

Original Research

LONG-TERM TRENDS OF AIRBORNE POLLEN IN PANČEVO

DOI: 10.5937/EcoTER26243N

Dubravka Nikolovski^{1,a*}, Snežana Đurić^{1,b}, Danijela Mičić^{1,c}, Gabriјela Trajkovska^{1,d},
Ljilјana Lazić^{1,e}, Tamara Stajić^{1,f}, Dušan Stošić^{1,g}, Ksenija Kralj^{1,h}, Jelena Zec^{1,i}

¹Institute of Public Health Pančevo, Miloša Obrenovića 2, 26000 Pančevo, SERBIA

^a <https://orcid.org/0000-0002-1602-095x> ^b <https://orcid.org/0009-0001-8540-1596>

^c <https://orcid.org/0009-0004-9505-3929> ^d <https://orcid.org/0009-0001-7988-8270>

^e <https://orcid.org/0009-0009-3241-5079> ^f <https://orcid.org/0009-0003-9100-0304>

^g <https://orcid.org/0009-0009-8162-2955> ^h <https://orcid.org/0009-0003-6609-007x>

ⁱ <https://orcid.org/0009-0005-8960-0620>

Abstract

This study presents a five-year aerobiological survey (2021–2025) of airborne pollen in Pančevo, Serbia, conducted using continuous volumetric sampling with standardized methodology. The monitoring period extended from February to November each year, encompassing tree, grass, and weed pollination seasons. Daily pollen concentrations were analyzed microscopically, with particular attention to annual maxima, cumulative value, and pollination duration.

Comparative analysis revealed that Cupressaceae/Taxus, Urticaceae, and Ambrosia pollen exhibited the highest average annual values, while Cupressaceae, Salix, and Betula recorded the greatest maximum concentrations. Poaceae, Pinaceae, and Urticaceae demonstrated the longest pollination periods. Increasing multi-year trends were observed for taxa such as Amaranthus, Fraxinus, and Populus, whereas declining trends were noted for Artemisia, Betula, Cannabaceae, and Poaceae.

The rising concentrations of ragweed (Ambrosia), a highly allergenic species, highlight the urgent need for preventive measures in both urban and rural environments. Overall, the findings emphasize the importance of continuous aerobiological surveillance and long-term assessment of pollen dynamics as a foundation for public health planning, allergen exposure reduction, and improvement of quality of life for sensitive populations in Pančevo.

Keywords: airborne pollen, long-term trend.

INTRODUCTION

Airborne pollen has represented a significant etiological factor in allergic reactions over the past century, when in the late 19th and early 20th centuries scientists began linking pollen exposure to allergic conditions. The first organized national airborne pollen survey was conducted in the United States in 1929. From there, techniques for pollen collection and counting were refined, and by the 1950s–1960s in Europe and other parts of the world, standardized methods and pollen counting networks were established. According to the

* dubravka.nikolovski@gmail.com

statement of the Environmental Protection Agency of Serbia, one measuring site represents a territory with a diameter of 30 km to 50 km, depending on the orography of the terrain [1]. Depending on meteorological conditions, pollen can be found at altitudes greater than 1 km [2]. Nowadays, systematic aeropollen monitoring provides the basis for clinical and public health purposes: the investigation, prevention, diagnosis, and management of pollen-induced allergies.

In Serbia, the measurement of airborne concentrations of allergenic pollen species is currently carried out by the Environmental Protection Agency, within the framework of the national monitoring network. This monitoring system is aligned with the recommendations of the International Association for Aerobiology, which defines the monitoring period according to climatic conditions. Data from this network are submitted to the European Aeroallergen Network (EAN).

MATERIALS AND METHODS

Study Area

The study was conducted in Pančevo, a city located in the southern part of Vojvodina, Serbia. Pančevo lies approximately 15 km northeast of Belgrade, at the confluence of the Tamiš and Danube rivers. The region is characterized by a continental climate, with cold winters, warm summers, and moderate precipitation. Its geographical position, combined with significant agricultural activity and surrounding forested areas, provides a diverse source of airborne pollen.

Sampling procedure

Aeropollen was collected using the continuous volumetric method [3]. Sampling was performed with a LANZONI VPPS 2000 SAMPLER, located in the building of the City Administration at a height of about 15 m above ground level and operating continuously for a period of seven days. From each seven-day sample, daily subsamples were prepared according to standardized methodology [4] and subsequently analyzed microscopically in the laboratory. The monitoring period was from the beginning of February until the first days of November.

Pollen identification

Microscopic analysis included identification of pollen grains from the following taxa: *Acer* (maple), *Alnus* (alder), *Ambrosia* (ragweed), *Artemisia* (mugwort), *Betula* (birch), *Cannabaceae* (hemp), *Carpinus* (hornbeam), *Chenopodiaceae/Amaranthaceae* (goosefoot/amaranths), *Corylus* (hazel), *Cupressaceae and Taxus* (cypress and yew), *Fagus* (beech), *Fraxinus* (ash), *Juglans* (walnut), *Moraceae* (mulberry), *Pinaceae* (pine), *Plantago* (plantain), *Platanus* (plane tree), *Poaceae* (grasses), *Populus* (poplar), *Quercus* (oak), *Rumex* (sorrel), *Salix* (willow), *Tilia* (linden), *Ulmaceae* (elm) and *Urticaceae* (nettle).

The following indicators are monitored [5–9]: annual maximum airborne pollen concentrations (grains/m³ per day), pollination period length (number of days), cumulative airborne pollen concentrations during the pollination period (grains/m³), and the number of days per year exceeding threshold values of pollen concentrations.

Airborne pollen measurements encompass three distinct pollination seasons. The tree pollination season begins in early February with the flowering of hazel (*Corylus*) and alder (*Alnus*) and continues until early May. The grass pollination season extends from May until the end of July, and in addition to grasses, this period is also marked by the flowering of pine (*Pinus*) and linden (*Tilia*). The weed pollination season lasts from early August until early November, characterized primarily by the flowering of ragweed (*Ambrosia*).

RESULTS AND DISCUSSION

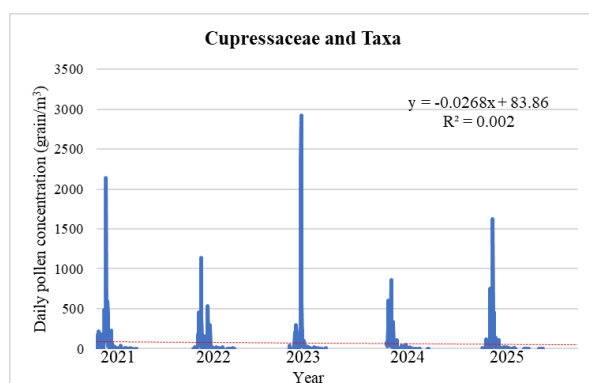
Daily concentrations of pollen in the air of the city of Pančevo were examined in the period from 2021 to 2025. In the five-year comparative analysis of daily pollen concentrations in the air, all available data are presented graphically

Here is presented (Figure 1) a trend of five-year daily pollen concentration for the six species with the highest total annual concentrations. All available data is presented numerically (Tables 2–4).

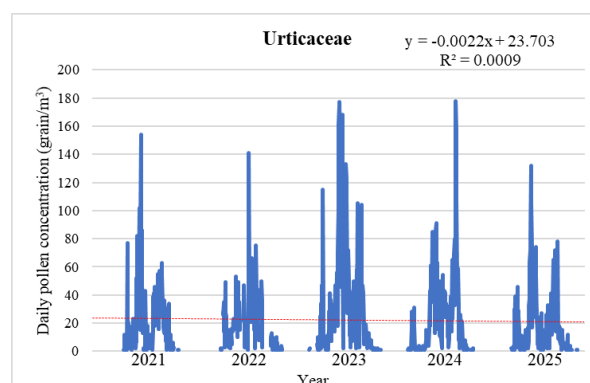
The comparative analysis of aeropollen examination results in the period from 2021 to 2025 by plant species was carried out for the following parameters: total annual pollen concentrations (Table 2), in the air referring to the monitoring period determined by the Environmental Protection Agency (Table 1), maximum annual pollen concentrations (Table 3), number of pollination days (Table 4), where the minimum, maximum and average values are given for each parameter.

Table 1 Airborne pollen monitoring periods from 2021 to 2025

Year	Start Date of Annual Pollen Season	End Date of Annual Pollen Season
2021	February 1, 2021	October 31, 2021
2022	January 31, 2022	October 30, 2022
2023	January 30, 2023	November 5, 2023
2024	February 5, 2024	November 3, 2024
2025	February 2, 2025	November 2, 2025



a) *Cupressaceae* and *Taxa*



b) *Urticaceae*

Figure 1 continued

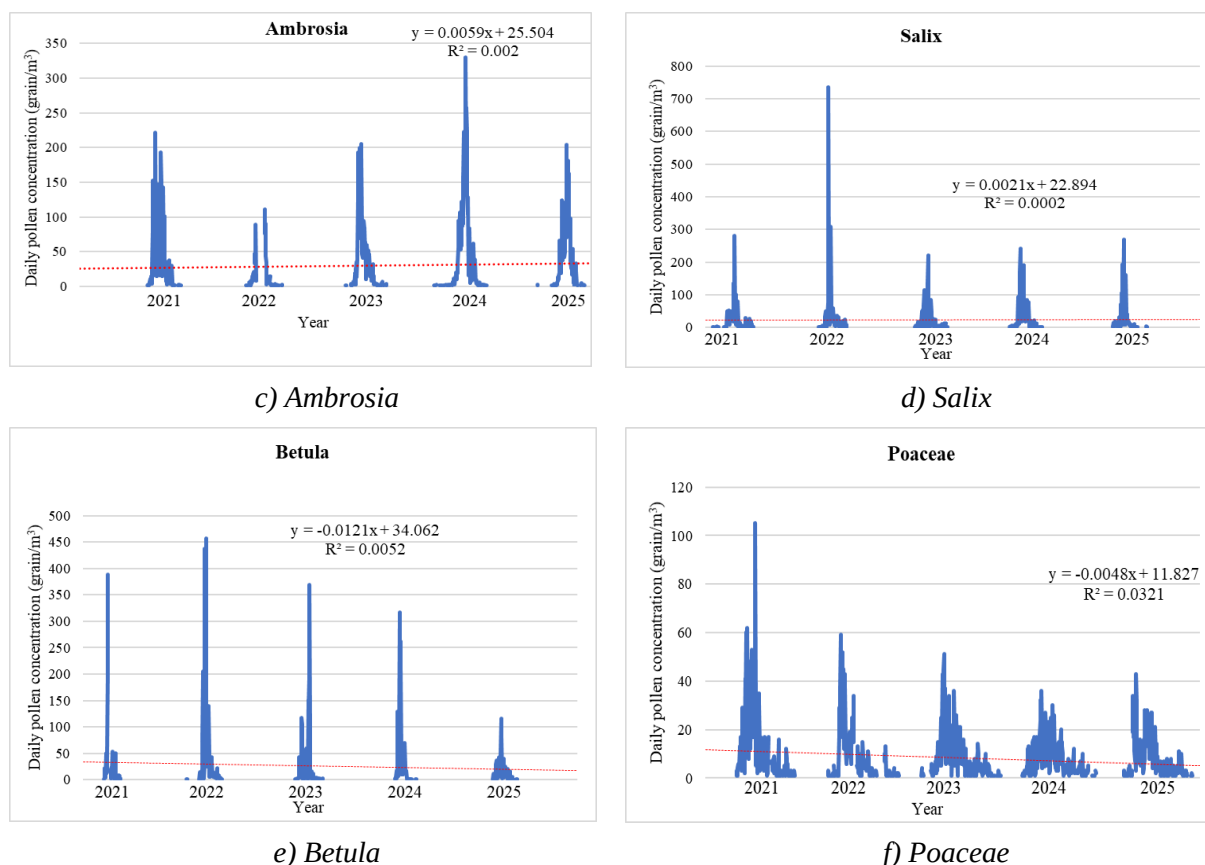


Figure 1 Trend of five-year daily pollen concentration - six species with the highest total annual concentrations: a) Cupressaceae and Taxa; b) Urticaceae; c) Ambrosia; d) Salix; e) Betula; f) Poaceae

Table 2 Total concentrations of aeropollen in the air of the city of Pančevo in the period from 2021 to 2025

Plant species	Total pollen concentration (number of pollen grains / m ³ of air)					Minimum	Maximum	Five-year average value*
	Year							
	2021	2022	2023	2024	2025			
Acer / maple	544	708	964	1144	729	544	1144	818
Alnus / alder	278	963	109	592	446	109	963	478
Ambrosia / ambrosia	2846	880	3302	4489	3130	880	4489	2929
Artemisia / mugwort	134	102	252	178	120	102	252	157
Betula / birch	1120	2598	1729	1722	840	840	2598	1602
Cannabaceae / hemp	287	193	278	408	196	193	408	272
Carpinus / hornbeam	150	1066	181	588	868	150	1066	571
Chenopodiaceae / Amar. / goosfoot/amaranth	212	187	268	553	230	187	553	290
Corylus / hazel	351	660	209	604	420	209	660	449
Cupressaceae / Taxae / cypress and yew	7858	5455	8552	5310	7091	5310	8552	6853
Fagus / beech	246	355	53	239	162	53	355	211
Fraxinus / ash	290	370	487	593	514	290	593	451
Juglans / walnut	454	278	523	446	267	267	523	394
Moraceae / mulberry	383	845	684	1561	202	202	1561	735
Pinaceae / pine	1036	421	353	447	707	353	1036	593

Table 2 continued

Plantago / plantain	82	70	231	187	135	70	231	141
Platanus / plane tree	183	71	90	87	144	71	183	115
Poaceae / grasses	1734	1201	1579	1410	1328	1201	1734	1450
Populus / poplar	504	466	700	331	599	331	700	520
Quercus / oak	246	167	224	191	306	167	306	227
Rumex / sorrel	74	45	74	72	67	45	74	66
Salix / willow	1647	2511	1624	2315	1929	1624	2511	2005
Tilia / linden	347	338	251	350	334	251	350	324
Ulmaceae / elm	141	208	150	286	295	141	295	216
Urticaceae / nettle	2737	2495	5628	4015	2841	2495	5628	3543

Among all analyzed taxa, *Cupressaceae* and *Taxa*, *Urticaceae*, and *Ambrosia* pollen demonstrated the highest average five-year value.

Table 3 Maximum concentrations of airborne pollen in the air of the city of Pančevo in the period from 2021 to 2025

Plant species	Maximum concentrations of airborne pollen					Minimum	Maximum	Five-year average value*
	(number of pollen grains / m ³ of air)							
	Year							
	2021	2022	2023	2024	2025			
Acer / maple	67	73	90	104	68	67	104	80
Alnus / alder	19	358	16	183	71	16	358	129
Ambrosia / ambrosia	222	111	205	330	204	111	330	214
Artemisia / mugwort	11	11	30	13	10	10	30	15
Betula / birch	389	457	369	317	116	116	457	330
Cannabaceae / hemp	22	16	16	21	21	16	22	19
Carpinus / hornbeam	17	240	18	61	65	17	240	80
Chenopodiaceae / Amar. / goosfoot/amaranth	12	10	17	17	8	8	17	13
Corylus / hazel	105	73	18	97	109	18	109	80
Cupressaceae / Taxae / cypress and yew	2143	1143	2921	859	1625	859	2921	1738
Fagus / beech	78	59	7	42	36	7	78	44
Fraxinus / ash	19	44	38	32	52	19	52	37
Juglans / walnut	74	30	68	57	33	30	74	52
Moraceae / mulberry	62	112	105	273	32	32	273	117
Pinaceae / pine	112	32	25	28	54	25	112	50
Plantago / plantain	7	4	6	10	6	4	10	7
Platanus / plane tree	31	15	9	13	32	9	32	20
Poaceae / grasses	105	59	51	36	43	36	105	59
Populus / poplar	102	78	236	42	93	42	236	110
Quercus / oak	35	24	43	41	44	24	44	37
Rumex / sorrel	6	4	4	3	5	3	6	4
Salix / willow	282	736	221	241	269	221	736	350
Tilia / linden	45	44	31	43	59	31	59	44
Ulmaceae / elm	20	22	24	42	59	20	59	33
Urticaceae / nettle	154	141	177	178	132	132	178	156

The highest average five-year maximum pollen value was recorded for *Cupressaceae*, *Salix*, and *Betula* pollen.

Table 4 Number of pollination days of airborne pollen in the air of the city of Pančevo in the period from 2021 to 2025

Plant species	Number of pollination days (n)					Minimum	Maximum	Five-year average value*
	Year							
	2021	2022	2023	2024	2025			
Acer / maple	73	58	77	83	79	58	83	74
Alnus / alder	48	54	31	43	46	31	54	44
Ambrosia / ambrosia	86	67	103	129	98	67	129	97
Artemisia / mugwort	49	39	72	70	47	39	72	55
Betula / birch	49	66	75	55	58	49	75	61
Cannabaceae / hemp	71	57	78	81	73	57	81	72
Carpinus / hornbeam	54	73	57	60	52	52	73	59
Chenopodiaceae / Amar. / goosfoot/amaranths	80	75	98	113	94	75	113	92
Corylus / hazel	49	57	44	38	47	38	57	47
Cupressaceae / Taxae / cypress and yew	97	100	105	94	115	94	115	102
Fagus / beech	33	41	24	31	27	24	41	31
Fraxinus / ash	85	81	93	81	76	76	93	83
Juglans / walnut	38	37	57	45	50	37	57	45
Moraceae / mulberry	31	29	40	38	31	29	40	34
Pinaceae / pine	102	89	96	109	115	89	115	102
Plantago / plantain	60	51	106	86	92	51	106	79
Platanus / plane tree	27	24	36	23	30	23	36	28
Poaceae / grasses	151	146	200	198	187	146	200	176
Populus / poplar	45	58	43	50	40	40	58	47
Quercus / oak	40	36	30	35	49	30	49	38
Rumex / sorrel	47	35	54	59	51	35	59	49
Salix / willow	87	80	86	82	79	79	87	83
Tilia / linden	52	56	62	63	62	52	63	59
Ulmaceae / elm	43	45	34	44	42	34	45	42
Urticaceae / nettle	137	138	177	179	172	137	179	161

Poaceae, *Urticaceae*, *Pinaceae*, and *Cupressaceae* and *Taxa* pollen had the longest pollination in the five-year average period.

CONCLUSION

Analysis of airborne pollen concentrations in Pančevo during the period 2021–2025 revealed distinct temporal trends among major allergenic taxa. Increasing concentrations were documented for *Acer*, *Alnus*, *Ambrosia*, *Carpinus*, *Chenopodiaceae/Amaranthus*, *Corylus*, *Fraxinus*, *Moraceae*, *Plantago*, *Populus*, *Quercus*, *Salix*, and *Ulmaceae*. Declining trends were observed for *Artemisia*, *Betula*, *Cannabaceae*, *Cupressaceae/Taxae*, *Fagus*, *Juglans*, *Pinaceae*, *Platanus*, *Poaceae*, *Rumex*, *Tilia*, and *Urticaceae*.

The taxa showing the most significant multi-year increases were *Amaranthus*, *Fraxinus*, and *Populus*, all of which have moderate allergenic potential. The upward trend in ragweed pollen concentrations highlights the importance of implementing preventive strategies for its control in both urban and rural areas, while promoting the planting of tree species with no allergenic potential to safeguard public health.

Continuous aerobiological surveillance and long-term evaluation of airborne pollen dynamics are critical for developing targeted interventions that reduce allergen exposure, improve the quality of life of sensitive populations, and provide a solid scientific basis for evidence-based public health planning in Pančevo.

ACKNOWLEDGEMENT

Pollen monitoring was financially supported by the City of Pančevo through Contract No. XI-13-404-210/2019 for the procurement of pollen monitoring services, dated December 30, 2019; Contract No. XI-13-404-250/2021, dated January 24, 2022; and Contract No. XI-13-405-129/2023, dated January 3, 2024.

REFERENCES

- [1] Environmental Protection Agency of Serbia. Pollen Monitoring Portal. 2026. Available from: <https://sepa.gov.rs/polen/> (accessed on March 2, 2026).
- [2] Sikoparija, B., Birgermajer, S., Ivosevic, B., *et al.* U. Atmosphere 2025, 16, 1060.
- [3] Hirst, J.M. Ann. Appl. Biol. 1952, 39(2), 257–265.
- [4] SRPS EN 16868:2019. Ambient Air – Sampling and Analysis of Airborne Pollen Grains and Fungal Spores for Networks Related to Allergy – Volumetric Hirst Method. Serbian Institute for Standardization: Belgrade, Serbia, 2019. Available from: <https://iss.rs/en/project/show/iss:proj:64320> (accessed on March 2, 2026).
- [5] Institute of Public Health Pančevo. Annual Report on the Measurements of Allergenic Pollen in Ambient Air in the Territory of the City of Pančevo for the Period from February 1, 2021, to October 31, 2021. Pančevo, Serbia, 2022. Available from: https://www.pancevo.rs/?wpfb_dl=4363 (accessed on March 2, 2026).
- [6] Institute of Public Health Pančevo. Annual Report on the Measurements of Allergenic Pollen in Ambient Air in the Territory of the City of Pančevo for the Period from January 31, 2022, to October 30, 2022. Pančevo, Serbia, 2023. Available from: https://www.pancevo.rs/?wpfb_dl=4735 (accessed on March 2, 2026).
- [7] Institute of Public Health Pančevo. Annual Report on the Measurements of Allergenic Pollen in Ambient Air in the Territory of the City of Pančevo for the Period from January 30, 2023, to November 5, 2023. Pančevo, Serbia, 2024. Available from: https://www.pancevo.rs/?wpfb_dl=5188 (accessed on March 2, 2026).
- [8] Institute of Public Health Pančevo. Annual Report on the Measurements of Allergenic Pollen in Ambient Air in the Territory of the City of Pančevo for the Period from February 5, 2024, to November 3, 2024. Pančevo, Serbia, 2025. Available from: https://www.pancevo.rs/?wpfb_dl=5576 (accessed on March 2, 2026).
- [9] Institute of Public Health Pančevo. Annual Report on the Measurements of Allergenic Pollen in Ambient Air in the Territory of the City of Pančevo for the Period from February 3, 2025, to November 2, 2025. Pančevo, Serbia, 2026. Available from: https://www.pancevo.rs/?wpfb_dl=5742 (accessed on March 2, 2026).