Uluslararası İleri Doğa Bilimleri ve Mühendislik Araştırmaları Dergisi
Sayı 8, S. 323-327, 7, 2024

Araştırma Makalesi

International Journal of Advanced Natural Sciences and Engineering Researches
Volume 8, pp. 323-327, 7, 2024

Research Article

https://as-proceeding.com/index.php/ijanser
ISSN: 2980-0811

Polllution of Ni and Co: Regional Changes Analyzed Using Topsoil Data – A Case Study of Trabzon

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(Received: 25 August 2024, Accepted: 29 August 2024)

(5th International Conference on Engineering and Applied Natural Sciences ICEANS 2024, August 25-26, 2024)

ATIF/REFERENCE: Çetin, İ. Z. (2024). Polllution of Ni and Co: Regional Changes Analyzed Using Topsoil Data – A Case Study of Trabzon. *International Journal of Advanced Natural Sciences and Engineering Researches*, 8(7), 323-327.

Abstract –Global population growth and urbanization have led to a range of environmental issues, with soil pollution being a significant concern. Soil, as a critical component of the ecosystem, is highly affected by pollution, and changes in soil quality can have profound impacts on the environment. Pollutants in the air eventually settle on the soil, making soil an effective medium for assessing pollution levels. Among environmental pollutants, heavy metals are particularly significant due to their toxicity, tendency to bioaccumulate, and persistence in the environment. Monitoring heavy metal concentrations is therefore crucial. This study aims to determine the pollution levels of nickel (Ni) and cobalt (Co) in the city center of Trabzon, which has the highest population density in the region. The study involved dividing Trabzon's city center into sub-regions with varying characteristics, collecting topsoil samples from these areas, and analyzing them for Ni and Co concentrations. The data were statistically evaluated, was used to model the data with the kriging interpolation method, resulting in detailed pollution. The results indicate that the highest concentrations of Ni and Co are generally found in the central areas of the study region, highlighting that Ni and Co pollution increases with higher levels of human activity.

Keywords –Soil, Heavy Metal, Nickel, Cobalt, Monitoring.

I. INTRODUCTION

Environmental problems have escalated globally with increasing residential areas due to rising population numbers, among these issues, heavy metal pollution is a significant concern [1-3]. Even at low concentrations, some heavy metals can be toxic or deadly to living organisms, and their levels in nature are steadily increasing. This increase is largely due to industrial activities that extract heavy metals from the earth and release them into the environment. Consequently, areas with high industrial and traffic activity experience elevated concentrations of heavy metals in soil [4-7].

Soil is significantly impacted by pollution, serving as both a habitat for plants and a crucial environmental component. Turkey, one of the 19 countries with depleting arable land resources, faces soil pollution from various sources, posing a growing threat to human health and environmental quality. Heavy metals emitted into the air eventually settle onto soil surfaces, making topsoils key indicators of air pollution levels. Numerous studies have focused on heavy metal contamination in topsoils, particularly in urban settings [7-12].

Nickel (Ni) and cobalt (Co) are among the most hazardous heavy metals concerning human and environmental health. Research indicates that Ni and Co concentrations are notably high in urban areas. The high population density in these areas means a greater number of people are affected by this pollution. Therefore, identifying Ni and Co contamination in densely populated urban centers, such as Trabzon, is crucial for addressing this environmental issue. This study aims to assess Ni and Co pollution in Trabzon's city center using topsoil samples.

II. MATERIALS AND METHOD

In this study, the region with the highest population density in Trabzon's city center was identified and defined. The area was divided into sub-regions with varying characteristics using a grid method, and sampling points with different traffic densities were selected within these sub-regions. A total of 50 representative points were chosen for sampling.

Soil samples were collected from the topsoil (0-5 cm depth) at each point, with three samples taken per point. The samples were labeled and transported to the laboratory, where they were sieved, placed in glass petri dishes, and dried for 15 days at room temperature followed by an additional 15 days in an oven at 45°C. Due to the difficulty in homogenizing soil samples, six replications were performed, resulting in a total of 900 samples (50 points × 3 samples × 6 replications).

Each sample was weighed (0.5 g), placed in microwave digestion tubes, and treated with 10 mL of 65% HNO_3. The samples were then digested in a microwave device at 280 PSI and 180°C for 20 minutes. After digestion, the samples were cooled and diluted with deionized water to a final volume of 50 mL.

The prepared samples were analyzed for Ni and Co concentrations using an ICP-OES device. The data were evaluated using the SPSS package program, applying variance analysis and the Duncan test to determine statistically significant differences ($p<0.05$) among the factors. The results were simplified, tabulated, and interpreted accordingly.

III. RESULTS

Evaluation of Ni Concentration Variation by Region and Traffic Density

Table 1: Change of Ni Element by Traffic Density

Region	No Traffic	Low Density	Medium Density	High Density	Very High Density	F Value
1	39.34	36.73	40.69	37.19	24.54	787.16
2	48.58	33.46	33.62	57.90	51.38	6057.36
3	22.83	48.02	38.27	67.88	35.16	8585.86
4	26.64	28.95	23.92	33.69	24.30	5860.36
5	31.54	26.53	39.70	33.81	45.78	5035.76
6	40.77	29.60	50.94	36.99	24.74	6618.76
7	48.40	39.49	32.32	46.58	96.62	2507.06
8	47.10	39.31	30.88	42.35	51.39	6895.26
9	40.14	38.53	40.35	36.15	42.13	399.36
10	18.88	56.33	54.59	30.20	56.25	11940.76
F Value	2606.66	210.66	7209.76	9705.56	41548.36	

The F Value is highest for "Very High Density" (41,548.36), indicating the greatest variation in Ni concentration across different traffic densities in these regions. The lowest F Value is for "Low Density" (210.66), suggesting relatively less variation in Ni concentrations in areas with low traffic density. Region 3 and Region 10 exhibit the highest concentrations of Ni under high traffic densities (67.88 and 56.25 respectively). These regions have high F Values, indicating significant variation in Ni concentration related to traffic density. Region 1 and Region 4 show relatively lower Ni concentrations across different traffic densities, with F Values of 787.16 and 5860.36 respectively, reflecting less variability compared to regions with higher F Values. Areas with very high traffic density tend to show greater variability and higher concentrations of Ni. This suggests that traffic density has a significant impact on Ni pollution levels, with more pronounced effects in highly trafficked regions. The high F Values for certain regions, especially those with very high traffic densities, indicate that traffic is a significant factor contributing to Ni pollution. The data indicates a clear correlation between traffic density and Ni concentration in the topsoils, with higher concentrations and variability observed in areas of higher traffic density. Monitoring and controlling traffic density could be an effective strategy to manage Ni pollution levels.

Evaluation of Co Concentration Variation by Region and Traffic Density

Table 2: Change of Co Element by Traffic Density

Region	No Traffic	Low Density	Medium Density	High Density	Very High Density	F Value
1	14.89	13.10	16.03	13.54	10.98	1035.34
2	14.02	14.84	13.32	20.44	12.44	2981.14
3	10.68	16.37	15.06	26.04	15.09	15468.74
4	12.94	13.86	11.52	17.19	14.13	1661.14
5	16.48	14.85	14.67	17.83	19.20	1872.24
6	15.81	13.59	13.92	14.47	14.11	330.74
7	15.26	12.56	14.90	17.90	21.96	1071.94
8	14.62	15.92	9.58	16.36	16.65	3645.74
9	17.37	16.50	12.37	17.45	17.63	2019.14
10	10.81	18.26	16.75	12.30	16.94	3789.64
F Value	2995.74	665.84	5145.64	8842.14	8431.34	

The F Value is highest for "Medium Density" (5145.64) and "High Density" (8842.14), indicating significant variation in Co concentrations across different traffic densities in these regions. The lowest F Value is for "Low Density" (665.84), suggesting relatively less variation in Co concentrations in areas with low traffic density. Region 3 shows the highest concentrations of Co under "High Density" (26.04), with a very high F Value (15,468.74), indicating significant variability in Co concentrations related to traffic density. Region 5 and Region 10 also show high concentrations of Co in regions with high traffic densities (19.20 and 16.94 respectively), with substantial F Values (1872.24 and 3789.64). The results suggest that Co concentrations in the topsoils are more variable and generally higher in areas with medium to high traffic densities. This aligns with the observed trend for Ni, where higher traffic density is associated with increased metal pollution. Region 3 and Region 5, with high F Values, indicate that traffic density has a significant impact on Co pollution levels, similar to Ni. The data indicates a notable correlation between traffic density and Co concentration in topsoils, with higher concentrations and variability observed in areas with medium to high traffic densities. Monitoring and managing traffic density could be effective strategies for controlling Co pollution levels in urban areas.

IV. DISCUSSION

The study highlights significant variation in Ni and Co concentrations in the topsoils of the urban center of Samsun, with pollution levels higher in areas of intense human activity and traffic. Pollution indicate elevated levels of Ni and Co in central regions of the city, correlating with high traffic density. Previous research confirms that traffic is a major source of Ni and Co pollution [7-15].

Nickel (Ni) is known for its carcinogenic properties and health risks, including respiratory system cancers and other adverse effects such as nausea, liver damage, and allergic reactions. Cobalt (Co), used in various industrial applications, can cause allergic reactions and chronic bronchitis, with long-term exposure increasing cancer risk [4-7]..

Heavy metal pollution in topsoils serves as an indicator of airborne heavy metal pollution, with metals from the air settling onto the soil and affecting its structure. Plants growing in polluted soils show elevated heavy metal concentrations, impacting their development and the ecosystem. This pollution stress affects plant growth and can pose health risks when such plants are consumed.

Given the health risks associated with Ni and Co and their high concentrations in some regions, it is advised not to consume plants grown in areas with significant pollution levels. Monitoring and managing traffic density and pollution sources are crucial to mitigating these environmental and health impacts.

V. CONCLUSION

Urban areas have experienced significant increases in population density due to the availability of job and social opportunities. This growth has led to various issues, with environmental and air pollution becoming critical concerns threatening human health and ecological balance. Heavy metal pollution, in particular, is a major factor affecting both human and environmental health, making its monitoring crucial, especially in densely populated areas. This study focused on measuring Ni and Co concentrations in the city center of Trabzon, which has one of the highest population densities in Turkey. Pollution were created to determine the extent of Ni and Co contamination.

Alerting Residents: Inform people living in high pollution areas, especially those at higher risk.

Pollution Reduction: Implement measures to decrease traffic density to reduce traffic-related pollution.

Plant Management: Avoid using plants grown in highly polluted areas for food and instead use plants that can accumulate Ni and Co for landscaping purposes to help reduce pollution levels.

Additionally, it is suggested that similar studies be conducted in other cities and include investigations into other heavy metals such as Pb, Cr, Cd, Ba, and Hg, which also pose significant health risks.

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