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Changes of Calcium Content on Some Trees in Kocaeli

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ABSTRACT

Soil is an essential component for the lives of plants, as well as water and air are. The elements in the soil direct the metabolic activities such as beginning, formation, and continuity of life. The level of nutrient elements in the body determines the status of vital activities. The amount of nutrient elements in soil and the mechanism of plants' intake of these elements vary between the species. Calcium (Ca), one of the main macronutrient elements, is of vital importance for many vital functions such as cell wall and membrane for plants and trees, but its deficiency results in developmental losses, yield losses, stress, and even death. In fact, under the effect of mutual interaction between genetic factors and environmental factors, it accumulates within the species at different levels. In this study, the species used for determining the amount of the Ca were obtained from an industrial zone in Kocaeli province in the year 2020. The annual rings of *Robinia pseudoacacia, Cupressus arizonica*, and *Platanus orientalis* were used during the analyses. Thanks to the multiple annual rings of these trees, the variability of the Ca concentrations could be determined by years.

Anahtar Kelimeler:
Yıllık halkalar,
Kalsiyum,
biriktirme,
Besin öğesi,
Ağaçlar.

ÖZ

Toprak, su ve hava gibi bitkilerin yaşamını devam ettirmesinde vazgeçilmez unsurdur. Toprak içindeki elementler ise yaşamın başlaması, oluşumu ve sürdürülmesi gibi metabolic faliyetlere yön vermektedir. Özellikle de besin elementlerinin hangi düzeyde bünyede bulunması ile yaşamsal aktivitelerinin durumlarını belirlemektedir. Topraktaki besin elementlerinin miktarı ve bitkilerin bunları bünyelerine almalarındaki mekanizması herbir tür için değişkenlik göstermektedir. Makro besin elementlerinin başında yer alan Kalsiyum (Ca) elementi bitkiler ve ağaçlar için hücre duvarı ve zar işlevi gibi oldukça hayati öneme sahip olmasına ragmen eksikliği ise bünyede olumsuz bir şekilde gelişim kayıplarına, ürün zayıflığına, strese hatta ölümle sonuçlanmaktadır. Esasında genetik faktörler ile çevresel faktörlerin karşılıklı etkileşimi altında türlerde farklı düzeylerde birikim yapmaktadır. Çalışma kapsamında Ca miktarlarının tespiti için kullanılan türlerin 2020 yılının sonunda Kocaeli iline ait sanayi bölgesinden temin edilmiştir. Bunlar sırasıyla *Robinia pseudoacacia, Cupressus arizonica* ve *Platanus orientalis* ağaçlarının yıllık halkalarından faydalanılmıştır. Bu ağaçların çok yıllık halkaları sayesinde Ca besin elementinin yıllara göre konsantrasyonlarının değişkenlikleri tespit edilmiştir.

1. Introduction

As a result of the rapid increase in world population, the problems such as unplanned urbanization, uncontrolled industrialization, out-of-purpose and unconscious use of agricultural lands, and gradual increase in the agricultural pesticides constantly decrease the fertile soils, which can be used for agricultural purposes [1-3]. Hence, various measures should be taken in order to protect these areas and make the best of them. Soil can be protected and sustained only by keeping its fertility optimized [4-6].

Sustainable use of soils, knowing the physical and chemical properties, and managing them in accordance with these properties are very important [7]. The nutrient materials should be present in the habitats of plants at appropriate concentrations and enough amounts. Deficiency and abundance of necessary nutrients negatively affect the plant development and their capacity to benefit from nutrient elements in soil and, consequently, it negatively affects the yield and quality [8]. Plant productivity and quality of soil, which supports the ecosystem services, directly depend on the deficiency or abundance of nutrient materials [9]. In addition, since the chemical and physical properties of the soil are well-known in sustainable agriculture, optimum benefit can be obtained from the fertilization process [10]. For this purpose, many studies were carried out in order to determine the productivity levels of different regions and soils and to foreknow the potential nutrition problems [11]. Calcium (Ca), which is an important macronutrient, has vital importance for plants and trees and is a dynamic molecule used in transmitting the signals between tissues of plants [12]. The Ca concentrations of soils vary between 4587 ppm and 8157 ppm at the depth of 0-30 cm and between 4688 ppm and 8413 ppm at the depth of 30-60 cm [13]. Ca concentrations between 3500 and 10000 ppm are considered as high and those higher than 10000 ppm are considered as very high [14]. The Ca is very mobile in the soil and it may accumulate on the surface of roots because of the mass flow [15]. However, high levels of Ca cause an increase in pH, surface minerals, aggregation, organic matter stabilization, and ample amount of worms [16]. In studies carried out on the intake of Ca in trees, it was observed that the concentrations of Ca varied between the biomasses of trees [17, 18]. Moreover, it was determined in other studies that Ca concentration increasing for 30 years caused an increase in acidity in soil and a decrease in productivity of species [19]. Since the mobility of Ca in phloem is limited, low amount of Ca is absorbed during the aging of leaves [20]. When compared to the old ones, young leaves absorb very higher amounts of Ca. In some study, reported an inverse proportion between heavy metals and Ca element [21, 22]. If the concentration of heavy metals in soil increases, then the decrease in Ca concentration causes a decrease in the intake by wood and other organs. If the Ca concentration increases in soil, then the intake of heavy metals decreases [23].

After various problems and uncertainties about the use of plants as biomonitors, studies reported that trees can also be used as biomonitors [24-28]. The most accurate information can be obtained by making use of needle-leaved trees such as pine, spruce, and fir, which have their needle-leaves on them for a long time and leaf-age of which can be clearly determined. In this method, max 10 years of data can be achieved. However, when using the annual rings, the data of longer periods can be achieved. In regions, where four seasons are seen, the development of trees was found to occur at different levels. The annual rings form in wood parts of these trees. With nutrients accumulating in annual rings, they provide important information about the history of tree [29]. The annual rings of trees increase with the age of the tree and there are trees that can live up to thousands of years. The annual rings of trees can be used as an indicator of pollution and they can provide important information about the distribution and chronology of nutrients at the location, where the tree is grown. The studies on usability of annual rings as biomonitor and the knowledge about the transfer of nutrient elements within their organisms are very limited [30].

In the present study, the calcium element was examined in terms of the years in annual rings. Within the scope of this study, the Ca concentrations in the annual rings of 3 different trees growing in an intense industrial zone in Kocaeli province were examined by years and organs. The trees used for this purpose were *Robinia pseudoacacia*, *Cupressus arizonica*, and *Platanus orientalis*. The concentrations of the Ca in outer bark, inner bark, and wood fractions of trees were analyzed. It was aimed to determine how the Ca concentration in the annual rings of trees changed by year and if these annual changes were similar.

2. Material and Method

This study was used with locust tree (*Robinia pseudoacacia* L.), arizona cypress (*Cupressus arizonica* G.) and eastern sycamore (*Platanus orientalis* L.). All samples were taken from the main trunk of the organized industrial zone (OSB) of Kocaeli city at December, 2020. A 10 cm thick log sample was taken from the trees from a height of 50 cm from the ground, by marking the north direction on the log. The annual rings of *Robinia pseudoacacia*, *Cupressus arizonica* and *Platanus orientalis* were determined to be 30 years old, have come from 1991-1993 to 2018-2020 in a three-year period (taking into account their widths). The wood surface was divided into groups for the age ranges. Also they were determined the outer bark, inner bark and wood of all ages. The wood samples taken are brought to the 1-2 cm interval without using metal. Samples taken into glass containers are kept at room temperature with their mouths open for 12 days, and then they are oven-dried at 55 ^{o}C for 60 hours. The samples were taken as 0.5 g weighed and 5 ml of 65% HNO_3 and 2 ml of 30% H_2O_2 were added. The combustion process was carried out in the microwave oven at 200 ºC for 15 minutes. The resulting samples were made up to 50 ml with ultrapure water and Ca analyzes were made in the by atomic emission spectrometry (ICP-OES) with a plasma source device (SpectroBlue, Spectro). In the study, all measurements are repeated in triplicate and the obtained data are analyzed by using the SPSS 22.0 package program, analysis of variance and Duncan test.

3. Results

The biomonitor chosen was the bark and organ of a *Robinia pseudoacacia*, *Cupressus arizonica* and *Platanus orientalis* which, due to its widely used and readily available. It has been proven that it can provide information on the presence of Ca element on the organ in Table 1.

Table 1. Change of Ca concentrations (ppm) based on species

Organ	Species			F value
	Robinia pseudoacacia	*Cupressus arizonica*	*Platanus orientalis*	
Wood	2790.4 Ba	1257.4 Aa	3753.6 Ca	32.9***
Inner Bark	8105.6 Bb	8025.7 Bc	8097.5 Ab	51.5***
Outer Bark	5636.2 Ab	5698.8 Ab	8105.7 Bb	1156.5***
F value	13.3***	2541.8***	156.3***	

Statistically significant *** $p<0.001$

According to the results of variance analysis (ANOVA) that the change in the concentration of Ca element on organ basis in all three species is statistically significant ($p<0.001$). The Duncan test results that the values obtained in wood in all species were in the first group, while the values obtained in the outer bark were in the second group. However, the values obtained in the inner bark were in the second group in *Robinia pseudoacacia* and *Platanus orientalis*, and in the third group in *Cupressus arizonica*.

According to these results, it can be said that the Ca concentration is ranked as wood<outer bark<inner bark. The lowest value in the outer bark is obtained in *Robinia pseudoacacia* with 5636.2 ppm, the highest value is obtained in *Platanus orientalis* with 8105.7 ppm, the highest value in the inner bark is obtained in *Robinia pseudoacacia* with 8105.6 ppm, and the lowest value is obtained in *Cupressus arizonica* with 8025.7 ppm. In the wood part, the lowest value is obtained in *Cupressus arizonica* with 1257.4 ppm, and the highest value is obtained in *Platanus orientalis* with 3753.6 ppm. According to these results, it can be said that the lowest values are obtained in *Cupressus arizonica* and the highest values are obtained in *Platanus orientalis*. The change in the Ca concentration in woods depending on the age range and direction is given in Table 2.

Table 2. The Ca concentration (ppm) age interval and species change of in wood

Range of age	Species			F value
	Robinia pseudoacacia	*Cupressus arizonica*	*Platanus orientalis*	
2018-2020	1532 Bc	898.9 Aa	4434 Ch	179***
2015-2017	2737.8 Be	1039.5 Ab	2914.4 Ca	16280.9***
2012-2014	3147.2 Bg	1116.6 Ac	3830.8 Cf	1248.5***
2009-2011	3004.3 Bf	1318.4 Ae	4222.6 Cg	121256.5***
2006-2008	2437.9 Bd	1480.8 Ah	3867.8 Cf	167844.7***
2003-2005	6149.9 Ch	1363 Afg	3218.1 Bb	41708***
2000-2002	6434.6 Ci	1146.2 Ad	3493.4 Be	223201.3***
1997-1999	686.5 Aa	1346.8 Bf	4859.4 Ci	396930.2***
1994-1996	881.5 Ab	1379.4 Bg	3291.2 Cc	57430.1***
1991-1993	892.2 Ab	1484.5 Bh	3404.8 Cd	23315***
F value	21513.9***	626.7***	1110.5***	

Statistically significant *** $p<0.001$

When the values showing the change of Ca element according to the age range are examined, it is seen that the highest value in *Robinia pseudoacacia* is obtained with 6434.6 ppm in 2000-2002, the lowest value with 686.5 ppm in 1997-1999, the lowest value in *Cupressus arizonica* in 2018-2020 with 898.,9 ppm, the highest value is obtained in the years 1991-1993 with 1484.5 ppm, the highest value in *Platanus orientalis* with 4434 ppm in the years 2018-2020, and the lowest value with 2914.4 ppm in the years 2015-2017. According to the analysis of variance results, it is determined that the variation of Ca concentration depending on the species is statistically significant at least 99.9% confidence level (p<0.001) in all age ranges. When the values are examined, it is very difficult to say that the Ca concentration changes regularly on the basis of species or year. This situation can be interpreted as the change of Ca concentration in plants does not change primarily depending on the species or year, and other factors are more dominant.

4. Discussion

Within the scope of this study, changes of Ca concentrations in outer bark, inner bark, and wood of *Robinia pseudoacacia*, *Cupressus arizonica*, and *Platanus orientalis* trees by year and organ were examined. Investigated in this study, Ca is a macronutrient element that is a necessity for the development and growth of plants and it plays important roles in cell growth and development, adjustment of membrane permeability, tissue stabilization, and quality of plants. Ca is of vital importance for fauna, microflora, plant, and soil. It has significant effects on the physical and chemical properties of the soil. It is of significant importance for the functional and structural characteristics of plant cell plasma membranes and its deficiency results in yield and quality losses in plants [31]. Hence, the studies examining the intake and accumulation of Ca in the plant body are very important.

At the end of this study, it was determined that the concentration of Ca significantly changed between wood, inner bark, and outer barks within the species and between species by organ. For instance, Ca concentration found to be 1257.4ppm in wood of *Cupressus arizonica* was determined to be 8025.7ppm in inner bark of *Cupressus arizonica* and 37.53.6ppm in wood of *Platanus orientalis*. It suggests that Ca concentration can vary significantly between the organs of a species or between the same organs of different species. Similar results were reported in the studies examining the element concentrations of plant organs. In these studies, it was determined that the concentrations of many macro and micronutrient elements significantly varied between different organs of a single species [32-34] and between the same organs of different species [35, 36]. This is because the intake and accumulation of elements in plant body occur through a complex mechanism. This process is closely related with the organ of plant and the structure of element [37]. The main factor influencing the element accumulation in plants is the plant metabolism [38, 39]. Hence, remarkably influencing the plant metabolism, many factors including stress level of plant, plant's genetic structure, environmental factors affect the element intake and accumulation [40-43].

One of the most important factors causing different levels of element accumulation in different organs of a single species is the structure of organ [44]. While the element intake can occur via air through the stoma opening in leaves, the element concentrations might reach much higher levels in outer bark because of the retention of particles contaminated by various elements [45]. Thus, when washed, the contaminated particles are removed from the organs and the concentrations of relevant elements can significantly change. Besides that, it was also determined that the concentrations of elements in inner bark and wood, which have no direct contact with outer environment, can be much lower than in the outer bark [46-48]. The results showed that Ca concentrations can significantly vary between the woods forming in a single tree during the subsequent years. For instance, Ca concentration of the wood of *Robinia pseudoacacia* forming in the period 1997-1999 was found to be 686.5 ppm, whereas the concentration in woods forming in the period 2000-2002 was found to be 6434.6 ppm. This finding proves that the transfer of Ca element within the wood is limited. Comparing the species examined here, it was determined that the highest change was observed in *Robinia pseudoacacia*. This finding showed that the most suitable species to be used in monitoring the change of Ca concentration by year is *Robinia pseudoacacia*.

Competing Interest / Conflict of Interest

The authors declare that they have no competing interests.

Author contribution

We declare that all Authors equally contribute.

5. References

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