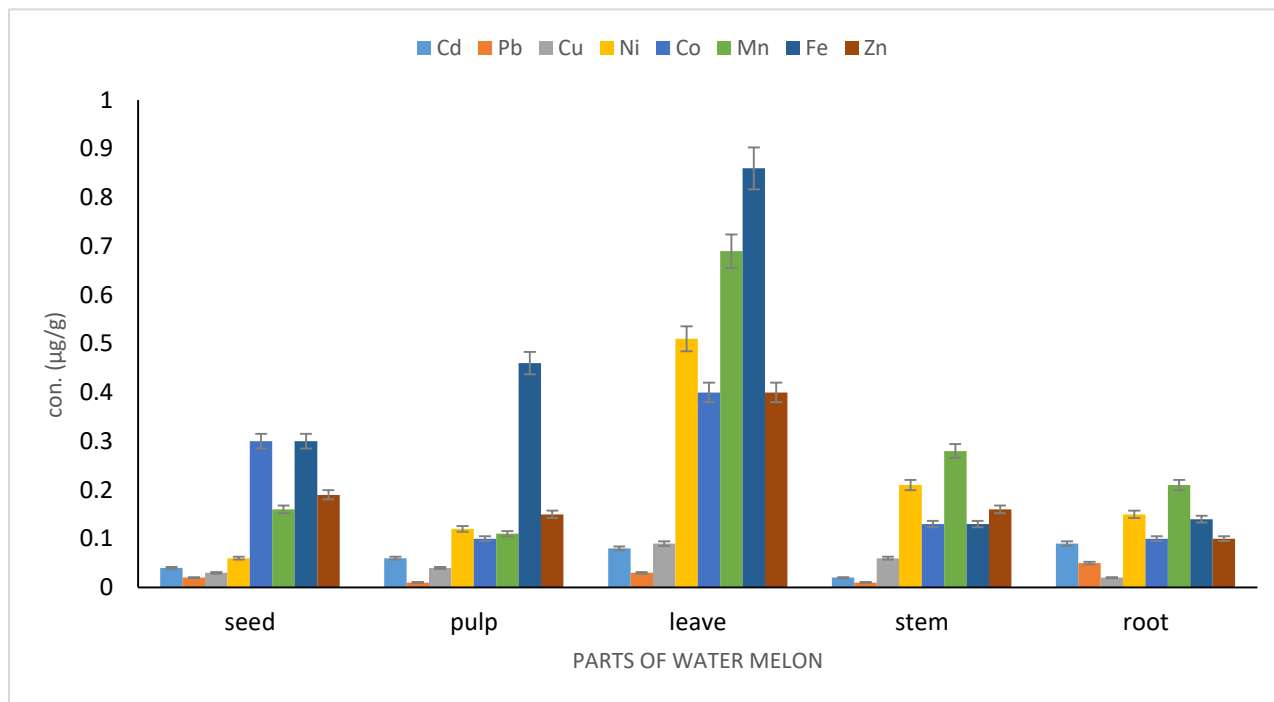
Depth	$\text{NO}_3^-$	$\text{NO}_2^-$	$\text{SO}_4^{2-}$	$\text{PO}_4$	$\text{K}^+$	$\text{Ca}^{2+}$	$\text{Na}^+$	$\text{Mg}^{2+}$
0-10 cm	$3.72^a \pm 0.26$	$2.24^a \pm 0.23$	$2.65^a \pm 0.10$	$1.63^a \pm 0.10$	$0.20^a \pm 0.07$	$58.47^a \pm 6.50$	$0.24^a \pm 0.06$	$14.09^a \pm 3.51$
10-20 cm	$3.93^b \pm 0.27$	$2.38^b \pm 0.22$	$7.45^b \pm 1.89$	$1.79^b \pm 0.27$	$0.34^b \pm 0.01$	$56.41^b \pm 3.15$	$0.54^b \pm 0.11$	$20.58^b \pm 4.38$
20-30 cm	$4.92^c \pm 0.71$	$3.55^c \pm 0.38$	$7.19^c \pm 0.95$	$2.69^c \pm 0.48$	$0.60^c \pm 0.02$	$53.62^c \pm 2.83$	$0.66^c \pm 0.05$	$23.95^c \pm 3.42$
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 mean  $\pm$  SD. Within the column, paired mean with different alphabets are statistically significant ( $p < 0.05$ ).

Key = SD = Standard deviation



**Figure 2:** Mean concentration of heavy metals ( $\mu\text{g/g}$ ) in different parts of watermelon sample (sugar baby) from Benishiekh agricultural location

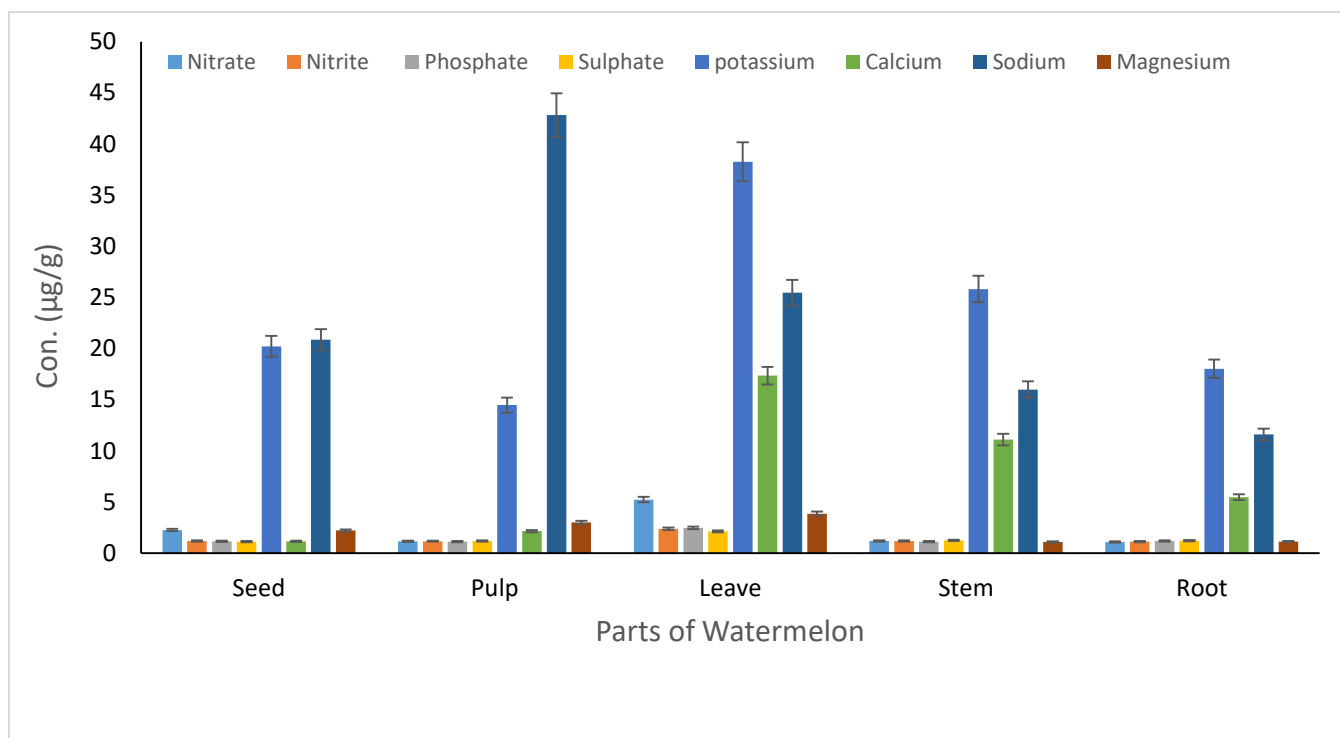


**Figure 3:** Mean concentration of heavy metals ( $\mu\text{g/g}$ ) in different parts of watermelon sample (crimson sweet) from Benishiekh agricultural location.

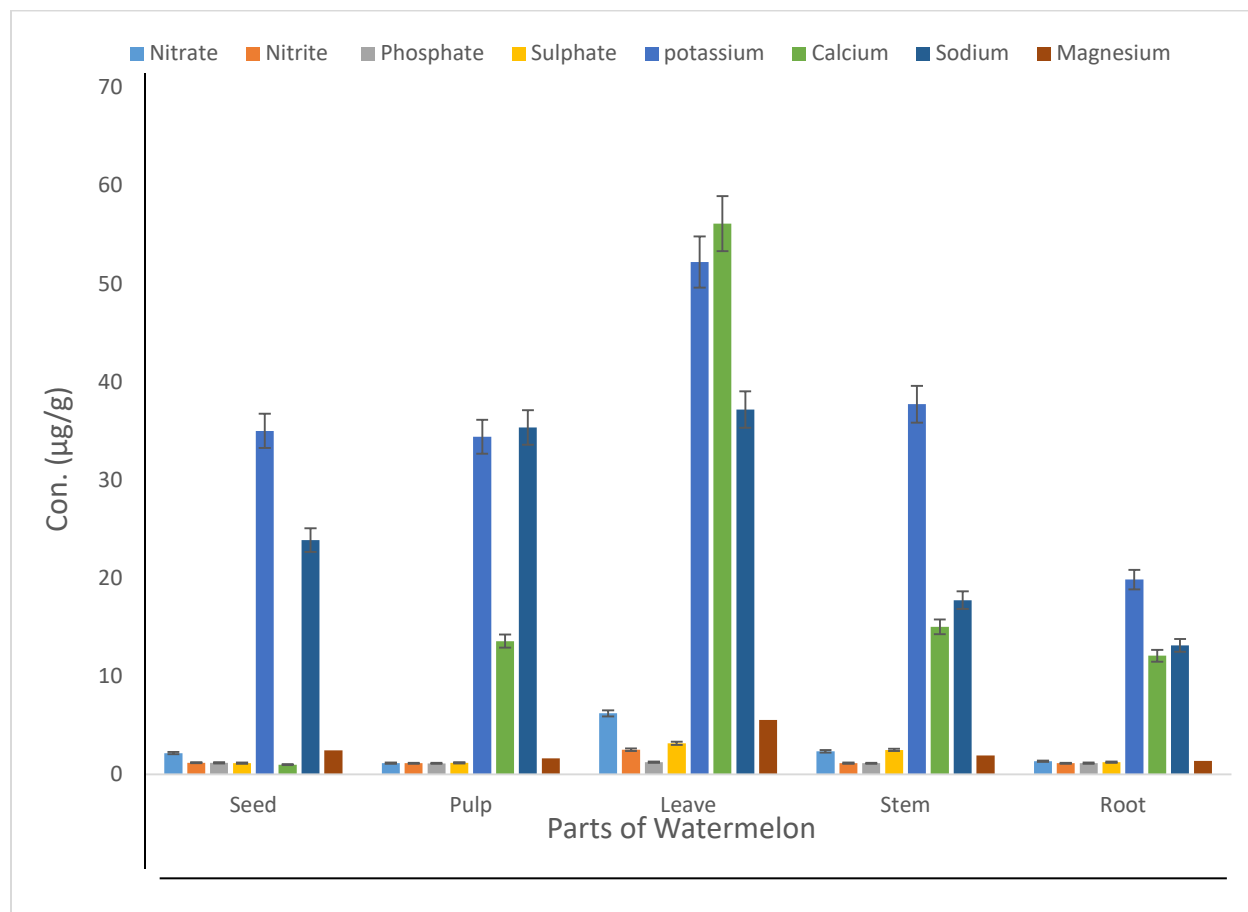
Figure 4 and 5 present mean concentration of anion and cation in watermelon samples from Benishiekh agricultural location, Kaga local government areas, Borno State. The result revealed that in sugar baby sample potassium showed the highest concentration. The concentration of potassium  $42.81 \pm 12.11 \mu\text{g/g}$  was highest in leaves and least in pulp  $14.47 \pm 3.15 \mu\text{g/g}$ . Phosphate showed the least concentration of  $1.12 \pm 0.14 \mu\text{g/g}$  in pulp analyzed. The order of concentration of ions

were  $\text{K}^+ > \text{Na}^+ > \text{Ca}^{2+} > \text{Mg}^{2+} > \text{NO}_3^- > \text{NO}_2^- > \text{SO}_4^{2-} > \text{PO}_4^-$ .

In crimson sweet sample calcium showed the highest concentration of  $56.13 \pm 13.10 \mu\text{g/g}$  in leaves and the least concentration of calcium was  $0.99 \pm 0.11 \mu\text{g/g}$  was shown in seed. Phosphate showed the least concentration of  $0.12 \pm 0.03 \mu\text{g/g}$  in pulp sample analyzed. The order of ion concentration were  $\text{Ca} > \text{K} > \text{Na} > \text{Mg} > \text{NO}_3^- > \text{SO}_4 > \text{NO}_2^- > \text{PO}_4$ .



**Figure 4:** Mean concentration of Ions ( $\mu\text{g/g}$ ) in different parts of watermelon sample (sugar baby) from Benishiekh agricultural location.



**Figure 5:** Mean concentration of Ions ( $\mu\text{g/g}$ ) in different parts of watermelon sample (crimson sweet) from Benishiekh agricultural location

## DISCUSSION

The result of the study on the soil of Benisheikh showed that, level of organic carbon and organic matter increased significantly with depth. Study by Radwan *et al.* (2006) also revealed that organic carbon increases to a depth of 20-30 cm. Similar study by Akilu *et al.* (2013) also reported that organic matter plays an important role in soil structure, aggregation, infiltration and retention of water and other physical characteristics

Organic matter is an important factor in the heavy metals dynamics in soil, given that OM is negatively charged, it has a great Metal adsorption capacity, forming metal complexes which decrease the amount of exchangeable metal ion (Bradl, 2004).

The soil pH of three locations decreases with depth. This implies that soils of this location are slightly acidic. Edward *et al.* (2013) reported that heavy metals mobility decreases with increasing soil pH due carbonates or formation of insoluble organic complexes.

The electrical conductivity values of soil samples also differ significantly with depth ( $p < 0.05$ ). Boulding (1994) classified electrical conductivity of soil as non-saline  $< 2$ , moderately saline 2-8, very saline 8-16, and extremely saline  $>16$ . The result of the study shows that electrical conductivity values increases with depth 0-10 cm, 10-20 cm and 20-30 cm. A similar study by Akan *et al.* (2013) revealed that pH, organic carbon, conductivity, salinity, organic matter increased to a depth of 30 cm. Similarly, the variations in the mean

levels in the varieties of watermelons can be attributed to such factors as the genetic makeup of the watermelons, the sites, amounts of analyte, pH and the physical conditions of the soils the watermelons were grown in (Pallardy and Theodore, 2008).

The result of heavy metal concentration levels revealed that the lead, cadmium, iron, copper, cobalt, manganese, nickel and zinc increases significantly with depth from 0-10 cm, 10-20 cm and 20-30 cm. This is an unusual behavior however it can possibly be due to the physical features of the study area because Akan *et al.* (2013) also reported similar trend when they estimated levels of some Agricultural pollutants in soil samples from Biu local government area of Borno State, Nigeria. Among the different parts of watermelon samples, lead is highest in leaves and least in pulp, the concentration of lead in watermelon samples increases as follows sugar baby > crimson sweet, cadmium concentration is found to be highest in leaves of sugar baby plant and least in pulp, iron is highest in crimson sweet leaf and least in sugar baby root sample, highest values of copper was shown in crimson sweet leaf and the least concentration was observed in sugar baby seed, cobalt is highest in sugar baby plant leaf and least in crimson sweet plant pulp, manganese is highest in sugar baby plant leaf and least in pulp sample, the highest concentration of nickel was observed in the leaf while the pulp showed a least concentration of accumulation, Zinc showed the highest concentration in crimson sweet leaf and the least concentration was showed in crimson sweet pulp.

Plant growth requires a continuous net shift of ions from the soil system into the plant, that is there is a steady input of ions from the solid phase into the soil solution, and a continuous metabolic removal of ions from the soil solution by the plant. For any short-time interval in a given environment the net release of ions equals the net amount assimilated by the plant. Ion uptake by plants from a soil system comes under

four ways, that is the release of the ions from the solid phase into the soil solution, the movement of the ion from any point in the soil solution to the vicinity of the root and the movement of the ion to the top of the plant (Azeez, 2017). The result of this study revealed that the concentration of calcium in soil sample increases significantly with depth from 0-10 cm, 10-20 cm and 20-30 cm. One-way ANOVA revealed that calcium ion was statistically significant at ( $P < 0.05$ ). In watermelon samples calcium ion was highest in crimson sweet leaves and least in seed, highest concentration of magnesium was shown in sugar baby plant leaves and the least concentration of magnesium was shown in crimson sweet plant root, concentration of potassium was highest in sugar baby plant leaf and least in crimson sweet plant root, the highest concentration of phosphate ion was showed in sugar baby leaves of Benishiekh and the least concentration was showed in crimson sweet pulp, sulphate ion showed the highest concentration in sugar baby plant leaves ( $10.00 \pm 0.12$ )  $\mu\text{g/g}$  and least in crimson sweet pulp, nitrate and nitrite were higher in leaf and least in pulp. The results of both the heavy metals and ions were found to be lower than the WHO (1999) safe limit.

## CONCLUSION

The level of the physicochemical parameters studied serves as indicators of agricultural pollutants in the soil and watermelon samples from Benisheikh agricultural location. The result of the pH indicated that the soil is within the acidic range and the result of electrical conductivity shows that the soil can be described as extremely saline. 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 analyte were lower than the WHO standard. Therefore, consumptions of these watermelons have no health effect on human.

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