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THE INVESTIGATION OF CADMIUM POLLUTION IN THE METAL PRODUCTION FACTORY IN RELATION TO ENVIRONMENTAL HEALTH

Abstract:

Heavy metals such as lead and cadmium are among the pollutants that are created by the metal production factories and disseminated in the nature. In order to study the quantity of cadmium pollution in the environment of the metal production factories, 50 saplings of the spruce species at the peripheries of the metal production factories were examined and the samples of the leaves, roots and stems of saplings planted around the factory and the soil of the environment of the factory were studied to investigate pollution with cadmium. They were compared to the soil and saplings of the spruce trees planted outside the factory as observer region. The results showed that the quantity of pollution in the leaves, stem and roots of the trees planted inside the factory environment were estimated at 1.1 milligram/kilogram, 1.5 milligram/kilogram and 2.5 milligram/kilogram respectively and this indicated a significant difference with the observer region ($P<0.05$). The quantity of cadmium in the soil of the peripheries of the metal production factory was estimated at 6.8 milligram/kilogram in the depth of 0-10 centimeters beneath the level of the soil. The length of roots in the saplings planted around the factory of metal production stood at 11 centimeters and 14.5 centimeters in the observer region which had a significant difference with the observer region ($P<0.05$). The quantity of soil resources and spruce species' pollution with cadmium in the region has been influenced by the production processes in the factory.

Keywords:

cadmium pollution, spruce, soil pollution and the factory of producing alloy metals

JEL Classification: I10

Introduction

With the growing industrialization of the cities and the pollution of the air with a variety of heavy metals and other pollutants, the plants will be affected like the other living things as a result of this pollution. Trees, green spaces and the industrial zones which are affected by these pollutants in different ways, maintain various response mechanisms as regards the tensions resulting from the heavy metals, soil and the weather. Due to their motionlessness, the plants are completely vulnerable to pollution. Generally, all plants are capable of absorbing the heavy metals, but the trees have a more effective role in the absorption of the metals existing in the urban environments and can protect residential areas and the densely populated regions against their unfavorable and damaging effects (Hasehmi, 2011). The vehicles are normally the main sources of the creation of heavy metals in the cities and enter the environment as particles being released from the exhaust system and the other parts of the cars and vehicles(Harrison etal.,1981 ; Garcia ,1998). The vehicle pollutants are distributed across the roads in the course of the traffic and contribute to the pollution of the soil and the plants in those regions. Lead and cadmium are among the vehicle pollutants which have been given enormous attention by different researchers because of their high heavyity for the nature and the human. Cadmium exists in the tires of the cars and enters the urban environment through the depreciation of the vehicles and traffic propagation (Wang, 2005). The frequency of the element of cadmium in the polluted soils can reach a level of 300 milligrams/kilogram (Bal Ram Singh, 1999). Annually, around 38,000 tons of cadmium and around one million tons of lead are added to the soils of the world as a great amount of them belongs to atmospheric dusts, the dissemination of the ashes and urban wastes while the rest has to do with the consumption of chemical fertilizers and wastewater sludge. The main sources of the unnatural addition of the heavy metals to the atmosphere mainly include the factories of melting and purifying the metals, the furnaces of the combustion of coal and rubbish, all of which lead to the pollution of the sources of soil and water in the regions being influenced by these factories (Page, 1982; Nriagu et al, 1988).

In some battery-producing companies in Sweden and Germany, such consequences as Emphyseme, Protoinuria, losing the sense of smelling, the decaying of the teeth and pulmonary diseases and other lung deficiencies as a result of exposure to cadmium have been reported and even the nose tightness rhinitis and insomnia were observed (Ballantyne et al, 1999). According to studies by WHO, 10 micrograms per liter of cadmium in the whole blood was selected as the experimental figure and no unfavorable result can be seen in this quantity. 3 micrograms of cadmium in an edible form have no damaging effect on the human body. 4.5 milligram of edible cadmium causes nausea and vomiting; however, it’s not lethal up to the level of 326 milligrams. In the workers who work on the melting of zinc which includes certain amounts of cadmium, bronchitis and nephrite have been observed, and for those who work on electroplating using cadmium, chronic inheavyation with the emergence of nausea, stomachache and diarrhea were seen prevalently (Jarup et al, 1998)Moreover joint pain and bone deformation as well as the emergence of yellow rings on the teeth have been found among the workers of cadmium battery production. Also in the people who work at the cadmium casting factories, coughing, ventricular and intestinal diseases, exhaustion and anemia have been observed (Nordberg, 2004). So far, only a few plants have been identified which can accumulate cadmium with a density of more than 100 milligrams/kilogram. *Salsola kali* plant can deposit 2000 milligrams/kilogram of cadmium in its different organs in the laboratory situation (Rosa et al, 2004). The purpose of the present study is to investigate the cadmium pollution in the saplings of the spruce species planted around the steel company in the Rasht city, northern Iran.

Materials and methodology

In the present research, a group of 50 identical saplings of the spruce tree at the peripheries of the metal production factory and also a group of 50 identical saplings of spruce tree outside the environment of the steel factory as the observer group were selected. In three stations of the environment of the alloy metal production company, samples of the soil were taken of the depths of 0-10 centimeters and 10-20 centimeters. The samples of soil were dried through exposure to the air, pounded using a plastic hammer and gone through a 2-mm sieve. The soil collected under the sieve was used for chemical synthesis (Haung et al, 2000). In order to measure the absorbable density of the heavy metal, DTPA extractor, chloride calcium and Triethanolamine were used and the pH of the extractor solution was estimated at about 7.3. Afterward, the density of the cadmium was determined using atomic absorption device (Page , 1982). Samples of the stem, roots and leaves of the spruce tree were selected and the dry weight of the samples of leaves, stem and roots were measured. The length of the roots was also measured. The quantity of the heavy metals was measured using the nitric acid digestion method. Moreover, the samples of the roots, stem and leaves of each vase were powdered using gristmill separately and then the contents of the metals were identified using dry ash method. In the present study, stem-cutting scissors were used for separating the stems, cellulosic pockets were used for collecting and carrying the herbal samples, distilled water and chloride acid were used for washing the herbal organs. Then each plant was divided into two aerial and root-based parts and dried inside the avon with a temperature of 70 degrees. The dry weight of the aerial and root parts were measured for each sample. In order to measure the accumulated cadmium, the samples were placed inside the electrical furnace with a temperature of 480 degrees centigrade and after cooling, the resulting ash was solved into 4 milliliters of 10% acid nitric. After purification, the resulting solution was poured into special plastic receptacles and the quantity of cadmium in the herbal pattern was determined using the Perkin Elemer 3030 atomic absorption device. The analysis of the data was carried out using the SPSS application and the Duncan test examination.

Results

The data used were subjected to the Kolmogorov–Smirnov test (K-S test) and the results showed that the data follow a normal distribution. Afterwards, the results of the density of cadmium in the leaves, roots, stem and soil of the spruce saplings planted around the factory were compared to the observer saplings planted outside the factory. The results of the test showed that there’s a significant difference between the cadmium measured existing in the leaves, roots and stem of the sapling spruces, the soil of the peripheries of steel factory and the saplings planted outside the factory (Table 1 ,Table2 ,P<0.05). The average cadmium in the roots, stem and leaves stood at 2.5 mg/kg1.5 mg/kg and 1.1 mg/kg respectively while cadmium was not found in the observer region (Figure 1 ,Table2). The density of cadmium in the aerial organs of the plant was less than that of the roots. The average weight of the aerial organs of the spruce sapling was calculated at 225 grams while the roots had an average weight of 34.5 gram per each spruce sapling planted at the peripheries of the steel factory, showing a significant difference with the saplings planted outside the factory (P<0.05). The weight of the aerial organs and the roots of the spruce sapling planted at the peripheries of the factory was less than the weight of the aerial organs and roots

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planted outside the factory (P<0.05). The dry weight of the roots in the saplings planted at the peripheries of the factory has decreased and shows a significant difference with the observer region (P<0.05).the Table 1 show Analysis of variance the amount of cadmium absorption in sapling.

Table 1 Analyses of variance of amount of cadmium absorption in stem, leaf and root.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	104.041	2	52.020	500.876	0.000
Within Groups	15.267	147	0.104		
Total	119. 308				

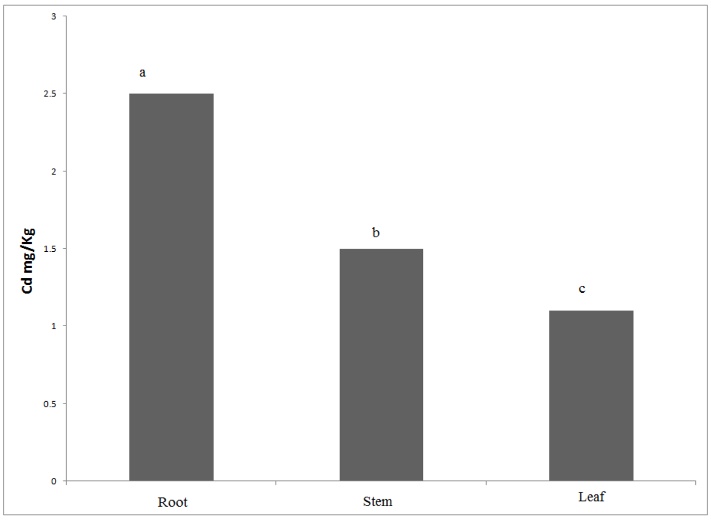

Figure 1: the average absorption of cadmium in the saplings of spruce species

Duncan test showed that significant difference between the cadmium measured existing in the leaves, roots and stem of the sapling spruces (Table 2).The density of cadmium in the soil with a depth of 0-10 centimeters at the peripheries of the steel factory was specified at 6.8 mg/kg and in the depth of 10-20 centimeters was calculated at 5.8 mg/kg. The Figure 2 shows the density of cadmium in the soil of the peripheries of the factory in two depths of 0-10 and 10-20 centimeters.

Table 2 Duncan test between leaf, stem and root

Duncan [a]	N	Subset for alpha=0.05		
		1	2	3
Leaf	50	0.5000		
Stem	50		1.5160	
Root	50			2.540
Sig.		1.000	1.000	1.000

a = Uses harmonic mean sample size =50.000

The presence of cadmium in the environment is one of the factors limiting the growth of the plants; however, some plants can continue to survive in the presence of a great amount of heavy metals which are naturally detrimental for the majority of the plants (Page , 1982). Furthermore, the length of the roots in the saplings planted at the peripheries of the steel factory is about 11 centimeters while it is about 14.5 centimeters in the observer region (P<0.05).

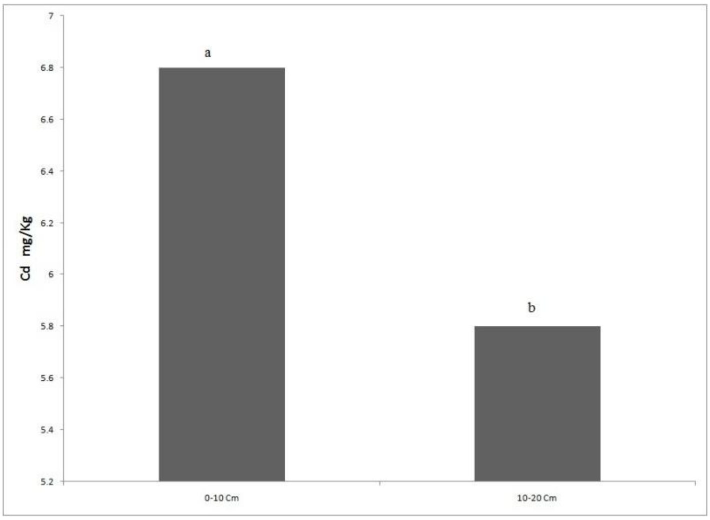

Figure 2: the density of cadmium in the soil of the peripheries of the factory in two depths of 0-10 and 10-20 centimeters

The average quantity and standard deviation of cadmium measured in the Table 3 has been shown in the Table 2. The results indicate that with the increasing of the depth of the soil, the density of the extractable cadmium decreases and this demonstrates the lack of leaching of cadmium into the deeper layers of the soil. This depends on the alkalinity of the soil and the existence of lime in the soil.

Table 3: the average and standard deviation of extractable density using DTPA (mg/kg) of the heavy metals in the soil

Depth of the soil	Average (mg/kg) soil	Standard deviation	Coefficient of variation
0-10	6.8	0.136	0.02
10-20	5.8	0.29	0.05

Discussion

The amount of the growth of the plant is one of the indices showing the resistance of the plant to the heavy metals. Since the roots are sensitive to the presence of heavy metals, the length of the root is considered to be one of the most important indices of the impact of metal's heavy it on the plant (Page , 1982). The decrease in the growth resulting from cadmium pollution is due to the reduction of photosynthesis and respiration and reduces the metabolism of carbohydrates. This reduction in the roots is more than leaves and stem. In other studies carried out by the researchers, it was demonstrated that the density of the lead in the roots is more than the aerial organs and increases in the stem, leaves and roots and that is why the most accumulation of lead takes place in the roots of the herbal species. Moreover, the density of the heavy metals in the roots of the plants follows its quantity in the soil .The density of cadmium decreases with the increasing of the depth of the soil. In a research study which took 6 years to be done, the scholars reached a similar conclusion. The permissible amount of cadmium that can enter the soil as reported by the United States Environmental Protection Agency is 20 kilogram per hectare. 18 milligram/kilogram of cadmium in the soil contributes to a decrease in the growth of the different species of the spruce sapling (Pais et al, 1997; Sillanppa et al, 1997).

The amount of cadmium that moves from root to the stem, leaves and consumptive organs depends on a number of factors including variety, sub-species, type of the soil, the primary density of the cadmium existing in the soil and the presence of steel factories. At the peripheries of these factories, the suspended particles in the air will come down on the agricultural soil in such a way that sometimes, the density of the cadmium in the agricultural crops, especially fruits and vegetables around these factories is in the dangerous level. The absorption of cadmium by the roots of the plants depends on the chemical forms of cadmium in the solution of rhizosphere soil (Bal Ram Sing et al, 1999). The normal amount of this component in the plants is between 0.8 and 0.2 milligram/kilogram of the dry matter, and the level of its heavyity has been reported to be 2 milligram/kilogram of the dry matter (Logan, 1983). The factors which have a great importance in determining the heavy metal absorbed by the plant include the chemical form of the element, pH of the soil, the density of the heavy metal and the plant species (Logan et al, 1983). The researchers have stated that the absorbable density of the heavy metals is related to the quantity and type of organic materials in the soil. In particular, in such a way that the synthesis of the organic species causes the release of these elements as bioavailable forms, these species may be dangerous for the agricultural crops; therefore, the heavy metals which enter the agricultural soils should be maintained in such a level that they may inflict the least damage on the soil and have the least danger of consumption through being mingled with nutritional cycle (McBride, 1995). Therefore, given the studies carried out and taking into consideration the 10-year history of the steel factory, it can be concluded that the amount of cadmium pollution of the soil resources and the spruce species in the region is affected by the processes of production in the factory. To control this pollution and preventing it from spreading, it's suggested that agricultural studies be carried out in the soil and agricultural crops of the region continuously and the density of metal pollutants in the soil and agricultural crops be identified on an annual basis.

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