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SEASONAL VARIATIONS OF AIRBORNE POLLEN IN ALLAHABAD, INDIA

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Abstract: Using a Burkard 7-day volumetric sampler a survey of airborne pollen grains in Allahabad was carried out from December 2004 – November 2005 to assess the qualitative and quantitative occurrence of pollen grains during different months of the year, and to characterize the pollen seasons of dominant pollen types in the atmosphere of Allahabad. 80 pollen types were identified out of the total pollen catch of 3,416.34 pollen grains/m^3. Bulk of the pollen originated from anemophilous trees and grasses. Thirteen pollen types recorded more than 1% of the annual total pollen catch. *Holoptelea integrifolia* formed the major component of the pollen spectrum constituting 46.21% of the total pollen catch followed by Poaceae, *Azadirachta indica*, *Ailanthus excelsa*, *Putranjiva roxburghii*, *Parthenium hysterophorus*, *Ricinus communis*, *Brassica compestris*, Amaranthaceae/Chenopodiaceae, *Madhuca longifolia*, *Syzygium cumini*, other Asteraceae and *Aegle marmelos*. Highest pollen counts were obtained in the month of March and lowest in July. The pollen types recorded marked the seasonal pattern of occurrence in the atmosphere. February – May was the principle pollen season with maximum number of pollen counts and pollen types. Chief sources of pollen during this period were arboreal taxa. September – October was the second pollen season with grasses being the main source of pollen. Airborne pollen spectrum reflected the vegetation of Allahabad, except for *Alnus* sp., which grows in the Himalayan region. A significant negative correlation was found of daily pollen counts with minimum temperature, relative humidity and rainfall.

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Key words: airborne pollen grains, meteorological parameters, pollen season, *Holoptelea integrifolia*, Allahabad (India).

INTRODUCTION

In the recent past, aerobiological studies have received much attention due to their wide application in allergology, forestry, agriculture and horticulture. Aeropalynology, a branch of aerobiology, specializes in the study of pollen content of the atmosphere including their release, stay, transportation or dispersal and deposition on various substrates which provides a valuable contribution to the basic biology (biogeography, ecology, environment) and allergology [31, 40]. Information of the pollen types and their pollen season is of special importance to clinicians and allergy patients for establishing a chronological correlation between air pollen concentration and hay fever and asthma symptoms to achieve a better management of these diseases [7]. Therefore, aeropalynological surveys have been carried out all over the world [1, 2, 5, 8, 11, 14, 18, 30, 33, 37, 38, 41].

In Allahabad, earlier aeropalynological surveys were conducted during 1973–79 [28, 29], and later during 1990-92 [34, 35, 36] using an air sampler manufactured locally as per design suggested by Lakhanpal and Nair, 1958 [21], based upon the impaction method governed by wind current. The present survey has been conducted using a Burkard 7-day volumetric sampler. The aim of the present study was to present the qualitative and the quantitative data of the airborne pollen grains of Allahabad. Monthly and seasonal variations in the pollen counts and pollen types

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are presented. Pollen seasons of dominant airborne pollen types of Allahabad have been characterized. Day-to-day variations in the pollen counts were correlated with the meteorological parameters such as maximum temperature, minimum temperature, mean temperature, relative humidity, rainfall and wind speed.

MATERIALS AND METHODS

The study was performed in the city of Allahabad (25.28ºN – Latitude/ 81.54ºE – Longitude) situated in North India at a height of 98 m above sea level. The city covers an area of 63.07 km^2 on the eastern extremity of the doab, which is formed by the confluence of two rivers *viz.* the Ganga and the Yamuna. It forms a part of the floristic sub-division of India known as the Gangetic plain. Allahabad has a sub-tropical climate.

A survey of airborne pollen was conducted for a period of one year from December 2004 – November 2005 using a Burkard 7 day volumetric sampler (Burkard Manufacturing Co. Ltd., England). The apparatus was placed on the terrace of a building about 4 meters above ground level. The sampling site is located in an open residential area of the George Town locality of Allahabad with several avenues of trees and some neglected plots. Cellophane tape coated with petroleum jelly was placed on the rotating drum of the sampler and changed after one week. The exposed tape was cut into seven 48 mm pieces, each denoting a 24 hour catch, and mounted on separate slides in safranin glycerine jelly with a coverslip (22 × 50 mm). The slides were scanned for pollen counts in 24 vertical traverses as per the method suggested by the British Aerobiological Federation, 1995 [42]. Pollen counts are expressed as the number of pollen grains/m^3 of air. Identification of pollen grains was conducted by comparing them with reference slides prepared from authentically identified ground plants and published literature [9, 15, 27, 45].

Identification of airborne pollen grains was carried out up to generic or specific level, but in certain cases up to family level *viz.* Amaranthaceae/Chenopodiaceae, Apiaceae, Asteraceae, Cyperaceae, Malvaceae and Poaceae, while some grains could be identified up to phylum level *viz.*, Monocotyledones.

Pollen season was characterized as per the criterion suggested by Jäger *et al.*, 1996 [16], which states 'Pollen season starts the first day that has a daily count higher than 1% of the annual pollen, presupposing that no more than 6 subsequent days follow with a zero count. It ends when 95% of the total annual pollen is reached.'

Statistical analysis was carried out using SPSS software version 10.0. The correlation between daily pollen counts and meteorological parameters (maximum temperature, minimum temperature, mean temperature, relative humidity, rainfall and wind speed) was calculated using Karl Pearson's correlation coefficient (r).

RESULTS AND DISCUSSION

Altogether, 80 pollen morphotypes were identified out of the annual catch of 3,416.34 pollen grains/m^3 recorded during the one year period of investigation (Tab. 1). Pollen spectrum showed dominance of 13 pollen types (>1% of the total pollen catch). The bulk of pollen originated from tree taxa (38 taxa) contributing 66.77% to the total annual catch. Dominance of arboreal taxa in the pollen spectrum has also been reported by other researchers [3, 13, 20, 22, 25, 31, 43]. Among arboreal taxa, pollen grains of *Holoptelea integrifolia* ranked first constituting 46.21% of the total catch followed by *Azadirachta indica* (2.90%), *Ailanthus excelsa* (2.76%), *Putranjiva roxburghii* (2.30%), *Madhuca longifolia* (1.65%), *Syzygium cumini* (1.36%) and *Aegle marmelos* (1.05%). After *Holoptelea integrifolia*, Poaceae was the second dominant type contributing 12.52% to the total annual pollen catch. Pollen grains originating from other herbaceous taxa were less frequent in the atmosphere (13.24%), the most abundant being *Parthenium hysterophorus* (2.27%), *Brassica compestris* (1.90%), Amaranthaceae/Chenopodiaceae (1.72%) and other Asteraceae (1.23%). Among the shrubs (4.14%), *Ricinus communis* was the only well represented taxon with 2.13% contribution. More than 13 types constituted 80% of the pollen spectrum. The remaining 67 types (16.67%) were recorded in less than 1% pollen of the total pollen catch, while 3.33% could not be identified (Tab. 1).

Monthly pollen counts showed variations during different months of the year. Highest pollen counts were registered in the month of March followed by February, April and October, while the lowest pollen count was registered in July (Fig. 1). The peak occurrence of pollen grains during March was due to *Holoptelea integrifolia* which constituted 81.81% of the pollen catch of March. *Holoptelea integrifolia* is anemophilous and is a high pollen producer (estimated 7,650 pollen grains/anther; Sahney and Chaurasia, unpublished observation). Further, the absence of leaves on the tree at the time of pollination facilitates easy dispersal of pollen grains. Similar observations were also made by Khandelwal and Vishnu-Mittre, 1973 [17]. The lowest pollen count of July, coincided with the maximum rainfall witnessed during the month, which cleaned the pollen grains from the atmosphere. Washing effect during the rainy season has also been reported by other researchers [6, 12, 26, 44].

The richness (number of pollen types) varied throughout the year with a more or less similar trend in the pollen concentration. Maximum number of pollen types was registered in March (49 types) and minimum in July (20 types, Fig. 1).

With respect to pollen counts, quantitative as well as qualitative, the period of February – May (spring – early summer) may be regarded as the principle pollen season when the maximum number of pollen grains (2,608.38/m^3) as well as pollen types (68 types) were recorded, constituting 76.35% of the annual catch (Fig. 1). Chief source

Table 1. Pollen types and their percentage contribution to the airborne pollen spectrum of Allahabad during 2004-2005.

Pollen types	Percentage contribution	Pollen types	Percentage contribution
Acacia spp.	0.30	*Lathyrus odoratus*	0.11
Aegle marmelos	**1.05**	*Leucaena glauca*	0.05
Ailanthus excelsa	**2.76**	***Madhuca longifolia***	**1.65**
Alnus spp.	0.36	Other Malvaceae	0.02
Alternanthera sessilis	0.07	*Mangifera indica*	0.01
Amaranthaceae/Chenopodiaceae	**1.72**	*Melilotus* spp.	0.01
Apiaceae	0.39	Other Monocots	1.41
Argemone mexicana	0.04	*Morus alba*	0.39
Artemisia spp.	0.54	*Murraya koenigii*	0.04
Other Asteraceae	**1.23**	*Nyctanthes arbor-tristis*	0.03
Azadirachta indica	**2.90**	*Ocimum sanctum*	0.05
Bombax ceiba	0.10	***Parthenium hysterophorus***	**2.27**
Bougainvillea spp.	0.16	*Phlox drummondii*	0.01
***Brassica* spp.**	**1.90**	*Pinus roxburghii*	0.18
Callistemon citrinus	*0.76*	*Pithecolobium dulce*	0.03
Cajanus cajan	*0.03*	**Poaceae**	**12.52**
Cannabis sativa	0.61	*Polyalthia longifolia*	0.06
Caryota urens	0.89	*Polygonum plebeium*	0.23
Cassia fistula	0.15	*Prosopis juliflora*	0.26
Cassia siamea	0.45	*Psidium guajava*	0.94
Casuarina equisetifolia	0.12	*Pterospermum acerifolium*	0.04
Celosia cristata	0.07	*Punica granatum*	0.04
Chrysanthemum spp.	0.08	***Putranjiva roxburghii***	**2.30**
Citrus spp.	0.07	*Raphanus sativus*	0.02
Convolvulus spp.	0.01	***Ricinus communis***	**2.13**
Coronopus didymus	0.22	*Rorippa dubia*	0.20
Croton bonplandianum	0.80	*Rumex dentatus*	0.29
Cyperaceae	0.99	*Stellaria media*	0.03
Delonix regia	0.16	*Strychnos nux-vomica*	0.01
Dianthus spp.	0.02	***Syzygium cumini***	**1.36**
Emblica officinalis	0.53	*Tamarindus indica*	0.03
Eucalyptus citriodora	0.32	*Tecoma stans*	0.10
Euphorbia heterophylla	0.05	*Terminalia arjuna*	0.14
Euphorbia splendens	0.07	*Thuja occidentalis*	0.88
Feronia limonia	0.09	*Tinospora cordifolia*	0.38
Gelonium multiflorum	0.04	*Toona ciliata*	0.41
Holoptelea integrifolia	**46.21**	*Typha angustata*	0.76
Iberis amara	0.23	*Xanthium strumarium*	0.47
Impatiens balsamina	0.12	*Ziziphus jujuba*	0.07
Justicia spp.	0.07	Unidentified	3.33
Lagerstroemia indica	0.12		

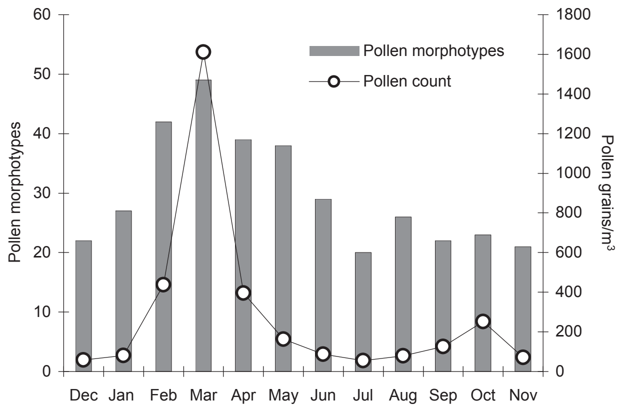

Figure 1. Monthly variations in pollen counts and pollen types in the atmosphere of Allahabad during 2004–2005.

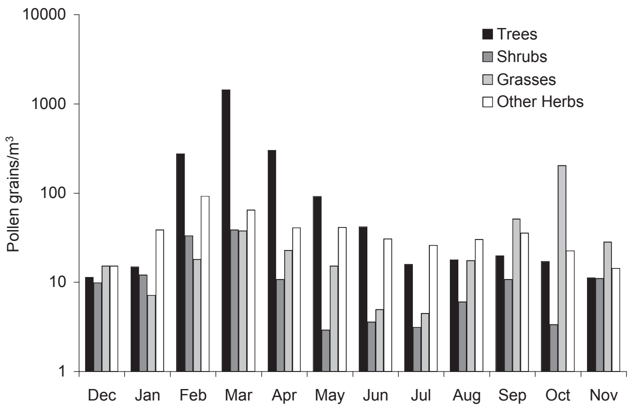

Figure 2. Differential pollen counts of trees, shrubs, grasses and other herbs during 2004–2005.

of pollen grains during this period were arboreal taxa (34 types, Fig. 2). Among them *Holoptelea integrifolia*, *Ailanthus excelsa*, *Putranjiva roxburghii*, *Azadirachta indica*, *Madhuca longifolia* and *Syzygium cumini* showed dominance. The other significant sources of atmospheric pollen during this period were grasses, followed by *Ricinus communis*, Amaranthaceae/Chenopodiaceae, *Brassica compestris* and *Parthenium hysterophorus* (> 1% of the pollen catch of February – May). Pollen grains of several other types (56 types) were also found to be present in the atmosphere during this period but in low concentration (< 1% of the pollen catch of February – May).

September – October (post-monsoon to early autumn) was the second high pollen period recording 11.08% of the annual pollen catch. During this period plants belonging to family Poaceae were the main source of pollen contributing 67.54% to the total pollen catch of September – October (Fig. 2). The rest of the pollen originated from post-monsoon weeds, apart from few trees and shrubs. Among them, pollen grains of Amaranthaceae/Chenopodiaceae, other Asteraceae, *Croton bonplandianum*, Cyperaceae, *Parthenium hysterophorus*, *Typha angustata*, *Xanthium strumarium*, *Artemisia* spp., *Callistemon citrinus*, *Cassia siamea* and *Psidium guajava* were well represented (> 1% of the pollen catch of September to October).

On the basis of the weekly pollen concentration, pollen seasons of the 9 most abundant taxa have been characterized as follows (Fig. 3):

1. *Holoptelea integrifolia*: *Holoptelea integrifolia* has a short pollen season, from the third week of February to the last week of March, with maximum pollen concentrations in the first week of March.

2. *Azadirachta indica*: *Azadirachta* pollen season started in the first week of April and terminated in mid-May. Highest concentration recorded in the third week of April.

3. *Ailanthus excelsa*: Pollen season began in mid-February, and ended towards last week of April, recording the highest concentration in the fourth week of March.

4. *Putranjiva roxburghii*: Pollen season of *Putranjiva* was from the third week of March to the last week of April, with the highest concentration recorded in the fourth week of April.

5. *Ricinus communis*: *Ricinus* recorded a long pollen season which started from the fourth week of December and ended in the first week of April, with maximum concentration in the second week of March.

6. *Brassica compestris*: Pollen season of *Brassica* was from the first week of January to the last week of March, with highest concentration in the first week of February.

7. *Madhuca longifolia*: Pollen season was from the first week of April to the second week of May, with the maximum pollen concentrations recorded in the third week of April.

8. *Syzygium cumini*: Pollen season started in the third week of April, recorded highest concentration in the first week of May, and ended by the second week of June.

9. *Aegle marmelos*: Pollen season started at the beginning of May and terminated by the end of June. The highest concentration was recorded in the first week of May.

No definite pollen season for Poaceae, Amaranthaceae/Chenopodiaceae and other Asteraceae could be demarcated as their plants exhibit consecutive flowering patterns which keep on contributing pollen grains to the atmosphere throughout the year. *Parthenium hysterophorus* too flowers all year round showing the presence of their pollen grains in the atmosphere throughout the year. Pollen grains of Poaceae recorded a major peak in the second week of October and a minor peak in the fourth week of March. Pollen grains belonging to Amaranthaceae/Chenopodiaceae recorded their highest concentration in the third week of April, and those of other Asteraceae in the second week of February, while the pollen grains of *Parthenium hysterophorus* showed their peak in the first week of May (Fig. 4).

Airborne pollen spectrum reflected the vegetation of Allahabad, except for *Alnus* which grow in the Himalayan region. The presence of *Alnus* pollen (in stray numbers) in the atmosphere of Allahabad may be considered an example of long distance transport. Pollen grains of *Alnus* have also been reported in previous surveys of Allahabad [28, 36] and from Delhi [39] and Lucknow [18].

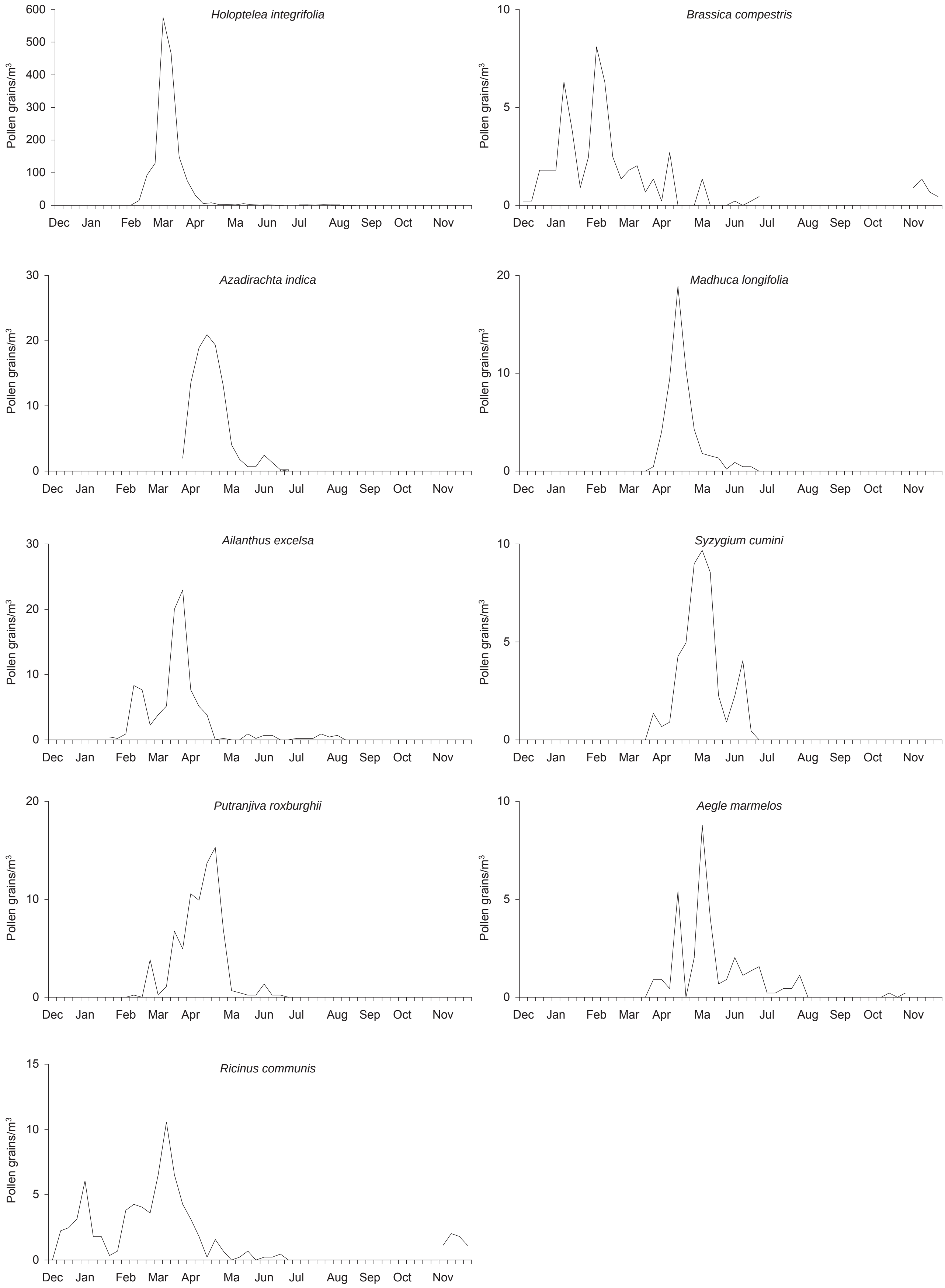

Figure 3. Weekly variations in pollen counts of dominant types in the atmosphere of Allahabad during 2004–2005.

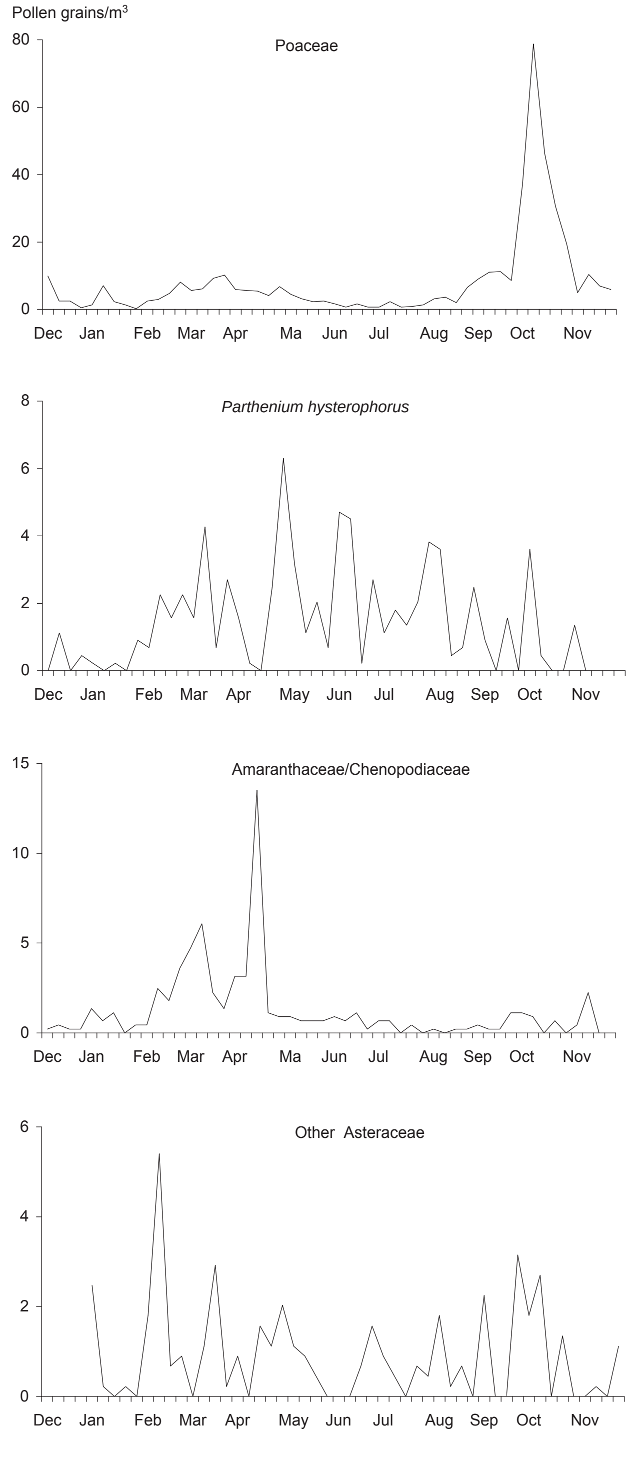

Figure 4. Weekly variations in pollen counts of dominant types in the atmosphere of Allahabad during 2004–2005.

It is well known that the bulk of airborne pollen originates from wind pollinated plants which usually have inconspicuous flowers but can produce a vast amount of pollen. The small size, smooth, dry and non-sticky nature of anemophilous pollen facilitates their easy dispersal in air. In the present survey, 68.16% of pollen catches were represented by anemophilous pollen grains (16 types), 20.01% of the pollen catches originated from amphiphilous plants (22 types) and 8.5% of pollen catches originated from entomophilous plants (42 types). Occurrence of pollen belonging to 42 entomophilous types in the air may be due to the wide variety of ornamentals (herbs and trees) growing around the sampling site. Among the 42 entomophilous types, pollen grains of *Parthenium hysterophorus* and *Syzygium cumini* were better represented in the atmosphere (> 1% of the total pollen catch) which may be due to their small size and light ornamentation which may have facilitated their suspension in air after detachment from the vector.

Table 2. Correlation between pollen counts and meteorological parameters by using Karl Pearson correlation coefficient (r).

Meteorological parameters	Daily pollen counts		
	Total pollen	*Holoptelea integrifolia*	Poaceae
Maximum Temperature	0.065	0.302*	0.036
Minimum Temperature	-0.166*	0.273*	0.073
Mean Temperature	-0.112	0.326*	0.057
Mean Relative Humidity	-0.190**	-0.067	0.108*
Rainfall	-0.124*	-0.132	-0.113*
Wind speed	-0.049	-0.058	-0.103*

Level of significance: * $p<0.05$; ** $p<0.01$

Karl Pearson coefficient of correlation calculated between total daily pollen counts and meteorological parameters *viz.* maximum temperature, minimum temperature, mean temperature, relative humidity, rainfall and wind speed, showed negative correlation of daily pollen counts with all the parameters, except with maximum temperature where it showed a positive correlation. Among these, minimum temperature, mean relative humidity and rainfall showed a significant negative influence on the daily pollen counts. Karl Pearson coefficient of correlation was also worked out to see the influence of meteorological parameters on the individual pollen counts of the 2 most dominant types in Allahabad *viz. Holoptelea integrifolia* and Poaceae. Pollen counts of *Holoptelea integrifolia* (during February-March) showed a significant positive correlation with temperature and a non significant negative correlation with relative humidity, rainfall and wind speed. Pollen counts of Poaceae showed a positive correlation with temperature and relative humidity (significant with relative humidity) and a significant negative correlation with rainfall and wind speed (Tab. 2).

Negative influence of rainfall and relative humidity on the pollen counts was also observed by other researchers [19, 4, 32, 23, 24, 10]. High environmental humidity inhibits the opening of anthers and also makes the pollen heavier, preventing the pollen grains from remaining suspended in air, while rainfall precipitates the pollen grains suspended in the air.

CONCLUSIONS

The present volumetric survey of airborne pollen has contributed to our existing knowledge of pollen grains of Allahabad. It is expected that the results of the present work will provide useful data to the allergologists of Allahabad for selecting pollen allergens during calendar months of the year which will facilitate proper diagnosis and treatment. Allergy sufferers can also use the information to plan their outdoor activities in order to avoid exposure to allergens.

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