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Change of Mn, Ni, and Zn concentrations in soils in the city center of Kastamonu and nearby by the use of soil

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Abstract

Environment pollution, especially heavy metal pollution, became one of the most important problems of urban areas. Heavy metals in the air threatening human and environmental health pass to the soil after a while. Thus, soil is the medium, which can reflect the level of pollution at best. In the present study, among the heavy metals posing threat to human health, Mn, Ni, and Zn concentrations were determined in soil samples taken from 15 points, which had different characteristics, in the city center of Kastamonu province and the changes in these heavy metals by location were compared using statistical methods. As a result, it was determined that rather than anthropogenic factors, the concentrations of these heavy metals in the soil samples were shaped by the soil lithology.

Keywords: Soil; Kastamonu; Heavy Metal; Mn; Ni; Zn

1. Introduction

As in the entire world, rural-to-urban migration significantly increased due to various reasons in our country too and a significant portion of the population started living in urban areas. Given the official data, the percentage of urban population in our country was 92.1% as of year 2015 but then increased to 92.3% as of year 2016, 92.5% as of year 2017, and 92.8% as of year 2019? In addition to the increase in urban population, economic advancements and increase in purchasing power caused an increase in the number of vehicles in these areas. Given the official records, the number of motor land vehicles in our country was 231,977 in year 1966 but increased to 1,696,681 in 1980, 3,750,678 in 1990, 8,320,449 in 2000, 15,095,603 in 2010, and 23,245,409 as of early 2020 [1-5].

Together with the concentration of population in the city centers, the increasing population caused or increased many problems such as environmental pollution, global climate change, unplanned urbanization, and unhealthy living conditions [6-11]. Among them, environmental pollution is one of the most important problems. One of the components affected by the increase in pollution the most is the soil. Soil both offers a nutrition and living medium for plants and also is one of the most important components of environment. Türkiye is identified as one of 19 countries having depleted cultivatable land sources. As in the rest of the world, the land sources in Türkiye that have been limited to date are exposed to pollutants originating from various sources. Soil pollution poses an increasing threat to human health and environment quality [1].

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The change in the soil quality because of the soil pollution significantly affects both nature and ecosystem. Among the soil and environment pollutants, heavy metals became more prominent in the recent period. Even though there are many reasons for this, the most prominent reasons are the population living in urban areas and the consequent increase in the number of vehicles. Thus, in many studies carried out using biomonitors, a significant relationship was found between traffic density and heavy metal concentrations in plants [12-17]. Nowadays, heavy metal pollution has reached such a dangerous level that the heavy metal concentrations in soils in several regions are at the level threatening the food security through herbal intake [18].

Hence, determining the soil pollution especially in urban areas is of significant importance. Within the scope of this study, it was aimed to determine the heavy metal pollution in soil samples, which had different characteristics, in city center and rural areas of Kastamonu province. Within the scope of the present study, the heavy metal pollution levels of soil samples taken from urban and rural areas and those of soils used for other purposes in those places.

2. Material and methods

Within the scope of the study, soil samples were taken from regions having different characteristics. The soil samples were taken from 15 points including;

2.1. City center

- Main street central refuge (L1)
- Main street roadside (L2)
- By-road roadside (L3)
- House garden at least 10m away from the main street (L4)
- House garden at least 30m away from the main street (L5)
- Industrial zone (L6)
- Nearby the industrial zone (L7)
- Open area border of residential area (L8)

2.2. Outside City Center (at least 5km away from residential area)

- Main road central refuge (L9)
- Main road roadside (L10)
- Industrial zone (L11)
- Nearby the industrial zone (L12)
- Forest area (L13)
- Agricultural area (L14), and
- Pasture area (L15)

Soil samples were taken from 30cm depth, which is the root zone of plants, at suitable points of the land. Taken using a spading shovel, 1kg soil sample was put into clean bags and labeled. Then, they were taken to the laboratory. After sieving, they were dried in a drying oven at 45°C. The concentrations of Ni, Mn, and Zn, among the most dangerous heavy metals for human and environmental health, were determined using ICP-OES. This method used in the present study is one of the most frequently used techniques in heavy metal analyses in recent years [19-25].Heavy metal analyses were triplicated.

The data obtained were tabularized and entered into Excel software and analyzed using SPSS package program. Data were subjected to Variance analysis and the confidence level was set at a minimum of 95% ($p<0.05$). Duncan test was performed for the data found to have a statistically significant difference.

3. Results

The results of Duncan's test and Variance analysis conducted in order to determine the changes in heavy metal concentrations by the locations are presented in Table 1.

Table 1 Change in Mn, Ni, and Zn concentrations in soils

Location	Mn (ppm)	Ni (ppb)	Zn (ppb)
L1	168 a	22588 b	89 812 j
L2	433 g	30639 g	34 202 a
L3	737 n	37087 j	160 813 k
L4	551 k	49532 k	48 890 e
L5	485 j	24969 d	38 306 b
L6	575 l	26179 e	54 945 g
L7	349 d	36538 i	60 498 h
L8	399 e	29121 f	37 027 b
L9	320 c	30372 g	51 665 f
L10	265 b	52691 l	69 378 i
L11	471 i	21055 a	33 948 a
L12	647 m	21016 a	36 915 b
L13	647 m	32854 h	42 132 c
L14	408 f	84612 m	51 151 f
L15	441 h	23690 c	44 423 d
F	8 853,5***	31786,2***	4 710,3***

Note: Letter refers to the vertical direction within each row, *** significant at 0.001 level.

Given the results presented in Table 1, it can be seen that the changes in all the heavy metals by the locations were statistically significant at the confidence level of 99.9% ($p<0.001$). The lowest concentrations were found in L1 for Mn, L12 for Ni, and L11 for Zn, whereas the highest concentrations were found in L3 for Mn, L14 for Ni, and L3 for Zn. It is interesting that the lowest and highest concentrations of Mn were found in the city center. The most remarkable finding achieved in the present study is that the lowest Ni concentration was found in industrial zone and the highest one in agricultural area.

4. Discussion

At the end of the study, it was determined that the concentrations of elements examined here significantly varied between the locations. However, no linear relationship was found between the locations and the traffic and industrial or residential areas, which were thought to be pollution factors. For instance, the lowest Ni concentration was found in industrial zone, whereas the highest Ni concentration was found in agricultural area. But, Ni is one of the harmful heavy metals to human and environmental health [26-29] and it was reported to origin mainly from industry and traffic [30-32].

However, besides the human interference, the heavy metal concentration in soil mainly depends on the mineralogical compositions of main material and the soil formation processes. Characteristics and mineral contents of soil might vary between the regions and even within a region depending on factors such as geological structure, topography, main material, and vegetation [1]. Thus, the results achieved might suggest that the concentrations of heavy metals examined here in the air were not at severe levels and that their concentrations in soil were shaped mainly by the bedrock.

Nowadays, urbanization is considered one of the irreversible problems throughout the world and urban areas bring many problems with them. Among these problems, the possibly most important one is the environmental pollution [33-38]. It was reported that the air, water, and soil pollution reach significant levels in urban areas [39-48]. The most prominent one among the components being affected by the increase in pollution at most is the soil because the pollutants and especially the heavy metals in the air come down and accumulate on the surface of soil.

Heavy metal pollution in the soil poses an important problem for all organisms, including the humans. First of all, soil is the structure, which all the ecosystem and organic life depend on. As known, the entire organic life directly or indirectly relies upon plants [49, 50]. The growth of plants requires appropriate climatic and soil conditions. In interaction with genetic structure of the plant, the environmental conditions shape the entire character of plants [51-60]. Soil, one of the most important environmental conditions, directly influences almost all the characteristics of plant including growth performance and nutrient content [61].

Soil pollution poses a gradually increasing threat to human health and environmental quality. The plants grown in soils polluted by heavy metals intake many of these heavy metals into their organism and consuming these plants as food cause severe medical problems. The change in soil quality due to the soil pollution reached such a level that threatens both nature and ecosystem. The current level of heavy metal pollution is such severe that the heavy metal concentrations in the air significantly threaten the human health and that heavy metal concentrations in soil in several regions reached the level threatening the food security via herbal intake [1, 62]. Although heavy metals are very important and dangerous pollutants for human and environmental health, their concentrations in soil, air, and water gradually increase. However, there are only few studies examining the extent of this increase. Thus, further studies should be carried out at a higher level of diversity on this subject.

5. Conclusion

The result of the study was determined that the elements changed significantly on the basis of locations, but this change was not directly related to traffic, industry, or urban areas, which are thought to be a pollution factor. This result shows that the concentrations of heavy metals in the soil are shaped by soil lithology rather than anthropogenic factors. Accordingly, it can be said that the soils in Kastamonu city center are not polluted in terms of heavy metals. However, detailed analysis should be made in agricultural soils where heavy metal pollution is relatively high, and it should be determined whether heavy metal pollution is caused by lithology or agricultural activities. In addition, agricultural products grown in the region should be examined in terms of heavy metal risks.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare that they no conflict of interest. The none of the authors have any competing interests in the manuscript.

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