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Atmospheric biopollutant monitoring in relation to meteorological parameters

SHRIPAD N. AGASHE and A. G. ALFADIL

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The present paper deals with the results of continuous aeropalynological survey of the atmosphere at Bangalore carried out for the past six years. The aeropalynological survey was conducted by trapping airborne bioparticles such as pollen and fungal spores by operating vertical cylinder pollen traps. The traps were installed at different ecogeographical sites in Bangalore City. The results of qualitative and quantitative analysis of the atmospheric biopollutants are correlated with the meteorological parameters such as temperature, relative humidity, wind speed and cloud cover. It is seen that generally the higher temperature and lower relative humidity enhance the liberation and distribution of pollen in the atmosphere; whereas the higher humidity and lower temperatures trigger the liberation and distribution of fungal spores in the atmosphere. Atmospheric pollen count is drastically reduced during the rainfall.

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Bangalore is a large city situated in the south eastern part of Karnataka State of South India. It is situated at 12°58' N and 77°35' E with an elevation of 920 m above mean sea level. The characteristic topography of the district with the underlying gneissic granite rock formation having a thin mantle of sandy loam or sandy clay soil accounts for the high degree of xeromorphy in the vegetation. The natural vegetation is largely of dry deciduous and scrub type. However, within the city limits, the luxuriant vegetation due to numerous parks, gardens and tree lined avenues has lent this city the name of the "Garden City of India".

The present aeropalynological study of Bangalore has been undertaken on account of relatively high incidence of allergic disorders among its population where the airborne pollen grains and fungal spores have been recognised as primary offenders (Agashe & Vinay 1980, Agashe & Anand 1982).

A systematic sampling of atmospheric pollen by means of impaction air samplers has been carried out for the past six years in different areas in Bangalore. Vegetation around the trapping sites con-

sists of trees, shrubs and herbs comprising of *Acacia*, *Amaranth-chenopod*, *Casuarina*, *Cyperaceae*, *Eucalyptus*, *Holoptelea*, *Parthenium*, *Peltophorum*, *Poaceae*, *Pongamia*, *Ricinus*, *Typha* and various weeds. The present investigation was undertaken with the following objectives: (1) to assist in the clinical evaluation of locally and generally known allergenic pollen; (2) to discover, identify and help to evaluate new allergenic pollen and (3) to correlate the atmospheric pollen content with meteorological parameters.

MATERIAL AND METHODS

Field botanical studies are a prerequisite to aerobiological studies, as a sound knowledge of the flora facilitates identification of airborne pollen and spores. A systematic field study was conducted for six years (1981-1986) at various sites in Bangalore. Weekly field trips were undertaken and detailed information was collected about grasses, herbs, shrubs and trees growing in and around the city. Plants were identified with the help of publications such as Flora of Bangalore District (Ramaswamy & Razi 1973), Flora of Hassan district (Saldanha & Nicholson 1976), Flora of The Presidency of Madras (Gamble 1967).

Fig. 1. Map showing pollen trap locations in Bangalore.

Identification of trapped airborne pollen types was made by comparison of morphological characters of pollen from reference slides prepared from known plants. Permanent slides were prepared by using Wodehouse technique (1935) and Erdtman's acetolysis method (1960). These slides allowed detailed microscopic study of pollen characters such as shape, size, colour, nature of aperture, exine stratification and exine ornamentation.

Airspora sampling technique

Vertical cylinder spore trap.—Acrobiological survey in the present investigation was carried out with vertical cylinder spore trap from 1 January 1981 to 31 December 1986. Vertical cylinder spore trap was shown to be reasonably efficient in sampling air-spores by Gregory (1951) and Hirst (1959). This was further modified by Ramalingam in 1968. The efficiency of the spore trapping was shown to be as much as 70%. The vertical cylinder was found in our investigation very efficient for trapping large sized particles such as pollen grains and spores. In view of this the vertical cylinder spore traps were installed in different localities differing in ecogeographical conditions and the same are depicted in Fig. 1.

Vertical cylinder spore trap, known for its simplicity, needs no power requirements and is easy to operate continuously. It works on the principle of impaction. The sampler consists of a glass cylinder, measuring 13 cm in length and 0.53 cm in diameter. A vaseline coated thin non-glossy cellophane tape wound around the cylinder acts as the adhesive surface. The glass rod is suspended vertically from a rod holder fitted with a bush and screw (Fig. 2). The rod was protected from above by a circular metal plate, providing protection to the adhesive coated tape being washed away by rain or melting of the jelly due to excessive direct heating by the sun. The trap was fixed

Fig. 2. Vertical cylinder pollen trap.

on a parapet wall on the terrace of a building about 20 meters above ground level. Spore trapping adhesive surface on the glass cylinders was prepared by nonglossy thin cellophane tape, measuring 2 cm^2 which was first washed by dipping in water with a fine pointed forceps. It was then dipped in molten petroleum jelly to form a thin coating and the excess jelly was allowed to drain off. The tape was wound carefully around the clean glass cylinder about $3/4$ down its length avoiding any folds. The glass rod with tape was carried in a glass tube to the sampling site to prevent contamination during transit. The tapes were exposed for a period of 24 h and replaced everyday at 0800 h IST (Indian Standard Time). The exposed tape on return to the laboratory was carefully removed from the glass rod with a forceps and placed on a microscope slide with a drop of molten glycerine jelly, with the exposed surface facing upwards. A drop of jelly was further added before mounting the cover slip on it. Slides were labelled with date and place of exposure and stored in slide cabinets. Pollen count per cm^2 was calculated in the following manner.

Exposed width of the tape	= 1.8 cm
Length of the tape	= 2.0 cm
Total area exposed	= $2 \times 1.8 = 3.6\text{ cm}^2$
Conversion to per cm^2	= Total count/3.6

OBSERVATIONS

Field botanical studies in Bangalore City were conducted to provide detailed information about the relative abundance of the source plants as well as their pollination period. The vegetation has been found to be rich and diverse. Flowering was observed throughout the year in one or the other plant taxa, unlike temperate regions where flowering is confined to a few months of the year. Grasses flowered throughout the year with a maximum flowering period from October to December. The majority weeds are those of *Amaranthus* spp., *Chenopodium* spp., Cyperaceae, *Parthenium* sp. and several Asteraceae members. However, 40 to

Fig. 3. Percentage of pollen during 1983 in Bangalore City.

60% of the weed population comprised *Parthenium hysterophorus* alone (Fig. 3). Their flowering was coincident with the rainy season.

A majority of the trees flowered between January to May. However, four categories of flowering among trees were recognised: (1) those with short, intense, flowering period, i.e. *Holoptelea integrifolia*; (2) flowering period with a duration of 2–4 months with a mid-season peak, i.e. *Pongamia* spp.; (3) types without any definite season, i.e. *Cocos* and *Eucalyptus*; (4) with double flowering pattern of short duration, i.e. *Casuarina equisetifolia*.

During 1981 a total of 11459 pollen/cm² were sampled. The monthly maximum attained during December being 2223 pollen/cm² accounting for 19.40% of the annual total. Analysis of the samples revealed that weed pollen contributed 27.94% of the annual catch with a total of 5475 pollen/cm². *Parthenium hysterophorus* alone contributed 48.00%, Poaceae 17.34% and *Casuarina equisetifolia* 8.11% (Table I).

During 1982, a total of 10726 pollen/cm² were recorded. A total of 3386 pollen/cm² accounting 31.57% was recorded during July, comprising 63.15% pollen of *Parthenium Hysterophorus*, *Casuarina equisetifolia* 9.15% and Poaceae 5.00%.

In 1983, a total of 14268 pollen/cm² were sampled with monthly catch of 2913 pollen/cm² during Octo-

Fig. 4. Seasonal variations 1981–1986.

Table I. Total airborne pollen grain counts (no/cm²) during 1981–1986

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Total	%
1981	1 146	815	472	663	327	981	1 043	674	1 187	808	1 120	2 223	11 459	15.40
1982	424	701	306	156	157	1 835	3 386	1 542	707	629	400	483	10 726	14.40
1983	314	967	2 005	1 569	1 637	518	1 434	1 016	1 008	2 913	626	261	14 268	19.13
1984	241	477	2 684	85	51	102	227	1 251	1 323	2 020	1 271	153	9 885	13.26
1985	640	1 357	1 693	1 199	1 064	949	1 473	756	1 485	658	952	1 610	13 836	18.60
1986	761	1 742	776	515	521	628	1 637	1 333	1 829	720	744	3 191	14 397	19.30
Total	3 526	6 059	7 936	4 187	3 757	5 013	9 300	6 572	7 539	7 748	5 113	7 931	74 571	

ber, accounting 20.4% of the annual total, while *Parthenium hysterophorus* contributed 38.42%, *Casuarina equisetifolia* 22.03% and Poaceae 8.84% to the annual total (Fig. 3).

During 1984, the total was 9885 pollen/cm². The maximum was attained during March in 2684 pollen/cm² accounting for 27.15% of annual total. *Casuarina equisetifolia* formed 36.60%, *Parthenium hysterophorus* 28.24% and Poaceae 18.35% of annual total.

A total of 13836 pollen/cm² were sampled during 1985 with a December total count of 1693 pollen/cm² accounting for 12.23% of the annual total. The percentage contributions in the annual total of *Casuarina equisetifolia* and *Parthenium hysterophorus* and Poaceae are 29.98%, 27.64% and 16.55% respectively.

During 1986, a total of 14397 pollen/cm² were

sampled. A maximum of 1829 pollen/cm² accounting for 12.70% of the annual total was attained during September. The prominent contributors in pollen count were *Casuarina equisetifolia* 23.30%, *Parthenium hysterophorus* 18.45%, *Cocos nucifera* 16.66% and Poaceae 15.07%.

During the six year survey, the monthly maximum was attained during July with 9300 pollen/cm² accounting for 12.33% followed by March with 7936 pollen/cm² (10.64%) of the annual total. The maximum annual pollen was observed during 1986 with 14268 pollen/cm² (19.13%), 1985 with 13836 pollen/cm² (18.60%) and the least of 9885 pollen/cm² (13.26%) during 1984.

DISCUSSION

The airborne pollen were placed in three categories, grasses, weeds and trees on the basis of their

Table II. Statistical correlation of major airborne pollen grains with meteorological parameters

No. of observations = 72 (1981 to 1986), No. of variables = 23, No. of selection = 12, X_1 max. temp. (°C), X_2 = min temp. (°C), X_3 = mean temp. (°C), X_4 = morning relative humidity (%), X_5 = evening relative humidity (%), X_6 = mean relative humidity (%), X_7 = mean wind speed (kmph) X_8 = total rainfall (mm) X_9 = no. of rainy days X_{10} = total cloud cover (Oktas) X_{11} = sun radiation (hrs)

Correlation coefficient	Mean	Standard deviation	Coeff. of variation	X_1	X_2	X_3
Amaranth – Chenopod.	25.25000	48.20840	190.92430	–0.21977	0.12662	–0.04262
<i>Casuarina equisetifolia</i>	148.98610	205.89140	138.19500	0.04113	–0.05898	0.00893
<i>Cocos nucifera</i>	40.18056	247.05470	617.10130	–0.13116	–0.06531	–0.11318
Cyperaceae	10.12500	38.05849	375.88640	–0.14007	–0.09350	–0.15086
<i>Eucalyptus</i> spp.	41.56944	44.68444	107.49350	–0.27371*	–0.11408	–0.24207
<i>Holoptelea integrifolia</i>	4.59722	14.60432	317.67710	0.18659	–0.05762	–0.10746
<i>Parthenium hysterophorus</i>	325.50000	307.48740	94.46617	–0.16041	0.05383	–0.08395
<i>Peltophorum pterocarpum</i>	11.00000	22.60064	205.46030	0.09219	0.21278	0.18116
Poaceae	101.94440	142.79530	140.07170	–0.10691	–0.37909***	–0.26107
<i>Pongamia</i> spp.	4.88889	11.77076	240.76560	0.50520***	0.19007	–0.48859***
<i>Ricinus communis</i>	26.45833	23.82503	90.04736	–0.20292	0.00061	–0.12260
<i>Typha angustata</i>	6.41667	11.62047	181.09820	0.26699*	0.05662	0.25507*

Correlation co-efficient value, *0.05; **0.01; ***0.001.

source. Grass pollen were well represented in the atmosphere as a result of several species which flowered successfully throughout the year. The bulk of the atmospheric pollen comprised of weed pollen. A marked weed pollen season could be demarcated between June and September. Numerically the important weed pollen was that of *Parthenium hysterophorus* which often accounted for 80% of the weed and 40–60% of total pollen during the specific season. The other major sources of atmospheric weed pollen were *Amaranthaceae*, *Chenopodiaceae*, *Typha angustata* and *Cyperaceae*. The tree pollen formed the second major type in the atmosphere. The tree pollen season virtually started in January with the initiation of flowering of most trees, reaching peak concentration during February and March and gradually subsiding to a minimum in August. Among the numerous tree pollen regularly recorded, only three occurred in abundance, i.e. *Casuarina equisetifolia*, *Eucalyptus globulus*, and *Cocos nucifera*. The other common types occurring in their individual seasons in lower concentration were *Peltophorum pterocarpum*, *Pongamia glabra* and *Holoptelea integrifolia*. The second seasonal peak in tree pollen occurred in September and October mainly due to the flowering of *Casuarina equisetifolia*.

Comparison of the percentage contribution of different groups segregated on the basis of their mode of pollination was made. It was found that 63.15% of total airborne pollen came from amphiphilous, 5% from anemophilous and 0.51% from entomophilous weeds. Among airborne tree pollen 15.89% of the catch came from anemophilous,

6.87% from amphiphilous and 0.61% from entomophilous trees annually.

Seasonal variations

Concentration of airborne pollen grains showed large day to day, seasonal as well as yearly variations. Among the types recorded over the six years study, only six occurred in significant number, together accounting for more than 85% of the annual catch. In order of dominance they are: *Parthenium hysterophorus*, *Casuarina equisetifolia*, *Poaceae*, *Eucalyptus globulus*, *Ricinus communis* and *Amaranth-Chenopod*.

Considerable differences were observed in the total pollen catch during the six years, i.e. 1981–86. The annual variations may be caused by several reasons, but most commonly they are related to intensity of flowering and pollen productivity. Differences in the pollen seasons of grasses, weeds and trees were detected between the six years. The peak period of weed pollen season was recorded during June and July whereas peak period of tree pollen season was during October. Double peak pattern was exhibited by *Casuarina* with peaks in February and October. Higher pollen peak of grasses was recorded in March. The pollen productivity of the chief herbaceous type appeared to be affected by rainfall during the period of vegetative growth resulting in growth and production of flowering shoot (Hyde 1952). The six years' aeropolynological survey carried out has clearly indicated a shift in the pollen season by a month as observed in *Casuarina equisetifolia*, *Eucalyptus globulus*, *Parthenium hysterophorus*, etc. (Fig. 4). Similar

X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}
0.24963*	0.25431*	0.34005**	0.17205	0.18953	0.34961**	0.36743**	-0.29858*
-0.25687*	-0.24843*	-0.22399	-0.27054*	0.02327	-0.14168	-0.11397	0.23122*
0.04634	0.03032	0.04290	0.11499	-0.08007	-0.09675	0.02185	0.05480
0.00247	0.03530	0.02361	0.13892	-0.07153	-0.06248	0.01012	0.04217
0.02177	0.02955*	0.03362	-0.04651	-0.12399	-0.12141	-0.09364	0.09017
-0.36726**	-0.40379***	-0.37319**	-0.13174	-0.18049	-0.27973*	-0.26971*	0.29216*
0.41595***	0.41620***	0.43057***	0.29581*	0.18688	0.51595***	0.47720***	-0.53265***
-0.07735	-0.05665	-0.06488	-0.06338	-0.04826	-0.01179	0.08262	0.09230
-0.10296	-0.01824	-0.03506	-0.08325	-0.18595	-0.22038	-0.18752	0.10564
-0.31739**	-0.31035**	-0.32128**	0.22122	-0.14765	-0.21364	-0.05693	0.30734**
-0.12973	0.011554	-0.06888	-0.04354	-0.03677	-0.04781	-0.12278	0.13353
-0.29511*	-0.28670*	0.29147*	-0.15789	-0.18249	-0.26322*	-0.13172	0.30709**

Fig. 5. Meteorological data on monthly temperature, relative humidity, total rainfall, wind speed and total cloud cover from January 1981 to December 1986.

annual variations have been observed by others also (Derrick 1966, Al-Doory et al. 1982).

Correlation of airborne pollen grains with meteorological factors

The relationship between atmospheric pollen counts and the individual meteorological variables were statistically correlated by computing the correlation co-efficient. Individual variables such as temperature, relative humidity, wind speed, rainfall, total cloud cover and radiation, influence atmospheric concentrations of various pollen types in

different ways but their combined effect may have a significant synergistic effect on the atmospheric concentration of the particles.

A critical perusal of Table II on statistical correlation of major airborne pollen grains with meteorological parameters (Fig. 5) brings out the following highlights.

With regard to co-efficient of variation, it was noticed that highest values were shown by *Cocos nucifera* pollen (617.10130) followed by *Cyperaceae* (375.88640), *Holoptelea integrifolia* (317.67710) and *Pongamia* spp. (240.76560).

Amaranth-Chenopod showed positive correlation with morning, evening, mean relative humidity (0.24963, 0.25431, and 0.34005), as well as number of rainy days (0.34961) and total cloud cover (0.36743) but negative correlation to radiation (-0.29358).

In case of *Casuarina equisetifolia* radiation had a positive correlation (0.23122) and negative correlation with morning, evening, relative humidity and wind speed (-0.25686, -0.24843, -0.27054), respectively. *Eucalyptus* spp. showed negative correlation to maximum and mean temperature (-0.27371, -0.24207).

As regards *Holoptelea integrifolia*, the positive correlation was noticed with radiation (0.29216) and negative correlation to morning, evening, mean relative humidity, number of rainy days and total cloud cover (-0.36726, -0.37319, -0.27973, -0.26971), respectively.

In *Parthenium hysterophorus*, the correlation was positive and highly significant with morning, evening, mean relative humidity, number of rainy days, total cloud cover (0.41595, 0.41620, 0.430571, 0.51595, 0.47720) respectively, but higher negative correlation was with sun radiation (-0.53265). Poaceae showed complete negative correlation to minimum and mean temperature (-0.32909, -0.26107).

In *Pongamia* spp. the positive correlation was observed with maximum, mean temperature and radiation (0.50520, 0.258859, 0.30734) but negative correlation to morning, evening and mean relative humidity (-0.31739, -0.31035, -0.32128).

In *Typha augustata*, maximum, mean temperature and radiation had positive correlation (0.26699, 0.25507, 0.30709) whereas negative correlation was shown to morning, evening, mean relative humidity and number of rainy days (-0.29511, -0.28670, -0.29147, -0.26322).

On the basis of the above, it can be concluded that a definite correlation has been observed between the incidence of pollen in the air and prevailing weather conditions. However, in respect of humidity and rainfall they have an inverse effect on the airborne pollen grains. This, however, cannot be generalised because in case of Amaranth-Chenopod and *Parthenium hysterophorus*, higher humidity seems to be favourable for higher atmospheric concentration. The effect of wind/speed was particularly noticeable in few types and was shown to have significant positive relation especially with the pollen of *Parthenium hysterophorus*. The rainfall

had no significant effect but negatively correlated with airborne pollen. The total cloud cover was seen to have a negative effect on airborne pollen. Radiation was also seen to have a positive effect on the airborne pollen of *Casuarina*, *Holoptelea*, *Pongamia* and *Typha augustata*.

In view of the foregoing discussion on various aspects of correlation of meteorological parameters with atmospheric pollen count, it can be concluded that correlation, positive or negative cannot be generalised and there is need to evaluate individual pollen types which may respond differently to different meteorological parameters. There is ample scope for more work in this direction.

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REFERENCES

- Agashe, S. N. & Anand, P. 1982. Immediate type hypersensitivity to common pollen and moulds in Bangalore City. — *Asp. Allergy Appl. Immunol.* 15: 49-52.
- Agashe, S. N. & Vinay, P. 1980. Aerobiological studies of Bangalore City. Part II. A preliminary report. — *Advances in Pollen spore research* 5-7: 185-194.
- Al-Doory, Y., Domson, J. F., Howard, W. H. & Best, J. 1982. Further studies of the airborne fungi and pollens of the Washington, D. C., Metropolitan area. — *Ann. Allergy* 49: 265-269.
- Bringfelt, B. 1978. Studies of pollen concentration in Stockholm and weather data. — *Proc. 1st Internat. Aerobiol. Conf. Munich*, pp. 14-22.
- Derrick, E. 1966. Airborne pollen and spores in Melbourne. — *Aust. J. Bot.* 14: 49-66.
- Erdtman, G. 1960. The acetolysis method. A revised description. — *Sven. Bot. Tidskr.* 54: 561-564.
- Gamble, J. S. 1967. Flora of the presidency of Madras. Vols. I, II & III. — *Bot. Surv. India*, Calcutta, Second print.
- Goulden, C. H. 1959. *Methods of statistical analysis*. 2nd ed. Asia Publ. House, New Delhi.
- Gregory, P. H. 1951. Deposition of airborne *Lycopodium* spores on cylinders. — *Ann. Appl. Biol.* 38: 357-376.

- Hirst, J. M. 1959. Spores liberation and dispersal. In: Plant pathology, problems and progress. (ed. C. S. Holten). — University of Wisconsin Press, Madison.
- Hyde, H. A. 1952. Studies in atmospheric pollen V., A daily census of pollens at Cardiff for the six years 1943–1948. — *New Phytol.* 51: 281–293.
- Ljungkvist, S., Bringfelt, S. & Fredrickson, V. 1977. Correlation between the pollen content of the Stockholm air and meteorological data — *Grana* 16: 145–146.
- Ramalingam, A. 1968. The construction and use of simple air sampler for routine aerobiological surveys. — *Environ. Health* 10: 61–67.
- Ramaswamy, S. V. & Razi, B. A. 1973. Flora of Bangalore District. Prasaraanga. — Univ. Mysore.
- Saldanha C. J. & Nicholson, D. J. 1976. Flora of Hassan District, Karnataka, India. — Anand Publ. Co. Pvt. Ltd., New Delhi.
- Smart, I. J., Tuddenham, W. G. & Knox, R. B. 1979. Aerobiology of grass pollen in the city atmosphere of Melbourne: Effects of weather parameters and pollen sources. — *Aust. J. Bot.* 27: 333–342.
- Wodehouse, R. P. 1935. Pollen grains. — McGraw-Hill, New York.