LEVEL OF SOME HEAVY METALS IN SELECTED FRUITS AND VEGETABLES

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ABSTRACT
This paper is aimed at assessing the level of the heavy metals: Lead (Pb), Arsenic (As), Cadmium (Cd), Chromium (Cr), Selenium (Se), Zinc (Zn) and Nickel (Ni) in some fruits and vegetables grown in Gongolon irrigation site, Jere local government area of Borno state. Bunches of soil, fruits and vegetables samples (lettuce, water-melon, cucumber, tomato, guava, onion and sorrel) were collected from the site. Prepared samples were digested using freshly prepared aqua regia (HNO_3 + HCl) in the ratio 1:3. Analysis of the samples was done using Atomic Absorption Spectroscopy (AAS). The result obtained shows that, the level of arsenic ranged from 0.018µg/g in onion to 0.038µg/g in lettuce. Cadmium had 0.107µg/g in sorrel, 0.630µg/g in tomato, 0.440µg/g in lettuce and 0.700µg/g in cucumber. The element (As) was not detected in guava, watermelon, onion and even the soil that support their growth. The levels; 0.571, 0.508, 0.275 and 0.073µg/g Chromium, were detected in tomato, onion, lettuce and sorrel respectively for Cr. The element was however not detected in cucumber, guava and watermelon. High level of Nickel (Ni) was found in onion (0.365µg/g) followed by tomato (0.351µg/g) and lettuce (0.275µg/g). Nickel was not detected in cucumber, guava, watermelon and sorrel. Lead (Pb) was only detected in tomato (0.150µg/g) and onion (0.141µg/g). Zinc Zn) was observed in all the vegetables and fruits, the level of which ranged from 0.719µg/g in onion to 2.202µg/g in tomato. Also selenium (Se) was observed in all the samples, the level ranged from 0.326µg/g in watermelon to 0.653µg/g in lettuce. The variation in the level of the elements in the fruits and vegetable could be attributed mostly to atmospheric deposition and the variety of the fruits or vegetable. Most fruits with hard pericarp had less level of the metals, the source of which therefore could be the soil. Those with soft pericarps or leafy vegetables, mostly has the highest level of the metals which could be attributed to atmospheric deposition in addition to absorption from the soil.

***Keywords** - Environment, Fruits, Heavy metal, Pollution, Soil, Vegetable.*

1. INTRODUCTION
Consumption of vegetables and fruits as food offers the most rapid and lowest cost means of providing adequate supplies of vitamins, minerals and fiber to the body. Vegetables are the leafy outgrowth of plants used as food and include those plants and parts of plants used in making soups or served as integral parts of the main sources of a meal [1]. Some vegetables and fruits have been noted to contain quite reasonable levels of proteins, carbohydrates and fats, which are often needed nutrients for a healthy, balanced diet. That is why it is important to grow or purchase fresh vegetables and fruits for consumption along with our daily meals [2]. They are vital to the human diet and in particular provide the well-known and required trace elements and heavy metals. Minor or trace elements are essential for good health if they come from an organic or plant source. In contrast, if they come from an inorganic or metallic source, they become toxic. Various classes of vegetables are grown in many parts of Nigeria, especially the Northeastern part, Borno State in particular, and are heavily cultivated and consumed as food [3].
Vegetables play important roles in our daily diet as economic crops. They constitute our essential diet components (protein, vitamins, iron, calcium and other nutrients), which are usually very scarce or are in short supply [4]. However, they contain both essential and non essential toxic elements at varying concentrations. Various human activities such as mining, industrial processing, vehicular emissions, pesticides and fertilizer application, especially the huge annual applications of organic livestock manure, which is the traditional agricultural fertilizer, are causing elevated heavy metal concentrations in the environment [5, 6]. Absorption and accumulation of these heavy metals in vegetables and fruits are influenced by many factors such as concentration of the metals in soil, atmospheric

deposition, precipitations, and phase of plant vegetation [7]. Accumulation of these metals in vegetables may therefore pose a direct or indirect threat to human health [8, 9].

Vegetables take up metals by absorbing them from contaminated soils, and atmospheric deposits on different parts of the vegetables exposed to the air from polluted environments [10]. It has been reported that nearly half of the mean ingestion of lead, cadmium and mercury for instance, through food is due to plant origin (fruit, vegetables and cereals). Heavy metals, such as cadmium, copper, lead, chromium and mercury, are important environmental pollutants, particularly in areas with high anthropogenic pressure. Chronic intakes of heavy metals have damaging effects on human beings and other animals [11, 12, 13]. For example, Cr, Cu and Zn can cause non-carcinogenic hazardous such as neurologic involvement, headache and liver disease, when they exceed their safe threshold values [14]. Their presence in the atmosphere, soil and water, even in traces, can cause great hazard to all organisms as well as agricultural production due to their adverse effects on food quality (safety and marketability), crop growth (due to phytotoxicity) [15, 16] and environmental health (soil flora/fauna and terrestrial animals).

Heavy metal-contaminated food can seriously deplete some essential nutrients in the body that are further responsible for decreasing immunological defenses, intrauterine growth retardation, impaired psychosocial faculties, disabilities associated with malnutrition and high prevalence of upper gastrointestinal cancer rates [18, 19]. Serious systemic health hazards can develop as a result of extreme dietary accumulation of heavy metals such as Cr, Cd, Ni and Pb [20]. Food is the major intake source of toxic metals by human beings. Among different food systems, vegetables are the most exposed food to environmental pollution due to aerial burden. Vegetables are consumed enormously in many countries and thus constitute one of the important food sources. It is therefore imperative to assess the level of trace or heavy metals in different varieties of vegetables. The main aim of this paper therefore is to assess the level of some heavy metals contaminants in some fruits and vegetables grown in Gongolon, Jere (one of the main supplier of vegetables) local government area of Borno state, north-eastern part of Nigeria.

2. MATERIL AND METHODS

2.1 Sampling Area

Gongolon irrigation site is located in Jere Local Government Area of Borno State, north eastern part of Nigeria (fig. 1). It is 9.75 Km from Maiduguri Metropolis, has an area of 868km^2 and a population of 211,204 at the 2006 census [21]. The major crops grown in the area include groundnut, beans, maize, millets etc. vegetables such as lettuce, onion, water-leaf, sorrel etc as well as fruits such as cucumber, tomato, mango, guava etc are also cultivated. Köppen-Geiger climate classification system classifies the climate of this area as hot semi-arid climate. The highest recorded temperature was 47 °C (117 °F) on May 28, 1983, whereas the lowest recorded temperature was 5 °C (41 °F) on December 26, 1979 [22].

Figure 1: Showing the Sampling Area Gongolon

2.2 Sample collection

Bunches of vegetables and fruits samples (lettuce, water-leaf, cucumber, tomato and sorrel) were collected from the sampling site by cutting with stainless knife from the shoot. These were then sliced into pieces, dried in an oven at 105^{o}c to a constant weight, grounded, sieved, packed in a polyethylene bags separately and labeled with a unique identification number. Soil samples were collected from the same sampling site as the vegetables. Soil collection was randomly made at the depth of 0 to 20cm and at the intervals of 20-30 meters apart using spiral auger, these were pulled together to represent a sample from each sampling point [23]. The soil collected were then dried, ground and sieved (using < 2mm nylon sieve) put in a clean plastic bags separately labeled and taken to the laboratory for subsequent analysis. Four different samples were collected monthly for the period of four months (from February to May 2017) to ensure replicate analysis.

2.3 Sample preparation and analysis

One gram (1g) of a well homogenized sample obtained from sample preparation procedure above was weighed into a Kjeldahl flask and 12ml of freshly prepared aqua regia (3ml HNO_3 + 9ml HCl i.e. ratio 1:3) was added. Then covered and heated for two hours on medium heat of a hot plate. The mixture was allowed to cool and then filtered through a Whatman No. 42 filter paper into a 50ml standard volumetric flask. The filtrate was diluted to 50ml with deionized water. The digested samples were then filtered and the volume of the filtrate was adjusted to 100 cm^3 with distilled water. Physiochemical properties of the soil were determined and the heavy metals; arsenic, cadmium, chromium, nickel, lead, selenium and zinc were determined using Atomic Absorption Spectroscopy (AAS) [23].

3. DATA HANDLING

All statistical analyses were performed using SPSS 17 package. Differences in heavy metal concentrations among the samples were detected using One-way ANOVA, followed by multiple comparisons using Turkey tests. A significance level of (P< 0.05) was used throughout the study.

4. RESULTS

Physiochemical Properties of the Soil

The taxonomic classification of the soil from the sampling site indicates that, the soil is sandy. It has less organic matter content of 1.170µg/g which shows that, it is also not rich in humus for that it is less fertile for plant growth. It therefore requires enhancement through fertilizer, manure or sewage application. The soil was found slightly acidic with the pH value of 6.468. The observed pH level of the soils is generally within the range for soil in the region. Soil pH plays an important role in the sorption of heavy metals. It controls the solubility and hydrolysis of metal hydroxides, carbonates and phosphates. It also influences ion-pair formation, solubility of organic matter, as well as surface charge of Fe, Mn and Al-oxides, organic matter and clay edges [24]. The electrical conductivity (EC) was observed to be 0.224 mS/cm whereas the CEC value was found to be 12.984. Cation Exchange Capacity measures the ability of soils to allow for easy exchange of cations between its surface and solutions. The relatively low level of clay and CEC indicate high permeability and leachability of metals in the soil from site one.

Table one below shows the distribution of the elements determined in the vegetables and soil that supported their growth. In the soil, Ni has the highest level of 0.357µg/g followed by Pb (0.350 µg/g. Chromium (Cr) has 0.315 µg/g and lowest level was observed for Zn (0.174 µg/g). In the vegetables, Zn has the highest level of 2.202 µg/g observed in tomato, 2.118 µg/g in sorrel, and 1.330 µg/g observed in cucumber. The lower levels; 0.719, 0.777, 0.804, and 0.854µg/g were observed in onion, water melon, lettuce, and guava respectively. The highest level of Cr (1.048 µg/) was observed in guava, whereas 1.015 µg/g was observed in cucumber. The lower levels of 0.073, 0.275, 0.429, 0.508, and 0.571µg/g in ascending order were observed in sorrel, lettuce, water melon, onion, and tomato respectively. The observed values for Ni range from 0.090 in sorrel to 0.980µg/g in guava whereas for Pb the values were found ranging from 0.054 in sorrel to 0.363µg/g in cucumber (Table 1).

Table 1: Mean Concentration (µg/g) of the Heavy Metals; Cr, Ni, Pb, and Zn, determined in the soil and the vegetables grown on the soil of this study

Samples Elements	Tom	Cuc	Gua	Let	Wtm	Oni	Sor	Soil
As	0.025 ±0.013	0.043 ±0.010	0.025 ±0.013	0.038 ±0.015	0.030 ±0.008	0.018 ±0.010	0.020 ±0.008	0.300 ±0.014
Cd	0.630 ±0.159	0.700 ±0.553	Nd	0.440 ±0.199	Nd	Nd	0.107 ±0.048	Nd
Cr	0.571 ±0.079	Nd	Nd	0.275 ±0.294	Nd	0.508 ±0.304	0.073 ±0.583	0.357 ±0.205
Ni	0.351 ±0.181	Nd	Nd	0.275 ±0.114	Nd	0.365 ±0.320	Nd	0.350 ±0.105
Pb	0.150 ±0.117	Nd	Nd	Nd	Nd	0.141 ±0.036	Nd	0.228 ±0.075
Zn	2.202 ±0.086	1.330 ±0.060	0.854 ±0.080	0.804 ±0.017	0.776 ±0.094	0.719 ±0.171	2.118 ±0.054	0.174 ±0.390
Se	0.504 ±0.316	0.430 ±0.193	0.625 ±0.127	0.653 ±0.100	0.326 ±0.017	0.353 ±0.053	0.432 ±0.104	0.556 ±0.069

Data are presented in mean ±SD (n = 4). No significant difference was observed among the means at (P = 0.05) according to Turkey test. SD = Standard Deviation, Nd Not detected, Tom = tomato, Cuc = Cucumber, Gua = Guava, Let = Lettuce, Wtm = Wate melon, Oni = Onion, and Sor = Sorrel

5. DISCUSSION

5.1 Zinc

Among all the heavy metals, Zinc is the least toxic and an essential element in human diet as it is required for the proper maintenance of the body functions. For example, the immune system, proper brain functioning and is vital for the development of fetal growth. Deficiency of Zn in the diet may be more dangerous to living organism including human than its high concentration in the diet. The recommended dietary allowance for Zinc is 15mg/day for men and 12mg/day for Women [25]. It is therefore an essential element for plants and animals; however, a small increase in the required level may cause interference with physiological processes. In this study, high concentration of zinc was observed in tomato (2.202 µg/g), sorrel (2.118 µg/g), and the level 1.330µg/g in cucumber. However, the levels observed for tomato, sorrel and onion in this study (Table 1) were found lower than (8.427 µg/g) in tomato and (9.650 µg/g) in onion in a study conducted in Misurata [26]. It is also many-folds lower than what was found in tomato and onion [27]. However, the levels observed for Zn in this study were very much greater than 0.55 and 0.15µg/g determined in tomato and cucumber respectively in a study from Hyderabad [28]. The lower levels of 0.719 and 0.777µg/g for Zn, observed in onion and water melon respectively were found lower than 5.110 and 11.400µg/g as observed in Misurata [26] but higher than 0.34 µg/g observed in onion from Hyderabad [28]. Zinc is reported as a coenzyme for over 200 enzymes involved in immunity, new cells growth, acid base regulation etc. Lack of sufficient amount of Zn results in reduced activity of related enzymes e.g. carbonic anhydrase [29]. According to ATSRD, [30] the daily intake limit of Zn is up to 15 mg/day. Data related to Zn toxicity is very rare [31]. It has been reported that Zn is more actively mobilize than Cu from roots to shoots [32]. The level of Zn observed in vegetable samples of this study is however much lower than the [33] safe limit of 99.40mg/kg which indicates the safety of the vegetables.

5.2 Nickel

Nickel plays its role as a coenzyme in different enzymes. Deficiency of Ni can lead to increased blood sugar level, hypertension and deficient growth in human but increased uptake of Ni in fruits and vegetables can reduced the blood glucose level, difficulty in breathing, nausea etc. According to ATSDR [34] the acceptable range of Ni daily intake is 3-7 mg/day. Ni is one of the essential element which is present in the environment in trace amount as well as it is considered as indispensable for number of metabolic reactions in living beings [35]. Ni is usually accumulated in vegetative part of the plant body and it is mobile through the plant structure, translocated and concentrated in the leaves but after ageningness of the leaves it is moved to the seeds for accumulation [36].

In this study the highest levels of Ni were found in guava (0.980 µg/g), followed by cucumber (0.812 µg/g), and onion (0.365 µg/g). In contrast, these values were found higher than 0.180µg/g observed in cucumber, 0.040 µg/g in guava, and 0.006µg/g in onion reported by Ismail et al. [28]. The levels were also found higher than 0.220 µg/g observed in cucumber and 0.32µg/g in onion from Misurata, Libya [26]. However, the levels of Ni observed in this study were many-folds lower than what was reported by Singh et al. [37] and Ali and Al-Qahtani, [38]. It is lower than what was observed in onion and tomato from Sharada, Kwakwaci and Jakara in Kano State Nigeria [27]. The increased concentrations of Ni are probably to a large extent the consequence of atmospheric deposition of particles. Generally, nickel and its salts do not affect the human body but in some cases it has been recorded to cause allergic problems as it comes in contact with moist skin. It also adversely affects the lungs and nasal cavities [39]. However, the permissible limit set by [40] in edible plants was 1.63 ppm.

5.3 Chromium

Chromium is present in human tissues in variable concentrations and its deficiency is characterized by disturbance in glucose, lipid and protein metabolism [41]. It is an element occurring in food products of both plant and animal origins. It is regarded as an essential trace element in humans and animals, taking part in various metabolic processes. As an element, it has been reported that it is usually present in food in the trivalent form; the hexavalent form of it however, is toxic and not normally found in food [42]. It has been reported to cause skin rashes, stomach ulcer, kidney, liver damages, lungs cancer and ultimate death [39]. Chromium (VI) can easily penetrate the cell wall and exert its noxious influence in the cell itself, being also a source of various cancer diseases [43]. It has been reported that the daily dietary intake of 0.05-0.2 mg of chromium contributes to well being of the human. The permissible limit set by [40] in edible plants was 0.02 ppm. In this study the highest level of chromium (0.571µg/g) was observed in tomato followed by onion (0.508µg/g). These levels were found lower than what was observed in both tomato and onion in Karaci city [44]. It is however higher than what was reported from Thomas dam Kano [28].

5.4 Lead

Lead is a serious cumulative body poison which enters into the body system through air, water and food and cannot be removed by washing fruits and vegetables [45]. Lead in some plants may probably be attributed to pollutants in irrigation water, soil or due to pollution from the highways traffic [46]. In many plants, Pb accumulation can exceed several hundred times the threshold of maximum level permissible for human consumption [47]. The contamination of agricultural soils is often a direct or indirect consequence of anthropogenic activities [48]. Trace elements are the natural constituents of the soil and due the variation in atmospheric condition their plant uptake equally varies through root to the shoot [49]. Other sources of anthropogenic contamination include the addition of manures, sewage sludge, fertilizers and pesticides to soils, with a number of studies identifying the risks in relation to increased soil metal concentration and consequent crop uptake [50, 51]. In this study, the level of lead (0.150 µg/g, and 0.141µg/g observed in tomato and in onion were found very much lower than what was observed in tomato (6.00 µg/g) and 17.00 µg/g in onion [37]. The levels of this study were also lower than what was reported from Sharada, Kwakwaci and Jakara in Kano State, Nigeria [27] and from Saudi Arabian market [38]. Both commercial and residential growing areas are also subject to atmospheric pollution, in the form of metal containing aerosols. These aerosols can enter the soil and be absorbed by vegetables, or alternatively be deposited on leaves and adsorbed. The levels observed however, in this study, were lower than the WHO safe limit of 2.0 mg kg^{-1} [52].

5.5 Selenium

Selenium (Se) is an essential micronutrient, necessary for normal function of human and animal physiology. It is incorporated into proteins to make selenoproteins, which are important antioxidant enzymes, vitamins, hormones and other protein tissues which help prevent cellular damage from free radicals resulting from oxygen metabolism. The absences of these antioxidants help contribute to the development of some chronic diseases and play a role in the depression of the immune system [53, 54]. It has been reported that, the deficiency of selenium in food and feed causes a number of diseases like cancer, cardiomyopathy, myocardial deaths, arthritis, rheumatoid and myxedematous endemic cretinism [55, 56]. Se deficiency has also been implicated in the progression of Human Immune Deficiency Syndrome (HIV) infection to full blown Acquired Immune Deficiency Syndrome (AIDS) [57, 58]. Selenium is toxic in large amounts, but trace amounts of it are necessary for cellular function. Short-term oral expo-sure to high concentrations can cause nausea, vomiting, and diarrhea. Major signs of selenosis are hair loss, nail brittle-ness, and neurological abnormalities. Brief exposures to high levels in air can result in respiratory tract irritation, bronchitis, difficulty breathing, and stomach pains. Longer- term exposure can cause respiratory irritation, bronchial spasms, and coughing [59].

Although there is little evidence that selenium is essential for vegetation growth, it is incorporated into the plant structure. Selenium concentrations in plants generally reflect the levels of selenium in the environment such that the same plant species grown over high and low selenium-available soils will contain concentrations reflecting the soil composition. However, an important factor that may determine whether or not selenium-related health problems manifest in animals and humans is the very wide-ranging ability of different plant species to accumulate selenium [60, 61, 62]. Plant foods are the major dietary sources of selenium in most countries of the world and the content of selenium in these food sources depends on the selenium content of the soil where they are grown [63, 64]. When we feed on plants and animals that had absorbed a large quantity of Se, selenium level will tend to increase in our systems. Selenium (Se) is a naturally occurring metalloid element, which is essential to human and other animal health in trace amounts but is harmful in excess. Of all the elements, selenium has one of the narrowest ranges between dietary deficiency (<40 μgday^{-1}) and toxic levels (>400μgday^{-1}) [65], which makes it necessary to carefully control intakes by humans and other animals, hence, the importance of understanding the relationships between environmental exposure and health.

5.6 Arsenic

Arsenic is regarded as human carcinogen from extremely low levels of exposure, having no possible beneficial metabolic functions for humans [66]. Its low level exposure cause nausea and vomiting decreased production of RBCs and WBCs, abdominal pain and its long term exposure causes darkening of skin and appearance of small corns on palm soles. Other affect includes abnormal ECG, anorexia, fever, fluid loss, goitre, hair loss, headache, herpes, im-paired healing, jaundice, keratosis, kidney and liver damage, muscle spasms, pallor, peripheral neuritis, sore throat, weakness and interferes with the uptake of folic acid [66]. Arsenic is extremely toxic. The concentration of arsenic exceeding the maximum permissible limit (0.03 μgg^{-1}) in foodstuff [67] cause short term (nausea, vomiting, diarrhea, weakness, and loss of appetite, cough and headache) and long term (cardiovascular diseases, diabetes and vascular diseases) health effects [68]. In this study, the level of Arsenic ranges from 0.018-0.043 μgg^{-1}. The element was observed in all the vegetables. The highest level however was found in Cucumber (0.043 μgg^{-1}) followed by lettuce (0.038 μgg^{-1}), the least of which was observed in onion (0.018 μgg^{-1}). The highest level of Arsenic observed in cucumber of this study is in agreement with was observed in cucumber (0.043 μgg^{-1}) from Pakistan [68]. The least level of arsenic observed in onion (0.018 μgg^{-1}) of this study was found many-folds lower than what was observed in onion (0.82 μgg^{-}1) from Kola village [69]

5.7 Cadmium

Cadmium is a heavy metal naturally present in soils. It may also be added to the soil as a contaminant in fertilizer, manure, sewage sludge and from aerial deposition. The amount of cadmium contributed from each source varies with location due to differences in soil formation, management practices and exposure to pollution sources, but the level of Cd in the soil appears to be increasing over time [70]. Although plants do not require Cd for growth or reproduction, the bioaccumulation index of Cd in green plants exceeds that of all other trace elements [71]. Plants can accumulate relatively high levels of cadmium, without adverse effects on growth [72]. Cadmium is retained for many years in the human body, so consumption of foods high in Cd may induce chronic toxicity [73]. The World Health Organization set a maximum provisional tolerable intake limit for an adult at 60 to 70 µg Cd per day [74] and the Codex Alimentarius Commission of FAO/WHO is discussing a limit of 0.1 µg/g. Vast areas of crop land can be considered to be uncontaminated or only slightly contaminated with Cd from phosphate fertilizer, manure and aerial deposition. Under such conditions, some crops such as durum wheat, flax, sunflowers and potatoes can accumulate amounts of Cd which exceed current and proposed maximum acceptable Cd concentrations. Uptake of Cd by the plant increases with increasing concentration of Cd in the soil solution and is influenced by the size and uptake characteristics of the plant root system [75]. Therefore, Cadmium accumulation in crops is a function of the complex interaction of soil, plant and environmental factors which influence Cd phytoavailability. In this study, the highest level of Cadmium (0.700 µg/g) was observed in Cucumber followed by lettuce (0.44 µg/g) the least of which was observed in sorrel (0.107 µg/g) as shown in Table one above. Cadmium in this study was found not detectable in guava, white melon and onion. The level observed in lettuce of this study was higher than what was observed in lettuce from Boolaro (0.213 µg/g), Sydney basin (0.015 µg/g) and port Kemla (0.060 µg/g) [76]. Although has been reported that, leafy vegetables accumulate higher metal contents than others [77]. It has also been reported that, concentrations of Cd in vegetables grown in uncontaminated soils generally varied from 0.005 to 0.5µg/g, with levels being somewhat higher in leafy vegetables and in belowground tissues than in other plant tissues [78]. Cadmium level observed in cucumber of this study was also higher than what reported by [26] from Misurata area of Libya. However, the level of cadmium determined in vegetables of this study was very much lower than was observed in vegetables from upstream (1.014 µg/g) and downstream (2.120 µg/g) from Kaduna state Nigeria [79]. Cadmium was however not detected in cucumber and lettuce in study from Jos-North [80]. It can therefore be concluded that our estimated daily intakes for the heavy metals studied here are below those reported by the FAO/WHO, which have set a PTDI limit for the heavy metal intake based on body weight for an average adult (60 kg body weight) for Pb, Cd, Cu, and Zn as 214 µg, 60 µg, 3 mg, and 60 mg, respectively [67]. The maximum permissible limit ($0.1 \mu g g^{-1}$) in foodstuff for cadmium has been reported [67]

6. CONCLUSION

From this study, it can be concluded that, the vegetables from Gongolon irrigation site is safe for consumption with the exception of Pb, Cd and to some extent Cr and Ni in tomato, lettuce, onion and sorrel that indicates above maximum permissible limits, this could be due to atmospheric deposits. Generally, the variation in the levels of the metals could be attributed mostly to atmospheric deposition and the variety of the fruits or vegetable. Most fruits with hard pericarp had less level of the metals, the source of which therefore could be the soil. Those with soft pericarps or leafy vegetables, mostly has the highest levels of the metals which could be attributed to atmospheric deposition in addition to absorption from the soil. Based on FAO/WHO safe limit data, cucumber is maximally contaminated with Cd followed by tomato and lettuce. The study suggests that washing technique can be used as a tool to assess the heavy metals load in vegetables through atmospheric depositions. This study further suggested that to reduce the health risk, vegetables should be washed properly before consumption as washing can remove a significant amount of aerial contamination from the vegetable surface.

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