

**A REVIEW ON HEAVY METALS CONTAMINATION IN SOME
VEGETABLES**

**BY
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BU/UP/2018/3528**

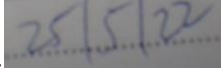
**A RESEARCH PROJECT REPORT SUBMITTED TO THE DEPARTMENT OF
CHEMISTRY IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE
AWARD OF A DEGREE OF BACHELOR OF SCIENCE EDUCATION OF BUSITEMA
UNIVERSITY**

APRIL

2022

Declaration

I Oloka Xaviour declare that this review report is my own original work unless otherwise cited, and where such has been the case reference has been stated and that the same work has not been submitted for any award in any other university or other tertiary institute of higher education.

Signature........ Date..........

OLOKA XAVIOUR

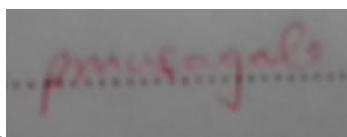
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Approval

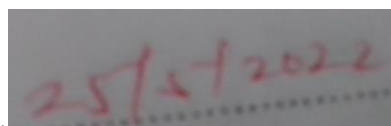
This review report has been submitted for examination with the approval of my supervisor.

Mr. MUSAGALA PETER

Signature...

A rectangular box containing a handwritten signature in red ink that reads "pmusagala".

Date.....

A rectangular box containing a handwritten date in red ink that reads "25/2/2022".

.....

Dedication

I dedicate this review report to my family and dear classmates of Busitema University.

Acknowledgement

I would like to express my special thanks of gratitude to my supervisor Mr. Musagala Peter for the good, kind consideration and assistance given to me as well as the chemistry department as a whole for their sincere commitment and guidance granted during my review report. I also do appreciate my parent Ms. Akoth Florence, hesfb for the financial support throughout my studies,

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Abstract

Agricultural produce such as vegetables has been a primary source of food for many homes. Green vegetables in the diet provide the body with vital vitamins, minerals and fibre which are very essential for human growth. There are two categories of HM namely; essential HM and non-essential HM. Essential HM include Manganese, Zinc, Copper and Iron, all the essential metals play different key roles in human body for example Iron as a metal complex in the heme plays a key role in binding molecular oxygen in the lungs and transport it to other cells in the body, Manganese is responsible for metabolism of lipids and amino acids, Copper is responsible for making red blood cells and Zinc responsible for cell division.

On the other hand non-essential HM include; Cadmium, Lead, Mercury, Arsenic, Chromium and Nickel. Essential HM is required by the human body in small portion however, when its concentration becomes high results into a number of diseases affecting the kidney, heart, brain and central nervous system. The human body gets exposed mostly to heavy metals through consumption of vegetables contaminated with heavy metals.

This has raised concern about the food security for good human health. Over use of fertilizers, mining, use of pesticides, use of waste water for irrigation of the vegetables mentioned but a few are some of sources of heavy metals.

This reviews heavy metals (Cd, Cr, Pb and Ni) accumulation in vegetable crops (onions, green pepper, cucumber, potatoes and tomatoes) and their impact on human health.

Key words: Bioaccumulation, Atomic absorption spectroscopy (AAS), Heavy Metals (HM)

1. Introduction

Green vegetables in the human diet are a vital source of minerals, vitamins and fibre which are very important for human growth and good health (Alam et al., 2018; Heshmati et al., 2019; Khezerlou et al., 2020). Heavy metals can be classified as essential and non-essential, the human body require manganese, iron, copper and zinc (essential HM) but in small quantities for physiological and biochemical function (Aiyesanmi et al., 2020). Zinc in the human body plays a key role in cell division and DNA replication as well as enhancing the transport of Vitamin A from the liver to the skin therefore protecting the body tissue from damage and repairing any damage just in case (Bhowmik, 2010).

Manganese as one of essential heavy metals in the human body is involved in the metabolism of lipids, amino acids, proteins, carbohydrates regulation of blood sugar, production of cell energy and blood clotting in the human body. Manganese also forms components of metalloenzymes that is manganese superoxide dismutase located at mitochondria which is responsible for facilitating the detoxification of superoxide free radicals (Tuschl et al., 2013).

Equation 1: Oxidation $O_2^- \rightarrow O_2 + e^-$

Equation 2: Reduction $O_2^- + e^- + 2H^+ \rightarrow H_2O_2$

Iron as an essential element is the central atom of the heme group, a metal complex that binds molecular oxygen in the lungs and carries it to all other cells in different body parts that require oxygen for the performance of their activities. Without iron in the heme group, there would be no site for the oxygen to bind hence no oxygen would be delivered to the other cells (Kambe, 2018).

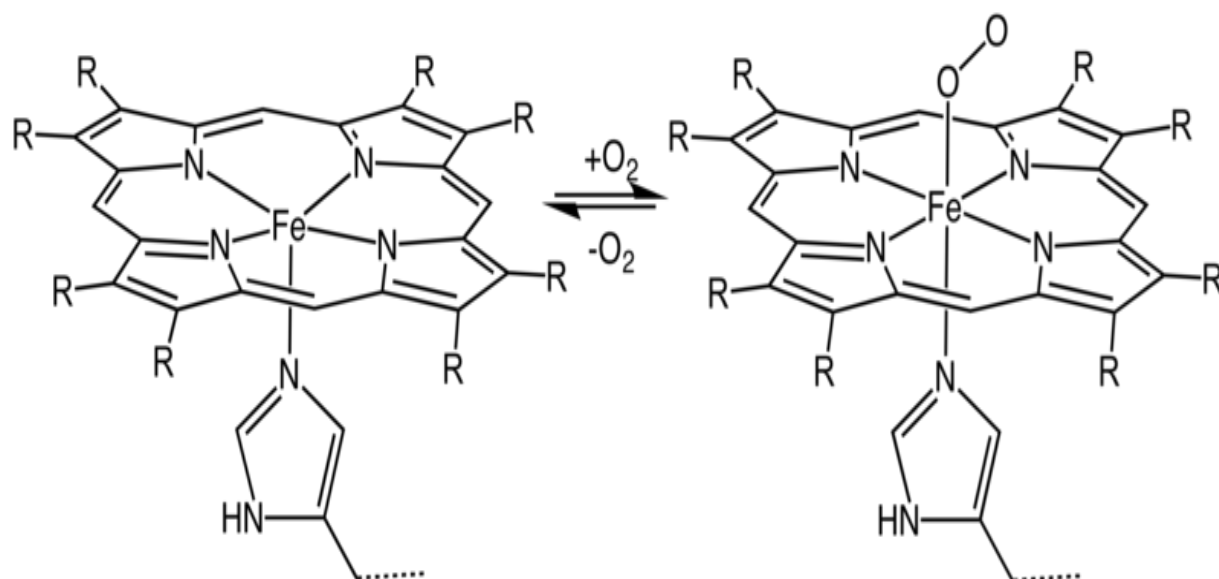


Figure 1: Binding of oxygen to a heme prosthetic group

Copper in the human body plays key role in making red blood cells, maintaining nerve cells and immune system (Manto, 2014).

On the other hand non-essential heavy metals include zinc, cadmium, lead, mercury, arsenic, chromium, copper and nickel (Magaji et al., 2020). Therefore, non-essential heavy metals are toxic to both human beings and plants as well (Aiyesanmi et al., 2020), essential elements are also toxic to humans beings when exceeded beyond certain limits in the body (Ultana et al., 2021).

Vegetables get mainly contaminated with heavy metals through bioaccumulation from soils as well as atmospheric pollution on the surfaces of the vegetables (Ultana et al., 2021).

Heavy metals have long time effects on the agricultural soils and the crops since they are non-biodegradable. Some of the heavy metals may be dumped into the vegetables surfaces and diffuse into the crop tissue system (Abdul et al., 2021). Vegetables crops absorb both nutrients and heavy metals in polluted soils with heavy metals. These heavy metals in the long run accumulate in the vegetables roots and leaves (Sandeep et al., 2019).

Crops uptake of HM from the soils depends on the soil pH, climatic condition, atmospheric deposit, maturity of the plant at time of harvest, soluble content in the soil and fertilizers (Aiyesanmi et al., 2020; Kumari et al., 2020; Sandeep et al., 2019; Ultana et al., 2021).

on the other hand the type of plant species is also another factor (Zwolak & Sarzy, 2019).

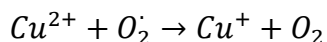
1.1 Effects of heavy metals

HM accumulation on vegetables may have negative impact to both humans and vegetables (Amshi et al., 2020). HM may greatly reduce the quality of vegetables at harvest (Kumari et al., 2020), cause reduction in growth rate in plants (Manzoor et al., 2018). Consumption of vegetables contaminated with HM is the major route for human exposure (Mohammed et al., 2020).

The consumption of vegetables contaminated with HM for a long time may lead to gradual accumulation of HM in the body organs such as the heart, lungs, neural tissues, kidneys and liver which in turn may cause cardiovascular, kidney, central nervous system disorder and bone diseases (Magaji et al., 2020). High exposure of HM such as cadmium may cause kidney dysfunction, lung cancer, bone fracture and hypertension, Chromium at high concentration is carcinogenic. Also Chromium deficiency in the human body may cause elevated body fat, reduced sperm count and hyperglycemia (Bahiru et al., 2019).

On the other hand high lead accumulation in the body may cause anemia, brain damage and central nervous disorder (Bahiru et al., 2019), lead accumulation may also cause slow growth rate in children (Heshmati et al., 2019) whereas excess accumulation of copper which is one of the essential heavy metal in the human body can lead to liver damage as well as neurological

dysfunction due to generation of hydroxyl radicals ($HO^\cdot$) through Fenton-type reaction (Kambe, 2018).



Equation 3



Equation 4: Fenton reaction

1.2 Sources of heavy metals

Heavy metals are introduced into the environment either by natural or anthropogenic sources. Natural sources are majorly rock material (Kumari et al., 2020).

Anthropogenic sources of HM include; mining from industries, burning of coal, welding, fertilizer application, smelting, industrial waste disposal, vehicle exhaust, pesticides application (Amshi et al., 2020).

Consumption of contaminated vegetables even with least concentration of HM can cause damage to humans. Therefore, this has been a concern by many researchers to determine HM concentration to ensure that HM concentration is within acceptable levels as per international standard and safe for human consumption (Magaji et al., 2020).

The general aim for this study is to review different studies that have been conducted by researchers to determine levels of HM concentration in vegetables.

The specific aim for this study is to review studies on levels of Cadmium, Chromium, lead and Nickel concentrations on fresh vegetables in Tororo Market.

1.3 Literature review of work done

Researchers have analysed different vegetables in different places of the world to find out the levels of HM concentration and compared to World Health Organisation (WHO) and Food and Agricultural Organisation (FAO) acceptable values for good human health.

Zahir Ur Rehman analysed agricultural soils and vegetables for HM (copper, zinc, chromium, nickel and Manganese). The vegetables crops were grown in the southern selected districts of khyber Pakhtunkhwa province in Pakistan (Zahir Ur Rehman et al., 2019). In the analysis all the vegetables were found to be with in the acceptable permissible risk limits except chromium was observed in a higher concentration in all vegetables in the selected area of study. Therefore, it was concluded that all the vegetables were approved to be safe for human consumption as the values of health risk index (HRI) for HM were less than 1.

Olfat M. Nassar analysed some popular fifteen vegetables species purchased from selected local markets in Rafh Governorate at northern Border region in kingdom of Saudi Arabia (Nassar et al., 2018).

In this category were leafy vegetables (Arugula, cabbage, corchorus, dill, parsley), fruits (cucumber, eggplant, green pepper, tomato) and tubers (garlic, onion, radish, potato and yam) and were tested for concentration of HM (cadmium, lead, arsenic, iron, copper and zinc). In the analysis, the findings were that Arsenic, Iron, Copper and Zinc concentrations in the vegetables were within FAO/WHO safe limits whereas Cadmium and Lead concentrations in the vegetables were beyond the permissible risk limits recommended by FAO/WHO.

Gebeyehu in 2020 reported levels of As, Pb, Cd, Cr and Hg higher than permissible limits in the vegetable samples in Mojo area, Ethiopia (Gebeyehu et al., 2020). Vegetables had potential risk to human health.

2. Atomic absorption spectroscopy

2.1 Introduction

AAS is one of the analytical techniques used for determining the concentration of a particular metallic element within a sample in ppm. AAS is a method of analysis based on absorption of radiation by atoms when a solution of metallic salt is aspirated into a flame.

2.2 Principles of AAS

AAS method is similar to that of spectrometer; the only exception is that the sample cell is replaced by a flame. A monochromatic light for a particular element is produced by a hollow cathode lamp utilizing that element as a cathode. It is beamed through a long a flame into which is aspirated solution to be analyzed. The heat energy from the flame dissociates the molecules and converts the components to atoms, some of the atoms in solution are activated but most of the atoms remain in the ground state and the ground state atoms of the same element as in hollow cathode lamp absorb their own resonance lines.

On the other hand the amount of light absorbed varies directly with the concentration of the elements, the transmitted light that is not absorbed reaches the monochromator where it passes only the wave lengths close to the resonance lines of a particular element to be analyzed then the transmitted light strikes the detector which in turn measures the intensity of the transmitted light (Beaty & Kerber, n.d.).

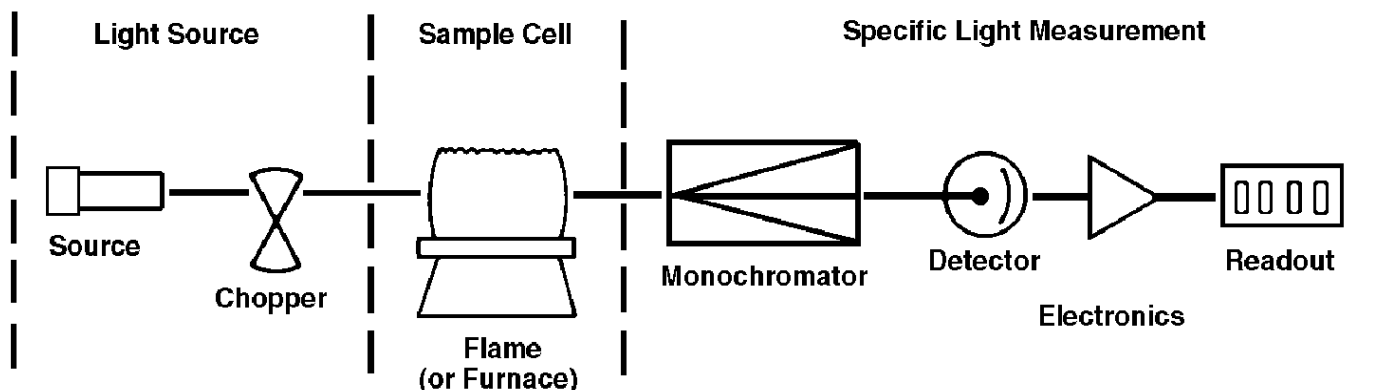


Figure 2: Basic AAS components

2.3 Components of AAS

AAS is composed of the following;

2.4 light source

Hollow cathode lamp (light source) emits atomic spectrum of a particular element and different lamps are used depending on the elements to be determined. The cathode and anode are sealed in a cylinder filled with either neon or argon gas at low temperature, the cathode of the lamp is a hollow-out cylinder of the metal whose spectrum is to be produced and at the end of the cylinder is a window transparent to the emitted radiations. Cathode lamps are stored in the compartment inside the AAS. The specific lamp needed for a given metal analysis is rotated into position for a specific experiment and when electrical potential is applied between anode and cathode, some of the fill gas atoms are ionized. The positively fill gas ions accelerate through the electrical field to collide with cathode and dislodge individual metal atoms. This process is called sputtering, the

sputtered metal atoms are elevated to an excited state and when the atoms return to ground state, the characteristic line spectrum of that atom is emitted and the emitted light is directed at the flame where the unexcited atoms of the same element absorb the radiation and in turn are raised to excited state then absorbance is measured (Beaty & Kerber, n.d.; Farrukh, 2009).

2.5 Beam chopper

It corrects the interference in the absorption measurements due to radiation from both hollow cathode lamp and the flame. It is a motor driven device that has open and solid alternating regions. One half of their rotation that is the region allows the beam obtained from the lamp to pass through while during the other half of their rotation that is the mirror region, the beam is reflected and not permitted to pass through (Beaty & Kerber, n.d.).

2.6 The flame/ burner system

Samples are introduced through the flame, the burner consist of three parts namely; nebulizer, Premix chamber and burner head. Nebulizer sucks up samples at controlled rate, creates fine aerosol, mixes the aerosol, fuel and oxidant thoroughly for introduction into the flame then sample droplets of about 5-10 nm are introduced into the flame while larger droplets are stopped by spoilers and flow out as waste. A small glass impact bead inside the chamber create a heterogeneous mixture of the gas and suspended aerosol then finest sample aerosol are carried with the combustion gases to the burner head where atomization takes place while the liquid sample that does not flow into the flame, drain out as waste. Burner heads are made up of titanium basically because they are resistant to heat and corrosion (Beaty & Kerber, n.d.).

2.7 Monochromators

Monochromators select a given emission line and isolate it from other lines. Light from the source enters it at the entrance slit and is directed to the grating where dispersion takes place, the diverging wavelength of the light are directed toward the exit slit and through adjusting the angle of the grating, a selected emission line from the source can be allowed to pass through the exit slit and fall onto the detector while all other lines are blocked from exiting (Beatty & Kerber, n.d.).

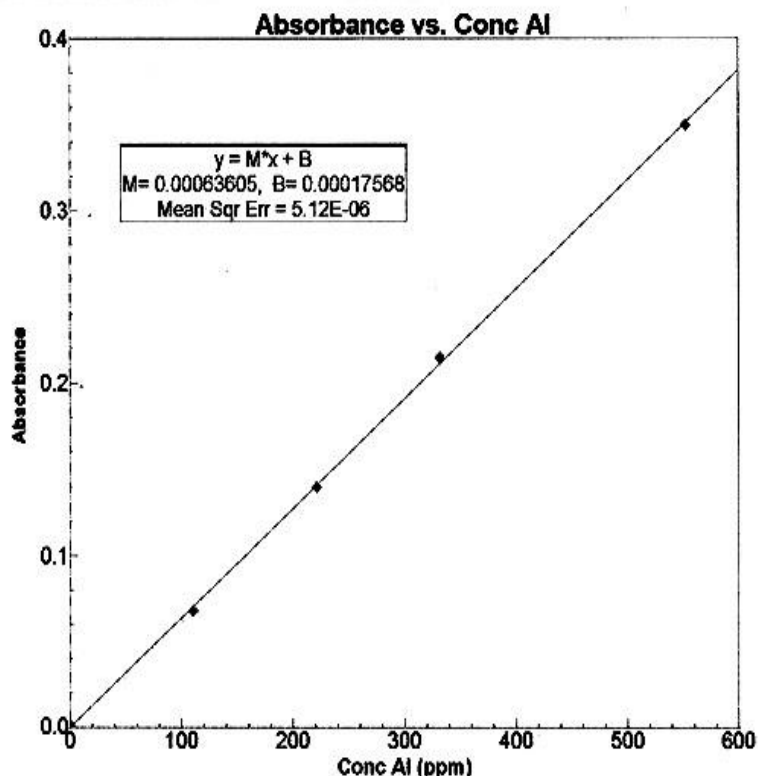
2.8 Detector

The detector measures the wave length of the light transmitted by the sample.

In quantitative analysis in AAS can be achieved by measuring the absorbance of a series of solution of known concentration then the calibration curve and equation of the line can be used to determine the unknown concentration based on its absorbance as illustrated in Table 1

Data Set 1: Data		
Row Num	Conc Al (ppm)	Absorbance ()
1	0.00	0.001
2	110.50	0.068
3	221.00	0.140
4	331.50	0.215
5	552.50	0.350
Number	5	5
Mean	243.10	0.155
Min	0.00	0.001
Max	552.50	0.350
Std Dev	212.55	0.135

Calibration Curve for the Determination of Aluminum by Atomic Absorption Spectroscopy



3.0 Sample preparation

During sample preparation, the samples of edible vegetable are randomly collected from market. The vegetables samples then are thoroughly washed with distilled water, cut into smaller pieces, dried in an oven at 70⁰ for 2 days to eliminate excess moisture and the samples grounded into fine powder.

The samples are then followed by wet digestion that is concentrated acid mixtures of HClO₄ and HNO₃ are added in a conical flask containing the samples. The resulting samples are then heated until a transparent solution is achieved for about 2 hours.

The samples are cooled then filtered using cellulose membrane (0.45 μm). Lastly the filtrate are diluted with distilled water (Altarawneh, 2019).

3.1 Sample analysis

The absorbance of the analytical blank is first determined then the standards with increasing concentrations, the absorbance determined and a graph of concentration versus absorbance is plotted. If the correlation for this curve is significant then small quantities of the diluted samples are introduced into the flame, the heat reduces the ions into elements and vaporizes, and the element absorbs light at specific wavelengths in the visible or ultraviolet spectrum. A light beam for the specific element being measured is directed through the flame to the monochromator then the light absorbed by the flame from the sample is compared with absorption from known standards to quantify the elemental concentration. Unknown concentration of the sample element in the solution is determined using the calibration curve, considering the concentration of the element as proportional to the ground state atom population in the flame (Farrukh, 2009).

3.2 Conclusion

Essential heavy metals namely; Manganese, Iron, Copper and Zinc are of great significance to the human body. Their deficiency as well as high levels in the human body may lead to several diseases like heart diseases, kidney failure and brain damage among others. Therefore scientist should carry out more research on soils, plants and water to find out levels of heavy metals and to ensure that human beings consume safe food and drink safe water.

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