

# Review of Heavy Metal Contamination in Soil



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## Abstract

Heavy metal toxicity is frequently the result of long-term, low-level exposure to common pollutants in our environment. Exposure to toxic heavy metals is associated with many chronic diseases and can cause a wide variety of health problems. Urban soils receive varying inputs of heavy metals from a variety of mobile or stationary sources such as vehicular traffic, industrial plants, power generation facilities, residential oil burning, waste incineration, construction and demolition activities and re-suspension of surrounding contaminated soils and makes a significant contribution to the pollution in the urban environment. The ratio of the composition of the soil also varies in different areas of biosphere as the road side soil is more polluted than the soil of any park or any farm or field. This variation is more remarkable in metro cities of India such as Delhi due to huge industrial and automobile development. Therefore, the study of urban soil is important for determining the origin, distribution, and level of heavy metal contamination in urban environments. Present paper deal with the review of the soil analysis and hazardous effects on human health.

The study of environment is going on from centuries and the chemical composition of naturally occurring soil is keep on changing according to the climatic and atmospheric conditions of biosphere. This ratio is the deciding factor of fertility of soil and as the composition of soil keep on changing the fertility and quality of soil degrading simultaneously. Two main sources of metal concentration inherited from parent rock, during origin of earth and anthropogenic contamination [1]. The introduction of origin of various heavy metals in metamorphic rocks through anthropogenic

manner and from human activates changes the metal composition in soil time to time, there are a huge possibilities that heavy metals show mobility from agricultural soil to surface and ground water [2]. It causes the change in heavy metal ratio in soil and plants during a period [3]. Although forests soil is less contaminated due to least human influence [3]. The variation in the composition of heavy metal in soil have disasters effect on nature of mine soils and its risk assessment in their respective studies [4]. During extraction of heavy metal from mine the metal retained in soil so composition of soil changes [15]. Wide range of studies on Environmental Pollution are available according to climatic conditions, varies Urban to Rural Worldwide. The amount/concentration of iodine and carbonates in various samples of rocks and sea water varies according to the environmental condition, the distribution of iodine throughout earth crust including surface of soil water and percentage presence of mica in clay and shale [5].

There is a dense relation of environmental chemical composition of natural recourses and pollution in their separate studies [6]. The water in India is specified under BIS, Indian standard drinking water specifications, IS: 10500, [7]. The distribution of heavy metals in surface water of Ranipet industrial area in Tamil Nadu, India [8]. The influence of heavy metal on environment arises from sewage sludge of ferrosols [9]. The consequences of emission of heavy metal through various sources and their dominance of toxicity or traces of metal on soil and natural water in the different areas of Planet Earth [10,11]. Metals also have a vital advantage for our bodies or living organisms, these are utilized by various modes in any biological system as

## Heavy Metals

**Nickel (Ni):** Ni is cubic crystal, silvery and a d-block metal (period 4 and group 10). It has atomic number 28, atomic mass 58.7, density 8.9 g/cm<sup>3</sup>, high melting and boiling point. It is an element that occurs in the environment only at very low levels and is essential in small doses. A very small amounts nickel is used by the body to produce red blood cells, but it can be dangerous when the maximum tolerable amounts are exceeded.

Nickel contaminations in the soil are metal plating industries, combustion of fossil fuels, nickel mining and electroplating. Humans may also be exposed to nickel (Ni) by inhalation, drinking water, and eating contaminated food. It is released into the air by power plants and trash incinerators and settles to the ground after undergoing precipitation reactions. Nickel can also end up in surface water when it is a part of wastewater streams.

It is used in the manufacture of stainless steel, coins, nickel for armor plates, burglarproof vaults, vegetable oils, ceramics and Ni-Cd batteries.

**Chromium (Cr):** Cr is a cubic crystal, steel gray, very hard and a d-block metal (period 4 and group 6). It has atomic number 24, atomic mass 52, density 7.19 g/cm<sup>3</sup>, high melting and boiling points. It occurs in combine states in its compound and alloys with other elements. Cr is a primary ore product is occurred in the form of mineral chromites, FeCr<sub>2</sub>O<sub>4</sub>. Sources of chromium (Cr) contamination include releases from electroplating processes and disposal of chromium (Cr) containing waste. Chromium (VI) is the form of Cr commonly found at contaminated sites and toxic levels are common in soils applied with sewage sludge. It can be reduced to Cr (III) by soil organic matter [12]. It can be transported by surface runoff to surface waters in its soluble or precipitated form. Most of chromium (Cr) released into natural waters is particle associated and ultimately deposited into the sediment. Chromium (Cr) is required for carbohydrate and lipid metabolism, utilization of amino acids and as pigments for paints, cement, paper, and rubber, metal plating for prevention of corrosion, leather tanning and textile color pigments [13]. It also contributes in maintaining a normal glucose tolerance factor. Chromium is required for carbohydrate and lipid metabolism and the utilization of amino acids. Chromium is used in metal alloys and pigments for paints, cement, paper, rubber, and other materials [14].

**Zinc (Zn):** Zn is a hexagonal crystal, bluish-white metal and a d-block metal (period 4 and group 12). It also has atomic number 30, atomic mass 65.4, density 7.15 g/cm<sup>3</sup>, Zn is a naturally occurring element in atmosphere in free and combine state as in air, soil, water and all food contents. It occurs naturally in soil but the concentrations are rising due to anthropogenic additions. Most additions are from industrial activities such as mining, coal, waste combustion and steel processing. Then also from the use of liquid manure, composted materials, fertilizers, and pesticides in agriculture [15]. It is used in industry to make paint, dye, rubber, wood preservatives and as well as ointments. Zinc (Zn) pollutes water due to the large quantities present in the wastewater of industrial plants and the water-soluble forms present in the soil can contaminate groundwater.

**Copper (Cu):** Cu is a cubic crystal, reddish and a d-block metal. (period 4 and group 11). Cu has atomic number 29, atomic mass 63.5, density 8.96 g/cm<sup>3</sup>, High melting point 1357 K and boiling point 2840 K. It occurs in rocks, soil, water, air, plants, and animals. It is also an essential micronutrient required in the growth of both plants and animals. Cu is also used in the production of blood hemoglobin, disease resistance, used for seed dressing in angiosperm plants and regulation of water in human body. It is also used as a component in metal alloys, electrical wiring, and preservatives for wood, leather, and fabrics.

**Cadmium (Cd):** Cd is a hexagonal crystal, silver white malleable and a d-block metal (period 5 and group 12). It

has atomic number 48, atomic mass 112.2, density 8.65 g/cm<sup>3</sup>, melting point 594 K and boiling point of 1038 K. It is an essential micronutrient for plants and animals but may cause malfunctioning of metabolic processes. Cd enters the environment through the uncontrolled burning of coal and garbage and through the food chain directly or indirectly from plants or animals [16]. The application of agricultural inputs such as fertilizers, pesticides, biosolids (sewage sludge), and the disposal of industrial waste and the deposition of atmospheric contaminants increases the total concentration of Cd. It can also result from burning of fossil fuels, sewage sludge, plastics waste, byproduct of Zn and lead refining, insecticides, and motor oil. Cadmium (Cd) uses include Ni/Cd batteries, pigments, stabilizers for polyvinyl chloride (PVC), in alloys, electronic compounds, barriers to control nuclear fission, phosphors in the production of televisions, anticorrosive coatings for metals, amalgam in dentistry and worm treatments for swine and poultry.

**Lead (Pb):** Pb is cubic crystal, silver blue-white, soft and a p-block metal (period 6 and group 14). Lead has atomic number 82, atomic mass 207.2, density 11.4 g/cm<sup>3</sup>, melting point 601 K and boiling point 2013 K. According to lead is a naturally occurring and found as a mineral combined with other elements such as sulphur (PbS, PbSO<sub>4</sub>) and oxygen (PbCO<sub>3</sub>). Also waste incineration contributes to a greater amount of lead available in urban areas. Its uses include storage batteries, solders, bearings, cable covers, ammunition, plumbing, pigments, caulking, sound and vibration absorbers. The two routes of exposure to lead come from inhalation and ingestion and the effects from both are the same.

### Heavy Metal Contamination

**Root Cause:** Urban soil is highly influenced anthropogenic sources such as industrial and economical activities. The trace metal in urban soil of 31 capital cities of China. The severe change and degradation in air, soil and water due to environmental pollution [16]. Urban soil raises the accumulation of organic and inorganic matter by direct and indirect sources [17,18] Bioaccumulation of various chemical in a living organism as compared to the chemical concentration in the environment was studied. Dietary intake of food may constitute a major source of long-term low level body accumulation of heavy metals [19]. Activates as agriculture, industrial waste, sewage wastewater, mining and metallurgy, manufacturing, fuel combustion and atmospheric deposition of dust particles can also introduce heavy metals into water bodies thereby contaminating them by human interference [20-23]. Local transport system or waste water disposal are major factors of variation and contamination of area specific soil.

The distribution of heavy metal in the edible plants grown at Jajmau, Kanpur (India) receiving treated tannery wastewater and Unnao industrial areas of the Ganaga plain Uttar Pradesh and reported metal contamination such as Cu, Pb, Sr, Zn, V

etc in considerable amount due to hazardous waste [24,25]. The trace metals sedimentation in a urban stream of Ohau [26]. The multi-element analysis of roadside deposition and sedimentation in Honolulu (Hawaii) [26,27], observed that Road deposited sedimentation (RDS) degraded the quality of water bodies, high concentration of transition metal like Pb, Cu and Zn were detected, which is the root cause of toxicity urban drainage system. In India contamination of soil by heavy metal was analyzed near Ganga Plain [28]. The sedimentation of heavy metal along Gomti River India [29]. The feasibility of estimating heavy metal in floodplain soil [30]. The deposition of cadmium lead and zinc in Europe during the period 1955-1987.

Every metal has different effect on soil, the effect of Cu and Cd metal ions on plant growth and on various environmental pollution. The effect of contaminated elements on terrestrial environment due to bioavailability and toxicity [31]. Organic matter contamination and their availability on terrestrial environment and the carcinogenic, mutagenic, toxicity of organic pollutants including polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans (PCDD/Fs), polychlorinated naphthalene (PCNs), and polybrominated biphenyl ethers (PBDEs) [32]. Irrigated water plays an important role in heavy metal contamination in soil [33]. Use of sewage water for irrigation for a long time degrades the quality of plants and increase the toxic elements [34]. Impure water from industrial area effects agricultural soil and river beds [35,36]. The benefits of heavy metal and other substances content of waste sewage water, on horticultural crops [37,38]. Studied the impact of fertilizer on plants irrigated in sewage water. Random Rise in amount of heavy metal in plants and vegetables is due to irrigating plants with sewage water.

Extractions of metals from their ores are one of the major source of environmental pollution release and increase of metal and metalloids as Pb, Zn etc through mining and smelting process was observed [39]. The 13% rise of Hg level in environment due to the process of mining of ores [40]. Soil contamination near non-ferrous metal smelters [41]. There is a remarkable decrease in Hg, Cd, Pb in the European areas of non-ferrous metal industry over last 50 years due to effluent gas cleaning system [40].

### Heavy Metal Contamination

#### Hazardous Effect

Human activities have been affected globally by heavy metals resulting in a progressive rise in the flux of bioavailable chemical forms to the atmosphere [41]. Heavy metals can sufficiently create hazardous effect in living organism as they can exist prolong in different organic and inorganic complex forms [42]. They are non biodegradable and therefore do not decay with time. The intake rate of heavy metals by an organism is relatively very high than its excretion rate, therefore these become dangerous for human health [43]. Heavy metals can

easily inhale, ingestion and dermal contact absorption by human body [44]. Metal can also accumulate in soils, plants and in aquatic animal and plants.

As heavy metals have a very long half life so they can accumulate and retain in living organism [45,46]. The existence of heavy metals can cause various health problems for organism and is highly dangerous for some organisms if it is present in the environment alone. Increasing exposure to toxic elements in marine and terrestrial organisms can have adverse toxicological effects. Heavy metal exposure is normally chronic (exposure over a longer period of time), due to food chain transfer [47] connected the soil with human health in his review paper [48-50]. Studied environmental risk assessment and remediation of soils contaminated due to waste disposal from tannery industries in Tamil Nadu and Kanpur (India), [51]. The risk of heavy metal contaminated soil on crop irrigated by contaminated water in Beijing(China).The effect of heavy metal concentrations (Cd, Zn and Pb) in agricultural soils, accumulation and food safety in soybean [52]. The effect the lead and its isotopes on soil in Hon Kong [53]. The soil contamination by toxic metals in the cultivated region of Agia (Greece) [54].

The composition of metal and traces of element through their work [55,56]. Any chemical change in this composition changes the fertility of soil this change in chemical ratio of soil is caused by deforestation, decomposition of hazardous waste, non-biodegradable chemical waste, industrial waste etc. This waste material are generating or increasing chemical impurities in soil which is the major root-cause of this random and an immense change in the natural chemical composition of soil. This mark increase in chemical impurity in soil is more noticeable in developing countries like India due to gigantic industrialization and population growth followed by climatic disorder. This environmental chaos is creating a noteworthy risk to the quality of the natural resources like water, trees and living being, Major risk factors due to these drastic changes in natural resources has been studied in several studies.

The accumulation risk of heavy metals in soil and vegetable crop irrigated with sewage water in a specific area of Saudi Arabia [57]. The contaminated soil effected by pollutants and toxic metals on edible plants irrigated by sewage water in their various studies [58,59]. The implement of heavy metal contamination on agricultural soil and its prolong effect on environment and human health. Fertilizers contain some amount of N, P and K nutrients which contribute to organic matter recycling and restoring the fertility [60]. Growth of heavy metal in agricultural soil through waste water affects the quality of food [60-65].The continues growth of metal contaminants in vegetables in various lands cultivated by sewage water.

The soil and plant showed higher values of heavy metal due to accumulation; however the sewage water contains a relative smaller quantity of heavy metals [66]. The accumulation of metal

in soil and tomatoes crop irrigated with sewage water in Mysore city, Karnataka, India [67]. Distribution and contamination of heavy metal in Red Sea Coastal areas and their effect on Benthic Foraminifera (Sea Plants) in Jeddah Saudi Arabia .The health risk to dietary intake of toxic metal from Spinaciaolerancea harvested from contaminated soil around Tshwane, South Africa [68]. Different metals have various hazardous effects on all macro and microorganism as mercury and selenium can be transformed and volatilized by microorganisms (USDA and NRCS, 2000). Exposure to chromium (Cr) can lead to allergic dermatitis in humans, bleeding of the gastrointestinal tract, cancer of the respiratory 18 tract and ulcers of the skin. Then also damage to the mucus membrane, liver and kidney damage.

Zn may increase the acidity of waters. Then can negatively influence the activity of microorganisms and earthworms thereby retarding the breakdown of organic matter. Copper (Cu) is not magnified in the body or bioaccumulation in the food chain. High doses of copper cause anemia, liver and kidney damage, stomach and intestinal irritation, neurological complications, hypertension and liver and kidney dysfunctions. It can also be described as a toxic waste and therefore unpalatable for consumption. Nickel (Ni) can result in lung, liver and kidney damage. In high quantities Ni can also cause cancer, respiratory failure, birth defects, allergies, dermatitis, eczema, nervous system and heart failure. Lead (Pb) accumulation in the body organs (i.e., brain) may lead to poisoning (plumbism) or even death. The presence of lead (Pb) may also affect the gastrointestinal tract, kidneys, and the central nervous system. For instance, children exposed to lead (Pb) suffer from impaired development, lower IQ, shortened attention span, hyperactivity and mental deterioration. Those at substantial risk are the children under the age of six [69]. Then in the case of adults" decreased reaction time, loss of memory, nausea, insomnia, anorexia, weakness of the joints, failures of reproduction, inhibition of haem synthesis, irritation, and producing tumors are all caused by exposure to lead.

**Aquatic:** The presence of heavy metals in water degrades their quality, which eventually affects human health .For instance, Coastal fish (such as the smooth toadfish) and seabirds (such as the Atlantic Puffin) are often monitored for the presence of such contaminants. Mention can also be made of Minamata disease and itai-itai disease from mercury and cadmium poisonings respectively. Heavy metal can rarely cause immediate poisoning by dermal contact process, but this case cannot be neglected that heavy metals being highly toxic can cause damaging effects even at very low concentrations [70-75]. The combination of heavy metals with other chemical substance produce dangerous cocktails though very little is known about their combined effects

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