

Original Research Article

Effects of Environmental Pollution in Industry (Case Study: Soil Pollution)

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ABSTRACT

Soil pollution has increasing risks for human health and environment. Heavy elements are considered among the most important pollutants in the environment, which have been highly concerned in the last few decades. The accumulation of heavy elements in the soil, especially in agricultural fields, is gradual and the concentration of heavy elements can reach a level that threatens human food security. Every year, thousands of tons of these elements, which are caused by urban, industrial, and agricultural activities, enter the soil. The study of different researchers inside the country shows that the intensification of industrial activities, on one hand, and the non-compliance of environmental issues and standards by some of the industrial owners, on the other hand, has caused environmental pollution in some areas of the country. Soil is one of the important components of earth's bio-travel and plays an important role in the health of humans and animals. Soil not only plays an important role in the production of food and clothing, but also has a significant effect on maintaining the environmental quality. Therefore, soil contamination by chemicals is one of the most important biological issues. In the last few decades, with the progress of industry, the amount of toxic elements in the soil has been increased. Municipal and industrial effluents, solid wastes from various urban, industrial and agricultural activities, various fertilizers, and chemical poisons are important sources of soil pollution with toxic elements.

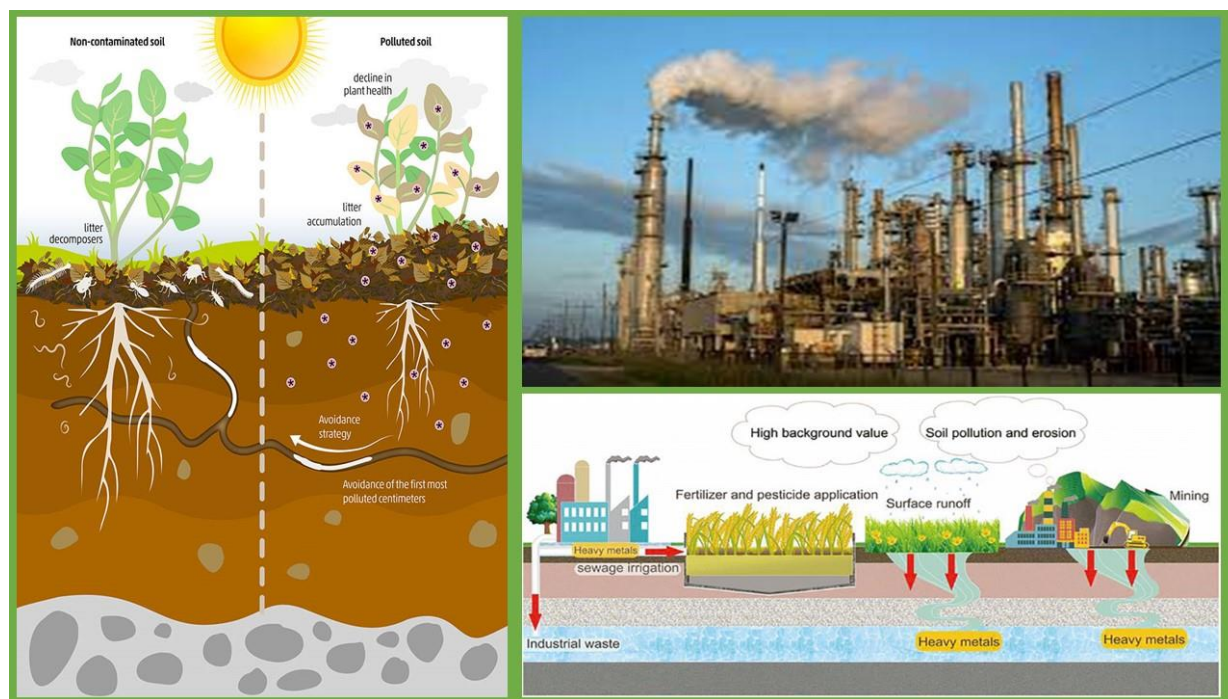
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GRAPHICAL ABSTRACT



Introduction

Soil pollution has increasing risks for human health and the environment, which have been strongly considered in the last few decades [1-3]. Polluting substances entering the environment are either of natural origin or are created as a result of human actions. Most of the natural pollutants are not concentrated in one place and decompose to a harmless extent. In contrast, the most acute type of human pollution occurs near cities or industrial areas, that is, where pollutants are concentrated in air, water, and soil in a dense and low volume [4-6]. In addition, many human pollutants are chemical compounds that do not break down in natural ways. Therefore, any city or point located in the vicinity of a polluting economic factor. Undoubtedly, it has been influenced and its effects can be seen in social, economic, and environmental aspects. Environmental pollution in every part (water, soil, air, and plants) is a problem whose harmful effects will be evident in the long term. Soil is actually the most sensitive and vital part of the

earth [7]. In addition to the role, they play in the continuation of life, soils have also left a major impact on the evolution and even the origin of life. Of course, industrial activities and as a result of soil pollution have irreparable effects on our lives, and knowing the polluting sources and preventing soil pollution makes possible the optimal use of resources and minimizes environmental risks [8-10]. Given that the soil importance as a fundamental resource in the production of society's wealth, development, and health programs of our society, we should pay enough attention to the soil health and protection program, and also try to avoid pollution or maintain its natural quality [11].

Research Background

- Rahmani (1995) in a study entitled: "Esfahan Mobarakeh Steel Company's Effluent Quality and its Effects on Under Cultivation" has come to the conclusion that soils irrigated by industrial effluents have absorbable concentration of heavy elements higher than

control soil and total concentration of heavy elements in critical concentration range of these elements is in the soil [12].

- Mousavi (2009) in a research entitled: *"Zonation of Soils Contaminated with Heavy Metals in Hamedan Region"*, has come to the conclusion that in terms of spatial correlation of heavy metals, all the studied elements have moderate correlation [13].
- Golchin *et al.* (2006) in research entitled: *"Evaluation of the Effect of Lead and Zinc Factories in Zanjan on the Contamination of Agricultural and Garden Crops with Heavy Metals"* have come to the conclusion that the concentration of lead and cadmium in plant samples near the factory is high and worrisome, and the most lead and cadmium contamination has been observed in fodder that is used by livestock and is also harmful to humans [14].
- Emami *et al.* (2006) in a study entitled: *"The Investigation of Concentration of Cadmium, Lead, and Zinc in the Profile of a Type of Calcareous Loam Soil after Washing with a Solution of These Elements"*, concluded that cadmium concentration in different depths of the soil had significant differences. And only from the depth of 14 to 30 cm, no significant difference was observed between different depths. It seems that the cause of concentration distribution is the way of filling the soil column because it is not possible to compress all soil layers equally. As a result, some layers become denser than other layers. This causes the more compressed layers to absorb a larger number of heavy elements due to the lower speed of the water and the longer contact of the solution with the solid phase [15].
- Khosravi *et al.* (2008) modeled the spatial distribution of total lead and total cadmium in the surface soil of Isfahan using discontinuous kriging method and ARC GIS92 software. The statistical analysis of the data of this study showed that there was a significant positive correlation between the amount of cadmium and lead at the level of 5%, but there was no significant correlation with other parameters [16].
- Amini *et al.* (2005) used index kriging for 255 surface soil samples (0-20 cm) to prepare a map of cadmium and lead contamination in the soils of Isfahan region with an area of 6800 km. They compared the obtained concentrations with the reference value of Switzerland, in more than 80% of the sample's cadmium was higher than the reference value and in only 2% of the samples the amount of lead was higher than the reference value. In this study, using kriging, the probability index maps of cadmium and lead concentrations exceeding the desired threshold were determined. The results showed that the contamination probability by cadmium is much greater (> 95%), while this probability is small (> 5%) for lead [17].
- In research in Zanjan, Atashnama *et al.* (2006) regarding the accumulation of some heavy metals in three fodder plants, Alfalfa and Flare Spurs, have concluded that the pollution presence has caused the accumulation of larger amounts of Pb and Cd in the aerial parts of plants which have grown in these soils. Therefore, the animals that feed on the mentioned plants will ingest metals such as Pb and Cd more than the amounts measured in this research [18].
- Abaspour *et al.* (2005) in research entitled: *"The Investigation of Cadmium and Lead Contamination of Some Agricultural Soils of Iran"*, concluded that in heavily contaminated soils, the mobility index of lead has increased significantly compared with cadmium. Increasing the mobility and accessibility of elements in the soil facilitates the possibility of leaching and transferring them to the surface and underground water [19].

- Dayani *et al.* (2009) in a study entitled: "*Geo-Statistical Analysis of Lead, Zinc, and Cadmium Concentration in the Soils of Sepahan Shahr Suburb" Located in the South of Isfahan*", concluded that the high concentration of heavy metals, especially zinc and lead, indicates an increase in this element in the surrounding lands are Sepahan City [20].
- Hodji *et al.* (2004) in research entitled: "*Distribution of Nickel, Manganese, and Cadmium in Soil and Agricultural Products in the Area of Mobarakeh Steel Complex*", concluded that the maximum concentration of nickel and manganese is in the northeast of the region and in the 0-5 cm layer of the soil [21].

Today, the issue of maintaining the environmental health and eliminating its polluting factors is one of the most important social issues. There is no doubt that everyone wants to live in a healthy environment and away from pollution. Human environment generally includes soil, water, and air. Regarding the environmental limitations, in the United Nations conference that was held in Stockholm, the capital of Sweden in 1972, the representatives of all the member countries commented on the issues of the human environment that "human environment includes issues related to environmental pollution, the issue of population settlement and the proper management of natural resources and in entire protection of nature" in a more accurate and comprehensive definition of the environment is the collection of air, soil, water, plants, etc.

Therefore, the urban environment should be prominently concerned, because the city dwellers are at the center of the most important environmental issues [22]. The environmental destruction affects directly on the economic process of the world [23].

Soil pollution

The meaning of pollution is due to the presence of one or more harmful inorganic or organic chemical substances or elements with specific accumulation and concentration in a soil environment. Very high amounts of soil pollution may be the result of the presence of large amounts of pollutants such as heavy metals or hazardous waste materials [24].

Any change in the characteristics of soil constituents so that its use becomes impossible is called soil pollution. Recently, the removal of waste from the human environment has been recognized as a necessity for the continuation of civilization. To minimize contamination, waste should be returned to its natural cycle as soon as possible. Soil is considered as a medium for the return of these wastes [25]. Contamination of water and soil resources is very important due to the close relationship between both of them with the nutrition of living organisms and their direct involvement in the production of agricultural products, even though the growth of plants and other organisms as well as waste transformation into the best nature's functions are one of the main functions of soil, but when this material is polluted for any reason, it will no longer be able to fulfill its role. The accumulation of heavy elements in the soil, especially in agricultural lands, is a gradual thing and the concentration of elements can reach levels that threaten human food security. Sewage and industrial waste materials that come out of factories and somehow enter the ground are also effective in soil pollution.

The entry of heavy metals through human activity has caused the pollution of many soils, so that the intensity of pollution in these soils is either more than normal or will soon reach it [26]. Huge chemical industries have caused environmental pollution through sewage, industrial wastes, and smelting industries by injecting toxic elements into the atmosphere and have faced many industrial cities with serious

risks. It is noteworthy that environmental pollution in every aspect (water, soil, air, and plants) is a problem whose harmful effects will be evident in the long run. Therefore, it is necessary for experts in different sciences to do comprehensive and extensive planning to control it.

Sources of pollution caused by human activities

The entry of metals into the environment through human activities is the main source of water and

soil pollution. From water and soil pollution viewpoint, these activities can be divided into two parts: Direct and indirect sources of pollution.

Indirect sources

These sources can often be considered the result of agricultural and horticultural activities, during which humans add polluting amounts to the soil under different headings with the aim of producing more crops (Figure 1).

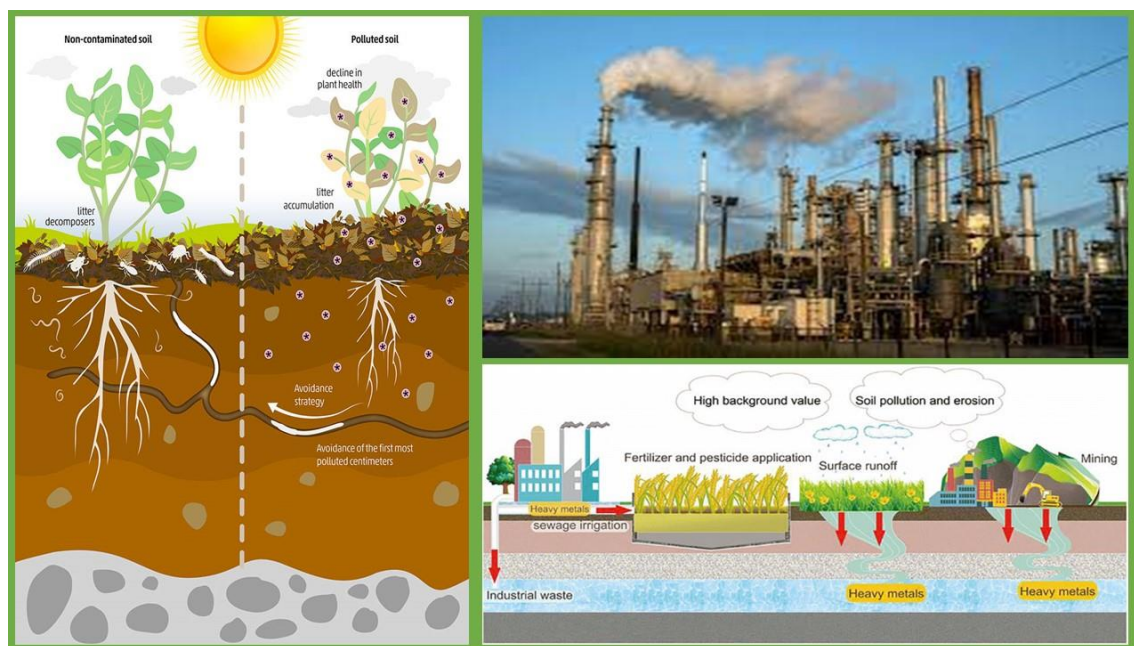


Figure 1. Plastic industry pollution to overtake coal in the US by 2030, report says | Ars Technica.

A. Fertilizers and soil amendments

Swain and Singh measured significant concentrations of heavy metals in fertilizers and amendments so that the amount of nickel and cadmium in phosphate rock was very high. In addition, Williams and David both reported that some fertilizers and limes contain more metals than are naturally present in the soil. For instance, the use of phosphate fertilizer contaminated with cadmium has increased the concentration of this element in the soil by 5 to 12 times.

B. Sewage sludge

Adding sewage sludge containing metals to agricultural lands can pollute soils, agricultural products, and water sources. Unfortunately, sewage sludge may contain significant amounts of heavy metals such as cadmium, copper, nickel, and mercury. The resulting soil pollution depends on the amount of sludge used, topography, climate, vegetation, and soil reaction.

C. Pesticides

Mineral pesticides used to control pests of agricultural plants, fruit, and vegetable gardens contain large amounts of lead, arsenic, mercury, or copper. Today, organic pesticides are used in developed countries.

Direct sources

This part of the resources is actually the wastes and effluents that are the result of human productions and activities, and humans are forced to discharge them into water and soil sources. These sources can be classified as follows.

Industrial resources

The transfer of metals to the environment from industrial sources is at least ten times more than the natural sources of these pollutants. Industrial and urban wastes are the most important sources of pollution by humans, which vary in volume and amount. In these effluents, there are usually toxic amounts of cadmium, zinc, copper, nickel, arsenic, mercury, lead, chromium, etc. as well as acids, insecticides, detergents, dissolved salts, harmful bacteria for plants, animals, and humans. Industries of all kinds cause at least one type of pollution. The major polluting industries can be listed as follows:

- **Metal industries:** Including aluminum and steel rolling, metalworking, iron smelting, and metal plating, which cause almost all types of physical, chemical, biological, and heavy metal pollution.
- **Oil and petrochemical industries:** Including petrochemical factories, refineries, rubber, and plastic industries that cause physical and chemical pollution.
- **Food industry:** Sugar and sugar factories, animal products, meat, and sausage production, which cause physical, chemical, and biological pollution.

- **Chemical industries:** Chemical and leather manufacturing factories that produce all kinds of pollution [27].
- **Cellulosic industries:** Chipboard, wood, paper, and cardboard, which cause physical and chemical pollution.
- **Production industries:** Construction materials that cause the most physical pollution.

Atmospheric precipitation

Some metals and pollutants along with dust and exhaust smoke from cars and factories pollute the air in the region and spread this pollution in a wide area depending on the direction and speed of the wind. Pollutants are finally added to water and soil sources in the form of dry particles or with rain. Examples of this type of pollution include lead from the combustion of leaded fuel in vehicles, zinc, and copper from the melting of non-ferrous metals, or cadmium in two phosphorus and cigarette smoke factories [28].

Urban and domestic sources

The volume of urban and industrial wastewater is a function of the urban and industrial population and the economic status of each region. Due to the presence of metalworking, battery making, and photography workshops in the city, urban sewage contains rare elements, detergents, soluble salts, and pathogenic organisms. Detergents are one of the pollutants in domestic sewage and water flowing from the road surface. Despite the efforts of researchers to replace mineral or non-mineral substances instead of phosphorus in detergents, phosphorus is still the most important part of the composition of detergents.

Drilling activities, metal extraction, and concentration

Such activities and their effluents cause severe pollution in the surrounding soil. Bokavar (1973) measured the values of zinc, 50000-80000 mg/kg, cadmium, 900-1500 mg/kg, 600-1200

mg/kg of copper, 200-1100 mg/kg of lead in the surface soil near the zinc concentration factory.

Heavy metals

Heavy metals are metal elements with a specific gravity higher than 5 grams per cubic centimeter. These metals exist in nature as cations and oxidized anions. Elements such as nickel, chromium, cobalt, mercury, zinc, cadmium, copper, and manganese are in the form of cations in the soil, while elements such as molybdenum, selenium, arsenic, and boron are combined with oxygen in the soil and have a negative charge. Gadd (1993) and Shaw (1989) also define heavy metals as elements with metallic properties (flexibility, conductivity, stability such as cations, specific ligands, etc.) and a large atomic number equal to 20 [28].

The role of toxic metals in human vulnerability

Toxic metals refer to heavy metals and those metal compounds that have very negative effects on human health. The heavy metals that are most associated with human poisoning are lead, mercury, arsenic, and cadmium. Some metals copper, zinc, and chromium are necessary for the human body in small amounts, but in large amounts they are also dangerous poisons. Humans are exposed to metals through inhalation of polluted air, consumption of contaminated food and water, proximity, and contact with soil and industrial wastewater. Some of these metals cause cancer, development of autoimmune diseases such as rheumatoid arthritis, destruction of nervous systems, and sometimes lead to death.

The use of heavy metals in industry and the need for some of them in the physiological activities of plants and animals, as well as having a direct impact on human health, agricultural production and environmental pollution are various aspects

that have given these elements special attention. Plants are able to absorb and store heavy metals in their organs without needing them, which will be detrimental to health. In this regard, several studies have been conducted on edible plants, especially vegetables, which all show that if these plants grow in contaminated soils, justified amounts of heavy metals are absorbed by these plants.

Soil pollution with heavy metals

During the last five decades, the discharge of heavy metals into the environment has reached 22,000 tons of cadmium, 939,000 tons of copper, 7,863,000 tons of lead, and 1,350,000 tons of zinc. The loss of soil fertility, which causes widespread land abandonment, is one of the side effects of the current methods used in agriculture and animal husbandry. Since 1945, 11% of the arable surface of the earth, an area larger than the lands of India and China, has been lost, and in many parts of the world, the per capita production of food is declining. Recently, toxic metals have been recognized as a new and perhaps more dangerous pollutant than other environmental pollutants.

Mineral compounds such as mercury, cadmium, lead, arsenic, nickel, copper, zinc, manganese, boron, fluorine, etc. can have polluting effects on the environment. Cadmium and arsenic are highly toxic, mercury, lead, nickel, and fluorine are moderately toxic, boron, copper, manganese, and zinc are relatively less toxic. Although these metals are not all heavy metals, they are called "Heavy metals" for convenience [3].

Chemical properties and general characteristics of cadmium

Cadmium has an atomic number and a mass number of 112.4 and is part of intermediate elements. In terms of abundance in the earth's crust, cadmium is in the 64th place (Table 1).

Table 1. Limit of concentration of heavy elements in soils [12]

Milligrams per kilogram of soil		Name of metal	
High	Low		
5.4	5.2	Usable iron	1
2	1	Manganese	2
1	5.0	Roy	3
8.0	2.0	Copper	4
3	1	On	5
15	1	Lead	6
3	1.0	Cadmium	7
5	1.0	Mercury	8
50	0.5	Nickel	9
100	5	Chrome	10

Soil contamination with cadmium

Cadmium has attracted a lot of attention in recent years because of its potential to cause toxicity in plants, animals, and humans. Making and photography are also used and found in chemical fertilizers. The cadmium concentration in phosphate fertilizers varies from zero to 170 mg/kg. Since this element is easily absorbed by the plant in acidic soils. Therefore, its unauthorized concentrations cause adverse effects. The cadmium concentration in normal agricultural soils is close to 1, and around metal smelting factories and consumers of this element up to 1700 mg/kg of soil. Chenj *et al.* (1984) noticed an increase in cadmium in the organic part of soils treated with sewage [3].

The origin of cadmium is mostly in soils, municipal sewage, and phosphate fertilizers and zinc sulfate. In European agricultural lands, 5% of cadmium comes from sewage and 10% from the use of phosphate fertilizers. Cadmium is non-dynamic in calcareous soils. Hence, it accumulates in the surface soil. Since cadmium is not toxic to plants, it can accumulate in the plant without showing signs of poisoning, but the presence of this element in the human food chain is very dangerous and causes kidney complications and other discomforts in the human body. For this reason, the world health authorities have determined its permissible limit

in the human diet to be very low, i.e. only one microgram per gram of dry matter. Cadmium easily moves from the soil to the plant roots and is easily absorbed by the plants. Therefore, plants grown in places contaminated with cadmium are dangerous sources of contamination for consumers.

Effects of cadmium

Cadmium is a carcinogen that acts in the following two ways:

- It directly damages DNA.
- It destroys DNA repair systems that play a role in cancer prevention.

Cadmium can enter soil particles or dissolve in water. Plants and animals receive cadmium from the environment and collect it in their bodies. Humans are exposed to cadmium by eating food, drinking contaminated water, and breathing contaminated air. Low concentrations of cadmium over a long period of time cause osteoporosis and damage the kidneys and lungs. Heavy metals play a role in causing many chronic diseases, and very small amounts of lead, cadmium, mercury, and arsenic cause a wide range of diseases.

Chemical properties and general characteristics of lead

This element has an atomic number of 92 and a mass number of 2.207 which is located in the sixth group of the periodic table. Lead is a gray and soft element, and in spite of its relative rarity in the earth's crust, it is one of the most well-known elements due to the wide variety of uses and applications for lead metal. The properties of lead that make it useful include its low melting point that allows simple handling, and the use of inexpensive methods when used as a liquid. It is a soft and malleable metal which can be easily transformed into various shapes. Its chemical activity causes a protective coating to form on it when exposed to moist air. It forms alloys with many other metals. The resulting alloys have different properties than pure lead. The density of lead is higher than the other metals except gold and mercury.

Soil contamination with lead

Lead is naturally one of the minor components of soil and plants. This amount can be increased by exposing the plant to soil or atmosphere with a higher level of lead. The largest amount of lead taken from the soil is concentrated in the roots. The fodder consumed by animals, because they are not washed, lead enters their bodies in this way. Lead pollution in soils is a widespread phenomenon that originates from the smoke of cars, mines, industrial waste, etc. Although lead is toxic to animals and humans, lead poisoning in plants and in field conditions is less reported, which is probably due to this. The reason is that lead is strongly stored in the soil and does not

dissolve. The risk of lead is mostly due to its low mobility in the environment and its high sedimentation.

Effects of lead

After being absorbed for a long time, lead can reach other parts of the body and cause consequences such as fever and anemia. Anemia is the first symptom of lead contamination. Because lead interferes with the production of heme, as the main component of hemoglobin, the average amount of red blood cells decreases. Another problem related to the toxic property of lead is the interference with the work of kidney enzymes, because it is difficult to measure lead in bones. Lead concentration in blood or urine is commonly used as an indication of the total amount of lead in the body. Its level in blood causes the clinical symptoms of lead poisoning "Plumbism". The concentration of lead in the body is divided into four categories: Normal, acceptable, high, and dangerous. Blood levels in healthy people are from 15 to 40 micrograms per 100 ml of blood. An average blood level of 20 micrograms per 100 ml of blood is acceptable. Several scientists have considered lead pollution as the most serious problem of metal pollution. Small amounts of lead in adults cause the occurrence of chronic kidney diseases, and in children it causes defects in brain function, decrease in intelligence and memory, and occurrence of nervous behaviors such as aggression and hyperactivity. High amounts of lead will cause irreparable brain damage and lead to death if not diagnosed on time (Table 2 and 3).

Table 2. Standards of different countries regarding the maximum acceptable concentration (MAC)

Germany	England	Japan	Poland	Canada	Australia	Metal
500	100	400	100	200	100	Pb
2	1	-	3	8	5	Cd

Table 3. Annual limit of heavy metals entering agricultural soils

England	Europe	Poland	
15	15	10	Pb
15%	15%	20%	Cd

Environmental problems

Most large and small industries without proper pollution control equipment such as filters and different gas purification systems are harmful and when the number of gases released is more than the standard, it has harmful effects on physical and mental health of the residents, which include headaches, fatigue, breathing difference, unconsciousness, convulsions, inflammation of the lungs, chronic bronchitis, anemia, eye irritations, reduced vision, and behavioral and speech problems. Likewise, pollutants have had harmful effects on the plants of the city, causing discoloration, reduction of greenness, rotting of leaves, creation of white, black, and brown spots and finally causing wilting and drying of plants in this area [12]. Air pollution threatens the plains and fields, and in addition to the destruction of the earth's atmosphere, through the fall of acid rain and infiltration into the soil, it leads to its pollution and destruction, and with the increase of heavy metals, lead, wormwood, and cadmium, it causes a decrease in the fertility of the soils of the region and environmental problems. Furthermore, polluting materials have caused damage to animal life and caused corrosion in metals and deterioration of buildings and works of art. Effluents and sewage from industrial factories in the region have caused surface and underground water pollution in the region [14].

The waste materials of the factories include chemicals such as iron salts, zinc, cream, sulfur, ammoniated salt, bitumen, hydrocarbon, dyes, fats, glazing materials, and waste materials that are removed from the factories around the region, a suitable environment for the growth of various microbes, and ultimately soil pollution.

Conclusion

In life based on soil, it is impossible to think of a world without soil. Because soil pollution destroys plants, animals and finally humans. As an efficient physical, chemical, and biological filter, soil can decompose some pollutants using biological processes. Of course, this capacity of self-purification is not unlimited, and the accumulation of polluting substances beyond the permissible limit causes its pollution, which can be transferred to water, air, plants, animals, and humans. Improving the level of living standards in the society should not be accompanied by the indiscriminate exploitation of primary resources. This principle has been accepted that all plans which lead to the destruction of natural resources. In the end, it will be doomed to failure and will lead to a disaster whose damage may be irreparable.

The first hypothesis: By analyzing the data, the soils of this area are contaminated with cadmium and lead.

The second hypothesis: Climatic conditions (wind) are one of the important factors in the stability or distribution of polluted air. The load is also able to transport polluted air on its way from above the polluted areas to the sky of residential and other centers. In such a case, the wind is considered a positive factor for the location, or source of pollution, and a negative factor for the residential center or centers affected by it. Every year, thousands of tons of elements that result from urban, industrial, and agricultural activities enter the soil. The study of different researchers inside the country shows that the intensification of industrial activities in the country, on the one hand, and the non-compliance of environmental issues and standards by some of the industrial owners, on

the other hand, have caused environmental pollution in some areas of the country. In pollution phenomena, it is expected that the pollutant concentration will decrease with increasing distance from the source of pollution.

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