



Original article

Poisonous and allergenic plant species in preschool's and primary school's yards in the city of Novi Sad



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ARTICLE INFO

Keywords:

Allergenic plants
Poisonous plants
Preschools
Primary schools

ABSTRACT

Presence of the poisonous and allergenic plant species was observed in 8 primary schools and 6 preschools in Novi Sad, Serbia. The aim of this research was to determine the extent to which pre-school and school-age children are exposed to harmful plant species and also to gain insight does the present landscaping take into account the appropriateness in the use of certain ornamental species in arranging preschool's and school's greenery. In the analyzed locations 22 poisonous plant species were noticed, mainly belonging to genera *Thuja*, *Symphoricarpos*, *Cotoneaster*, *Juniperus*, *Berberis* and *Taxus*, represented with 367 specimens. Along with poisonous, 21 allergenic plant species mainly belonging to genera *Acer*, *Tilia*, *Betula*, *Populus*, *Platanus*, *Celtis*, *Aesculus*, *Thuja*, *Ulmus*, *Robinia* and *Quercus*, represented with 675 specimens, were determined. The calculated allergenic index grouped most of the investigated species into strongly allergenic (calculated A.I. = 7) due to their prolonged phenantesic period, high abundance and possible cross-reactivity with other species noticed in the greenery. Establishment and enhancement of the collaboration between schools and experts from relevant institutions would result in the removal of the very most allergenic and poisonous landscape plants and ultimately toxic-free and allergy-friendly school yards. Gradual removal might temper the public reluctance to this measurement, but finally only joint efforts and complete abandonment of pointed species can convert unhealthy school yards into ones that are safe and allergy-friendly.

1. Introduction

Appropriately designed outdoor spaces of educational institutions are important for mental and physical development as well as children's health. Greenery is significant component of open spaces. It enriches the environment in which children reside, creates a healthy microclimate that protects from harmful external influences (dust, gases, noise and extreme temperatures) and provides children contact with nature (Anastasijević, 2007). Thereby, serious approach in planning and designing educational institution's yards, which among other things includes careful selection of plant species, is necessary.

According to American Association of Poison Control Centers database, analyzed for the period 2000–2008, 3.4% of all poisoning in the United States was due to plants and nearly 70% of victims were children under the age of six (Petersen, 2011). Studies in some European countries were carried out as well (Vichova and Jahodar, 2003; Lamminpää and Kinos, 1996). Study conducted in Germany, from 2001 to 2010 reported 13001 plant exposures of which over 85% cases involved children (Plenert et al., 2012). Plant toxicity derives due to the

presence of toxic compounds such as alkaloids, glycosides, saponins, oxalates and etc (Douglas, 2005; Dražić, 2002). Although the number of poisoning cases registered suggests that their incidence has been decreasing in recent decades, plant poisoning can't be underestimated. Contact with these plants can cause skin and/or eyes irritation or even consummation poisoning. Toxicity varies due to maturation stage and toxic compounds content in different plant parts. Thus, certain amounts of the poison entered can be almost harmless for adults but lethal to children (Filmer, 2012; Grlić, 1984). Sometimes plant poisoning may not be properly identified, since general population has scarce knowledge about the toxicity of plants commonly present in their environment. When it comes to children's poisoning, sometimes the symptoms are not at first associated with exposure to a plant and the exposure may not even be witnessed by the adults (Monseny et al., 2015).

Disorders and changes in the immune system functioning caused by allergens lead to allergic reactions (Igić, 2012; Nestorović et al., 2011). Pollen in more than 20% of the human population causes allergic reactions (bronchitis, conjunctivitis, dermatitis, hay fever), while long term exposure to high concentrations can cause chronic bronchitis and

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<http://dx.doi.org/10.1016/j.ufug.2017.05.007>

Received 9 December 2016; Received in revised form 26 April 2017; Accepted 15 May 2017

Available online 20 May 2017

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bronchial asthma (Zrnić, 2010). Cariñanos and Casares-Porcel (2011) stated some of major causes of allergenicity: low species biodiversity at planting reflected as the overabundance of certain species acting as pollen sources; male individuals utilization in dioecious species; the presence of invasive species; exotic species introduction; the appearance of cross-reactivity between species; lack of garden management and maintenance and the interaction between pollen and air pollutants. According to 'Report on the pollen counts' in the city of Pančevo (Serbia) in 2012, limiting value for concentrations of pollen grains in air for all allergenic plants should be 30 pollen grains per 1 m³ of air. Except for ragweed (*Ambrosia artemisiifolia* L.), for which 15 pollen grains per 1 m³ of air are critical. Concentrations of pollen grains in air above those values carry risk of allergic reactions.

The aim of this research was to determine the extent to which preschool and school-age children are exposed to harmful plant species and also to gain insight does present landscaping take into account the appropriateness in the use of certain ornamental species in arranging preschool's and school's greenery in Novi Sad.

2. Material and methods

2.1. Analyzed locations

Presence of poisonous, allergenic and invasive plant species was observed in 14 educational institutions (Fig. 1), 8 primary schools and 6 preschools. The survey covered 10 city districts in the City of Novi Sad (45°15'18"N 19°50'41"E) – Liman I, Liman II, Liman III, Grbavica, Adamovićevo naselje, Sajmište, Novo Naselje, Satelit, Rotkvarija and

Klisa (Fig. 1). In each location species affiliation and specimens number was determined (Table 1). The city of Novi Sad was analyzed as an exemplary study illustrating the general trend in preschools and school's greenery landscaping in previous period.

2.2. Greenery assessment

Dendrological determination was carried out according to Ocokoljić and Ninić-Todorović (2003). Data concerning poisonous plant species was obtained from Grlić (1984), Kojić and Janjić (1991), Dražić (2002) and Filmer (2012). Allergenic plant species were determined according to Igić et al. (2005), Igić (2012), Nestorović et al. (2011) and Zrnić (2010).

Analysis included data from field research and was complemented with information obtained using literature. For recorded poisonous species, parts of plant that contain toxins were specified. Toxicity class was defined according to modified classification proposed by Filmer (2012): (A) plants with major toxic effect that may cause serious illness or death, (B) plants with minor toxic effect, ingested cause vomiting or diarrhea, (C) plants whose oxalate crystals ingested can irritate mouth, tongue and throat, resulting in throat swelling, breathing difficulties, burning pain and stomach upset (D) sap or thorns of these plants may cause a skin rash or irritation. With respect to allergenic pollen production potential, determined species were divided into three groups denoted as high, moderate or low potential.

For those species the allergen index value (A.I.) was calculated according to Hruska (2003), taking into account several distinguished parameters. This is a modified 1–10 numerical plant-allergy scale first



Fig. 1. Distribution of the investigated locations across the City of Novi Sad with graphical illustration of the most abundant poisonous and allergenic plant species for the given localities.

Table 1
List of analyzed locations.

Location number	Educational institutions	City district	Open space area (m ²) ^a	Number of recorded specimens in open space
I	'Zarko Zrenjanin' Primary School	Liman III	7897	115
II	'Jovan Popović' Primary School	Liman II	13662	187
III	'Sonja Marinković' Primary School	Grbavica	5625	118
IV	'Vasa Stajić' Primary School	Adamovićevo naselje	6208	148
V	'Prva vojvodanska brigada' Primary School	Novo naselje	7416	111
VI	'Miloš Crnjanski' Primary School	Satelit	13990	226
VII	'Kosta Trifković' Primary School	Rotkvarija	5400	93
VIII	'Dušan Radović' Primary School	Slana bara	9797	155
IX	'Razlićak' Preschool	Liman III	6 533	64
X	'Kalimero' Preschool	Liman II	1 220	41
XI	'Mrvica' Preschool	Liman I	2 594	72
XII	'Palčica' Preschool	Sajmište	3 900	74
XIII	'Zlatna ribica' Preschool	Sajmište	3 593	54
XIV	'Vendi' Preschool	Novo naselje	1 490	46
				Total No. of specimens = 1504

^a Source of data Official Gazette of the City of Novi Sad No. 14/06 and 03/09.

introduced by Dr Thomas Leo Ogren, in 2000 (Ogren, 2000), registered as 'OPALS™ – The World's First Plant-Allergy Scale', widely recognized and used in the greenery assessment. Each parameter is presented with numeric value which expresses the potential of a plant species to cause allergic manifestations in human: (i) life cycle of species (annual = 1, biannual = 2, perennial = 3), (ii) length of the phenantesic period (less than one month = 0.5, more than one month = 2), (iii) presence of cross reactivity phenomena (none present = 0, present = 1) assigned according to detailed guidelines by Igić (2012), (iv) species abundance (rare = 0.5, present = 1, rather common = 2, abundant = 3, very abundant = 4). Abundance marks are derived from number of recorded specimens of allergenic plant species and it's calculated percentage in total educational institution's dendroflora (< 1% – rare, 1–25% – present, 25–50% – rather common, 50–75% – abundant, 75–100% – very abundant) representing frequency of allergenic plant species appearance in dendroflora of all observed locations.

Calculated A.I. represents the sum of the values determined for each of the mentioned parameters. Based on this index, plants are grouped into strongly allergenic (A.I. = 7–10), moderately allergenic (A.I. = 4–6), and slightly allergenic or of uncertain effect (A.I. ≤ 3). For each location, total number of specimens of poisonous and allergenic plant species and their percentages in total dendroflora of institution's yards was calculated.

3. Results

Results yielded by this study showed moderate species diversity in educational institution's yards with areas occupying from 1220 m² to 13990 m² (Table 1). The greatest species diversity was recorded in institutions 'Jovan Popović' Primary School (location II), 'Prva vojvodanska brigada' Primary School (location V) and 'Razlićak' Preschool (location IX) where 31 species were noticed. The lowest number of species was noted in 'Kalimero' Preschool (location X), 'Palčica' Preschool (location XII) and 'Zlatna ribica' Preschool (location XIII) with 18, 17 and 16 species, respectively. In remaining surveyed institutions no less than 20 species were identified.

The floristic composition of preschools and primary school's yards, included 22 poisonous and 21 allergenic plant species, represented with 367 and 675 specimens, respectively. According to results presented in Table 2, the greatest diversity of poisonous plant species was found in 'Jovan Popović' Primary School (location II) and 'Prva vojvodanska brigada' Primary School (location V) with 7 detected species, represented with 47 and 17 specimens, respectively. Preschools 'Vendi' (location XIV) and 'Zlatna ribica' (location XIII) were characterized by the lowest poisonous species diversity with only 2 species. The highest percentage of poisonous plant species in total institution dendroflora

was determined for 'Sonja Marinković' Primary School (location III) with 45.76% (54 specimens). Significant percentage of poisonous plant species in total institution dendroflora was observed for 'Kalimero' Preschool (location X) with 43.90% (18 specimens) and 'Miloš Crnjanski' Primary School (location VI) with 41.15% (93 specimens). The lowest percentage of poisonous plant species in total dendroflora was noted for 'Zlatna ribica' Preschool (location XIII) with 5.55% (3 specimens). Observed by species the most frequent proved to be *Cotoneaster horizontalis* Decne., *Robinia pseudoacacia* L. and *Thuja occidentalis* L., appearing in 8 different locations, followed by *Thuja orientalis* L. appearing in 7 locations and *Taxus baccata* L. noted in 6 locations (Table 2).

Considering allergenic plant species the most abundant was *Betula pendula* Roth. with 108 specimens, present in 10 surveyed locations, followed by *Platanus × acerifolia* Willd. with 54 specimens found in dendroflora of 12 educational institutions. In several locations, significant number of *Tilia cordata* Mill., *Populus nigra* L. 'Italica' and *Acer pseudoplatanus* L. representatives was noticed, with 62, 56 and 54 specimens, respectively. Least frequent were species of genera *Cupressus* with less than 0.5% in total institutional dendroflora (Table 4). 'Dušan Radović' Primary School (location VIII) was characterized by the highest percentage of allergenic plant species in total institutional dendroflora with 75.48%, while in albeit all observed pre-schools allergenic plant species took more than 30% in total dendroflora, reaching up to 66.66% in location XIII (Table 3).

The calculated A. I. grouped most of the investigated species into strongly allergenic (calculated A.I. > 6). *B. pendula* and *T. orientalis* achieved the highest scores (calculated A.I. = 7) since their phenantesic period lasts over a month, survey results confirmed their common presence (high abundance) and used literature suggested possible cross-reactivity with other species noticed in the greenery (Table 4). Appearance frequency of *Corylus avellana* L. *Cupressus sempervirens* L., *Cupressus arizonica* Greene and *T. baccata* in analyzed locations was not high, but possible cross-reactivity with other species nearby and their long phenantesic period resulted in high allergenic potential (calculated A.I. = 6.5). In addition to previously mentioned, value 1 for presence of cross reactivity phenomena was assigned to *B. pendula*, *C. avellana*, *C. columnata*, *C. sempervirens*, *C. arizonica*, *T. orientalis*, *T. baccata* and *P. × acerifolia* due to food nutrient related cross-reactivity (Table 4).

4. Discussion

4.1. Poisonous plant species in observed locations

Present study highlights the risks of children exposure to plants with harmful effects growing in extant greenery they reside in. Specimens of

Table 2
Poisonous plant species and their percentage in total dendroflora of each observed location.

Location number	Family	Species	Plant parts that contain toxins and their toxicity class	No. of recorded specimens	Total No. of specimens and percentage in total dendroflora of location (%)
I	Berberidaceae	<i>Berberis julianae</i> Schneid.	berry (B,D)	2	15/
	Caprifoliaceae	<i>Lonicera caprifolium</i> L.	berry (B)	2	13.04%
	Cupressaceae	<i>Juniperus horizontalis</i> Moench	whole plant (B)	3	
	Cupressaceae	<i>Thuja orientalis</i> L.	whole plant (B,D)	6	
	Rosaceae	<i>Prunus laurocerasus</i> L.	whole plant (A)	1	
II	Rosaceae	<i>Cotoneaster horizontalis</i> Decne.	berry (B)	1	
	Caprifoliaceae	<i>Sambucus nigra</i> L.	unripe berry (A)	2	47/
	Caprifoliaceae	<i>Symphoricarpos albus</i> (L.) S.F.Blake	berry (B)	6	25.13%
	Cupressaceae	<i>Juniperus sabina</i> L.	whole plant (B)	30	
	Cupressaceae	<i>Thuja occidentalis</i> L.	whole plant (B,D)	2	
III	Fabaceae	<i>Laburnum anagyroides</i> Medik.	seed, shoots (B)	1	
	Fabaceae	<i>Robinia pseudoacacia</i> L.	seed, shoots (B)	4	
	Taxaceae	<i>Taxus baccata</i> L.	whole plant (A)	2	
	Caprifoliaceae	<i>Sambucus nigra</i> L.	unripe berry (A)	4	54/
	Cupressaceae	<i>Juniperus sabina</i> L.	whole plant (B)	2	45.76%
IV	Cupressaceae	<i>Thuja occidentalis</i> L.	whole plant (B,D)	37	
	Fabaceae	<i>Robinia pseudoacacia</i> L.	seed, shoots (B)	5	
	Oleaceae	<i>Ligustrum ovalifolium</i> Hassk.	leaves,berry (B,D)	hedge	
	Rosaceae	<i>Cotoneaster horizontalis</i> Decne.	berry (B)	6	
	Araliaceae	<i>Hedera helix</i> L.	whole plant (B,D)	2	39/
V	Cupressaceae	<i>Thuja occidentalis</i> L.	whole plant (B,D)	30	26.35%
	Cupressaceae	<i>Thuja orientalis</i> L.	whole plant (B,D)	6	
	Fabaceae	<i>Robinia pseudoacacia</i> L.	seed, shoots (B)	1	
	Oleaceae	<i>Ligustrum ovalifolium</i> Hassk.	leaves,berry (B,D)	hedge	
	Berberidaceae	<i>Berberis vulgaris</i> L.	berry (B,D)	1	17/
VI	Berberidaceae	<i>Berberis thunbergii</i> DC.	berry (B,D)	2	15.31%
	Cupressaceae	<i>Thuja orientalis</i> L.	whole plant (B,D)	2	
	Oleaceae	<i>Ligustrum ovalifolium</i> Hassk.	leaves,berry (B,D)	hedge	
	Rosaceae	<i>Cotoneaster horizontalis</i> Decne.	berry (B)	8	
	Rosaceae	<i>Prunus laurocerasus</i> L.	whole plant (A)	3	
VII	Taxaceae	<i>Taxus baccata</i> L.	whole plant (A)	1	
	Araliaceae	<i>Hedera helix</i> L.	whole plant (B,D)	2	93/
	Caprifoliaceae	<i>Sambucus nigra</i> L.	unripe berry (A)	3	41.15%
	Caprifoliaceae	<i>Symphoricarpos albus</i> (L.)S.F.Blake	berry (B)	54	
	Fabaceae	<i>Robinia pseudoacacia</i> L.	seed, shoots (B)	5	
VIII	Rosaceae	<i>Cotoneaster horizontalis</i> Decne.	berry (B)	11	
	Cupressaceae	<i>Thuja occidentalis</i> L.	whole plant (B,D)	18	
	Berberidaceae	<i>Berberis thunbergii</i> DC.	berry (B,D)	13	18/
	Cupressaceae	<i>Thuja occidentalis</i> L.	whole plant (B,D)	2	19.35%
	Cupressaceae	<i>Thuja orientalis</i> L.	whole plant (B,D)	3	
IX	Oleaceae	<i>Ligustrum ovalifolium</i> Hassk.	leaves,berry (B,D)	hedge	
	Rosaceae	<i>Pyracantha coccinea</i> M.Roem.	berry (B,D)	hedge	
	Cupressaceae	<i>Juniperus virginiana</i> L.	whole plant (B)	1	23/
	Cupressaceae	<i>Thuja occidentalis</i> L.	whole plant (B,D)	2	14.84%
	Cupressaceae	<i>Thuja orientalis</i> L.	whole plant (B,D)	10	
X	Rosaceae	<i>Cotoneaster horizontalis</i> Decne.	berry (B)	10	
	Caprifoliaceae	<i>Lonicera xylostium</i> L.	berry (A)	3	12/
	Cupressaceae	<i>Thuja orientalis</i> L.	whole plant (B,D)	2	18.75%
	Fabaceae	<i>Robinia pseudoacacia</i> L.	seed, shoots (B)	4	
	Rosaceae	<i>Prunus laurocerasus</i> L.	whole plant (A)	2	
XI	Rosaceae	<i>Pyracantha coccinea</i> M.Roem.	berry (B,D)	1	
	Caprifoliaceae	<i>Lonicera xylostium</i> L.	berry (A)	1	18/
	Caprifoliaceae	<i>Symphoricarpos orbiculatus</i> Moench	berry (B)	10	43.90%
	Cupressaceae	<i>Thuja occidentalis</i> L.	whole plant (B,D)	2	
	Rosaceae	<i>Cotoneaster horizontalis</i> Decne.	berry (B)	1	
XII	Taxaceae	<i>Taxus baccata</i> L.	whole plant (A)	4	
	Caprifoliaceae	<i>Symphoricarpos orbiculatus</i> Moench	berry (B)	3	17/
	Caprifoliaceae	<i>Symphoricarpos albus</i> (L.)S.F.Blake	berry (B)	6	23.61%
	Fabaceae	<i>Robinia pseudoacacia</i> L.	seed, shoots (B)	3	
	Ranunculaceae	<i>Clematis vitalba</i> L.	whole plant (D)	1	
XIII	Rosaceae	<i>Cotoneaster horizontalis</i> Decne.	berry (B)	2	
	Taxaceae	<i>Taxus baccata</i> L.	whole plant (A)	2	
	Cupressaceae	<i>Thuja orientalis</i> L.	whole plant (B,D)	4	8/
	Fabaceae	<i>Robinia pseudoacacia</i> L.	seed, shoots (B)	3	10.81%
	Taxaceae	<i>Taxus baccata</i> L.	whole plant (A)	1	
XIV	Cupressaceae	<i>Thuja occidentalis</i> L.	whole plant (B,D)	1	3/
	Fabaceae	<i>Robinia pseudoacacia</i> L.	seed, shoots (B)	2	5.55%
XV	Rosaceae	<i>Cotoneaster horizontalis</i> Decne.	berry (B)	2	3/
	Taxaceae	<i>Taxus baccata</i> L.	whole plant (A)	1	6.52%

Table 3
Allergenic plant species and their percentage in total dendroflora of each observed location.

Location number	Family	Species	Allergenicity according to used literature ^a	No. of recorded specimens	Total No. of specimens and percentage in total dendroflora of location (%)
I	Aceraceae	<i>Acer platanoides</i> L.	low	1	25/
	Aceraceae	<i>Acer saccharinum</i> L.	low	11	21.74%
	Cupressaceae	<i>Thuja orientalis</i> L.	moderate	6	
	Fagaceae	<i>Quercus robur</i> L.	moderate	3	
	Platanaceae	<i>Platanus × acerifolia</i> (Aiton) Willd	low	2	
II	Tiliaceae	<i>Tilia tomentosa</i> Moench	moderate	2	
	Aceraceae	<i>Acer platanoides</i> L.	low	13	82/
	Aceraceae	<i>Acer pseudoplatanus</i> L.	low	14	43.85%
	Betulaceae	<i>Betula pendula</i> Roth	high	18	
	Cupressaceae	<i>Cupressus sempervirens</i> L.	moderate	2	
	Fabaceae	<i>Robinia pseudoacacia</i> L.	moderate	5	
	Fagaceae	<i>Quercus robur</i> L.	moderate	1	
	Hippocastanaceae	<i>Aesculus hippocastanum</i> L.	moderate	5	
	Tiliaceae	<i>Tilia platyphyllos</i> Scop.	moderate	13	
	Tiliaceae	<i>Tilia cordata</i> Mill.	moderate	11	
III	Aceraceae	<i>Acer pseudoplatanus</i> L.	low	10	55/
	Aceraceae	<i>Acer platanoides</i> L.	low	2	46.61%
	Betulaceae	<i>Betula pendula</i> Roth	high	1	
	Corylaceae	<i>Corylus colurna</i> L.	moderate	1	
	Fabaceae	<i>Robinia pseudoacacia</i> L.	moderate	4	
	Oleaceae	<i>Ligustrum ovalifolium</i> Hassk.	low	hedge	
	Platanaceae	<i>Platanus × acerifolia</i> (Aiton) Willd	low	5	
	Salicaceae	<i>Populus nigra</i> L. 'Italica'	moderate	2	
	Tiliaceae	<i>Tilia platyphyllos</i> Scop.	moderate	4	
	Tiliaceae	<i>Tilia tomentosa</i> Moench	moderate	2	
	Ulmaceae	<i>Celtis australis</i> L.	moderate	24	
IV	Aceraceae	<i>Acer saccharinum</i> L.	low	1	87/
	Betulaceae	<i>Betula pendula</i> Roth	high	24	58.78%
	Cupressaceae	<i>Cupressus sempervirens</i> L.	moderate	1	
	Cupressaceae	<i>Thuja orientalis</i> L.	moderate	6	
	Fabaceae	<i>Robinia pseudoacacia</i> L.	moderate	1	
	Oleaceae	<i>Ligustrum ovalifolium</i> Hassk.	low	hedge	
	Platanaceae	<i>Platanus × acerifolia</i> (Aiton) Willd	low	4	
	Sapindaceae	<i>Aesculus hippocastanum</i> L.	moderate	2	
	Tiliaceae	<i>Tilia cordata</i> Mill.	moderate	41	
	Ulmaceae	<i>Celtis australis</i> L.	moderate	7	
	Aceraceae	<i>Acer pseudoplatanus</i> L.	low	5	66/
	Aceraceae	<i>Acer platanoides</i> L.	low	3	59.46%
V	Aceraceae	<i>Acer saccharinum</i> L.	low	1	
	Betulaceae	<i>Betula pendula</i> Roth	high	6	
	Corylaceae	<i>Corylus colurna</i> L.	low	3	
	Corylaceae	<i>Corylus avellana</i> L.	low	1	
	Cupressaceae	<i>Thuja orientalis</i> L.	moderate	2	
	Fagaceae	<i>Quercus robur</i> L.	moderate	3	
	Hippocastanaceae	<i>Aesculus hippocastanum</i> L.	moderate	4	
	Oleaceae	<i>Ligustrum ovalifolium</i> Hassk.	low	hedge	
	Platanaceae	<i>Platanus × acerifolia</i> (Aiton) Willd	low	2	
	Salicaceae	<i>Populus nigra</i> L. 'Italica'	low	10	
	Tiliaceae	<i>Tilia platyphyllos</i> Scop.	moderate	2	
	Tiliaceae	<i>Tilia tomentosa</i> Moench	moderate	3	
	Ulmaceae	<i>Celtis australis</i> L.	moderate	11	
	Ulmaceae	<i>Ulmus pumila</i> L.	moderate	10	
VI	Aceraceae	<i>Acer saccharinum</i> L.	low	3	62/
	Aceraceae	<i>Acer pseudoplatanus</i> L.	low	4	27.43%
	Betulaceae	<i>Betula pendula</i> Roth	high	9	
	Corylaceae	<i>Corylus colurna</i> L.	low	1	
	Fabaceae	<i>Robinia pseudoacacia</i> L.	moderate	5	
	Fagaceae	<i>Quercus robur</i> L.	moderate	3	
	Hippocastanaceae	<i>Aesculus hippocastanum</i> L.	moderate	23	
	Platanaceae	<i>Platanus × acerifolia</i> (Aiton) Willd	low	8	
	Salicaceae	<i>Populus nigra</i> L. 'Italica'	low	6	
	Aceraceae	<i>Acer pseudoplatanus</i> L.	low	1	32/
VII	Betulaceae	<i>Betula pendula</i> Roth	high	6	34.41%
	Corylaceae	<i>Corylus colurna</i> L.	low	5	
	Corylaceae	<i>Corylus avellana</i> L.	low	2	
	Cupressaceae	<i>Thuja orientalis</i> L.	moderate	3	
	Fagaceae	<i>Quercus robur</i> L.	moderate	4	
	Oleaceae	<i>Ligustrum ovalifolium</i> Hassk.	low	hedge	
	Platanaceae	<i>Platanus × acerifolia</i> (Aiton) Willd	low	4	
	Tiliaceae	<i>Tilia platyphyllos</i> Scop.	moderate	3	
	Tiliaceae	<i>Tilia cordata</i> Mill.	moderate	4	
	Aceraceae	<i>Acer pseudoplatanus</i> L.	low	9	117/

(continued on next page)

Table 3 (continued)

Location number	Family	Species	Allergenicity according to used literature ^a	No. of recorded specimens	Total No. of specimens and percentage in total dendroflora of location (%)
IX	Aceraceae	<i>Acer platanoides</i> L.	low	6	75.48%
	Aceraceae	<i>Acer saccharinum</i> L.	low	1	
	Betulaceae	<i>Betula pendula</i> Roth	high	25	
	Corylaceae	<i>Corylus colurna</i> L.	low	1	
	Cupressaceae	<i>Chamaecyparis lawsoniana</i> Parl.	moderate	1	
	Cupressaceae	<i>Thuja orientalis</i> L.	moderate	10	
	Hippocastanaceae	<i>Aesculus hippocastanum</i> L.	moderate	2	
	Platanaceae	<i>Platanus × acerifolia</i> (Aiton) Willd	low	11	
	Salicaceae	<i>Populus nigra</i> L. 'Italica'	low	37	
	Tiliaceae	<i>Tilia tomentosa</i> Moench	moderate	3	
	Tiliaceae	<i>Tilia platyphyllos</i> Scop.	moderate	5	
	Ulmaceae	<i>Ulmus pumila</i> L.	moderate	6	
	Aceraceae	<i>Acer pseudoplatanus</i> L.	low	1	
	Aceraceae	<i>Acer saccharinum</i> L.	low	2	
	Cupressaceae	<i>Cupressus sempervirens</i> L.	moderate	2	
	Cupressaceae	<i>Thuja orientalis</i> L.	moderate	2	
	Fabaceae	<i>Robinia pseudoacacia</i> L.	moderate	4	
	Fagaceae	<i>Quercus robur</i> L.	moderate	3	
	Platanaceae	<i>Platanus × acerifolia</i> (Aiton) Willd	low	2	
X	Tiliaceae	<i>Tilia tomentosa</i> Moench	moderate	1	34.37%
	Ulmaceae	<i>Celtis australis</i> L.	moderate	1	
	Ulmaceae	<i>Ulmus pumila</i> L.	moderate	4	
	Aceraceae	<i>Acer platanoides</i> L.	low	2	
	Aceraceae	<i>Acer saccharinum</i> L.	low	1	
	Platanaceae	<i>Platanus × acerifolia</i> (Aiton) Willd	low	2	
	Salicaceae	<i>Populus nigra</i> L. 'Italica'	low	1	
	Taxaceae	<i>Taxus baccata</i> L.	moderate	2	
	Tiliaceae	<i>Tilia cordata</i> Mill.	moderate	1	
	Ulmaceae	<i>Celtis australis</i> L.	moderate	5	
XI	Corylaceae	<i>Corylus colurna</i> L.	low	2	30.55%
	Fabaceae	<i>Robinia pseudoacacia</i> L.	moderate	3	
	Platanaceae	<i>Platanus × acerifolia</i> (Aiton) Willd	low	3	
	Taxaceae	<i>Taxus baccata</i> L.	moderate	1	
	Tiliaceae	<i>Tilia cordata</i> Mill.	moderate	2	
	Tiliaceae	<i>Tilia tomentosa</i> Moench	moderate	2	
	Tiliaceae	<i>Tilia platyphyllos</i> Scop.	moderate	7	
	Ulmaceae	<i>Ulmus pumila</i> L.	moderate	2	
	Aceraceae	<i>Acer platanoides</i> L.	low	4	
	Betulaceae	<i>Betula pendula</i> Roth	high	5	
XII	Cupressaceae	<i>Cupressus arizonica</i> Greene	moderate	7	47.30%
	Cupressaceae	<i>Thuja orientalis</i> L.	moderate	4	
	Fabaceae	<i>Robinia pseudoacacia</i> L.	moderate	3	
	Fagaceae	<i>Quercus robur</i> L.	moderate	5	
	Hippocastanaceae	<i>Aesculus hippocastanum</i> L.	moderate	1	
	Platanaceae	<i>Platanus × acerifolia</i> (Aiton) Willd	low	4	
	Tiliaceae	<i>Tilia cordata</i> Mill.	moderate	2	
	Aceraceae	<i>Acer pseudoplatanus</i> L.	low	6	
	Betulaceae	<i>Betula pendula</i> Roth	high	10	
	Fabaceae	<i>Robinia pseudoacacia</i> L.	moderate	2	
XIII	Platanaceae	<i>Platanus × acerifolia</i> (Aiton) Willd	low	7	66.66%
	Tiliaceae	<i>Tilia platyphyllos</i> Scop.	moderate	4	
	Ulmaceae	<i>Ulmus pumila</i> L.	moderate	7	
	Aceraceae	<i>Acer platanoides</i> L.	low	5	
	Aceraceae	<i>Acer pseudoplatanus</i> L.	low	4	
XIV	Aceraceae	<i>Acer saccharinum</i> L.	low	2	45.65%
	Betulaceae	<i>Betula pendula</i> Roth	high	4	
	Hippocastanaceae	<i>Aesculus hippocastanum</i> L.	moderate	1	
	Tiliaceae	<i>Tilia tomentosa</i> Moench	moderate	2	
	Tiliaceae	<i>Tilia cordata</i> Mill.	moderate	1	
	Ulmaceae	<i>Ulmus pumila</i> L.	moderate	2	

^a Spieksma (1990) and Nestorović et al. (2011).

the plants which contain toxins in all their parts like *T. baccata*, *Prunus laurocerasus* L., *T. occidentalis*, *T. orientalis*, *Juniperus sabina* L., *Juniperus horizontalis* Moench, *Juniperus virginiana* L., *Hedera helix* L. and *Clematis vitalba* L. were noted in each observed location. Species like *T. baccata*, *P. laurocerasus*, *Sambucus nigra* L. and *Lonicera xylosteum* L. with potentially lethal toxic effect (Grlić, 1984; Riordan et al., 2002; Dražić, 2002) were detected in 10 different studied locations. Species belonging to genera *Thuja* and *Juniperus* are toxic when eaten, but the fruits of these species are not appealing to children, by color, odor or

taste, thus should be pointed out as poisonous, rather than eliminated from the greenery.

Most dangerous proved to be plants with berry fruits. Berries are bright, juicy and as attractive for preschool children. Grlić (1984) reported that children are attracted by berries of ornamental bushes such as *Ligustrum ovalifolium* Hassk., *Ilex aquifolium* L., *T. baccata*, *Symphoricarpos* sp., *H. helix*, *Euonymus europaeus* L. with whom they come into contact on playgrounds, parks etc. The Swiss Centre for toxicological information (1978) reported that poisoning with *P.*

Table 4
Allergen index value (A.I.) calculated for allergenic plant species recorded in observed locations.

Family	Species	No. and percentages of specimens in total dendroflora of all locations	A.I. (Life cycle + Phenanthestic period ^a + Cross-reactivity ^b + Abundance ^c)
Aceraceae	<i>Acer saccharinum</i> L.	22/1.46%	3 + 2 + 0 + 1 = 6
	<i>Acer platanoides</i> L.	36/2.39%	3 + 2 + 0 + 1 = 6
	<i>Acer pseudoplatanus</i> L.	54/3.59%	3 + 2 + 0 + 1 = 6
Betulaceae	<i>Betula pendula</i> Roth	108/7.18%	3 + 2 + 1 + 1 = 7
Corylaceae	<i>Corylus colurna</i> L.	13/0.86%	3 + 0.5 + 1 + 0.5 = 5
	<i>Corylus avellana</i> L.	3/0.20%	3 + 2 + 1 + 0.5 = 6.5
Cupressaceae	<i>Cupressus sempervirens</i> L.	5/0.33%	3 + 2 + 1 + 0.5 = 6.5
	<i>Cupressus arizonica</i> Greene	7/0.46%	3 + 2 + 1 + 0.5 = 6.5
	<i>Thuja orientalis</i> L.	33/2.19%	3 + 2 + 1 + 1 = 7
Fabaceae	<i>Robinia pseudoacacia</i> L.	27/1.79	3 + 2 + 0 + 1 = 6
Fagaceae	<i>Quercus robur</i> L.	22/1.46%	3 + 2 + 0 + 1 = 6
Hippocastanaceae	<i>Aesculus hippocastanum</i> L.	38/2.53%	3 + 2 + 0 + 1 = 6
Oleaceae	<i>Ligustrum ovalifolium</i> Hassk. hedge		3 + 2 + 0 + 1 = 6
Platanaceae	<i>Platanus</i> × <i>acerifolia</i> Willd.	54/3.59%	3 + 0.5 + 1 + 1 = 5.5
Salicaceae	<i>Populus nigra</i> L. 'Italica'	56/3.72%	3 + 2 + 0 + 1 = 6
Taxaceae	<i>Taxus baccata</i> L.	3/0.20%	3 + 2 + 1 + 0.5 = 6.5
Tiliaceae	<i>Tilia tomentosa</i>	15/0.10%	3 + 2 + 0 + 0.5 = 5.5
	<i>Tilia platyphyllos</i> Scop.	38/2.53%	3 + 2 + 0 + 0.5 = 5.5
	<i>Tilia cordata</i> Mill.	62/4.12%	3 + 2 + 0 + 0.5 = 5.5
Ulmaceae	<i>Celtis australis</i> L.	48/3.19%	3 + 0.5 + 0 + 1 = 4.5
	<i>Ulmus pumila</i> L.	31/2.06%	3 + 2 + 0 + 1 = 6

^a Igić et al. (2005).

^b Igić (2012).

^c value derived from calculated percentage in third column.

laurocerasus and *T. baccata* in more than 90% involved children. *Taxus baccata* was noted in 6 observed locations, 4 preschools and 2 primary schools, with even four specimens in 'Kalimero' Preschool. Since the whole plant, except the pulp of the berry, contains toxic alkaloid taxine, consequences of exposure should not be neglected. Digested needles or/and seeds can furthermore cause cardiac or respiratory failure (Palmer and Betz, 2006; Riordan et al., 2002). Other species with berry fruits like *Berberis* sp., *C. horizontalis* Decne., *Symphoricarpos* sp., *L. ovalifolium* and *Pyracantha coccinea* M.Roem. if ingested can cause stomach ailments. Same symptoms can be caused by ingested parts of *Thuja* sp., *Juniperus* sp., *R. pseudoacacia* L. and *Laburnum anagyroides* Medik. (Vichovaand Jahodar, 2003; Dražić, 2002; Dražić, 2002; Vichovaand Jahodar, 2003; Dražić, 2002), while *H. Helix* and *C. vitalba* plant parts may also cause a skin rash or irritation (Kojić and Janjić, 1991; Palmer and Betz, 2006). Some of the noted species are thorny which makes them particularly pernicious.

4.2. Allergenic plant species in observed locations

Some of the investigated educational institutions were recognized as allergic pollen spreaders. A number of authors pointed out *B. pendula* (birch) pollen as major allergen carrier in Northern, Central and Eastern Europe (D'amato et al., 2007; Igić, 2012; Spieksma, 1990). D'Amato et al. (2007) stated intensive use of birch in ornamental compositions as main reason for increased allergic sensitization to this allergen. Another reason is that species of *Corylus* genera shed pollen early in the spring triggering allergic sensitization to birch pollen. For example *Quercus* pollen emerges shortly before birch pollen, prolonging clinical symptoms during the birch pollen season. Studies showed that exposure to high level of birch pollen in early infancy (0–6 months) and during the first year of life, increase the risk of sensitization to the same allergen in childhood (Kihlström et al., 2002; Björkstén et al., 1980). This data must be considered seriously due the fact that *B. pendula* is frequently present in preschools greenery.

It is proved that people allergic to pollen of genera *Betula*, *Alnus*, *Corylus*, *Carpinus*, *Castanea*, *Quercus*, *Fagus*, *Platanus* can also have

similar reactions aggravated by food-related allergic reactions to fruits (e.g. apples and nuts) through cross-reactivity (Troise et al., 1992; Igić, 2012). In addition high degree of cross-reactivity exists between recognized species in the field, like between *Cupressus* sp. and *T. baccata* or *T. baccata* and *T.orientalis* (Igić, 2012). Although pertinent literature suggests low allergenicity (Spieksma, 1990; Nestorović et al., 2011), calculated A.I. in present study, showed moderate or high calculated allergenicity. Inconsistency comes from abundant use and possible cross-reactivity of species in greenery.

As Cariñanos and Casares-Porcel (2011) pointed out that urban green spaces of a temperate climate are often characterized by an overabundance of a small number of species which results in the uniformity of green spaces. Since *P. × acerifolia*, *Tilia* sp. and *Acer* sp. frequently appear in allay greenery of Novi Sad calculated A.I. for those species was high. Considering that *Platanus* species produce approximately 13×10^6 pollen grains per inflorescence (Tormo Molina et al., 1996), with leaf trichomes concurrently causing respiratory irritation reactions, *Platanus* can be regarded as significant allergen (Spieksma, 1990). According to pertinent literature regarding urban greenery commonly present spaces are *R. pseudoacacia* (black locust) and *Aesculus hippocastanum* L. (horse chestnut) that were proven to cause allergic sensitizations in children (Popp et al., 1992). Due to entomophilous pollination black locust and horse chestnut pollen gets airborne only occasionally causing pollinosis in people. Same applies for *Tilia* sp. and *L. ovalifolium* as hedge forming shrub that is commonly planted in green spaces. The allergic reactions caused by *Ligustrum* sp. appear only close to the source, but since continuous pruning usually diminishes flower production, exposure to pollen is rare (Igić, 2012). *Populus* species also exhibit allergenicity potential since exposure to seed trichomes cause respiratory irritation reactions (Spieksma, 1990).

Ogren (2002) draw attention to increased use of pollen intensive dioecious male plants often selected from asexually propagated clones. Fruit bearing female plant individuals are sometimes avoided, as their fruits, if heavy, can fall and damage vehicles or harm people, have undesirable odor or cause stain and slippery ground surfaces. Such female individuals' avoidance practices altered natural sexual balance

towards increased pollen loads correspondingly causing allergies and asthma in people. In those species, breeding should be directed to selection of male sterile genotypes for mass production and usage. If available in certain species male sterile individuals should be given the advantage over fertile once. In all other species, the best recommendation is planting of only female specimens that are both pollen-free and pollen-trapping. Avoidance of male specimens belonging to genera *Juniperus* and *Taxus* in the greenery is required, as pollen from these specimens is not only allergenic, but toxic as well. Environmental pollution and climate changes increase pollen allergic effect. Climate changes alter the blooming towards the earlier and longer flowering, sometimes up to twice a year, thereby producing greater amounts of pollen in the air (D'amato et al., 2007; Igić, 2012).

5. Conclusions

Use of poisonous and allergenic plant species as ornamentals was recognized in greenery of all analyzed educational institutions. Caution must be taken in selection of plant material for the children's educational institutions yards greening. There is a demand for building children's knowledge about toxic plants. Proper identification will minimize the potential of poisoning from hazardous plants. In order to manage allergenicity, proposed guidelines should be followed: use of low pollen producing species, efforts toward increase of biodiversity, control of invasive species and introduction of exotic species, avoid fostering cross-reactivity and massive use of male individuals of dioecious species. If available in certain species male sterile individuals should be given the advantage over fertile once. In all other species, the best recommendation is planting of only female specimens that are both pollen-free and pollen-trapping. Random and willful assortment should be minimized, whilst adoption of appropriate management, maintenance strategies and active consultation with experts when selecting the most suitable species for a given green space should be given the priority. Preschools and primary schools as entities, as well as their employees are not expected to be familiar with all characteristics of ornamentals present in their environment. This is the reason why continuous collaboration with experts from relevant institutions, such as Department for Fruit science, Viticulture, Horticulture and Landscape architecture, Department for biology and ecology, as well as Public Enterprise 'The city greenery', should be established. Enhancement of this collaboration would result in the removal of the very most allergenic landscape plants and ultimately toxic-free and allergy-friendly school yards. Gradual removal might temper the public reluctance to this measurement, but finally only joint efforts and complete abandonment of pointed species can convert these unhealthy school yards into ones that are safe and allergy-friendly.

In order to permanently eliminate these plants continuous education and consultation as well as more strict control of all horticultural market participants must be conducted. Market influences which plant material will be utilized by consumers in the given area, and vice versa. The chain starts with importers, garden centers, nurseries and flower shops ending with final consumers – public or private landscape architects, gardeners and horticulturalists, that can significantly reduce demands for problematic plant species, and thus eliminate it from market.

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