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Assessment of Some Heavy Metals Contamination in Some Vegetables (Tomato, Cabbage, Lettuce and Onion) in Ethiopia: A Review

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Abstract: Heavy metals in the soil are associated with various chemical forms that related to their solubility nature which directly bear on their mobility and biological availability. Vegetable and other crops can absorb heavy metals from soil and, deposited on the part of their tissues. The aim of this review is to assess the extent of heavy metals in some vegetables (lettuce, tomato, cabbage and onion) which are grown in different part of Ethiopia. These vegetables are staple and common vegetables consumed by all classes of Ethiopians, due to high consumption rate of these vegetables. Vegetables are vital to human being diet as they contain essential components need by the human body such carbohydrates, proteins, vitamins, minerals and also trace elements. Consumption of vegetables like tomato, lettuce, cabbage and onion are is one of the pathways by which heavy metals enter the food chain. According to different studies in Ethiopia the concentration of heavy metals in vegetables has been compared with the standard value recommended by WHO/FAO, and other organization are recorded comparative average concentrations and above the recommended limit. The higher concentration of heavy metal in vegetables might be due industrialization and agricultural activities. Based on facts obtained from different studies we suggests concerned official body (ies) to take the necessary precaution measures for agricultural activities, polluted factory effluents, gasses and solid wastes and other heavy metal source.

Keywords: Heavy Metals, Vegetables, Contamination

1. Introduction

Heavy metals are defined as elements in the periodic table having high atomic number, atomic weight, specific gravity greater than 5 and atomic densities of more than 5 g/cm^3 generally excluding alkali metals and alkaline earth metals [1]. The environmental problems associated with heavy metals are that they as elements are undestroyable and most of them have toxic effects on living organism when exceeding their limited concentration. Furthermore, some heavy metals are being subjected to bioaccumulation, geo-accumulation and may pose a risk to human health when transferred to the food chain [1].

They became concentrated due to industrialisation, urbanization, uncontrolled farming practice and can enter pant, animal and human tissues through inhalation, diet and manual handling. They can interfere with cellular components. Cd, Pb, Cr, Hg and as appear among the 10 list of chemicals of major public concern to WHO [2]

Food crops for examples: fruits, tubers, vegetables and nuts that are cultivated in contaminated farm land can accumulate toxic heavy metal (HMs). Humans exposure to toxic HMs is via inhalation of dust intake of contaminated water and food crops. HM via food accumulate in the several organs causing altered metabolism in liver and kidney, cardiovascular, nervous and bone disorders [3].

Vegetables are rudimentary eating routine taken by peoples in all through the world, being wellsprings of fundamental supplements, antioxidants agents and metabolites. They likewise go about as buffering specialists for acid substance obtained during the digestion process. However, both essential and toxic components are available in vegetables over an extensive variety of concentrations as

they are said to be great absorber of metals from the soil [4]. Different plants accumulate its different concentration. Some accumulate more than others. Vegetables being carrier of metals, when taken up by human beings, get ingested into human body. Heavy metals can be exceptionally unsafe to the human body even in low concentrations as there is no powerful excretion mechanism [5]. Therefore, the present review was conducted with an aim to assess the heavy metals accumulation potential on tomato, lettuce, cabbage and onion in Ethiopia and it sources also reviewed.

2. Sources of Heavy Metals in Vegetables

Industrialization and urbanization has contributed elevated levels of heavy metals in the environment of developing [5; 6; 7; 8; 9]. Heavy metals are nonbiodegradable and persistent in the environment, which deposited in soil or absorbed into the tissue of vegetables.

2*.1. Soil*

Heavy metals in the soil are associated with various chemical forms that related to their solubility nature which directly bear on their mobility and biological availability. Vegetable and other crops can absorb heavy metals from soil and, deposited on the part of their tissues. (Haiyan and Stuanes, 2003). Heavy metal toxicity can directly affect plant physiology, growth, and many case of toxicity from heavy metals have been reported. Jorgensen group show that intensive horticultural systems in urban areas may be threatened by soil toxicity through trace elements such as Zn, Cu, As and Pb [9].

2.2. Wastewater

Water contaminated by toxic heavy metals in some areas due to natural process and anthropogenic activities. Toxic heavy metals contamination of agricultural soil from wastewater irrigation is serious problems since it has implication on human health. The extent of absorption of heavy metals by the plant depends on the nature of the plant and the chemical constitution of the pollutant. Many studies have been shows that wastewater irrigation has increase the levels of heavy metals in the receiving [9; 10; 11; 12; 13; 14]. The accumulation of toxic heavy metals in vegetables has serious adverse effects on human health and plants [9; 15]. According to Fisseha, 2003, the Ethiopian metal tools factory is the major source of pollution of rivers, which used to irrigate part of vegetable farms. In addition to that the author reported that wastewater from eastern industry zone, Dukem Ethiopia discharged into the farm land around that park were above the recommended levels set FAO/WHO in the vegetables produced by irrigating these contaminated water [16].

2.3. Anthropogenic

Anthropogenic source of heavy metals include addition of manures, sewage sludge, fertilizers and pesticides, which may affect uptake of heavy metals by vegetables [17]. Whatmuff and McBride found that, increasing concentrations of heavy metals in soil increased the crop uptake. Plant cultivation areas near in the highways, also exposed to atmospheric pollution in the form of heavy metal containing aerosols. These aerosols can deposited on soil and absorbed by the vegetables or alternatively deposited on the leaves and fruits and then absorbed [9; 18; 19]. Emission of heavy metals from the industries. Source of different heavy metals are presented in the Table 1.

Table 1. *Source of different heavy metals: Manufacturing/Industries/Industrial effluents [9].*

Heavy metals	Manufacturing/Industries/Industrial effluents as sources heavy metals
Arsenic	Phosphate fertilizers, Mining, Smelting, Metal hardening, Paints, Textile, Industrial dusts, Medicinal, Pharmaceuntical, Wastewater, Pesticides, Smelting of gold, lead, copper and nickel, Production of iron and steel, Industrial waste, Combustion of fossil fuel, Industrial waste.
Cadmium	Mining and metallurgy, Phosphate fertilizer, Fertilizers, Electronics, Pigments and paints, Industrial and incineration dust and fumes, Wastewaters, Pesticides, Baterry, PVC products, Color pigments.
Chromium	Mining and metallurgy, Metal plating, Rubber, Photography, Industrial dust and fumes, Tanning, Leather industry, Chemical industry, Fertilizers, Textile industry, Paints and pigments.
Lead	Mining and metallurgy, Industrial dust and fumes, Application of lead in gasoline, Combustion fossil fuel, Solid waste, Solid waste combustion and Incineration, Industrial waste, Paints and pigments, Explosive, Ceramics and dishware, Some types of PVC, Pesticides, Fertilizers, Manufacturing of lead—acid batteries, Paints and pigments, Urban runoff.
Mercury	Mining, Smelting and metallurgy, Chlor-Alkali, Scientific instruments, Production of chemicals, Industrial dust and fumes, Industrial wastewater, Fossil fuel combustion, Solid waste combustion, Incineration of municipal wastes, Fertilizers, Pesticides, Electrical switches, Fluorescent bulbs, Mercury arc lamps, Production of mercury products (batteries, thermometers, mercury amalgam), Explosive, Rubber and plastics, Cellulose and paper.
Nickel	Mining and metallurgy, Electroplating, Production of iron and steel, Industrial dust, Industrial aerosols, Incineration of waste, Fertilizers, Combustion of coal, Battery, Chemical industries, Food processing industries.
Zinc	Mining and metallurgy, Galvanization, Plating iron and steel, Electroplating, Fertilizers, Metal waste.
Copper	Mining and metallurgy, Plating, Rayon, Electrical and electronics waste, Mining and metallurgy, Pesticides, Paints and pigments, Textile industry, Explosive.

3. Heavy Metal and Consumer Health

Heavy metals accumulation human body in considerable amount that will bring damage the boy system, due to non-biodegradable properties of heavy metals. They also have higher affinity towards the body system, which enables them

to remain longer in the body. Oral exposure is the most compelling way for those heavy metals to enter the human body and cause disruption [20]. The polluted soil, water and air that transfer heavy metals in to crops indirectly involved heavy metals in the food chains that later will harm the consumers [21].

Heavy metals enter to the human body through different pathway (Figure 1) for examples dust and air pollution, conception of vegetables grown in contaminated soils [9; 22; 23]. Accordingly, assessment of heavy metals health risk give the impression necessary [24; 25; 26], their fore remediation heavy metals levels is useful method for safeguard of human health [27].

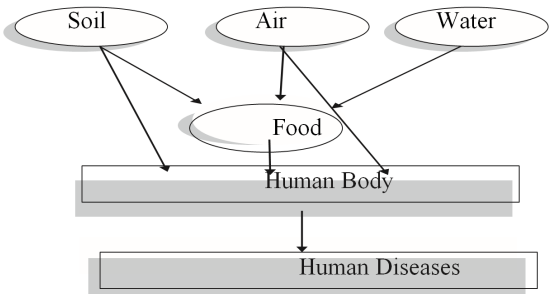

Figure 1. *Different pathways of heavy metals entrance into human body.*

4. Vegetables and Heavy Metal Contamination in Ethiopia

Vegetables are one of the diet by contributing Fe, Ca, and other nutrients. Vegetables are human diet as they contains needed by human bogs like carbohydrates, proteins, vitamins, minerals and trace elements. In recent years 2008 their consumption is increasing gradually, particularly among the urban community. This is due to increasing awareness on foods value of vegetable, as result of exposure to other cultures and acquiring proper education. However, vegetables are contains both essential and toxic elements over a wide range of concentrations [28].

Human beings are encouraged to consume more vegetables and fruits, which are a good source of vitamins, minerals, fibers and also beneficial to their health. However, these plants contain both essential and toxic metals over a wide range of concentrations. It is well known that plants take up metals by absorbing them from contaminated soils as well as from deposits on parts of the plants exposed to the air from polluted environments. The publicity regarding the high level of heavy metals in the environment has created a certain apprehension and fear in the public as to the presence of heavy metal residues in their daily food. The public is confused and alarmed about their food safety [29].

A primary concern in urban agriculture is the transfer of trace metals from vegetables through the food chain to humans. For example it has been estimated that this route contributes up to 70% of the dietary intake of Cd. Vegetables may accumulate trace metals from contaminated soil and are also exposed to surface deposition onto their shoots in polluted atmospheric environments [23].

However, little information is available regarding human exposure to contaminants via urban agriculture in developing cities. In many cities in the developing world, there is inadequate or nonexistent waste collection, rapidly increasing traffic and largely unchecked industrial contamination. Thus, urban agriculture faces major problems in balancing demands associated with increasing populations against potential hazards arising from the use of contaminated urban sites for consumption of vegetables is one of the pathways by which heavy metals enter the food chain [23].

Difference in concertation of heavy metals in vegetables seems to imply different in different vegetable type. In spite of element uptake by root, plants are known to respond to the amount of readily mobile type of metals in soil. Different vegetable species accumulated different toxic heavy metal levels and types depending on environmental conditions, metals species and plant available forms of heavy metals [30]. A report on heavy metals levels on vegetables from Addis Ababa market showed that lettuce contained the highest Cd whereas cabbage accumulate the least [31; 32]. Similar trends of higher accumulation of metals in Swiss chard and low accumulation in cabbage were observed in vegetables from Akaki farm, which was irrigated with industrial effluent [33]. And also Bahiru and Bahiru and teju [10; 11] are reported that the heavy metals accumulation in different vegetables are above the recommended levels set by different organization like FAO, WHO and in addition to those, other several studies reports in similar way as shown in Table 2

Table 2. *Concentration of heavy metals in different vegetables according to different studies in Ethiopia.*

Vegetable	Studied location	Source of Heavy metals
Tomato	Around Eastern industry zone, Dukem, Central Ethiopia	Industrial effluents
	Gondar, Ethiopia	Urban wastewater irrigation
	Abaya lake area, south Ethiopia	Urban waste, agricultural activity
	Arbaminch textile share company area, south Ethiopia	Industrial effluents
	Kulfo river area, south Ethiopia	Urban waste, agricultural activity
	Chamo lake area south Ethiopia	Urban waste, agricultural activity
	Zeway floriculture, Rift valley Ethiopia	Floriculture effluent
Onion	Mojo, East Shewa Central Ethiopia	Leather industry effluents, agricultural practices
	Meki, East Shewa Central Ethiopia	floriculture farms effluents and agricultural practices
	Zeway, East Shewa Central Ethiopia	floriculture farms effluents and agricultural practices
	Gondar, Ethiopia	Urban wastewater irrigation
	Addis Ababa, Ethiopia	Urban wastewater irrigation

Vegetable	Studied location	Source of Heavy metals
Cabbage	Wonji Gefersa East Shewa Zone, Ethiopia	Contaminated Awash river water
	Meka Hadi East Shewa, Ethiopia	Contaminated Awash river water
	Gondar, Ethiopia	Urban wastewater irrigation
	Abaya lake area, south Ethiopia	Urban waste, agricultural activity
	Arbaminch textile share company area, south Ethiopia	Industrial effluents
	Kulfo river area, south Ethiopia	Urban waste, agricultural activity
	Chamo lake area south Ethiopia	Urban waste, agricultural activity
	Kera, Addis Ababa	Urban wastewater and industrial effluent irrigation
	Peacock, Addis Ababa	Urban wastewater and industrial effluent irrigation
Lettuce	Wonji Gefersa, East Shewa Zone, Ethiopia	Contaminated Awash river water
	Meka Hadi East Shewa, Ethiopia	Contaminated Awash river water
	Gondar, Ethiopia	Urban wastewater irrigation
	Abaya lake area, south Ethiopia	Urban waste, agricultural activity
	Arbaminch textile share company area, south Ethiopia	Industrial effluents
	Kulfo river area, south Ethiopia	Urban waste, agricultural activity
	Chamo lake area south Ethiopia	Urban waste, agricultural activity
	Burayu, Addis Ababa Ethiopia	Urban waste of Gefersa River,
	Kuskuam Upper, Addis Ababa Ethiopia	Tap water from public water supply
	Ziway Ethioflora, Rift valley Ethiopia	Urban waste of Ziway lake
	Kera, Addis Ababa	Urban wastewater and industrial effluent irrigation
	Peacock, Addis Ababa	Urban wastewater and industrial effluent irrigation

Table 2. *Continued.*

Vegetable	Studied heavy metals	Levels of heavy metals in mg/kg respectively	Reference
Tomato	Cr, Cd, Zn, Fe, Pb and Cu	2.97, 2.20, 45.63, 358.17, 4.60 and 10.20	[10; 11]
	Pb, Cd, Cr, Cu, Zn, Ni and Mn	5.95, 2.43, 5.80, 2.01, 24.61, 13.88 and 2.42	[34]
	Cd, Cr, Pb, Zn, Cu and Ni	0.32, 1.45, 0.18, 15.09, 32.46 and 15.40	[35]
	Cd, Cr, Pb, Zn, Cu and Ni	0.28, 1.52, 0.16, 10.24, 19.56 and 24.45	[35]
	Cd, Cr, Pb, Zn, Cu and Ni	0.43, 1.85, 0.28, 13.65, 24.23 and 26.89	[35]
	Cd, Cr, Pb, Zn, Cu and Ni	0.41, 1.70, 0.21, 19.56, 26.37 and 25.87	[35]
	Cd Cr Pb and Cu	0.025, 0.32, 0.48 and 0.39	[36]
Onion	Cr, Cu, Zn, Pb, Cd, Mn and Fe	4.87, 3.93, 12.42, 0.33, 0.05, 8.20 and 20.87	[37]
	Cr, Cu, Zn, Cd, Mn and Fe	4.13, 1.33, 7.71, 0.03, 13.40 and 24.33	[37]
	Cr, Cu, Zn, Cd, Mn and Fe	3.25, 0.87, 13.47, 0.06, 7.53 and 0.80	[37]
	Cd, Cr, Cu, Zn, Ni and Mn	3.93, 6.66, 2.15, 19.15, 9.25 and 3.94	[34]
	As, Cd, Cr, Cu, Hg, Ni and Zn	0.105, 0.018, 2.81 5.24, 0.201, 0.44 and 15.4	[38]
	Cr, Cd and Pb	0.29, 0.20 and 0.30	[39]
	Cr, Cd and Pb	0.85, 0.23, and 0.31	[39]
Cabbage	Pb, Cd, Cr, Cu, Zn, Ni and Mn	3.80, 6.62, 10.00, 2.82, 27.87, 7.41 and 7.27	[34]
	Cd, Cr, Pb, Zn, Cu and Ni	0.30, 2.05, 0.31, 16.40, 20.65 and 11.95	[35]
	Cd, Cr, Pb, Zn, Cu and Ni	0.33, 2.85, 0.29, 10.46, 14.56 and 18.65	[35]
	Cd, Cr, Pb, Zn, Cu and Ni	0.42, 2.78, 0.46, 14.26, 16.54 and 19.89	[35]
	Cd, Cr, Pb, Zn, Cu and Ni	0.37, 2.17, 0.42, 21.56, 18.47 and 17.95	[35]
	As, Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb and Zn	0.13, 0.02, 0.06, 0.89, 3.03, 73.00, 29.00, 0.80, 0.21 and 31.80	[38]
	As, Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb and Zn	0.11, 0.01, 0.13, 1.63, 3.30, 173.00, 25.00, 0.91, 0.29 and 31.81	[38]
	Cr, Cd and Pb	1.33, 0.32, and 0.40	[39]
	Cr, Cd and Pb	2.40, 0.40, and 0.65	[39]
Lettuce	Pb, Cd, Cr, Cu, Zn, Ni and Mn	2.38, 0.23, 6.66, 1.61, 64.55, 48.14 and 41.52	[37]
	Cd, Cr, Pb, Zn, Cu and Ni	0.18, 1.55, 0.19, 24.34, 18.55 and 9.88	[35]
	Cd, Cr, Pb, Zn, Cu and Ni	0.19, 1.45, 0.16, 18.56, 13.90 and 15.86	[37]
	Cd, Cr, Pb, Zn, Cu and Ni	0.25, 1.82, 0.31, 22.46, 16.42 and 17.70	[35]
	Cd, Cr, Pb, Zn, Cu and Ni	0.22, 1.63, 0.30, 27.46, 17.44 and 16.81	[35]
	Cd, Cr, Pb and Zn	0.07, 1.08, 1.17 and 46.29	[40]
	Cd, Cr, Pb and Zn	0.05, 0.81, 1.24 and 36.83	[40]
	Cd, Cr, Pb and Zn	0.03, 0.76, 0.52 and 20.76	[40]
	As, Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb and Zn	1.04, 0.13, 0.76, 9.47, 6.62, 1345.00, 106.00, 1.86, 1.59 and 48.03	[38]
	As, Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb and Zn	0.31, 0.08, 0.17, 1.21, 6.24, 351.00, 54.00, 0.71, 0.39 and 47.80	[38]

5. Conclusion

Heavy metals are very harmful because of their non-biodegradable nature, long biological half-lives and their potential to accumulate in different body parts. Vegetables are vital to human diet as they contain essential components needed by the human body such as carbohydrates, proteins, vitamins, minerals and also trace elements. Consumption of vegetables is one of the pathways by which heavy metals enter the food chain. Recently, in many part of our country Ethiopia heavy metal assessment in vegetables were done by different researcher, and they report the concentration of different heavy metals in tomato, lettuce, cabbage and onion

are above the recommended limit set by FAO, WHO, UNEPA, CMH, and other organization. These are due to industrialization, household activities, and agricultural activities like fertilizer, pesticide, and excess use of fertilizer organic materials in vegetables production. Therefore the concerned body should be give attention bout heavy metal pollution in vegetables and the researchers give attention for the heavy metal remediation techniques.

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