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Review Article

Environmental Pollution by Heavy Metal: An Overview

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Abstract: Environmental pollution by heavy metals has become a global issue in the recent years as it affects public health. Especially with the continue increase in anthropogenic activities such as industries and urbanization which releases pollutants in to the environment without control and effects remedies. Among the numerous environmental pollutants, heavy metals plays an important role as its concentrations in air, soil and water are continuously increasing due to anthropogenic activities. Heavy metal is any metal that is toxic regardless of their density or atomic mass. Heavy metals occur naturally in the soil environment from the pedogenetic processes of weathering of parent materials and from anthropogenic sources such as traffic emission, industrial and energy production, waste disposal, vehicle exhaust as well as coal and fuel combustion. Excess of metal pollutants deposited on soils may be transformed and transported to vegetation and from plants they pass on to animals and human being through the food chain. Excessive levels of heavy metal can be damaging to the organism and plants by disrupt metabolic functions of vital organs and glands. Also they displace the vital nutritional minerals from their original place, thereby, hindering their biological function. Therefore it is important to continually assess and monitor the levels of heavy metals in an environment due to increase in anthropogenic activities for evaluation of human exposure and for sustainable environment The aim of this paper is to discuss illustratively environmental (air, soil and water) pollution by heavy metals. Sources of heavy metals in an environment as well as their effects on organisms and plants were examined. Different methods of assessing their level of pollution were also considered and remedies were presented.

Keywords: Environment, Pollution, Heavy, Metal, Effect, Remedy

1. Introduction

The environmental issues related to heavy metals contamination are becoming serious in developing countries due to increase in geologic and anthropogenic activities. These activities increased the concentration of these elements to amount that are harmful to the environment [1]. With the rapid industrialization and urbanization trend, the increment of traffic activities substantially contributes to the accumulations of heavy metals discharged by vehicles in the environments. Heavy metals pollution in agricultural areas owing to traffic emissions may contaminate the crops growing in the environment [2, 3]. Plants growing on these soils show a reduction in growth, performance and yield. Growth reductions as a result of changes in physiological and biochemical processes in plants growing on heavy metal polluted soils have been recorded [4]. Declined in plants growth reduces yield which eventually lead to food insecurity [5]. In agricultural areas, uptake of heavy metals through the soil-crop system could play a predominant role in human exposure to heavy metals.

Heavy metal contaminants can easily impact people residing within the vicinity of the source via suspended dust or direct contact [3]. If there are farmlands within the scope that the contaminants can reach, they may enter the food chain as a result of their uptake by edible plants [6] thus causing serious health risks. Because of their toxicity (especially for Cd and Pb), persistence and non-degradability characteristics, it is of great importance to monitor the heavy metals concentrations in our environment.

2. Heavy Metal

Any toxic metal may be called heavy metal, irrespective of their atomic mass or density [7]. Heavy metals are a member of an ill-defined subset of elements that exhibit metallic properties. These include the transition metals, some metalloids, lanthanides, and actinides. According to Nies [8] heavy metals are one of the common transition metals, such as copper, lead, and zinc.

Heavy metals are metals or metalloids (elements that have both metal and non-metal characteristics). Elements of highest concern include: arsenic, cadmium, cobalt, chromium, copper, mercury, manganese, nickel, lead, tin, and thallium persistent in all parts of the environment. Generally, have densities above $5g/cm^3$, cannot be degraded or destroyed [9].

Heavy metals enlist a relatively large series of elements with specific density over $5g\ cm^{-3}$ and relative atomic mass above 40. Fifty three of the ninety naturally occurring elements are heavy metals ([10]. Of these, Fe, Mo and Mn are important as micronutrients, while Zn, Ni, Cu, Co, Va and Cr are toxic elements, but have importance as trace elements. Ag, As, Hg, Cd, and Pb do not have known function as nutrients, and seem to be toxic to plants and microorganism [9, 11].

Heavy metals are chemical elements with a specific gravity that is at least four to five times the specific gravity of water at the same temperature and pressure [12]. Metal elements are those with positive valances and occupy group I to III in the periodic table. [13].

According to Singh [14], heavy metal is any metallic element that has a relatively high density and is toxic or poisonous even at low concentration. These include the transition metals, some metalloids, lanthanides, and actinides. Mcintyre [15] state that heavy metals are one of the common transition metals, such as copper, lead, and zinc.

Paul *et al.* [16] defined heavy metals as metallic elements that have a relatively high density compared to water, with the assumption that heaviness and toxicity are inter-related, heavy metals also include metalloids, such as arsenic, that are able to induce toxicity at low level of exposure. Heavy metals are metals or metalloids (elements that have both metal and non-metal characteristics) [14]. Elements of highest concern include: cadmium, cobalt, chromium, copper, mercury, manganese, nickel, lead, tin, and thallium, persistent in all parts of the environment [8].

2.1. Source of Heavy Metals

Heavy metals occur naturally in the soil environment from the pedogenetic processes of weathering of parent materials at levels that are regarded as trace ($<1000mg\cdot kg^{-1}$) and rarely toxic [17, 18]. Other sources of heavy metals in the environment include geogenic, industrial, agricultural, pharmaceutical, domestic effluents, and atmospheric sources [16]. Industrial sources include metal processing in refineries, coal burning in power plants, petroleum combustion, nuclear power stations and high tension lines, plastics, textiles, microelectronics, pesticides, wood preservation and paper processing plants [19]. In arable lands in most countries, the source of Heavy metal include natural source, mining, smelting, agrochemicals and sewage sludge applications and livestock manure uses [20].

Owing to more complex roadside environments and more intense driving conditions on mountainous highways, heavy metal accumulation and distribution patterns in farmland soil due to traffic activity could be different from those on plain highways [21]. Automobile traffic pollutes roadside environments with a range of contaminants [22]. Heavy metals are found in the walls of fuel tanks, in engines, in fuels and other vehicle components, and in catalytic converters, brake pads and tires, as well as in road surface materials [23, 24].

Traffic activities are one of the major sources leading to heavy metal contamination in roadside soils due to their long-term accumulation [21]. Emission of heavy metals from traffic activities is an important pollution source to roadside farmland ecosystems. Metal such as Cr, Pb, Zn, Cd, Fe and Cu are heavy metals frequently reported in literature with regards to potential hazards and occurrences in contaminated soils [25, 26] Emission from heavy traffic were reported to contain cadmium, zinc and nickel which are present in fuel as anti-knock agent [27, 28]. Vehicle exhausts, as well as several industrial activities emit these heavy metals such that soils, plants and even residents along roads with heavy traffic loads and industry vicinities are subjected to increasing levels of contamination with heavy metals [29].

The sources of heavy-metal emissions from vehicles include fuel combustion, lubricating oil consumption, tire wear, brake wear and road abrasion. Cd emission is mainly from lubricating oil consumption and tire wear. Zn comes from tire wear and galvanized parts such as fuel tanks. Brake wear is the most important source for Cu and Pb emissions. Pb comes also from exhaust gas and worn metal alloys in the engine [30].

The mechanisms of heavy metal emission from vehicles consist of fuel consumption, engine oil consumption, tire wear, brake wear, and road abrasion [31]. Engine oil consumption is responsible for the largest emission for Cd, tire wear contributes the most important emission for Zn, and brake wear is the most important source of emissions for Cu and Pb [21]. Though the use of unleaded gasoline has caused a subsequent reduction in fuel emissions of Pb, it may still occur in exhaust gas and come from worn metal alloys in the engine. Bitumen and mineral filler materials in asphalt road surfaces contain different heavy metal species, including Pb, Cu, Cd, and Zn [30].

Through the atmospheric deposit or road runoff, heavy metals can be transported into the roadside soils [32]. Plants absorb these heavy-metals from the soil through their roots. The plants' leaves or stems may also absorb heavy metals from atmospheric particles [33]. Due to the disturbance and acceleration of nature's slowly occurring geochemical cycle of metals by man, most soils of rural and urban environments may accumulate one or more of the heavy metals above defined background values high enough to cause risks to human health, plants, animals, ecosystems, and other media [34].

2.2. Heavy Metal Pollution

Any metal (or metalloid) species may be considered a "pollutant" if it occurs where it is unwanted, or in a form or concentration that causes a detrimental human or environmental effect. Metals/metalloids include lead, cadmium, mercury, arsenic, chromium, copper, selenium, nickel, silver, and zinc. Other less common metallic pollutant includes aluminium, cesium, cobalt, manganese, molybdenum, strontium, and uranium [15].

In recent years, there has been an increasing ecological and global public health concern associated with environmental contamination by these metals. Among the numerous environmental pollutants, heavy metals plays an important role as its concentrations in air, soil and water are continuously increasing due to anthropogenic activities [35, 4]. The problem of environmental pollution due to toxic metals is of major concern in most major metropolitan cities. The toxic metals entering the ecosystem may lead to geoaccumulation, bioaccumulation and biomagnifications [36, 37]. Pollution of the natural environment by heavy metal is a worldwide problem because these metals are indestructible and most of them have toxic effects on living organisms, when they exceed a certain concentration [29].

Metal distribution between soil and vegetation, is a key issue in assessing environmental effect of heavy metals in the environment [38]. Heavy metals such as copper, lead, and zinc are a cause of environmental pollution from sources such as leaded petrol, industrial effluents, and leaching of metal ions from the soil into lakes and rivers by acid rain [39]. Environmental pollution is very prominent in point source areas such as mining, foundries and smelters, and other metal-based industrial operations [40]. Rapid industrialization and addition of the toxic substances to the environment are responsible for altering the ecosystem [41].

Although heavy metals are naturally occurring elements that are found throughout the earth's crust, most environmental contamination and human exposure result from anthropogenic activities such as mining and smelting operations, industrial production and use, and domestic and agricultural use of metals and metal-containing compounds [42]. Environmental contamination can also occur through metal corrosion, atmospheric deposition, soil erosion of metal ions and leaching of heavy metals, sediment re-suspension and metal evaporation from water resources to soil and ground water. Natural phenomena such as weathering and volcanic eruptions have also been reported to significantly contribute to heavy metal pollution [43]. Human activity affects the natural geological and biological redistribution of heavy metals through Pollution of the air, water and soil [19].

2.2.1. Air Pollution by Heavy Metal

Air pollution has long been recognized as a lethal form of pollution. Much of the problems of societal concern today are the heavy metals associated with air pollution) [44]. Heavy metal mobilization in the biosphere by human activities has become an important process in the geochemical cycling of these metals [45]. This is evident in industrial areas where stationery and mobile sources release large quantities of heavy metals into the atmosphere, soil and plants exceeding the natural emission levels [46]. Air pollutants, responsible for vegetation injury and crop yield losses, are causing increased concern. Air pollution has become a major threat to the survival of plants in the industrial areas [47].

Heavy metals in the soil can also generate airborne particles and dust which may affect the quality of air. Inhalation of substantial quantities of heavy metal particle over period of time may add to human body burden of the metals and constitute health risk [35].

2.2.2. Soil Pollution by Heavy Metals

Soils have been shown a considerable contamination due to both depositions of vehicle and industry derived metal as well as the relocation of metal deposited on the road surface and industry vicinity [48]. Because of the severe adverse environmental and / or ecological and health effect of these heavy metals, there are many studies of heavy metal contamination in soils along major road and industrial sites [49].

According to Okunola *et al*. [5] these metals also get accumulated when plants and crops cultivated along major roads and within industry vicinities are consumed by man and animal especial livestock, either directly or indirectly. These accumulation may fast reach lethal levels quickly [49].

The risk posed by heavy metals to food safety and the environment are of great concern to governments and society in many countries. Heavy metal pollution in agricultural soils is becoming serious with the rapid industrialization and urbanization in developing countries [50]. Heavy metal pollutant are of significant ecological / environmental concern because they are not biodegradable and have long halve live in the soil, thus predicting far reaching effect on biological systems including soil microorganism and other soil biota [5]. Heavy metals frequently reported in literature with regards to potential hazards and occurrences in contaminated soils are Cd, Cr, Pb, Zn, Fe and Cu [25, 26].

Metal concentration in soil typically ranges from less than one to as high as 100,000 mg/kg [51]. Heavy metals are the main group of inorganic contaminants and a considerable large area of land is contaminated with them due to use of sludge or municipal compost, pesticides, fertilizers, and emissions from municipal wastes incinerates, exudates, residues from metalliferous mines and smelting industries [40].

Metal pollution of soil dust and agricultural soils arising from industrial activities, vehicular emissions, and waste disposal sites are well documented [38, 52]. Changes in soil properties have been associated with environmental alteration that takes place, for example as a result of human activity [36].

Mining, manufacturing, and the use of synthetic products (e.g. pesticides, paints, batteries, industrial waste, and land application of industrial or domestic sludge) can result in heavy metal contamination of urban and agricultural soils. Potentially contaminated soils may occur at old landfill sites (particularly those that accepted industrial wastes), old orchards that used insecticides containing arsenic as an active ingredient, fields that had past applications of waste water or municipal sludge, areas in or around mining waste piles and tailings, industrial areas where chemicals may have been dumped on the ground, or in areas downwind from industrial sites [53].

The pressure on the unique ecosystem in the anthropogenic living areas of the developing country is predictably increasing. Traffic activities are one of the major sources leading to heavy metal contamination in soils due to their long-term accumulation. Therefore, the local contamination resulting from transportation activities is receiving increasing attention in the developing countries [54].

Fan *et al*. [21] conducted a study using design factors including altitude, roadside distance, terrain, and tree protection were considered to analyze their influences on Cu, Zn, Cd, and Pb concentrations in farmland soils along a mountain highway around Kathmandu, Nepal. They found out that on average, the concentrations of Cu, Zn, Cd, and Pb at the sampling sites are lower than the tolerable levels. Correspondingly, pollution index analysis does not show serious roadside pollution owing to traffic emissions either.

Emission from heavy traffic on roads contain lead, cadmium, zinc and nickel, which are present in fuel as anti-knock agents [27, 28]. The deposition of vehicle derived metal and the relocation of metals deposited on road surface by air and runoff water have led to contamination of soil [55, 54]. Contamination of soils by heavy metals is the most serious environmental problem and has significant implications for human health [56].

Heavy metals in soils have been considered as powerful tracers for monitoring impact of anthropogenic activity such as industrial emission (cement plant, fossil fuel and coal combustion chemical plants), vehicular emission, and atmospheric deposited [57]. Generally, the topsoil adjacent to the road edge is collected for analyzing the heavy metal pollution levels. Most observational studies on the concentrations of heavy metals in roadside soils were focused on Cu, Zn, Cd, and [58]. Some research extended the monitored metals to Cr, Ni and As [3, 59]. On average, the heavy metals' concentrations in roadside grasses are significantly lower than those in roadside soil [60, 61, 39].

On the Other hand, soil is not only a medium for plant growth or pool to dispose of undesirable materials, but also a transmitter of many pollutants to surface water, groundwater, atmosphere and food [38]. Therefore, soil pollution may threaten human health not only through its effects on the hygiene quality of food and drinking water, but also through its effect on air quality especially in enriched trace metal content in airborne particles originating from soil. Soil pollution by heavy metals is a significant environmental problem worldwide [25]. In particular, heavy metal pollution of surface soils due to intense industrialization and urbanization has become a serious concern in many developing countries [62, 63, 64].

Soil contamination by heavy metals can cause long term problems on the biogeochemical cycle, which may affect soil functioning systems, leading to changes in soil fauna [52].

2.2.3. Water Pollution by Heavy Metal

Water pollution can be defined in many ways. Usually, it means one or more substances have built up in water to such an extent that they cause problems for animals or people [65].

All metals are toxic at higher concentrations and their presence in water lead to water pollution [66]. Excessive levels can be damaging to the organism. Certain heavy metals such as mercury, plutonium, and lead are toxic metals that have no known vital or beneficial effect on organisms, and their accumulation over time in the bodies of animals can cause serious illness [67].

Water pollution is a major global problem which requires ongoing evaluation and revision of water resource policy at all levels (international down to individual aquifers and wells). It has been suggested that water pollution is the leading worldwide cause of deaths and diseases and that it accounts for the deaths of more than 14,000 people daily [65, 36].

2.3. Factors Affecting Accumulation of Heavy Metals in an Environment

The accumulation of heavy metals in an environment is affected by many variables, including parent material and soil properties, as well as by human activities, such as industrial production, traffic, farming, and irrigation. Large areas of land can be contaminated by heavy metals released from smelters, waste incinerators, industrial wastewater, and from the application of sludge or municipal compost, pesticides, and fertilizers [68].

Also heavy-metal concentrations were influenced by multiple factors, such as traffic volume, highway characteristics road and roadside terrain, roadside distance, wind direction, rainfall, seeded strip, local economy [69, 70]. The natural soil concentration of heavy metals depends primarily on the parent material composition [32].

The content of heavy metals in soil and their impact on ecosystems can be influenced by many natural factors, such as parent material, climate, and soil processes, and anthropogenic activities such as, industry, agriculture, and transportation [71]. Their bioavailability is influenced by physical factors such as temperature, phase association, adsorption and sequestration. It is also affected by chemical factors that influence speciation at thermodynamic equilibrium, complexion kinetics, lipid solubility and octanol/water partition coefficients [72]. Biological factors such as species characteristics, trophic interactions, and biochemical/physiological adaptation, also play an important role [73].

2.4. Effects of Heavy Metal on Organisms

Excess of metal pollutants deposited on soils may be transformed and transported to vegetation and from plants they pass on to animals and human being [27]. Heavy metal exposure to human occurs through three primary routes namely inhalation, ingestion and skin absorption. The threat that heavy metals pose to human and animal health is aggravated by their low environmental mobility, even under high precipitations, and their long term persistence in the environment [58]. Also, human exposure has risen dramatically as a result of an exponential increase of their use in several industrial, agricultural, domestic and technological applications [28]. All metals are toxic at higher concentrations [66]. Excessive levels can be damaging to the organism. Other heavy metals such as mercury, plutonium, and lead are toxic metals that have no known vital or beneficial effect on organisms, and their accumulation over time in the bodies of animals can cause serious illness. Certain elements that are normally toxic are for certain organisms or under certain conditions, beneficial. Examples include vanadium, tungsten, and even cadmium [74].

According to Reena *et al*. [75] heavy metals disrupt metabolic functions in two ways: They accumulate and thereby disrupt function in vital organs and glands such as the heart, brain, kidneys, bone, liver, etc. They displace the vital nutritional minerals from their original place, thereby, hindering their biological function.

It is, however, impossible to live in an environment free of heavy metals. There are many ways by which these toxins can be introduced into the body such as consumption of foods, beverages, skin exposure, and the inhaled air. Soil to plant transfer is one of the key processes of human exposure to heavy metals through the food chain.

Heavy metals can also directly harm public health by entering the body via soil and dust, dermal contact or breathing [76]. The typical elements Cd, Pb, Zn, and Cu in the roadside soils coming from traffic activity can be transported through the food chain into the human body and thus be very toxic to people. In agricultural areas, intake of heavy metals through the soil-crop system could play a predominant role in human exposure to heavy metals [77].

In general, heavy metals with high concentrations in the environment result in health problems adversely affecting the nervous, blood forming, cardiovascular, renal and reproductive systems. The consequences of heavy metal pollution include reduced intelligence, attention deficit and behavioral abnormality, as well as contribution to cardiovascular disease in adults [78]. Some trace metals (such as Cu and Zn) are harmless in small amounts, but the others (mainly Pb, As, Hg and Cd), even at extremely low concentrations, are toxic and are potential cofactors, initiators or promoters in many diseases, including increased risk of cancer [79, 80]. However, it is not easy to remove heavy metals from the soils because of their irreversible immobilization within different soil components [21].

The concentrations of heavy metals in animals have harmful effects especially when consume above the bio-recommended limits from plants. Although individual metals exhibit specific signs of their toxicity, the followings have been reported as general signs associated with cadmium, lead, iron, zinc, and copper poisoning: gastrointestinal (GI) disorders, diarrhoea, stomatitis, tremor, hemoglobinuria causing a rust-red colour to stool, ataxia, paralysis, vomiting and convulsion [12]. When volatile vapours and fumes are in-haled it can cause depression and pneumonia. The nature of effects can be toxic (acute, chronic or sub-chronic), neurotoxic, carcinogenic, muta-genic or teratogenic [81]. In humans, trace metals such as Pb may affect the brain and cause retarded growth, especially in children. [21].

2.5. Effect of Heavy Metals on Plants

Plants experience oxidative stress upon exposure to heavy metals that leads to cellular damage and disturbance of cellular ionic homeostasis [82]. To minimize the detrimental effects of heavy metal exposure and their accumulation, plants have evolved detoxification mechanisms mainly based on chelation and subcellular compartmentalization [83]. A principal class of heavy metal chelator known in plants is phytochelatins (PCs), are synthesized no--translationally from reduced glutathione (GSH) in a transpeptidation reaction catalyzed by the enzyme phytochelatin synthase (PCS). Therefore, availability of glutathione is very essential for PCs synthesis in plants at least during their exposure to heavy metals [75].

In plants, excessive Pb alters normal metabolic pathways by disrupting specific cellular enzymes and may also inhibit the photosynthetic ability of plants. Generally, excessive levels of heavy metals may result in the induction of oxidation stress, damage to DNA, and disturbances in the biosynthetic pathways [52].

Heavy metal uptake via the roots from contaminated soils and direct deposition of contaminants from the atmosphere onto plant surfaces can lead to plant contamination by heavy metal [84]. Heavy metals contamination may alter the chemical composition of plants and thereby seriously affect the quality and efficacy of the natural plant products produced by medicinal plants species. Heavy metal toxicity has an inhibitory effect on plants growth, enzymatic activity, stoma functions, photosynthesis activity and accumulation of other nutrient elements, and also damage the root system [76]. Accumulation of heavy metals can degrade soil quality; reduce crop yield and the quality of agricultural products [85].

2.6. Assessment of Heavy Metal Level of Contamination

The level of contamination of heavy metals can be assess by contamination indices such as contamination factor (Cf), the degree of contamination (CD), pollution load index (PLI), Enrichment factor (EF) and Geoaccumulation index (I-geo) [4].

Contamination factor (CF) is the ratio of the measured concentration of the examined metals in soil to the geochemical background concentration or reference value of the heavy metals or the background value of heavy metal in the uncontaminated soil, while the degree of contamination is the summation of the values of the contamination factor. On the other hand pollution load index is the amount of tress placed upon an ecosystem by pollution, physical or chemical released into it by manmade or natural means. Product of the values of CF rises to one over the number of CF under consideration. However, I-geo is the log to base two of the ratio of the values of the concentration of the metal measured to the concentration in the unpolluted soil [86, 52].

The Geoaccumulation Index (Igeo) was originally defined by Müller [87] for metal concentrations in the 2-micron fraction and was developed as global standard shale values. Geoaccumulation Index (Igeo) and Enrichment Factor (EF) in metals are indicators used to assess the presence and intensity of anthropogenic contaminant deposition on surface soil. These indexes of potential contamination are calculated by the normalization of one metal concentration in the topsoil respect to the concentration of a reference element. A reference element is an element particularly stable in the soil, which is characterized by absence of vertical mobility and/or degradation phenomena. The constituent chosen should also be associated with finer particles (related to grain size), and its concentration should not be anthropogenically altered [86. 87].

According to Taofeek and Tolulope [4] Cf, CD, PLI and I-geo can be calculated through these formulae:

$$Cf= Cs/Cb \tag{1}$$

$$CD=\sum Cf \tag{2}$$

$$PLI= (Cf_1 x Cf_2 \ldots\ldots Cf_n)^{1/n} \tag{3}$$

$$I\text{-}geo=Log_2[Cs/(1.5xCb)] \tag{4}$$

Where Cs is the measured concentration of the examined metal in the soil, Cb is the geochemical background concentration or reference value of the metal or the background value of heavy metals in the uncontaminated soil and where n is the number of metal studied.

The factor 1.5 introduce is to minimize the effect of possible variations in the background values, Cb which may be attributed to lithogenic variation in soils.

This method assessed the metal pollution in terms of seven (0 to 6) enrichment classes ranging from background concentration to very heavily polluted as shown in Table 1.

Table 1. *Different Type of Model and the Categories for the Description of the Contamination.*

Model	Class		Description
Contamination factor	Cf<1		Low
	1<Cf<3		Moderate
	3 < Cf < 6		Considerable
	6 < Cf		Very high
Degree of Contamination	Cd<5		Low
	5 < CD < 10		Moderate
	10 < CD < 20		Considerable
	20 < CD		Very high
	PLI < 1		Perfection
Pollution level index	PLI = 1		Base line level of pollution
	PLI > 1		Deterioration of sites quality
Geo accumulation	Igeo	Igeo	
	value >5	class	Designation of soil class
	4-5	6	extremely contaminated
	3-4	5	Strongly to extremely contaminated
	2-3		Strongly contaminated
		4	Moderately to strongly contaminated
	1-2	3	Moderately contaminated
	0-1		Uncontaminated to moderately contaminated
		2	Uncontaminated
	0	1	
		0	

Taofeek and Tolulope, [4].

The assessment of heavy metal and level of contamination in soil require pre-anthropogenic knowledge of metal concentration to act as pristine values [87]. A number of different enrichment calculation methods and reference material have been reported [88, 89].

Mafuyai *et al.* [87] establish the degree of anthropogenic pollution by adopting enrichment

$$EF = \frac{C_m sample}{medianC_m Background + 2MADC_m Background} \tag{5}$$

Where,

C_m sample, is the concentration of a given metal in the soil sample.

Median C_m background is the median concentration of an element in the background soil sample and MAD C_m Background is the median absolute deviation from median defined as:

$$MAD=median/x_1\text{-}median\ (x_j)/,\ j=1, 2,\ldots\ n \tag{6}$$

This method is less affected by extremes in the tail often encountered with geochemical data, because the data in the tails have less influence on the calculation of the median than they do on the mean.

Five of the following categories are recognized on the basis of enrichment factor EF < 2: Deficiently to minimal enrichment.

$2 \leq EF < 5$: Moderate enrichment.

$5 \leq EF < 20$: Significant enrichment.

$20 \leq EF < 40$: Very high enrichment.

$EF \geq 40$: Extremely high enrichmen.

2.7. Remedy of Effect of Heavy Metal

Irrespective of the origin of the metals in the environment, excessive levels of many metals can result in soil quality degradation, crop yield reduction, and poor quality of agricultural products, posing significant hazards to human, animal, and ecosystem health [51].

Therefore, it becomes essential to remove the accumulated metals. The removal of single heavy metals like Co and Zn from aqueous solutions using various lo-cost adsorbents (Fe_2O_3, Fe_3O_4, FeS, steel wool, Mg pellets, Cu pellets, Zn pellets, Al pellets, Fe pellets, and coal) was investigated [90]. The solution pH on metal adsorption using Fe_2O_3 and Fe_3O_4 was significantly effective, and the removal was p-independent over the +entire pH range studied (1.5–9.0) [91]. Mechanisms proposed to be involved in transition metal accumulation by plants are phytoaccumulation, phytoextraction, phytovolatilization, phytodegradation, and phytostabilization [91, 75].

According to Reena et al. [75] systematic remediation technologies for heavy Metal contaminated environments include:

Physical/Chemical remediation: Heavy Metal Removal from Aqueous Solution Using Libyan Natural Zeolite. Soil washing for remediation of heavy metal contaminated soils and sediments.

Phytoremediation: is the direct use of living green plants for in situ, or in place, removal, degradation, or containment of contaminants in soils, sludge, sediments, surface water and groundwater. Uptake of cadmium, lead and chromium-Contaminated soils using Jatropha curcas L. Cleanup of heavy metal polluted soils by barley (Hordium Vulgare), wheat (Triticum sativum) and garden cress (Lipidium sativum).

Microbial remediation: Heavy metal removal by biosorption has been extensively investigated during the last several decades. Some reviews have been published focusing on different aspects of heavy metal biosorption. Heavy metals biosorption using microorganisms: Saccharomyces cerevisiae (yeast), Streptococcus Equisimilis (bacteria) and Aspergillus niger (fungi). The behaviour of the organisms differs considerably in metal uptake rate depending on some factors (e.g metal, temperature, pH).

Integrated remediation: Traditional Remediation of Contaminated Soil. Once metals are introduced and contaminate the environment, they will remain. Metals do not degrade like carbon-based (organic) molecules. The only exceptions are mercury and selenium, which can be transformed and volatilized by microorganisms. However, in general it is very difficult to eliminate metals from the environment. Traditional treatments for metal contamination in soils are expensive and cost prohibitive when large areas of soil are contaminated. Treatments can be done in situ (on-site), or ex situ (removed and treated off-site). Both are extremely expensive. Some treatments that are available include: High temperature treatments (produce a vitrified, granular, non-leachable material); Solidifying agents (produce cement-like material) and Washing process (leaches out contaminants).

Soil and crop management methods can help prevent uptake of pollutants by plants, leaving-them in the soil. The soil becomes the sink, breaking the soil-plant-animal or human cycle through which the toxin exerts its toxic effects [92]. According to Reena *et al* [75] the following management practices will not remove the heavy metal contaminants, but will help to immobilize them in the soil and reduce the potential for adverse effects from the metals note that the kind of metal (cation or anion) must be considered:

Increasing the soil pH to 6.5 or higher cationic metals are more soluble at lower pH levels, so increasing the pH level make them less available to plants and therefore less likely to be incorporated in their tissues and ingested by humans. Raising pH has the opposite effect on anionic elements.

Draining wet soils: Drainage improves soil aeration and will allow metals to oxidize, making them less soluble. Therefore when aerated, these metals are less available. The opposite is true for chromium, which is more available in oxidized forms. Active organic matter is effective in reducing the availability of chromium.

Applying phosphate: Heavy phosphate applications reduce the availability of cationic metals, but have the opposite effect on anionic compounds like arsenic. Care should be taken with phosphorus applications because high levels of phosphorus in the soil can result in water pollution.

Carefully selecting plants for use on metal-contaminated soils: Plants translocate larger quantities of metals to their leaves than to their fruits or seeds. The greatest risk of food chain contamination is in leafy vegetables like lettuce or spinach. Another hazard is forage eaten by livestock, Plants for Environmental Clean-up. Research has demonstrated that plants are effective in cleaning up contaminated soil [93]. Phytoremediation is a general term for using plants to remove, degrade, or contain soil pollutants such as heavy metals, pesticides, solvents, crude oil, polyaromatic hydrocarbons, and landfill leacheates. For example, prairie grasses can stimulate breakdown of petroleum products. Wildflowers were recently used to degrade hydrocarbons from an oil spill in Kuwait. Hybrid poplars can remove ammunition compounds such as high nitrates and pesticides [94]. Plants for Treating Metal Contaminated Soils, Plants have been used to stabilize or remove metals from soil and water. The three mechanisms used are phytoextraction, rhizofiltration, and phytostabilization.

Rhizofiltration is the adsorption onto plant roots or absorption into plant roots of contaminants that are in solution surrounding the root zone (rhizosphere). Rhizofiltration is used to decontaminate groundwater. Plants are grown in greenhouses in water instead of soil. Contaminated water from the site is used to acclimate the plants to the environment. The plants are then planted on the site of contaminated ground water where the roots take up the water and contaminants. Once the roots are saturated with the contaminant, the plants are harvested including the roots. In Chernobyl, Ukraine, sunflowers were used in this way to remove radioactive contaminants from groundwater [95]. Phytostabilization is the use of perennial, non-harvested plants to stabilize or immobilize contaminants in the soil and groundwater. Metals are absorbed and accumulated by roots, adsorbed onto roots, or precipitated within the rhizosphere.

Metal-tolerant plants can be used to restore vegetation where natural vegetation is lacking, thus reducing the risk of water and wind erosion and leaching. Phytostabilization reduces the mobility of the contaminant and prevents further movement of the contaminant into groundwater or the air and reduces the bioavailability for entry into the food chain [75].

Phytoextraction is the process of growing plants in metal contaminated soil. Plant roots then translocate the metals into above ground portions of the plant. After plants have grown for some time, they are harvested and incinerated or composted to recycle the metals. Several crop growth cycles may be needed to decrease five contaminant levels to allowable limits [91, 96].

3. Conclusion

The problem of environmental pollution due to toxic metals is of major concern in most major metropolitan cities. The toxic metals entering the ecosystem may lead to geoaccumulation, bioaccumulation and biomagnifi-cations.

Pollution of the natural environment by heavy metal is a worldwide problem because these metals are indestructible and most of them have toxic effects on living organisms and plants, when they exceed a certain concentration. Heavy metals occur naturally in the soil environment from the pedogenetic processes of weathering of parent materials and from anthropogenic sources such as traffic emission, industrial and energy production, vehicle exhaust, waste disposal as well as coal and fuel combustion.

High levels of heavy metals can result in soil quality degradation, leading to crop yield reduction, poor quality of agricultural products, posing significant hazards to human, animal, and ecosystem health.

Therefore it is important to continually assess and monitor the levels of heavy metals in an environment due to increase in anthropogenic activities for evaluation of human exposure and for sustainable environment. The accumulated metals should be removed by employing Systematic remediation technologies for heavy metal contaminated environments such as: Physical/Chemical remediation, Phytoremediation, Microbial remediation, integrated remediation, Soil and crop management methods.

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