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Cedrus atlantica's Usability for Reducing and Monitoring the Change in Lithium Pollution in the Air

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Abstract: The most important and harmful components of air pollution that affect the health and cause the death of millions of people every year around the world are heavy metals. Due to their potential harm, monitoring the change in the concentration of heavy metals in the air and reducing pollution are essential. This study aimed to determine the usability of *Cedrus atlantica* grown in Düzce, where heavy metal pollution is reported to be high, for monitoring and reducing the change in lithium pollution in the air. For this purpose, the change in Li concentration in *Cedrus atlantica* annuals grown in Düzce was evaluated in the 60-year period. As a result of the study, it was determined that Li pollution in the region has increased significantly in the last decade. The highest values were generally obtained in the north direction, and this result was interpreted as Li concentration originating from the highway in this direction, i.e., traffic. As a result of the study, *Cedrus atlantica* is a very suitable species for monitoring and reducing the change in Li pollution.

Keywords: Heavy metal, Lithium, Biomonitor, *Cedrus atlantica*, Düzce

Öz: Dünyada her yıl milyonlarca insanın sağlığına zarar veren ve ölümüne neden olan hava kirliliğinin en önemli ve zararlı bileşenleri ağır metallerdir. Potansiyel zararları nedeniyle havadaki ağır metal konsantrasyonundaki değişimin izlenmesi ve kirliliğin azaltılması esastır. Bu çalışmada, ağır metal kirliliğinin yüksek olduğu bildirilen Düzce'de yetiştirilen *Cedrus atlantica*'nın havadaki lityum kirliliğindeki değişimin izlenmesi ve azaltılmasında kullanılabilirliğini belirlemek amaçlanmıştır. Bu amaçla, Düzce'de yetiştirilen *Cedrus atlantica* yıllıklarındaki Li konsantrasyonundaki değişim 60 yıllık periyotta değerlendirilmiştir. Çalışma sonucunda, bölgedeki Li kirliliğinin son on yılda önemli ölçüde arttığı belirlenmiştir. En yüksek değerler genellikle kuzey yönünde elde edilmiş olup, bu sonuç Li konsantrasyonunun bu yöndeki karayolundan yani trafikten kaynaklandığı şeklinde yorumlanmıştır. Çalışma sonucunda, Cedrus atlantica'nın Li kirliliğindeki değişimin izlenmesi ve azaltılması için oldukça uygun bir tür olduğu ortaya çıkmıştır.

Anahtar Kelimeler: Ağır metal, Lityum, Biomonitor, *Cedrus atlantica*, Düzce

1. Introduction

Today, air pollution is one of the most critical problems worldwide (SOURCE). Air pollution causes approximately 6 million premature births, 3 million low-weight babies, and 7 million premature deaths worldwide [1]. It is stated that approximately 2.5 million living spaces are polluted throughout Europe, 90 percent of the world's population breathes polluted air, and one in every 8 deaths is related to air pollution [1-3]. Air pollution also has an unfavorable impact on global climate change [4]. Moreover, global climate change with urbanization is now defined as irreversible problems [5-6].

The most dangerous and harmful components of air pollution are heavy metals. Therefore, many studies have been conducted on known and widespread heavy metals such as Cr [7], Ni [8], and Cd [9]. However, in recent years, in addition to heavy metals such as Pd [1], Ba [10] and Sb [11], which are extremely harmful even at low concentrations, many studies have been conducted on heavy metals such as Fe [12], Al [13], Cu [14], Mg [15] and Zn [16], which are necessary as nutrients for living things but can be harmful at high concentrations. Studies have shown that heavy metals are harmful to living things above a certain concentration in all cases [17] and become more harmful when taken into the human body through the respiratory tract [3]. Therefore, monitoring the change in heavy metal concentration in the air and reducing pollution is essential.

This study investigated the usability of *Cedrus atlantica* in monitoring the change of lithium (Li) pollution in the air and reducing pollution. Lithium has no known biological use and does not appear to be an essential element for life. The Australia Inventory of Chemical Substances has classified metallic lithium as a health, physiochemical, and/or

ecotoxicological hazard according to the National Occupational Health and Safety Commission (NOHSC) approved criteria for classifying hazardous substances. Lithium, lithium aluminum hydride, and lithium methanolate are hazardous substances found on the Danish list [19]. When the Li element is released, it can very quickly join the food chain. Since it mixes with water and can replace other elements, it can be taken up very quickly by the living body and can threaten living life [19].

2. Material and Method

The study was carried out on a *Cedrus atlantica* growing in Düzce province, one of Europe's 5 most polluted cities, according to the World Air Pollution Report 2021 [7]. The topography and meteorological parameters of Düzce province, located in the Western Black Sea province of Türkiye, play a part in the increased air pollution. The primary pollutants that cause air pollution in Düzce arise from industrial facilities, domestic fuel use, and vehicle traffic load. In 2022, log samples taken outside the vegetation season by determining the north direction were brought to the laboratory, and the surface was smoothed. Annual rings were examined and determined that the tree was 60 years old. Annual rings were grouped over five years, and sawdust samples were taken from each group of wood (WD), as well as the inner bark (IB) and outer bark (OB), with the help of a steel drill. The samples were dried in a 45 °C oven and subjected to pre-combustion. Then, Li concentrations were determined with the ICP-OES device. This method is one of the most frequently used methods in previous studies in this field [20]. Variance analysis was applied to the obtained data with the help of the SPSS package program and evaluated with the Duncan test.

3. Results

The average values and statistical analysis results regarding the changes in Li concentration in cedar based on organs and directions are given in Table 1.

Table 1. Changes in Li concentration (ppb) in cedar based on organs and directions

Organ	North	East	South	West	F	Mean
OB	85478.3 aC	84118.9 B	91137.2 bD	81804.8 A	172.2***	85634.8 A
IB	191371.1 bC	81922.8 A	85328.3 aB	85248.0 B	4057.7***	110967.5 B
WD	107033.7 aB	81331.0 A	88713.0 abA	83586.2 A	12.3***	90353.9 A
F	8.3**	1.1 ns	4.2*	0.2 ns		4.4*
Mean	111518.1 b	81590.9 a	88644.4 a	83577.6 a	16.8***	

*Different letters following each other represent the statistical difference at p≤0.05. Uppercase letters represent from top to bottom direction while lowercase letters from right to left. ns=not significant. *<0.05. **<0.01 ***<0.001. This explanation is valid for all tables*.

When the table results are examined, it is seen that the change in Li concentration in cedar is statistically significant in all organs in direction and directions other than east and west. The highest value was obtained in the inner bark when looking at the organs according to average values. Similarly, the highest value was obtained in the north direction when looking at the directions according to average values. The change in Li concentration by period and direction is given in Table 2.

Table 2. Change in Li concentration (ppb) in cedar by period and direction

Age	North	East	South	West	F	Mean
2018-2022	190299.2 fB	82103.6 bcdA	81897.8 aA	86362.9 cA	1514.0***	110165.9 B
2013-2017	191938.6 fB	81066.2 bcdA	87410.1 bcA	88396.2 cA	5925.1***	122581.6 B
2008-2012	98932.8 eC	72725.9 aA	86722.4 bB	87138.6 cB	87.3***	86379.9 A
2003-2007	93733.1 dD	80069.5 bA	88515.5 cdC	86206.2 cB	166.9***	87131.1 A
1998-2002	92101.6 cdC	80255.7 bA	88929.0 deBC	87291.4 cB	25.4***	87144.4 A
1993-1997	90811.4 bcdC	80395.5 bA	88488.9 cdB	86921.7 cB	51.1***	86654.4 A
1988-1992	88344.6 abB	81862.2 bcA	89026.2 deB	87043.2 cB	11.5**	86569.0 A
1983-1987	89443.8 abcC	83372.5 cdeA	90085.5 efC	86730.1 cB	18.2**	87408.0 A
1978-1982	87859.1 abB	82293.8 bcdeA	91008.7 fgC	86761.8 cB	43.2***	86980.8 A
1973-1977	86463.5 aBC	82884.4 cdeB	90005.0 efC	67305.7 aA	50.6***	81664.6 A
1968-1972	87554.3 abC	84240.9 deB	90962.5 fgD	76294.3 bA	47.5***	84763.0 A
1963-1967	86922.2 aC	84436.5 eB	91504.2 gD	76581.9 bA	113.2***	84861.2 A
F	1318.0***	21.6***	38.2***	27.4***		3.8***

When Table 2 is examined, it is seen that the change in Li concentration in cedar is statistically significant in all periods, directionally and in all directions, period by period. When the periods are examined according to the average values, it is

striking that there has been a significant increase in the last 10 years. When it is examined in terms of direction, it is seen that the highest values are generally obtained in the north direction.

4. Discussion

As a result of the study, it was determined that cedar trees can accumulate significant amounts of Li in both wood and bark. Two significant results were obtained from the current study. The first is that there has been a significant increase in Li concentration in the last decade, and the second is that the highest values were obtained in the north direction. When these results are compared with the studies conducted to date, it can be said that they are generally consistent. Namely, the highest values obtained in the north direction can be interpreted as Li pollution caused by traffic. Because one of the busiest highways in Türkiye passes from the north of the study area, there is a heavy traffic flow. In many studies, it is frequently stated that traffic is one of the most important sources of heavy metal pollution [21, 22].

As a result of the study, it was determined that Li pollution in the air has increased significantly in the last decade. Li has been widely preferred in the innovative industry of recent times. It is used in organic synthesis, glass, plastic, and aluminum production, radio engineering, computers, cameras, phone batteries, electronics, and laser devices. With the increase in Li use in these areas, the amount of Li in the biosphere also increases [23]. Studies have shown that Li accumulation in plants can be caused by traffic [24]. The accumulation of heavy metals in trees, especially in organs such as outer bark and leaves, is associated with particulate matter. After heavy metals leave their source, they infect particulate matter in the air, and particulate matter that becomes a heavy metal sink can lead to serious health problems [25]. Especially in urban areas, the number of people living per unit area is much higher. Since air pollution factors such as heavy metals and particulate matter pollution are also relatively high in these areas, pollution in urban areas directly affects the health of many people [14-26]. According to data from the European Environment Agency, fine particulate pollutants in the atmosphere caused the deaths of more than 400,000 people in 2018. Over 1200 deaths in people under 18 years of age are estimated to be caused by air pollution every year in EEA member and collaborating countries [27]. Many of these deaths are caused by particulate matter contaminated with heavy metals [10].

Particulate matter contaminated with heavy metals also helps heavy metals enter the plant body. As it is known, heavy metals can enter the plant body from leaves, roots, or stem sections [9]. Particulate matter contaminated with heavy metals adheres to the leaves or bark and facilitates the entry of heavy metals into the plant body.

As a result of the current study, Li concentrations in cedar trees were very high. This result shows that cedar can be used effectively to reduce Li pollution. This result is significant because studies show that each tree has a different heavy metal accumulation potential level. Therefore, species that can be used in monitoring and reducing pollution should be determined separately for each heavy metal [10]. Because the potential of plants to absorb and accumulate heavy metals depends on many factors that affect each other. For example, heavy metal accumulation depends on plant physiology, and plant physiology is shaped by the interaction of genetic structure [28-29] and environmental conditions [11-30]. Therefore, all factors affecting plant physiology also affect the entry and accumulation of heavy metals into the plant, which is shaped by the interaction of many interrelated factors such as genetic structure [4], edaphic [31], climatic factors [5-22], stress factors [32].

After heavy metals enter the plant body, the transport of elements within the wood part is primarily related to the cell structure and especially the cell wall (apoplastic pathway). Cell wall proteins (CWP) in plants come into play in various abiotic stresses [11]. Plants frequently face stress factors in their lives. The most common stress factors that plants encounter are high or low temperatures [34] and climatic factors [34]. Drought, in particular, is the factor that stresses plants the most [35], and it is stated that the effects of this factor will be felt more intensely with the impact of global climate change [5-36]. The presence of stress factors changes the environmental conditions where plants grow, thus affecting plant development in many ways. This change also directly affects the process of plants absorbing and accumulating heavy metals.

5. Conclusion and Suggestion

The study resulted in the highest Li concentrations in the north direction, which was interpreted as the Li concentration originating from the highway in this direction, namely traffic. Regarding public health, heavy metal pollution from the highway in question should be prevented from affecting residential areas. For this purpose, it is recommended to place barriers on the sides of the highway and, if possible, to plant live fences. The Li concentration in the species in question was very high in the woods. This result shows that *Cedrus atlantica* can be used effectively to reduce Li pollution. Cultivating *Cedrus atlantica* in areas with high levels of Li pollution can help reduce Li pollution.

Li is a heavy metal yet to be studied sufficiently despite being extremely important for human and environmental health. The study results show that the Li concentration in the air has increased significantly, especially in recent years. Therefore, more research should be done on the effects of the Li element, monitoring and reducing its pollution, and research on the subject should be diversified and continued by increasing.

Conflict of Interest

All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript.

Ethics Committee Approval

Ethics committee approval is not required.

Author Contribution

Conceptization: ŞK, BA, RE; methodology and laboratory analyzes: BA, RE; writing draft: ŞK, BA, RE; proof reading and editing. All authors have read and agreed to the published version of manuscript.

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