Environmental & Socio-economic Studies

DOI:10.2478/environ-2025-0004

Environ. Socio.-econ. Stud., **2025, 13, 1: 41-52**

Original article

Exposure of children to allergenic trees near primary schools in Mila city, Northeastern Algeria

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ABSTRACT

Urban trees play a crucial role in providing ecosystem services and promoting mental and physical health, particularly among urban populations. However, certain tree species, such as allergenic trees, can exacerbate airway diseases in local populations, especially in vulnerable groups such as children. Therefore, the main aim of this study was to determine the extent to which children in primary schools in Mila city are exposed to allergenic tree species. Exposure was assessed by examining the proximity of primary schools to allergenic trees and their species diversity within 100, 200 and 300 m buffer zones around these schools. Based on the results, Mila city is estimated to have 968 allergenic trees of 27 species and belonging to12 botanical families. Citywide, 10 primary schools with a total enrollment of 2,770 students were located within 100 m of allergenic tree species; 6 primary schools were within a distance of 100–200 m and only one primary school was at a distance greater than 200 m. Considering the allergenic potential of the tree species, 38 trees, representing 82.6% of all trees within the 100 m buffer zone, exhibited a high to very high allergenic potential, whereas only 8 trees (17.4%) had low allergenicity. The results of this study should inform a comprehensive decision-making process, guide policies and interventions to mitigate allergen exposure in schools and promote a healthier environment for children in Mila city.

KEY WORDS: pollinosis, primary schools, school children, risk mapping, Mila

ARTICLE HISTORY: received 30 October 2024; received in revised form 7 February 2025; accepted 3 March 2025

1. Introduction

Seventy-four percent of Algeria's population resides in urban areas, a proportion that is expected to increase to 84% by 2050 (FAO, 2016). Algerian cities are home to a high number of resident tree species, which are either planted or naturally occurring. These trees ranging in scale from isolated specimens to urban parks, are maintained by volunteers and the Popular Municipal Assembly as part of its beautification program. There are multiple benefits provided by urban trees, including sequestering carbon, producing oxygen, filtering air, reducing water quality problems, providing habitat for wildlife, reducing noise, reducing air temperature, improving mental health and enhancing the aesthetics of the town (Liu & Li, 2012; Nowak & Crane, 2002; Lai & Kontokosta, 2019; Berglihn & Gómez-Baggethun, 2021; Olusola & Agbelade, 2022; Jang & Woo, 2022; Collins et al., 2022). Despite these services, some trees are important pollen sources with different allergenic properties in urban environments. This group of trees' pollen contains specific allergen types during the pollen season that trigger allergic inflammatory responses via mast cell activation in the human mucosa of target organs, leading to systemic reactions (Kiotseridis et al., 2013). This makes life miserable for millions of human allergy sufferers each year. In certain epidemiological research, there is a direct connection between urban green spaces and asthma and pollen allergies (Scharte & Bolte, 2012; Lovasi et al., 2013; Andrusaityte et al., 2016).

In recent decades, pollen exposure has increased, and this trend is predicted to continue due to urbanization, air pollution, and climate change (D'Amato et al., 2016; Lake et al., 2017; Senechal et al., 2015). The population living in large industrial agglomerations is primarily affected by allergies (Benčaťová et al., 2012). According to Després et al. (2012), pollen sensitization can be aggravated by the presence of air pollutants, especially nitrogen dioxide, ozone and diesel exhaust particles. Air pollutants adhere to the surface of pollen grains and change their morphology and allergenic potential (Senechal et al., 2015; Traidl-Hoffmann et al., 2003). In addition, global warming can lengthen the growing season for trees and increase the total amount of pollen produced per season (Ziska et al., 2019; McInnes et al., 2017). Although symptoms of allergic reactions usually do not require hospitalization, they can have a negative impact on a person's quality of life (Mansouritorghabeh et al., 2019). Pollen released during the flowering period can have a deleterious impact on antiviral immunity, increasing vulnerability to viral infections, regardless of the allergy status (Gilles et al., 2020) and may also exert an adverse impact on biological air quality (Cariñanos et al., 2001).

A recent study indicates that millions of children and adolescents worldwide are affected by allergic diseases like rhinoconjunctivitis, asthma and eczema, possibly because their bodies are still developing (Melén et al., 2022). Compared to adults, children have higher respiration rates and engage in more outdoor physical activities, making them more vulnerable to hazardous airborne substances such as pollen and other environmental contaminants (Melén et al., 2022). In recent years ecologists and other scientists have become aware of the need to identify and inventory urban pollen emission sources, which can endanger the general public and particularly sensitive populations (Kremenska et al., 2019; Cariñanos et al., 2016; Prigioniero et al., 2021). In Algeria, research in this field is almost nonexistent, even though the countryis currently experiencing an epidemiological transition characterized by an increase in the prevalence of chronic pathologies, particularly respiratory and allergic. Estimates of the prevalence of these diseases show the presence of more than one million asthmatics and nearly three million allergic rhinitis cases (Douagui, 2007). Multidisciplinary research on how we plant and manage street trees as part of urban green infrastructure is required in response to increasing concerns about urban quality of life (Locke et al., 2011). For this reason, the aim of this study is to geolocate and quantify the allergenic potential of allergenic trees near primary schools in Mila city, Northeastern Algeria. This study will serve as a basis for designing healthier green infrastructure and for future studies to assess pollinosis risk in Mila city.

2. Materials and method

2.1. The study area

The study area, spans 1,313.8 hectares, and is located in the Northeast region of Algeria, between latitudes 36°25'35 and 36°28'03 North and longitudes 6°13'41 and 6°16'54 East, specifically focusing on the city of Mila (Fig. 1), which is known for its Beni Haroun dam, the largest dam in Algeria with a capacity of 960 million m^3.

The study area encompasses 10 urban sectors with different topographical characteristics. The local bioclimate is subhumid with an average annual temperature of 15.3°C (range, 9.2°C – 27.7°C) and an accumulated average annual precipitation of 596 mm, which intensifies between November and April. Mila city has 19 primary schools which served 5,540 students in the 2024 school year.

2.2. Data collection and analysis

The field inventory method was used to geolocate allergenic trees throughout the entire urban network of Mila city. Firstly, handheld GPS devices were utilized to determine geographical coordinates for each observed allergenic tree. Field identification guides were used to identify tree species (Aichele & Schwegler, 2016; Russell et al., 2006). In cases of ambiguity, multiple leaves were collected and further examined in the Natural and Materials Sciences Laboratory. Additionally, species allergenicity level and pollination modes were determined using the study results of Cariñanos et al. (2014, 2016), Kasprzyk et al. (2019) used as references. Allergen species were categorized, based on their potential for producing allergenic pollen, into fourgroups designated as very high, high, moderate or low potential. Subsequently, all public primary schools of Mila city (17 primary schools in total) (Table 1) were digitized using Google Earth satellite images and mapped using Geographic Information System (GIS). According to the Algerian educational system, primary schools are defined as those educating pupils from 6 to 11 years of age (OJAR, 2016).

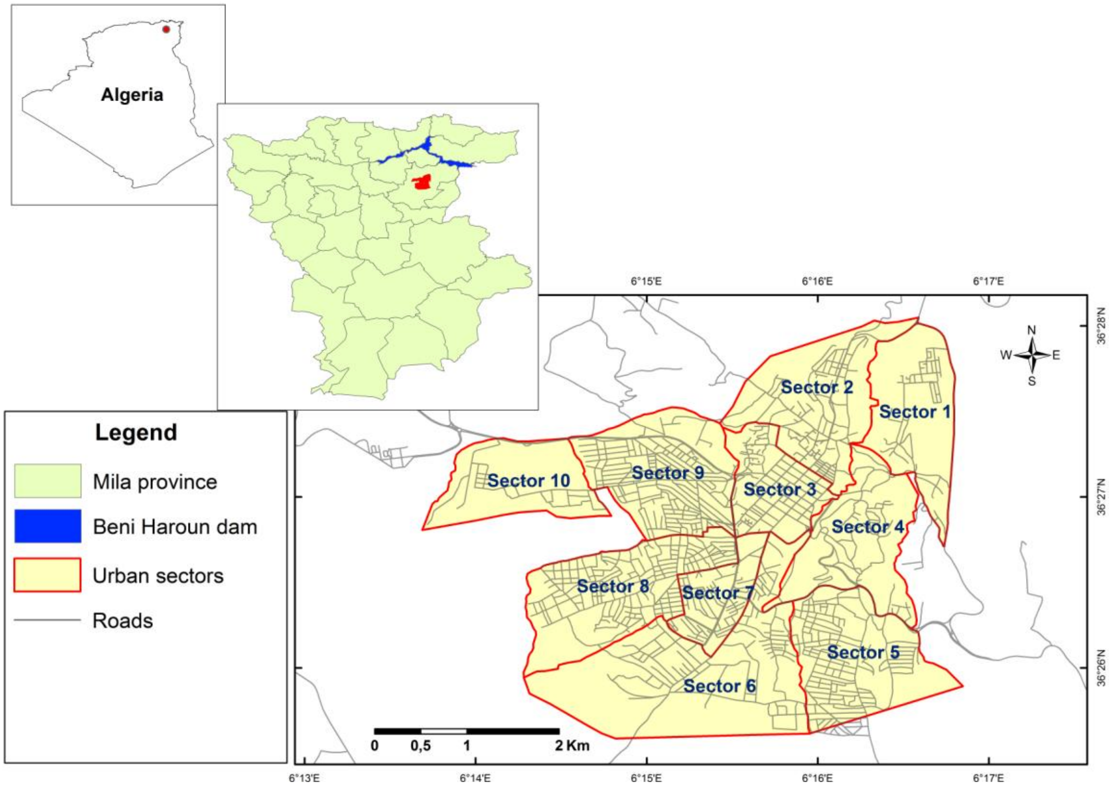

Fig. 1. Location of the study area

Table 1. List of primary schools in Mila city (Mila Directorate of Education, 2023)

Primary schools	City sector	Construction area (m^2)	Number of students
Zerrafi Abdellah Primary School	Sector 1	2,228	330
Ali Saadani Primary School	Sector 2	2,842	637
Rabeh Lahmer Primary School		2,044	198
Ziani Said Primary School	Sector 3	1,763	346
Chriet Fodhil Primary School		1,960	194
Mechri El Meki Primary School		2,269	473
Ben Redjem Laarbi Primary School		2,532	199
Belattar Ibrahim Primary School		2,925	161
Chaibi Mohamed Primary School		3,995	317
Abdelhamid Benbadis Primary School		2,401	202
Benhorra Hayat El-Chabab Primary School		2,315	227
Bennacef Ali Primary School	Sector 4	1,886	181
Aliouch Ismail Primary School		2,479	470
Boutebdja Aissa Primary School	Sector 5	2,461	210
Saleh Messai Primary School	Sector 7	3,617	568
Boubissi Amar Primary School	Sector 9	2,032	442
Lezghed Khoudja Primary School		1,463	385

Density values of the trees were calculated as the total number of allergenic trees per family across the entire study area, quantifying their relative abundance and highlighting the dominant families, thereby offering insights into their distribution patterns.

The proximity method was used to assess primary school exposures to allergenic tree pollen. Using analysis tools in ArcGIS software (ESRI, v10.8), three buffer zones were created around each allergenic tree, of 100 m, 200 m and 300 m. High exposure to allergenic tree species was defined when primary schools are situated less than 100 meters from a tree, moderate exposure with a distance of 100–200 m and low exposure with a distance greater than 200 m. The Shannon-Weaver diversity index (H') is awidely used index for comparing various habitats (CLARKE &D WARWICK, 2001). It was calculated by using species abundances to measure allergenic tree biodiversity for each 100 m buffer zone around a primary school (SHANNON & WEAVER, 1964; LEPS & HADINCOVA, 1992). This index is calculatedusing the following formula:

$$H' = -\sum_{i=1}^{i=n} \mathrm{Pi} \ln \mathrm{Pi}$$

Where:
i: allergenic tree species;
Pi: the proportional abundance of i species;
n: total number of species observed.

3. Results

3.1. Identifying allergenic trees and their locations

A total of 968 individual allergenic tree s of 27 different species and belonging to 12 families were recorded in Mila city. The three most allergenic trees were *Cupressus arizonica* (159 trees, 16.42%), *Fraxinus angustifolia* (152 trees, 15.7%), and *Olea europaea* (139 trees, 14.35%) collectively accounting for 46.47% of the total number of allergenic trees. We recorded 311 allergenic trees representing nine species in sector 7 compared with only twelve allergenic trees belonging to one species in sector 10 (Fig. 2). The seven dominant species in sector 7, which accounted for 71.1% of the total allergenic trees identified, are *Olea europaea* (139), *Morus alba* (77), *Ligustrum lucidum* (49), *Platanus occidentalis* (25), *Fraxinus angustifolia* (4), *Juglans regia* (4) and *Fraxinus ornus* (2).

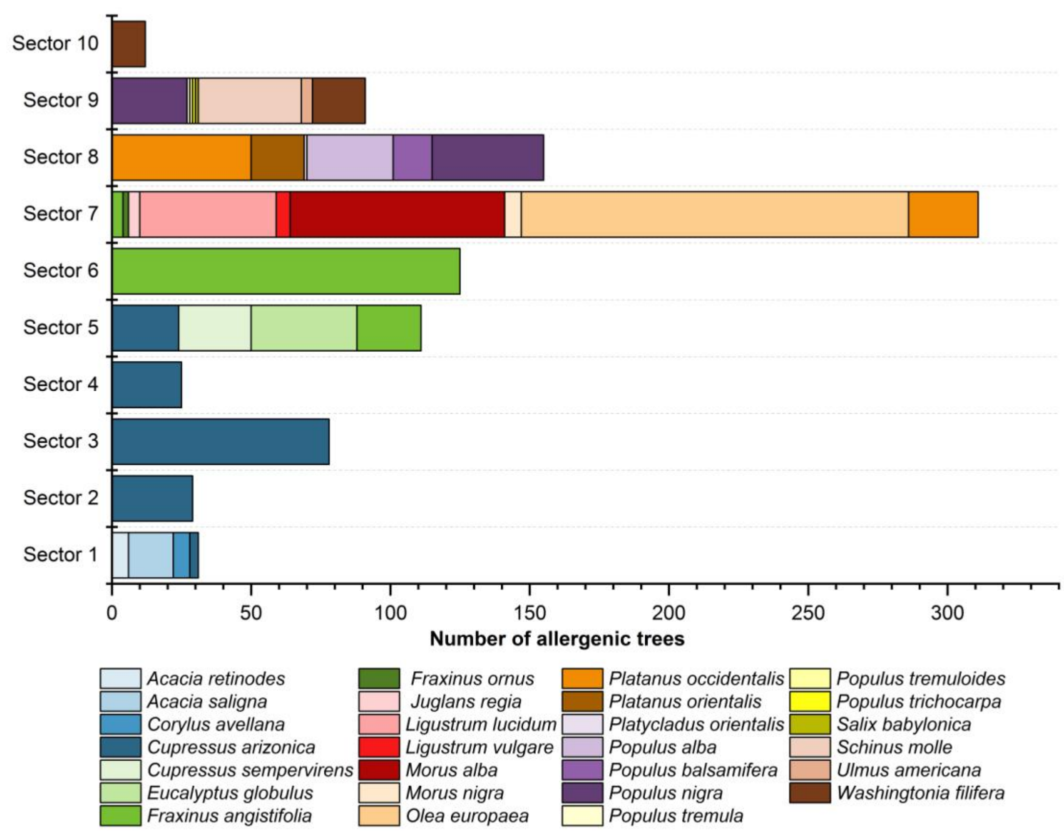

Fig. 2. Number of allergenic tree species by urban sectors

The diversity of the allergenic tree families in Mila city and within buffer is shown in Figure 3. The most abundant family in the study area was Oleaceae with 5 species (36%), followed by Cupressaceae (3 species, 19%) and Salicaceae (7 species, 12%). These three families had the highest density values, which when combined, represented approximately 67% of all allergenic trees identified in the study area. Within the 100 m buffer surrounding the elementary schools, the most represented families are Cupressaceae (30%), Platanaceae (27%) and Oleaceae (21%). The remaining families only represent percentages equal, or less than, 8%.

A compilation of the geographic origin of the 27 species found in the urban sectors of Mila city indicates that 29.4%, of the species originated in North America. This was followed by Europe (20.35%) and the Mediterranean region (17.05% species) and those of southern American origin (3.82%) (Fig. 4). In the 100 m buffer zone around the primary schools, the allergenic species of Mediterranean origin are represented by only two species: *Olea europaea* (3.79%) and *Cupressus sempervirens* (1.26%). *Cupressus arizonica* and *Platanus occidentalis*, which are of North American origin, have the highest cumulative allergenic tree totals (23 and 15 respectively), accounting for about 48.1% of the total number of allergenic trees recorded around primary schools.

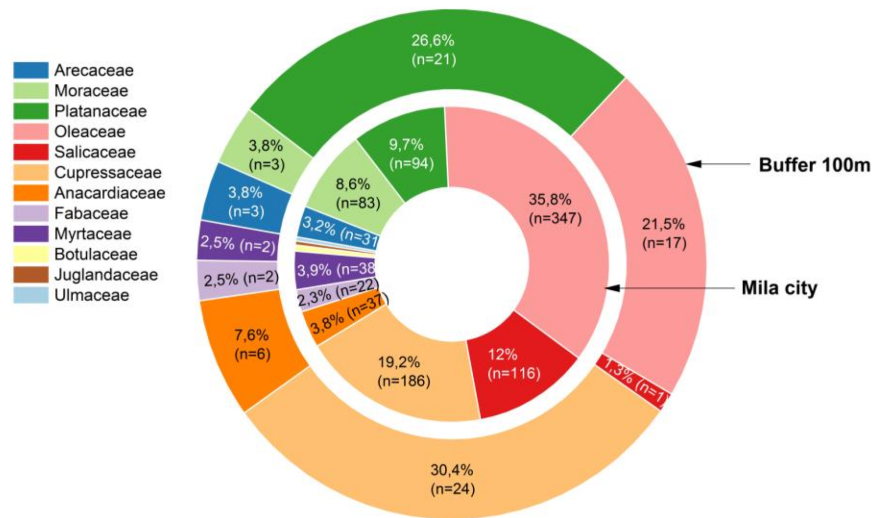

Fig. 3. The percentage of allergenic tree species by family in Mila city and within buffer zones around primary schools

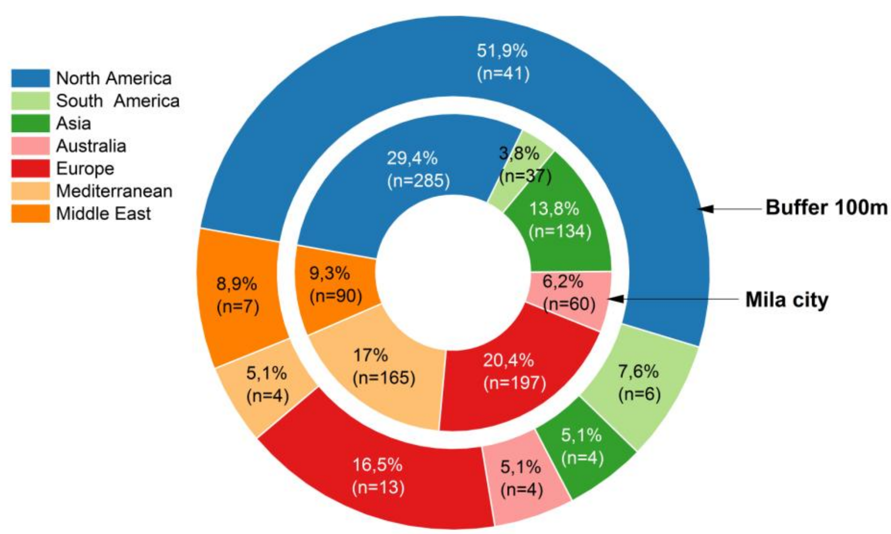

Fig. 4. Native origin of allergenic tree species in the city of Mila

539 allergenic trees (55.7%) were classified as having high allergenic potential. Additionally, 343 trees (35.4%) exhibited a very high allergenicity level, while trees with moderate and low allergenicity accounted for only 37 (3.8%) and 49 (5.1%) respectively of the total trees recorded (Fig. 5).

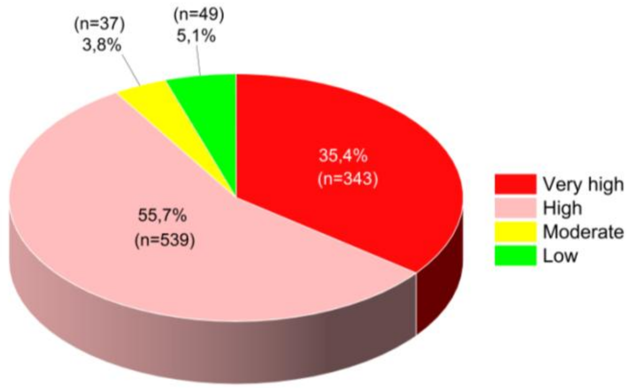

Fig. 5. Species allergenicity levels

3.2. Mapping of exposure to allergenic trees

All the primary schools in the study were found to be within 300 m of allergenic tree, with varying densities and proximities of these trees influencing the level of exposure. The average distance of a school from the nearest allergenic tree was 98 m, with a minimum distance of 19 m and a maximum of 265 m (Table 2, Fig. 6).

Based on the nearest distance criteria, high exposure levels were attributed to 10 primary schools with a total enrollment of 3,149 students (56.84%), these primary schools are as follows: Aliouch Ismail primary school, Belattar Ibrahim primary school, Ben Redjem Laarbi primary school, Benhorra Hayat El-Chabab primary school, Bennacef Ali primary school, Chriet Fodhil primary school, Mechri El Meki primary school, Saleh Messai primary school, Zerrafi Abdellah primary school and Ziani Said primary school. Six primary schools were classified as having moderate exposure (Ali Saadani primary school, Abdelhamid Benbadis primary school, Chaibi Mohamed primary school, Lezghed Khoudja primary school, Boubissi Amar primary school and Boutebdja Aissa primary school), while only one primary school in which about 198 children study, Rabeh Lahmer primary school, had low exposure.

For the high-risk zone, the nearest allergenic species was *Fraxinus angustifolia*, located at a distance of 19 m from the Belattar Ibrahim primary school (Table 2). With the exception of *Eucalyptus globulus*, all the nearest allergenic species have high to very high levels of allergenicity.

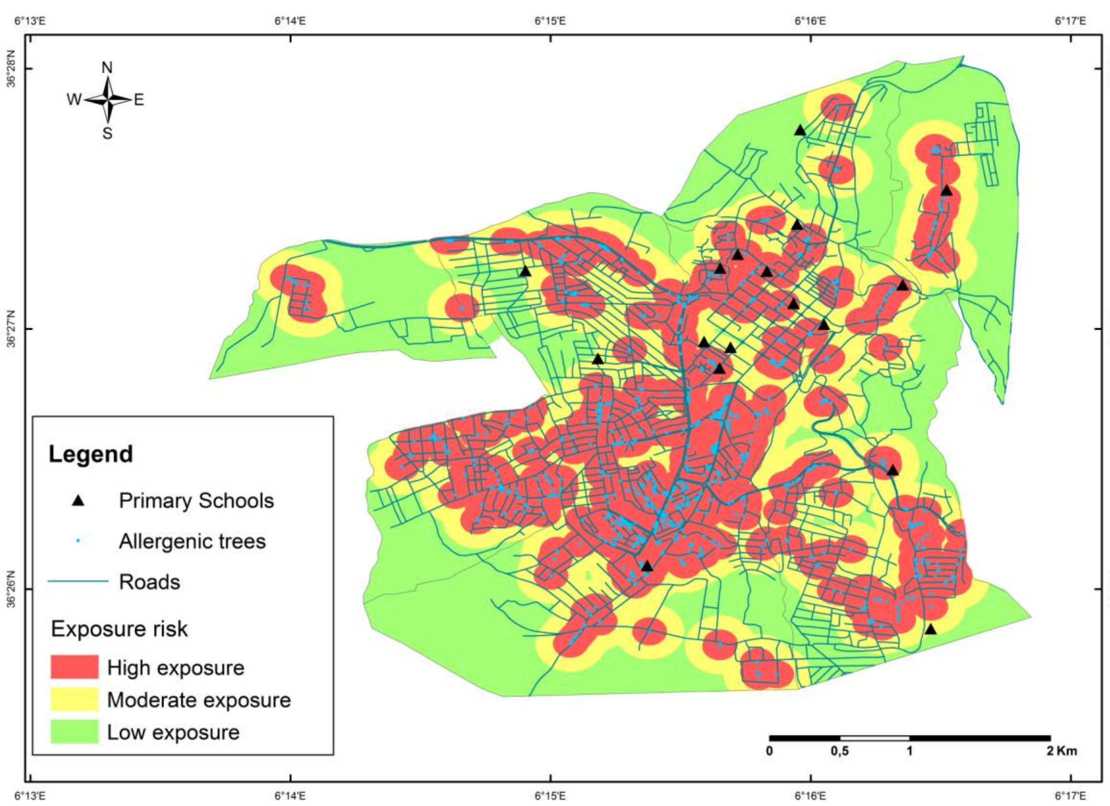

Fig. 6. Allergenic tree exposure levels in primary school children

Table 2. Exposure levels of primary schools and the characteristics of their closest allergenic tree species

Exposure levels	Primary Schools	Nearest allergenic tree species	Distance to nearest allergenic tree (m)	Allergenicity level
High	Aliouch Ismail Primary School	*Eucalyptus globulus*	54	Moderate
	Belattar Ibrahim Primary School	*Fraxinus angistifolia*	19	High
	Ben RedjemLaarbi Primary School	*Platanus occidentalis*	42	High
	Benhorra Hayat El-Chabab Primary School	*Platanus orientalis*	36	High
	Bennacef Ali Primary School	*Fraxinus angistifolia*	54	High
	Chriet Fodhil Primary School	*Schinusmolle*	21	High
	Mechri El Meki Primary School	*Fraxinus angistifolia*	63	High
	Saleh Messai Primary School	*Olea europaea*	28	Very high
	Zerrafi Abdellah Primary School	*Olea europaea*	64	Very high
	Ziani Said Primary School	*Platanus occidentalis*	96	High
Moderate	Ali Saadani Primary School	*Cupressus arizonica*	116	Very high
	Abdelhamid Benbadis Primary School	*Platanus occidentalis*	143	High
	Chaibi Primary School	*Platanus occidentalis*	131	High
	Lezghed Khoudja Primary School	*Fraxinus angistifolia*	189	High
	Boubissi Amar Primary School	*Cupressus sempervirens*	191	Very high
	Boutebdja Aissa Primary School	*Cupressus arizonica*	156	Very high
Low	Rabeh Lahmer Primary School	*Fraxinus angistifolia*	265	High

Among the 968 allergenic trees inventoried in Mila city, 46 are located less than 100 m from a primary school, which represents 4.75 % of the total of allergenic trees. The results show that these belong to 11 species, which represent 40.74% of all allergenic tree species found in Mila city. In this buffer zone, the dominant allergenic tree species were *Platanus occidentalis* with 16 individuals (34.78%), *Fraxinus ornus* with seven individuals (15.22%), and *Cupressus arizonica* with five individuals (10.86%), which accounted for 60.86% of the total allergenic species (Fig. 7).

In terms of biodiversity, the greatest diversity of allergenic tree species was found within the 100 m buffer around Saleh Messai primary school, with the highest Shannon-Weaver index value (1.47) and with 10 trees belonging to the following 5 species: *Cupressus arizonica*, *Cupressus sempervirens*, *Acacia saligna*, *Olea europaea* and *Morus alba* (Table 3). The second highest biodiversity index was found near Aliouch Ismail primary school, which was characterized by the presence of three allergenic trees species (*Eucalyptus globulus*, *Fraxinus angustifolia* and *Cupressus arizonica*). Zerrafi Abdellah, Ben Redjem Laarbi, Mechri El-Meki and Ziani Said primary schools were characterized by null values of the Shannon-Weaver index, with only one allergenic species.

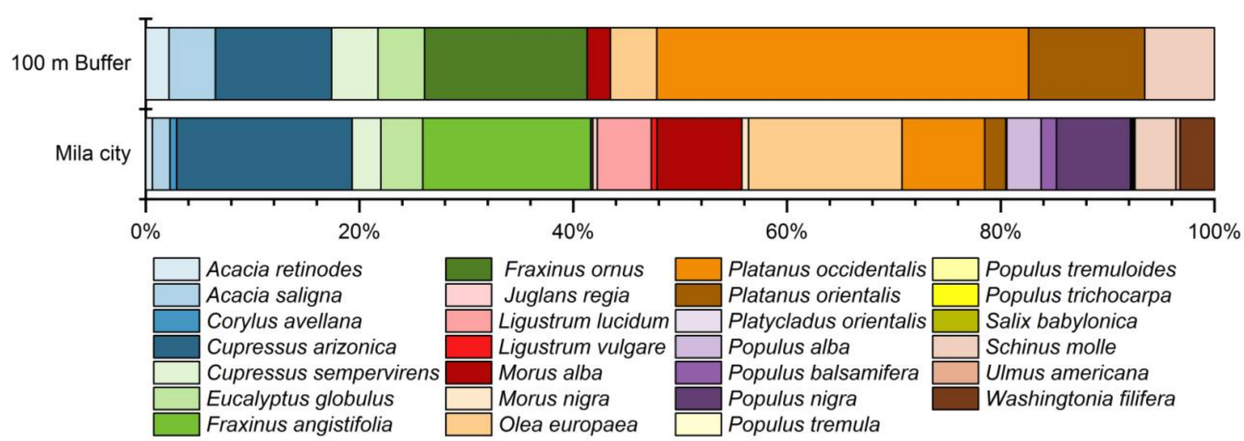

Fig. 7. Percentage of allergenic tree species inside Mila city and within the 100m buffer zone around primary schools

Table 3. Shannon-Weaver index (H') and allergenic tree species within 100 m of primary schools

Primary Schools	Species	Number of recorded specimens	Total number of specimens	Shannon-Weiner index (H')
Aliouch Ismail Primary School	*Eucalyptus globulus*	2	4	1.04
	Fraxinus angistifolia	1		
	Cupressus arizonica	1		
Belattar Ibrahim Primary School	*Platanus occidentalis*	6	8	0.56
	Fraxinus angistifolia	2		
Ben Redjem Laarbi Primary School	*Platanus occidentalis*	7	7	0
Benhorra Hayat El-Chabab Primary School	*Schinus molle*	2	7	0.60
	Platanus orientalis	5		
Bennacef Ali Primary School	*Fraxinus angistifolia*	2	4	0.69
	Platanus occidentalis	2		
Chriet Fodhil Primary School	*Acacia retinodes*	1	2	0.69
	Schinus molle	1		
Mechri El Meki Primary School	*Fraxinus angistifolia*	2	2	0
Saleh Messai Primary School	*Morus alba*	1	10	1.47
	Cupressus arizonica	4		
	Acacia saligna	2		
	Olea europaea	1		
	Cupressus sempervirens	2		
Zerrafi Abdellah Primary School	*Olea europaea*	1	1	0
Ziani Said Primary School	*Platanus occidentalis*	1	1	0

In terms of abundance, the highest number of allergenic trees was of *Platanus occidentalis* which were present within the 100 m buffer around Ben Redjem Laarbi (7 specimens) and Belattar Ibrahim primary schools (6 specimens) (Table 3), followed by *Platanus orienta*lis with 5 specimens found within the 100 m buffer around Benhorra Hayat El-Chabab primary school and *Cupressus arizonica* with 4 specimens located less than 100 m from Saleh Messai primary school. Around the other studied primary schools, no more than two species were identified.

4. Discussion

Urban trees provide important ecosystem services for city inhabitants. However, their selection should be approached judiciously, in collaboration with the scientific community and landscape experts to prevent emerging health threats from allergenic trees. In this study, we identified allergenic tree species in the vicinity of primary schools in Mila city, Algeria. The aim was to inform parents and decision-makers aboutthe significant health risk for both seasonal allergic rhinitis and asthma caused by the presence of allergenic pollen trees.

This study revealedan inequitable distribution of allergenic trees in Mila city that may contribute to significant health disparities by sectors of the city. Schools in Sector 3 were surrounded by more allergenic trees than schools in other sectors. This finding was not surprising because this urban Sector is considered the center of Mila city and most of the urban afforestation programs target it as an interface for the town where most of the administrative institutions are located. It should be mentioned here that most urban trees in Mila city were primarily planted voluntarily by citizens at their own expense. Our results cannot be compared with others because no similar studies have inventoried allergenic tree species in the literature.

In the 100 m buffer zone around the city primary schools, only 4 (approximately 5%) of the allergenic trees are native to Mediterranean countries, this classified as indigenous species, while the predominant majority (285 trees, 51.9%) originate from North America. Non-indigenous allergenic plants typically have a lesser impact on allergies than indigenous allergenic plants because they are generally found in lower abundance (AERTS ET AL., 2021). According to D'AMATO ET AL. (2007), the risk of allergic sensitization is greater in the Mediterranean region than in other bioclimatic regions because the climatic conditions extend the flowering season of many tree species.

Anemophily is the predominant method of pollination for allergic trees in the urban area of Mila city. Kasprzyk et al. (2019) indicate that the adverse effect of vegetation on those suffering from allergies increases with the presence of wind pollinated trees. Thus Cariñanos et al. (2016) show that wind-pollinated species are associated with higher allergenicity values.

According to the 2024 census, Mila's urban population of children aged 6 to 11 was approximately 5,540, distributed across 10 urban sectors. Around 56.84% of this population is classified as frequenting areas with high exposures to pollens, as their primary schools are situated within 100 meters of allergenic trees. Proximity of primary schools to allergenic trees servesas an indirect measure of exposure, which was used as a proxy for exposure to pollen from these trees. We used this measure to characterize chronic exposure to these pollutants, as the location of primary schools can be linked to continuous exposure, resulting in cumulative health effects throughout life. Since children frequent their schools daily and spend a large part of their time in, or near them, they are inevitably at greater risk of developing allergic disease due to the presence of allergenic trees surrounding these schools.

In recent decades, volunteers and the municipal services of Mila city have increased their interest in green spaces, but they have not paid attention to the potential threat of certain plant species. The study reveals that the Saleh Messai primary school, the most populated school institution, is in an area where children and allergic individuals should not stay for long periods of time because it is characterized by plants with a very large number of taxa with high allergenicity. These results indicate that people and children frequenting this primary school can be exposed to very high concentrations of sometimes strongly allergenic pollen without being aware of it. A number of health problems, including allergic rhinitis, asthmatic flare-ups in sensitive individuals, and atopic dermatitis (eczema), are linked to exposure to allergenic pollen (Cecchi, 2012). In addition to children, the most vulnerable members of the population, such as pregnant women, may also affected by the pollen pollution generated from allergenic vegetation. The study by Kihlstrom et al. (2003) showed that exposure of the mother during pregnancy to high levels of tree pollen caused an increased risk of sensitization to the same allergen and symptoms of atopic disease in children with atopic heredity.

This study identified 46 allergenic trees located less than 100 m around primary schools. *Platanus occidentalis*, *Fraxinus ornus* and *Cupressus arizonica* were some of the most abundant species (16, 7 and 5 trees respectively) which accounted for 60.86% of the total allergenic species. All of them are anemophilous species producing high quantities of pollen grains which spread into the atmosphere provoking allergies in the sensitized population (D'amatoet al., 2007). Regarding Platanus species, its pollen has beenevaluated as a strong allergen and is known to promote allergic respiratory symptoms particularly during the months of March and April (Alcázar et al., 2011) because of their high sensitization capability and their abundant presence in urban green infrastructure as ornamental urban trees (Vrinceanu et al., 2021). Alcázar et al., (2004) concluded that plane tree pollen poses a risk to city dwellers and that symptoms are more intense and persistent in neighbourhoods with a higher density of plane trees. Fraxinus species are also known as one of the anemophilous species that produce large amounts of pollen grains (Kremenska et al., 2019). The genus Cupressus, which includes both Cupressus *sempervirens* and *Cupressus arizonica* releases an enormous amount of anemophilous pollen for more than a month, due to its microsporophyll gradual maturation mechanism, from bottom to top of the flower (Hidalgo et al., 2003; D'Amato et al., 2007). It has long been recognized as being responsible for a large part of increasing pollinosis in several Mediterranean countries (D'Amato et al., 2007).

Only two allergenic species of Mediterranean origin are represented in the 100 m buffer zone around the primary schools: *Olea europaea* and *Cupressus sempervirens*. D'Amato et al., (2007) showed that these species produce the most allergenic pollen in Mediterranean regions. The olive tree**,** the emblematic tree of the Mediterranean region, releases large quantities of pollen which cause a variety of allergy problems (Gaussorgues, 2009; Feo et al., 2011). The clinical results of the analysis of the pollen allergen frequency of Algerian patients show that olive pollen sensitization occupies the second position after the cypress pollens (Necib & Boughediri, 2021) and mite allergens (Bounil et al., 2022).

The results of the Shannon-Weaver index (H') reveal significant variations in the diversity of allergenic tree species around the studied primary schools. The 100 m buffer zone around Saleh Messai School exhibits the highest diversity (H' = 1.47), with five identified species, suggesting a more complex habitat that may be more conducive to allergen dispersion (MAGURRAN, 2013). In contrast, the schools Zerrafi Abdellah, Ben Redjem Laarbi, Mechri El-Meki, and Ziani Said show zero diversity, with only one allergenic species detected, indicating ecological homogeneity that may limit the variety of pollen sources. These differences could influence students' exposure to allergens, as higher allergenic species diversity is often associated with more complex and potentially more intense exposure (D'AMATO ET AL., 2017). These findings highlight the importance of considering plant diversity in the assessment of allergic risks in school environments, aligning with previous studies linking biodiversity to human health.

While our study highlights the presence of allergenic trees in close proximity to elementary schools in Mila and their potential contribution to local pollen exposure, it is important to note that the risk of allergies in school children cannot be solely attributed to these local sources. Numerous studies have demonstrated that tree pollen can be transported over long distances, even hundreds or thousands of kilometers from its origin, due to atmospheric dynamics (JĘDRYCZKA ET AL., 2023; BOURGEOIS ET AL., 2001; DE WEGER ET AL., 2016; SKJØTH ET AL., 2007; ROUSSEAU ET AL., 2003). This long-distance transport means that children in Mila may also be exposed to pollen originating from regions far beyond the study area.

The findings of this study can contribute to a better understanding of allergenic tree diversity in Mila city and improvement of urban planning and management. The maps produced provide very useful information for organizations involved in the planting of urban trees as well as for allergic people, children and their families because avoiding contact with the allergen is the best way to prevent the allergic reaction and a much better solution than expensive and long-term treatment. According to some authors (CARIÑANOS & CASARES-PORCEL, 2011; MCINNES ET AL., 2017), the precautions against allergenic pollens are as follows: regulated introduction of exotic species, selection of tree species with low pollen production, avoiding botanical sexism, participation of consultants and specialists during the planning process, and developing detailed maps of allergenic pollen producing taxa and individual trees. Those urban trees to be planted must be selected on a scientific basis after studying the allergenic potential of each species, and all highly allergenic species should be avoided. Moreover, a primary school curriculum should include knowledge of urban vegetation and allergenic species that all students should know.

This study provides a foundational assessment of allergenic tree species near elementary schools in Mila, but there are several avenues for future research to build upon these findings. First, expanding the scope to include allergenic herbaceous plants would offer a more comprehensive understanding of allergenic sources in the urban environment. Second, measuring pollen concentrations in the air would provide critical data on actual exposure levels and help clarify the relationship between tree distribution and pollen dispersion. Third, conducting surveys with parents to identify the frequency of allergic symptoms among children could reveal valuable insights into the real-world health impacts of allergenic exposure. Finally, incorporating diagnostic tests, such as skin tests confirmed by specialists, would strengthen the clinical relevance of the findings by directly linking exposure to allergic outcomes. These future directions would not only enhance our understanding of allergenic risks in Mila but also contribute to the development of targeted public health interventions.

5. Conclusion

Because ecosystem services provided by allergenic trees are often overlooked, we identified and geolocated the allergenic tree species surrounding primary schools in Mila city. We found that more than half of the primary schools, with 3,149 students, are highly exposed to allergenic trees. This is the first study in Algeria to examine proximity of primary schools to this type of allergen. It demonstrates how data and GIS technology can contribute to deeper insights into urban ecology. By mapping allergenic trees around schools, continuous monitoring and targeted interventions can be implemented more effectively. Finally, based on the results of this study, which indicate the presence of several allergenic trees in close proximity to primary schools, it appears necessary for the Algerian government and environmental associations to take initiatives aimed at reducing school children's exposure to this type of allergen through the preventive removal of the main allergenic tree species, careful urban tree species selection in tree planting programs and increased public awareness of pollen allergy risks.

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