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EFFECTS OF LANDSCAPE PLANTS ON PUBLIC HEALTH: THE CASE OF BURSA-MUDANYA

Zencirkiran M.[1*], Çelik B.H.[2], Seyidoğlu Akdeniz N.[1]

[1]*Bursa Uludağ University, Faculty of Agriculture, Department of Landscape Architecture, Görükle Campus, Nilüfer – BURSA-TURKEY*
[2]*Bursa Uludağ University, Graduate School of Natural and Applied Science, Landscape Architecture Doctoral Program, Görükle Campus, Nilüfer – BURSA-TURKEY*
**Corresponding Author Email: mzencirkiran@uludag.edu.tr*

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Abstract – Plants are a part of life, and they are elements that are an inseparable part of landscape designs, especially in areas that are widely used by large masses of people. It is of great importance to know and choose the properties of plants that affect public health due to their aesthetic, functional, and psychological effects, as well as some components they contain. Toxic components in different organs of plants cause adverse effects for humans and animals by touching and ingesting. Furthermore, many plants can cause allergic reactions because of their pollens.
This study examined open green areas designed for public use in Bursa province of Turkey, Mudanya district, and the taxa of woody landscape plants in these areas were evaluated in terms of their toxic properties for public health.
In the study, it was determined that 79.4% of the 107 taxa of woody landscape plants showed toxic and allergenic properties, while 20.6% did not show toxic properties. On the other hand, it was observed that the rate of non-toxic but allergenic taxa was 18.6 %. As a result of statistical studies with the obtained data, a significant relationship among the parameters examined was determined in the study.
Landscape designs made by considering the toxicological properties of plants may reduce the cases of poisoning caused by plants, and the measures to be taken for existing designs may raise awareness of the public on this issue.

Keywords: Toxicological classification of plants, toxic plants, allergenic plants, importance of plant selection, Mudanya.

Introduction

Plants are living organisms that form a remarkable part of the ecosystem, have great functions within the environment and human factors, have dynamic features, and are constantly evolving (Eroglu et.al., 2005; Acar & Sari, 2010). Plants, which cover a large part of the ecosystem, are important in creating livable green spaces, especially in urban and rural areas (Akdeniz et.al., 2017; Domina et.al., 2024).

Landscape plants, which are used in open and green areas designed to meet the needs of people for green space and located among the concrete building blocks in cities as a result of rapid population growth and unplanned urbanization, help to keep the ongoing mutual interaction between the human and environmental system in balance with effects such as reducing air pollution, hide unattractive vistas, directing pedestrian traffic, preventing soil erosion, creating space that are contributing to urban aesthetics and

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are having psychological, emotional, and mental functions on people (Booth, 1990; Scarfone, 2007; Karasah & Var, 2012; Sari & Karasah, 2018; Beckmann-Wübbelt et.al., 2021; Lausi et.al., 2022).

Many features, especially dendrological, ecological, aesthetic, and functional features, are considered in the selection of landscape plants for landscape designs (Paganová & Jureková, 2012). Due to the increase in health problems (allergic reactions, etc.) in humans and animals in recent years, it is of great importance to consider the toxic components of plants. Some of the plants known for their unique properties in the 'Plant Universe' show toxic effects due to the components they contain, and their effects arise as a result of interactions with humans and animals in different ways (Çelik, 2020; Domina et.al., 2024).

A poisonous plant is defined as a plant that creates negative effects through the poisonous substances it contains (Wagstaff, 2008). There are cases of poisoning as a result of ingestion of different parts of the plant or contact with the skin and these poisonings can cause cases whose symptoms disappear spontaneously, as well as serious cases that end up with death (Benzeid et al., 2018; Serrano, 2018; Nithaniyal et al., 2021). Toxic components are found in many genera and species in different families. The components which are toxic to humans and animals are the primary components that plants synthesize to maintain their basic metabolism, as well as the secondary components they produce, such as protein, fat, and carbohydrates. Some of them are alkaloids, glycosides, oxalates, saponins, terpenes, tannins, polyenes, resinous components, fatty acids, volatile oils, toxic amino acids, proteins, and peptides. These components, which can have toxic effects on humans and animals, also take on the task of protecting plants against pathogens. The severity of poisoning in humans and animals varies according to gender, age, body weight, type of toxic substance, the amount contained in the plant, and the way and amount of these components are taken into the body (Ginsburg & Deharo, 2011; Serrano, 2018). It is also possible that the concentration of a toxic substance is greater in some communities of a plant within the same species. As a result, the severity of symptoms seen in living things affected by plants in different communities can vary. Responses to plant toxins may also be influenced by human genetic variation that can detoxify many of these substances (Peterson, 2011). The ingestion of the leaves, stems, and roots of some plants or contact with their sap can result in toxic effects. Depending on the degree of toxicity, this can cause serious illnesses (Knight, 2007; Poppenga, 2010; Filmer, 2012; Domina et.al., 2024). Especially in this context, plants that cause high toxicity can cause serious damage and even death. On the other hand, ingestion or chewing of plants with low toxicity may cause minor discomforts such as vomiting and diarrhea, while plants containing oxalate crystals in their sap cause symptoms such as mouth, tongue, and throat irritation, swelling, burning, and stomach disorders. Moreover, the sap or thorns of plants that cause dermatitis cause itching, redness, or irritation on the skin through their villus. Plants that cause animal toxicity can have toxic effects, especially for pets. It is also possible that the concentration of a toxic substance is greater in some communities of a plant within the same species (Nelson et.al., 2007; Knight, 2007; Poppenga, 2010; Filmer, 2012; Zencirkiran et.al., 2018).

On the other hand, in addition to the toxic components contained in the plant, the pollen produced by the trees at different times of the year, mostly in the spring, can cause allergies such as rhinitis, asthma, and conjunctivitis in some people. It is estimated that approximately 10-30% of the world's population has pollen-related rhinitis. It's revealed the necessity of focusing on whether the landscape plants to be used in plant designs are also allergenic due to the effects of tree pollens on asthma and their cross-reactivity (Stach et.al., 2008; Steinman, 2008; Lauriola & Talluri, 2022).

In this context, within the scope of this study, which was carried out based on the hypothesis that "human and animal health needs to know the toxic properties of landscape plants that will be included in the designs of open green areas where there is an intense public use, and to consider this issue in designs", woody landscape plants of the light green areas of Mudanya district of Bursa province were evaluated according to their toxicity status.

Materials and methods

This research was carried out in Mudanya district of Bursa province. Mudanya district is located between 28°- 29° east

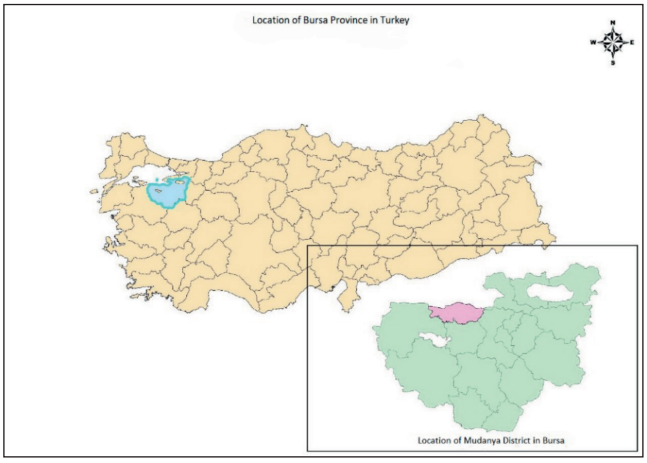


Figure 1. Bursa province and Mudanya district location map.

longitude and 40°- 41° north latitude and has a surface area of 366 km^2. Mudanya district has a coast to the southeast of the Sea of Marmara (Fig. 1) and is adjacent to the district of Karacabey in the west, Nilüfer and Osmangazi in the south, and Gemlik in the east (Anonymous, 2022).

The main material of the study consists of woody landscape plants in 123 open green areas located within the borders of Mudanya district of Bursa province. Observation technique and document analysis methods were used. In the field study, it was carried out within the scope of the observation technique (Ozdemir, 2010; Baltaci, 2019; Kiral, 2020), which is a technique that provides access to the data first and records the observations of the researcher who approaches the subject impartially without making any changes (Ozdemir, 2010; Baltaci, 2019; Kiral, 2020). The visits were made by the study team 40 times in total, once every two weeks during the vegetation period (spring - summer), and the samples were taken from the shoots, leaves and flowers of woody landscape plants. During sampling, each plant was photographed with a Nikon D5200 camera to obtain visual material. The samples were dried by natural drying method. This method was applied by placing the plants between papers and changing the papers daily in an environment where the air was active and direct sunlight was not received (Uma & Duzenli, 2012). For this purpose, the plant samples were placed in papers of newspaper in an orderly manner, and pressed in wooden presses, and dried in the laboratory of the department. After drying, the plants were placed on white cardboard sheets and identified. Plant identifications were carried out by the study team using the document analysis method (Ozdemir, 2010; Kiral, 2020), which enables the examination and systematic analysis of all documents, including printed and electronic materials. In this context, different sources (Davis, 1965-1988; Kayacik, 1980, 1981, 1982; Krusmann, 1984-1986; Dirr, 1992; Pamay, 1992, 1993; Yaltirik, 1993; Anonymous, 1998; Mataraci, 2002; Zencirkiran, 2004; Zencirkiran, 2009; Zencirkiran, 2013; Zencirkiran & Akdeniz, 2017; Çelik 2020) and samples from Bursa Uludag University Faculty of Science and Literature Herbarium were used.

Plants were included in more than one toxicity group (Tab. 1) depending on different parameters such as the toxic components it contains, the amount of toxic substance entering the body of the affected organism, the way the toxic substance taken into the body. The woody taxa identified in the study were classified and evaluated under 7 groups in terms of toxicity and allergenicity (Baytop, 1989; Knight, 2007; Nelson et al., 2007; Steinman, 2008; Wagstaff, 2008; Filmer, 2012; Atasoy, 2012; Zencirkiran et al., 2018; DiTomaso, 2019; Friday, 2019; Çelik, 2020; Çelik & Zencirkiran, 2021; Kušen et al., 2022).

Table 1. Toxicity groups and their effect.

Group 1. Major Toxicity	These plants may cause serious illness or death.
Group 2. Minor Toxicity	Ingestion of these plants may cause minor illnesses such as vomiting or diarrhea.
Group 3. Oxalates	The juice or sap of these plants contains oxalate crystals. These needle-shaped crystals can irritate the skin, mouth, tongue, and throat, resulting in throat swelling, breathing difficulties, burning pain, and stomach upset.
Group 4. Dermatitis	The juice, sap or thorns of these plants may cause a skin rash or irritation.
Group 5. Animal Toxicity	Plants in this group are toxic to animals such as cats and dogs.
Group 6. Allergen	Plants in this group can cause allergic disorders such as rhinitis, asthma, conjunctivitis in humans due to the pollen they produce.
Group 7. Non-toxic	Plants in this group are not harmed.

SPSS 28 (IBM, 2022) program was used for statistical analysis of the obtained data. Differences between taxa and toxic groups were determined by one-way and two-way analysis of variance, Duncan's test (Duncan, 1955) was used for differences between groups, and the significance levels were lettered as $p \leq 0.05$. On the other hand, Pearson Correlation analysis was used to determine the relationships between toxic groups and taxa.

Results

107 taxa of woody landscape plants were identified in 123 open green areas examined in the district of Mudanya. Observations revealed that 84 of the identified taxa were in the Angiospermae subdivision and 23 in the Gymnospermae subdivision.

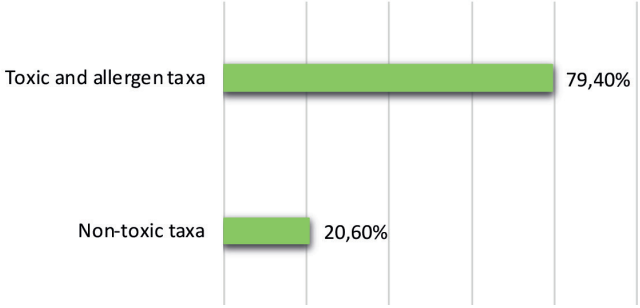
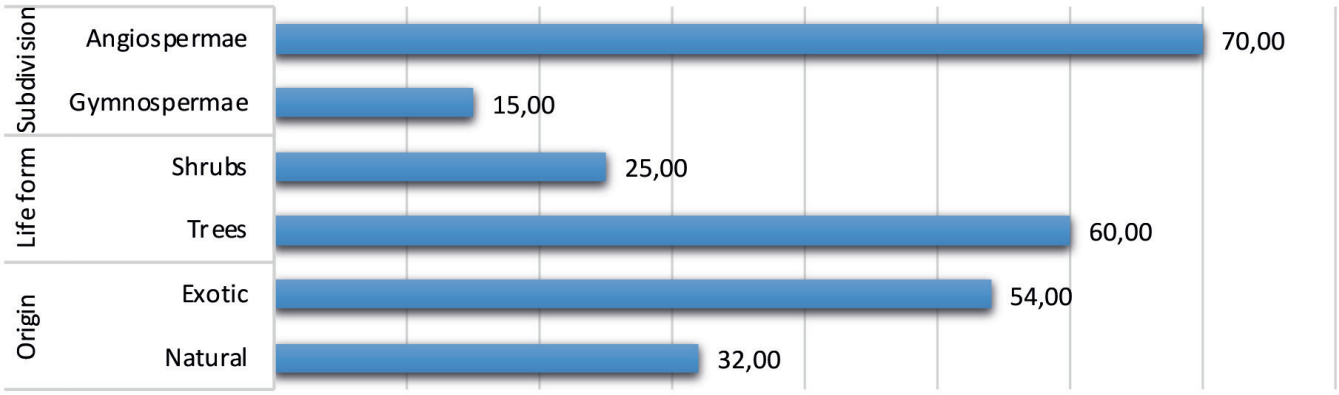


Figure 2. Distribution of toxic - allergen and non-toxic taxa.



	Origin		Life form		Subdivision	
	Natural	Exotic	Trees	Shrubs	Gymnospermae	Angiospermae
Number of Toxic Taxon	32,00 b	54,00 a	60,00 a	25,00 b	15,00 b	70,00 a*

Figure 3. Number of toxic taxa by subdivision, origin and life forms (*The letters indicate different groups at the $p \leq 0.05$ level).

Table 2. Number of taxa by toxic groups.

Toxic Groups	Number of taxa
Group 1	13 d*
Group 2	30c
Group 3	1 e
Group 4	32 b
Group 5	42 a
Group 6	41 a
Group 7	42 a

(*The letters indicate different groups at the $p \leq 0.05$ level).

79.40% (85 units) of the 107 woody taxa detected showed toxic and allergenic properties, while 20.60% (22 units) were non-toxic (Fig. 2). On the other hand, 20% (17 units) of the detected toxic taxa were allergen-toxic and 23.52% (20 units) were allergen-non-toxic.

The study determined that the distributions of toxic taxa numbers differed significantly in terms of subdivision, life form, and origin at $p \leq 0.05$ level.

70 taxa in the subdivision of Angiospermae, 60 taxa in tree form, and 54 taxa of exotic origin showed toxic properties (Fig. 3).

As a result of statistical analyses, there were significant differences between the toxic groups at the $p \leq 0.05$ level. The

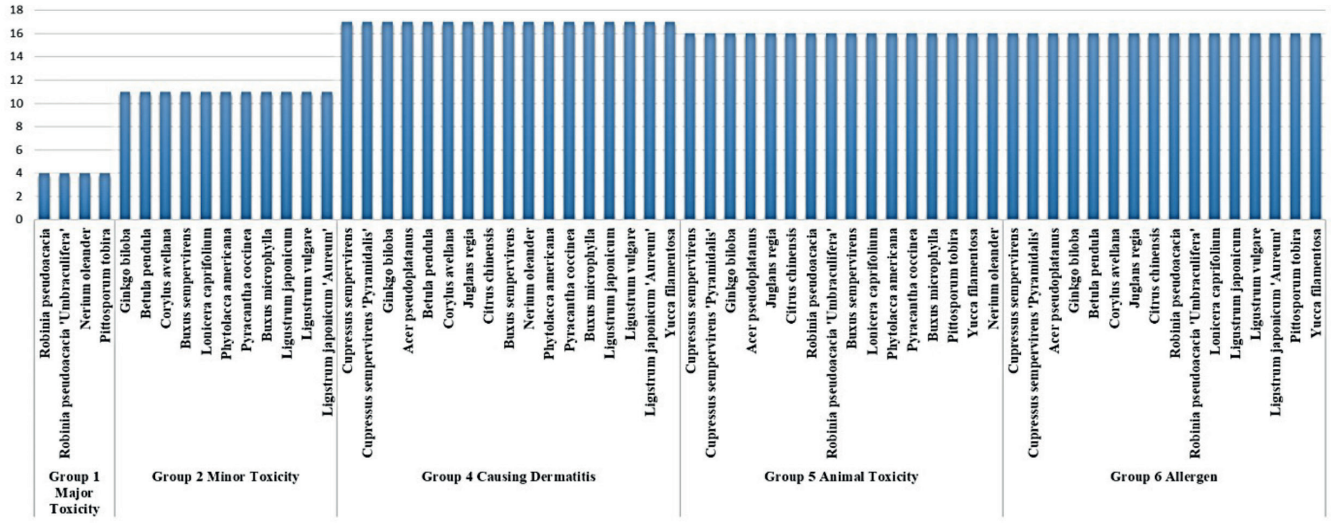


Figure 4.Distribution of taxa in three or more toxic groups according to toxic groups.

study determined that the highest number of taxa were in Group 7 and Group 5, and the least number of taxa were in Group 3 (Tab. 2). Taxa in three or more toxic groups are shown in Fig. 4. The correlation analysis between taxa and toxicity groups revealed a positive relationship between the total number of taxa and the number of toxic taxa, and the number of toxic taxa increased depending on the increase in the number of taxa (Tab. 3).

Table 3. The correlation analysis between total taxa in toxic groups and toxic taxa.

Total Taxa	Toxic Taxa	
	Pearson Correlation (r)	1,000**
	Significant (Sig.)	0.000

** Correlation is significant at the 0.01 level (2-tailed).

On the other hand, an evaluation of the relationship between the total number of taxa and toxic groups revealed a linear relationship since the correlation coefficient was (+) positive and the number of taxa in toxic groups increased as the total number of taxa increased (Tab. 4).

The results of the correlation analysis between the toxic groups exhibited that the toxic groups were positively (+) correlated with each other. Accordingly, an increase in the number of taxa in each group also increases the number of taxa in other groups (Tab. 5).

The results of the two-way analysis of variance revealed that the interactions of subdivision x toxic groups, life form x toxic groups, and origin x toxic groups were significant at the $p \leq 0.05$ level. An examination of the interaction of subsection x toxic groups revealed that the highest number of taxa was in Angiospermae subdivision x group 5, followed by Angiospermae subdivision x group 6. The study determined no taxon in Gymnospermae subdivision x group 3 (Tab. 6).

The analysis of the interaction of life form x toxic groups exhibited that the highest number of taxa was in Trees x group 7, followed by Trees x group 6. (Fig. 5).

The examination of the origin x toxic groups interaction revealed that the highest number of taxa was in exotic x group 5, followed by exotic x group 7. No taxa were determined in natural x group 3 (Tab. 7).

Conclusion

Plants can cause toxic effects for humans and animals due to some of the components they contain, and they can also cause allergic reactions with the pollen they spread. The results of research have demonstrated that species can bear different toxic properties, and that toxic compounds can also vary across species (Al-Qura'n, 2005; Çelik & Zencirkiran, 2021; Domina et.al., 2024). Also, a species can cause different toxic effects due to the components it contains. Poisoning caused by plants varies depending on various factors such as the amount and type of poison contained in the plant, and the age of the affected living being, and this may result in mild or even fatal situations. Emergent cases have been reported in the worldwide for species such as *Datura stramonium*, *Euphorbia* sp., *Nerium oleander* and *Ricinus communis* (Nithaniyal et al., 2021; Domina et.al., 2024).

For this reason, determining and knowing the toxicity status of plants is vital for well-being and a healthy environment. Accordingly, within the example of Mudanya district, 123 woody landscape design plants used in open green areas were identified and each taxon was examined in terms of toxicological properties and divided into different groups according to their properties.

The interactions of these groups with each other were revealed by making various analyses. As a result, the percentages of the 107 woody taxa were determined as 78.5% (with 84 taxa) in Angiospermae, 21.5% (with 23 taxa) in the subgroup Gymnospermae, 37.4% (with 40 taxa) in the subgroup natural and 62.7% (with 67 taxa) in exotic origin. In addition, it was also determined that 79.4% of the taxa showed toxic and allergenic properties, and 20.6% did not show toxic properties. On the other hand, the observations revealed that 18.6% of the taxa showed allergenic properties although they did not show toxic properties.

Turkey is a very rich country in terms of biodiversity with approximately 12.000 plant species, and registered poisonous plant species with properties that may pose a danger to human and animal health increasing day by day. It's also known that there are approximately 200 toxic plants registered in the country (Baytop, 1989; Ozturk et al., 2008; Gokkur & Dogan, 2018).

Domina et al. (2024) and Sebald et al. (2023) reported 137

Table 4. The correlation analysis between toxic groups and taxon numbers.

		Major Toxicity	Minor Toxicity	Oxalates	Dermatitis	Animal Toxicity	Allergen	Non-Toxic
Total taxon	Pearson Correlation	1,000**	1,000**	1,000**	1,000**	1,000**	1,000**	1,000**
	Sig. (2-tailed)	0,000	0,000	0,000	0,000	0,000	0,000	0,000

** Correlation is significant at the 0.01 level (2-tailed).

Table 5. The relationships between toxic groups

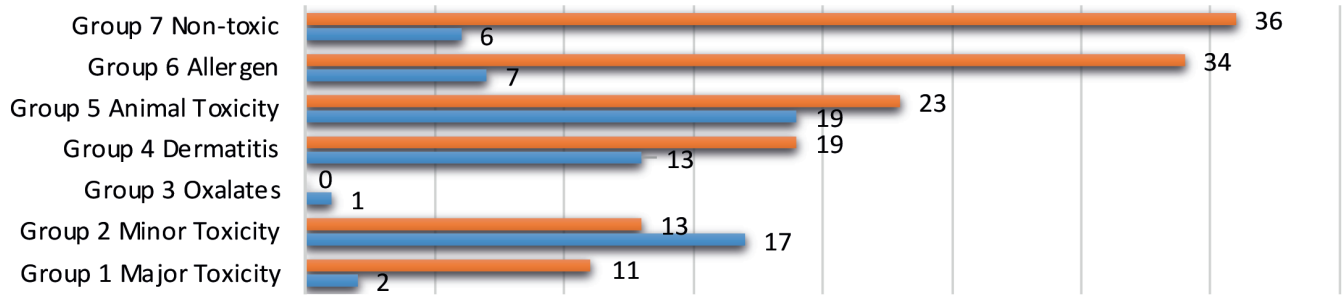
		Total taxon	Major Toxicity	Minor Toxicity	Oxalates	Dermatitis	Animal Toxicity	Allergen	Non-Toxic
Total Taxon	Pearson Correlation	1	1,000**	1,000**	1,000**	1,000**	1,000**	1,000**	1,000**
	Sig. (2-tailed)		,000	,000	,000	,000	,000	,000	,000
Major Toxicity	Pearson Correlation		1	1,000**	1,000**	1,000**	1,000**	1,000**	1,000**
	Sig. (2-tailed)			,000	,000	,000	,000	,000	,000
Minor Toxicity	Pearson Correlation			1	1,000**	1,000**	1,000**	1,000**	1,000**
	Sig. (2-tailed)				,000	,000	,000	,000	,000
Oxalates	Pearson Correlation				1	1,000**	1,000**	1,000**	1,000**
	Sig. (2-tailed)					,000	,000	,000	,000
Dermatitis	Pearson Correlation					1	1,000**	1,000**	1,000**
	Sig. (2-tailed)						,000	,000	,000
Animal Toxicity	Pearson Correlation						1	1,000**	1,000**
	Sig. (2-tailed)							,000	,000
Allergen	Pearson Correlation							1	1,000**
	Sig. (2-tailed)								,000
Non-Toxic	Pearson Correlation								1
	Sig. (2-tailed)								

**. Correlation is significant at the 0.01 level (2-tailed).

Table 6. Distribution of taxa among subdivision x toxic groups.

Subdivision	**Toxic groups**	**Number of taxa**
Gymnospermae	Group 1 Major Toxicity	1 j
	Group 2 Minor Toxicity	4 ı
	Group 3 Oxalates	0 j
	Group 4 Dermatitis	9 g
	Group 5 Animal Toxicity	6 h
	Group 6 Allergen	7 h
	Group 7 Non-toxic	11 f
Angiospermae	Group 1 Major Toxicity	12 f
	Group 2 Minor Toxicity	26 d
	Group 3 Oxalates	1 j
	Group 4 Dermatitis	23 e
	Group 5 Animal Toxicity	36 a
	Group 6 Allergen	34 b
	Group 7 Non-toxic	31 c

(*The letters indicate different groups at the $p \leq 0.05$ level)



	Group 1 Major Toxicity	Group 2 Minor Toxicity	Group 3 Oxalates	Group 4 Dermatitis	Group 5 Animal Toxicity	Group 6 Allergen	Group 7 Non-toxic
Trees	11 g	13 f	0 j	19 d	23 c	34 b	36 a*
Shrubs	2 ı	17 e	1 ıj	13 f	19 d	7 h	6 h

Figure 5. Distribution of taxa among life form x toxic groups (*The letters indicate different groups at p ≤ 0.05).

and 106 toxic plants in their studies in parks and urban community gardens, while Akdeniz & Zencirkiran (2024) reported that 36 of 79 species identified in hospital gardens with a dense user base were toxic. However, plant poisoning is difficult to diagnose, and the epidemiology of plant poisonings is geographically specific (Ng et al., 2019).

According to the American Association of Poison Control Center report, in 2015, between 1.80 - 2.29% of the poisoning complaints were caused by plants, plants ranked 10th in the poisonings seen in children aged 0-5, and plants were reported to be among the top 25 in the general ranking (Mowry et al., 2016; Zencirkiran et.al., 2018). Since the spring and summer months, when urban open green spaces are frequently used, coincide with the period when the fruits and flowers of many plants with higher toxic components, the poisoning caused by plants increases (Gul & Topcu, 2017). The most common cause of poisoning from plants is the unconscious use of plants without being aware of their toxic properties (Kocabas, 2020).

Table 7. Distribution of taxa among origin x toxic groups.

Origin	Toxic groups	Number of taxa
Natural	Group 1 Major Toxicity	2 ı
	Group 2 Minor Toxicity	9 h
	Group 3 Oxalates	0 j
	Group 4 Dermatitis	15 f
	Group 5 Animal Toxicity	12 g
	Group 6 Allergen	19 d
	Group 7 Non-toxic	18 de
Exotic	Group 1 Major Toxicity	10 h
	Group 2 Minor Toxicity	21 c
	Group 3 Oxalates	1 ıj
	Group 4 Dermatitis	17 e
	Group 5 Animal Toxicity	30 a
	Group 6 Allergen	21 c
	Group 7 Non-toxic	24 b

(*The letters indicate different groups at the p ≤ 0.05 level).

In this study, it was proven that toxic groups were related to each other, and it was also seen that 41 of the toxic taxa were allergens and 42 were taxa with animal toxicity. It can be said that this situation may have negative effects on the users. Similarly, Frenguelli & Passaleva (2003) and Stach et al. (2008) emphasized in their studies that there is a periodic release of pollen in urban open green areas and that reactions such as pollen allergy, rhinitis and conjunctivitis recur every year. Ozgen (1987) stated that it is necessary to use surface air flow maps to control the effects of allergenic pollen.

Plants, which are an inseparable part of the universe, have been used by people for centuries to make medicine, host animals, and provide emotional and psychological contributions to people even are much more than their appearance and functions. For this reason, knowing more about them will be beneficial for humanity in every sense.

Designs should be made by taking into account the aesthetic and functional features of existing plants in urban open green areas such as children's playgrounds, hospital gardens, city parks, etc., especially where the user mass is intense, as well as their toxic and allergenic properties. However, in order to activate people's awareness and draw attention, it is

important to put the warning signs on the taxa in these areas. These signs should contain information such as toxic and allergenic properties of the plant, and also toxic parts of the plants. Considering that there are few studies on the toxicity and allergenicity properties of plants, it is obvious that this study will be instructive for future applications.

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