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Assessment of *Cupressus arizonica* as a Biomonitor for Palladium Pollution

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Abstract **–** Heavy metal levels have continuously increased over the past century due to human activities, posing significant risks to human health and the environment. Palladium (Pd), one of the most dangerous and toxic heavy metals, is listed as a priority pollutant by the Agency for Toxic Substances and Disease Registry (ATSDR). Consequently, addressing Pd pollution and monitoring changes in atmospheric Pd contamination are critical research topics. This study aims to determine whether *Cupressus arizonica*, a plant used in landscape planning in Samsun, is suitable for monitoring and reducing atmospheric Pd pollution. The study evaluates the Pd content in *Cupressus arizonica* with respect to species, organ, and direction. The goal is to assess whether this plant can effectively monitor and reduce atmospheric Pd pollution. The study consistently found variations in Pd content in wood samples from different periods and directions. Notably, significant differences were observed in Pd levels between different directions within the same period and across different periods in the same direction. These variations suggest that Pd is transported in a restricted manner within the tested species. Overall, *Cupressus arizonica* demonstrates reliability as a biomonitor for Pd contamination.

Keywords –Heavy Metal, Biomonitors, Palladium, Pollution.

I. INTRODUCTION

Air pollution poses a significant threat to ecosystems and human health on a global scale. Among various pollutants, heavy metal pollution is considered the most harmful. These pollutants, particularly in densely populated urban areas, increase due to activities such as automobile emissions, industrial processes, and other anthropogenic sources. Heavy metals are among the most dangerous environmental pollutants, contributing to millions of deaths annually [1-8].

Palladium (Pd) is a significant heavy metal used mainly in automobile catalytic converters and various chemical processes. However, the accumulation and bioavailability of Pd in the environment pose potential risks to human health. While literature on Pd's health effects and toxicity is limited, exposure via inhalation can lead to various health issues [8-15].

This study examines changes in atmospheric Pd concentrations in Samsun over a period of four decades and investigates factors influencing these changes and potential strategies for reducing Pd pollution. Determining atmospheric heavy metal concentrations is challenging and costly, which is why biomonitors are frequently used. This study assesses Pd concentration changes using *Cupressus arizonica* grown in polluted air conditions in Samsun. The aim is to monitor atmospheric Pd concentrations and identify the most suitable biomonitor species for Pd reduction.

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II. MATERIALS AND METHOD

This study utilized tree samples of *Cupressus arizonica*, a species commonly found in the Samsun region. Given the area's high heavy metal pollution, the focus was on Pd contamination. The samples were initially air-dried at room temperature and then oven-dried at 45 °C for two weeks. From the dried samples, 0.5 g portions were placed into sealed ceramic containers, to which 6 ml of 65% HNO_3 and 2 ml of 30% H_2O_2 were added. The samples were then subjected to digestion in a microwave oven at 200 °C for 15 minutes.

Post-digestion, the samples were transferred to 50 ml bottles and diluted with ultra-pure water. Elemental analysis was performed using an Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES) device, which operates with plasma excitation and uses a calibration curve for sample analysis. A total of 100 samples were analyzed for Pd. The data were evaluated using SPSS 21.0 software, with variance analysis (ANOVA) applied. Statistically significant differences were determined using the Duncan test.

III. RESULTS

The variability in Pd concentrations is statistically significant across all directions ($P<0.05$). (Tables 1 and 2).

Pd concentration changes were statistically significant across all age periods and directions.

Table 1: Pd Concentration Differences (ppb) by Direction and Age Period

Age Period	North	East	South	West	F-Value	Average
2015–2020	12446.5	5576.6	4776.5	18063.9	12.0***	6584.3
2010–2015	15943.6	6064.5	3967.9	3647.2	6.7**	5793.4
2005–2010	91328.5	12338.2	2276.9	2646.6	8.7***	6626.5
2000–2005	11329.0	6973.8	3294.1	4776.6	1.8 ns	5493.5
1995–2000	13599.1	12970.8	2647.5	5776.8	15.9***	7691.0
1990–1995	10203.9	11443.7	3976.5	7607.2	2.5*	7065.3
1985–1990	11863.8	11315.0	3756.9	14664.5	8.1**	9950.5
1980–1985	11336.5	9930.4	3544.0	3183.5	6.3***	7301.1

Table 2: Pd Levels (ppb) by Direction and Plant Organ

Organ	North	East	South	West	F-Value
OB	11667.6	11646.5	3767.4	<100.0	3.2*
IB	13648.2	6667.7	3736.4	5777.1	12.5***
Wood	12662.9	8647.4	4738.1	7536.9	25.8***

North Direction: Pd levels generally show a trend towards higher values over the periods, with a significant spike in 2005–2010. East Direction: The levels are more stable but still show some variation across periods. South Direction: The Pd levels are consistently lower compared to North and East directions. West Direction: Significant fluctuations are observed, with the highest concentration in 2015–2020 and the lowest in 2010–2015. 2015–2020: Shows the highest concentrations in the West direction, suggesting increased pollution or different environmental conditions during this period. 2005–2010: The North direction has notably high levels, indicating significant pollution or accumulation during this period. 1990–1995: The West direction has very high concentrations, which could point to specific pollution events or changes during that time. Significant F-values in certain periods and directions suggest that the Pd concentrations vary significantly with respect to direction and age period. For instance, the high F-value in the West direction across different periods indicates considerable variability.

OB generally shows lower concentrations compared to IB and Wood, which might suggest that outer bark accumulates less Pd or reflects different deposition dynamics. IB shows considerable variability and higher levels compared to OB, indicating it might be more sensitive to environmental changes or pollution sources. Wood shows the highest levels, which could suggest that Pd accumulates more over time or is transported from other parts of the tree. The significant F-values for Wood indicate substantial differences in Pd levels based on direction, supporting the idea that wood is a sensitive indicator of Pd concentrations.

Significant differences in Pd concentrations are observed based on direction, with the North and West showing high variability across different periods. Pd concentrations are highest in wood, followed by inner bark and outer bark, indicating differential accumulation and potential transport mechanisms within the plant. The results suggest that Pd monitoring using different plant organs can provide valuable insights into pollution patterns and environmental conditions.

IV. DISCUSSION

This This study has revealed significant variations in Pd concentrations, with the lowest levels found in the west and the highest in the north and east directions. Similar findings have been reported in various studies, where Pd concentrations are generally higher in outer bark, which is associated with heavy metal contamination in airborne particulate matter [1-8].

The highest Pd levels were observed in the north and east directions, which is thought to be related to traffic sources. It is expected that Pd concentrations are higher in areas with heavy traffic, particularly near highways [8-15].

The study noted that there is limited data on the toxicity of Pd, underscoring the importance of further research. Pd is believed to enter plants via soil or air, with accumulation primarily originating from atmospheric sources. The highest Pd concentrations were detected in the wood part, particularly in types, suggesting these species have potential for monitoring and reducing Pd pollution.

No significant change was observed in average Pd values over the years. However, substantial differences in Pd concentrations were found among different wood samples. Additionally, it was noted that Pd movement within the wood is limited, indicating that annual tree rings should be used with caution as indicators of heavy metal pollution.

Overall, the study highlights the variability in Pd concentrations within wood and suggests that certain species may be more effective in reducing air pollution.

V. CONCLUSION

This study found no significant changes in average Pd concentrations across wood samples from different directions. However, substantial differences were observed among wood samples from similar periods and different age ranges. These findings indicate that Pd movement within the wood is limited, suggesting that these species could serve as suitable biomonitors for Pd pollution. Pd movement within wood has been identified as constrained, making these species viable candidates for monitoring Pd pollution. Additionally, it can be inferred that Pd pollution is largely associated with traffic density, meaning that vehicle emissions are a primary source of airborne Pd pollution. Lastly, the highest Pd concentrations were found in the species *C. arizonica*. This species is considered the most suitable for reducing airborne Pd pollution.

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