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RESEARCH ARTICLE

Determining the Some Heavy Metal Content of *Pinus sylvestris* Needles and Soil in the Urban Forest by the Side of the Road

Emre Çomaklı[1], Mehmet Semih Bingöl[2*], Tuğba Çomaklı[3]

[1] *Atatürk University Environmental Problems Research Center, Erzurum/Turkey*
[2] *Atatürk University East Anatolia High Technology Application and Research Center, Erzurum/Turkey*
[3] *Eastern Anatolia Forest Research Institute, Erzurum/Turkey*

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ABSTRACT

One of the significant factors having a role in plant development is elements. The decrease in quantities of some elements results in plant nutrition disorders while the increase of them might do harm to plant. Apart from that, there are elements that affect plants in terms of toxic effect. They are mostly heavy metals. Heavy metals with industrial-based and transportation-based pollutants have an impact on the natural environment. It is clear that plants are affected by environmental factors, too. Heavy metal pollution in soil is also one of the significant environmental problems. It has a big influence on human and animal health via the food chain. Hence, it is quite vital to recognize the type and the amount of heavy metal as well as reasons causing accumulation in the sense of plant development and soil health. In this sense, the aim of the present research is to determine the effects based on heavy metals especially vehicle-driven on plants and soil by using *Pinus sylvestris* needles and soil samples. In the study, it is confirmed that heavy metal contents tended to decrease depending on the distance to the road.

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Introduction

Air pollution has adverse effects on human, plant, and animal health. It is composed of exhaust gases, plant emissions, fuel burning, and also other sources. Air pollution occurs as a result of mixing in the air of a gas mixture from solid and liquid particles which happen because solid fuel and carbonyl compounds in fuel oil do not completely burn (Müezzinoğlu, 1987)

The urban forests are significant parts of urban ecosystem. They make the contribution to human welfare. They provide numerous ecological services influenced deeply by urbanization. Heavy metal concentrations in building lands have reached the toxic level because of rapid urbanization and industrialization in the last 20-30 years. Heavy metals release trace on air, water, and ground due to human-based activities such as exhaust emissions, pesticides and fertilizer practices, sewage mud (Barona, 2015; Song, You, & Wang, 2000).

Heavy metals are considered as major pollutants accumulating in the environment. It has become a serious environmental issue that heavy metal has been accumulated in soil because of rapid industrialization and randomly

* Corresponding author
E-mail address: semihbingöl@hotmail.com (S. Bingöl)

urbanization all over the world. The issue has been increased day by day by exploiting outdoors, a growing number of cars, and demographic pressure (Tangahu et al., 2011). Heavy metals are generally described to have metallic characteristics and as elements which are bigger than atomic number 20. Some of these metals are essential micronutrients for plant development such as Zn, Cu, Mn, Ni, and Co while others (Cd, Pb and Hg etc.) have no biological functions (Gaur & Adholeya, 2004). Metal pollution has a harmful impact on biological systems. And also, it does not undergo biological decaying. Toxic heavy metals such as Pb, Co, Cd can be distinguished from other pollutants as they are not biologically taken to pieces. However, they can be accumulated in living organisms. Thus, they cause various damages even in relatively low concentrations (Pehlivan, Özkan, Dinç, & Parlayici, 2009).

Heavy metals have caused a great number of health hazards to high organisms due to their duration of being soil for thousand years. It is also known that they have an adverse impact on plant development, floor coverings, and soil microflora (Roy et al., 2005). It is well known that heavy metal cannot be chemically taken into pieces and they need to be removed physically or to be converted into non-toxic compounds (Gaur & Adholeya, 2004)

Increasing accumulation and the risk of potential exposure in building lands have become an increasingly public issue owing to their possible detrimental effects on human health, soil, and (Barbieri, Sappa, Vitale, Parisse, & Battistel, 2014; Nriagu, 1996). In many studies, the accumulation and contamination of heavy metals such as Cd, Cu, Pb, Cr, and Zn have been examined especially in the fields of agriculture and mining. Forest systems which are considered as the most important terrestrial systems have been mostly ignored (Wingfield, Brockerhoff, Wingfield, & Slippers, 2015). The maintenance of forest systems requires a running ground system. Besides, the quality of forest soils affects the sustainable progress of forests directly or indirectly. Thus, it is a must to focus on the levels of pollution and the potential ecological risk of heavy metals in soils of forest ecosystems especially thanks to their importance in urban forest ecosystem (Castello & Teale, 2011).

Erzurum city center is relatively a densely populated region in regard to its region. The situation results in traffic density on the main drag. In this study, soil samples was taken from the urban forest along the roadside where there is a traffic density and the quantities of heavy metals (Pb, Zn, Ni, Cu, Cr, and Cd) accumulated in the samples from *Pinus Sylvestris* needles have been examined. Specifically, this research aimed to determine particularly the effects of vehicle-induced heavy metals on plants and soil.

Material and Method

The Study Site

Erzurum is the biggest city of the Eastern Anatolia Region of Turkey, at 1850 m. altitude, and with the population of 760.460 (TUIK 2017). The field of study is the urban forest which is located within the central campus of Ataturk University along with highway E80 where the traffic is intense. The study site is located in 39º54’30.54”N and 41º14’32.78”E.. The urban forest is covered with *Pinus Sylvestris* at ages of between 50 and 60. Roughly 20.000 vehicles pass by daily on highway E80 which is just next to the study site. Types and numbers of vehicles passing by on the main road are given in Table 1.

Table 1. Numbers and types of vehicles passing by on the main road next to the study

Vehicles	Number of passes in a day
Automobile	15622
Medium Commercial Vehicle	1548
Bus	267
Truck	1550
Truck+Trailer, Tow truck+Semi-trailer	379
Total	**19366**

Totally 8 sample points are selected from the roadside and the forest (Figure 1).

Figure 1. The map of the study field and the sample points

Receiving Samples and Preparing Them for Analyzing

Needle and soil samples were taken from the chosen sample points along with a line at certain intervals before the vegetation period (at the beginning of May) started. Soil samples were taken from the surface (0-30 cm) while needle samples were taken from perennial growths of trees. Soil samples were labeled, put into polybags, and spread in a lab so as to dry for one month. After the drying process, soil samples were sieved with a 0.15 mm sieving and weighted on an analytical balance in certain amounts (0.3 gr.). Agilent 7800 ICP-MS was used to determine heavy metal accumulation in soil and needles.

Burning process was fulfilled with a microwave system named Milestone Ethos Up. It was performed by adding 8 mL nitric acid and 2 mL hydrogen peroxide to needle samples, and 3 mL nitric acid, 1 mL hydrogen peroxide, and 6 mL hydrochloric to soil samples, and by keeping them in the microwave oven for one hour. After the burning process, to make up 50 mL, samples were diluted with pure water, filtered, and loaded into ICP-MS device for elemental specification.

Result and Discussion

Findings Obtained from Needle Samples

The amounts of heavy metal in needle samples were examined. The rates of heavy metal of the chosen points were shown in Table 2.

Table 2. The amount of heavy metal in needle samples (mg/kg)

Mg/kg	A1	A2	A3	A4	A5	A6	A7	A8
Lead	50.65	40.65	25.45	21.56	19.98	16.69	16.85	20.96
Cadmium	Trace	Trace	Trace	Trace	Trace	Trace	Trace	Trace
Nickel	88.93	79.47	61.76	57.90	26.91	19.84	16.70	15.67
Copper	34.87	30.25	29.10	25.84	11.53	12.51	11.81	20.98
Zinc	62.32	75.73	50.07	76.22	86.84	64.49	84.02	73.2
Chrome	12.13	10.45	9.78	8.95	6.80	6.58	6.28	9.16

Findings obtained from soil samples

The amounts of heavy metal in soil samples were examined. The findings obtained from the chosen points were provided in Table 3.

Table 3. The amount of heavy metal in soil samples (mg/kg)

Mg/kg	A1	A2	A3	A4	A5	A6	A7	A8
Lead	202.99	125.32	100.24	96.45	95.10	85.78	79.47	93.03
Cadmium	2.06	2.5	2.45	2.23	2.787	2.77	2.45	2.06
Nickel	111.22	131.19	112.45	100.47	105.78	67.21	89.44	101.05
Copper	143.34	154.18	125.45	101.75	81.30	85.47	78.45	78.92
Zinc	454.33	364.55	332.89	336.78	380.78	305.029	330.34	330.92
Chrome	163.13	138.83	123.87	89.47	56.53	58.74	50.47	61.99

Conclusion

The Effects of Heavy Metals on Plants

Zinc; it carries out various and significant metabolic functions in plants like in humans and animals. It has a direct impact on the quality and the quantity of the manufactured product as a result of its effects on enzyme activation, photosynthesis, respiration, and biological membrane stability as well as participating in protein and carbohydrate synthesis (Rout & Das, 2009). Zinc reaches soil via waste water from heavy industrial areas, sewage, and acid rains (Vaillant, Monnet, Hitmi, Sallanon, & Coudret, 2005)). The total Zn concentration is between 10-300 mg/kg in soils; 5-100 mg/kg in normal plants. Toxicities are generally observed after 400 ppm (Schachtschabel, Blume, Brümmer, Hartge, & Schwertmann, 1995). In Zinc toxicity, stool development of plants decreases, roots get thinner, young needles wriggle and chlorosis is seen, cell growth and elongation are prevented, cell organelles are taken into pieces and chlorophyll synthesis decreases (Rout & Das, 2009).

Copper; it is an essential element as it has a role in enzyme activation of plant structure, carbon hydrate and lipid metabolism (Kacar & Katkat, 2006). Copper pollution results from human activity-based emission and atmospheric deposits, usage of pesticides, recycling of sewage as fertilizer, coalfields and mineral springs. It shows a toxic effect if soil contains copper more than 100 mg/kg and plant solids contain copper more than 15-30 mg/kg. Copper toxicity usually gets out in plant root systems and it causes some physiological incidents such as protein synthesis, photosynthesis, respiration, ionic intake, and cell membrane stability to get worse in plant structures (Alaoui-Sossé et al., 2004).

Cadmium; it reaches topsoil and spreads through industrial activities, phosphoric fertilizers, sewage, and atmospheric deposits (Haktanır & Arcak, 1998)A toxic effect is observed if soil contains cadmium more than 3 mg/kg while plant solids contain it more than 1 mg/kg (Schachtschabel et al., 1995). A large amount of cadmium reaching plants and soils comes into existence through precipitation of dust particles with cadmium from air. It has been measured that 0.2-1.0 mg was added to m2 per year because of dust precipitation on the roadsides where the traffic was intense (Haktanır & Arcak, 1998)

Lead; it is a frequent seen element around inasmuch as it is commonly used in industrial and agricultural activities. It can reach soils due to the usage of plumbeous pesticides in addition to its use as tetraethyl and tetramethyl as battery and gasoline additives in automobile industry. It is not a vitally essential element for plants. Unless lead concentration surpasses 150 ppm in soil, it does not pose hazard for human and plant health. However, when it surpasses 300 ppm, it can be a potential danger to human health (Durust, Durust, Tugrul, & Zengin, 2004).

Nickel; it is considered as one of the absolutely necessary elements today. Besides that, it is known that its concentration in topsoil is insufficient. Yet, nickel substance of soils consisting of ultrabasic igneous rocks like serpentine shows an alteration between 100 and 5000 mg Ni/kg (Kacar & Katkat, 2006). The critical toxic level is 100 mg/kg in soil, > 10 µg/ g in sensible plants, and > 50 µg/ g in dry and moderate sensible plants (Schachtschabel et al., 1995). Nickel replaces heavy metals found in enzymes in plants and physiological active centers as it easily constitutes chilette compounds. Nickel is a metal nutrient of urease and many hydrogenase enzymes. Thus, plants with a shortage of nickel can not benefit from nitrous fertilizer which is applied in the manner of ure. Additionally, ure toxically affects these plants (Kacar & Katkat, 2006).

Chrome; it is used in metallurgical industry which is about stainless steel production, various solder and anti-rust production, in paint, polish, glass, and ceramic materials, and in leather industry. It is naturally found in ground. It is found in ground in 5-100 mg/kg rates even if the rate changes with regard to the main material. It causes toxical effect on lots of high plants as it is found in 100 mg/kg rate in dry matter in plants (Schachtschabel et al., 1995).

Forests are not only entities that produce wood as raw material but also they have "Ecological and social functions". They keep solid pollutants on their crowns or leaves through adsorption and absorption. They function as filters by avoiding movements of wind-borne particles because they are able to make wind slower. The function of reducing air pollution of a forest can be observed within certain gauge limits. For instance, according to a study, a ladinwood is able to keep 32 tons of solid pollutants, a pinewood is able to keep 36.4 tons of solid pollutants, and a beechwood with the same size is able to keep 68 tons of solid pollutants. Filtering function of forests are closely related to surfaces of canopies causing roughness as well as temperature and heights of trees. As 100.000 of leaves of an old beech tree cover a 100-meter squared field, and hundreds or thousands of trees form an unmeasured surface in a forest, it is clear that a beech tree has a cleanser effect. The fact that branches and trunks definitely have a role in the function of forests mentioned above should not be underestimated (Uslu & Karaöz, 1984). Heavy metal accumulation has a negative impact on microbial life in soil in addition to decreasing efficiency.

Based on the findings of the study, it has been revealed that the amounts of Lead (Pb) are 16.69-50.65 mg/kg in needles and 79.47-202.99mg/kg in soils, the amounts of Cadmium (Cb) are in trace amount in needles while they are 2.06-2.78 mg/kg in soils, the amounts of Nickel are 15.67-88.93 mg/kg in needles while they are 67.21-131.19 mg/kg in soils, the amounts of Copper (Cu) are 11.53-34.87 mg/kg in needles and 78.45-154.18 mg/kg in soils, the amounts of Zinc (Zn) are 50.07-84.02 mg/kg in needles and 305.02-454.33 mg/kg in soils, the amounts of Chrome (Cr) are 6.28-12.13 mg/kg in needles and 50.47-163.13 mg/kg in soils (figure 2). It has been observed that the amounts of Nickel, Lead, and Chrome decrease toward the deep of the forest on the road where approximately 20.000 vehicles pass by daily while the amounts slightly increase on a nearby side road. It has been found out that Cadmium is in trace amount in needles and on non-toxical level in soil. Moreover, it has also been revealed that the soil sample of Zinc received only from the roadside is on toxic level; however, its amount from needles is not on toxic level to affect badly plant development. The amount of Copper is on toxic level in samples obtained from the roadside while it is not on toxic level in samples obtained from the forest. As a result of these findings based on data analysis, it has been revealed that the amount of heavy metal in soil samples is far more than the one in needle samples. In this sense, it has been ascertained that *Pinus sylvestris* needles adsorp heavy metal less as compared to soil.

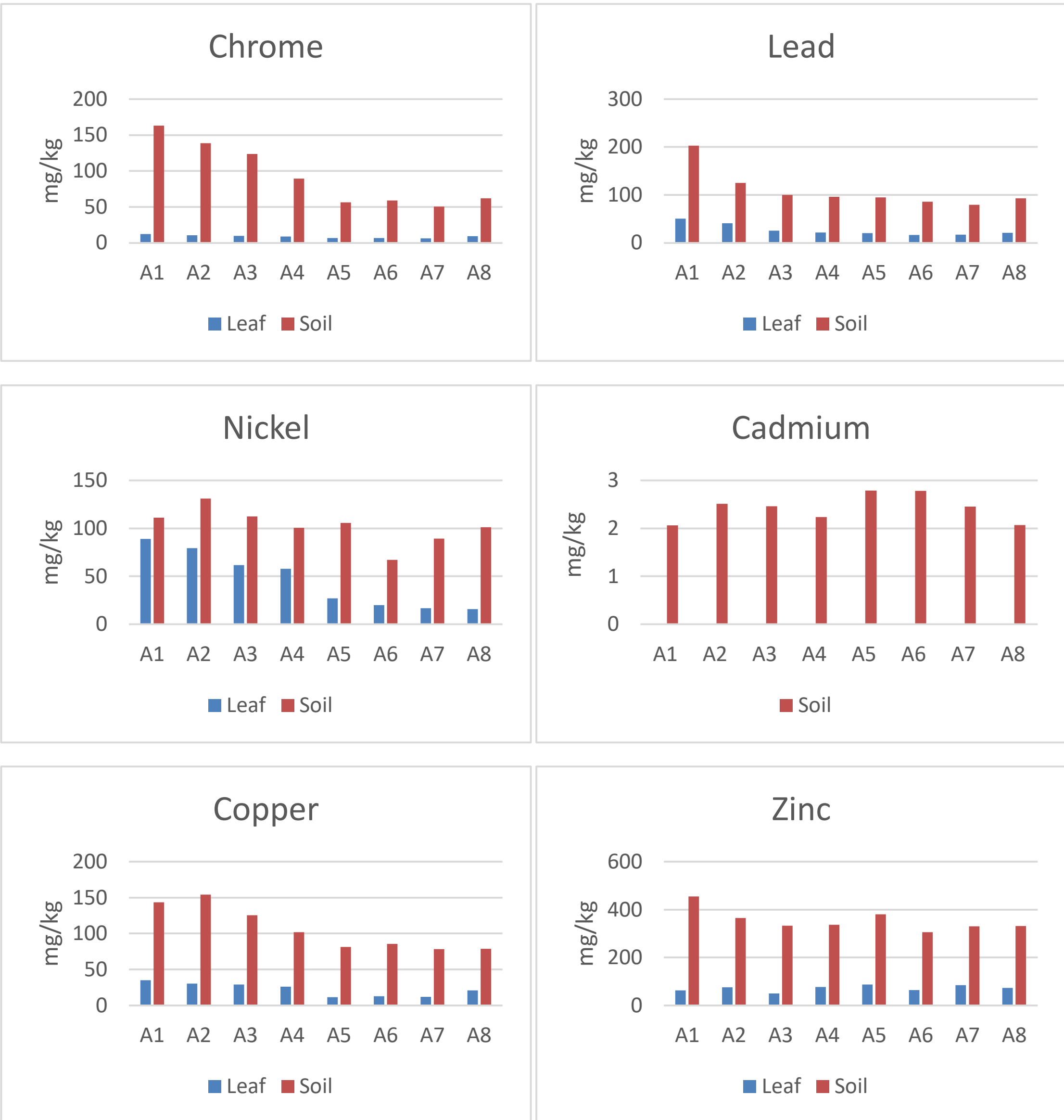

Figure 2. Comparisons of heavy metals in leaf and soil samples

As it is inferred from results of the study, traffic-based pollution is the leading reason of heavy metal pollution. It is known that especially Lead (Pb) spreading from exhausts of vehicles has a negative effect on both human, plants, and also animals. The rate of human exposure will be minimized by the way of avoiding agricultural activities in regions where traffic is heavy, and building roads on highlands as much as possible rather than farm lands. Furthermore, it is suggested that necessary measures should be taken by determining the degree of contagion of livings and farm lands, which are around the current main roads where traffic is heavy, from heavy metals. Besides, planting works should be taken into consideration. Lastly, lead-free petrol should be preferred in vehicles, and measurements of exhaustgase emissions of these vehicles should be constantly controlled.

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