Harmful Impacts of Heavy Metal Contamination in the Soil and Crops Grown Around Dumpsites

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ABSTRACT

Waste disposal is a serious global environmental threat resulting in heavy metal pollution. Contaminated soil with heavy metals has become a concern for agricultural scientists because of the progress made in agricultural product safety. Heavy metals are metalloids with biological toxicity. The most common are arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), mercury (Hg), lead (Pb), and zinc (Zn). These metals exist throughout the terrestrial environment and produced from anthropogenic and natural activities. Recently, the landfills have been reported as persecutor to soil contamination, but still, there is no promising way proposed for the waste disposal management in some developing countries. This is the biggest threat to the soil, crops, and the communities living around the dumpsites. Soil polluted with heavy metals result in human health risks, groundwater pollution, plant phytotoxicity and decline in crop and soil production. Absorption of heavy metals through plant roots is the major pathway in which heavy metals penetrate the food chain and their successive crowding along the food chain is a critical threat to animal and human health. The previous findings reported that soil, vegetables, and other food crops around dumpsites are contaminated with heavy metals. The soil contaminated with heavy metals is a leading cause of vegetables and other crops contamination, which is a cause of adverse health outcomes in developing countries’ cities. Therefore, there is an urgent need for continuous monitoring of heavy metals in different open dumpsites. The necessary measures to reduce the high concentration of heavy metals in the soil and crops should be put in place. This paper aimed to review the harmful impacts of heavy metal contamination to the soil and crops grown in the vicinity of dumpsites, but also several techniques treating heavy metals pollution in the soil were discussed in this review.

Keywords

cadmium, disposal site, mercury, lead, soil contamination, zinc

1. Introduction

Waste disposal is a serious global environmental issue resulting in heavy metal pollution of both soils, water, and crops. Heavy metals are metals with a specific gravity higher than 5 g cm⁻³. The most common environmental heavy metals are copper (Cu), nickel (Ni), chromium (Cr), lead (Pb), cadmium (Cd), mercury (Hg), iron (Fe) and arsenic (As) [1]. Some heavy metals, such as iron and nickel are essential to the survival of all forms of life at low concentrations [1]. However, heavy metals like lead, cadmium, and mercury are toxic to living organisms not only in high concentration but also in low concentrations. They are contributors of metabolic abnormalities to organisms especially consumers of food from plants and other crops grown from contaminated soil [1]. Generally, heavy metals are naturally occurring components of the earth’s crust with large differences in concentrations. However, the
pollution from human activities has contributed to the high occurrence heavy metals into the ecosystem [2]. The concern of environmental pollution from heavy metals mostly came from different sources such as urban-industrial aerosols, solid and liquid wastes, mining activities, industries, and agriculture chemicals [3]. According to Singh and Kumar [4], the concentrations of heavy metals in the soil around waste dumpsites are influenced by some factors including types of wastes, topography, runoff, and level of scavenging [4].

Disposal of waste has been observed as a serious implication of modernization [5]. Due to demographic growth, lifestyle change and rapid urbanization, waste is on the rise in cities of developing countries [6,7,8]. This has resulted in environmental pollution, specifically in developing countries where important efforts towards developed waste management and disposal practices have not been made at high level [9]. Similarly, with the rising influence of advanced technology in developed countries, more municipal solid wastes and wastewaters are being produced and need treatment and proper disposal.

Healthy environment is associated with good human health. Some disposed materials containing heavy metals in open dumpsites are of concern and pose dangers to people in contact with the soil and plants contaminated by heavy metal from bad waste disposal management [10]. Waste generation and disposals have been noticed as one of the driving forces of heavy metals contamination in the soil. Generally, waste in landfills is from different sources, composed of different materials, and are disposed randomly in these dumpsites [11]. There are no guidelines proposed for waste disposal, which cause the mixture of the waste and create leachate that relocates into the soil and groundwater [11]. The decomposition of organic matter in municipal solid waste by micro-organisms results in hazardous liquids called leachate that consists of organic matter, macro-inorganic components, and heavy metals polluting both soil and aquatic environment [3]. Consequently, in developing countries, landfills with leachate are improperly managed, uncontrolled leachate flows and diffuses and penetrates into the groundwater, therefore, contaminating the surrounding environment and human being in the vicinity of the landfill [6,12]. Besides, most landfills are located near the settlements and some wastes are dumped recklessly without paying attention to environmental implications. Moreover, in some dumpsites, wastes are burnt at the sites, and results to unhealthy environment [13].

Heavy metals pile persistently exists in the waste disposal at the environmentally threatening level. This results in unhealthy conditions and environmental problems due to the poisoning effects of heavy metals in plants and potential health implications to humans and animals consuming such vegetables [3]. Once heavy metals are introduced into the soil, they cannot be degraded either biological or chemical and can persist in the environment for a long time, therefore, they cause serious environmental pollution and harmful effects to ecosystem including bioaccumulation [12,14]. There is an increasing concern about the likelihood of soil contamination resulting in the introduction of dangerous elements in food chains through uptake by plants and thereby affecting food safety [15]. Heavy metals accumulation in the soil and plants have a negative influence to the physiological activities of plants such as photosynthesis, gaseous exchange, and nutrient absorption which result in plant growth reduction and dry matter accumulation [8,15].

The heavy metals’ environmental pollution and associated health effects are among the leading cause of health concerns all over the world. For example, bioaccumulation of Pb in the human body interferes with the functioning of mitochondria, thereby impairing respiration, and also causes constipation, swelling of the brain, paralysis, and eventual death [16]. As reported by Yılmaz [17], lead (Pb) is a particular dangerous metal without any biological role and negatively affects children in significant ways. The situation is very critical in developing countries where research towards environmental monitoring was not prioritized by the stakeholders. Heavy metals concentration in the environment are not only attributed to geological factors, but also human activities do modify considerably the
mineral composition of soils, crops, and water [18]. Industrial growth have led to increased production of domestic, municipal, and industrial wastes, which are indiscriminately dumped in landfills and water bodies without treatment [6,7,8].

The presence of heavy metals in the environment is of great ecological significance due to their toxicity at certain concentrations, translocation through food chains, and non-biodegradability which is responsible for their accumulation in the biosphere [19]. Soil is a vital natural resource for sustaining human needs of quality food supply and quality environment [8]. Once plants are grown in the land polluted with municipal, domestic or industrial wastes can absorb heavy metals in the form of mobile ions from the soil solution through their roots or foliar absorption. The absorbed metals get bio-accumulated in the roots, stems, fruits, grains, and leaves of plants [10]. Some heavy metals like As, Cd, Hg, and Pb are particularly hazardous to plants, animals, and humans [20]. In dumpsites, the municipal wastes contains heavy metals such as As, Cd, Co, Cu, Fe, Hg, Mn, Pb, Ni, and Zn which end up in the soil as the sink when they are leached out from the dumpsites [20].

Vegetables cultivated in contaminated soil uptake heavy metals in high amounts to cause potential effects to agricultural products, and result in adverse health outcomes to consumers [19]. Since heavy metals are destroyers of the environment, plants and animals, soil and water, as well as human health, it is very important to continuously monitor these pollutants in the environment. The investigation of heavy metals is very essential since slight changes in their concentration above the acceptable levels, whether due to natural or anthropogenic factors, can result in serious environmental and subsequent health problems. To understand the heavy metals situation and their impacts to the soil and crops, the present study will investigate the harmful effects of heavy metals concentration in the soil and the crops grown in the vicinity of the landfill and explore their sources and remediation methods to deal with the overabundance of these metals’ contamination in the soils.

2. Sources of heavy metals in the environment

Heavy metals are everywhere in the environment as a result of both natural and anthropogenic activities (Table 1). People are exposed to them in different ways [1,19]. Heavy metals are ever-lasting environmental, undecomposed pollutants and enter the body through food, air, water and accumulated biologically over a period of time. Meanwhile, pollution from the activities of humans has introduced some of heavy metals into the ecosystem [2]. The presence of heavy metals in the environment even at low concentrations is still an environmental issue because their toxicity. The slight changes in their concentration above the acceptable level, whether due to natural or anthropogenic factors is a great concern since they result to serious environmental and subsequent health problems. It can be seen in Table 1 that anthropogenic sources of heavy metal pollution involve agricultural activities, such as the application of pesticides and herbicides, contaminated irrigation water, utilization of municipal waste for fertilization purposes [1, 20]. Additionally, the anthropogenic source also includes waste disposal in farmland, mining activities, smoking, traffic emissions, the discharge of sewage, and building materials like paints [21,22]. The previous findings from studies carried out in Indonesia reported that heavy metals released into the environment by human activities in Indonesia cities are mainly from Industrialization, waste disposals, and agricultural activities [23]. Budiyanto and Lestari [23] reported that the coastal area of Indonesia is polluted by metals from the direct discharge of about 1,100 tons of solid wastes. This massive discharge of pollutants is embarrassing the water safety and aquatic life since it contributes to death of aquatic animals such as the death of coral reefs on a large scale [23]. Humans and animals are also contaminated by toxic heavy metals via inhalation of dusty soil [24]. Heavy metal pollutants such as copper, lead and zinc from additives used in gasoline and lubricating oils are also deposited in highway soils and vegetation [24].
Table 1: Sources of some heavy metals in the soil

| Heavy metals | Source of heavy metals                                                                 | References                        |
|--------------|---------------------------------------------------------------------------------------|-----------------------------------|
| Cadmium      | Natural                                                                               |                                   |
|              | 1. Cd can be naturally found in Black shale.                                           | Bakshi et al. [1]                 |
|              | 2. Volcanic activity also is the main natural source of Cd in the soil and atmosphere, Parent material, marine sedimentary rocks, and phosphates | Khan et al. [25]                  |
|              | Anthrotopgenic                                                                        |                                   |
|              | 1. Extraction and refining of non-ferrous metals                                        |                                   |
|              | 2. Manufacture and application of phosphate fertilizers                                 | Bakshi et al. [1]                 |
|              | 3. Burning of fossil fuel                                                              | Somani et al. [26]                |
|              | 4. Incineration, domestic sewage, and disposal of waste                                 | Ramelli et al. [27]               |
|              | 5. Tannery industry, electroplating, spent rechargeable as well as the household batteries | Rezapour et al. [28]              |
|              | 6. Cd can be added to the soil by batteries, paint, stained glass, and paper ink that are common in MSW |                                   |
| Lead         | Natural                                                                               | Bakshi et al. [1]                 |
|              | 1. The acidic igneous rocks and argillaceous rocks, and sedimentary rocks               |                                   |
|              | 2. The limestone and dolomites also can contribute to the concentration of Pb in the soil. Besides Shale especially black shale are also the sources of Pb in the soil |                                   |
|              | Anthrotopgenic                                                                        |                                   |
|              | 1. Pb can be distributed in the soil from the mining and smelter sites                 | Bakshi et al. [1]                 |
|              | 2. Paint, gasoline additives, smelting, automobile demolition, and pesticide application | Ekere [11]                        |
|              | 3. Pb can be released in the soil from manufacture/ industrial effluent                | Khan et al. [25]                  |
|              | 4. The use of Pb-containing products like storage batteries, solders, pottery glazes, leaded crystal glassware, cosmetics, hair dyes, jewelry, a gunshot and ammunition, relic fishing sinkers, tire weights, and imported children’s toys, traditional or folk remedies, and candy/food packaging) |                                   |
|              | 5. Burning coal and oil, domestic sewage effluent, and burning of waste                 |                                   |
| Zinc         | Natural                                                                               | Bakshi et al [1]                  |
|              | 1. Sedimentary rocks and acidic granitic rocks                                         |                                   |
|              | 2. Black shale and clayey sediments                                                    |                                   |
|              | 3. Sandstone, limestone, and dolomite                                                  |                                   |
|              | Anthrotopgenic                                                                        | Bakshi et al. [1]                 |
|              | 1. Mining activities                                                                   | Khan et al. [25]                  |
|              | 2. Zinc production facilities and steel production                                     | Lundberg et al. [29]              |
|              | 3. Combustion of coal and fuel                                                         |                                   |
|              | 4. Waste disposal and incineration                                                     |                                   |
|              | 5. The use of fertilizers and pesticides containing zinc                                |                                   |
| Copper       | Natural                                                                               | Bakshi et al [1]                  |
|              | 1. Cu is naturally found in different parent rocks and can be abundant in basic igneous rock (basalts) | Barceloux [30]                    |
|              | 2. The abundance of Cu also can be found naturally in shale-clay and black shale.      |                                   |
From Table 1, each of discussed heavy metals have its source and pathway to reach the soil. Regardless the differences in origin, heavy metals follow a general biogeochemical cycle after entering the environment, although their transportation, residence time, and fate differ from certain environments [1]. Regional pollution occurs in overpopulated areas, factory zones, motor vehicles, and municipal waste locations [1]. Table 1 shows all the metals mentioned have a similar anthropogenic source such as waste disposal and incineration, mining activities, and fertilizer. Municipal solid waste incineration; application of pesticides, herbicides, and fungicides; industrial waste storage, and the production of metals and alloys have increased heavy metals concentration in the soil [1,25], which implies their significant contribution to the occurrence of heavy metals in the environment.

The study by Bakshi et al. [1] reported that 25,000–125,000 tones/year of mercury enters the environment naturally. Meanwhile, only 10,000 tons per year enters the environment through mining and smelting, and this has been increasing with the annual rate of 2% since 1973. Furthermore, Luoma and Rainbow [31] reported that the anthropogenic contamination of Cd was approximately 31 times higher than that of natural origin. Worldwide, 5.6–38×10⁶ kg of Cd year⁻¹ was introduced in the soil via human activity.

3. Harmful impacts of heavy metals on soil and crops

3.1 The impacts of heavy metals on soil

Heavy metals are considered one of the important sources of soil pollution. Heavy metal contamination in the soil is caused by various types of metals, mainly Cu, Ni, Cd, Zn, Cr, and Pb [32]. Human activities such as Waste generation and disposal in landfills and dumpsites have been observed as the major source of soil pollution by heavy metals. The concentrations of heavy metals in the soil around waste dumps are influenced by various factors such as the types of wastes, topography, run-off, and level of scavenging [33]. Improper waste disposal can result in contamination of both soil and groundwater. Municipal solid waste contains paper, food waste, metal scraps, glass, ceramics, and ashes. The decomposition or oxidation process releases the heavy metal form the wastes to the nearby soil [34]. Heavy metals in the soil result to the changes in soil quality and fertility, groundwater contamination, bio magnification, and ultimately irreparable damage of soil biota [35].

Historically, soil systems were subjected to physical stress by the ingestion of foreign substances, such as heavy metals. When heavy metals are abundant in the soil results to unhealthy ecology which affects the entire health of the living organisms (Table 2). Table 2 discussed the harmful impacts of heavy metals. Table 2 shows lead (Pb) is a
toxic metal with very low mobility but high bioavailability. On the soil surface, Pb persists for long time [36]. Cadmium and its compounds can move through the soil, but its portability depends on several factors including soil pH and the amount of organic matter, which depends on the local environment [37]. Besides, cadmium binds tightly to organic material, and becomes immobile in the soil and absorbed by plants, and eventually enters the food chain [38]. According to Singh and Kalamdhad [16], soil contaminated with heavy metals is associated with excessive concentration in heavy metals, insufficient nutrient, and organic content, low water retention capacity, and low cation exchange capacity [16]. Furthermore, The increase of heavy metals concentration in the soil results to the toxic effects in the soil biota by influencing important microbial processes and reducing microorganism’s number and activity [16]. Heavy metals indirectly affect soil enzyme activities by altering the microbial community synthesizing enzymes [37]. According to Bakshi et al. [1], the pollution of heavy metals causes a decrease in the specific adsorption of other cations by the increase in saturation or super saturation of the cation exchange sites by heavy metal cations, which displaces the protons in the soil solution and result in lower pH. Heavy metals contamination in the soil inhibits enzymatic activity and cause the attenuation of SOM mineralization and nutrient cycle [1].

It also can be seen from Table 2 that heavy metal like Cd reported as a harmful metal to the activities of the enzymes. The findings of the study conducted by Karaca et al. [37], reported that the concentration of Cd at 10 µg g\(^{-1}\) in the soil did not have any significant change in soil enzyme, while the addition of Cd at 50 µg g\(^{-1}\) resulted to the reduction of the soil enzyme activity. This study reported that the greatest effects of Cd on enzyme activities were higher in sandy loam compared in loam or clay loam soils. Hemida et al. [39] also found that the activities of urease were completely disappeared with 2,000 µg of heavy metals like (Cu\(^{2+}\) and Zn\(^{2+}\)) g\(^{-1}\).

### Table 2: Heavy metals effects on soil

| Heavy metals | Effects on soil                                                                 | References               |
|--------------|--------------------------------------------------------------------------------|--------------------------|
| Lead (Pb)    | Abnormalities in the metabolic function of organisms                           | Alloway et al. [20]      |
|              | Shortage of soil macronutrients like Phosphorus                               | Fenn et al. [40]         |
|              | Affect soil enzyme activities: Decrease urease, catalase, invertase, and acid phosphatase activity | Bakshi et al. [1]       |
|              | Interrupts water balance, enzyme activity and mineral nutrition               | Somani et al. [26]      |
|              | Reduces soil productivity.                                                    | Karaca et al. 2010 [37] |
| Cadmium (Cd) | Abnormalities in the metabolic function of organisms                           | Akanchise et al. [36]   |
|              | harm the protease, urease, and alkaline phosphatase activity                  | Bakshi et al. [1]       |
|              | Reduce the availability of soil N and S for crop production                  | Karaca et al. [37]      |
| Zinc (Zn)    | Phytotoxic and can directly affect soil fertility                             | Balkhair and Ashraf [42]|
|              | Decrease the microbial biomass N                                             | Fenn et al. [40]        |
|              | Shortage of soil macronutrients like Phosphorus                               | Yao at al. [43]         |
| Copper (Cu)  | Reduced the availability of soil N and S for crop production                 | Bakshi et al. [1]       |
|              | Inhibit the activity of β-glycosidase more than the activity of cellulose    | Karaca et al. [37]      |
|              | Decrease the microbial biomass N                                             | Yao at al. [43]         |
| Mercury (Hg) | Abnormalities in the metabolic function of organisms                          | Akanchise et al. [36]   |
3.2 The harmful effects of heavy metals on Plants

Plants growing in a Municipal Solid Waste landfill and its surroundings are associated with heavy metals contamination that can affect the food chain [44]. Heavy metals can affect the plant in so many ways (Table 3). Heavy metals are indestructible and have a global environmental impact. Heavy metals are one of the major types of pollutants that are found on the surface and in the tissues of fresh vegetables [42]. Some heavy metals can function as plant nutrients depending on their concentration in the environment, others like mercury, lead, cadmium, silver, and chromium distributed by human activities and contribute to toxic effects even at low concentrations [45]. Kumar et al. [41] documented that the uptake and accumulation of heavy metals in plant tissue depend on various factors, such as temperature, humidity, organic matter, pH, and nutrient availability. This study reported that the absorption and accumulation of some metals like Cd, Zn, Cr and Mn in spinach were found higher during the summer, while Cu, Ni and Pb accumulated more during the winter. It is estimated that the rate of decomposition of organic matter during the summer was most likely to release heavy metals into the soil solution for possible plant uptake. The higher assimilation of heavy metals like Cd, Zn, Cr and Mn in summer was expected to be caused by the high sweating while in winter heavy metals accumulation rate expectation is due to high ambient temperature and low humidity [41].

Table 3: Heavy metals effects on crops/plants

| Heavy metals | Effects on crops                                                                 | References |
|--------------|----------------------------------------------------------------------------------|------------|
| Lead (Pb)    | - Seed germination by gradually slowing down the seed germination                 | Singh and Kalamdhad [16] |
|              | - Abnormality of plant metabolism, morpho-physiological features, plant growth, and productivity | Tang et al. [48] |
|              | - Reduce plant growth, resulting in malformation of cellular structure, lowering chlorophyll biosynthesis, imbalance hormones, and induce over-production of reactive oxygen species (ROS); which can cause oxidative stress within plant cells and readily attack biological structures and biomolecules, thus result in metabolic dysfunction |           |
|              | - Reduce soil productivity                                                        | Kumar et al. [49] |
| Cadmium (Cd)| - Cause many abnormalities in different parts of the plant such as roots, shoots, leaf, fruit, and also increased dry to fresh mass ratio (DM / FM) in all organs | Singh et al. [50] |
|              | - Can exhibits adverse effects on sugar content and amino acids in some plant species by strengthening their concentration, indicating inhibition of starch hydrolysis |           |
|              | - Imbalance the macro and micronutrients by augmenting the macronutrients and reducing micronutrients in Aeluropus littoralis | Bakshi et al. [1] |
|              | - Leading to less assimilation of photosynthetic carbon when interact with various photosynthetic complexes. Also, Cd bothers the guard cell regulation thus affecting the water status of the plant | Singh et al. [50] |
|              | - Poisoning the soil and this affects the production of phytochelatins due to obstruction of the transporter/channel for loading other elements and an imbalance of plant nutrients | Bakshi et al. [1] |
| Zinc (Zn)    | - Phytotoxic and can directly affect crop yield                                  | Balkhair and Ashraf [42] |
|              | - Affects the growth of pea plants                                              | Bakshi et al. [1] |
| Copper (Cu)  | - Reduced the availability of soil N and S for crop production                  | Bakshi et al. [1] |
|              | - Inhibit the activity of β-glycosidase more than the activity of cellulose     | Karaca et al. [37] |
Heavy metals uptake by plants and their subsequent accumulation in food chains is a risk to animals and human health. In this case, mobile heavy metals cause serious pollution problems because of their easy absorption by plants and enter food chains or contaminate groundwater [46]. Some of the factors influencing the uptake of heavy metals by the plants are metals species and plant species. As documented by several earlier scientist, Vegetables, especially leafy vegetables grown in the soil contaminated with heavy metals accumulate the high amounts of metals through their leaves [47]. Heavy metals at excessive level are harmful to plant growth, they can cause oxidative stress in plants and damage cell structure by replacing defective elements with toxic heavy metals and inhibiting photosynthetic reactions in plant cells [1]. Furthermore, heavy metals affect seed germination and reduce the possibility of harvest production. Heavy metals cause a detrimental effect on plant growth compared to other environmental stresses. Some enzymatic activities like (amylase, protease, and ribonuclease) have been delayed due to Ni toxicity and therefore affect plant germination and plant growth [1]. Ni can result to plant height reduction, roots length reduction, the decrease of chlorophyll content, reduction of photosynthetic pigments and the accumulation of Na+, K+, and Ca2+ in the plant[1]. Heavy metal potential toxic effects and phytotoxicity in plants lead to chlorosis, poor plant growth, and plant depression, but also associated with reduced nutrients uptakes, plant metabolism disturbance, and reduced ability to repair molecular nitrogen in leguminous plants [16]. The main harmful impacts of heavy metals on plant are discussed in Table 3.

4. Remediation technics of soil contaminated with heavy metals

Heavy metals are unspoiled, and if introduced in the soil, they overstay. Soil is a biochemical and geochemical heterogeneous complex material and composition [20], therefore it holds heavy metals longer than air and water [51]. There are various techniques available for restoring contaminated soil by heavy metals. Remediation technologies usually involve physical, chemical or biological processes as discussed in Table 4.

It is shown in Table 4 that the first technique in remediation is engineering remediation. In engineering remediation, the method is by adding a huge number of clean soils to cover the polluted soil or to blend with the latter [21,52]. The soil removal and isolation are by involving the removal of polluted soil and renewing it with clean soil, this method is necessary for seriously contaminated soil with a small area. The next method is by soil electrokinetic remediation, which involves the DC-voltage to produce the electric field gradient on all sides of the electrolytic tank which holds the polluted soil and works well in low permeability soil [21,51,53]. Other method is by involving cleaning of contaminated soil with certain reagents thereby remove heavy metal complexes and dissolved iron adsorbed on solid-phase particles [21]. The last method is by the fixation and adsorption by clay minerals for example bentonite, zeolite, and so forth [54].

Table 4 also shows the bioremediation technique which involves phytoremediation and microbial remediation. The phytoremediation involves the growing of particular plants in the contaminated soil for example Cruciferae plants such as the genus Brassica, Alyssums, etc. [21,51,55]. These types of the plant must have certainty hyper accumulation capacity for contaminants in the soil, where the most important key here is to found plants with a strong capability to accumulate and tolerate heavy metals [30]. The mechanism of the phytoremediation is by the plant resistance of producing proteins and expressing the detoxifying enzyme and nucleic acid, the mechanism is integrated with plant protection against injury [49]. Another mechanism is by the production of phytochelatins (PSc) by plants which binding the heavy metals and sequestering the compounds inside the cell so the heavy metals cannot disturb the cell metabolism [52].

On the other hand, microbial remediation involves the use of several microorganisms to carry out the absorption, deposition, oxidation, and reduction of heavy metals in the soil with the main bio-remediator are bacteria, archaea
and fungi [21,51,56]. Many ions in the microbial cell surface functional groups such as nitrogen, oxygen, sulfur and phosphorus can be substituted with metal ions called as coordination atoms [52]. The heavy metal pass through the cell membrane wall of microbial remediation microorganism which are negatively charged and carry the cationic group [36].

Table 4: Remediation techniques

| Techniques                  | Method                          | Brief overview                                                                 | References               |
|-----------------------------|--------------------------------|--------------------------------------------------------------------------------|--------------------------|
| Engineering remediation     | Replacement of contaminated soil| Implies adding a huge amount of clean soil to cover the polluted soil surface or to blend with the latter | Su et al. [21]           |
|                             | Soil removal and isolation      | Involves the removal of polluted soil and renewing it with clean soil, this method is necessary for seriously contaminated soil with a small area | Zheng et al. [52]       |
| Electrokinetic remediation  |                                | This method uses the principle where DC-voltage is involved to produce the electric field gradient on all sides of the electrolytic tank which holds the polluted soil. The pollutants in the soil are carried to the processing room placed on 2 poles of the electrolytic cell employing electric migration, electric seepage, or electrophoresis, thereby reducing the pollution. This method works well in low permeability soil. | Su et al. [21]           |
|                             |                                |                                                                              | Kamari [51]              |
|                             |                                |                                                                              | Hanson et al. [53]       |
| Soil leaching               |                                | Involves cleaning of contaminated soil with certain reagents thereby remove heavy metal complexes and dissolved iron adsorbed on solid-phase particles. Heavy metals removed by this method are then recovered from the extraction solution | Su et al. [21]           |
| Adsorption                  |                                | Fixation and adsorption by clay minerals for example bentonite, zeolite, and so forth | Wang and Zhou [54]       |
| Bioremediation              | Phytoremediation               | Involves the growing of particular plants in the contaminated soil for example Cruciferae plants such as the genus Brassica, Alyssums, etc. | Su et al. [21]           |
|                             |                                |                                                                              | Kamari [51]              |
|                             |                                |                                                                              | Xin et al. [55]          |
| Microbial remediation       |                                | Involves the use of several microorganisms (bacteria, archaea and fungi) to carry out the absorption, deposition, oxidation, and reduction of heavy metals in the soil. | Su et al. [21]           |
|                             |                                |                                                                              | Kamari [51]              |
|                             |                                |                                                                              | Fred et al. [56]         |

5. Conclusion and recommendations

This narrative overview discussed the harmful effects of heavy metal concentrations in the soil and crops grown around landfills. The excessive increase in waste entering the landfills, the accumulation of heavy metals in landfills seep toward the surrounding area, contaminating the soil and absorbed by plants. Heavy metals reaching in the soil result to the soil quality deterioration, decrease the soil fertility, contaminates groundwater, and irreparable damage of soil biota. The high concentration of heavy metals in soils is reflected by concentrations of metals in plants, water, animal, and human bodies. Soil contamination around the landfill implies the food contamination harming the human health. This is a serious issue that requires emergency attention and action. Since slight changes in their concentration above the acceptable levels result in serious environmental and subsequent health problems.
Regular monitoring and awareness are needed to ensure separation of waste before dumping to reduce elevated levels of pollution. Besides, it is advised to stop the continuous cultivation of consumable crops in the vicinity of dumpsites before implementing the necessary techniques to reduce heavy mental pollutants in the soil.

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