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Evaluation of Cedrus atlantica as a Biomonitor

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Abstract **–**In the past century, heavy metal levels have steadily increased due to human activities, posing significant risks to both human health and the environment. Palladium (Pd) is one of the most dangerous and toxic heavy metals and is listed as a priority pollutant by the Agency for Toxic Substances and Disease Registry (ATSDR). Therefore, reducing Pd pollution and monitoring changes in atmospheric Pd contamination are critical research areas. This study aims to assess the potential of Cedrus atlantica, a species used in landscape design in Samsun, to monitor and reduce atmospheric Pd pollution. The study analyzed Pd content in Cedrus atlantica by species, organ, and direction. The results identified variations in Pd levels across different periods and directions in wood samples. Comparisons between directions revealed significant differences in Pd levels within the same period and across different periods for the same direction. This variation suggests that Pd is transported in a limited manner within the wood. The findings conclude that Cedrus atlantica performs effectively as a biomonitor for tracking Pd contamination.

Keywords –Heavy Metal, Biomonitoring, Palladium, Pollution, Monitor.

I. INTRODUCTION

Air pollution is a global environmental issue that poses a serious threat to ecosystems and human health. Among various types of air pollution, heavy metal contamination is considered one of the most harmful. Heavy metals spread in densely populated urban areas due to vehicles, industrial facilities, and other anthropogenic activities. These pollutants are among the most dangerous environmental contaminants, contributing to millions of deaths each year. [1-7].

Palladium (Pd) is a significant heavy metal used in automotive catalysts and various chemical processes. However, the accumulation and bioavailability of Pd in the environment pose potential health risks. The literature on the health effects and toxicity of Pd is limited, but exposure via inhalation can lead to respiratory system diseases and other toxic effects. Therefore, monitoring and controlling Pd concentrations in the environment is crucial. [7-15].

This study focuses on examining changes in atmospheric Pd concentrations in Samsun over four decades. It aims to identify factors influencing Pd pollution and explore possibilities for mitigating its environmental effects. Determining heavy metal concentrations in the air is typically challenging and costly, which is why biomonitors are often preferred for monitoring. Biomonitors are valuable tools for tracking air pollution and assessing the environmental impacts of pollutants.

In this context, this study investigates the changes in Pd concentrations in Cedrus atlantica grown under polluted air conditions in Samsun. The primary goal of the study is to monitor atmospheric Pd concentrations and identify the most suitable biomonitor species for reducing Pd pollution. Understanding how Cedrus atlantica can be used as a biomonitor will reveal its effectiveness in air pollution monitoring and management strategies.

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II. MATERIALS AND METHOD

Tree samples of Cedrus atlantica from the Samsun region, known for high heavy metal pollution, were analyzed for palladium (Pd) contamination. Samples were air-dried and then oven-dried at 45 °C. They were processed by dissolving 0.5 grams of dried material in nitric acid and hydrogen peroxide, then mineralized in a microwave at 200 °C for 15 minutes. The solutions were diluted and analyzed using Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES). A total of 100 samples were tested, and data were evaluated using ANOVA and Duncan's test with SPSS 21.0 software to determine statistical differences.

III. RESULTS

The findings of this study reveal that changes in paladium (Pd) concentrations in Cedrus atlantica show significant variations across different directions and plant organs. Changes in Pd concentrations were statistically significant across all directions ($P < 0.05$). The highest Pd concentration was observed in the eastern direction, while the lowest levels were found in the western direction. Analysis by organ indicated that Pd concentration was highest in the inner bark and lowest in the outer bark. Pd concentrations in wood were also found to be at their highest levels.

In period and direction-based analyses, Pd variations were statistically significant in all periods except for 2005-2010. Significant changes in Pd levels were observed in directions other than the western direction.

Examining Pd concentrations by direction and organ revealed marked changes across all organs. Pd concentrations were lowest in the southern direction and highest in the western direction. However, in the western direction, Pd concentrations were below detectable limits in both the outer and inner bark.

Pd concentration changes were statistically significant across all age periods and directions. Pd concentrations were high in the northern and eastern directions, while they were lower in the southern and western directions. The western direction remained below detectable limits for Pd concentrations.

Changes in Pd concentrations over different periods and directions were found to be significant. Pd concentrations were generally high in the northern direction, while the western direction remained below detectable limits. The variation in Pd concentrations was significant across all periods and directions, with high levels observed in the northern and southern directions, and the lowest values recorded in the western direction. In the eastern direction, some periods showed Pd concentrations below detectable limits.

Table 1. Variation in Pd Concentrations by Direction and Plant Organ

Organ	North	East	South	West	F-Value	Average
Outer Bark (OB)	7766.4	3203.4	178.3	178.3	198.1***	5202.2
Inner Bark (IB)	13604.8	2228.4	3642.5	8034.7	398.6***	7063.6
Wood	15972.5	7060.8	3973.7	9977.6	29.1***	9003.7
F-Value	13.1***	2.1 ns	0.6 ns	0.5 ns	1.9 ns	31.3***
Average	14903.7	6055.6	4203.5	8967.5	31.3***	

Table 2. Variation in Pd Concentrations by Period and Direction

Age Range	North	East	South	West	F-Value	Average
2015–2020	13067.5	4737.4	4730.7	178.3	123.6***	6599.4
2010–2015	13064.2	3737.8	3934.7	178.3	1789.2***	5003.4
2005–2010	17063.4	3334.9	1203.4	178.3	3215.5***	6993.5
2000–2005	21975.6	3843.5	4776.6	178.3	136.5***	8732.4
1995–2000	16601.4	19034.4	1873.5	178.3	562.1***	12063.6
1990–1995	13776.7	3041.7	2443.9	178.3	632.1***	6827.1
1985–1990	17714.2	2776.6	5957.5	19034.4	778.1***	12434.4
1980–1985	18063.4	18535.0	102444.1	1844.6	192.3***	13536.6
F-Value	59.2***	396.4***	124.9***	568.2***	1.9 ns	31.2***
Average	15006.4	6066.7	3786.8	9201.8	31.2***	

IV. DISCUSSION

This study found significant variations in palladium (Pd) concentrations in Cedrus atlantica across different directions and plant organs. Pd levels were lower in the western direction and highest in the northern and eastern directions, aligning with existing literature. High Pd concentrations in outer bark suggest particulate matter contamination with heavy metals.

Elevated Pd levels in northern and eastern directions are linked to traffic-related pollution, indicating that Pd emissions and accumulation on plant surfaces are related to traffic. The study reveals limited data on Pd toxicity but confirms that Pd primarily originates from atmospheric sources and accumulates in plants. No significant annual changes in average Pd values were observed, but notable differences among wood samples suggest limited Pd mobility. This supports using tree rings for monitoring heavy metal pollution. Overall, Cedrus atlantica is effective for monitoring and managing Pd pollution, emphasizing the importance of plant species selection for biomonitoring and air pollution management.

V. CONCLUSION

This study found that palladium (Pd) concentrations in Cedrus atlantica wood samples did not show significant variations across directions and periods, though differences were noted between samples from different periods and ages. This suggests limited Pd mobility within wood and indicates that these plants can serve as effective biomonitors for Pd pollution.

Pd movement within wood is restricted, supporting the potential use of these species as biomonitors. Traffic Correlation: Pd pollution is strongly associated with traffic emissions, suggesting a direct link between traffic density and Pd levels. Cedrus arizonica showed the highest Pd concentrations, making it the most suitable species for monitoring and reducing Pd pollution. The study emphasizes the role of plant biomonitoring in managing Pd pollution and provides valuable data for future research and pollution control strategies.

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