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Aerobiology: Aspects and Prospects

ASHA KHANDELWAL

Birbal Sahni Institute of Palaeobotany, 53 University Road, Lucknow 226 007, India.
E-mail: ashakhandelwal@yahoo.com

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ABSTRACT

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Aerobiology is the study of all biologically significant materials that are transported in the atmosphere. Air-borne bioparticles are either beneficial or hazardous, affecting the health and economic prosperity of man on one hand and serving as bio-indicators on the other. Aerobiology has been used as a discipline and as well as a tool for other disciplines such as medicine (allergology - both human & animal diseases, immunology, occupational hygiene), agriculture (plant pathology, pest management, arthropod dispersal), forestry & gene ecology, meteorology, climatology, biometeorology, microbiology, biodeterioration, indoor air quality, air pollution, industrial aerobiology, cultural heritage, palaeobotany, etc. Aerobiologists should encourage closer collaboration among various disciplines in order to achieve a more meaningful outcome.

Key-words—Aerobiology, Allergy, Annual pollen & Fungal spore calendars.

वायुजैविकी : पहलू एवं संभावनाएं

आशा खंडेलवाल

सारांश

वायुजैविकी समस्त जैविक रुप से सार्थक (उल्लेखनीय/महत्वपूर्ण) पदार्थों का अध्ययन है जो वायुमंडल में वाहित हो गए हैं। वायु-वाहित जैवकण या तो लाभदायक या फिर खतरनाक हैं, एक तरफ मनुष्य का स्वास्थ्य एवं आर्थिक समृद्धि को प्रभावित कर रहे हैं तथा दूसरी ओर जैवसूचकों के रुप में काम कर रहे हैं। वायुजैविकी विषय के रुप में तथा अन्य विषयों हेतु सूत्र (यंत्र) के रुप में भी प्रयोग होती रही है जैसे कि औषधि (एलर्गोलॉजी- मानव एवं पशु दोनों रोगों, प्रतिरक्षाविज्ञान, व्यावसायिक स्वास्थ्यविज्ञान), कृषि (वनस्पति रोगविज्ञान, नाशक जीव प्रबंधन, आर्थोपोड विसर्जन), वन विद्या एवं वंश पारिस्थितिकी, मौसम विज्ञान, जलवायु विज्ञान, जीव-मौसमविज्ञान, सूक्ष्मजीवविज्ञान, जैव अवनति, अंतः वायु गुणवत्ता, वायु प्रदूषण, औद्योगिक वायुजैविकी, सॉंस्कृतिक विरासत, पुरावनस्पतिविज्ञान आदि। वायुजैविकीविदों को और अधिक अर्थपूर्ण परिणामों को प्राप्त करने हेतु विभिन्न विषयों के मध्य घनिष्ठतम सहयोग को प्रोत्साहन देना चाहिए।

संकेत-शब्द—वायुजैविकी, प्रत्यूर्जता, वार्षिक पराग एवं कवकी बीजाणु कलेंडर।

INTRODUCTION

AEROBIOLOGY is the scientific discipline focussed on the study of the passive transport of organisms and particles of biological origin in the atmosphere. It deals with source of organisms or materials, their release into the atmosphere, dispersion, deposition, and impact on animal, plant, or human systems. It includes the study of viruses, bacteria, Actinomycetes, fungi and associated metabolites, spores of bryophytes and pteridophytes, pollen grains of higher plants, mites and their body parts and fecal pellets, etc. Proteins released from plant and animal cells during industrial processing and products of biotechnological processes are also included in the realm of Aerobiology (Mandrioli & Ariatti, 2001). In recent past, Scientific Committee on Antarctic Research (SCAR) had organized air-monitoring programme to protect the natural environment of Antarctica from air-pollution. Similarly, International Geosphere Biosphere Programme (IGBP) has provided additional opportunities to Aerobiologists to detect changes of global climate (Benninghoff, 1991).

Aerobiological investigations are broadly distinguished as outdoor or extramural aerobiology and indoor or intramural

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aerobiology. The study of aerobioparticles in closed areas such as buildings, hospitals, libraries, museums, etc. is known as indoor aerobiology whereas outdoor aerobiology is concerned with the survey of biological materials in open spaces such as crop fields, forests, etc. Aerobiological sampling methods are very diverse and differ according to individual's interest in the component of airspora to be studied. The sound and efficient techniques are essential to understand the composition of airspora.

AEROBIOLOGY BOTH AS A TOOL AND DISCIPLINE

In fact, aerobiology is a limitless science. It has been used as a discipline and as well as a tool for other disciplines such as medicine (allergology – both human & animal diseases, immunology, occupational hygiene), agriculture (plant pathology, pest management, arthropod dispersal), forestry & gene ecology, meteorology, climatology, biometeorology, microbiology, biodeterioration, indoor air quality, air pollution, industrial aerobiology, cultural heritage, palaeobotany, etc.

Aerobiology and Forestry

It is well known that air-borne spores, conidia and mycelial fragments are important infecting agents of plant communities. Aerobiological investigations pertaining to diseases of forest trees provide useful information in reducing the loss of vegetation. More attention is to be paid to horticultural crops of humid tropics of Indian subcontinent.

Aerobiology and Gene Ecology

The knowledge of transfer of genetic material from one geographic region to another is important so as to know the mechanism of dispersal of microbes and other aerobioparticles. Atmospheric dispersal of viable pollen is equally important in breeding of crop plants and forest trees. The knowledge about the sources of such viable propogules would be helpful in resolving many problems that are of considerable economic importance.

Aerobiology and Plant Pathology

Majority of plant pathogens which cause disease are air-borne and have an active or passive mechanism of liberation of their spores in turbulent air. Bacteria, viruses, mycoplasma and fungal spores dominate among the aerobioparticles. Their numbers and types may vary with time of day, season, geographical locations and sources. Grasses and cereal crops are important sources of the fungal spores and they often dominate the airspora. Crops and stored crops are studied aerobiologically and are often found implicated in respiratory diseases of man and animals caused by actinomycetes and fungi, of which 'farmer's lung disease' is the classic example. Thus, aerobiology is useful both to agriculturist and plant pathologists in their ultimate aim of protecting the crops. The efficient forecasting system is to be developed for effective spray schedule and uses of both pesticides and fungicides.

Aerobiology and Biodeterioration

An application of aerobiology in relation to biodeterioration of materials in stores, warehouses, museums, libraries is an emerging field of research (Khandelwal, 2002, 2003). The biodeterioration includes mildewing, rotting, staining, foxing of materials mainly by fungi. Aerobiology awaits extensive investigation on the damages done to paintings, stored food grains, leather articles and other valuables. The biodeteriogens are to be identified to reduce the enormous losses.

Aerobiology and Reconstruction of vegetational history

Palynology has played a significant role in reconstructing past climates and cyclic recurrence of warm and cold, wet and dry periods during the last several million years. This is usually done by reconstructing the past vegetation patterns from their pollen and spores, comparing them with their modern counterparts and inferring the same climatic pattern as of modern times. Air plays important role in transportation of pollen grains from one plant to another plant. Wind pollinated plants produce enormous quantity of pollen grains, out of which majority of them settle down by gravity or rain-wash on the surface of ground or lakes, swamps and marshes. Later on, these pollen grains are deposited every year and get preserved in the bottom of the lakes entombed by the sediments. Their living contents are destroyed in course of time but their resistant wall is preserved permanently. Their recovery by chemical treatment from sediments of ancient lakes imparts the knowledge of flora and fauna that had formerly existed on the surface of the earth.

Aerobiology and Eco-friendly afforestation

All over in the country different agencies such as Development Authorities of the cities, Municipal Councils and Corporations, Forest Department and NGOs undertake large-scale plantation of trees and shrubs in green-belts, woodlands, along road-sides, parks, public places, national parks and sanctuaries. The database generated on aerobiological and immunological studies has proved the allergenicity of several plants. They trigger the allergic symptoms in hypersensitive individuals. It has been estimated that more than 10 percent population suffers from naso-bronchial allergy. Despite the availability of data regarding allergy causing plants for the last five decades, several allergenically significant plants are still being planted by various agencies. These include *Ailanthus excelsa, Morus alba, Prosopis juliflora, Putranjiva roxburghii, Salvadora persica, Holoptelea integrifolia, Albizzia lebbek*, etc. The plantation of such aeroallergenic trees should be discouraged with the integration of available

aerobiological information at the planning stage itself. It is the need of hour to sensitize horticulturists, foresters, botanists and others associated with eco-development board, national tree plantation and afforestation programmes so that respiratory health hazards could be minimised in future.

Aerobiology and Human diseases

The importance of aerobiological researches in causation of respiratory diseases has been well documented. Air-borne particles of biological origin are matter of concern to both aerobiologists and allergists. Airborne dust and its particles, which include mold spores, animal danders, mites and other allergens in indoor air are the major source of allergic reaction. Environmental biopollutants such as pollen grains and fungal spores may incite allergic responses in susceptible individuals. Every individual who has allergies is unique and generalisation is not possible. The analysis of environmental biopollution is an important issue related with health hazards of living systems. At Aerobiology Research Laboratory, attempts are made to identify all potential aeroallergens, their diurnal and seasonal distribution in the atmosphere. It is hoped that its prevention and control would be within our reach and command to achieve health for all living system in near future.

Annual pollen & fungal spore calendars and their importance

Aerobiological studies have gained significant importance in the recent years because of its application in the diagnosis and treatment of allergic disorders such as allergic rhinitis, bronchial asthma, atopic dermatitis and Urticaria, etc. In general allergic rhinitis, also called "Hay-fever", varies from 6 to 12% in USA, Canada, Finland, New Zealand and Australia. Preliminary statistics available from India suggest that nearly 10% of the population suffer with this syndrome. Extensive aerobiological investigations have been carried out in India and abroad. These investigations have been helpful in the estimation and correct assessment of the allergenic pollen and spore load in the atmosphere. Regional pollen and spore calendars are available which are based on seasonal variation and circadian periodicity. The pollen grains of ragweed (*Ambrosia*) in United States of America and mainly grasses in Europe and south-east Asia have been recognized aeroallergenic. Similarly in India, some tropical plants such as *Holoptelea*, *Ricinus* and *Prosopis* of Gangetic plains, coastal plants viz., *Cocos, Borassus* and *Anacardium* in Penninsular region, temperate plants namely *Pinus, Quercus, Betula, Alnus* in Himalayan region have been identified as aeroallergenic. A close coordinated work by aerobiologists and allergists would contribute in the management of asthmatic patients in more meaningful manner.

Cunningham (1873) pioneered first systematic aerobiological work in India at Calcutta. Later on, two important centers S.M.S. Medical College at Jaipur and Vallabhbhai Patel Chest Institute at Delhi initiated the aerobiological investigation with particular emphasis on clinical relevance of air-borne pollen. Now the aerobiological studies have its own national network at many centres in the country such as Kolkatta, Bangalore, Gwalior, Chennai, Hyderabad, Imphal, Gorakhpur, Poona, Aurangabad, Delhi, Nagpur, Lucknow, etc.

Lakhanpal and Nair (1958) earlier carried out the survey of atmospheric pollen grains at B.S.I.P., Lucknow. In the year 1969, the analysis of aeromycoflora was incorporated along with pollen studies in order to complete the picture of the aerobiota (Vishnu Mittre & Khandelwal, 1973). During the year 1976-77, the survey of air-borne fungal flora of Lucknow University area was conducted in relation to plant and surface mycoflora (Wadhwani, 1979). A two-year (1980-81) survey of air borne pollen alone was carried out in the National Botanical Research Institute, Lucknow (Chaturvedi *et al.*, 1987-88). The qualitative and quantitative evaluation of important pollen grains and fungal spores of year 1969-70, 1970-71 and 1983-86 have been found useful for ready assessment of daily fluctuations in their frequencies (Vishnu Mittre & Khandelwal, 1973; Khandelwal, 1991, 1992). The aerobiological data generated over a period of four years in All India Coordinated Project entitled "Aeroallergens and Human Health: Aerobiological studies" at BSIP, Lucknow employing three internationally recognized samplers viz., Burkard, Rotorod and Andersen could not be compared with earlier records due to changed methodology and sampling sites. However, forty-three types of pollen grains, forty types of fungal spores and thirty-six types of fungal colonies were registered. The qualitative and quantitative variation in number and composition of airspora has been recorded from both urban and suburban areas (Khandelwal, 2001). The pollen grains of family Poaceae, fungal spores of *Cladosporium* and fungal colonies of *Alternaria alternata* were found dominant almost from all the investigated sites. Co-dominance was recorded by pollen grains of families Chenopodiacae/Amaranthaceae, fungal spores of *Alternaria*/'small round spores' and colonies of *Fusarium oxysporum /Penicillium funiculosum*. The Burkard air sampler has also been used for monitoring the Antarctic air (Bera & Khandelwal, 2003).

The pollen and spore calendars are useful in identifying allergies against particular airborne pollen and fungal spore types. However, the limitation of pollen calendar is the occurrence of year to year variation in both number and time of appearance of each type of pollen grains and fungal spores. The emphasis has been laid for continuous periodical monitoring at different sites in a given area in order to provide specific zonal data to local clinicians/allergists. The standard record of aerospora of Lucknow assembled so far is being utilized as a 'Ready reckoner' for periodic biopollutant predictions required for the treatment of various allergic disorders caused by air-borne pollen grains and fungal spores (Khandelwal, 2002).

Aeroallergenic pollen grains & fungal spores of Lucknow

The significant pollen allergens of Lucknow area, based on clinical investigation carried out at King George Medical College, Lucknow are *Amaranthus spinosus, Azadirachta indica, Chenopodium album, Cynodon dactylon, Cyperus rotundus, Holoptelea integrifolia, Prosopis juliflora, Putranjiva roxburghii, Ricinus communis* (Agnihotri & Singh, 1971; Khandelwal, 1974). Similarly, aeroallergenic fungal flora are *Alternaria alternata, Aspergillus flavus, A. fumigatus, A. nidulans, A. niger, A. terreus, Cladosporium cladosporioides, Curvularia lunata, Fusarium oxysporum, Helminthosporium spiciferum, Monilia* sp., *Penicillium citrinum, Phoma* sp., *Rhizopus* sp., *Trichoderma virde,* etc. (Jamil *et al.,* 1981, 1986; Wadhwani *et al.,* 1986). Besides, the role of intact pollen grains, microaerosols originating from the same or different taxa contributing towards total allergenic load are yet to be thoroughly studied.

Management of allergy

The first step in the treatment strategy for an allergic person is to avoidance of the allergen. Since it is not completely possible, and medication is usually essential for controlling the symptoms. The following steps are to be taken to control allergy:-

1. Allergen avoidance
2. Medication
3. Immunotherapy
4. Surgery

AEROBIOLOGY VISION 2005 AND BEYOND

Global aerobiological network

There is a need for the establishment of global network for aerobiological monitoring. Air monitoring has immense significance in weather forecasting. Identification and prevalence of clinically significant aerobiopollutants are the prerequisite and then dissemination of generated data in various parts of the world is needed where such data is unavailable.

Integrated and Co-ordinated National Programme

Aerobiology was basically developed at the junction of several traditional sciences just to answer questions specifically concerning these sciences. Since then, aerobiology has become a science in its own right – a multidisciplinary one. Although very effective groups are working together all around the world but the integrated or cooperative efforts are necessary to tackle such complex system has not been fully operational in the aerobiology community.

Similarly in India, there is no integrated and co-ordinated national program as yet on different aspects of environmental pollution, which is a serious lacuna in the promotion of better hygiene and health. The utility of existing detest, predictive models of specific pollutant are required for better understanding and proper management.

Storage of Data

At present, there is no means for keeping the account of acquired data of current studies in Indian aerobiology other than the efforts of the overseas centres. The International Association of Aerobiology exchanges information but there are no arrangements for data storage. It was felt that the SAROD (Storage and Retrieval of Atmospheric Data) and EPA (Environmental Protection Agency) should also handle the aerobiological data of other countries as well. Establishment of data retrieval centre and computer based forecasting system are important for avoidance strategies.

Standardization of methods and procedures

Characterization of different pollen allergens for their allergenic components is inadequate and efforts should be made to characterize and standardize most of the pollen allergens on global basis.

Education

Unfortunately, aerobiology is not officially taught at Indian Universities, except for a very few states, where it has been recently introduced in Science Courses at Graduation and Post-Graduation levels. The need for aerobiology to be identified both inside universities as an academic discipline and inside governmental institutes as a scientific discipline is presently strongly felt by the aerobiologists actively engaged in this field.

Forecasting System

Most of the advanced countries have devised an efficient integration of aerobiology with the early warning system for forecasting plant and human diseases by using mass-media such as newspaper, television, radio, electronic media, etc. A similar pattern of warning and prediction system should be evolved in our country, which might contribute towards a more direct and immediate benefit for local population in general and allergic patients in particular.

CONCLUSION

With the beginning of the new millennium, aerobiology is marching towards more comprehensive vision. The ramification of aerobiology in terms of its applications in wide spectrum of scientific and developmental pursuits, embracing Botany, Palaeobotany, Medicine, Agriculture, Forestry, Biodeterioration, etc, is well recognized. Aerobiologists should encourage closer collaboration among themselves and with the scientists working in related fields in order to achieve a more meaningful 'aerobiological spirit'. It may imply organizational and educational efforts and creativity, which in turn will also contribute to the motivation of young

aerobiologist with an exciting target to see the emergence of broader global understanding of the aerobiological phenomena.

REFERENCES

Agnihotri MS & Singh AB 1971. Observations on pollenosis in Lucknow with special reference to offending factors. Aspects of Allergy and Applied Immunology 5: 71-75.

Benninghoff WS 1991. Aerobiology and its significance to biogeography and ecology. Grana 30: 9-15.

Bera SK & Khandelwal A 2003. Aerospora over Southern Ocean and Schirmacher Oasis, East Antarctica. Current Science 85: 137-140.

Chaturvedi M, Datta K & Nair PKK 1987-88. A fresh survey of airborne pollen at Lucknow. Journal of Palynology (G.Thanikaimoni Memorial Volume) 23-24 : 117-143.

Cuninngham DD 1873. Microscopic examination of air. Government Printer, Calcutta.

Jamil Z, Khan BK, Mukherjee PK & Nath J 1981. Cutaneous reactivity to aeroallergens in respiratory allergy in Lucknow. Proceeding of IV International Palynological Conference, Lucknow (1976-77) 3: 512-514.

Jamil Z, Khan MM, Ali Abid, Tahir A, Rizvi SHI, Naqvi H & Misra AK 1986. Allergenic pollens and fungal spores from the air in Lucknow. Journal of Recent Advancement in Applied Sciences 1: 181-184.

Khandelwal A 1974. Studies in atmospheric pollen grains and fungal spores at Lucknow. Ph.D.Thesis, Lucknow University, Lucknow.

Khandelwal A 1991. Pollen and spore rain in Lucknow city during 1983-1986. *In:* Agarwal OP & Dhawan S (Editors)—Proceeding of International Conference. Biodeterioration of Cultural Property. N.R.L.C., Lucknow: 387-396.

Khandelwal A 1992. Aeromycological survey at Lucknow. Geophytology 21: 199-206.

Khandelwal A 2001. Survey of aerospora by Rotorod sampler in Lucknow, India: Qualitative and quantitative assessment. Aerobiologia 17: 77-83.

Khandelwal A 2002. Biodeterioration: an aerobiological approach. *In:* Mathur GN, Srivastava RB & Agarwal OP (Editors)—National Seminar on Biodeterioration of Materials, Kanpur. Part 2: 11-15.

Khandelwal A 2003. Sampling and estimate of fungal biodeteriogens of Lucknow, AICCM Bulletin, Australia 28: 76-79.

Lakhanpal RN & Nair P KK 1958. Survey of atmospheric pollen at Lucknow. Journal of Scientific and Industrial Research 17: 80-87.

Mandrioli P & Ariatti A 2001. Aerobiology: future course of action. Aerobiologia 17: 1-10

Vishnu Mittre & Khandelwal A 1973. Airborne pollen grains and fungal spores at Lucknow during 1969-70. Palaeobotanist 22: 177-185.

Wadhwani K 1979. Airborne fungal flora of Lucknow (University area). Journal of Palynology 15: 105-110.

Wadhwani K, Srivastava AK, Jamil Z, Rizvi HI, Misra AK & Naqvi H 1986. Allergenic aspergilli and smut spores from the air in Lucknow, Journal of Recent Advancement in Applied Sciences 1: 8-12.