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The Chancing of Mg Concentrations in Some Plants Grown in Pakistan Depends on Plant Species and the Growing Environment

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ABSTRACT

In this study, it has been tried to determine how Mg, which is one of the most important macronutrients for plants, changes in various organs of some plants grown intensively in urban centers in Pakistan, and how this change is affected depending on the washing status and traffic density. For this purpose, the variation of Mg concentrations in leaves and branches of *Ficus bengalensis*, *Ziziphus mauritiana*, *Conocarpus erectus*, and *Azadirechta indica* species depending on washing status and traffic density were determined. As a result of the study, it was determined that the Mg concentration changed statistically significantly ($p<0.05$) depending on the plant type and organ in all traffic densities, but there was no linear relationship between the change of Mg concentration and traffic density.

ÖZ

Anahtar Kelimeler:
Pakistan,
Magnezyum,
Mg,
Trafik.

Bu çalışma kapsamında bitkiler için son derece önemli makro besin elementlerinden olan Mg'un Pakistan'da kent merkezlerinde yoğun olarak yetiştirilen bazı bitkilerin çeşitli organlarında nasıl değiştiği, yıkama durumu ve trafik yoğunluğuna bağlı olarak bu değişimin nasıl etkilendiği belirlenmeye çalışılmıştır. Bu amaçla *Ficus bengalensis, Ziziphus mauritiana, Conocarpus erectus* ve *Azadirechta indica* türlerinin yaprak ve dallarındaki Mg konsantrasyonlarının yıkama durumu ve trafik yoğunluğuna bağlı değişimi belirlenmiştir. Çalışma sonucunda Mg konsantrasyonunun bütün trafik yoğunluklarında bitki türü ve organına bağlı olarak istatistiki olarak anlamlı düzeyde ($p<0,05$) değiştiği belirlenmiş, Mg konsantrasyonunun değişimi ile trafik yoğunluğu arasında ise doğrusal bir ilişki bulunmamıştır.

1. Introduction

The world population has increased significantly in the last century and is concentrated in urban areas [1, 2]. The most important problems of our age worldwide are the increase in population [3, 4] and the concentration of the population in urban areas, that is, urbanization [5, 6] listed as other problems. The demands and needs of the increasing population also diversify and increase in line with the requirements of the age, and the industrial production to meet these needs also increases the need for raw materials and energy [7, 8].

The wastes generated as a result of industrial production in this process cause excessive pollution of air [9,10], water [11,12], and soil [13-17]. Global climate change [13-17] and urbanization [18-20] are shown as the biggest irreversible problems of our age [21], and environmental pollution is seen as the most important problem threatening living life and ecosystem [22-24]. Especially in regions with high population density, air pollution is one of the most important problems threatening human life [25-27]. It is reported that 92% of the world's population lives in areas with low air quality and approximately 1 in 8 deaths are caused by air pollution [6, 27].

Plants grown in areas with high air pollution are also affected by this pollution. Because plant development, structure, and phenotypic characters are shaped depending on genetic structure [28-30] as well as environmental conditions [31-33]. While air pollution changes the composition of the air, it also changes the microecological conditions, and since plant growth is shaped by climatic [34] and edaphic [35,36] factors, plant growth, and content are directly affected.

In this study, it has been tried to determine how Mg, which is one of the most important macronutrients for plants, changes in various organs of some plants grown intensively in urban centers in Pakistan, and how this change is affected depending on the washing status and traffic density.

2. Material and Method

Within the scope of the study, it was aimed to determine the change of Mg concentration in *Ficus bengalensis* (Fb), *Ziziphus mauritiana* (Zm), *Conocarpus erectus* (Ce), and *Azadirechta indica* (Ai) plants, which are grown intensively in urban centers in Pakistan, depending on the organ, washing status, and traffic density. The study was conducted on materials collected from high-traffic (TRCOK), moderately heavy-traffic (TRAZ), and almost non-traffic (TRYOK) areas. The washing process was also performed on the branch and leaf samples taken from the individuals subject to the study, and the washed organs (Yk) and the unwashed organs (Ykm) were evaluated within the scope of the study.

Branch samples taken from individuals suitable for the study purpose were brought to the laboratory, separated into leaf and branch parts, and then washing was applied in half of these samples. The samples were kept in laboratory conditions for 15 days until they became room dry and then dried in an oven at 45 °C for two weeks. The dried plant samples were ground into powder and weighed 0.5 g and placed in tubes designed for microwave. 10 mL of 65% HNO3 was added to the samples. The prepared samples were then burned in a microwave device at 280 PSI and 180 ºC for 20 minutes. After the processes were completed, the tubes were removed from the microwave and allowed to cool. Deionized water was added to the cooled samples to make up to 50 ml. After the prepared samples were filtered through filter paper, they were read at appropriate wavelengths in the ICP-OES device. Mg concentrations were calculated by multiplying the obtained values with the dilution factor. This method used in the study is a method used in many studies to determine elemental analyzes in plants [8-10,37].

The obtained data were evaluated with the help of the SPSS package program, variance analysis was applied to the data, and homogeneous groups were obtained by applying the Duncan test to the groups that were statistically different at least 95% confidence level. The data obtained were simplified and interpreted by tabulating.

3. Results

The results of the analysis of variance regarding the variation of Mg concentrations depending on the plant species and traffic density are given in Table 1.

Table 1. Variation of Mg (ppm) concentrations by species and traffic density

	TRYOK	**TRAZ**	**TRCOK**	**F**
Fb	3628,4 Bb	1424,5 Aa	2582,5 ABb	5,4**
Zm	698,1 Aa	1325,1 Ba	1203,5 Ba	7,4**
Ce	3576,9 b	3640,4 c	3246,3 b	0,1 ns
Ai	1507,9 Aa	2628,0 Bb	2189,7 Bab	7,3**
F	9,4***	13,0***	5,2**	

***: p<0,001

When the variation of Mg concentrations based on species and traffic density is examined, it is seen that the changes based on species in all traffic densities are statistically significant (p<0.01) at a confidence level of at least 99%. As a result of the Duncan test, it was determined that the values obtained in Zm were in the first groups and the values obtained in Ce were in the last groups at all traffic densities.

It was determined that the change of Mg concentrations depending on the traffic density based on species was not statistically significant (p<0.05) in the Ce species. In other species, it is seen that the Mg concentration does not change concerning the traffic density. The results of the analysis of variance regarding the variation of Mg concentrations depending on the species, organs, washing conditions, and traffic density are given in Table 2.

Table 2. Variation of Mg (ppn) concentrations

		Status of wash	TRYOK	TRAZ	TRCOK	F
Fb	Leaf	Yk	374,6 Ac	1453,0 Bg	3560,0 Cl	20130,4***
		Ykm	7247,6 Cp	1884,4 Ah	3924,2 Bm	79126,9***
	Branch	Yk	3425,3 Bl	1211,8 Ab	1183,5 Ad	18777,2***
		Ykm	3465,9 Cm	1148,9 Aa	1662,2 Bg	57372,7***
Zm	Leaf	Yk	1121,6 Af	1294,2 Bd	1868,7 Ci	37638,0***
		Ykm	1066,4 Ae	1233,1 Bc	1680,5 Cg	15182,1***
	Branch	Yk	327,8 Ab	1394,8 Cf	657,5 Bb	63924,2***
		Ykm	276,7 Aa	1378,2 Cf	607,5 Ba	52937,8***
Ce	Leaf	Yk	5558,4 Bo	5963,5 Co	5445,2 Ao	180,5***
		Ykm	5473,8 Cn	5171,8 Bn	4717,5 An	1387,3***
	Branch	Yk	1617,4 Bh	2098,0 Ci	1233,2 Ae	12087,8***
		Ykm	1658,0 Ci	1328,4 Ae	1589,3 Bf	1914,7***
Ai	Leaf	Yk	2167,8 Ak	2712,6 Bl	3175,3 Ck	9012,3***
		Ykm	1873,7 Aj	2547,7 Bk	3062,9 Cj	22166,5***
	Branch	Yk	631,0 Ad	3045,1 Cm	1768,2 Bh	53252,2***
		Ykm	1359,0 Bg	2206,5 Cj	752,5 Ac	48612,7***
F			57746,0***	40926,8***	38497,3***	

***: p<0,001 Yk: washed Ykm. unwashed

When the table values are examined, it is seen that the change of Mg concentration based on organ in all traffic densities and based on traffic density in all organs is statistically significant at the 99.9% confidence level (p<0.001). In TRYOK areas, the lowest values were obtained in Fb leaves washed with Zm branches, the highest values were obtained in unwashed Fb leaves and Ce leaves. In TRAZ areas, the lowest values were obtained in washed Fb branches and unwashed Zm leaves, and the highest values were obtained in Ai branches washed with Ce leaves. The lowest values in TRCOK areas were obtained in Ai branches that were not washed with Zm branches, and the highest values were obtained in Fb leaves that were not washed with Ce leaves. Apart from this, it can be said that there is no general relationship between the change of Mg concentration in organs and traffic density.

4. Discussions

As a result of the study, it was determined that the changes in Mg concentrations in all traffic densities based on species were statistically significant (at least p<0.01). Mg, which is the subject of the study, is a macro element used by plants and is considered as the iron of the plant world and enters the chlorophyll structure. Mg is the central atom of chlorophyll and is vital in photosynthesis. The excess of Mg prevents K uptake and negatively affects the root development of trees [38]. Numerous studies on Mg and other elements reveal that the level of element accumulation in different species is at different levels [37]. Studies show that the most important factor affecting element accumulation in plants is plant type [39].

The results of the study show that there is no linear relationship between traffic density and Mg concentration. The entry of elements into the plant body and their accumulation in organs can be mainly through roots and leaves. However, it is not easy to determine the source of the elements determined in the plant because these uptake pathways can work simultaneously [40]. Therefore, factors affecting soil and air composition also affect element concentrations in plants [41]. In urban areas, especially traffic-related air pollution increases the concentration of elements, many of which serve as micronutrients for plants [42,43]. Air pollution and anthropogenic factors in urban areas can also cause soil pollution [44-47]. Therefore, the concentrations of these elements in plants grown in these areas are at higher levels [48].

As a result of the study, it was determined that the Mg concentrations in different organs of the plants subject to the study were at different levels at all traffic densities. This situation is largely shaped by the anatomical structure of the plant and the mutual interaction of the plant and the elements. Like all phenotypic characters, plant metabolism also depends on plant genetic structure [49-53] and environmental conditions [54-56]. Therefore, stress level, which significantly affects plant metabolism [57-60], hormone applications [61-63], cultural processes such as pruning and shading [64,65] and many factors affect the accumulation of elements in plants [66].

In addition, the changing environment and soil structure due to human influence in urban areas and micro-ecological factors [67-69] also affect the change of element concentration in plant organs. Therefore, the elements in the soil or air also significantly shape plant development. High levels of elemental concentrations in the air or soil are a source of stress for the plant [70] and other stress factors affect plant structure and development [71,72,73]. Therefore, high concentrations of some elements in the air cause stress in plants, affecting plant growth, and the accumulation of these elements in plant organs are at a higher level [39,40].

The fact that the element concentrations in different organs of plants grown in the same environment are at different levels is directly related to the structure of the plant organ. Factors such as morphology, surface area, surface texture, and size of plant organs affect the entry and accumulation of elements in the plant organ [3]. Plant leaves take in the air through stomata, while they can also take in the elements in the air. Similarly, the hairy structure of the leaf or the rough and cracked surface of the bark can facilitate the adhesion of the elements, and especially the particles contaminated with various elements that can be a pollutant in the air, on the surface of the organs [7,73,74].

5. Conclusions and Recomendations

As a result, the change of element concentration in plant organs is the result of a complex mechanism depending on the interaction of many factors, and this mechanism has not been fully resolved yet. Studies on this subject have mostly focused on annual plants, and the number of studies on trees is relatively limited. For this reason, it is recommended that the studies on the subject be continued by diversifying and increasing and that the studies be carried out in controlled environments as much as possible.

Competing Interest / Conflict of Interest

"The authors declare that they have no competing interests"

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6. References

[1] Kilicoglu, C., Cetin, M., Aricak, B., & Sevik, H. (2020). Site selection by using the multi-criteria technique-a case study of Bafra, Turkey. Environmental Monitoring and Assessment, 192 (9), 1-12.
[2] Bayraktar, O. Y. (2020). The Use of Rice Husk Waste in Foam Concrete Production. *Turkish Journal of Agriculture-Food Science and Technology*, *8*(12), 2716-2722.
[3] Aricak, B., Cetin, M., Erdem, R., Sevik, H., & Cometen, H. (2020). The usability of Scotch pine (Pinus sylvestris) as a biomonitor for traffic-originated heavy metal concentrations in Turkey. Polish Journal of Environmental Studies, 29 (2): 1051-1057
[4] Ozturk, S., Isinkaralar, O. (2018). New Trends in Tourism: A Research on Farm Tourism. Journal of Current Researches on Social Sciences, 8 (4), 537-546.
[5] Öztürk, S., Işınkaralar, Ö., Yılmaz, D., Şimşek, M., Almansourı, H. M. S. & Elahsadı, A. H. M. (2021). Covıd-19'un tüketici alışkanlıklarına etkisi üzerine bir araştırma: Türkiye-Libya karşılaştırması. Doğu Coğrafya Dergisi, 26 (46) , 97-108 . DOI: 10.17295/ataunidcd.958864
[6] Elsunousi AAM, Sevik H, Cetin M, Ozel HB., Ucun Ozel H (2021) Periodical and regional change of particulate matter and CO2 concentration in Misurata. Environ Monit Assess 193: 707 (2021). DOI: 10.1007/s10661-021-09478-0
[7] Koc, İ. (2021). Using Cedrus atlantica's annual rings as a biomonitor in observing the changes of Ni and Co concentrations in the atmosphere. *Environmental Science and Pollution Research*, 1-7.
[8] Savas, D.S., Sevik, H., Isinkaralar, K. Turkyilmaz, A., Cetin, M. (2021). The potential of using *Cedrus atlantica* as a biomonitor in the concentrations of Cr and Mn. *Environ Sci Pollut Res* (2021). https://doi.org/10.1007/s11356-021-14826-1
[9] Sevik, H., Cetin, M., Ozturk, A., Ozel, H. B., & Pinar, B. (2019). Changes in Pb, Cr and Cu concentrations in some bioindicators depending on traffic density on the basis of species and organs. Applied Ecology and Environmental Research, 17 (6), 12843-12857.
[10] Sevik, H., Ozel, H. B., Cetin, M., Özel, H. U., & Erdem, T. (2019). Determination of changes in heavy metal accumulation depending on plant species, plant organism, and traffic density in some landscape plants. Air Quality, Atmosphere & Health, 12 (2), 189-195.
[11] Ucun Ozel, H., Ozel, H. B., Cetin, M., Sevik, H., Gemici, B. T., & Varol, T. (2019). Base alteration of some heavy metal concentrations on local and seasonal in Bartin River. *Environmental monitoring and assessment*, *191*(9), 594
[12] Demir, T., Mutlu, E., Aydın, S., & Gültepe, N. (2021). Physicochemical water quality of Karabel, Çaltı, and Tohma brooks and blood biochemical parameters of Barbus plebejus fish: assessment of heavy metal concentrations for potential health risks. *Environmental Monitoring and Assessment*, *193*(11), 1-15.
[13] Canturk, U., & Kulaç, Ş. (2021). The effects of climate change scenarios on Tilia ssp. in Turkey. *Environmental Monitoring and Assessment*, *193*(12), 1-15.
[14] Adiguzel, F., Bozdogan Sert, E., Dinc, Y., Cetin, M., Gungor, S., Yuka, P., Sertkaya Dogan O., Kaya, E. Karakaya, K., & Vural, E. (2021). Determining the relationships between climatic elements and thermal comfort and tourism activities using the tourism climate index for urban planning: a case study of Izmir Province. Theoretical and Applied Climatology, 1-16. Theor Appl Climatol (2021). https://doi.org/10.1007/s00704-021-03874-9
[15] Bozdogan Sert, E., Kaya, E., Adiguzel, F., Cetin, M., Gungor, S., Zeren Cetin, I., & Dinc, Y. (2021). Effect of the surface temperature of surface materials on thermal comfort: a case study of Iskenderun (Hatay, Turkey). Theoretical and Applied Climatology, 144(1), 103-113. https://doi.org/10.1007/s00704-021-03524-0
[16] Varol, T., Ozel, H. B., Ertugrul, M., Emir, T., Tunay, M., Cetin, M., & Sevik, H. (2021). Prediction of soil-bearing capacity on forest roads by statistical approaches. *Environmental monitoring and assessment*, *193*(8), 527.

[17] Varol T, Canturk U, Cetin M, Ozel HB., Sevik H. (2021) Impacts of climate change scenarios on European ash tree (*Fraxinus excelsior* L.) in Turkey. Forest Ecology and Management. *Forest Ecology and Management* 491 (2021) 119199. DOI: 10.1016/j.foreco.2021.119199

[18] Işınkaralar, Ö. & Varol, Ç. (2021). Kent Merkezlerinde Ticaret Birimlerin Mekansal Örüntüsü Üzerine Bir Değerlendirme: Kastamonu Örneği. Journal of Architectural Sciences and Applications, 6(2), 396-403.https://doi.org/10.30785/mbud.927529

[19] Sahin, G., Cabuk, S. N., & Cetin, M. (2021). The change detection in coastal settlements using image processing techniques: a case study of Korfez. *Environmental Science and Pollution Research*, 1-16.

[20] Kalayci Onac A, Cetin M, Sevik H, Orman P, Karci A., Gonullu Sutcuoglu G (2021) Rethinking the campus transportation network in the scope of ecological design principles: case study of Izmir Katip Çelebi University Çiğli Campus Environmental Science and Pollution Research (2021). https://doi.org/10.1007/s11356-021-14299-2

[21] Cetin, M. (2020). The changing of important factors in the landscape planning occur due to global climate change in temperature, Rain and climate types: A case study of Mersin City. *Turkish Journal of Agriculture-Food Science and Technology*, *8*(12), 2695-2701.

[22] Turkyilmaz, A., Sevik, H., Isinkaralar, K., & Cetin, M. (2018). Using Acer platanoides annual rings to monitor the amount of heavy metals accumulated in air. Environ Monit Assess 190:578.

[23] Ghoma WEO, Sevik H and Isinkaralar K (2021) Using indoor plants as biomonitors for detection of toxic metals by tobacco smoke. Air Quality, Atmosphere & Health, https://doi.org/10.1007/s11869-021-01146-z (In press)

[24] Cetin, M., Sevik, H., Cobanoglu, O. (2020). Ca, Cu, and Li in washed and unwashed specimens of needles, bark, and branches of the blue spruce (Picea pungens) in the city of Ankara. Environmental Science and Pollution Research, 1-10.

[25] Sevik, H., Cetin, M., Ozel, H. B., Ozel, S., Zeren Cetin, I. (2020). Changes in heavy metal accumulation in some edible landscape plants depending on traffic density. Environmental Monitoring and Assessment, 192 (2), 78.

[26] Sevik, H., Cetin, M., Ozel, H. U., Ozel, H. B., Mossi, M. M. M., Zeren Cetin, I. (2020). Determination of Pb and Mg accumulation in some of the landscape plants in shrub forms. Environmental Science and Pollution Research, 27 (2), 2423-2431.

[27] Cetin, M., Sevik, H., Turkyilmaz, A., Isinkaralar, K. (2021). Using Abies's Needles as Biomonitors of Recent Heavy Metal Accumulation. *Kastamonu University Journal of Engineering and Sciences*, *7*(1), 1-6.

[28] Hrivnák, M., Paule, L., Krajmerová, D., Kulaç, Ş., Şevik, H., Turna, İ., Tvauri, I., Gömöry, D. (2017). Genetic variation in Tertiary relics: The case of eastern-Mediterranean Abies (Pinaceae). Ecology and evolution, 7 (23), 10018-10030.

[29] Güney, D., Yahyaoglu, Z., Bayraktar, A., Atar, F., Turna, I. (2019). Genetic diversity of Picea orientalis (L.) Link populations in Turkey. *Šumarski list*, *143*(11-12), 539-547.

[30] Kulaç, Ş., Nayır, H. N. (2021). Determination of Grafting Adaptation of Some Chestnut (Castanea sativa Mill.) Genotypes with Marigoule (C. Sativa× C. Crenata) Cultivar. *Turkish Journal of Agriculture-Food Science and Technology*, *9*(8), 1555-1559.

[31] Cetin, M., Sevik, H., Yigit, N., Ozel H.B., Aricak, B., Varol, T. (2018) The variable of leaf micromorphogical characters on grown in distinct climate conditions in some landscape plants. Fresenius Environmental Bulletin, 27 (5): 3206-3211.

[32] Cetin, M., Sevik, H., Yigit, N. (2018). Climate type-related changes in the leaf micromorphological characters of certain landscape plants. Environmental monitoring and assessment, 190 (7), 404.

[33] Yigit, N., Mutevelli, Z., Sevik, H., Onat, S.M., Ozel, H.B., Cetin, M., Olgun, C. (2021). Identification of Some Fiber Characteristics in *Rosa sp.* and *Nerium oleander* L. Wood Grown under Different Ecological Conditions. BioResources, 16(3): 5862-5874. DOI:10.15376/biores.14.3.7015-7024

[34] Sevik, H., Cetin, M., Ozturk, A., Yigit, N., & Karakus, O. (2019). Changes in micromorphological characters of Platanus orientalis L. leaves in Turkey. Applied Ecology and Environmental Research, 17 (3), 5909-5921.

[35] Kravkaz Kuscu, I. S., Cetin, M., Yigit, N., Savaci, G., Sevik, H. (2018). Relationship between Enzyme Activity (Urease-Catalase) and Nutrient Element in Soil Use. *Polish Journal of Environmental Studies*, *27* (5). 2107-2112.

[36] Kravkaz-Kuscu, I. S., Sariyildiz, T., Cetin, M., Yigit, N., Sevik, H., Savaci, G. (2018). Evaluation of the soil properties and primary forest tree species in Taskopru (Kastamonu) district. Fresenius Environmental Bulletin, 27 (3), 1613-1617.

[37] Turkyilmaz, A., Cetin, M., Sevik, H., Isinkaralar, K., & Saleh, E. A. A. (2020). Variation of heavy metal accumulation in certain landscaping plants due to traffic density. Environment, Development and Sustainability, 22 (3), 2385-2398.

[38] Ozel, H. B., Varol, H. N., & Sevik, H. (2021). Change of Mg concentration in several plants depending on plant species, washing status, and traffic density.

[39] Karacocuk, T., Sevik, H., Isinkaralar, K. Turkyilmaz, A., Cetin, M (2021). The change of Cr and Mn concentrations in selected plants in Samsun city center depending on traffic density. Landscape Ecol Eng . https://doi.org/10.1007/s11355-021-00483-6

[40] Shahid, M., Dumat, C., Khalid, S., Schreck, E., Xiong, T., & Niazi, N. K. (2017). Foliar heavy metal uptake, toxicity and detoxification in plants: A comparison of foliar and root metal uptake. *Journal of hazardous materials*, *325*, 36-58.

[41] Aricak, B., Cetin, M., Erdem, R., Sevik, H., & Cometen, H. (2019). The change of some heavy metal concentrations in Scotch pine (Pinus sylvestris) depending on traffic density, organelle and washing. Applied Ecology and Environmental Research, 17 (3), 6723-6734.

[42] Alaqouri, H. A. A., Genc, C. O., Aricak, B., Kuzmina, N., Menshikov, S., & Cetin, M. (2020). The possibility of using Scots pine needles as biomonitor in determination of heavy metal accumulation. Environmental Science and Pollution Research International.

[43] Isinkaralar, K. & Ramazan, E. (2021). Landscape Plants as Biomonitors for Magnesium Concentration in Some Species. International Journal of Progressive Sciences and Technologies, 29(2), 468-473.

[44] Bayraktar, O. Y., Saglam-Citoglu, G., Belgin, C. M., Cetin, S., Cetin, M. (2019). Investigation of effect of brick dust and silica fume on the properties of portland cement mortar. Fresenius Environmental Bulletin, 28(11), 7823-7832.

[45] Bayraktar, O. Y., Saglam-Citoglu, G., Belgin, C. M., Cetin, M. (2019). Investigation of the mechanical properties of marble dust and silica fume substituted portland cement samples under high temperature effect. Fresenius Environmental Bulletin, 28(5); 3865–3875.

[46] Gencel, O., Kazmi, S. M. S., Munir, M. J., Kaplan, G., Bayraktar, O. Y., Yarar, D. O., ... & Ahmad, M. R. (2021). Influence of bottom ash and polypropylene fibers on the physico-mechanical, durability and thermal performance of foam concrete: An experimental investigation. *Construction and Building Materials*, *306*, 124887.

[47] Gencel, O., Benli, A., Bayraktar, O. Y., Kaplan, G., Sutcu, M., & Elabade, W. A. T. (2021). Effect of waste marble powder and rice husk ash on the microstructural, physico-mechanical and transport properties of foam concretes exposed to high temperatures and freeze–thaw cycles. *Construction and Building Materials*, *291*, 123374.

[48] Sevik, H. (2021). The Variation of Chrome Consantration in Some Landscape Plants Due to Species, Organ and Traffic Density. *Turkish Journal of Agriculture-Food Science and Technology*, *9*(3), 595-600.

[49] Güney, D., Kulaç, Ş., Turna, İ. (2012). Study on cone formation stage of Caucasian Fir (Abies nordmanniana ssp. nordmanniana). *Kastamonu University Journal of Forestry Faculty*, *12*(3), 228-233.

[50] Kulaç, Ş., Guney, D., Çiçek, E., Turna, İ. (2013). Effect of provenance, stratification and temperature on the germination of European hophornbeam (Ostrya carpinifolia Scop.) seeds. *Food, Agriculture and Environment (JFAE)*, *11*, 2815-2819.

[51] Kulaç, Ş., Güney, D., Çiçek, E., Somay, Ş., Özbayram, A. K. (2013). Farklı Orijinli Kayacık (Ostrya carpinifolia Scop.) Tohumlarının Bazı Tohum Özelliklerinin Belirlenmesi. *Düzce Üniversitesi Orman Fakültesi Ormancılık Dergisi*, *9*(1), 62-70.

[52] Yildiz, D., Nzokou, P., Deligoz, A., Koc, I., Genc, M. (2014). Chemical and physiological responses of four Turkish red pine (Pinus brutia Ten.) provenances to cold temperature treatments. *European journal of forest research*, *133*(5), 809-818.

[53] Koc, İ., Nzokou, P., & Cregg, B. (2021). Biomass allocation and nutrient use efficiency in response to water stress: insight from experimental manipulation of balsam fir, concolor fir and white pine transplants. *New Forests*, 1-19.

[54] Güney, D., Atar, F., Atar, E., Turna, İ., Kulaç, Ş. (2015). The effect of pre-treatments and seed collection time on the germination characteristics of common hornbeam (Carpinus betulus) seeds in the Eastern Black Sea Region, Turkey. *Seed Science and Technology*, *43*(1), 1-9.

[55] Ertugrul, M., Varol, T., Ozel, H. B., Cetin, M., & Sevik, H. (2021). Influence of climatic factor of changes in forest fire danger and fire season length in Turkey. *Environmental Monitoring and Assessment*, *193*(1), 1-17.

[56] Koc, İ. (2021). Examining Seed Germination Rate and Seedlings Gas Exchange Performances of Some Turkish Red Pine Provenances Under Water Stress. Düzce University Journal of Science & Technology, 9(3), 48-60.

[57] Kulaç, Ş., Nzokou, P., Guney, D., Cregg, B. M., Turna, I. (2012). Growth and physiological response of Fraser fir [Abies fraseri (Pursh) Poir.] seedlings to water stress: seasonal and diurnal variations in photosynthetic pigments and carbohydrate concentration. *HortScience*, *47*(10), 1512-1519.

[58] Yildiz, D., Nzokou, P., Deligoz, A., Koc, I., & Genc, M. (2013). Chemical and Physiological Response of Turkish Red Pine (Pinus brutia Ten.) and American Red Pine (Pinus resinosa Ait.) Seedlings Exposed to Artificial Cold Temperature Treatments. In *Hortscıence* 48(9); 169-S170

[59] Koc, I., Nzokou, P. (2018) Effects of water stress and cold treatments on the germination of two conifers (*Pinus nigra* and *Pinus brutia*) species from Turkey. Hortscience, 53(9), 259.

[60] Koc, I. (2019). Conifers Response to Water Stress: Physiological Responses and Effects on Nutrient Use Physiology. Ph.D. Dissertation, Michigan State University.

[61] Turna, İ., Kulaç, Ş., Güney, D., Seyİs, E. (2013). Effects of media and hormones on highbush blueberry (Vaccinium corymbosum L.) production from cuttings. *Düzce Üniversitesi Orman Fakültesi Ormancılık Dergisi*, *9*(2), 93-104.

[62] Güney, D., Bayraktar, A., Atar, F., Turna, İ. (2020). Effects of root undercutting, fertilization and thinning on seedling growth and quality of oriental beech (Fagus orientalis Lipsky) seedlings. *Artvin Çoruh Üniversitesi Orman Fakültesi Dergisi*, *21*(2), 214-222.

[63] Yıldırım, N., Bayraktar, A., Atar, F., Güney, D., Öztürk, M., Turna, I. (2020). Effects of different genders and hormones on stem cuttings of Salix anatolica. *Journal of Sustainable Forestry*, *39*(3), 300-308.

[64] Wilson, A. R., Nzokou, P., Güney, D., Kulaç, Ş. (2013). Growth response and nitrogen use physiology of Fraser fir (Abies fraseri), red pine (Pinus resinosa), and hybrid poplar under amino acid nutrition. *New Forests*, *44*(2), 281-295.

[65] Shults, P., Nzokou, P., Koc, I. (2020). Nitrogen contributions of alley cropped Trifolium pratense may sustain short rotation woody crop yields on marginal lands. Nutrient Cycling in Agroecosystems, 117(2), 261-272.

[66] Turkyilmaz, A., Sevik H., Isinkaralar K, & Cetin M. (2019). Use of tree rings as a bioindicator to observe atmospheric heavy metal deposition, Environmental Science and Pollution Research, 26 (5), 5122-5130.

[67] Cetin, M., Onac, A. K., Sevik, H., & Sen, B. (2019). Temporal and regional change of some air pollution parameters in Bursa. *Air Quality, Atmosphere & Health*, *12*(3), 311-316.

[68] Cetin, M., Sevik, H., Aricak, B., Ozturk, A., Genc, C. O., Aisha, A. E. S. A., Jawed, A.A., Aljama, A.M.O. & Alrabiti, O. B. M. (2019). The Investigation of the Changing in Conccentration of Some Heavy Metals in Seeds, Leaves, and Branches because of Traffic Density: a Case Study of Acer Platanoides. *Kastamonu Üniversitesi Mühendislik ve Fen Bilimleri Dergisi*, *5*(2), 83-92.

[69] Ucun Ozel, H., Gemici, B. T., Gemici, E., Ozel, H. B., Cetin, M., & Sevik, H. (2020). Application of artificial neural networks to predict the heavy metal contamination in the Bartin River. *Environmental Science and Pollution Research*, 1-18.

[70] Turkyilmaz, A., Sevik, H., Cetin, M., & Ahmaida Saleh E. A. (2018). Changes in heavy metal accumulation depending on traffic density in some landscape plants. Pol J Environ Stud 27 (5):2277–2284.

[71] Ozel HB, Cetin M, Sevik H, Varol T, Isik B., Yaman B. (2021) The effects of base station as an electromagnetic radiation source on flower and cone yield and germination percentage in Pinus brutia Ten. *Biologia Futura* (2021). https://doi.org/10.1007/s42977-021-00085-1

[72] Ozel, H.B., Abo Aisha, A.E.S., Cetin, M. Sevik, H., Zeren Cetin, I. (2021). The effects of increased exposure time to UV-B radiation on germination and seedling development of Anatolian black pine seeds. Environ Monit Assess 193, 388. https://doi.org/10.1007/s10661-021-09178-9

[73] Bozdogan Sert, E., Turkmen, M., & Cetin, M. (2019). Heavy metal accumulation in rosemary leaves and stems exposed to traffic-related pollution near Adana-İskenderun Highway (Hatay, Turkey). Environmental Monitoring and Assessment, 191(9), 553. https://doi.org/10.1007/s10661-019-7714-7

[74] Yigit, N., Cetin, M., Ozturk, A., Sevik, H., & Cetin, S. (2019). Varitation of Stomatal Characteristics in Broad Leaved Species Based on Habitat. Applied Ecology and Environmental Research 17 (6):12859-12868.