RESEARCH PAPER:

Airborne biological materials: Their identification, origin and impact on environment

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SUMMARY

Identification, origin and impact on environment of airborne fungal spores, pollen grains and other biological materials of Tiruchirappalli, Tamilnadu was studied for a period of one year from January to December 2009 at 10 m height from the ground level using vertical cylinders as trap. *Alternaria padwickii, Aspergillus niger, Cladosporium herbarum, Curvularia lunata, Helminthosporium oryzae* and *Nigrospora oryzae* were major concentrated fungal spores. *Azadirachta indica, Casuarina equisetifolia, Cocos nucifera, Eucalyptus globules,* Grass spp. including *Oryza sativa, Parthenium hysterophorus, Typha anquastata* were the major contributors of pollen types. The other biological materials included, epidermal cells, epidermal hairs, protozoan cyst, mites and thrips. The major concentration of fungal spores, pollen and mites will lead to allergy and trigger attacks of asthma.

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Key words : Allergy, Asthma, Biological materials, Fungal spores, Pollen grains

Study of airborne biological materials is known as aerobiology (Meier *et al.,* 1933). This field is related to the study of fungal spores, pollen grains, bacteria and other biological materials present in the air. The scope of it is now well known to carry a heterogenous population of an array of bio-particles (Singh *et al*., 2005). These bio-particles vary in origin, size and structural complexity and were called to constitute airspora (Studenkin and Sokolova, 1977; Nilsson, 1992).

Several aerobiological studies were conducted by many workers (Gregory, 1973, 1983; Norman and Lichtenstein, 1986; Rao *et al.*, 1995; Singh, 1998; Dales *et al.,* 2000; Potdar *et al.,* 2000; Anderson *et al.*, 2001; Sears *et al.,* 2006; Amato *et al.*, 2007; Emberlin, 2008). The purpose of this report is to provide a comprehensive picture of airspora for the clinical aspects because the inhalation of spores of different species results in different health effects from allergy to Aspergillosis (Tobin *et al.*, 1987; Miller, 1990).

MATERIALS AND METHODS

Vertical cylinders of 0.5 cm diameter (Fig. 1) were used as trap (Ramalingam, 1968). A cellophane strip is stuck on the cylinder and coated with glycerine jelly. Exposed it daily round the clock for a period of one year at 10 m height at three different places in Tiruchirappalli to know the atmospheric concentration of fungal spores, pollen grains and other biological materials and their average was expressed in number (cm^3). The exposed cellophane strips (2x2 cm) on the cylinders were prepared for microscopy (Ramalingam, 1968). An area of 0.15 cm^2 was scanned from each exposure for the biological material counts. The fungal spore types were identified and confirmed with the literature of eminent biologists (Ellis, 1971; Subramanian, 1971; Ainsworth *et al.,* 1973; Gregory, 1973; Gilman, 1975; Tilak, 1982). The pollen types were identified and confirmed with the help of literature of some other biologists (Erdman, 1969; Tilak, 1982; Nair *et al.,* 1986). The identification was confirmed with the help of reference slides of pollen collected directory from the plants. The pollen grains were mounted in safranin stained glycerine jelly.

RESULTS AND DISCUSSION

Table 1, 2 and 3 illustrate the list of atmospheric concentration of fungal spores, pollen grains and other biological materials respectively. Altogether 24 fungal spores, 15 pollen types and other biological materials like

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Table 1. Incidence of airborne fungal spores during January 2009 – December 2009

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Total	Percentage
Alternaria longipes	320	125	110	180	112	120	80	82	102	78	60	65	1165	2.179
Alternaria padwickii	180	290	210	220	250	110	120	160	202	220	110	320	3052	5.711
Ascospores	120	80	112	16	20	25	12	10	25	112	120	160	934	1.751
Aspergillus niger	1120	820	780	620	642	520	126	180	520	924	1080	1020	9052	16.941
Camptomeris albizziae	12	20	21	10	0	0	1	25	18	30	12	18	217	0.513
Cercospora personata	125	180	212	120	85	12	20	21	30	22	25	10	928	1.740
Chaetomium globosum	110	12	20	0	0	0	0	18	52	132	116	18	111	1.395
Cladosporium herbarum	1520	1880	2110	815	812	642	685	920	1682	1120	1820	1180	15318	28.835
Curvularia lunata	520	182	365	120	110	510	112	580	612	120	165	510	6328	11.866
Drechslera veicola	12	61	25	32	12	18	22	12	10	21	62	15	156	0.855
Nasmium oxysporum	82	52	80	12	32	60	20	11	31	61	60	52	632	1.185
Heplosporella sp.	185	210	82	110	15	12	110	120	82	90	120	12	1310	2.569
Helminthosporium oryzae	120	360	280	110	120	210	182	152	126	210	316	182	3088	5.790
Helminthosporium carbonum	25	12	28	10	28	62	10	22	11	28	32	36	398	0.746
Myrosphaerella musicola	32	61	22	22	10	0	0	18	26	12	32	26	291	0.545
Nigrospora oryzae	112	310	282	210	180	162	182	110	210	282	320	182	2392	5.650
Periconia circinata	212	121	218	120	121	160	210	182	116	128	170	210	2001	3.752
Pleurospora herbarum	12	21	25	8	12	6	1	10	6	20	11	8	150	0.281
Pringslemia sp.	132	12	10	23	18	10	21	25	11	11	18	121	122	0.751
Pseudocercella sp.	16	29	12	20	31	32	18	18	12	35	11	12	103	0.755
Sphaeropsis tumefaciense	32	60	21	18	11	15	30	32	26	21	20	26	312	0.598
Sporonella megalospora	12	18	13	12	10	8	2	1	0	0	25	20	125	0.234
Tetrapola sp.	11	12	16	20	20	12	10	18	12	10	10	10	150	0.367
Trichocoma padwickii	125	310	312	282	321	120	125	112	102	65	82	61	2355	4.771
Total	6311	5612	7392	3591	3116	3218	2810	3351	1351	5059	5526	5261	53333	100.000

Table 2: Incidence of airborne pollen grains during January 2009 - December 2009

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Percentage
Ailanthus excelsa	160	112	52	10	0	0	0	0	0	0	0	12	196	1.315
Amaranthus spinosus	63	88	12	24	0	0	36	18	102	86	80	66	695	2.303
Arachis indica	10	86	812	1226	160	120	20	0	0	0	0	0	282	9.351
Casuarina equisifolia	831	520	82	0	0	0	0	0	0	80	152	120	2185	1213
Cocos nucifera	125	380	310	580	210	210	120	530	310	180	110	280	1095	13.511
Eucalyptus globulus	82	116	252	110	12	0	0	0	20	16	82	112	900	2.985
Mangifera indica	385	112	210	82	31	0	0	0	0	0	51	16	1251	1.155
Poa sativa	1560	1120	820	611	280	160	180	325	130	112	380	210	1692	25.198
Parthenium hysterophorus	116	586	320	282	252	110	239	520	116	336	121	636	5185	11.185
Pithecolobium dulce	62	30	20	0	0	0	0	0	0	26	38	18	221	6.112
Prosopis juliflora	81	80	11	18	30	32	10	12	0	0	61	81	509	1.681
Ricinus communis	126	81	66	10	11	20	0	0	0	10	180	120	720	2.385
Tamarindus indicus	110	120	0	0	0	10	82	0	0	0	80	110	512	1.895
Terminalia catappa	0	0	12	12	38	0	0	0	0	23	30	26	231	0.765
Typha angustata	516	625	180	310	180	0	0	0	0	0	285	210	2611	8.613
Total	5328	4520	3582	3138	1600	992	1008	1165	1338	1289	2012	3191	30170	100.000

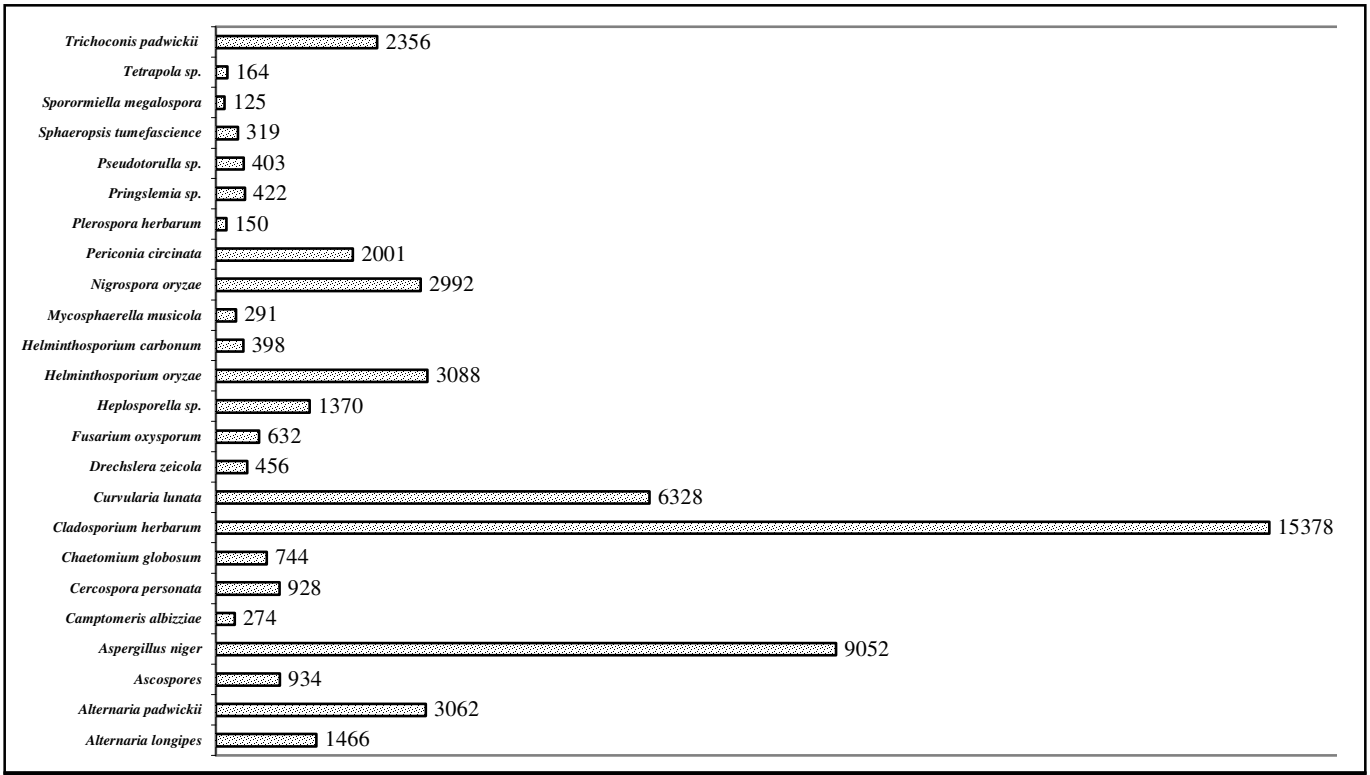
Table 3: Incidence of airborne fungal spores and cysts during January 2009 - December 2009

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Percentage
Hyphomycetes (mucoid)	82	112	121	120	112	120	210	190	91	81	36	20	1391	18.00
Hyphomycetes (dry)	25	31	30	25	12	35	18	10	20	18	22	25	358	1.91
Stigma (mucoid)	12	10	11	21	20	21	20	15	10	12	12	11	185	2.50
Hyphomycetes	16	10	26	12	10	80	12	21	26	20	21	20	151	6.71
Uredinomycetes	20	11	21	25	12	60	21	18	22	11	20	15	300	1.05
Hyphomycetes (sickle)	15	12	15	21	21	28	30	15	20	18	20	20	211	3.29
Basidiospores (mucoid)	12	12	80	15	82	115	180	12	110	80	90	12	1112	15.01
Basidiospores (dry)	112	82	182	15	210	182	110	110	82	110	80	92	1288	20.09
Protozoan cysts	28	12	35	38	12	80	12	15	32	15	18	22	112	5.91
Dermatyasms sp.	32	20	15	12	80	62	12	35	20	12	35	20	308	6.85
Chyphaqua sp.	12	10	8	15	21	12	6	8	12	8	10	6	129	1.11
Pyemotes sp.	22	35	10	52	50	11	18	12	20	18	15	10	318	1.29
Tetranychus sp.	8	12	11	10	8	15	12	12	11	12	8	8	131	1.81
Thrips sp.	11	18	12	8	11	12	6	8	10	12	6	5	105	1.12
Tyroglyphus sp.	28	12	18	31	28	30	15	12	20	18	26	12	284	3.83
Total	190	555	610	621	895	872	805	681	512	512	121	363	7108	100.00

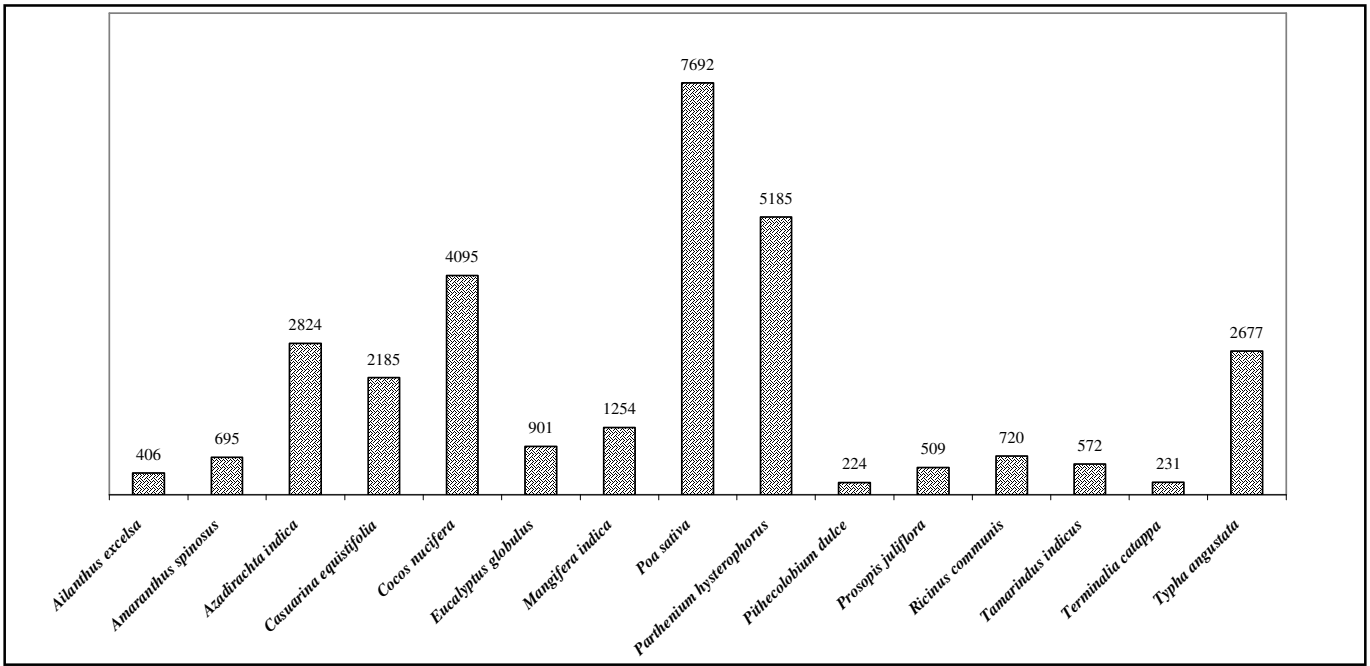
trichomes, epidermal peelings, mites thrips and cysts were identified from the exposed vertical cylinders (Histograms 1-3).

Fungal spores:

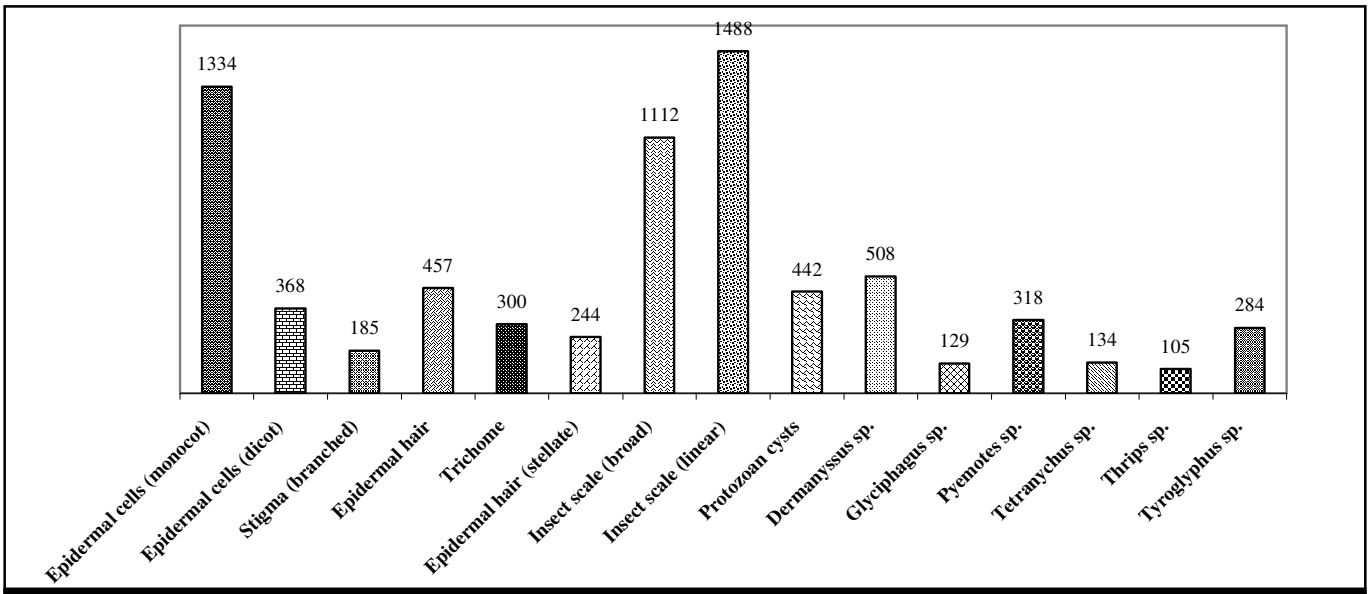
The maximum concentration of fungal spores of 28.83% was recorded for *Cladosporium herbarum* followed by *Aspergillus niger* 16.97%, *Curvularia lunata* 11.86%, *Helminthosporium oryzae* 5.79%, *Alternaria padwickii* 5.74%, *Nigrospora oryzae* 5.61%, *Trichoc*onis padwickii 4.41%, and Periconia circinata 3.75%. All these spores were found throughout the year



Histogram 1: Incidence of atmospheric fungal spores during Jan-Dec 2009 (Total No.)



Histogram 2: Incidence of atmospheric pollen spores during Jan-Dec 2009 (Total No.)



Histogram 3: Incedence of atmospheric biological materials-cyst-mites and thrip during Jan-Dec 2009 (Total No.)

Fig. 1: Aeroscope (vertical glass cylinder type)

and all these spores showed seasonal distribution peaks. The concentration of spores in air are quite variable according to the source of spores and infiltration rate at the time of sampling (Anonymous, 1988; Hunter *et al.* 1988). C. herbarum exhibited peak during September to March and A. niger exhibited peak during October to January. All types of spores except Camptomeris albizziae, Chaetomium globosum, Mycosphaerella musicola and Sporormiella megalospora occured throughout the year. The fungal spore in maximum concentrations dispersed in microdroplets of aerosols penetrate deep into the lungs which will lead to allergy and trigger attacks of asthma (Dales *et al.*, 2000; Anderson, 2001; Geiser *et al.,* 2000).

Identification features of fungal spores

Alternaria longipes:

Conidiophores solitrary, simple, septate, olivaceous brown, smooth. Conidia ovoid, short, cylindrical beak, smooth, with 2 or 3 transverse and longitudinal septa, 40-50 x 30-35 µm. It originates from damp ceiling paper, cardboard and textiles (Fig. 2a: a). causes leaf spot disease in tobacco.

Alternaria padwickii:

Conidia ovoid, cylindrical beak with scars, occurs in chain, 4 or 5 transverse and longitudinal septa, 75-100 15-25 µm. Originates from decaying vegetable and plant debris (Fig. 2a: b). causes leaf spot disease in paddy.

Ascospores:

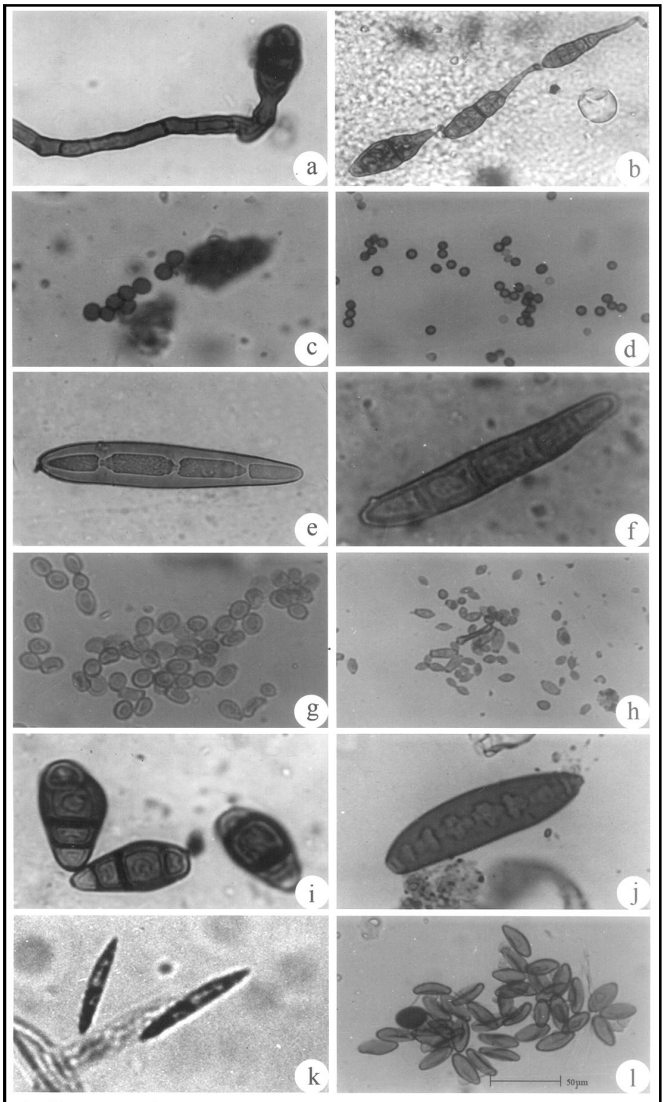
Spores are globose, unicellular, occur in groups, spore wall smooth 10-12 µm. Originate from decaying vegetable and fruits (Fig. 2a: c). The fungus producing such type spores causes decay and degradation of vegetables and fruits.

Aspergillus niger:

Spores are very small, round, unicellular, echinate 3-5 µm. Originates from decaying food stuff of different kinds and decaying paper and wood (Fig. 2a: d). Causes allergy and Aspergillosis on excessive amount of inhalation.

Camptomeris albizziae:

Conidia long, cylindrical, septa 4 or 5, cylindrical beak



a) *Alternaria longipes*
b) *Alternaria padwickii*
c) *Ascospores*
d) *Aspergillus niger*
e) *Camptomeris albizziae*
f) *Cercospora personata*
g) *Chaetomium globosum*
h) *Cladosporium herbarum* (ascospo
i) *Curvularia lunata*
j) *Drechslera zeicola*
k) *Fusarium oxysporum* (macro coni
l) *Heplosporella* sp.

Fig. 2(a): Airborne fungal spores

with scar. 180-200 × 30-40 µm. Originates from decaying plant debris (Fig. 2a: e) causes leaf spot disease in crop plants.

Cerospora personata:

Conidia long, cylindrical, septa present 5 or 6, cylindrical beak with scar. 200-210 × 25-35 µm. Originates from burnt soil, infected leaf debris (Fig. 2a: f), causes leaf spot disease in groundnut plant.

Chaetomium globosum:

Conidia oval, unicellular 15-20 mm. Originates from decaying fruits (Fig. 2a: g). Occurs on damp paper, clothes, decaying materials.

Cladosporium herbarum:

Conidia oblong with prominent scar, occur in branched chains, some conidia are septate, 8-12 µm, occurs on damp paper, cloth, decaying fruits and vegetable (Fig. 2a: h). Causes deacay and degradation of fruits and vegetable.

Curvularia lunata:

Conidia broad, septate 2-4, second septa broad, conidia typically bent with prominent scar, 80-90 x 40-50 µm. Originates from decaying food stuff, soil debris (Fig. 2a: i). Causes leaf spot infection in many crop plants.

Drechslera zeicola:

Conidia, long, cylindrical, pseudosepta present 6-10, 140-150 × 35-45 mm, originates from infected paddy straw and decaying soil debris (Fig. 2a: j). Causes leaf spot infection in paddy and allied crops.

Fusarium oxysporum:

Macroconidia fusiform, septate, 3-6, 30-40 x 5-8 µm, originates from soil, infected leaf debris, decaying fruits (Fig. 2a: k). Causes wilt disease in many crops including banana.

Heplosporella sp.:

Conidia oval, single celled with prominent scar. 25-30 x 10-12 µm. Originates from decaying vegetable (Fig. 2a: l). Causes decay and degradation of vegetable and crop residues.

Helminthosporium oryzae:

Conidia long and cylindrical, beak smooth, septa 6-8, with basal scar 320-340 x 50-60 µm. Originates from soil, infected plant debris like grass, paddy and maize (Fig. 2b: m). Causes leaf spot disease in paddy and allied crops.

Helminthosporium carbonum:

Conidia long slightly bent, cylindrical, beak smooth, septa 7-9, with basal scar 360-380 × 60-70 µm. Originates from soil, infected plant debris like grass, paddy and maize (Fig. 2b: n). Causes leaf spot in paddy, maize and allied crops.

Mycosphaerella musicola:

Conidia oblong, septate, 3 celled, middle cell larger than other two cells, with basal scar 70-80 × 30-40 µm. Originates from decaying fruits (Fig. 2b: o). Causes

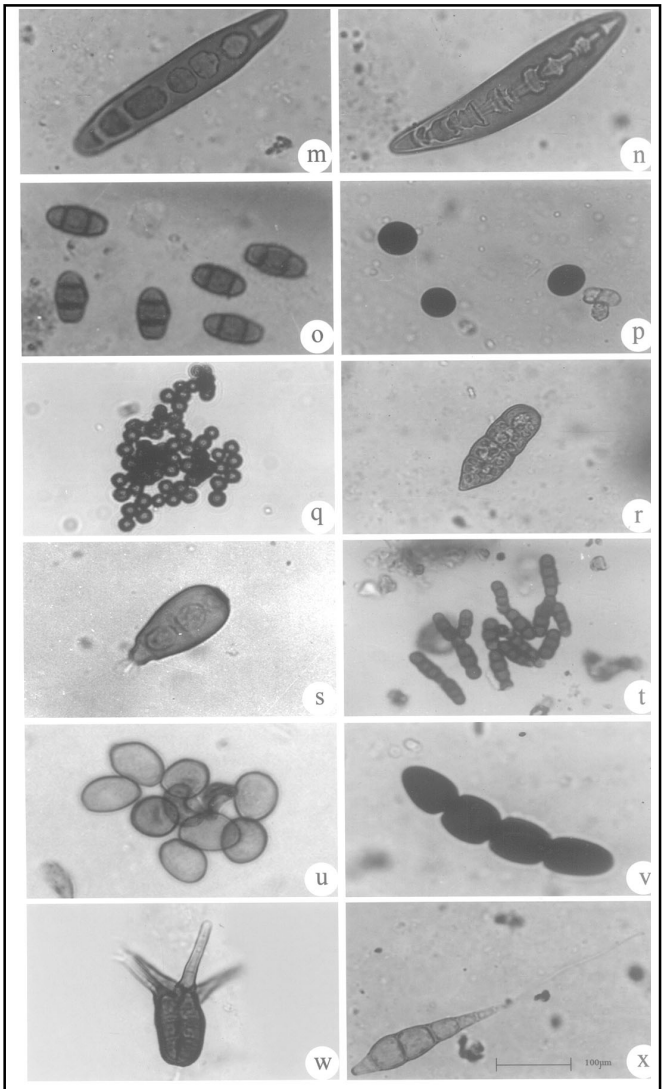


Fig. 2(b): Airborne fungal spores

degradation of organic debris.

Nigrospora oryzae:

Conidia, single celled oval to globose, opaque, black, 40-50 µm. Originates from soil and infected grass and paddy (Fig. 2b: p). Causes leaf spot infection in paddy and other grasses.

Periconia circinata:

Conidia globose, 1 celled, dark brown echinulate 20-25 mm. Originates from soil, decaying vegetable and fruits (Fig. 2b: q). Causes degradation of organic materials.

Pleospora herbarum:

Conidia oblong, septata 2-4, cylindrical beak with basal scar. 130-150 65-75 µm. Originates from soil, decaying plant debris (Fig. 2b: r). Causes decay and degradation of plant debris.

Pringshemia sp.:

Conidia oblong, pseudosepta present 2-3, cylindrical beak with prominent scar 140-150 x 50-60 µm. Originates from soil and decaying plant debris (Fig. 2b: s). Causes decay and degradation of organic debris.

Pseudotorulla sp.:

Conidia 4 celled to 8 celled chains, branched, each conidia is globose 90-100 x 10-12 µm (8 celled chain). Originates from decaying fruits (Fig. 2b: t). Causes decay of organic debris.

Sphaeropsis tumefascience:

Conidia large, 1 celled oval to globose 60-80 x 50-60 µm. Originates from soil and decaying plant debris (Fig. 2b: u). Causes degradation of organic matter.

Sporomiella megalospora:

Ascospores very dark, 3-septate, much constricted at septa 300-350 × 50-60 µm, middle cells cylindrical, end cells slightly longer and somewhat conical. Originates from decaying vegetable and horse dung (Fig. 2b: v). Bring about degradation process of organic materials.

Tetrapola sp.:

Conidia cylindrical with 4 radiating septate appendage. Conidia septate 4 celled, 110-120 × 60-70 µm appendage 90-100 mm long. Originates from decaying aquatic plants (Fig. 2b: w). Causes decay of aquatic plant debris.

Trichoconis padwickii:

Conidia 6-9 celled with a prominent long trichome like back. Apical cell somewhat conical second and third cells are broader than other cells, 220-240 × 20-60 µm, trichome 180-220 µm long. Originates from soil, decaying paddy straw (Fig. 2b: *x*). Causes leaf spot infection to paddy and allied crops.

Pollen grains:

The maximum concentration of pollen grains of 25.49% was recorded for *Poa sativa*, followed by 17.18% for *Parthenium hysterophorus*, 13.57% for *Cocos nucifera*, 9.36% for *Azadirachta indica*, 8.87% for *Typha angustata*, 7.24% for *Casuarina equisetifolia*,

and 4.15% for *Mangifera indica*. *C. nucifera, P. sativa* and *P. hysterophorus* pollen grains were abundant and found throughout the year and all these pollen showed seasonal distribution peaks which attributed to the effects of climate (Amato *et al.,* 2007), whereas low amount of pollen source are *Ailanthus excels, Amaranthus spinosus, Eucalyptus globulus, Pithecolobium dulce, Prosopis juliflora, Ricinus communis, Tamarindus indicus* and *Terminalia catappa*. The abundant pollen such as *P. sativa, P. hysterophorus, C. nucifera, A. indica, T. angustata* and *equisetifolia* derived from dispersed microdroplets represent a possible mechanism by which allergy/pollinosis can trigger attacks of asthma (Menz *et al*., 2006; Pham *et al.,* 2006; Amato *et al.,* 2007).

Identification features of pollen grains:

Ailanthus excelsa (Simaroubaceae): Pollen grains 3-zonocolporate, oblate spheroidal. Grain size 90-95 µm. Colpus long, streak-like, exine thicker at poles. Exine surface finely reticulate (Fig. 3: a).

Amaranthus spinosus (Amaranthaceae):

Pollen grains multiporate, spherical. Grain size 80-90 mm. Pore membrane crustate. Exine surface granulate (Fig. 3: b).

Azadirachta indica (Meliaceae):

Pollen grains, 4-zonocolporate, prolate spheroidal. Grain size 135-145 µm. Exine thick, ectexine thicker than endexine. Exine tectate, surface psilate and punctate (Fig. 3: c).

Casuarina equisetifolia (Casurinaceae):

Pollen grains 3-zonoporate, oblate, grain size 100-110 µm, amb triangular with slightly convex sides. Pores aspidate. Exine surface psilate (Fig. 3: d).

Cocos nucifera (Arecaceae):

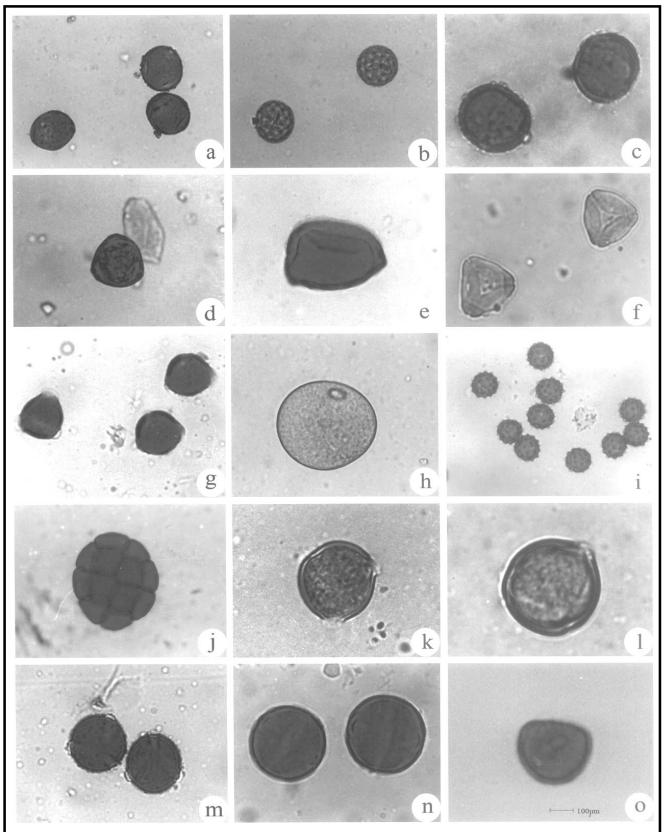
Pollen grains ellipsoidal, 1-colpate. Exine thick and conspicuously folded, surface psilate. Grain size 185-195 x 70-75 µm (Fig. 3: e).

Eucalyptus globuslus (Myrtaceae):

Pollen grains amb triangular, 3-zynocolporate, exine surface granulate. Grain size 90-100 µm (Fig. 3: f).

Mangifera indica (Anacardiaceae):

Pollen grains 3-zonocolporate, suboblate. Grains size 85-95 µm. Endocolpium elongate. Exine surface striate (Fig. 3: g).



a) *Ailanthus excelsa*
b) *Amaranthus spinosus*
c) *Azadirachta indica*
d) *Casuarina equisetifolia*
e) *Cocos nucifera*
f) *Eucalyptus globulus*
g) *Mangifera indica*
h) *Poa sativa*
i) *Parthenium hysterophorus*
j) *Pithecolobium dulce*
k) *Prosopis juliflora*
l) *Ricinus communis*
m) *Tamarindus indica*
n) *Terminalia catappa*
o) *Typha angustata*

Fig. 3 : Airborne pollen

Poa sativa (Poaceae):

Pollen grains monoporate, pore circular, annulate, spheroidal. Grain size 185-195 µm. Exine surface psilate (Fig. 3: h).

Parthenium hysterophorus (Asteraceae):

Pollen grains 3-zonocolporate, suboblate. Exine surface spinate tip acute. Grain size 40-50 µm (Fig. 3: i).

Pithecolobium dulce (Mimosoideaceae):

Individual pollen grains. Unite to form a polyad, spheroidal, polyad 16 celled. Exine thicker at outer margin thinner towards inner margin. Exine surface granulate. Grain size 170-190 µm (Fig. 3: j).

Prosopis juliflora (Mimosoideaceae):

Pollen grains 3-zonocolporate, Endocolpium la-longate. Exine surface striate. Grain size 150-160 m (Fig. 3: k).

Ricinus communis (Euphorbiaceae):

Pollen grains 3-zonocolporate, suboblate, endocolpium la-longate, colpus ends pointed, exine surface finely reticulate. Grain size 190-200 µm (Fig. 3: l).

Tamarindus indica (Caesalpiniaceae):

Pollen grains 3-zonocolporate, endocolpium la-longate, exine surface regulate. Grain size 100-110 µm (Fig. 3: m).

Terminalia catappa (Combretaceae):

Pollen grains 3-zonocolporate with 3 alternating pseudocolpi, oblate spheroidal, endocolpium circular. Grain size. 140-150 µm (Fig. 3: n).

Typha angustata (Typhaceae):

Pollen grains 1-porate, spheroidal, exine surface reticulate. Grain size 130-140 mm (Fig. 3: o).

Epidermal cells, stigma, epidermal hairs, insect scales and protozoan cysts:

Epidermal cells of monocot, dicot plants, stigmatic part of flower, epidermal hairs, trichome, stellate hairs of plant origin, insect scales of various size and shape and protozoan cysts, mites and thrips were of common occurrence in air (Fig. 4 a-i). These will lead to the relative risks of development of allergy and asthma (Sears *et al*., 2006).

Characteristic features of mites and thrips:

Dermanyssus sp. (Dermanyssidae):

The chicken mites, pest of poultry, long oval body the cephalothorax long, oval body, require blood meal and quite resistant to starvation. 450-500 µm in length 120-130 µm broad (Fig. 4: j) (Singh and Sachan, 2004).

Glyciphagus sp.:

The flour mite, cylindrical cephalothorx and broad abdomen 360-380 x 90-110 µm (Fig. 4: *k*) (Wallis, 2002).

Pyemotes sp. (Pediculoididae):

The straw itch mite, causative agent of hay or grain itch, attack human in hot weather and causes intense itch, long tubular body. 210-220 x 65-85 µm (Fig. 4:l) (Singh and Sachan, 2004).

Tetranychus sp. (Tetranychidae):

The two-spotted spider mite, suck the plant sap. oval body 130-140 x 80-90 µm (Fig. 4: m) (Singh and Sachan, 2004).

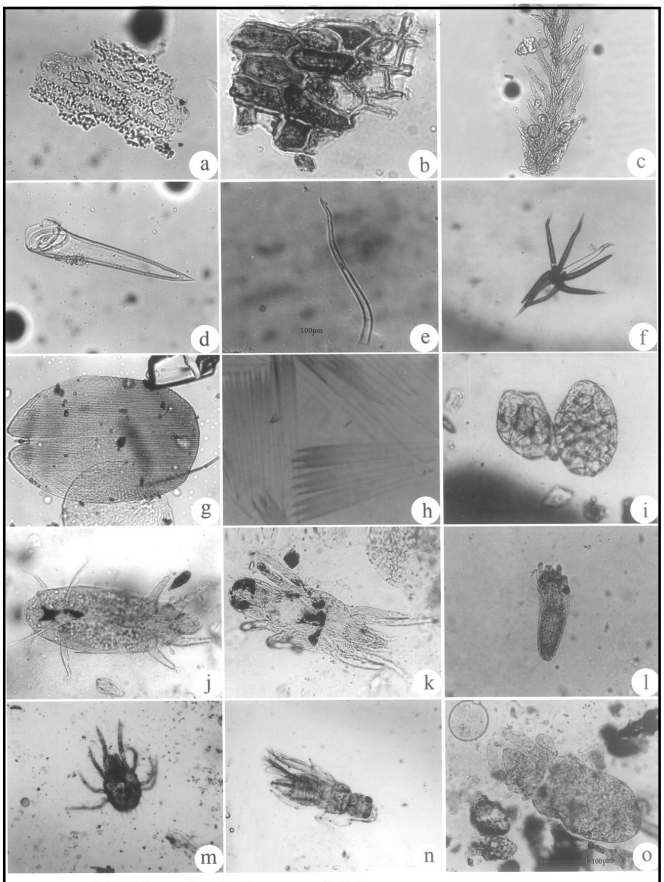


Fig. 4 : Airborne pollen

Thrips sp.:

The flower thrips with distinct head, thorax and abdomen with narrow end. 230-240 × 70-80 µm (Fig. 4: n) (Wallis, 2002).

Tyroglyphus sp.:

The common cheese mite, shows a division into two parts the cephalothorax and abdomen measures 330-350 mm × 120-140 µm (Fig. 4: o) (Wallis, 2002).

Conclusions:

The results of this study demonstrate that differences in ambient concentration of biological materials and meteorological conditions appear to influence allergic rhinitis, conjunctivitis and allergic asthma to the population.

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