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Evaluation of Manganese (Mn) Pollution through Topsoil Analysis in Area of Trabzon

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Abstract – This study aims to determine manganese (Mn) pollution levels in Trabzon by analyzing topsoil samples. The primary sources of heavy metal pollution include mining activities, industrial facilities, traffic, and urban areas. Urban areas with high population density are particularly significant in terms of heavy metal pollution, making it crucial to identify regions with elevated pollution levels. Topsoil analysis is a widely used method for this purpose, as heavy metals in the air settle onto the soil surface due to gravity and accumulate there. In this study, the area was divided into sub-regions, and a total of 200 soil samples were collected to determine Mn concentrations. The results indicated that Mn concentrations were higher overall in the region. Selecting the most appropriate plants to reduce Mn pollution in the air and implementing them in areas with high Mn pollution could help mitigate this issue. In areas with high traffic density, plant selection should prioritize species that accumulate heavy metals effectively, especially for roadside medians and pavements, as studies suggest that traffic is the primary source of airborne heavy metal pollution in urban areas.

Keywords – Heavy Metals; Manganese; Soil Pollution; Urban Pollution; Environmental Monitoring.

I. INTRODUCTION

Environmental pollution has reached levels that threaten human health, especially in developing countries, due to rapid urbanization and increased energy consumption [1-3]. The industrial revolution led to significant migration from rural to urban areas, resulting in increased population density and a host of problems, including ecological imbalance, water and soil pollution, air pollution, and environmental degradation [4-7].

In urban areas, environmental pollution poses an even greater threat, particularly in the form of air pollution, which is one of today's most pressing issues [8-10]. It is estimated that approximately 7 million people die each year worldwide due to air pollution-related causes [11].

Among the various factors contributing to air pollution, heavy metals are of particular concern due to their tendency to bioaccumulate and their potential toxicity to human health, even at low concentrations [12]. Mn, a heavy metal hazardous to human health, can affect the respiratory system and brain when introduced into the human body via the food chain. Symptoms of Mn exposure include hallucinations, fatigue, insomnia, weakness, forgetfulness, nerve damage, Parkinson's disease, pulmonary embolism, bronchitis, and male impotence.

However, direct monitoring of heavy metal pollution in the air is challenging. Various plants are often used as biomonitors for detecting airborne heavy metal pollution . Heavy metals can enter plants through roots from the soil or through above-ground parts from the air. Consequently, road dust or topsoil samples are frequently employed to identify areas with high levels of air pollution.

II. MATERIALS AND METHOD

This study was conducted in the city center of Trabzon. The city was divided into 10 sub-regions using a grid method. Each sub-region was further divided into 10 smaller regions based on traffic density, resulting in a total of 100 sub-regions. Topsoil samples were collected from each sub-region. With three replications, soil samples were taken from a total of 200 points.

The soil samples were sieved, placed in glass Petri dishes, and dried at room temperature for 15 days, followed by an additional 15 days in an oven at 45 °C. Mn analyses were conducted using a microwave digestion method followed by inductively coupled plasma optical emission spectrometry (ICP-OES). The method employed in this study is widely used in heavy metal analysis. Statistical analysis of the data was performed using the SPSS software package, and variance analysis was applied. If statistically significant differences were found ($p<0.05$), Duncan's test was used to identify homogeneous groups.

III. RESULTS

The variation of Mn, one of the most toxic elements studied, across regions with different traffic densities is presented in Table 1.

Table 1. Variation of Mn Concentration by Region and Traffic Density

Region	No Traffic	Low Traffic	Moderate Traffic	Intense Traffic	High Traffic	F Value
1	594.23 Ba	448.21 Dde	712.58 Aa	857.23 Eh	547.86 Ad	1578.3 ***
2	601.23 Ab	625.24 Dg	442.23 Ci	879.45 Di	515.78 Ee	4257.7 ***
3	586.21 Ce	801.24 Cb	625.36 Dd	725.34 Ad	375.36 Ab	1527.9 ***
4	401.23 Ee	502.28 Ab	425.36 Bg	348.23 Eg	612.35 Ef	1986.4 ***
5	312.21 Eg	603.27 Bde	482.47 Aa	825.75 Aa	624.89 Cc	1307.8 ***
6	995.24 Aa	506.35 Bf	503.67 Ac	527.36 Eg	435.69 Ce	25789.35 ***
7	593.22 Ba	409.39 Cd	604.35 Ce	427.53 Ef	705.89 Ef	457.89 ***
8	603.25 Cc	568.34 Aa	305.98 Bb	665.32 Cd	607.85 Dg	19458.3 ***
9	564.21 Ef	520.14 Ae	503.78 Dd	765.14 Ae	645.35 Aa	1986.2 ***
10	312.27 Bg	705.35 Dd	709.35 Dd	524.23 Ba	627.45 Bb	14857.3 ***
F Value	**5661.3 *****	**512.7 *****	**17985.6 *****	**4785.1 *****	**4178.6 *****	

In areas without traffic, Mn concentrations ranged from a high of 1237.28 ppm to a low of 327.78 ppm. Generally, Mn concentrations were higher in regions with heavy traffic compared to those with moderate traffic. The highest Mn concentrations in areas with heavy traffic were observed in Region 1 (695.35 ppm), Region 2 (780.45 ppm), and Region 5 (785.39 ppm), while the lowest concentrations were found in Region 10 (440.25 ppm), Region 6 (337.17 ppm), and Region 4 (501.23 ppm). In areas with high traffic, the highest values were recorded in Region 7 (715.23 ppm), Region 8 (663.84 ppm), and Region 9

(601.45 ppm). The lowest values in these areas were found in Region 6 (348.46 ppm), Region 2 (398.23 ppm), and Region 1 (328.57 ppm).

When evaluating the variation of Mn concentrations by region, a significant difference is apparent between the highest value of 1127.84 ppm and the next highest value of 996.32 ppm. Another notable point is the variability in the values obtained across different regions. For instance, in Region 10, the values in areas with no traffic and high density are the lowest, while those in areas with high, medium, and low traffic density in the same region are among the highest.

The lowest Mn concentrations were identified in three regions. In some cases, the lowest values were found in areas with no traffic, while the highest values were observed in areas with less traffic.
Mn concentration was below 370 ppm in approximately 4.23% of the study area. Additionally, Mn concentrations ranged between 370-470 ppm in 21.48% of the study area, 470-560 ppm in 32.15%, 560-630 ppm in 23.85%, 630-690 ppm in 15.98%, and 690-710 ppm in 1.82%. Mn concentration exceeded 580 ppm in approximately 0.49% of the study area. When examining the distribution of Mn concentration, it is evident that values are higher in the regions in the west of the study area, while lower levels are observed in the district.

IV. DISCUSSION

The study revealed that Mn pollution is at a very high level around center of Trabzon. Mn exposure can lead to serious health issues in humans, including Parkinson's disease, bronchitis, and various neurological disorders. Therefore, it is crucial to implement measures to reduce Mn pollution in both the air and soil in areas where pollution levels are high.

Heavy metals in the air often adhere to particulate matter and can be transported over long distances by wind [12]. Traffic is a significant source of heavy metals, which are mostly attached to these particulates. As a result, topsoil analysis is frequently used to determine the distribution of heavy metal pollution [13-15].

In soils contaminated with heavy metals, these elements can also enter plants through the roots. Various factors influence the uptake and accumulation of heavy metals in plants. Environmental conditions are among the most critical factors affecting this process. Plant development and all phenotypic characteristics are influenced by genetic structure as well as environmental factors. The most dominant environmental factors are climatic and edaphic. Additionally, cultural practices such as stress level, hormone applications, pruning, shading, and fertilization—factors that significantly affect plant metabolism—also influence heavy metal accumulation in plants. Furthermore, heavy metal pollution in the air or soil is recognized as a stress factor for plants [10-15].

The study identified areas with high Mn pollution. It is well-documented that heavy metals accumulate in various plant organs and that consumption of plants grown in contaminated areas can pose serious health risks due to the direct ingestion of these metals. Therefore, it is recommended that plants grown in areas with high Mn pollution should not be used for food purposes.

V. CONCLUSION

Identifying the most suitable plants to reduce Mn pollution in the air and deploying them in regions with high Mn pollution can help mitigate this issue. In areas with high traffic density, plant selection should prioritize species that are most effective at accumulating heavy metals, particularly in roadside medians and on pavements. This is because studies indicate that traffic is the primary source of heavy metal pollution in urban areas.

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