International Journal of Environmental Trends (IJENT)
http://dergipark.gov.tr/ijent
International Journal of Environmental Trends (IJENT)
2021; 5 (2),48-59
ISSN: 2602-4160
Turkish JournalPark ACADEMIC

Review Article

Heavy Metals in Soils Pb (Lead), Hg (Mercury), Cd (Cadmium), As (Arsenic) Effects on Human Health

Nuray Dag[1], Omer Kagan Arici[2]

[1]Selçuk University Sarayönü Vocational High School Department of Environmental Protection and Control Konya, (ORCID Number: https://orcid.org/0000-0003-0273-4764)

[2]Konya Technical University, Geological Engineering Department, Selçuklu, Konya, Turkey (ORCID Number: https://orcid.org/0000-0003-2149-6829),

Abstract

Soils are formed by the fragmentation of rocks as a result of abrasion and/or erosion. An "ideal" soil suitable for growing plants consists of %45 minerals, %25 air, %25 water, and %5 organic substances. The deterioration of the physical, chemical, and biological balance of the soil with various pollutants is called soil pollution. Heavy metals are the main pollutants that cause soil pollution and are elements that can have toxic effects even at low concentrations. They are often referred to as metals or semi-metals associated with contamination and potential toxicity or ecotoxicity. Heavy metals are taken into the organism through the mouth, respiration, and skin contact, and most of them cannot be excreted through the body's excretory pathways without special support. Therefore, most of the heavy metals accumulate in biological organisms. High doses of these metals, which concentrate on living things as a result of accumulation, can cause various diseases, especially cancer and death, depending on factors such as genetics, immunity, age, nutrition, and general health status. In this article, the effects of Pb, Hg, Cd, and As heavy metals on human health are mentioned.

Received
03 June 2021

Accepted
22 October 2021

Keywords
Soil,
Heavy Metals
Heavy Metals in Soil
Effects of Heavy Metals in Soil on Human Health

Topraklarda Bulunan Pb (Kurşun), Hg (Cıva), Cd (Kadmiyum), As (Arsenik) Ağır Metallerin İnsan Sağlığı Üzerinde Etkisi

Özet

Topraklar, kayaçların aşınma ve/ veya erozyona uğraması sonucu parçalanması ile oluşmaktadır. Bitkilerin yetişmesine uygun ‘’ideal’’ bir toprağın %45’i mineral, %25’i hava, %25’i su ve %5’i organik maddelerden oluşur. Toprak kirliliği, fiziksel, kimyasal ve biyolojik dengesinin çeşitli kirletici unsurlarla bozulması olayına toprak kirliliği adı verilir. Toprak kirlenmesine sebep olan başlıca kirleticiler başında ağır metaller vardır. Ağır metaller düşük derişimlerde bile toksik etki gösterebilen elementlerdir. Genellikle kontaminasyon ve potansiyel toksite ya da eko- toksite ile ilişkilendirilen metaller ya da yarı metaller olarak adlandırılırlar. Ağır metaller organizmaya ağız, solunum ve deri yolu ile alınır ve çoğu özel bir destek olmadan vücudun boşaltım yolları ile atılamazlar. Bu nedenle ağır metallerin büyük bir bölümü, biyolojik organizmalarda birikirler. Birikim sonucu, canlıların bünyesinde yoğunlaşan bu metallerin yüksek dozları insanın genetik, bağışıklık, yaş, beslenme ve genel sağlık durumu gibi faktörlere bağlı olarak değişik hastalıklara ve özellikle de kansere ve ölüme neden olabilmektedir. Bu makalede topraklarda bulunan Pb, Hg, Cd ve As ağır metallerinin insan sağlığı üzerindeki etkisinden bahsedilmiştir.

Anahtar Kelimeler
Toprak
Ağır Metal
Topraktaki Ağır Metal
Topraklardaki Ağır Metallerin İnsan Sağlığına Etkileri

[2] Corresponding Author Email: Omer Kagan Arici omerkagan@gmail.com

INTRODUCTION

Soils are formed by the fragmentation of rocks as a result of corrosion and/or erosion. It is the process of eroding rocks by physical or chemical events in place or where they are transported to some storage basin, that is, the activation process of rocks. For this reason, it is thought that there is a geochemical relationship between the soil and the source rock. The type of disintegration process that sediments undergo and the amount of transport affect the nature of the micro and macrostructure of the soil [1].

The deterioration of the physical, chemical, and biological balance of the soil with various pollutants is called soil pollution. Discharge and mixing of solid and liquid wastes into soils causes physical, chemical, and biological contamination of these soils. Major soil pollutants are heavy metals, artificial fertilizers, pesticides, wastewater, atmospheric emissions. The factors that anthropologically control heavy metal accumulation in the soil, fertilizers, pesticides, sewage water discharged to the soil, treatment liquid and solid wastes [2,3,4], road transport, and abandoned mines are sources of heavy metal [5, 6]. Apart from this, there may be heavy metal contamination in the soils formed on the primary material of rocks containing minerals with high heavy metal content [2,7,8,9]. Heavy metals in the soil can enter the body through herbal food. Some of these elements are called necessary elements for the body, and some are toxic and harmful elements [10,11]. While some of these substances can have toxic effects on the body at high doses, some of them may cause harmful effects due to biological accumulation, even if they are taken in low doses. [2].

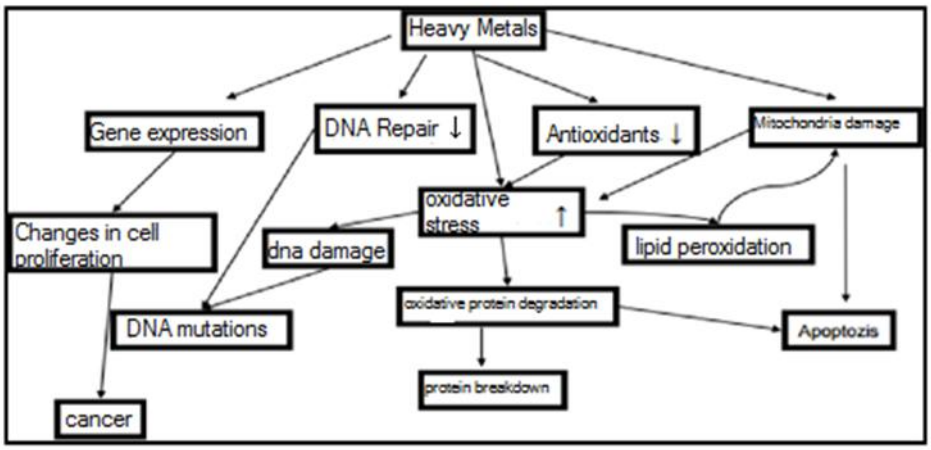
RESULT AND DISCUSSION

Heavy metal is a term used for metals that are in the third or higher period of the periodic table and whose density is higher than 5 g / cm^3 in terms of physical properties. More than 60 metals including lead, cadmium, chromium, iron, cobalt, copper, nickel, mercury, and zinc are included in this group. These elements are inherently present in the earth depending on the stable compound or silicates in the form of carbonate, silicate, and sulfur [2]. The symptoms and effects of some heavy metals in humans are given in Table 1.

Table 1. Symptoms and Effects of Some Heavy Metals on Humans [2]

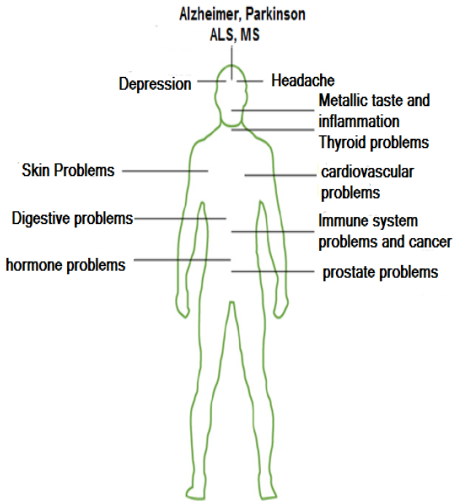
Element	Initial Symptoms	Advanced Symptoms	Effects
Nickel	Headache Fainting Weakness Vomiting	Shortness of breath Chest pain Difficulty in breathing	Tachycardia (interfering with calcium diffusion). Edema Laryngeal cancer, lung cancer, negative effects on the respiratory tract. Respiratory diseases (pneumonia), dermatitis.
Zinc	Vomiting Diarrhea	Chest pain Cough Cold Fever	Ulcer (skin). Irritation of mucous membranes. Pulmonary edema. Destruction of the respiratory tract.
Copper			It causes a high rate of miscarriage during pregnancy.
Cadmium	Vomiting Nausea Abdominal pain	Chemical pneumonia Pulmonary edema Teratogen Cancer	It blocks the calcium-binding protein in the small intestine. It can cause problems with the buildup in the digestive system. It prevents proteins passing between cells from passing through cell membranes. It can be transported to cells by an active transport mechanism. May cause kidney damage. Causes damage to the immune system (macrophage and antibody production is affected). It affects cardiac cells. It causes damage to blood cells. It affects protein synthesis.

Figure 1. Intracellular Effects of Heavy Metals [12].



Heavy metals are classified as vital and non-vital according to their degree of impact on biological processes. The components of vitamins and hormones that play a role as a co-factor in an enzymatic reaction and that must be present at a certain concentration in the organism are classified as vital. They also act toxic (Fe, Cu, Zn, Ni, and Se) after a certain concentration (1-10 ppm: part per million / one million). On the other hand, non-vital heavy metals (Hg, Cd, and Pb) show toxic effects from their initial concentrations and can cause health problems by affecting the psychological structure even at very low concentrations. Especially Hg and Cd can be toxic even at very low concentrations such as 0.001-0.1 ppm [12].

Fig. 2. Symptoms Due to Heavy Metals [12].



Heavy metals can be taken into the organism through mouth and skin contact. Even if they enter the organism in trace amounts, they may cause problems because they are excreted very slowly from the metabolism and they accumulate in the organism over time and reach the dangerous dose. The way they are ingested affects the type of tissue in which they accumulate but also directs the effects of their toxic effects [12].

The effects of heavy metals on the body depend not only on the concentration of the heavy metal but also on the structure of the metal ion, its solubility value, its chemical structure, its ability to form redox and complexes, the way it is taken into the body and the frequency of its presence in the environment. The main reason for the toxic effect they create in the body is the disturbances they cause in the metabolic processes they create in the intracellular metabolic processes. These disorders include DNA damage, oxidative protein degradation due to increased oxidative stress, mitochondria damage and induction of apoptosis (Fig. 1.), autoimmune diseases (ulcerative colitis, Crohn's disease, rheumatism, etc.), organic diseases (kidney disease, allergy, eczema, asthma, etc.) and neurological disorders (depression, migraine, Alzheimer's disease, Parkinson's disease) (Fig. 2). Most of these health problems caused by heavy metals are chronic diseases or cancers that require advanced diagnosis and treatment options. In many, treatment options are limited and death is frequently observed [12].

Due to the importance of the effects of heavy metals on human health, in this article information was given about the effects of Lead which has the highest publication, Cadmium which causes the greatest toxicological damage, Mercury which causes acute poisoning, Arsenic which shows different biological effects depending on the dose, exposure time and metabolism of the body tissue, and the effects of other heavy metals on human health.

Lead (Pb)

It is the primary metal that causes serious damage to the ecological system through human activities. It is a soft metal with a bluish or silver-gray color. Lead is the most important heavy metal that creates environmental pollution as it emits into the atmosphere as metal or compound and is toxic in all cases. According to the World Health Organization (WHO), the allowable limit in the working environment is 0,1 mg / m³ [13].

Most of the lead that causes environmental pollution is caused by tetraethyl lead, which is produced as a result of the burning of gasoline used in motor vehicles. As a result of the transportation of industrial wastes with water, lead contamination is encountered in marine creatures [13].

Sources of particulate lead compounds can be listed as burning of solid and liquid fuels, alkali lead synthesis plants, lead extraction furnaces, brass mills, lead oxide mills, etc [13].

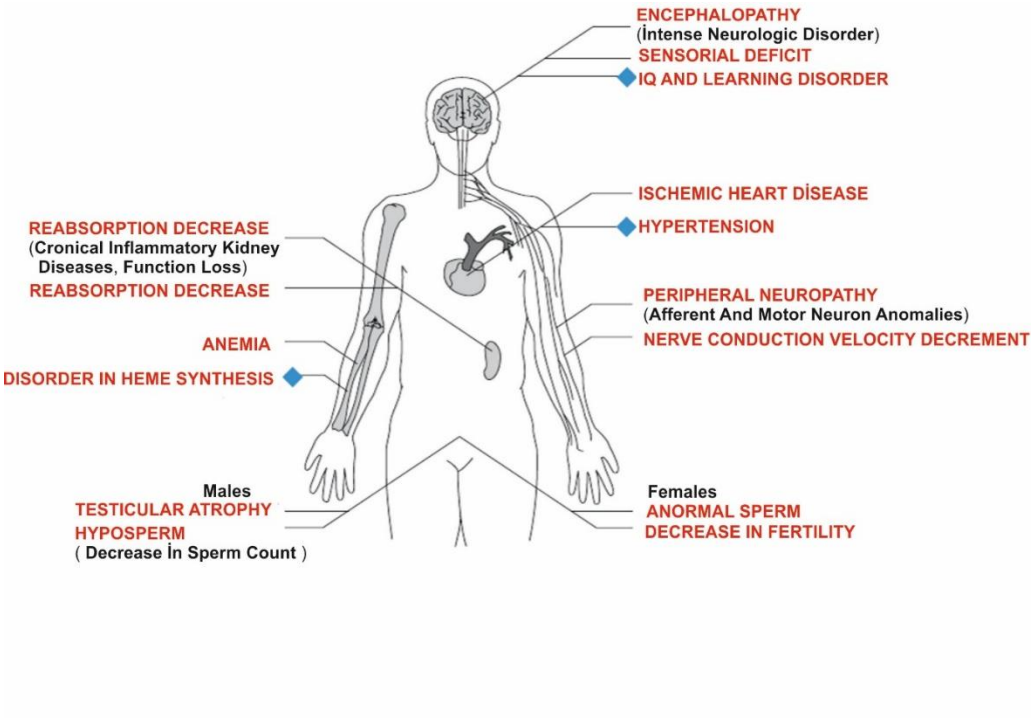
Lead is found in trace amounts in soil and plants. Generally, the lead concentration in the earth (upper layer) is higher than the lead concentration in the ground. Various plants also contain lead in different percentages. The natural lead level in plants is below 5ppm. The natural lead level may increase depending on the soil where the plant is grown and the atmosphere it is in. Most of the lead taken by the plant accumulates in the roots of the plant. Lead is rarely found in the above-ground parts of the plant. The plant's absorption or assimilation of lead is at the level of 0.05-5ppm soluble lead concentration in the soil rather than the total lead in the soil. Highly soluble lead compounds turn into insoluble lead compounds in soil [13].

The average amount of lead in the human body is around 125-200 mg, and under normal conditions, the human body can throw 1-2 mg of lead per day with normal functions. The daily amount that many people are exposed to does not exceed 300-400 mg. However, according to the bone analysis made on very ancient skeletons, it is seen that today's human bones contain 500-1000 times more lead than our ancestors. Lead mixed with blood circulates

to bones and other tissues or is excreted through feces and kidneys. Although most of the lead is stored in bones, it can also pass into the brain, fetus in the womb, and breast milk. The low rate of lead in infants and children increases with age and lead exposure. When the blood pressure level exceeds 40 mg / L, the blood pressure increasing effect occurs. According to the World Health Organization classification, lead is in the Class 2 carcinogen group [13].

The physiological systems and organs affected by lead in humans are as shown in Figure 3. The main target in lead toxicity is the nervous system in both adults and children. In addition, the sensitivity of the hematological system to the cardiovascular system and the kidneys to lead plays an important role in the evaluation of its toxicity [12].

Fig. 3. Systems and Organs Affected By Lead [12].



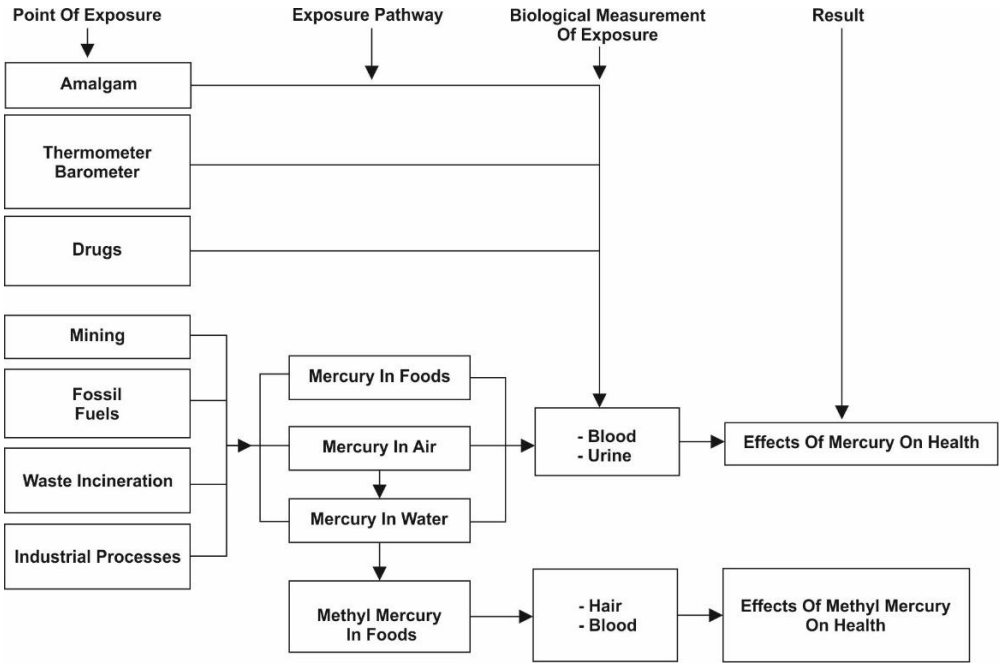
Mercury (Hg)

Since mercury is a volatile element, it is the only element that evaporates continuously at room temperature. It acts as a poison in the environment where it evaporates. Powder sulfur should be sprinkled on any surface when mercury is spilled. Mercury has several compounds in the form of Hg^{+1} and Hg^{+2}. It is available in metallic, inorganic, or organic form.

Although its thermal conductivity is poor, its electrical conductivity is quite good. Mercury easily interferes with other metals. These alloys are called "amalgams". Mercury can combine with electric current with noble gases such as neon, argon, krypton, and xenon. One of the important properties of mercury is that it can grow and accumulate within the food chain in living things. This feature is called "biological growth". Organic mercury compounds are more responsible for the effect of mercury through food [13].

The use of mercury in agriculture, electrical industry, in the production of paper and cellulose, in the chemical industry as a catalyst in paints, as a mercury transmitter in many electrical outlets, in the production of fluorescent lamps, thermometers, barometers, and manometers, as a filling material (in amalgams) in dentistry causes environmental pollution. It is used in the production of inorganic mercury compounds and pesticides. Organic mercury compounds are also used as antibacterial in the paper and cellulose industry.

Fig. 4. Chart of Mercury Exposure [12].



Foods, especially fish, fish products, and other seafood, are the most important organic mercury sources. Mercury can be detected in blood, urine, and hair in the body [13].

Mercury is immobilized in the soil to form low-soluble forms such as phosphate, carbonate, and sulfide. Mercury plants that become immobilized and do not dissolve in water are not absorbed by the compounds. However, these compounds can reduce metallic mercury again. Thus, the evaporation and environmental movement of mercury may be possible [13].

Cadmium (Cd)

Cadmium, a silver-white, soft, highly electropositive, and machinable metal, resembles zinc with its many properties. Cadmium and its compounds are highly toxic substances. Cadmium does not have a single mineral in nature. It is found in very small amounts in the zinc mineral as CdCOS or CdS. Cadmium is present in the earth's crust in less than 1 mg/kg [13].

The emission amount of cadmium in nature is 25,000 - 30,000 tons annually, of which 4000 - 13,000 tons arise due to human activities. Important sources of cadmium affecting human life are cigarette smoke, refined foodstuffs, water pipes, coffee, tea, coal burning, shellfish, fertilizers used in the seed stage, and flue gases formed during industrial production stages. Cadmium is especially used in rechargeable batteries and alloys [13].

Cadmium has the highest water solubility among heavy metals. For this reason, it shows rapid diffusion in nature and is not an essential element for human life. Due to its water solubility feature, it is taken into biological systems by plants and marine creatures in the form of Cd^{2+} and it can accumulate. It can easily mix with soils as it also contains cadmium fertilizers and pesticides. It is taken into the body with foods such as liver, mushrooms, shellfish, mussels, cocoa powder, and seaweed [13].

According to the data of the World Health Organization, it has been calculated that the atmosphere in residential areas is contaminated with cadmium at an average level of 0.001 g / m^3. As a result, it has been determined that people take 0.02-2 mg of cadmium daily by the respiratory tract. High inhalation of cadmium oxide in the form of smoke has been shown to cause acute, pneumonitis, pulmonary edema, and fatal effects. The kidney is the most affected

organ from prolonged exposure. It is not possible to eliminate the damage in the kidney. The effect of cadmium has also been determined in the development of lung and prostate cancers [13].

Arsenic (As)

Arsenic is found in most minerals, usually a combination of sulfur and metals, or as a pure elemental crystal. Arsenic is a metalloid. It has a variety of allotropes, but only the gray form with a metallic appearance is important to the industry.

Arsenic is very common in the environment. Especially (+5) valuable compounds are found in the soil more than other arsenic types. It is possible to come across in the amount of 0.1-40 ppm in the soil. Arsenic, which is also found in connection with the organic substances in the soil, passes to the water and from there to the plants when the organic substances are oxidized. There are varying amounts of arsenic in natural water resources and seas. In places where the temperature of the water increases, the proportion of arsenic also increases [14].

Arsenic, which is odorless and colorless, is absorbed from the gastrointestinal system (the mouth to the anus, including all organs of the digestive system), the respiratory system, and the parenteral (vascular) routes. The gastrointestinal absorption rate of inorganic arsenic is very high. The greatest absorption occurs in the small intestine. It reduces casein absorption in milk [14].

Inhaled arsenic results in 80% systemic absorption. Systemic absorption of arsenic by the skin is not much. In acute uptake, the greatest distribution is in the liver and kidney, then in the brain [14].

Symptoms of acute arsenic exposure are affected by many factors such as the amount of arsenic, the time of intake, and the age of the patient. The most important effects are gastrointestinal and cardiac disorders. They can result in severe abdominal pain, metallic taste

in the mouth, tightness in the throat, vomiting, diarrhea like cholera, convulsions in the legs, weak and irregular pulse, pale face, collapse in the eyes, cold and wet skin, convulsions, paralysis, collapse, coma, and death. Very few skin reactions have been observed with acute exposure [14].

Symptoms of chronic intoxication symptoms are loss of appetite, general weakness, vomiting, bleeding gums, hyperkeratosis, severe skin rash, colic, garlic odor in the breath, light spots on the finger, and toenails [14].

CONCLUSION

Heavy metals pose a danger and risk to all living and human life as pollution factors. They cause various diseases, especially cancer, in humans depending on factors such as exposure dose, genetics, immune resistance, and general health status of the person, age, and nutritional level. Apart from the food chain, real serious damages to living things are also reported through respiration and skin [13, 15].

In some studies conducted today, behavioral disorders due to mental and neurological effects, neurotransmitter production, and dysregulation in function have been observed in people exposed to heavy metals [12].

The effects of heavy metals on human health have been revealed by studies. For this reason, the origin (geogenic or anthropogenic) of heavy metals, which are very dangerous and have high toxic effects, should be determined and measures should be taken by taking general or special measures according to the nature of the source.

REFERENCE

[1] Solgun E, Horasan BY & Ozturk A. Heavy metal accumulation and potential ecological risk assessment in sediments from the southwestern Konya district (Turkey). Arab J Geosci 14, 730 (2021). https://doi.org/10.1007/s12517-021-07088-1

[2] Effects of Soil Heavy Metal Contamination on Human Health and Solution Offers

[3] Oden MK, Özer I, Horasan BY. (2019), Investigation of Usage Samples of Treatment Sludges in Agricultural Areas, Turkish Journal of Agriculture - Food Science and Technology. 7(5): 743-749. DOI: https://doi.org/10.24925/turjaf.v7i5.743-749.2400

[4] Ozturk, A., Arici, O.K. Carcinogenic-potential ecological risk assessment of soils and wheat in the eastern region of Konya (Turkey). Environ Sci Pollut Res 28, 15471–15484 (2021). https://doi.org/10.1007/s11356-020-11697-w

[5] Horasan, B. Y. and Temur, S., 2006. Wall-rock Alteration caused by Epithermal Fluids Related to the Sizma Mercury Deposit, Konya, Central Turkey TMMOB JMO Turk Geol Bull 49(3):41–65.

[6] Horasan, B.Y. The environmental impact of the abandoned mercury mines on the settlement and agricultural lands; Ladik (Konya, Turkey). Environ Earth Sci 79, 237 (2020). https://doi.org/10.1007/s12665-020-08985-6

[7] Horasan BY, Ozturk A, Unal Y (2020) Geochemical and anthropogenic factors controlling the heavy metal accumulatıon in the soils of Sarayonu Ladık link roads. Carpathian J Earth Environ Sci 15(1):145–156. https://doi.org/10.26471/cjees/2020/015/117

[8] Öztürk, A, Bozkır Özen, Y, Arık, F. (2020). Geochemistry and Mineralization Potential of the Ophiolitic Rocks in Konya Region. International Journal of Environmental Trends (IJENT), 4 (2), 93-109. Retrieved from https://dergipark.org.tr/en/pub/ijent/issue/58257/828929

[9] Coskun A, Horasan BY, Ozturk A (2021) Heavy metal distribution in stream sediments and potential ecological risk assessment in Konya Northeast region. Environ Earth Sci 80, 181. https://doi.org/10.1007/s12665-021-09495-9

[10] Kabata-Pendias A (2011) Trace elements in soils and plants. 4 th edn. CRC Press,

[11] Horasan BY, Arık F (2019) Assessing Heavy Metal Pollution In The Surface Soils Of Central Anatolia Region Of Turkey Carpathian Journal of Earth and Environmental Sciences 14 No. 1:107 – 118 doi:http://doi.org/10.26471/cjees/2019/014/063

[12] Effects of Heavy Metal Toxicity on Human Health Gülüzar Özbolat1, Abdullah Tuli1

[13] Heavy Metals Pollution in Air and Soil Tolgahan Seven1, Büşra Can1, Begüm Nur Darende1, Sevda Ocak1

[14] Dr. Fatih Yağmur*, Dr. Ý. Hamit Hancý* Ankara sted 2002 • cilt 11 • sayı 7 •250, 251

[15] Horasan, B, Öztürk, A. (2021). Evaluation of heavy metal content of salts between Eskıkışla and Ocakbaşı (Kırıkkale) villages. Turkish Journal of Engineering, 5 (1), 29-34. DOI: 10.31127/tuje.652452