Change Patterns of Agronomy and Agricultural Lands by War

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Abstract: Environmental pollution is created due to entering contaminants with high concentration in large amount in the environment. War is one of the intense pollution resources of water and soil environment. Widespread use of weapons such as lead particles, explosives, pneumatic bombardment, cannon balls, chemical weapons and chemical, microbial bombs, etc will definitely be followed by environmental destructive effects. Nowadays, damage to the environment is used by the parties involved as a military strategy. Pollution problems created by military activities have plagued a lot of nations. Have been indications of great destructions in relation to the environment. It is a long time that war and its due environmental damages have attracted a lot of attentions. Soil pollution also is one of the most important war environmental effects. Cultivation of crops in a land intensely polluted chemically and the use of waters contaminated with lethal compounds in agricultural farms will cause irrecoverable effects. In most cases, war bombardment and various bullets used during wars contaminate soils in terms of heavy metals. The study done by environmental Organization, Forest Organization and Switzerland National Development Plan (SAEFA) show that the contacts of bombs and bullets widely pollute heavy metals. Lead and copper are the main polluting metals. Due to the movement of most aquatic species and the close relationship between contaminated sediments and waters on the other hand and the lack of distinction between these two, investigation of the effects of trace elements in aquatic ecosystems is very hard. Soil erosion also is the most important process that pollutes aquatic ecosystem by heavy metals. The issue of plants intoxication by trace elements also is emphasized for two reasons. Firstly, in case of outbreak of intoxication in agricultural plants, their function is significantly reduced per surface unit. Secondly, the onset of intoxication in plants of an area and loss of vegetation causes sharp increase in water and wind erosion in those areas. But one of the most important aspects of the issue is penetration of these metals into plants and subsequently the animals feeding on them.
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1. Introduction

Environmental pollution is created because contaminants enter into this area with high concentration and in great amounts. War is one of the intense pollution resources of water and soil environment. Widespread use of weapons such as lead particles, explosives, pneumatic bombardment, cannon balls, chemical weapons and chemical, microbial bombs, etc will definitely be followed by environmental destructive effects.

War is a phenomenon resulting from passage of time and man's progress. There are various motivations in relation to war. But the more objectives are, the greater environmental damages will be. Specially, with science development and production of weapons with high power of destruction, combats have taken a new form.

Nowadays, damage to the environment is used by the parties involved as a military strategy. Pollution problems created by military activities have plagued a lot of nations.

In 1980, United Nations Organization declared its anxiety in relation to war effects on the environment and paid great attention to environmental effects of nuclear war. In 1995, in Persian Gulf War and Kosovo war also, tests have been indications of great destructions in relation to the environment.

It is a long time that war and its due environmental damages have attracted a lot of attentions. Soil pollution also is one of the most important war environmental effects. Cultivation of crops in a land intensely polluted chemically and the use of waters contaminated with lethal compounds in agricultural farms will cause irrecoverable effects. In most cases, war bombardment and various bullets used during wars contaminate soils in terms of heavy metals. The study done by environmental Organization, Forest Organization and Switzerland National Development Plan (SAEFA) show that the contacts of bombs and bullets widely pollute heavy metals. Lead and copper are the main polluting metals.

Due to the movement of most aquatic species and the close relationship between contaminated sediments and waters on the other hand and the lack of distinction between these two, investigation of the effects of trace elements in aquatic ecosystems is very hard. Soil erosion also is the most important process that pollutes aquatic ecosystem by heavy metals.

The issue of plants intoxication by trace elements also is emphasized for two reasons. Firstly, in case of outbreak of intoxication in agricultural plants, their function is significantly reduced per surface unit. Secondly, the onset of intoxication in plants of an area and loss of vegetation causes sharp increase in water and wind erosion in those areas.

But one of the most important aspects of the issue is penetration of these metals into plants and subsequently the animals feeding on them.

The onset of gastrointestinal complications and numerous cancers in relation to these metals are attributed to foodstuffs. For example, in the case of lead, it is more emphasized on its toxicity effect in men, animals, aquatic organisms and birds; however, this metal rarely causes intoxication in plants. Therefore, it can penetrate into a plant with high concentration without having any dangers to it; but after entering other creatures' bodies, it can be dangerous. Of course currently, there are lots of blind spots in relation to man's knowledge about war. Discontinuation of studying systems, lack of registered information and the existing problems related to sampling have limited studying in this field.

Bombardments, destruction of houses and cities and villages and homelessness of many individuals, have constantly placed people under pressure; but the discomforts and diseases after the war should not be disregarded. Iran and Iraq war is not an exception and has caused a lot of damages to the environment. Unfortunately, after the war and clearing the occupied territories, the lands are used for agriculture, aquaculture and other cases without investigation in terms of soil and water pollution state and the products enter the market and this can result in serious problems.

Review of the Resources

1-1 War impacts

In general, the effects caused by war can be divided into two following groups:

1-1-1Short-term effects

The issue can be investigated from different aspects. Among the indirect effects on the environment, it can be referred to military activities such as construction of airports, digging canals and trenches, tanks nests, means of transportation and … which require broad lands that cause destruction of lots of plant and animal species. In addition, a lot of countries allocate wide lands for testing their different weapons and all of these greatly damage the ecosystem.

When a heavy bomb is thrown, it produces the temperature of about 300 degrees centigrade which is sufficient alone for destruction of plant and animal community and also for degradation of soil surface levels which require a time period of about thousands of years for their reproduction.

Of course, human aspect of the disaster should not be neglected, that killing defenseless individuals can be identified as the worst effect of bombardments and war.

Over Iran and Iraq war, more than 3 million palm trees were burned and 5000 hectares of fruit gardens were destroyed. A hundred and thirty thousand hectares of natural forests and 73500 hectares of pastures were burnt and became unusable. War has also damaged arable lands. In Khuzestan, Ilam and Kermanshah, about 251000 hectares of lands under irrigated cultivation and 53700 hectares of lands under dry farming were destroyed.

1-1-2 Long-term effects

Most weapons have chemical complex compounds which can have long-term and highly great effects. Some of these metals have high permeability and some of them even can penetrate hard armors and leave their effects, the most important of which affects the environment. During Iran and Iraq war, Iraqi army widely used chemical weapons which have included 20 long-range rockets carrying chemicals, 284 chemical attacks and 74 chemical artillery attacks which can have great long-term effects. Wars can have lots of dangers, the most important of which affect the environment and which we investigate.

1-1-2-1 Flora and fauna

In most cases, burning of trees and farms not only disperses different particles in the environment but also destroys plant and animal communities and makes resistant species dominate and this can sometimes cause the change of ecosystem in the region.

Destruction of different plant species by fire in Serbestan war has been broadly reported. As examples, it can be referred to degradation and loss of different plant species in Scadera Lake International Park and also three other international parks.

Ground and aerial bombardments cause destruction of forests and subsequently, we see water flow and erosion.

Meanwhile, animal community also tolerates a lot of damages. Reports emphasize that in Persian Gulf war, 3000 seagulls were lost because of

war, %50 of coral pulses were damaged and hundreds of square fluids of sea grass were influenced.

1-1-2-2 Air pollution

Fires caused by bombing can enter lots of ash into the environment. Due to breathing, these metals can cause lung diseases and endanger man's health. Of course, this pollution can also affect the areas which are far from war zones. Wind often disperses these particles.

During Persian Gulf War, with targeting oil installation in Kuwait by Iraq, 5-6 oil barrels were burnt in fire every day and this resulted in evaporation of a large amounts of gas pollutions such as carbon dioxide and sulfur dioxide (constructive substances of acid rain) of whose important effects, acid and greasy rainfalls in Iraq and Arabia can be named. Moreover, black snowfall was reported in Kashmir which is 1500 miles away from these regions.

1-1-2-3 war diseases

War often causes diseases and a variety of disasters which have taken new aspects nowadays with production of chemical and biological weapons. During Serbestan war, women were forbidden from having children because the children might have been incomplete. Those who used fishes and vegetables cultivated in the lands of those regions or had water, experienced discomfort in the abdomen area, nausea and …….

Over Iran and Iraq war also, prevalence of a lot of diseases has been reported. Penetration of the existing metals in weapons into soil, environment and water can have great harmful effects. The onset of ocular infections, digestion system diseases and coetaneous complications caused by war in Khuzestan has been reported. Due to the outbreak of ecological imbalance, the increase of insects carrying diseases and pests has been reported. In addition, respiratory diseases and increase in the number of those suffering from diarrhea and vomiting that can be related to drinking water have been reported in many cases after the war.

1-1-2-4 Water contamination

As the resource of underground water in many cases is atmospheric precipitation, therefore, it can be easily contaminated with by means of war. Acid and contaminated rains not only themselves can be the resource of underground water, but also through washing contaminated metals used in war ammunition which have been remained in soil have caused contamination of underground water.

As underground water is usually one of the main resources of drinking and irrigation water, the issue requires more studies.

In addition, the problem which was especially in Persian Gulf, Iran and Iraq war was contamination of Persian Gulf which was the result of oil precipitation caused by bombardment of oil platforms. In Iran and Iraq war, lots of load and oil shipping terminals have been attacked and the oil entering water affected ecosystem in Gulf. Sea herbs, which are the nourishment resource of aquatic organisms, were affected by poisonous and contaminated hydrocarbons resulting from sediments; therefore, animal community of the area was seriously damaged and a large number of fish and shrimps were lost due to this factor.

Of course, the issue becomes more important with passage of time, because the sea currents transport pollution out of Persian Gulf. Therefore, this contamination may enter oceans and be dangerous in long-term.

1-1-2-5 Damage to soil

As plants are permeable to heavy metals, therefore, considering soil contamination is one of the most important aspects of investigation of the damages caused by war.

By entering the food chain, these metals enter human bodies and other creatures feeding them and cause disturbances in their bodies. Therefore, it is very important to study about the presence of these metals in soil where they have mostly long life. These polluting metals can accumulate in man's body and when exceeding the permitted and standard limit of concentration, they cause a lot of side effects. Yet it requires more studies and researches because of the probability of their transformation into more poisonous materials due to chemical interactions, and carcinogen of some of these compounds.

However, because of the deep motion of these polluting metals in soil, pollution can also endanger underground water. For example, it can be referred to Vietnam War in which America polluted about 3460 square kilometers of lands by distribution of 55 million kilograms chemical and fatal materials in agricultural lands and this pollution entered underground water. This vast use of chemicals for destruction of agricultural fields, forests and water resources is unprecedented.

Currently also every year, a large deal of cultivated products in the regions which were exposed to bombardments in the past, enter the market. These products include summer vegetables, cereals and various green-stuffs.

1-2 Review of previous studies

As pollution caused by war is of great importance in today's world, lots of studies have been done in this relation.

During Iran and Iraq war, surface soil compaction caused flooding in farmlands and left great effects. On the other hand, change and

conversion of the flow of rivers, cutting off irrigation waters, saturation and becoming a salt marsh have been reported as lands turned into wetlands at the time of destruction of irrigation channels.

Karun River in Khuzestan province is one of the most important regions in terms of economic activities. Due to war, it was contaminated severely. Drowned ships and carcasses of the aircraft which are still seen along Arvand River threaten fishing industry and ecology of the region.

In Persian Gulf War also, 6-8 million barrels of crude oil were spilled in the sea. This oil was created due to sinking of oil tankers or bombardment of oil platforms. Smoke arising from burning of wells also has had great impacts.

Because of burning of these platforms, 40000 tons of sulfur dioxide, 3000 tons of hydrogen sulfide and 500000 tons of carbon monoxide in addition to 50000 tons of Greazy Soot particles were released. From its effects, it can be referred to black rainfall in Himalayas which is 2700 kilometers away, or acid rain in China and also reduction of temperature in Kuwait.

Based on the studies done by Zare-Maivan (1998), lots of people informed about the change of quality of drinking water and also irrigation water in Iran.

In an experiment done in Khuzestan, the lead levels of acid rain fallen in Dezful and Ahvaz were respectively reported 0/24ppm and 0/33ppm in comparison with 0/11ppm and 0/18ppm in Bandar Abbas and Shiraz. The amounts of chlorides, sulfides, iron, sodium and nitrate also have been very high and this issue can affect all aspects of human lives. For example, drinking, irrigation and underground waters are contaminated and it is very dangerous.

Over the studies done by Sedigh et al., regional dispersion of thousands of tons of heavy metals, caused by Persian Gulf War in Iran, has been reported.

The underground water discharged from Zagros is one of the most important drinking and irrigation water supply resources. High levels of acidity and contaminated sediments, which are considered as dangers for people in this area, have been reported in this mountain (including SO_4^{-2} and other contaminants).

Main polluting materials such as NO_x and SO_4^{-2}, smoke particles, organic materials and carbon resulting from burning of wells can be stopped by Zagros Mountain due to the height, but through washing by precipitation enter catchment and groundwater and finally can threaten underground and surface waters.

Throughout World War II also, contamination of the Pacific Ocean has been reported. Burning vessels and explosion of submarines all have helped the pollution of this area. A lot of islands local and migrant birds were annihilated in those areas. Their nests were burnt and their eggs were destroyed and there was extinction danger of many species. Many hunting animals (ferals) also were lost in the islands of this ocean.

In 1995, Al-Ajami reported that during Persian Gulf War, due to destruction and loss of protecting layers of soil, bulk motion of coastal sand in Kuwait was accelerated after the attack of Iraq. It was followed by blocking of irrigation canals, roads and products and fields entries, especially covering of %20 of farm lands.

Mine application, digging tunnels, fogging caused by oil, oil spilling, formation of oil lakes and movement of military vehicles all affect flora and fauna.

During the studies done by Zaman and Al-Sadir Avi, the critical effects of war on plant community in Kuwait became quite clear. A very high level of heavy metals was measured in vegetation. The existence of oil lakes severely threatened animals and birds. In discharging only one oil lake, lots of dead birds, which were trapped in this area, were found.

According to the studies done by Omar Aldosari on deserts in Kuwait, it became clear that these areas are the shelter of more than 374 plant species which made them appropriate places for bird and animal life. These places attract thousands of migratory birds. In these areas, there are more than 300 different bird species, %61 percent of which is native. Extensive movement of vehicles, digging tunnels and channels, explosions and other military activities have greatly damaged this community.

Due to precipitation of oil particles and aerosols on perennial plants, these plants include a high level of heavy metals. The plants should be prevented from grazing domestic and wild animals because they can intensely poison them.

Based on the studies done by Savari and Nabavi on Persian Gulf waters during Iran and Iraq war and also Persian Gulf War, the rate of heavy metals such as lead, cadmium, copper, zinc, nickel and cobalt was higher than standards in sediments in this area. During the war with Iraq, the rate of lead in waters of the northern Persian Gulf which were directly attacked was more than the time of Persian Gulf War. The rate of these metals in this area in comparison with oceans water that was studied by Menari Railey and Chaster is much higher and in some cases 1000 times or more.

On the base of these studies, it was specified that the rate of lead, in the sediments of Khuzestan region to Boushehr and the north of Kharg Island, is high. Other metals like copper and zinc show higher amount especially in Kharg and Bushehr regions. For nickel and cobalt also such a trend can be obviously seen especially in sediments of regions such as Bandar Rig and Kharg Island which are located near Norouz wells.

In addition, in a study done on the rate of heavy metals in Shayegan region, intense contamination of sediments and aquaculture in terms of heavy metals was reported. As the power supplies of Shadegan wetland are Jarrahi River, Karun flooding and also winter outbursts of Bahman Shir River through coastal estuaries; therefore, there is the danger of contamination of this wetland which is one of natural environments for lots of plant species and birds.

The studies by Farrokhian and Imandel confirm the existence of a large amount of metals such as lead, cadmium and zinc in the animal bodies and also water and soil environments. One of the reasons can be attributed to the sediments resulting from Bahman Shir River, and also carrying contaminated sediments from Abadan and Khorramshahr.

1-3 War instruments compounds

1-3-1 Heavy metals in military compounds

As it was referred to before, the most important components of ammunitions used in war are heavy metals. As a matter of principle, heavy metals or trace elements refers to metals whose density is more than 5 grams per cubic centimeter? These elements exist in soil in small amounts and include Cd, Ni, Cu, Cr, Co, Pb and …. Of course, given that manganese and iron are among the elements used in blacksmith industry, these elements were also investigated.

1-4 Heavy metals in soil

This title is often used for some metals (and their ions) with high-density which mainly belong to transition series of periodic table. Some of these are called trace elements or microelements in agriculture.

In many cases, contamination caused by heavy metals in soil is due to external factors such as industrial sources, urban activities or because of the use of sewage contaminated with heavy metals.

The issue under investigation in this research is different from the mentioned cases. In the recent century, contamination caused by wars between nations can be regarded as one of important factors in the increase of these metals in soil.

In terms of these elements, the soil initial content is related to mother stone nature. But factors such as fertilizing the soil, also lixiviation of dietary cycle inside a plant result in displacement of these elements and sometimes their accumulation in a specific horizon of soil or their disposal in drainage water.

The issue of soil and consequently plant contamination through heavy metals has been constantly considered by man. One of the most important chemical features of soils is their ability to retain and exchange ions on colloidal surfaces. This ability for cation exchange is one of the most important existing differences between soil and other environments of plant roots and it has made soil a suitable place for plants growth. In most cationic discussions, it has been assumed that a borderline exists between exchangeable cations and the product. However, neutrality of electric charge indicates the equality of total of cations and anions.

Distribution of different ions on colloidal surfaces is related to two factors of the minimum energy and the maximum disorder; however, this cation distribution around the soil particles is similar to distribution of gas molecules in the atmosphere. That is, ions are accumulated around colloidal particle which is negatively charged. But this cation arrangement around the particle is due to intense cation attraction by the particle (the minimum energy) and on the other hand, ions affinity to static distribution and scattering (the maximum disorder) and, it forms the ions arrangement around the colloidal particle.

In general, heavy metals in soil can have the following final forms:

- *Creation of mineral deposits such as carbonates and sulfides and also hydroxides*
- *Creation of complicated complexes with higher molecular mass with organic materials of soil*
- *Creation of strong bonds with clay minerals, manganese oxide and hydrated iron*

Overall, a limit has been considered for heavy metals; however, in spite of water and air pollution, which is easily measurable in terms of chemical compounds, given the soil complex system and dynamics, soil contamination cannot be easily measured and a definition for the soil without contamination is hard.

Along with other released elements, microelements also enter soil solution when silicate minerals are analyzed. The fate of these elements is controlled by different factors. These elements may be deposited or remain in soil.

Prediction of each of the above possible states is done through a factor called ionic potential (ion radius/charge (nm)). The elements having ionic potential values more than 95 make oxy-onions in solution including W, Si, Mo (VI) and Cr(VI). The

elements having ionic potential values less than 30 make cations in solution including Cd, Co, Cu, Fe(II), Pb, Ag, Mn(II), Ni and Zn. These elements may be held in compounds sediments of elements with ionic potential in the range of 30 to 95 (the third group). The third group which are the ionic potential between 30-95 include Cr(III), Fe(III), Mn(III), Mn(IV), V(III), Mo(IV) and V(v). As hydrated oxides in many soils, these elements are on soil aggregates in the form of a cover or enter inside soil capillary network. These compounds have a chemical control on other ions activities.

Oxy-hydroxides also serve as a template for other microelements in soil and when they are formed, other micro elements can remain invisible in sedimentary oxides.

Nickel and cobalt are among the elements which are in relation with manganese oxides. Copper and zinc also are in connection with iron oxide and manganese.

These oxides often have high affinity which is increased with the rise of Ph. Microelements are easily superficially absorbed in oxides; however, they may enter the crystal structural lattice. Hydrated oxides can be in the form of solution, but they deposit again in response to the change in reduction potential with soil Ph.

Microelements are often in the form of compounds and rarely are seen in released form. Table 1-1 shows the predicted affinity of elements for making complex with organic and mineral ligands in aerobic soils in acidulous and calcareous state. (Overall from left to right, reduction is reduced)

1-5 Factors affecting heavy metals absorption

Numerous factors affect absorbing heavy metals. From among them we can refer to these factors:

- *Oxidation and reduction potentials*
- *Complex formation (selective superficial absorption)*
- *PH*

1-5-1 Oxidation and reduction potentials

Saturation conditions and reduction of oxygen in soil make living organisms (such as anaerobic bacteria) use the second electron acceptor such as NO_3^-, Fe^{+3} and Mn^{+4} and regenerate them; and consequently, oxidation and reduction (Eh) potentials are reduced.

This factor is important because electrochemical and biochemical changes caused by flooding soil directly or indirectly affect solubility and accessibility of microelements in soil. Flooding results in increase in iron, manganese and molybdenum absorption and in many cases develops heavy metals toxicity.

Oxy-hydroxides and also organic oxides of heavy metals are usually accumulated in soils which have adequate ventilation and change into insoluble form. For example, the existence of Fe^{+3} and Mn^{+4} which is of low solubility in soil is due to oxide conditions. But reduction (anaerobic conditions) makes these elements change into Fe^{+2} and Mn^{+2} which have no longer sedimentary state and increase concentration of these elements in soil.

One of the observable changes created after reductive conditions is O_2 consumption and then the use of other electron acceptors which causes H^+ consumption, for example,

$$MnO_2 + 2e^- + 4H^+ \rightarrow Mn^{+2} + 2H_2O$$

$$FeOOH + e^- + 3H^+ \rightarrow Fe^{+2} + 2H_2O$$

So, this process will increase ph. But in fact, CO_2 acts as pH buffering agent in these soils and remains constant at about 6 or 7 and this operation is through HCO_3 and H_2CO_3 reactions.

In the absence of CO_2, soil Ph. should go higher than 7 and H^+ consumption continue. But because metal ions (including heavy metals) dissolved by reductive reactions can deposit on carbonates, hydroxides and sulfides and produce protons; therefore, a mechanism opposite proton production; that is, consumption occurs.

$$Mn^{+2} + H_2CO_3 \rightarrow MnCO_3 + 2H^+$$

$$Mn^{+2} + H_2CO_3 \rightarrow MnCO_3 + 2H^+$$

1-5-2 Complex formation

Generally, heavy metals absorption is controlled by a mechanism called selective superficial absorption which is in fact inter-spherical complex formation. This absorption is markedly different from other metals absorption and accordingly, chemical reactions, accessibility and their other activities in soil are different. In fact, complexes formation is done through claths which can form strong bonds with heavy metals. The existence of these claths is important due to their effects in increase of metal ion solubility in soil solution. For example, if we consider claths as a reactant with Ca ion, we will also have Mn and Fe cations as microelements:

$$LT = L\sum H_{nL} + \sum CaXL + \sum Fe(III)XL + \sum MnXl$$

The total concentration of clath has been shown by LT, L the amount of free clath, $\sum H_{nL}$ clathic protonic species, $\sum MnXL$, $\sum Fe(III)$ and

$\sum CaxL$ are clathic species including Ca^{+2}, Fe^{+3} and Mn^{+2}. In fact, X represents a specific clath which contains H^+ or OH^- and $\sum MXL$ refers to clath-metal species which can exist.

Based on source, claths are divided into 2 organic and nonorganic groups. Organic claths are produced from organic materials analysis. However, these organic materials may also artificially enter the environment (such as adding sewage to the soil).

Nonorganic claths include multivalent ions- Si(IV), C(IV), N(V), S(IV), P(V), B(III), Se(VI), Mo(VI) and As(V)- which are able to produce poorly oxygenated acids in soil. Anionic form of these weak acids in soil- SiO_4^{-4}, NO_3^-, SO_4^{-2}, PO_4^{-3}, BO_3^{-3}, SeO_3^{-2}, MoO_4^{-2}, AsO_4^{-3} and CO_3^{-2}- can act as clath and form a complex with heavy metals.

Pearson (1993) has divided metals into 3 general groups. On the base of the difference of the type of complex which is produced by microelements in comparison with complexes of other metals, he used the term HSAB (soft and hard acid and base). This principle, which classified metal ions to classes A, B and transitional metals, is based on hard and soft acid and bases theory that was offered by A.Herlands in 1985.

The base of this classification is the affinity of these elements for formation of stable complexes with ligand atoms in periodic table or compound compositions obtained from this table.

Class A ions are called hard acids which have electronic shield with spherical symmetry and are not easily affected by electric field.

Class B is called soft acid. They have electronic shield and are not symmetrical and can be affected by electric fields. Other metals also are placed intermediate between them.

In contrast, ligands also are divided into A and B groups. A ligands have high electro negativity and are oxidized hard. B group ligands have low electro negativity and are easily oxidized. The most stable complexes between metal and ligand A-A and B-B are formed. But other compositions are not so stable.

The term HSAB is experimental but it can give us useful information in the field of reactions of complex formation in soil solution.

Unlike conventional cations, in soil, which are hard acids (Mg^{+2}, K^+ and Na^+), lots of heavy metals are soft. Therefore, they make a link with ligands more easily. However, the increase in concentration of Cl^- (a transitional ligand inclined to soft base) can affect different species of heavy metals. Classification of elements to A and B groups and also their ligands are in table 1-2. Soft metal cations have higher toxicity in relation to transitional cations which themselves have higher toxicity in relation to hard cationic metals. Therefore, considering these elements in soil can prevent the onset of lots of toxicities in plants and also human beings.

1-6 Absorption of heavy metals in plants

Absorption of these elements is often taken place through the root and transmitted to pneumatic organs. The action depends on different factors such as:

- *Total amount of these elements in soil*
- *Proportion of all the elements which have a form absorbable in a plant*
- *Plant ability for carrying metals along root-plant system*

Due to some surveys, Tiffen (1977) mentioned that plants are pseudo acceptors for trace elements or heavy metals; however, this statement was expressed based on apparent indications.

Absorbency of these elements by plant depends on the chemical form and the position of these elements in soil. That part of metals which have been located in solution phase can more easily be absorbed by root but on the contrary, absorption of the parts which form a bond with solid phase of soil (for example, inside crystal network of initial stone) is hard.

However, another effective factor is the charge of absorbing parts of the surface of minute particles such as clay and organic materials. The higher the charge is, the more rigidly it is absorbed.

Moreover, acidity, organic material and drain conditions are factors which affect metals chemical form and thus its absorption by plant.

Due to having cationic exchange ability, the root surface can absorb metals. When heavy metals in soil are more than the standard level, they damage roots or leaves and finally the product; and if used for animal's grazing or man's nourishment, they can be dangerous. For example, the intensity of cadmium and lead may not harm plant but it is very harmful for the feeding man.

However, the damages to microscopic creatures should not be neglected. Rath et al. (1987) reported that microbes are the first community damaged by the presence of heavy metals. Growth reduction and fixation of nitrogen by cyanobacteria can be seen as the result of adding heavy metals to soils.

In general, through entering the bodies of these microscopic organisms, these elements affect their metabolism; and in many cases, they produce toxic substances which lead to the loss of organisms.

In case of human and other creatures feeding on contaminated materials also, we see creatures' physiological, physical or psychological disruption; because, after entering a body, the materials cause illness. These elements often enter a body through skin, digestive system and inhalation.

1-6 Absorption of heavy metals in soil

The most important chemical feature of soils is their ability in absorbing and exchanging positively charged ions on colloids surface. Due to the type of research, heavy metals including zinc, cadmium, lead, chromium, nickel, and also manganese and copper have been studied in terms of quantity and their changes in soil.

There are different attitudes about cations absorption on colloids surface and probably the simplest attitude is the law of mass effect which is discussed under the title of The Law of Mass Action in chemistry. For instance, if we consider one of the elements under study, the following equation can be presented for it:

$$nA^{+m} + mB^{+n} \leftrightarrow mB^{+n} + nA^{+m}$$

As we see, the equation consists of 2 components. One component is related to a solution phase and the other is a solid phase. Given that the dominant cation in most Khuzestan soils is calcium, the issue of covalent elements exchange, which is easily justified, is raised:

$$Cax + Pb^{+2} \leftrightarrow Pbx + Ca^{+2}$$

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