

# Identification of airborne pollens in Delhi

[Raj Kumar](#), [Deepak Kumar](#), [Kamal Singh](#), [Anil Kumar Mavi](#), [Manoj Kumar](#)

Department of Pulmonary Medicine, National Centre of Respiratory Allergy, Asthma and Immunology, Vallabhbhai Patel Chest Institute, University of Delhi, New Delhi, India

**Source of Support:** None, **Conflict of Interest:** None

**DOI:** 10.4103/ijaai.ijaai\_35\_17

## Abstract

**Aims:** To quantify and identify the pollen grains in the atmosphere of Delhi.

**Settings and Design:** The study was conducted at the National Centre of Respiratory Allergy, Asthma and Immunology, Vallabhbhai Patel Chest Institute (VPCI), University of Delhi, Delhi, India.

**Subjects and Methods:** The study was conducted for 2 months at VPCI, University of Delhi (North Campus), Delhi. Pollen grains were collected on a daily basis using 24-h Burkard (UK) volumetric air sampler. Trapped pollen film was stained with a fuchsin stain that is protected with a cover slip and examined under a light microscope. Identification was done with the help of manuals for pollen identification.

**Statistical Analysis Used:** Data analysis was done by Microsoft Excel 2007.

**Results:** In this study period (April and May 2017), a total of 10,858/m<sup>3</sup> pollens were counted; of these, 7758/m<sup>3</sup> pollens of 34 species of trees, weeds, and grasses were identified. Overall, *Juniper* sp. (1385/m<sup>3</sup>) pollen of tree was found to be the most dominant pollen, followed by *Cannabis sativa* (726/m<sup>3</sup>), Pooideae grasses (e.g. *Poa* sp., *Lolium perenne*, *Dactylis glomerata*) (654/m<sup>3</sup>), *Cynodon dactylon* (509/m<sup>3</sup>), *Amaranthus* sp. (506/m<sup>3</sup>), *Artemisia* sp. (460/m<sup>3</sup>), *Cassia* sp. (447/m<sup>3</sup>), *Chenopodium album* (412/m<sup>3</sup>), *Helenium autumnale* (381/m<sup>3</sup>), and *Parthenium* (301/m<sup>3</sup>). *Juniper* sp. (1310/m<sup>3</sup>) pollens in April 2017 and *C. sativa* (421/m<sup>3</sup>) pollens in May 2017 have shown their dominance.

**Conclusions:** In our study, various pollens of different plant species were counted and identified in this short study period. The common pollens found were *Juniper* sp., *C. sativa*, Pooideae grasses (e.g. *Poa* sp., *Lolium perenne*, *Dactylis glomerata*), *C. dactylon*, *Amaranthus* sp., *C. album*, *H. autumnale*, *Parthenium*, and *Artemisia* sp. in 2 months. This short study may be helpful for the respiratory allergic patients to protect themselves by pollens.

**Keywords:** Airborne pollen, identification, respiratory allergy

Airborne pollen grains of various plant species are responsible for the different types of allergies. The pollen grains and fragments transported by the air generally range between 10 and 50 µm.<sup>[1]</sup> The ambient air is never completely free from microbial propagules which are collectively called air spora.<sup>[2]</sup> Pollens of various plant species are reported to cause respiratory allergies and bronchial asthma. These allergenic particles contain proteins and glycoproteins that are released on coming in contact with the human respiratory tract and elicit an allergic reaction in the body.<sup>[1],[3]</sup>

Aerobiological studies can be utilized to forecast daily pollen and spore count on electronic media.<sup>[4]</sup>

Identification of pollen origin is a central aspect in pollination ecology studies<sup>[5],[6],[7]</sup> and agroecological research.<sup>[8],[9]</sup> Conventional pollen identification utilizes light microscopy and discriminates species according to morphological characteristics.<sup>[10]</sup> This requires expert knowledge for the bioregion, and taxa of interest<sup>[11]</sup> is time-consuming<sup>[12]</sup> and lacks discriminatory power at lower taxonomic levels.<sup>[8],[12]</sup>

The pollen grains released by wind-pollinated plant constitute a major part of flora. The concentration and composition of atmospheric pollen flora depend on the local vegetation, climate, and geographical location. Aerobiological studies at Delhi have shown the presence of different types of biocomponents in the atmosphere. A detailed study of pollen spectrum in the atmosphere of given place is of great importance to allergologists, as airborne pollens are the main causative agents of respiratory allergies. Hay fever allergy and asthma are common health problems in the world.<sup>[13],[14],[15],[16]</sup> Airborne pollen grain monitoring has become an essential field for the medical community as pollen calendar can serve as the supportive tool to take such steps which would be helpful in the prevention of allergies. The purpose of the present study is to quantify and identify the pollen grains of different plant species in Delhi environment in 2 months (April and May 2017).

## Subjects and Methods



The study was carried out over a period of 2 months (April and May 2017) at Vallabhbhai Patel Chest Institute (VPCI), University of Delhi (North Campus), Delhi. The instrument for daily monitoring of pollens was installed on the roof of the multistoried building (up to a height of 20 m) of the VPCI.

### Preparation of slides

The Burkard sampler's 24-h lid assembly using a standard 3 inch × 1 inch microscope slide was cleaned with a dry tissue paper and then the slide was coated with a thin and uniform layer of petroleum jelly with the help of a painting brush. The slide was placed on the clock assembly by marking to show the start of the trace. Hold the wind vane with one hand, unlock the revolving part of the trap, and climb down before releasing the wind vane. The slide carriage will move clockwise in an upward direction at 2 mm/h and put back into the trap with secured locking bar. The sampler was started by connecting it to the power supply (12 V) and left for 1-day recording. Trapped pollen film was stained with the fuchsin stain that is protected with the coverslip and examined under a light microscope.

### Quantification and identification of pollen

A total of 34 species of pollens of trees, weeds, and grasses were counted and identified. Pollens were collected by the Burkard's 24-h recording volumetric trap for 2 months from April 2017 to May 2017. The instrument was installed on the roof of the multistoried building (up to a height of 20 m) of VPCI, located in the University of Delhi (North Campus), Delhi. Twenty-four-hour sampling was done (12 pm to 12 pm) and then pollen was counted under a microscope by reading slides prepared from the pollen-trapping assembly. Pollen counts of each group were reported as total grains per cubic meter of air (grains/m<sup>3</sup>). Identification was done with the help of manuals for pollen identification.

## Meteorological data

The meteorological factors including temperature and relative humidity were recorded daily from the Indian Agricultural Research Institute, Pusa, New Delhi.

## Results

In this study period (April and May 2017), a total of 10,858/m<sup>3</sup> pollens were counted; of these, 7758/m<sup>3</sup> pollens of 34 species of trees, weeds, and grasses were identified. Overall, *Juniper* sp.(1385/m<sup>3</sup>) pollen of tree was found to be the most dominant pollen, followed by *Cannabis sativa* (726/m<sup>3</sup>), Pooideae grasses (e.g. *Poa* sp., *Lolium perenne*, *Dactylis glomerata*) (654/m<sup>3</sup>), *Cynodon dactylon* (509/m<sup>3</sup>), *Amaranthus* sp.(506/m<sup>3</sup>), *Artemisia* sp. (460/m<sup>3</sup>), *Cassia* sp. (447/m<sup>3</sup>), *Chenopodium album* (412/m<sup>3</sup>), *Helenium autumnale* (381/m<sup>3</sup>), and *Parthenium* (301/m<sup>3</sup>). In this duration, minimum and maximum temperatures and humidity were 24.1°C and 36.5°C and 43.5 RH and 84 RH observed, respectively. Temperature and humidity affect (increase/decrease) the pollen count directly.

## Identified pollens in April 2017

A total of 7099/m<sup>3</sup> pollens were counted, in which 5202/m<sup>3</sup> pollens of 34 species of trees, weeds, and grasses were identified in April 2017. In this month, *Juniper* sp. (1310/m<sup>3</sup>) of tree was found to be the dominant pollen, followed by Pooideae grasses (e.g. *Poa* sp., *Lolium perenne*, *Dactylis glomerata*) (485/m<sup>3</sup>), *Artemisia* (368/m<sup>3</sup>), *C. sativa* (305/m<sup>3</sup>), *Amaranthus* sp. (298/m<sup>3</sup>), *C. dactylon* (284/m<sup>3</sup>), and *C. album* (260/m<sup>3</sup>) [Table 1] and [Figure 1] & [Figure 2]. The monthly mean values of pollens, temperature, and relative humidity were found 236.6/m<sup>3</sup>, 29.5°C and 55.6% respectively.

| Pollen type  | Pollen (34)                                                                                | Pollen (count/m <sup>3</sup> ), n (%) |
|--------------|--------------------------------------------------------------------------------------------|---------------------------------------|
| Tree         | <i>Juniper</i> sp.                                                                         | 1310 (18.45)                          |
|              | <i>Acer</i>                                                                                | 162 (2.28)                            |
|              | <i>Morus alba</i>                                                                          | 268 (3.77)                            |
|              | <i>Betula</i>                                                                              | 192 (2.70)                            |
| Weeds        | <i>Artemisia</i> sp.                                                                       | 368 (5.18)                            |
|              | <i>Cannabis sativa</i>                                                                     | 305 (4.29)                            |
|              | <i>Amaranthus</i> sp.                                                                      | 298 (4.20)                            |
|              | <i>Chenopodium album</i>                                                                   | 260 (3.66)                            |
|              | <i>Helenium autumnale</i>                                                                  | 194 (2.73)                            |
|              | <i>Parthenium</i>                                                                          | 137 (1.93)                            |
| Grasses      | Pooideae grasses (e.g. <i>Poa</i> sp., <i>Lolium perenne</i> , <i>Dactylis glomerata</i> ) | 485 (6.83)                            |
|              | <i>Cynodon dactylon</i>                                                                    | 284 (2.84)                            |
| Unidentified |                                                                                            | 1897 (26.72)                          |

Table 1: Pollen shown dominance in April 2017

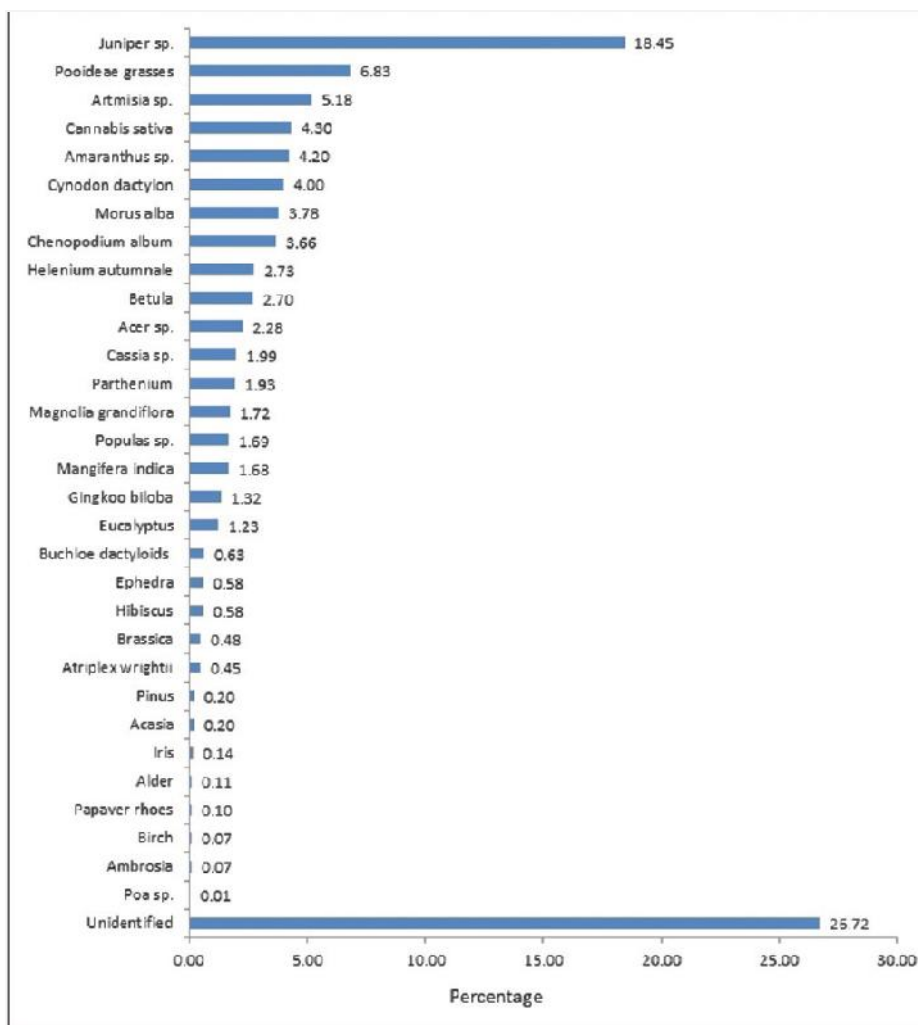


Figure 1: Identified pollen in April 2017

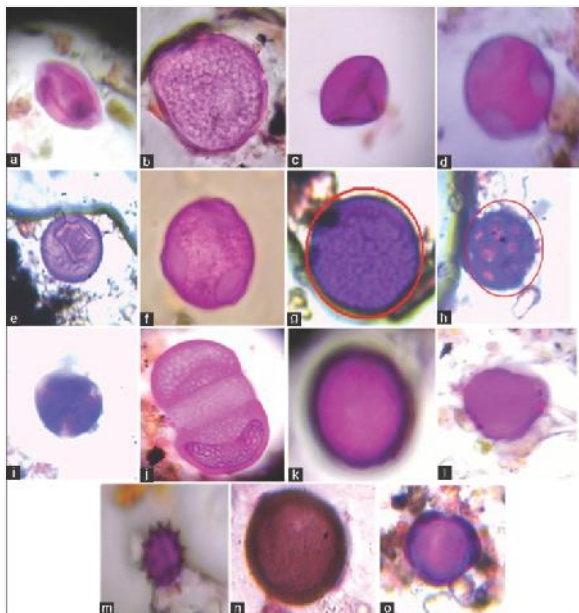


Figure 2: Identified Pollens (a) *Magnolia grandiflora*, (b) *Iris*, (c) *Juniper* sp., (d) *Celtis occidentalis*, (e) *Cynodon dactylon*, (f) *Cannabis sativa*, (g) *Buchloe dactyloides*, (h) *Amaranthus* sp., (i) *Acer* sp., (j) *Pinus strobus*, (k) *Melandrium album*, (l) *Papaver rhoeas*, (m) *Parthenium*, (n) *Pooideae* grasses (e.g. *Poa* sp., *Lolium perenne*, *Dactylis glomerata*), (o) *Artemisia* sp.

### Identified pollens in May 2017

A total of 3759/m<sup>3</sup> were counted and 2556/m<sup>3</sup> were identified in May 2017. *C. sativa* (305/m<sup>3</sup>) was found to be the dominant pollen, followed by *Cassia* sp. (306/m<sup>3</sup>), *C. dactylon* (225/m<sup>3</sup>), *H.*

*autumnale* (187/m<sup>3</sup>), *Parthenium* sp.(164/m<sup>3</sup>), Pooideae grasses (e.g. *Poa* sp., *Lolium perenne*, *Dactylis glomerata*) (169/m<sup>3</sup>), *Buchloe dactyloides* (161/m<sup>3</sup>), *Amaranthus* sp. (208/m<sup>3</sup>), and *C. album* (152/m<sup>3</sup>) [Table 2], [Figure 2] & [Figure 3]. The monthly mean values of pollens, temperature, and relative humidity were found 121.3/m<sup>3</sup>, 31.9°C and 55.9% respectively.

| Pollen type | Pollen (34)                                                                                | Pollen (count/m <sup>3</sup> ), n (%) |
|-------------|--------------------------------------------------------------------------------------------|---------------------------------------|
| Tree        | <i>Cassia</i> sp.                                                                          | 306 (8.14)                            |
|             | <i>Juniper</i> sp.                                                                         | 75 (1.99)                             |
| Weeds       | <i>Cannabis sativa</i>                                                                     | 421 (11.20)                           |
|             | <i>Chenopodium album</i>                                                                   | 260 (6.92)                            |
|             | <i>Amaranthus</i> sp.                                                                      | 208 (5.53)                            |
|             | <i>Helenium autumnale</i>                                                                  | 187 (4.97)                            |
|             | <i>Parthenium</i>                                                                          | 164 (4.36)                            |
|             | <i>Artemisia</i> sp.                                                                       | 92 (2.45)                             |
|             | <i>Cynodon dactylon</i>                                                                    | 225 (5.98)                            |
| Grasses     | Pooideae grasses (e.g. <i>Poa</i> sp., <i>Lolium perenne</i> , <i>Dactylis glomerata</i> ) | 169 (4.49)                            |
|             | Unidentified                                                                               | 1203 (32.00)                          |

Table 2: Pollen shown dominance in May 2017

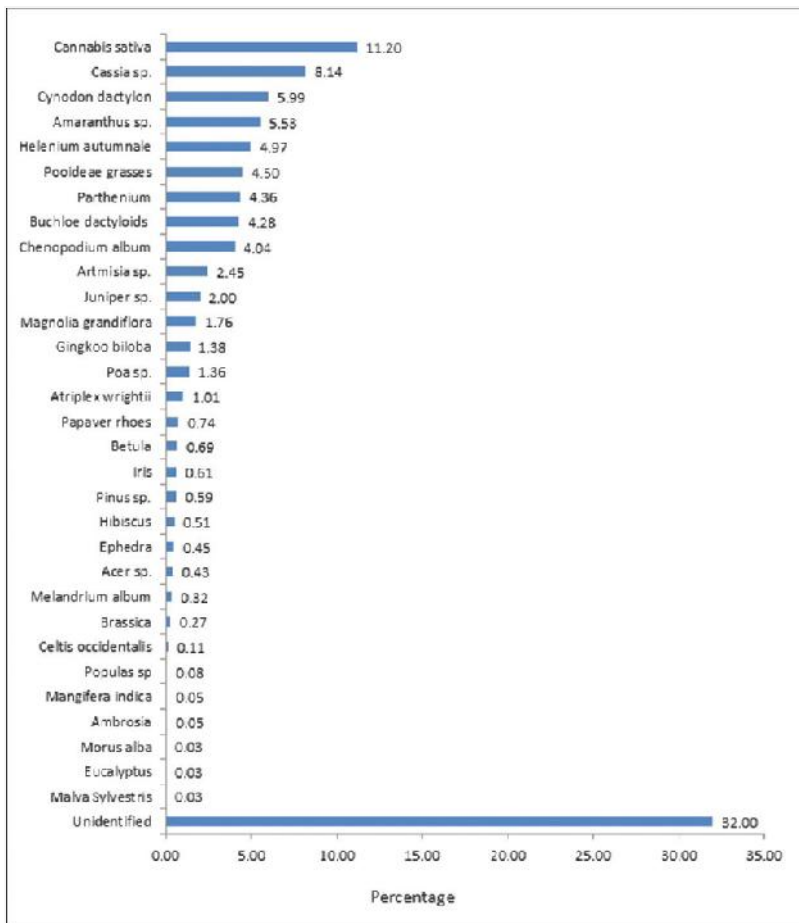


Figure 3: Identified pollen in May 2017

## Family-wise dominance of pollens of trees, weeds, and grasses in April and May 2017

### April 2017

In tree pollens, *Cupressaceae* family (18.45%), *Moraceae* family (3.77%), *Betulaceae* family (2.89%), and *Sapindaceae* family (2.29%) have shown their dominance in April. In weeds, *Asteraceae* family (9.92%), *Amaranthaceae* family (8.31%), and *Cannabaceae* family (4.30%)

have shown their dominance in April. In grasses, *Poaceae* family (11.48%) has shown its dominance in April [Table 3].

| Category     | Family               | Month        |                                |
|--------------|----------------------|--------------|--------------------------------|
|              |                      | April        | May                            |
|              |                      | Percentage   | Pollen (count/m <sup>3</sup> ) |
| Tree         | <i>Cupressaceae</i>  | 1310 (18.45) |                                |
|              | <i>Moraceae</i>      | 268 (3.77)   |                                |
|              | <i>Betulaceae</i>    | 205 (2.89)   |                                |
|              | <i>Sapindaceae</i>   | 162 (2.28)   |                                |
|              | <i>Fabaceae</i>      | 155 (2.18)   | 306 (8.14)                     |
| Weeds        | <i>Asteraceae</i>    | 704 (9.92)   | 443 (11.78)                    |
|              | <i>Amaranthaceae</i> | 590 (8.31)   | 398 (10.59)                    |
|              | <i>Cannabaceae</i>   | 305 (4.30)   | 425 (11.31)                    |
| Grass        | <i>Poaceae</i>       | 815 (11.48)  | 606 (16.12)                    |
| Unidentified |                      | 1897 (26.72) | 1203 (32.00)                   |

Table 3: Dominant plants family in April and May 2017

## May 2017

In tree pollen, *Sapindaceae* family (306/m<sup>3</sup>; 8.14%) has shown its dominance in May. Among grasses, *Poaceae* family (606/m<sup>3</sup>; 16.12%) has shown its dominance in May. Among weeds, *Asteraceae* family (443/m<sup>3</sup>; 11.78%), *Cannabaceae* family (425/m<sup>3</sup>; 11.31%), and *Amaranthaceae* family (398/m<sup>3</sup>; 10.59%) are shown in [Table 3].

## Discussion



Delhi, the capital city of India, comes under semi-arid tropics and supports thorny, bushy vegetation. In our short study, *Juniper*, *Betula*, *Morus alba*, and *Cassia* were found to be the dominant tree pollens in Delhi environment. *C. dactylon* and Pooideae grasses (e.g. *Poa* sp., *Lolium perenne*, *Dactylis glomerata*) of *Poaceae* family were found to be the dominant grass pollens in Delhi environment. *Artemisia*, *Cannabis*, *C. album*, and *Amaranthus* were found to be the dominant weeds in Delhi environment. These identified pollens were compared with hospital visits of respiratory allergic patients and environmental factors.

In our study, grass pollens belonged to *Poaceae* family (13.09%) were found to be the dominant pollens, commonly *C. dactylon* and Pooideae grasses (e.g. *Poa* sp., *Lolium perenne*, *Dactylis glomerata*). In studies, grass pollens belonged to *Poaceae* family (25.1%) had also shown dominant pollen types. [16],[17] Periodical surveys in Delhi have been conducted by Singh and Shivpuri, [18] Singh and Babu, [19] and Malik *et al.* [20] Dominant pollen types recorded were grasses. Shivpuri *et al.* [21] reported that 100 grass species were found in Delhi environment, in which *Cenchrus*, *Cynodon*, and *Pennisetum* are the main contributors to harm the environment of the city.

In our study, *Cannabis* (6.69%), *Amaranthus* (4.66%), *Artemisia* (4.24%), and *C. album* (3.79%) were found to be the dominant weed pollens which were similar to studies in the past. Singh *et al.* [16],[17] had reported and found *Cannabis*, *Chenopod/Amaranth* (14.5%), and *Artemisia* dominant weeds along with *Parthenium* and *Xanthium*. Singh and Shivpuri, [18] Singh and Babu, [19] and Malik *et al.* [20] had also reported that dominant weed pollens are *Chenopod/Amaranth*, *Cannabis*, and *Artemisia* along with *Ailanthus*, *Xanthium*, and *Holoptelea*. Shivpuri *et al.* [21] had also reported *Amaranthus* and *Chenopodium* dominant along with *Cyprus* and *Scirpus*.

In the current study, *Juniper* (12.76%), *Cassia* (4.12%), *Morus alba* (2.48%), and *Betula* (2.01%) were found to be the dominant tree pollens. Due to the short duration of the study, some tree pollens are not found in comparison to studies in the past, but *Morus alba* was also found to be dominant in previous studies. In his study, Singh *et al.* <sup>[16],[17]</sup> found that the tree pollens (*Morus*, *Prosopis*, and *Eucalyptus*) were shown dominance against other pollens, while pollens of *Ricinus* and *Morus* were also found dominant in his previous studies that were conducted by Singh and Shivpuri, <sup>[18]</sup> Singh and Babu <sup>[19]</sup> and Malik *et al.* <sup>[20]</sup>. Shivpuri *et al.* <sup>[21]</sup> reported *Morus* (*Moraceae*) and *Ricinus*, were moderately common while *Celtis*, *Pinus*, and *Broussonetia* (*Moraceae*) were rare in the environment of Delhi. Whereas in these studies *Juniper* is not found in Delhi environment and therefore, its pollens must have come from other areas of Delhi-NCR.

The results of our short study found that *Cynodon*, *Amaranthus*, and *Chenopodium* were commonly identified in the atmosphere of Delhi. These three pollens were also identified in other three studies Singh *et al.*, Malik *et al.*, and Shivpuri *et al.* *Morus* and *Artemisia* was identified in our study that also found in other two studies Singh *et al.* and Shivpuri *et al.* *Cannabis* and *Parthenium* were identified in our study that were also identified by Singh *et al.* <sup>[17]</sup> *Artemisia* was identified in our study; it was also identified by Malik *et al.* <sup>[20]</sup> in 1991 [Table 4].

| Pollen                                                                                                                  |                                      |                                      |                                   |
|-------------------------------------------------------------------------------------------------------------------------|--------------------------------------|--------------------------------------|-----------------------------------|
| Present study<br>Raj Kumar <i>et al.</i>                                                                                | AB Singh<br><i>et al.</i> (2003)     | Malik <i>et al.</i><br>(1991)        | Shivpuri<br><i>et al.</i> (1960)  |
| <i>Juniper</i> sp.                                                                                                      | <i>Cynodon</i>                       | <i>Cynodon</i>                       | <i>Cynodon</i>                    |
| <i>Cassia</i> sp.                                                                                                       | <i>Cannabis</i>                      | <i>Chenopodium</i>                   | <i>Pennisetum</i>                 |
| <i>Morus alba</i>                                                                                                       | <i>Chenopodium</i>                   | <i>Amaranthus</i><br>sp.             | <i>Cenchrus</i>                   |
| <i>Cannabis sativa</i>                                                                                                  | <i>Amaranthus</i><br>sp.             | <i>Ailanthus</i><br><i>altissima</i> | <i>Amaranthus</i><br>sp.          |
| Pooideae<br>grasses (e.g.<br><i>Poa</i> sp., <i>Lolium</i><br><i>perenne</i> ,<br><i>Dactylis</i><br><i>glomerata</i> ) | <i>Prosopis</i>                      | <i>Holoptelea</i>                    | <i>Chenopodium</i>                |
| <i>Cynodon</i><br><i>dactylon</i>                                                                                       | <i>Artemisia</i> sp.                 | <i>Artemisia</i>                     | <i>Cyperus</i>                    |
| <i>Amaranthus</i> sp.                                                                                                   | <i>Morus</i>                         | <i>Xanthium</i>                      | <i>Scirpus</i>                    |
| <i>Chenopodium</i><br><i>album</i>                                                                                      | <i>Eucalyptus</i>                    |                                      | <i>Morus</i>                      |
| <i>Helenium</i><br><i>autumnale</i>                                                                                     | <i>Prosopis</i>                      |                                      | <i>Ricinus</i><br><i>communis</i> |
| <i>Parthenium</i>                                                                                                       | <i>Ricinus</i><br><i>communis</i>    |                                      |                                   |
| <i>Artemisia</i> sp.                                                                                                    | <i>Xanthium</i><br><i>Parthenium</i> |                                      |                                   |

Table 4: Common pollen in the atmosphere of Delhi current and past studies

## Conclusions

In our study, various pollens of different plant species were counted and identified in this short study period. The common pollens found were *Juniper* sp., *Morus alba*, *Cassia* sp., *C. sativa*, Pooideae grasses (e.g. *Poa* sp., *Lolium perenne*, *Dactylis glomerata*), *C. dactylon*, *Amaranthus*, *C. album*, *H. autumnale*, *Parthenium*, and *Artemisia* in 2 months. The relationship between pollen number and respiratory allergy episodes is known. The findings of our study have shown the dominance of pollens of various plant species in the environment of Delhi with reference to affect

respiratory diseases.

### Financial support and sponsorship

Nil.

### Conflicts of interest

There are no conflicts of interest.

### References

1. Knox RB. Pollen and Allergy. London: Edward Arnold; 1979. [↑](#)
2. Gupta M, Jain AK. Incidence of airborne pollen grains in the atmosphere of Gwalior district: A one year study. J Environ Res Dev 2012;6.3A:631-7. [↑](#)
3. Eva B, Villaba M, Ledemma A, Xoze Puele S, Europa RR. An allergene extract from Salone extract of Olivo tree (*Olea europaea*) pollen. Eur J Biochem 1995;241:772-8. [↑](#)
4. Cariñanos P, Emberlin J, Galán C, Domínguez-Vilches E. Comparison of two pollen counting methods of slides from a Hirst type volumetric trap. Aerobiologia 2000;16:339-46. [↑](#)
5. Carvell C, Westrich P, Meek WR, Pywell RF, Nowakowski M. Assessing the value of annual and perennial forage mixtures for bumblebees by direct observation and pollen analysis. Apidologie 2006;37:326-40. [↑](#)
6. Köppler K, Vorwohl G, Koeniger N. Comparison of pollen spectra collected by four different subspecies of the honey bee *Apis mellifera*. Apidologie 2007;38:341-53. [↑](#)
7. Behl M, Horn H, Schwabe A. Analysis of pollen loads in a wild bee community (Hymenoptera: Apidae) – A method for elucidating habitat use and foraging distances. Apidologie 2008;39:456-67. [↑](#)
8. Williams NM, Kremen C. Resource distributions among habitats determine solitary bee offspring production in a mosaic landscape. Ecol Appl 2007;17:910-21. [↑](#) [\[PUBMED\]](#)
9. Krupke CH, Hunt GJ, Eitzer BD, Andino G, Given K. Multiple routes of pesticide exposure for honey bees living near agricultural fields. PLoS One 2012;7:e29268. [↑](#)
10. Mullins J, Emberlin J. Sampling pollens. J Aerosol Sci 1997;28:365-70. [↑](#)
11. Keller A, Danner N, Grimmer G, Ankenbrand M, von der Ohe K, von der Ohe W, *et al.* Evaluating multiplexed next-generation sequencing as a method in palynology for mixed pollen samples. Plant Biol (Stuttg) 2015;17:558-66. [↑](#)
12. Galimberti A, De Mattia F, Bruni I, Scaccabarozzi D, Sandionigi A, Barbuto M, *et al.* A DNA barcoding approach to characterize pollen collected by honeybees. PLoS One

2014;9:e109363. ‡

- [13.](#) Puc M, Puc MI. Allergenic airborne grass pollen in Szczecin, Poland. *Ann Agric Environ Med* 2004;11:237-44. ‡
- [14.](#) Tripathi DM, Kale MK, Rajan KE. Atmospheric pollen and fungal spores at Pune city. *Indian J Allergy Asthma Immunol* 2004;18:45-50. ‡
- [15.](#) Nilakshee D, Sharma GC. Incidence of airborne pollen grains in central Guwahati with special reference to their allergenic significance. *Indian J Aerobiol* 2007;20:35-44. ‡
- [16.](#) Sharma D, Dutta BK, Singh AB. Pollen, fungal and house dust mites survey at the residence of 90 allergic patients in greater Silchar Area of Assam, Indian. *Res J Allergy* 2008;1:1-11. ‡
- [17.](#) Singh AB, Pandit T, Dahiya P. Changes in airborne pollen concentrations in Delhi, India. *Grana* 2003;42:168-77. ‡
- [18.](#) Singh K, Shivpuri DN. Studies on yet unknown allergenic pollen of Delhi state metropolitan: Botanical aspects. *Indian J Med Res* 1971;59:1392-410. ‡
- [19.](#) Singh AB, Babu CR. Pollen types in the atmosphere of Delhi. *Phytomorphology* 1980;30:180-9. ‡
- [20.](#) Malik P, Singh AB, Babu CR, Gangal SV. Atmospheric concentration of pollen grains at human height. *Grana* 1991;30:129-36. ‡
- [21.](#) Shivpuri DN, Viswanathan R, Dua KL. Studies in pollen allergy in Delhi area. Part I. Pollination calendar. *Indian J Med Res* 1960;48:15-20. ‡