

Toxic and allergenic plant species in primary school yards of Zagreb's Lower Town district

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The green infrastructure of Zagreb's Lower Town is made up of row-planted trees and green spaces within blocks of buildings. All schools are surrounded by green spaces that have a positive impact on the environment. Although most green spaces contribute to improving the quality of life, they also contain toxic and allergenic species which are potentially hazardous, particularly to children. This paper aims to make an inventory of plant species in the environment of primary schools in Zagreb's Lower Town district, and to determine the presence of toxic and allergenic species. The field research was conducted from March to the end of May 2021 at 7 primary school locations. 13 either annual or biennial plant families were catalogued. In total, 34 species of herbaceous perennials and geophytes, and 36 species of trees from 17 plant families were listed. A total of 38 species of shrubs and climbers were found. Also, a total of 35 poisonous and 28 allergenic plant taxa are planted in the green spaces surrounding primary schools. The most common poisonous species found are *Hedera helix* and *Taxus baccata*, and *Ilex aquifolium*, a highly poisonous species, was also found. No moderately poisonous species have been found at all. As far as allergenic species are concerned, school environments are dominated by those that produce low and moderate levels of pollen concentration in the air. Species that produce high levels of pollen concentration (e.g., *Betula pendula*, *Robinia pseudoacacia*, etc.) are the least represented ones, while species that produce a very high concentration of pollen have not been recorded in any of the localities.

Keywords: primary schools, school gardens, ornamental plants, poisonous plants, allergies

1 Introduction

Within the context of urban green spaces, special attention should be given to primary school gardens. Titman (1994) sees school grounds as: a place to work in (physical activity and new skills development), a place to think in (to study and develop new skills), a place for the senses (to enjoy colours, smells, sounds, and nature in general), and a place to be (for privacy and enjoyment of silence). In other words, school gardens are spaces that facilitate the physical, psychological, and intellectual development of children and young people.

From the second half of the 18th to the end of the 19th century, Croatia's education system was regulated by directives, orders, and decrees which sought to set up a school garden in each school (Slačanac & Munjiza, 2007). At the end of the 19th century, school gardens were declared commercial gardens as well, which expanded their use, and enabled schools to start

generating profit from their gardens (Kolar-Dimitrijević, 2014). The 1923 Education Act made the institution of school garden obligatory. In 1936, the agricultural administrative authorities were assigned the task of preparing the commercial framework of school gardens, proposing school garden layouts and plans, and seedling distribution at no cost. In 1956, school cooperatives of different orientations (e.g., field crop husbandry, fruit and vegetable growing, floriculture, beekeeping, etc.) were established, whose development actually led to the silent liquidation of school gardens (Munjiza, 2003). Interest in school gardens was reignited after 1990. The then new conception of Croatian education reaffirmed school gardens (Židovec et al., 2018), and recognised their role in developing interest in the field of ecology and environmental education, and in being young people's social and psychological support with elements of psychotherapy through work (Munjiza, 2003).

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Due to a long tradition of school gardens, and their use encouraged in teaching, it is expected that children will, at some point, get exposed to direct or indirect contact with plant species. Although teaching in the natural environment of school gardens has many positive aspects, the possibility of negative outcomes due to allergic reactions or poisoning via consumption of toxic plant parts is always present. In the last few decades, an increase in the use of ornamental plants in parks and gardens, public and workplaces have become a new source of aeroallergens (D'Amato et al., 2007). Eder, Ege & von Mutius (2006) estimate that pollen allergy has risen by 40%, and exposure to allergens is a key environmental factor, much like other air pollutants, that causes asthma. The accidental poisoning of children by ingestion of plants causes over 50% of all poisoning cases in Slovakia (Plackova, Caganova & Kresánek, 2006). It is suggested that children's inadequate plant identification skills are responsible for their consumption of some poisonous plant parts. The risk of toxic plant consumption is considered to be highest amongst younger children who lack awareness about the toxicity of plants or their fruit (Fančovičová & Prokop, 2011). Familiarity that results from exposure to plants in nature influences children's ability to identify plants (Lindemann-Matthies, 2005). It is evident from the above historical overview that school gardens have a long tradition, and that continued emphasis has been placed on their importance. School gardens in urban areas are also an integral part of the latter's green infrastructure. Although most species planted in cities and school gardens contribute to improving the quality of life, they can be poisonous and allergenic, which is potentially hazardous, particularly to children.

This paper aims to make an inventory of the ornamental plant species in the gardens of primary schools in Zagreb's Lower Town district, and to determine the presence of toxic and allergenic species.

2 Material and methods

The research was conducted in the green spaces of primary schools in Zagreb's Lower Town (Donji Grad) district. The Lower Town district is Zagreb's strict city centre and is located at 45° 48' N longitude and 15° 58' E latitude, covering 301.64 ha in area, and occupying 3.02% of the total area of the city (Grad Zagreb, 2017).

The field research was conducted from March to the end of May 2021. The research included 7 primary schools and was approved by the principals who granted the researchers entry, and permission to take photographs. Two of the primary schools do not have their own schoolyards but have other small green areas and also

use public green area in front of the school in the same way they would use schoolyard (Table 1).

Table 1 Primary schools of Zagreb's Lower Town

Primary school mark	Year of opening	Schoolyard
PS-1	1961	×
PS-2	1957	×
PS-3	1895	-
PS-4	1925	-
PS-5	1901	×
PS-6	1864	×
PS-7	1875	×

To measure the size of plot around the schools, the Geoportal of the State Geodetic Administration of the Republic of Croatia (2021) was used. Using the GIS online tool, the area of the schoolyards was measured: the total area of each plot; each construction area; each front yard area; each schoolyard area; and the length of each hedgerow. Each area was measured in square metres (m²), and each hedgerow in metres (m).

To make an inventory of plant species, the field research was conducted from March to the end of May 2021. To determine the species of plants, their taxonomy, and invasiveness, relevant botanical literature was used. Poisonous plant species were determined based on: Crvenka (1996), Forenbacher (1998), Grlić (1984), Petrić and Tomašević (2003). The toxicity class of each plant species is presented in accordance with Filmer's (2012) modified plant toxicity categorisation. The allergenicity of each plant species was determined based on D'Amato et al. (2007).

Potentially aeroallergenic plants must contain allergenic compounds in their pollen grain, be anemophilous, and produce pollen in large quantities. The allergenicity category of each plant species was determined in accordance with the modified categorisation of Peternel et al. (2004), which classifies dendrological plants according to their level of allergenicity as follows: low (I), moderate (II), high (III), and very high (IV) pollen levels. Highly sensitive individuals will develop symptoms of an allergic reaction even when the pollen count is low (1), most sensitive individuals when the count is moderate (2), and when the pollen count is high (3) and very high (4), all individuals sensitive to pollen will develop symptoms of an allergic reaction.

Table 2 Plot areas of primary schools in Zagreb's Lower Town district (m²)

PS	Total plot area (m ²)	Construction area (m ²)	Green space area (m ²)	Sports ground area (m ²)
PS-1	3,741	761	2,980	–
PS-2	5,876	1,840	1,755	2,281
PS-3	4,190	2,415	910*	865
PS-4	3,631	3,034	597*	–
PS-5	3,766	800	996	1,970
PS-6	3,908	1,050	558	2,300
PS-7	8,139	2,604	1,316	4,219
Average	4,750	1,786	1,302	2,327

* public areas located in front of the primary school included

3 Results and discussion

With the help of the Geoportal of the State Geodetic Administration of the Republic of Croatia, the area of each school garden was measured: the total area of each plot; each construction area; the area of each green space; and the area of each school's sports grounds. The total area of each primary school plot includes the school building, the school's sports hall, the school's car park, paths, green spaces, and its sports grounds.

PS-7 has the largest total plot area (Table 2). PS-4 has the largest construction area, while PS-5 has the smallest construction area. There are green space areas adjacent to three schools: PS-3, PS-4, and PS-6. The green space areas of PS-3 and PS-4 do not belong to the cadastral parcels of the two schools, but are public green space areas that have been included in the total school plot area, given that pupils use them for their needs (placement of flowerpots, break time, etc.). PS-3 shares its cadastral parcel with other public facilities. The primary schools on the outskirts of Zagreb's Lower Town district have a significantly larger total plot area than those in the centre of the district.

As Table 3 shows, a total of 22 species of annual or biennial plant species from 13 plant families, 34 perennials and geophytes from 19 plant families, 38 species of shrubs and woody climbers from 20 plant families, and 34 species of trees from 17 plant families were catalogued. A total of 6 invasive species were found. Most perennials and geophytes are from the Asparagaceae and Lamiaceae families, most shrubs and woody climbers from the Lamiaceae and Rosaceae families, and most trees from the Aceraceae family.

35 poisonous plant species have been found, the most common of which is *Hedera helix*, which is present in all the primary schools. *Taxus baccata*, and *Prunus laurocerasus* are amongst the more common poisonous species. In terms of their toxicity class, 15 are highly

toxic (2), 12 slightly toxic (4), and 8 fatally toxic (1). From amongst the highly poisonous plant species, *Ilex aquifolium* should be singled out. It is a protected plant species that was found in the immediate vicinity of PS-1's schoolyard. It has prickly leaves, which makes it unsuitable for the schoolyard. The presence of *Ligustrum vulgare* should also be noted as it is a species which is poisonous in its entirety. It forms the hedgerow in as many as four locations.

From amongst the fatally toxic species, *Prunus laurocerasus* and *Taxus baccata* stand out. Both species are poisonous in their entirety, and their toxins can affect human health adversely (causing vomiting, diarrhoea, heart palpitations, etc.). Although the (seedless) aril of *Taxus baccata* is edible, caution is advised because the fruit's bright colour creates interest in children exposing them to the risk of poisoning. *Nerium oleander* is an evergreen shrub that is taken indoors in winter. All its parts are poisonous. In pregnant women, it can cause strong contractions and a miscarriage, and its juice can cause skin irritation and allergic reactions (Maretić, 1986). Planting *Nerium oleander* in primary schools should definitely be avoided.

28 allergenic plant species were found. *Taxus baccata* is the most widely spread, while *Betula pendula*, *Ligustrum vulgare*, and *Platanus* are also common. It is important to notify that only male plants of yew produce pollen. In terms of allergenicity, the green spaces of schools are dominated by species that produce low levels of pollen concentration in the air (11). Highly allergenic (3) species are the least represented ones. This group includes *Betula pendula*, *Robinia pseudoacacia*, and *Parietaria judaica*, a perennial which blooms from May to September, and which produces a large amount of pollen during flowering causing allergies (Nikolić et al., 2008).

Table 3 List of catalogued species, their incidence (number of locations where the species had been recorded), invasiveness, toxicity class, and allergenicity category

Plant family	Plant species	Incidence	Invasiveness	Toxicity class	Allergenicity category
Annual and biennial plant species					
1	Apiaceae	<i>Petroselinum crispum</i> (Mill.) A. W. Hill	1		
2	Asteraceae	<i>Arctium lappa</i> L.	1		
3		<i>Argyranthemum frutescens</i> (L.) Sch.Bip.	1		
4		<i>Dahlia pinnata</i> Cav.	1		
5		<i>Euryops pectinatus</i> Cass.	1		
6		<i>Osteospermum ecklonis</i> (DC.) Norl.	1		
7		<i>Tagetes erecta</i> L.	2	x	
8	Balsaminaceae	<i>Impatiens walleriana</i> Hook.f.	1	x	
9	Begoniaceae	<i>Begonia semperflorens</i> Link et Otto	2		
10		<i>Heliotropium arborescens</i> L.	1		1
11	Boraginaceae	<i>Myosotis sylvatica</i> Ehrh.	1		
12	Brassicaceae	<i>Lobularia maritima</i> (L.) Desv.	1		
13	Caryophyllaceae	<i>Dianthus caryophyllus</i> L.	2		2
14		<i>Dianthus chinensis</i> L.	1		
15	Crassulaceae	<i>Crassula</i> sp. L.	1		
16	Lythraceae	<i>Cuphea hyssopifolia</i> Kunth	2		4
17	Geraniaceae	<i>Pelargonium</i> sp.	1		
18	Lamiaceae	<i>Ocimum basilicum</i> L.	1		
19	Scrophulariaceae	<i>Veronica persica</i> Poiret	1	x	
20	Solanaceae	<i>Calibrachoa parviflora</i> (Juss.) D'Arcy	1		
21		<i>Petunia axillaris</i> (Lam.) B.S.P.	1		
22		<i>Solanum lycopersicum</i> L.	1		
Perennials and geophytes					
1	Acoraceae	<i>Acorus gramineus</i> Sol. Aiton	1		
2	Aizoaceae	<i>Delosperma cooperi</i> (Hook.f.) L. Bolus	1		
3	Amaryllidaceae	<i>Narcissus</i> sp.	1		2
4	Apocynaceae	<i>Vinca major</i> L.	1		
5		<i>Vinca minor</i> L.	2		
6		<i>Vinca minor</i> L. 'Variegata'	1		
7	Asparagaceae	<i>Hosta</i> sp.	1		
8		<i>Hyacinthus orientalis</i> L.	1		2
9		<i>Muscari neglectum</i> Guss. ex Ten.	1		
10		<i>Yucca gloriosa</i> L.	1		
11	Asteraceae	<i>Bellis perennis</i> L.	1		4
12		<i>Chrysanthemum indicum</i> L.	2		
13	Boraginaceae	<i>Glandora diffusa</i> (Lag.) I. M. Johnst.	1		
14	Crassulaceae	<i>Sedum ternatum</i> Michx.	1		
15		<i>Sempervivum tectorum</i> L.	4		
16	Iridaceae	<i>Crocus vernus</i> (L.) Hill	1		
17		<i>Iris germanica</i> L.	1		

First continuation of table 3

Plant family	Plant species	Incidence	Invasiveness	Toxicity class	Allergenicity category
18	<i>Glechoma hederacea</i> L.	1		2	
19	<i>Mentha × piperita</i> L.	1			
20	<i>Origanum vulgare</i> L.	1			
21	<i>Plectranthus forsteri</i> 'Marginatus'	1			
22	<i>Lilium</i> sp.	1			
23	<i>Tulipa</i> sp.	1		2	
24	<i>Paeonia mascula</i> (L.) Mill.	1			
25	<i>Phyllostachys bissetii</i> (Carr.) A.et C.Riv.	1			
26	<i>Phlox subulata</i> L.	1			
27	<i>Duchesnea indica</i> (Andr.) Focke	1	x		
28	<i>Fragaria × ananassa</i> Duchesne ex Weston	3			
29	<i>Heuchera</i> 'Green Spice'	1			
30	<i>Heuchera</i> sp.	1			
31	<i>Saxifraga × arendsii</i> Engl.	1			
32	<i>Parietaria judaica</i> L.	1			(III)
33	<i>Verbena × hybrida</i> Groenland & Rümpler	1			
34	<i>Viola odorata</i> L.	1			
Shrubs and climbers					
1	<i>Sambucus nigra</i> L.	2		1	(I)
2	<i>Nerium oleander</i> L.	1		1	
3	<i>Ilex aquifolium</i> L.	1		2	
4	<i>Hedera helix</i> L.	7		2	
5	<i>Santolina rosmarinifolia</i> L.	1			
6	<i>Berberis thunbergii</i> DC.	3		4	
7	<i>Campsis radicans</i> (L.) Seem. ex Bureau	1		4	
8	<i>Lonicera caprifolium</i> L.	2			
9	<i>Lonicera nitida</i> E. H. Wilson	1			
10	<i>Euonymus fortunei</i> (Turcz.) Hand.-Maz.	2		2	
11	<i>Euonymus japonicus</i> Thunb.	1		2	
12	<i>Juniperus</i> sp. L.	2			(II)
13	<i>Rhododendron indicum</i> (L.) Sweet	1		1	
14	<i>Wisteria sinensis</i> (Sims) Sweet	1		1	
15	<i>Deutzia scabra</i> Thunb.	1			
16	<i>Lavandula angustifolia</i> Mill	1			
17	<i>Lavandula officinalis</i> Chaix	3			
18	<i>Lavandula stoechas</i> L.	1			
19	<i>Rosmarinus officinalis</i> L.	1			
20	<i>Rosmarinus officinalis</i> L. 'Capri'	2			
21	<i>Salvia officinalis</i> L.	2			
22	<i>Thymus vulgaris</i> L.	1			
23	<i>Thymus × citriodorus</i> 'Silver Queen'	1			

Second continuation of table 3

Plant family	Plant species	Incidence	Invasiveness	Toxicity class	Allergenicity category	
24	Malvaceae	<i>Hibiscus syriacus</i> L.	1			
25	Myrtaceae	<i>Myrtus communis</i> L.	1	2		
26	Oleaceae	<i>Forsythia suspensa</i> (Thunb.) Vahl	1			
27		<i>Ligustrum ovalifolium</i> Hassk.	1	2		
28		<i>Ligustrum vulgare</i> L.	4	2	(II)-(III)	
29		<i>Syringa vulgaris</i> L.	3		(I)	
30	Pinaceae	<i>Pinus mugo</i> Turra	1			
31	Ranunculaceae	<i>Clematis vitalba</i> L.	2	4		
32	Rosaceae	<i>Chaenomeles japonica</i> (Thunb.) Lindl. ex Spach	1			
33		<i>Cotoneaster horizontalis</i> Decne.	2	2		
34		<i>Photinia</i> × <i>fraseri</i> Dress	1			
35		<i>Prunus laurocerasus</i> L.	6	1		
36		<i>Rosa</i> sp.	4		(I)	
37		<i>Rubus caesius</i> L.	1			
38		<i>Spiraea</i> × <i>vanhouttei</i> (Briot) Zabel	1			
Trees						
1	Aceraceae	<i>Acer campestre</i> L.	1			
2		<i>Acer negundo</i> L.	3	x	4	(II)
3		<i>Acer palmatum</i> Thunb. ex E. Murray	1		4	
4		<i>Acer pseudoplatanus</i> L.	1		4	(II)
5		<i>Acer saccharinum</i> L.	2		4	(II)
6	Altingiaceae	<i>Liquidambar styraciflua</i> L.	1		(I)	
7	Betulaceae	<i>Betula pendula</i> Roth.	5		4	(III)
8		<i>Carpinus betulus</i> L.	1			(II)
9		<i>Carpinus betulus</i> L. 'Fastigiata'	1			(II)
10	Cupressaceae	<i>Chamaecyparis lawsoniana</i> (A. Murray) Parl.	1			(II)
11		<i>Thuja occidentalis</i> L.	1		2	(II)
12	Fabaceae	<i>Gleditsia triacanthos</i> L.	1			
13		<i>Robinia pseudoacacia</i> L.	1	x	1	(III)
14	Hippocastanaceae	<i>Aesculus hippocastanum</i> L.	2		2	(II)
15	Magnoliaceae	<i>Magnolia liliiflora</i> Desr.	1			
16	Moraceae	<i>Ficus carica</i> L.	1			
17		<i>Maclura pomifera</i> (Raf.) C. K. Schneid.	1			
18	Oleaceae	<i>Fraxinus angustifolia</i> Vahl	1		4	(II)-(III)
19		<i>Fraxinus excelsior</i> L.	2		4	(II)-(III)
20	Pinaceae	<i>Abies alba</i> Mill.	1			(I)
21		<i>Cedrus atlantica</i> (Endl.) Manetti ex Carriere 'Glaucua'	1			
22		<i>Picea abies</i> (L.) H. Karst.	1			(I)
23	Platanaceae	<i>Platanus</i> × <i>acerifolia</i> /Aiton/Willd.	4			(II)-(III)
24	Rosaceae	<i>Malus domestica</i> Borkh.	1			

Third continuation of table 3

Plant family	Plant species	Incidence	Invasiveness	Toxicity class	Allergenicity category
25	Rosaceae	<i>Prunus avium</i> (L.) L.	1		
26		<i>Pyrus communis</i> L.	2		
27	Salicaceae	<i>Populus nigra</i> L. 'Italica'	1		(I)
28	Sapindaceae	<i>Koelreuteria paniculata</i> Laxm.	1		
29	Taxaceae	<i>Taxus baccata</i> L.	6	1	(II)
30	Tiliaceae	<i>Tilia cordata</i> Mill.	3		(I)
31		<i>Tilia platyphyllos</i> Scop.	2		(I)
32		<i>Tilia tomentosa</i> Moench	2		(I)
33	Ulmaceae	<i>Celtis australis</i> L.	1		(I)
34		<i>Celtis occidentalis</i> L.	1		

4 Conclusions

Due to school spaces being restricted and green schoolyard areas being mostly small, in Zagreb's Lower Town district a relatively small number of species have been catalogued. In turn, this showed that toxic and allergenic species in the total number of species catalogued is high when it comes to woody plant species (trees, shrubs and climbers). The most frequent poisonous and allergenic species (*Taxus baccata*, *Betula pendula*, *Hedera helix* and *Ligustrum vulgare*) catalogued in the immediate vicinity of primary schools in Zagreb's Lower Town district are the same as those that have been catalogued in similar studies (Vlahović & Karlović, 2013; Perinčić, Milović & Radoš, 2014; Mrđan et al., 2017; Židovec et al., 2018) conducted in the vicinity of other education institutions elsewhere. This points to the fact that there is no growing knowledge about potential problem. Awareness should be raised among personnel responsible for planning and planting on all green areas around education institutions. Species planted should be chosen more carefully, avoiding species that are moderately and strongly allergenic or poisonous in their immediate vicinity. However, this should not result in repeatedly planting just a few "safe" plant species, an effort should also be made to preserve and increase biodiversity in cities. Poisonous trees and shrubs should be surrounded by other plants that are not poisonous in a way (e.g., impenetrable hedges) that prevents contact with them by children. Growing of poisonous annuals, biennials and perennials should be avoided. Children should be more informed about plant species, their value and characteristics.

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