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# Risk assessment of outdoor airborne biological allergens in India: A review

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**Abstract**
Airborne biological allergens trigger an allergic response required for the development of atopic disease. Biological allergens are released into the air by wind, rain and active discharge mechanisms. In this review article an attempt has been made to evaluate the published literature on prevalence and types of air borne allergens in India. Important pollen allergens reported from India were: *Prosopis juliflora, Morus alba, Alnus nitida, Quercus incona, Cedrus deodara, Argemone mexicana, Amaranthus spinosus, Parthenium hysterophorus, Cassia* and members of Poaceae. Similarly *Aspergillus fumigatus, Aspergillus* spp., *Alternaria alternata, Cladosporium cladosporoides, mucedo, Fusarium solanii, Curvularia lunata, Neurospora sitophila* fungal allergens were reported as clinically important allergens. The incidence of allergy from pollens and fungal allergens had been reported from Northern region of India as compared to other regions.

**Keywords:** Pollen, Fungal spores, Allergens, Allergenicity, and India.

## 1. Introduction
Allergens can be found in a variety of sources, such as pollen, pet dander, dust and mite excretion [1]. In technical terms, an allergen is an antigen capable of stimulating a type-I hypersensitivity reaction in atopic individuals through Immunoglobulin E (IgE) responses [2]. The aerodynamic characteristics of these particles play an important role in the degree and manner of exposure. Smaller particles remain airborne for longer periods, increasing exposure levels. Larger particles will settle more quickly, except in high winds. Particle size also determines the manner in which allergen exposure occurs. Particles that are larger than about 5 µm in diameter are deposited largely in the nose and are unlikely to penetrate to the lung. Despite the fact that most mold and pollen spores are 20-60 µm in diameter and affect eyes and nasal mucosa [3]. The present paper reviews the type and compositions of outdoor biological allergens from different regions. It also includes clinically important pollen and fungal allergens.

## 2. Monitoring Airborne Outdoor Biological Allergens
Diurnal, seasonal and annual fluctuations in airborne pollen and fungal spores in any geographical area are essential for effective diagnosis and treatment of allergy. Aerobiological sampling is being carried out to achieve this aim through various sampling devices. Collection of material and Sample analysis are two different phases of the recognition of aeroallergens [4]. Different methods employed to achieve the objectives generally exploit the following basic regimes of collection:
1. Fall out on a fixed surface through gravitational force
2. Impaction on a rapidly moving surface
3. Impaction through suction of air
4. Filtration
5. Immunochemical assays

**For analysis of data following procedures are followed:**
1. Microscopic enumeration of individual particles.
2. Immunochemical assays for bulk reservoirs.

## 3. Sampling devices
Monitoring of airborne biological particles has carried out by various gravimetric, impaction,

and suction sampling devices [5-6]. In addition new immunochemical techniques were also being used for detecting allergenic pollen and measuring the size of allergen-carrying particles [7].

## 4. Outdoor Allergens

Outdoor allergens are an important part of the biological allergens that lead to allergic diseases. The most widely recognized and abundant sources for these outdoor allergens are pollen grains and fungal spores [3]. Understanding the role of outdoor allergens requires knowledge of the nature of outdoor allergen-bearing particles, source of distributions of and the nature of the aerosols (particle types, sizes, and dynamics of concentrations). Primary sources for outdoor allergens include vascular plants (pollen, fern spores, soy dust) and fungi (spores, hyphae). Some Non vascular plants, algae, and arthropods also contribute small numbers of allergen-bearing particles. Particles are released from sources into the air by wind, rain and mechanical disturbance mechanisms.

Weather conditions greatly influence the concentrations of outdoor allergens. Particle concentration increases with increasing wind speed, but in gusty winds these particles may be swept into the upper atmosphere and reduce the chances to reach the ground.

In the cool and calm evening hours, these particles may resettle toward the ground and increase the exposure. The brisk rainfall caused by thunderstorms does not reduce the airborne pollen and spore levels, while long periods of rainfall can lead to reduce the level of these allergens in the environment [8].

## 5. Composition of outdoor biological allergens:

### 5.1 Pollen

Pollen grains are the male gametophyte in the sexual reproduction of flowering plants (angiosperms) and conifers (gymnosperms) and released from mature anthers during specific months of a year. Pollen grains are usually more or less spherical, at least when hydrated, with a rigid cell wall formed of a complex polysaccharide based substance called sporopollenin. Pollen grains are identified using light microscopy by the shape and size of the grain, and its wall structure. Many pollen grains have apertures or pores that help in identification. Study of pollen allergens has shown that they are typically low-molecular-weight proteins or glycoproteins (5-60 kDa) and released quickly upon contact with aqueous solutions [9].

Based on clinico-immunological studies with pollen antigens, important allergenic pollen of India have been identified as *Prosopis juliflora, Ageratum, Ailanthus, Amaranthus, Anogeissus pendula, Artemisia, Cassia siamea, Cenchrus ciliaris, Chenopodium, Cynodon dactylon, Ipomoea fistulosa, Paspalum distichum, Poa annua, Cedrus deodara. Ricinus communis, Morus alba, Alnus, Quercus, Argemone Mexicana* and *Holoptelea* [10-11-12]. The Centre for Biochemical Technology (Council for Scientific and Industrial Research) has published a book on pollen calendars of 12 different states in India, which provides important pollen season for grass, weeds and trees prevalent in India. Pollen calendars are very useful for clinicians as well as allergic patients to establish chronological correlation between the concentration of pollen in air and seasonal allergic symptoms [13].

In India, first systematic atmospheric survey was initiated at Calcutta. More than a century ago since then researchers, all over India have conducted many studies on airborne pollen types and their concentration [14]. After a prolonged gap, Kasliwal and his colleagues precede such studies in Jaipur [15]. However, Shivpuri and his students did extensive studies on outdoor pollens in Delhi [16].

## 6. Outdoor Airborne Biological Allergens in four Different regions of India:

### 6.1 Northern India

It includes the state of Jammu and Kashmir, Himachal Pradesh, Haryana, Punjab, Rajasthan, Delhi and Union Territory of Chandigarh. A total 94 type of pollens were identified during the seven years of pollen survey in Delhi and the major contributors of pollens to the Delhi atmosphere were found to be *Morus*, *Cannabis*, Poaceae, *Amaranth*, *Prosopis*, *Artemisia*, *Eucalyptus*, *Ricinus*, *Parthenium* and *Xanthium* [17].

A total of 43 types of pollen have been recorded from Northern India. The dominant types were: *Holoptelea*, Poaceae, Asteraceae, *Eucalyptus*, *Casuarina*, *Putranjiva*, *Cassia*, *Quercus*, *Pinus* and *Cedrus* [18]. A survey of airborne pollen and fungal spores was carried at Dehradun for two consecutive years (1980-81) by using a gravity settling device in two distinct peak pollen periods, February-April and August-October [19].

During atmospheric survey of pollen concentration in Rohtak (Haryana) from (July 2007–June 2009) at a fixed height (1.8m) and a total of 31 pollen types were identified. The major contributor to the pollen load was *Cannabis sativa* (28.9%) followed by Poaceae (20.65%), Chenopodiaceae, Amaranthaceae (10.56%), *Parthenium hysterophorus* (6.80%), *Morus alba* (6.15%), *Artemisia* sp. (4.03%), *Cyperus* sp.(3.20%) and *Eucalyptus* sp. (3.07%) and two major pollen seasons were recognized i.e July– October and March–April [20].

An aerobiological survey was conducted in Punjab from (2012- 2014) and during the study period, 30 different kinds of pollens were recorded belonging to 17 families. A total of 13 different kinds of pollens were characterized for their allergenic properties. The pollens with allergenic properties belong to 10 families, viz. Meliaceae, Xanthorrhoeaceae, Amaranthaceae, Brassicaceae, Cannabinaceae, Chenopodiaceae, Myrtaceae, Moraceae, Poaceae and Asteraceae. The most prevalent type of pollens observed during the present study belongs to the family Asteraceae, Moraceae and Myrtaceae [13]. Aerobiological sampling was done using Burkard 24 h spore trap system at, Jaipur during 2011 and 2012 and concluded that Pollen count showed two seasonal peaks during March–April and from August to October [21].

### 6.2 Western India

It includes the state of Gujarat, Maharashtra and Goa. Aerobiological surveys carried out at Mumbai, Pune and Kolhapur revealed *Cicer, Ricinus communis, Holoptelea, Amaranth, Argemone, Cocos nucifera* and *Hibiscus* as the dominant pollen types [22]. Aerobiological survey at Pune revealed *Parthenium* to be the highest contributor to the pollen load with two peak seasons *i.e*. from September to November and January to April while *Cocos* and *Cassia* were observed throughout the year. Pollens of *Cocos* were recorded in high concentration in April - May and November – December [23].

At Aurangabad, *Datura alba* was prevalent in air from August to October with 8.2% annual concentration. *Cleome* contributed 6.8% pollen in June to August and other

important contributors were *Alternanthera, Typha, Bougainvellia* etc. In Gujarat most predominant allergens causing nasobranchial allergy was *Cassia Siamea* (29.17%) followed by *Morus Alba* (25%) and *Ricinus Communis* (25%) [24].

### 6.3 South India

It comprises the state of Andhra Pradesh, Karnataka, Kerala, Tamilnadu and the union territory of Puducherry. The studies were conducted from Southern India revealed that *Casuarina, Parthenium, Spathodia, Cheno/Amaranth, Cocos, Eucalyptus,* Poaceae, *Peltophorum* and Cyperacea as dominant pollen types [18-23].

Aerobiological survey carried out at Visakhapatnam, Bangalore, Trivandrum, Kodaikanal and Chennai revealed that *Casurina, Parthenium, Spathodia, Cheno/Amaranth, Cocos* and *Ecualyptus* sp. were dominant pollen types. However, at Visakhapatnam, 24 pollen types were recorded and Poaceae, *Peltophorum, Cocos, Casurina*, Cyperacea, *Eucalyptus* sp. were dominant types [25-26-27-28].

A qualitative and quantitative analyses of airborne fungal spores and pollen grains in four working environments (market, saw mill, poultry and cow sheds) in Thiruvananthapuram, the capital city of Kerala, (India) were carried out for 2 years and a total of 32 pollen types from outdoor were captured Poaceae, *Cocos, Artocarpus, Chenopodium* and *Tridax* were the common and dominant pollen types observed in all the sites [29]. From Bangalore city during one year period from January 2011 to December 2011 a total of 28 pollen types were identified, among which 7 were present throughout the year. These belonged to Poaceae, *Tridax* sp., *Eucalyptus* sp., *Parthenium hysterophorus, Cocus nucifera, Croton sparsiflorus* and *Mimosa pudica*. The most predominant pollen was *Parthenium hysterophorus* (23.87%) followed by Poaceae (16.19%), *Mimosa Pudica* (11.31%), *Delonix regia* (8.77%) and *Eucalyptus* spp. (7.58%) [30].

### 6.4 Eastern India

It includes the states of Bihar, West Bengal, Odisha, Jharkhand, Andaman and Nicobar Islands. An aerobiological survey in West Bengal revealed a total of 59 pollen types in air and dominant types were *Trema orientalis, Pongamia, Areca catechu, Xanthium, Cocos,* Asteracea and Chenopodiaceae. Studies carried out at Gauhati revealed *Amaranth, Putranjiva, Mangifera, Eucalyptus* spp., Poaceae, Asteraceae were the dominant types of pollen [18-23]. From the Eastern Himalayas dominant tree pollen types recorded were *Acer, Alnus nepalensis, Betula, Bucklandia populnea, Eucalyptus* and *Pinus* [31-32].

An aeropalynological survey of the atmosphere of Calcutta was carried out from 2004 to 2006. The dominant pollen types were *Trema* (19%), *Poaceae* (12.98%), *Cacuarina* (5.76%), *Cocos* (5.7%), *Azadirachta* (4.65%), *Peltophorum* (3.71%), Cyperaceae (3.68%), *Delonix* (3.18%) and *Areca* (2.56%) [33].

### 6.5 Central India

Survey carried out from Central India, reported Poaceae, Asteraceae, Apocynaceae, *Rosa, Ricinus, Ailanthus, Holoptelea, Amaranth, Cyperus, Cicer, Argemone, Cocos nucifera* and *Hibiscus* as dominant pollen types [18-23-34]. A survey of pollen flora in atmosphere of Korba, Chhatishgarh from March 2007 to February 2008 reported a total of 40 indigenous and exotic pollen types. The dominating pollen flora included *Cynodon dactylon* (9.42%) and *Ocimum sanctum* (7.13%) and exotic plant species *Parthenium hysterophorus* (8.43%) and *Cassia siamea* (4.98%) contributed maximum percentage of total pollen catch [35]. From Agra city an aerobiological survey was conducted with special reference to allergic significance of pollens and a total of 35 species of pollens belonging to 23 angiosperm families have been identified. The most prevalent pollens in air belonged to Asteraceae (5222/$m^3$) and *Parthenium hysterophorus* contributed to maximum (17.91%) of the total air spora [36].

## 7. Types of Prevalent Pollens in India

### 7.1 Tree pollens

Tree pollens are important outdoor biological allergens and contribute main part in the total allergens of a particular atmosphere. Trees such as *Prosopis juliflor, Celtis occidentails* and *Morus alba* were found as an important source of pollen allergens [37]. Pollens of *Holoptelea intgerifolia* found to cause allergy in human beings and widely distributed in Northern and Eastern India.

Pollens of *Casuarina equisetifolia* (wind breaker) were reported in large amount from the atmosphere of Bangalore. *Holoptelea intgerifolia* contribute 70% of total pollen load in the atmosphere of Bangalore [38]. Important tree pollens of different parts of country already described by Singh and Kumar [18] are reproduced in Table1.

**Table 1:** Common allergenic tress of different seasons in India.

| Seasons | | |
|---|---|---|
| **Spring (Feb- April)** | **Autumn (Sept- Oct)** | **Winter(Nov- Jan)** |
| *Ailanthus excelsa* | *Anogeissus pendula* | *Cassia siamea* |
| *Holoptelea integrifolia* | *Eucalyptus sp.* | *Cedrus deodara* |
| *Casuarina equisitifolia* | *Cedrus deodara* | *Mallotus phillipensis* |
| *Prosopis juliflora* | *Cocus nucifera* | *Salvadora persica* |
| *Mallotus phillipensis* | *Prosopis juliflora* | *Quercus incana* |
| *Putranjiva roxburghii* | *Mallotus phillipensis* | |
| *Bauhinia variegate* | *Phoenix sylvestris* | |
| *Quercus incana* | *Quercus incana* | |

### 7.2 Grass Pollens

There is a significant allergenic overlap among the proteins of these regional species, and skin test reactivity will often overlap. Because of this cross allergenicity, differences in exposure to specific temperate grass species are not clinically significant as they are for tree or weed pollens. In India, grass pollens were reported at highest percentage from Aurangabad (80.64%), followed by Bhavnagar (70.26%) and Raipur (66.73%) [39]. Grass pollens were the major contributors (39%) to the total pollen load in the air of Eastern Zone of India [40]. In Lucknow, Poaceae (grass) pollens (11.8%) were recorded with maximum concentration followed by Asteraceae pollens in the month of April to June. At Solan (Himachal Pradesh) 22 types of pollen were reported and

pollens of family Poaceae and Asteraceae were recorded in high concentration. Peak pollen season of Asteraceae was recorded from March to October with maximum concentration in April, while Poaceae pollen was recorded in high concentration in September [23]. Important grass pollens of different parts of country already described by Singh and Kumar [18] are reproduced in Table 2.

**Table 2:** Common allergenic grasses of different seasons in India.

| | Seasons | |
|---|---|---|
| **Spring (Feb- April)** | **Autumn (Sept- Oct)** | **Winter (Nov- Jan)** |
| *Cynodon dactylon* | *Bothriochloa pertusa* | *Cynodon dactylon* |
| *Dicanthium annulatum* | *Cenchrus ciliaris* | *Eragrostis tenella* |
| *Imperata cylindrical* | *Hetropogon contortus* | *Poa annua* |
| *Polypogon Monspeliensis* | *Pennisetum typhoides* | *Phalaris minor* |
| *Paspalum distichum* | *Sorghum vulgare* | |
| *Poa annua* | | |

### 7.3 Weed Pollen

A was survey carried out in Punjab found *Parthenium hysterophorus* as the most dominant allergenic weed and contributes (41.82%) to total pollen load [12]. Atmospheric survey in Bangalore from January 2011 to December 2011 also revealed that *Parthenium hysterophorus* to be dominant allergenic plant with (23.87%) in total pollen load [31]. Aerobiological survey in Gujrat reported that *Ricinus Communis* contribute (25%) of total pollen load [24]. Important weed pollens of different parts of country already described by Singh and Kumar [18] are reproduced in Table1.

**Table 3:** Common allergenic weeds of different seasons in India.

| | Seasons | |
|---|---|---|
| **Spring (Feb- April)** | **Autumn (Sept- Oct)** | **Winter(Nov- Jan)** |
| *Cannabis sativa* | *Amaranthus spinosus* | *Ageratum Conyzoides* |
| *Chenopodium murale* | *Artemisia scoparia* | *Argemone Mexicana* |
| *Parthenium spp.* | *Cassia occidentalis* | *Chenopodium Album* |
| *Suaeda fruiticosa* | *Ricinus communis* | *Asphodelous Tenuifolius* |
| *Plantago major* | *Xanthium Strumarium* | *Ricinus communis* |

## 8. Clinically Important pollen allergens

Pollen antigens from important allergenic plants of India have been identified on the bases of clinico-immunological evaluation. From Northern India, important allergens were identified as: *Prosopis juliflora*, *Ricinus communis*, *Morus*, *Mallotus*, *Alnus*, *Quercus*, *Cedrus*, *Argemone*, *Amaranthus*, *Chenopodium*, *Holoptelea* [24]. The work on pollen allergy was initiated in the 1950's by Shivpuri in Delhi. Subsequently, Kasliwal and his colleagues reported important pollen allergens from Jaipur [10]. common allergens found in aerospora of Delhi were listed as *Ageratum, Ailanthus, Amaranthus, Anogeissus pendula, Artemisia, Cassia siamea, Cenchrus, Chenopodium, Cynodon, Ipomoea fistulosa, Paspalum distichum* and *Poa annua* [41]. *Cedrus deodara* (Pinaceae) pollen has been recognized as a new allergen from India in the patients from the Himalayan region [42].

From Eastern India, *Lantana, Cucurbita maxima, Cassia fistula, Cocos nucifera* and *Calophyllum inophyllum* were found to be significant allergic pollens. Studies based on clinical and immunologic parameters reported *Phoenix, Ricinus communis* and *Aegle marmelos* as causative agents of allergy [23].

From South India, *Cassia, Ageratum, Salvadora, Ricinus, Albizia lebbeck* and *Artemisia scoparia* have been reported as important aeroallergens [43-44]. High skin reactivity to *Casuarina equisetifolia* was also reported in patients from Bangalore [38]. Allergenicity to *Parthenium hysterophorus* pollen extracts was reported in 34% of allergic rhinitis and 12% bronchial asthma patients from Bangalore [45].

In Delhi, 12.6% of the atopic population was found positive *to Amaranthus spinosus*, 8.5% to *Populus deltoides* and 7.5% to *Dodonea viscosa*, *Bauhinia vareigata*. Skin sensitivity was highest against *Rumex acetosa* and *Ailanthus excelsa* (17.6%), followed by *Trewia nudiflora* (9.7%), *Argemone mexicana* (9.5 %), and *Cedrus deodara* (9.3%) at Chandigarh. A total of 28.8% of the patients were sensitive against *Solanum sysimbrifolium*, 21.1% to *Crotalaria juncea* and 18.2% to *Ricinus communis* and *Ipomea fistulosa* in Calcutta. In Trivandrum, maximum skin reactivity was recorded against *Mallotus phillipensis* (12.1%), followed by *Prosopis juliflora* (6.3%) [46]. Based on such evaluation from different parts of India a list of clinically important allergens of which is already described by Singh and Kumar [18] are reproduced in Table 4.

**Table 4:** Clinically important pollen allergens of different regions in India.

| S.No. | Name of Allergen | Habitat | North | South | East | West |
|---|---|---|---|---|---|---|
| 1 | *Ailanthus* | T | + | - | - | + |
| 2 | *Alnus* | T | + | - | + | - |
| 3 | *Argemone* | W | + | - | - | - |
| 4 | *Artemisia* | W | + | + | + | + |
| 5 | *Azadirachta* | T | + | - | - | - |
| 6 | *Borassus* | T | - | - | - | + |
| 7 | *Brassica* | W | + | - | + | + |
| 8 | *Cassia* | T | + | + | - | - |
| 9 | *Casuarina* | T | - | - | + | - |

| | | | | | | |
|---|---|---|---|---|---|---|
| 10 | *Cedrus* | T | + | - | + | - |
| 11 | *Cheno-Amranth* | W | + | + | - | - |
| 12 | *Cocos* | T | - | + | + | - |
| 13 | *Cynodon* | G | + | + | + | + |
| 14 | *Dodonaea* | W | + | - | - | - |
| 15 | *Holoptelea* | T | + | - | - | + |
| 16 | *Malotus* | T | + | - | - | + |
| 17 | *Morus* | T | + | - | - | + |
| 18 | *Parthenium* | W | - | - | + | - |
| 19 | *Pennisetum* | G | + | - | + | - |
| 20 | *Phoenix* | T | - | + | + | + |
| 21 | *Prosopis* | T | + | - | - | - |
| 22 | *Salvadora* | T | + | - | - | - |
| 23 | *Sorghum* | G | + | - | - | - |
| 24 | *Syzygium* | T | - | + | - | - |
| 25 | *Xanthium* | W | + | - | - | + |

G = Grasses, T = Tree, W = Weed

**9. Fungi**

Fungi belonging to Zygomycota have multinucleated mycelium with no barriers, and posses the ability to multiply vegetatively or by spores. There are more than 80,000 species of fungi, which have elaborate mechanisms for spore dispersal and dissemination. The spore size facilitates their suspension in the atmosphere for a long time and when inhaled by the susceptible population, sensitization may occur. In outdoor environment the source of fungal spores include cereal crops, decaying vegetables and organic wastes on which fungi grow. Fungi are potent biological allergens and atmospheric surveys have reported that seasonal variations in fungal concentrations could be the prime cause of clinical allergy and asthma [47]. The knowledge of season and concentration of various fungi is one of the essential factors for effective diagnosis and management of allergic diseases [48]. Symptoms of allergy and asthma including fatal asthma episodes have also been suspected due to allergic sensitization to fungi [49-50].

Many of the allergenic proteins produced by these fungi have been characterized at molecular level, such as Alt a 1 (*Alternaria altemata*) [51] Cla h 8 (*Cladosporium herbarium*) [52] and Asp f 1 (*Aspergillus fumigates*) [53]. Shivpuri and his students initiated the survey on fungal allergens in Delhi and the work was further extended by Agarwal, Singh and their students [54-55].

Airobiological survey in North India were reported *Aspergilli-Penicilli, Cladosporium, Helminthsporium, Epicoccum* and *Drechslera* as important fungal allergens. As a result of two year of aerobiological survey from five different locations in Delhi, a total of 98 fungal types were reported. *Cladosporium* contributed maximum (25-40%) to the total air borne fungal load followed by *Ustilago* (24%), *A. flavus* (10-13%), *Alternaria* (11%) and *A. niger* (8%) [56].

A survey of airborne fungal spores was carried out using a gravity settling device at Dehradun for two consecutive years (1980-81) and most prevalent types were *Cladosporium, Alternaria,* smut spores, *Curvularia, Ascospores, Nigrospora,* and *Aspergilli* while *Epicoccum* was found dominating [19]. *Nigrospora* has been reported as dominant fungs from Madras (Chennai) [57].

A study conducted from Western India reported that *Deuteromycetes* contribute 70% to the total fungal aerospora in Aurangabad [58]. Airobiological survey reported 18 fungal types and 22 fungal types from Aurangabad and Pune, respectively. *Cladosporium, Aspergilli-Penicilli, Curvularia, Rhizopus* and *Helminthosporium* were the common fungal types [23].

**10. Clinically Important Fungal Allergens of Different Regions of India**

From Bangalore, *Mucor mucedo, Fusarium solani, Curvularia* and *Nigrospora* were reported to be allergenically significant. *Aspergillus flavus Heminthosporium, Neurospora, Candida albicans and Cladosporium* has been reported to be important allergenic fungi in Andhra Pradesh [44]. Important fungal allergens causing sensitization in patients of nasobronchial allergy of hilly regions of India have been identified [19] and reproduced in Table no. 5. *Ganoderma lucidum*, a new fungal type has been reported to induce sensitization in hypersensitive patients in Delhi [59]. A total of 17 fungal antigens were skin tested on patients with respiratory allergy in Agra. *Rizopus nigricans* showed maximum (20-95%) allergenicity followed by *Fusarium* solani (14.80%) [60].

**Table 5:** Clinically important fungal allergens of different regions of India

| S.No. | Name of allergen | North | South | East | West |
|---|---|---|---|---|---|
| 1 | *Alternaria* | + | - | + | + |
| 2 | *Ascospores* | - | + | - | - |
| 3 | *Aspergilli* | + | + | - | + |
| 4 | *Candida* | + | + | + | + |
| 5 | *Cladosporium* | + | + | + | + |
| 6 | *Curvularia* | + | + | + | + |
| 7 | *Helminthosporium* | + | + | - | + |
| 8 | *Mucor* | + | + | - | + |
| 9 | *Nigrospora* | + | - | - | + |
| 10 | *Phoma* | + | - | + | - |
| 11 | *Smuts* | + | + | - | + |
| 12 | *Uredospores* | - | + | - | - |

**Conclusion**

The present work is a pioneer attempt to review the prevalence and allergenicity of pollen and fungal spore types found in the different regions of India. Pollens such as *Morus alba,* Poaceae, *Chenopodium*/*Amaranthus, Eucalyptus, Ricinus, Parthinium, Holoptelea, Cicer*, *Acassia* and *Cocos* are major contributor to the pollen load. Among these the potential source of allergy are *Parthenium* spp., *Ricinus communis*, *Morus alba* and *Amaranthus.* Various fungal species i.e. *Aspergilllus* spp., *Alternaria*, *Nigrospora*, *cladopsorium* and *Epicoccum* found as clinically important fungal allergens in the aerospora of different regions of India. In conclusion, there seems to be geographical differences in the prevalence of pollen and fungal allergens. Since, there remains a need to explore fascinating association between prevalence and level of allergenicity in different regions.

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