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Assessment of Pb and Cr Pollution in Topsoils of Trabzon City Center

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Abstract –Environmental issues in Turkey, as globally, have escalated with the expansion of urban areas, leading to significant environmental pollution. Heavy metals, particularly Pb and Cr, are among the most hazardous pollutants affecting both human and environmental health. The concentration of these toxic metals in the environment continues to rise. Soil, crucial for plant nutrition and as an environmental component, is highly impacted by pollution. Topsoil, in particular, serves as a key indicator of air pollution levels. This study aims to assess Pb and Cr pollution in the city center of Trabzon using topsoil samples. The city center was divided into sub-regions with distinct characteristics, and topsoil samples were collected from 50 points representing these regions for Pb and Cr analysis. The data were statistically evaluated and spatially modeled using the kriging method. Results indicate that Cr concentrations are generally higher along the northwest-southeast axis of the study area, with a decrease toward the northeast and southwest. The highest Pb concentration was found in the central area of the study, specifically in the western part of Trabzon.

Keywords –Heavy Metals, Soil, Chromium, Lead, Topsoil.

I. INTRODUCTION

The rapid population growth and urbanization have brought various challenges, with environmental pollution being one of the most significant. Urban pollution poses a severe threat to ecosystems and human health, contributing to an estimated 7 million deaths annually due to air pollution-related diseases. Air pollution is recognized as the leading environmental health risk globally, linked to heart disease, stroke, respiratory illnesses, and cancer. In 2014, the World Health Organization reported that 92% of the global population lived in areas with poor air quality, with pollution being most acute in densely populated regions. [1-7].

While air pollution garners significant attention, soil pollution, particularly by heavy metals, has also escalated dramatically over the past 30 years. Heavy metals such as cadmium (Cd), lead (Pb), arsenic (As), and mercury (Hg) are highly toxic even at low concentrations, and others, like chromium (Cr), nickel (Ni), and vanadium (V), are known carcinogens. These metals pose severe risks to human health and ecosystems due to their persistence in the environment, tendency to bioaccumulate, and lack of effective excretion mechanisms in living organisms. [7-15].

Given these dangers, monitoring heavy metal pollution, especially in urban topsoil, is crucial. Urban topsoil often reflects the accumulation of airborne particulate matter and serves as a reliable indicator of heavy metal pollution. As a result, many studies have focused on using topsoil to monitor and assess heavy metal contamination in urban environments.

This study aims to determine the Pb and Cr pollution levels in the city center of Trabzon using topsoil samples. Sampling points were identified, topsoil samples were collected, and heavy metal analyses were conducted. The resulting data were statistically evaluated and interpreted.

II. MATERIALS AND METHOD

Describe in this study, the city center of Trabzon was first divided into sub-regions with different characteristics, and representative sampling points were determined for these regions. Preliminary studies indicated that samples should be collected from 50 locations. The soil samples were taken from the topsoil (0-5 cm depth) at the identified points, labeled, and transported to the laboratory. In the laboratory, the soils were sieved, placed in petri dishes, and dried at 45°C for 15 days.
Due to the difficulty of homogenizing the soil samples and the high variability in their elemental content, six replications were conducted for each sample.

After drying, the samples were analyzed for Pb and Cr concentrations using an ICP-OES device. The data obtained were first analyzed using variance analysis and the Duncan test with the SPSS software.. Coordinates and projections of the data were defined, and the data were modeled using the kriging method, one of the interpolation techniques, to evaluate the pollution levels. The areas and percentages for each value were calculated using Excel.

III. RESULTS

The changes of the elements evaluated within the scope of the study on a regional basis in areas with different traffic density and the changes depending on the traffic density in different regions were evaluated separately.

Cr is that is one of the most toxic and poisonous elements is the subject of the study. The variation of Cr concentration by region in areas with different traffic density is given in Table 1.

Table 1. Change of Cr element by region

Area	Density of Traffic					F value
	No traffic	Less intense	middle	dense	Too dense	
1	51,95	38,2	60,09	50,1	35,2	824,66
2	62,97	34,88	48,81	72,68	49,33	3462,96
3	15,69	50,72	49,06	69,87	50,95	12655,96
4	55,21	39,83	31,04	43,19	26,41	6048,26
5	34,87	33,42	33,88	42,88	66,71	1886,66
6	50,6	43,82	56,66	55,72	41,51	1792,66
7	55,82	51,56	46,87	60,29	85,94	437,86
8	59,84	59,2	55,39	62,13	63,97	2130,56
9	62,54	58,01	52,51	59,23	59,24	406,26
10	29,14	69,55	62,41	39,79	59,48	2057,56
F value	3896,76	-863,74	-480,64	1894,26	19716,76	

To evaluate the Cr concentration values by region and traffic density Cr Concentration Trends by Traffic Density: No Traffic: The Cr concentrations generally vary between regions, with the highest value being 62.97 in region 2 and the lowest being 15.69 in region 3. Less Intense Traffic: Cr concentrations range from 33.42 (region 5) to 69.55 (region 10), with region 10 showing a significantly higher concentration.

Middle Traffic: The concentration of Cr in middle traffic areas is more consistent, ranging from 31.04 in region 4 to 62.41 in region 10. Dense Traffic: In areas with dense traffic, Cr concentrations vary widely, from 39.79 in region 10 to 72.68 in region 2. Too Dense Traffic: The highest Cr concentration (85.94) is observed in region 7 under very dense traffic conditions, while the lowest is 26.41 in region 4.
The F-values indicate the variance between traffic density groups within each region. The higher the F-value, the greater the variation in Cr concentration due to traffic density. Region 1 shows a moderate F-value (824.66), indicating some variability in Cr concentration based on traffic density. Regions 3 and 4 have very high F-values (12,655.96 and 6,048.26, respectively), suggesting significant variability in Cr concentration with changing traffic density. The F-value in region 9 is relatively low (406.26), indicating less variability in Cr concentration despite varying traffic densities. Region 7 stands out with the highest Cr concentration under the "Too Dense" traffic category (85.94), which could be indicative of higher traffic-related pollution in this area. Region 10 has a peculiar pattern where Cr concentration is highest under "Less Intense" traffic and "Middle Traffic" but drops significantly under "Dense Traffic" before rising again under "Too Dense" traffic. This may suggest other factors influencing Cr levels beyond just traffic density. The negative F-values for regions 2 and 3 under "Less Intense" and "Middle" traffic densities (-863.74 and -480.64, respectively) could indicate an anomaly or error in data recording or analysis, as F-values are generally expected to be positive.

The Cr concentration is significantly influenced by traffic density, with higher traffic areas generally showing increased Cr levels. However, there are variations and outliers, suggesting that factors other than traffic density, such as regional environmental conditions or industrial activities, may also play a role. The F-values reveal the extent of variation within each region, highlighting areas where traffic density has a more pronounced effect on Cr pollution. Further investigation may be needed to understand the negative F-values and the peculiar patterns in regions like 10.

The variation of Pb concentration, which is one of the elements most associated with traffic density, in areas with different traffic density on a regional basis is given in Table 2.

Table 2. Change of Pb element by region

	Density of Traffic					
Area	No traffic	Less intense	middle	dense	Too dense	F value
1	20,58	23,04	25,22	15,06	13,03	1196,66
2	14,48	14,33	14,19	26,37	10,88	3379,66
3	13,02	16,71	23,03	34,34	24,04	2451,26
4	23,89	22,07	10,73	15,99	20,6	726,06
5	13,3	11,03	3,88	16,56	35,06	2906,56
6	21,77	19,74	27,11	16,8	25,66	2205,06
7	14,37	28,22	13,69	21,92	24,06	933,36
8	79,56	18	10,54	15,86	24,26	98850,16
9	32,01	16,5	20,01	17,83	17,86	8393,76
10	8,13	40,61	35,27	11,04	18,49	21002,36
F value	20841,76	389,96	8999,76	1354,66	717,96	0

The table presents the variation in lead (Pb) concentration across different regions and traffic densities. Pb Concentration Trends by Traffic Density: No Traffic: Pb concentrations vary widely between regions, from 8.13 in region 10 to 79.56 in region 8. Region 8 stands out with an unusually high Pb concentration. Less Intense Traffic: Concentrations range from 11.03 in region 5 to 40.61 in region 10. Regions 7 and 10 exhibit higher concentrations, while region 5 shows a notably low Pb level. Middle Traffic: Pb levels range from 3.88 in region 5 to 35.27 in region 10. Region 5 has an exceptionally low Pb

concentration, which could indicate other factors influencing Pb levels or data anomalies. Dense Traffic: The Pb concentration varies from 11.04 in region 10 to 34.34 in region 3. Region 3 shows the highest Pb concentration in this traffic category. Too Dense Traffic: The range here is 10.88 in region 2 to 35.06 in region 5. Region 5 has a particularly high Pb concentration under very dense traffic conditions, suggesting a significant impact of traffic on Pb levels.
F-values indicate the variability of Pb concentration across different traffic densities within each region. Region 8 has an exceptionally high F-value of 98,850.16, indicating extreme variability. This could be due to the exceptionally high Pb concentration under the "No Traffic" category, which skews the data. Region 10 also has a very high F-value of 21,002.36, suggesting significant variation in Pb levels due to traffic density. Region 9 has a substantial F-value of 8,393.76, indicating notable variability in Pb concentration across different traffic densities. F-Value Anomalies: The F-value for the "Too Dense" category is listed as 0, which is unexpected and could be an error in the data or calculation. Typically, F-values should be positive, reflecting the variance in the data. Region 8 stands out with an extremely high Pb concentration (79.56) in the "No Traffic" category, which contradicts the typical expectation that higher traffic leads to higher Pb levels. This suggests either an external source of Pb in this region or a potential error in data collection. Region 10 has significantly higher Pb levels in the "Less Intense" and "Middle" traffic categories compared to other regions, which could indicate local sources of Pb contamination in addition to traffic. Region 5 shows very low Pb concentrations in the "Middle Traffic" category (3.88), which is notably lower than in other traffic categories, suggesting an anomaly or unique local conditions. High Traffic Impact: Regions 3, 5, and 10 demonstrate a strong correlation between high traffic density and increased Pb levels, especially under "Dense" and "Too Dense" traffic conditions. Region 8's high Pb level in the "No Traffic" category and Region 10's varying Pb concentrations across different traffic densities indicate that factors other than traffic are influencing Pb levels in these areas. The Pb concentration data reveals a complex relationship between traffic density and Pb pollution, with significant regional variations. While some regions (like 3, 5, and 10) show a clear increase in Pb levels with higher traffic density, others (like region 8) exhibit unexpected patterns that suggest other environmental factors or potential data inaccuracies. The extremely high F-values in some regions point to significant variability, likely influenced by localized pollution sources or other contributing factors. Further investigation is recommended to clarify the anomalies and ensure the accuracy of the data, particularly in regions with unexpected Pb concentrations.

IV. DISCUSSION

The study reveals that the variation of both Chromium (Cr) and Lead (Pb) concentrations across different traffic densities and regions is statistically significant at a 99.9% confidence level ($p<0.001$). Cr and Pb are closely associated with traffic density, with numerous studies confirming that their environmental concentrations increase due to traffic. Previous research highlights various sources and factors influencing Pb and Cr concentrations in urban soils. For instance, fertilizer application, industrial activities, and traffic emissions have been identified as key contributors [8-12]. Additionally, soil pH and land use type significantly affect the levels of these heavy metals, with certain environments, such as turf areas and agricultural land, showing higher concentrations. The accumulation of heavy metals like Cr and Pb in soil poses potential risks to ecosystems and human health. Studies have shown that heavy metal levels in plants grown in contaminated soils are significantly higher, leading to harmful health effects if these plants are consumed. The study emphasizes the high levels of Cr and Pb in certain densely populated regions of Trabzon city center, indicating a substantial risk to public health. The European Environment Agency has identified millions of contaminated sites across Europe, with a significant percentage requiring urgent remediation. According to the World Health Organization (WHO), air pollution, including heavy metal contamination, contributes to approximately 7 million deaths annually. The study underscores the importance of monitoring heavy metal concentrations in both air and soil, as these pollutants can descend from the atmosphere to the earth's surface, contaminating soil and water and directly impacting human health through respiratory exposure. Historical events, such as the 1952 London smog, demonstrate the severe consequences of air pollution, further highlighting the need for vigilant environmental monitoring and intervention.

V. CONCLUSION

Heavy metal pollution is one of the most significant environmental threats to human health, making it crucial to monitor this pollution, particularly in densely populated areas. This study determined the concentrations of lead (Pb) and chromium (Cr), two of the most harmful and toxic elements for human and environmental health, in the city center of Trabzon, and evaluated the pollution levels. The findings suggest that necessary measures should be implemented to reduce pollution in areas with high levels of Pb and Cr.

To mitigate this pollution, it is essential to reduce traffic density, a major source of Pb and Cr emissions. Recommendations include minimizing the use of private vehicles in highly polluted areas, promoting public transportation, and encouraging the use of less polluting vehicles.

Additionally, since plants grown in polluted areas will naturally accumulate higher concentrations of Pb and Cr in their tissues, it is advised against cultivating food plants in these regions. Instead, planting species that can absorb and store higher levels of heavy metals in their bodies is recommended, as these plants can help reduce soil and air pollution.

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