Lithium Concentration in Tree Rings of Cedar (*Cedrus* sp) Exposed to Vehicle Pollution

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Abstract

Heavy metal is one of the biggest concerns of urban surroundings among air pollutants because it could stay in the environment for centuries. These elements bio-accumulate resulting in increased concentration over time. Main sources of heavy metals include vehicle emissions, corrosion of metals, vehicle tires, and gas exhaust in households, industries, and commercial establishments. It is important to trace the heavy metal contamination in the atmosphereover time through annual rings of plants as biomonitors. This study aims to determine the changes of Lithium (Li) concentrations in the tree annual rings of logs obtained from the cedar tree (*Cedrus* sp.) stem. Results showed a higher concentration of Li in tree sections facing the pathway, suggesting the relation of Li concentration in plants with traffic orientation.

Keywords: *Annual Rings, Lithium, Cedar, Cedrus, Heavy metal*

I. INTRODUCTION

Global climate change impacts have concretely manifested in recent years [1-8]. Industrialization, fossil fuel consumption, disposition of factory wastes, heavy use of fertilizer, domestic waste, mines are large contributors to causes of climate affecting not only in natural sites [9-11] but also settlement areas [12]. One of the leading environmental pollutants that cause many environmental problems are heavy metals. Non-biodegradable heavy metals, which are usually products of anthropogenic activities are released into the atmosphere and deposited back into the soil and water, and then absorbed by living organisms,

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and ultimately find its way to households affecting human health [9, 13-16]. Even those that are considered as nutritional elements can be harmful, and may cause fatal effects when taken in excessive amounts by living organisms [17-20]. Increased death rates associated with lung cancer and respiratory and heart diseases are partly attributed to pollution, particularly heavy metals [21-22]. In Europe, air pollution has contributed to more than 400,000 human deaths in 2018 [23].

Plants have the ability to accumulate harmful gases and particulate matter in the atmosphere [24-26], hence, a good bio-monitors of pollutants. These pollutants could be adsorbed or absorbed in fruit, branches, wood, leaves, bark, and wood, which acts as archives of many airborne pollutants [27-29]. The level of absorbed pollutants in these parts of the plants provides a valuable information about the extent of pollution that plants have been exposed in the past. For example, some authors reported that the samples taken from the wood part of the annual ring plant species revealed the level of air pollution in the past, especially the heavy metal contamination and the factors associated with this pollution [27, 30-32].

Although Li is crucial for human and environmental health, this element is less investigated compared with other heavy metals such as Pb, Hg, Ni, Cd, and Cr. When the Li is released, it can be quickly added to the food chain because it dissolves in water, replaces other elements, readily absorbed by living organisms. This study aims to examine the accumulation of Lithium (Li) in tree rings of a 39-year-old cedar tree.

II. MATERIALS AND METHODS

Sample Collection and Preparation

A cross-sectional wood sample was taken from the main trunk of a 39-year-old Cedar (*Cedrus*) bordering the main road. The section of the tree fronting the road was marked before it was cut approximately 80 cm above the ground. The age of the tree was determined by counting the annual rings, which turned out to be 39 years old. The growth rings of the wood samples were divided into 13 groups, each group consists of 3 growth rings. Using a steel drill bit, samples were taken from the wood, and then placed in petri dishes. The samples were dried in an oven at 45 ºC to constant weight, which lasted for 15 days.

Chemical Analysis

The dried specimens were ground into a fine powder, and 0.5 g of it was placed in glass tubes for microwave, and then a 10 ml of 65% HNO_3 was added. The prepared samples were burned in the microwave at 280 PSI and 180 ºC for 20 minutes. Deionized water to make up to 50 ml was added to the cooled samples after the incineration process. The solutions that passed through filter paper were read at proper wavelengths in the ICP-OES (Inductively Coupled Plasma- Optical Emission Spectrometry) device.

Statistical Analysis

Data were analyzed using the analysis of variance (ANOVA) (SPSS Statistical Package). Separation of significant differences among treatment means was analyzed using the Duncan test ($p = 0.05$).

III. RESULTS AND DISCUSSION

Results

Depending on the organ and age, the variations of inward, outward-oriented and mean values of lithium concentrations were summarized under Table 1 and Table 2.

Table 1. Concentrations of Li element (ppb) based on organ and orientation.

Organ	Inward-facing	Outward-facing	Mean
Outer bark	-	1871.0^b	1871.0^b
Inner bark	1077.4^b	684.0^a	880.7^a
Wood	688.8^a	740.6^a	719.4^a
F value	16.609***	61.210***	63.345***

Note: same letters are not significantly different at 95% probability level
*** highly significantly different

Li element concentrations in inward- and outward-facing orientation showed significant differences ($p<0.05$) were found in the inward and outward-facing. While the highest value of Li concentration in the outward-facing part was observed in the outer bark sample, no statistically significant differences were statistically detected between the wood and inner bark samples. Li concentration remained below the detectable limits in the inner part of the outer bark sample. The lowest value was found in the wood while the highest value was obtained in the inner bark. The Li concentration in the wood sample, which is about 740.6 ppb in the section facing the outward, is higher than in the wood, which is about 688.8 ppb, in the interior facing section.

Table 2. Li Concentration (ppb) across Different Ages.

Age	Inward-facing	Outward-facing	Average
1-3	743.3	872.3	807.8
4-6	751.4	649.3	759.1
7-9	638.3	530.4	584.3
10-12	636.5	616.6	626.6
13-15	657.1	692.7	674.9
16-18	751.4	758.7	755.1
19-21	561.3	885.2	723.2
22-24	674.5	759.0	716.7
25-27	668.4	827.4	747.9
28-30	-	701.2	701.2
31-33	-	596.4	596.4
34-36	-	841.7	841.7
37-39	-	896.8	896.8
F value	1.243 ns	1.955 ns	1.524 ns

Based on age, the Li concentrations showed no significant differences. The Li concentration in the inward part, which tended to increase with age, decreased to 561.3 ppb between the ages 19-21 and remained below the detectable limits after age 28. In the outward-facing section, an increased Li concentration was observed after these ages. It is also notable that the Li concentrations were high at the earlier stages of growth from ages 1 to 3 (872.3 ppb in the outward-facing part, 743.3 ppb in the inward-facing, and 807.8

ppb in the mean values in 1-3 years) and the concentration of Li decreased at the ages 7 to 9 (i.e., 530.4 ppb in the outward-facing, 638.3 ppb in the inward-facing and the average is 584.3 ppb). Also, the Li concentration, which decreased to 596.4 ppm at the age of 31-33 in the outward-facing part, increased to 896.8 ppb, which is a difference of about 300 ppb, at ages 37 to39.

Discussion

Lithium is one of the elements found in many organic synthesis products such as glass, plastic, aluminum products, computers, cameras, telephone batteries, electronics, and laser devices, which are sources of Li in the biosphere [33]. The uptake of Li into the plant may depend on ions with physicochemical properties similar to the elemental Li and the emitted Li in vehicles. The excess of Li concentration in the plant, which can be toxic for plants with low tolerance [35], can adversely affect plant physiology and biochemistry due to its adverse effects on nucleic acids [34]. The Li can also replace Ca^{2+}, Mg^{2+}, and K^{+} ions in various enzyme binding sites and biological membranes [36]. While the Li concentration in the plant showed a negative correlation with Mg, Mo, and Mn, it showed a positive correlation with Zn, K, Fe, and Ca, suggesting that Li changed the functions of the primary element carriers [37]. While it can be beneficial when the Li concentration is at a normal level, it can be toxic when it is high. There are limited studies on how much amount of Li needed by plant and how does it affect the plant at excessive level. To date, the movement of Li in the biosphere is less investigated [38], hence needs further exploration.

In this study, the Li concentration in the outward-facing part of the outer bark was relatively high, while the concentration in the outer bark of the inward-facing part remained below the detectable level. The high concentration of Li in the outer bark can be attributed to traffic exposure, which. is then adsorbed into the rough organs, such as bark, of plants [24, 39]. Although Li is not among the nutrients or elements actively absorbed by plants, traces of this element can be found in the wood through passive adsorption. The non-significant differences in the concentration of this element in the wood across different ages suggests that the level of concentration and adsorption of this element is homogenous over different period of time. Although there are studies that attempted to understand the entry of this element into the wood [40, 27], the mechanisms of its entry into the wood remains an interesting question to be investigated.

IV. CONCLUSION AND RECOMMENDATIONS

Lithium element is vital for human and environmental health and can be quickly added to the food chain. This study tried to determine the variation of Li concentration in a 39-year-old cedar tree based on traffic. While the Li concentration in the outer bark stayed under the detectable ranges in the inward-facing part, it was found to be very high in the outward-facing part. This shows that Li concentration is caused by traffic. The high concentrations of Li in wood indicate that the wood of the studied species has a high Li accumulation, suggesting that this species absorbed Li, hence, a good material to remediate Li and minimize the human health hazards brought about by this pollutant. However, there is no statistically significant difference between Li concentrations in the parts formed in different years in wood, suggesting that Li can be transferred in wood, hence, this species is not suitable for tracing the Li concentration change in the air. Therefore, it is suggested that more research should be done on this subject of which tree species and organs the Li element accumulates more and at what rate this element is transferred in different organs of these different tree species. In addition, it should be investigated in which way (soil and air) more of this element enters the plant body and at what rate it accumulates.

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