

Review Article

Accumulation of Toxic and Trace Metals in Agricultural Soil: A Review of Source and Chemistry in Ethiopia

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Abstract: The main aim of this paper review is to know the extent of toxic and trace metals in some listed part Ethiopian farmland soil and its cause. Heavy metals are persistent in the agricultural soils (environments), they are non-termly and biological degradable. Among those toxic heavy metals, Pb, Cd, As, Hg, Cr, Co, Ni, Cu, Zn, Fe, Mn, are some of them. Every year's large amount of industrial wastes, urban wastes, automobile emission, fertilizer, pesticide, wastewater irrigation and other agricultural activities are common in large agricultural farm land of Ethiopia. Those leads in to contamination of farmland with toxic heavy metals and other pollutants, The effect of those pollutants lower the quality of products finally they affect the health of consumers. According to different reports, in Ethiopia the farmland around cities and industry zone have accumulated large amount of toxic and trace heavy metals with compared to other farmlands. Mostly the concentration of those toxic metals were above the recommended limit set by different organization like FAO, WHO, EP and other. Therefore, the concerned body should be set different strategy and rule for agricultural activities, polluted factory effluents, gasses and solid wastes and other heavy metal source in order to protect the consumers from different heavy metals caused diseases.

Keywords: Heavy Metals, Contaminated Soil, Pollutants, Agricultural Activities

1. Introduction

Heavy metal is a member of element that exhibits metallic properties. It includes transition metals, some metalloids, lanthanides and actinides. Many different definitions have been proposed- some based on density, some based on atomic number or atomic weight and some on chemical properties or toxicity [1]. Heavy metal pollution and contamination of the soil, water and air has been become common because of anthropogenic activities. Environmental pollution by heavy metals has increase due to industrial revolution, thereby causing serious ecological problems ecological problems [2, 3]. Soil is dynamic body of natures and complex system they undergo physical, chemical, biological, geological and bio geophysical reactions [4].

Potentially toxic elements are often presented as "trace metals" or "heavy metals. Trace metals relate to the elements present in soils in trace amounts (normally described as 1 mol m⁻³). Heavy metals, a loosely defined group of elements,

represent the elements that exhibit metallic properties with atomic mass over 20 (excluding the alkali metals) and specific gravity more than 5 [5]. According to some researchers, heavy metals are the elements with an atomic density >6 gcm⁻³ (except for As, B, and Se) [6].

Uncontrolled agriculture is difficult phenomenon, they give useful, and harmful effect on environment. [7]. Environmental Pollution is a big problem because of its adverse effect on human health, plans, and animals. [8]. Among environmental pollution, the heavy metals toxicity have received special attention globally and become an environmental problem of worldwide concern due to neurotoxin, carcinogenic and several other impacts arising from their consumption even at lower contents [9]. Therefore, the present review was conducted with an aim to assess the heavy metals accumulation potential on agricultural soil in Ethiopia, it sources, and chemistry reviewed.

2. Source of Heavy Metals in Agricultural Soils

Heavy metals are very harmful because of their non-biodegradable nature, long biological half-lives and their potential to accumulate in different body parts. Most of the heavy metals are extremely toxic because of their insolubility in water. Even low concentrations of the heavy metals have damaging effects to man and animals because there is no good mechanism for their elimination from the body systems. Nowadays, heavy metals are ever-present because of their excessive use in industrial applications. Wastewater contains substantial amounts of toxic heavy metals, which create problems [10]. Excessive accumulation of heavy metals in agricultural soils through wastewater irrigation may not only result in soil contamination, but also affect the food quality and safety [11]. Knowing the source of heavy metals in agricultural soils are important in order to know levels of contamination, for taking of proper treatment and keeping sustainable agricultural development.

2.1. Natural Source

The first source of toxic heavy metals in agricultural soils are parent materials from which the soil are derived, but influence of parent materials on heavy metal concentration and forms of heavy metals in agricultural soil is modified to varying degrees by pedogenetic processes [12]. In different areas heavy metals in soils derived mainly from pedogenetic parent materials, the levels of heavy metals status was affected by several factors among them moisture and management patterns. According to report conducted Li in 2008 soil aqua regia soluble fraction of Co, Ni, Pb and Zn were highly correlated with soil aluminum and iron. These elements were associated with indigenous clay minerals in the soil high in Al and Fe [13, 14].

2.2. Wastewater

In many part of the world, urban wastewater is used for irrigation water for production different crops mostly vegetables. Wastewater mostly contains many nutrients like heavy metals, organic compounds and pathogens that may have a negative impact on the environment and human [15]. Most of the studies in Ethiopia shows that the use of heavy metals contaminated wastewater for irrigation over long period of time increases the heavy metal content of the soil above safe limits [16, 17]. In the end, increasing the heavy metal content in soil also increases the uptake of heavy metals by plants depending upon the soil type, plant growth stages and plant species [18, 19]. The soil type, plant growth stages and plant species [18, 19].

2.3. Fertilizers

Agricultural activity was the major human influence on the agricultural soil. Some agricultural soils are deficient in metals (such as Co, Cu, Fe, Mn, Mo, Ni, and Zn) that are vital for healthy plant growth, and crops may be supplied

with these as an addition to the soil or as a foliar spray. Large quantities of fertilizers are regularly added to soils in intensive farming systems to provide adequate N, P, and K necessary for crop growth. Application of certain fertilizers inadvertently adds potentially toxic elements to the soil. The raw materials and components used for the production of fertilizers contain trace amounts of heavy metals (e.g., Cd, Pb, Hg, As, Ni, Cu, Mn, V) as impurities, which, after continued fertilizer application, may significantly increase their content in the soil and the transfer to the food chain [20-22].

2.4. Pesticides

Several common pesticides used extensively in agricultural activities mostly in horticulture production they contained substantial concentration of heavy metals. For instance in the recent past, about 10% of the chemicals have approved for use as insecticides and fungicides in UK were based on compounds which contain Cu, Hg, Mn, Pb, or Zn. Although in Australia, timbers have been preserved with combination of copper, chromium and arsenic (CCA) and there are now many derelict sites where soil concentration of these elements greatly exceed background concentrations [23].

2.5. Biosolids and Manures

Biosolids (sewage sludge) are primarily organic solid products, produced by wastewater treatment processes that can be beneficially recycled [24]. The application of numerous biosolids (livestock manures, compost, municipal sewage sludge) in to agricultural soils inadvertently leads to the accumulation of heavy metals such as Arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, molybdenum, zinc, titanium and antimony in the agricultural soil [25].

3. Toxic and Trace Metals in Different Farmland Soil of Ethiopia

Agricultural soil pollution by heavy metals has cerise global problems [26, 27]; especially for developing countries like Ethiopia where waste disposal is a big problem. Although heavy metals occur naturally in soil, human activities such as agricultures, urbanization, industrialization, and other activities are gradually rise the levels of heavy metal in soil [28].

Because of urbanization and industrialization, the disposal of wastes and the use of agrochemicals the pollution levels of heavy metals reached alarming situation in Ethiopia [29-32].

At the resent time, agricultural soil of Ethiopia was becoming polluted with different trace and toxic heavy metals, especially in urban centers. The dominant heavy metal pollution sources in Ethiopian agricultural soils are irrigation with stream/river and industrial effluents, and application of agrochemicals [29, 33, 34].

According to Deribachew groups in 2015, assessment of heavy metals (chromium, cobalt, cadmium and lead) concentration in soil of Haramaya universities farm site, around Haramaya, Awadey, and Harer cities farm lands were determined, almost all in the sites the concentration of those

metals are above the recommended levels set by different organizations [35]. In similar studies, Bahiru groups 2019 and Bahiru and Teju, 2019 are reported that concentration of heavy metals (Cr, Cd, Pb, Zn, Cu and Zn) in the soil around eastern

industry zone, Dukem central Ethiopia have the recommended levels set by WHO, USEPA, CMH ([29, 30]. The concentration of those heavy metals and other several studies were presented in Table 1.

Table 1. Levels of trace and toxic heavy metals in agricultural soils of Ethiopia.

Soil samples collected area	Soil originated crops	Source of heavy metals in the studied area	Studied heavy metals	Levels of heavy metals in studied soil samples in mg/kg respectively	Reference
Eastern industry zone, Dukem Ethiopia farm land	Tomato	Industry effluents, agricultural activities	Cr, Cd, Zn, Fe, Pb and Cu	50.50, 45.33, 114.86, 20065.00, 63.00 and 146.10	[29, 30]
Eastern industry zone, Dukem Ethiopia farm land	Cabbage	Industry effluents, agricultural activities	Cr, Cd, Zn, Fe, Pb and Cu	66.30, 42.33, 108.44, 18318.00, 64.87 and 142.77	[29, 30]
Eastern industry zone, Dukem Ethiopia farm land	Lettuce	Industry effluents, agricultural activities	Cr, Cd, Zn, Fe, Pb and Cu	62.23, 45.00, 123.77, 12051.00, 63.33 and 140.33	[29, 30]
Modjo Rift valley Ethiopia	Onion	Lather factory effluent, urban and municipal wastes	Cr, Cu, Zn, Pb, Cd, Mn and Fe	39.13, 35.88, 145.66, 0.83, 0.10, 1264.82 and 27427.33	[36]
Meki Rift valley Ethiopia	Onion	Agricultural activities, floriculture	Cr, Cu, Zn, Pb, Cd, Mn and Fe	18.37, 32.80, 153.30, ND, 0.08, 1546.42 and 25922.67	[36]
Zeway Rift valley Ethiopia	Onion	Floriculture, agricultural activities,	Cr, Cu, Zn, Pb, Cd, Mn and Fe	7.03, 19.25, 92.40, ND, 0.13, 789.43 and 9947.00	[36]
Laga Mariam East wollega zone, Ethiopia	Land around the river	Municipal waste of Nekemte town and agricultural activities	Cu, Mn and Fe	0.83, 0.76 and 1.12	[37]
Sorga lake East wollega zone, Ethiopia	Land around the river	Municipal waste of Nekemte town and agricultural activities	Cu, Mn and Fe	0.33, 0.46 and 0.83	[37]
Hadiya river East wollega zone, Ethiopia	Land around the river	Municipal waste of Nekemte town and agricultural activities	Cu, Mn and Fe	0.34, 0.65 and 1.05	[37]
Haramaya university, eastern Ethiopia	Cabbage, potato and khat	Agricultural activities, municipal waste, urban waste	Cr, Cd, Co and Pb	41.54, 2.56, 23.59, and 47.29	[35]
Harar, eastern Ethiopia	Cabbage, potato and khat	Agricultural activities, municipal waste, urban waste	Cr, Cd, Co and Pb	37.62, 1.38, 17.69 and 26.04	[35]
Haramaya, eastern Ethiopia	Cabbage, potato and khat	Agricultural activities, municipal waste, urban waste	Cr, Cd, Co and Pb	29.52, 0.79, 17.69 and 26.04	[35]
Maddawalabu University (MU) farm land north-eastern Ethiopia	Different crops	Agricultural activities	Cr, Cd, Cu, Zn, Fe and Pb	34.90, 0.88, 37.44, 96.41, 44585.22 and 19.10	[38]
dump site were found in MU, Robe town,	Non cultivated land	Municipal wastes, urban wastes	Cr, Cd, Cu, Zn, Fe and Pb	41.81, 0.93, 37.06, 170.48, 49012.18 and 19.43	[38]
dump site were found around Mebrat Hayle, Robe town	Non cultivated land	Municipal wastes, urban wastes	Cr, Cd, Cu, Zn, Fe and Pb	41.47, 0.67, 28.54, 83.67, 36482.75 and 20.77	[38]
Radio station dump site, Robe town, north-eastern Ethiopia	Non cultivated land	Municipal wastes, urban wastes	Cr, Cd, Cu, Zn, Fe and Pb	34.77, 0.76, 27.69, 74.05, 33483.55 and 20.51	[38]
farm land were found out of the town, Robe town,	Different crops	Agricultural activities	Cr, Cd, Cu, Zn, Fe and Pb	32.53, 057, 26.54, 72.79, 33973.75 and 18.04	[38]
Robe TVET school farm land	Different crops	Municipal wastes and Agricultural activities	Cr, Cd, Cu, Zn, Fe and Pb	32.91, 0.79, 27.93, 66.98, 35753.48 and 19.64	[38]
The farm land found around Shaya river, Robe town	Different crops	Municipal wastes and Agricultural activities	Cr, Cd, Cu, Zn, Fe and Pb	35.49, 0.84, 34.35, 97.01, 45008.20 and 16.08	[38]
At source of Tseada Agam river irrigation farm, Mekelle city, Tigray	(vegetable) Spinach	Urbanisation, municipal waste, industrialisation, agricultural activities	Cu, Zn, Pb, Co, Cd, Ni, Mn, Fe and Cr	34.50, 318.17, 2.49, 29.75, 13.94, 12.42, 633.49, 33563.56 and 37.01	[39]
Irrigation farm around Tseada Agam River near market pace, Mekelle city, Tigray	(vegetable) Spinach	Urbanisation, municipal waste, industrialisation, agricultural activities	Cu, Zn, Pb, Co, Cd, Ni, Mn, Fe and Cr	38.85, 495.33, 3.42, 30.58, 14.55, 20.61, 616.06, 36966.00 and 39.43	[39]
Irrigation farm a place where the Tseada Agam river receives a liquid waste from Ayder Referral Hospital, Mekelle city, Tigray	(vegetable) Spinach	Hospital wastes, Urbanisation, municipal waste, industrialisation, agricultural activities	Cu, Zn, Pb, Co, Cd, Ni, Mn, Fe and Cr	34.67, 320.50, 1.17, 31.39, 14.50, 25.58, 683.94, 35464.67 and 42.92	[39]
Irrigation farm place where the Tseada Agam river leaves the city, Mekelle city, Tigray	(vegetable) Spinach	Agricultural activities, municipal wastes	Cu, Zn, Pb, Co, Cd, Ni, Mn, Fe and Cr	38.50, 285.50, 1.50, 31.53, 13.87, 26.30, 811.30, 36231.00 and 40.14	[39]
Mojo, East Shewa Zone, Lome woreda of Oromia Regional State	Tomato	Different industry wastes, municipal wastes, agricultural activities	As, Pb, Cd, Zn, Cu, Fe, Mn, Cr, Hg, Ni and Co	24.50, 37.93, 5.30, 98.86, 25.96, 46426.67, 1763.33, 36.23, 6.26, 35.58 and 15.13	[34]
Mojo, East Shewa Zone, Lome woreda of Oromia	Cabbage	Different industry wastes, municipal wastes,	As, Pb, Cd, Zn, Cu, Fe, Mn, Cr, Hg, Ni	24.06, 35.80, 4.76, 93.66, 25.50, 41410.00, 1696.67, 35.93, 7.30, 30.50	[34]

Soil samples collected area	Soil originated crops	Source of heavy metals in the studied area	Studied heavy metals	Levels of heavy metals in studied soil samples in mg/kg respectively	Reference
Regional State		agricultural activities	and Co	and 14.93	
Guagusa shikudad, Awı Zone, Amhara Regional State,	Potato	Agricultural activities	Cu, Zn, Cd, Pb and Ni	383.39, 268.34, 18.76, 77.00 and 6.02	[40]
Fagita lecoma, Awı Zone, Amhara Regional State,	Potato	Agricultural activities	Cu, Zn, Cd, Pb and Ni	223.81, 244.20, 17.99, 75.33 and 60.26	[40]
Banja, Awı Zone Amhara Regional State,	Potato	Agricultural activities	Cu, Zn, Cd, Pb and Ni	125.17, 287.87, 17.11, 76.10 and 101.78	[40]
Dire Dawa textile industry	Potato	Textile industry effluent irrigation	Cu, Ni Zn and Cd	81.79, 115.13, 122.54 and 0.59	[41]
Selate, Harar Ethiopia	Non cropping place	City solid waste	Fe, Mn, Zn, Cu, Pb, Cd, Cr, Co and Ni	220.80, 96.69, 63.80, 7.50, 17.88, 1.65, 0.14, 0.41 and 0.17	[42]
Kile Harar Ethiopia	Non cropping place	City solid waste	Fe, Mn, Zn, Cu, Pb, Cd, Cr, Co and Ni	8.19, 0.55, 173.50, 51.06, 65.15, 1.97, 11.71, 0.49, 0.14, 0.41 and 0.08	[42]
Akafila Haramaya eastern Harargie, Ethiopia	Groundnut	Agricultural activities	Cr and Cd	1.767±0.58 0.97±0.01	[43]
Edobebe Haramaya east Harargie, Ethiopia	Groundnut	Agricultural activities	Cr and Cd	1.77 and 0.74	[43]

4. Suggestion

Heavy metal remediation technologies were required for agricultural soil, in order to secure human health from different toxic heavy metals caused diseases.

5. Conclusion

Heavy metals are persistent in the agricultural soils (environments), they are non-termly and biological degradable. Among those toxic heavy metals, Pb, Cd, As, Hg, Cr, Co, Ni, Cu, Zn, Fe, Mn, are some of them. Huge amount of city, household and other disposal of municipals and industrial wastes, mining activities, application of fertilizer and pesticides for agriculture and automobile emission have main effect for continuous accumulation of heavy metals in agricultural soils. The concentration of heavy metals in different farming land in Ethiopia according to different reports show above the value recommended by WHO, FAO and other organization limit set for agricultural soils. The investigation of heavy metals in agricultural soils Ethiopia are low, it need different assessment especially around cities, industry zones, floriculture farms and other possibly suspected areas, and also environmentally friend and economically safe heavy metal remediation techniques are required especially in suspected areas.

Conflict of Interest

The authors declare that they have no competing interests.

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