J.Mycopathol.Res. 64(3) : 487-497, 2026, ISSN : 0971-3719 (Print), 2583-6315 (Online) doi.10.57023/JMycR.64.3.2026.487

REVIEW

Aerobiology and Air Samplers: To Protect Human and Environmental Health

SUBRATA RAHA
Department of Botany, Sidho-Kanho-Birsha University, Purulia- 723104, West Bengal

Received : 01.08.2026 Accepted : 29.08.2026 Published : 28.09.2026

With the improvement of research methods for studying airborne pathogens has come evidence indicating that microorganisms (e.g., viruses, bacteria, and fungal spores) from an infectious source may disperse over very great distances by air currents and ultimately be inhaled, ingested, or come into contact with individuals who have had no contact with the infectious source.The use of air sampling equipment that effectively captures targeted bioaerosols, the meteorological conditions, and the method of analysis are all necessary for accurate and dependable bioaerosol quantification and identification. There are different kinds of air samplers starting from the simple earlier models to modern mechanisms suited for collection of spores, pollens and other allergens from long distances. Passive and active air samplers are the two primary types of air samplers. Selecting the appropriate one can significantly impact the accuracy of air quality data because each has unique applications and benefits. A new model of Air sampler has been developed by us named as Chanda Air sampler.

Keywords : Aeromycology, air sampler, airborne pathogens, Rotorod Air sampler, Chanda Air sampler

INTRODUCTION

The air around us carries an innumerable invisible biomass of particulate matter of plant and animal origin. This aerial biomass consists of pollen grains, fungal spores, algal filaments, insects, scales, etc. Aerobiology is a scientific and multidisciplinary approach focused on the transport of biologically significant materials.

Aeromycology is a branch of aerobiology that focuses on the distribution, seasonal patterns, and effects of airborne fungi and their spores on ecosystems, agriculture, and human health.

After a long gap following Cunningham's work in Calcutta (1873), some Indian scientists started aerobiological work in the middle of the last century with an emphasis on plant pathology, among whom K. C. Mehta (1952) and T. Sreeramulu (1959) are noteworthy. T. Sreeramulu worked as a Professor & Head of the Department of Botany, Andhra University at Waltair (Visakhapatnam) until his untimely death on December 9, 1974.

In his short lifespan, he established aerobiological research in India and is also known as the Father of Indian Aerobiology. The major aeromycological contribution of T. Sreeramulu comprised of pathogenic fungal spore dispersal, especially airborne plant pathogens in crop fields. He trained research students such as A. Ramalingam, C. Subba Reddi, B. P. R. Vittal, K. V. Mallaiah, and S. T. Tilak, who became outstanding aero-biologists in India.

IMPORTANCE OF AIR SAMPLING

Some people are sensitive to moulds. Exposure to moulds can cause symptoms such as nasal stuffiness, eye irritation, wheezing, skin irritation, fever, shortness of breath and asthma. Some people suffer from chronic lung illnesses; obstructive lung disease may develop due to mould infections in their lungs. Exposure to

Correspondence: subrata-raha@skbu.ac.in
27th Prof. S.N.Banerjee Memorial Award Lecture organized by Indian Mycological Society delivered on 16th March 2026 at the Department of Botany, University of Calcutta

airborne pathogens is commonly shared by all human life. With the improvement of research methods for studying airborne pathogens has come evidence indicating that microorganisms (e.g., viruses, bacteria, and fungal spores) from an infectious source may disperse over very great distances by air currents and ultimately be inhaled, ingested, or come into contact with individuals who have had no contact with the infectious source. Airborne pathogens present a unique challenge in infectious disease and infection control, for a small percentage of infectious individuals appear to be responsible for disseminating the majority of infectious particles.

Early-warning systems for plant diseases are valuable when the systems provide timely forecasts that farmers can use to inform their pest management decisions. The data included for disease forecasting are temperature, precipitation, RH, dew point, solar radiation, wind speed, location, crop growth, epidemic onset, infection rate, age effect, temperature effect, wetness effect and aggregation.

WHY AIR SAMPLING?

- Monitoring air quality is crucial for environmental safety and public health.
- Various kinds of air samplers aid in the collection and measurement of contaminants.
- Passive and active air samplers are the two primary types of air samplers.
- Selecting the appropriate one can significantly impact the accuracy of air quality data because each has unique applications and benefits.

The use of air sampling equipment that effectively captures targeted bioaerosols, the meteorological conditions, and the method of analysis are all necessary for accurate and dependable bioaerosol quantification and identification.

TYPES OF AIR SAMPLERS

Rotorod sampler : Developed by W.A. Perkins,this collector is made up of two thin, impaction-medium-covered rods that rotate like an electric fan (Fig 1). Poor sampling effectiveness for particles <10 μm is a drawback (Agri Samplers Ltd.https://agri-samplers.co.uk/product/rotorod-spore-sampler/).

Sampling of bioaerosols was carried out using a Rotorod sampler by Kakde and Kakde (2012). Altogether, fifty-nine fungal spore types were recorded on the Rotorod strips from the air of a vegetable market in Nagpur. *Aspergillus/ Penicillium*, *Cladosporium*, and *Alternaria* were the most common spore types.

Crisp *et al.* (2013) used a Rotorod sampler for a volumetric study of spores in San Antonio, Texas, to compare with the Burkard 7-day recording volumetric spore trap and observed that the Burkard and Rotorod had significantly different median total mould counts (2,581 particles/m^3 vs. 951 particles/m^3).

Tauber trap: Henrik Tauber invented a non-volumetric pollen sampler in the 1960s. The Tauber trap is a passive deposition sampler that waits for pollen to fall into it, in contrast to “active” samplers that draw in air. Because its sampling technique closely resembles how pollen naturally settles into lake sediments or soil, it is the gold standard for paleoecology and quaternary science researchers (Fig 2). The trap has three primary components: the container, an aerodynamic lid with a hole in the middle (usually 5 cm in diameter), and the medium (a mixture of distilled water, glycerol, and a preservative such as formalin or thymol) (Krzywinski, 1977).

Fungal spore components of the atmosphere in Garki, Abuja, North-Central Nigeria, were surveyed by Ezike *et al.* (2016). A modified Tauber-like pollen trap was used to capture airborne samples. Throughout the sampling periods, a large number of fungal spores were captured, with *Alternaria, Fusarium, Cladosporium*, and *Curvularia* species predominating. These fungi are dermatophytic, causing a variety of skin conditions, and have been linked to allergy disorders.

Boehm’s Personal Pollen Collector: It is a specific device, developed by Dr G. Boehm (Medical clinician) and Leuschner (Botanist) of Switzerland, for individual hay fever sufferers to monitor their allergen exposure by collecting

Fig 1. Rotorod sampler
Source: Agri Samplers Ltd.

Fig 2. Tauber trap
Source: https://doi.org/10.1128/AEM.00724-17

Fig 3. Impinger
Source: SKC Ltd.

Fig 4. Button sampler
Source: SKC Ltd.

Fig 5. IOM sampler
Source: SKC Ltd.

airborne pollen directly onto a sticky surface for microscopic analysis. Aversion of the personal pollen collector was developed by the late Prof. S.T. Tilak. An improved version, Partrap FA52, is a battery-powered personal sampler used in aerobiology to collect airborne biological particles (Boehm and Leuschner, 1987).

Impingers: Impingers capture particles using a liquid medium. Usually, a suction pump draws sampled air into a tiny flask that holds the collection medium via a narrow intake tube. Any suspended particles are sucked into the collection liquid when the air suddenly changes direction upon contact with the liquid's surface (Fig 3). The collected liquid can be used to count live bacteria/ fungi. Quantification possible using the flow rate and sampling time (SKC, https:// www.skcltd.com/contact-skc.html).

Button sampler and the IOM sampler: Both the Button Sampler (Fig 4) and the IOM Sampler (Fig 5) are active, filter-based samplers used in environmental monitoring and occupational hygiene to gather airborne particles, especially the inhalable fraction, which includes pollen and fungi. Their intake design, flow rate, and handling of the collected sample are the main areas where they diverge. The Button sampler typically operates at a higher flow rate of 4 L/min, whereas the IOM sampler operates at a standard flow rate of 2 L/min for personal sampling (Adhikari *et al*. 2003; SKC, https://www.skcltd.com/products2/ sampling-heads/button-sampler.html).

Due to the complexity of bioaerosol composition and the absence of standardized sampling/ analysis techniques, Wang *et al.* (2015) carried out a study to thoroughly assess human bioaerosol exposure in occupational and indoor contexts. The bacterial concentration was found to be4983 CFU/m^3 in the Button sampler and 1523 CFU/m^3 in the IOM sampler, whereas inoutdoor settingsthe concentrations were 4261 CFU/m^3 in the Button sampler and 2034 CFU/m^3 in the IOM sampler. The Fungal concentration was found to be 1633 CFU/m^3 in the Button sampler and 872 CFU/m^3 in the IOM sampler, whereasthe concentration in outdoor settingswas 1060 CFU/ m^3 in the Button sampler and 2195 CFU/m^3 in the IOM sampler.

Two identical Button Samplers, one facing the prevailing wind and the other facing the opposite, were used to sample the airborne particles. A Rotorod Sampler was positioned next to each Button Sampler. The overall pollen concentration varied from 4 to 4536 pollen/m^3, while the total fungal spore concentration varied from 129 to 12,980 spores/m^3 (Adhikari *et al.* 2003).

SIGMA-2 sampler : Through sedimentation in the 2.5 µm to 100 µm range, the unique design of the Sigma-2 process achieves impaction of the particle sizes (Fig 6). After being adhered to an adhesive plate, the particles are examined under a microscope. The analysis's outcome displays the grain size distribution, which can then be used to compute an approximate PM10 value in conjunction with the particle count (Fiorina *et al.* 1997).

Hirst spore trap : The first aspiration sampler was created by J. M. Hirst (1952). This apparatus consists of an air-passage chamber that draws in air at 10 L/min. It directs the airflow via a 14 x 2-mm slit that is always oriented windward (Fig. 7). A vertical slide covered in petroleum jelly is exposed to the airflow exiting the slit. The slide moved relative to the slit at a rate of 2 mm/h (Hirst, 1952).

Dananché *et al*. (2017) used a feasible impaction sampler and HTST to sample indoor air. The three outdoor HTSTs collected samples with median total fungal burdens of 3,025.0, 3,287.5, and 3,625.0 particles/m_3. The viable impaction sampler found *Aspergillus* spp. in 63.1% of the indoor air samples, but HTST-I only revealed Aspergillaceae fungal burdens in 3.6% of the samples. Additionally, they suggested that the standard method for measuring fungal contamination of indoor air is still air sampling using a viable impaction sampler.

In Payerne (Western Switzerland), sixty-three propagule types (spores, sporangia, and hyphae) were identified in the air using the conventional approach of Hirst trap and microscope analysis. The average spore concentrations detected over the entire period were 4145 ± 263.0 spores/m^3. Average quantities of 26 different spore species exceeded 10 spores/m_3. In Payerne, airborne

Fig 6. SIGMA-2 sampler
Source: ssp-europe.com/chrom_e.html

Fig 9. Viable Six-stage Andersen cascade impactor
Source: https://tcr-tecora.com/en/laboratory-instruments/andersen-cascade-impactor-6-stage-viable/

Fig 7. Hirst spore trap
Source: https://doi.org/10.1007/s10453-025-09874-w

Fig 10. HiMedia air Petri sampling system mark II Source: https://www.himedialabs.com

Fig 8. Burkard Seven-Day Volumetric Spore-Trap
Source: Burkard Manufacturing Co Ltd

Fig 11. HiAirflow
Source: https://www.himedialabs.com

fungal propagules exhibited a distinct seasonal pattern, rising from early spring low values to summer peaks. From mid-June forward, daily average concentrations above 5000 spores/m_3 were nearly consistent throughout the summer (Fernández-Rodríguez *et al*. 2018).

Burkard Seven-Day Volumetric Spore-Trap: The Burkard Seven-Day Volumetric Spore-Trap (Fig. 8) was invented by the Burkard company in the late 1970s. The sampler that is entirely based on the Hirst principle. But it also has the benefit of impaction occurring onto a 345-mm band rather than onto a 76-mm slide, allowing for a continuous seven-day sample interval as opposed to the Hirst device's 24-hour duration (Burkard Manufacturing Co Ltd, https://burkard.co.uk/product/7-day-recording-volumetric-spore-trap).

For two years, from November 2002 to October 2004, the composition and variability of airborne fungal spores were investigated in an outdoor setting in a suburb of Kolkata using two complementary sampling techniques. The Andersen two-stage viable sampler was used to isolate the cultivable airborne fungus, while the Burkard 7-day volumetric sampler was utilized to monitor the overall fungal spore burden in the air. *Cladosporium*, unidentified ascospores, unidentified basidiospores, Aspergilli/Penicilli, *Nigrospora, Periconia, Chaetomium*, *Drechslera, Alternaria, Coprinus, Ganoderma, Pithomyces*, and rust spores were the most common among the 37 fungal spore types found in the air samples. The two samplers shared only six species of fungal spores: *Alternaria*, Aspergilli/Penicilli, *Cladosporium, Curvularia, Drechslera*, and *Nigrospora*. The non-viable sampling method (Burkard sampler) underestimated the spore concentration for *Drechslera, Nigrospora*, and Aspergilli/Penicilli (Das and Gupta-Bhattacharya, 2012).

José-Rodríguez *et al*. (2014) conducted a study in Badajoz, SW Spain, between March 2009 and July 2011. For the non-viable sampling, a Burkard fixed spore trap was employed. Throughout the investigation, daily average total concentrations of 1954 spores m_3 were reported, with a range of 93–10 274 spores m_3. For the first and second years of the study, the daily averages were 1,823 and 2,052 spores m_3, respectively. Autumn had the highest concentration of total spores (2845 spores m^{-3}), whereas October had the highest concentration (5121 spores m_3).

Viable six stage Andersen cascade impactor: The viable six-stage Andersen cascade impactor has six stages with 400 orifices each and six Petri dishes (Fig 9). It runs at 28.3 litres per minute. The collection of size-fractionated droplets and aerosols over several Petri dishes is made possible by the orifices' decreasing size as stage number increases, which also increases impaction velocity (Westech Scientific Instruments,https://www.viable-cisamplers.com).

In Taihang chicken houses, this study examined stage-specific differences in fungal aerosol concentration, size distribution, and community composition during three growth stages (15, 60, and 150 days). The amounts of culturable fungi rose considerably with avian age, from 3.16×10^3 CFU/m^3 to 1.24×10^4 CFU/m^3. ITS sequencing showed clear community changes between phases and gradual increases in fungal richness. At every stage, a number of potentially zoonotic fungi were found, such as *Aspergillus, Cladosporium, Cryptococcus*, and *Fusarium* (Yang *et al*.2025).

HiMedia air Petri sampling system mark II & Hi Airflow: It is a portable, automated, impaction-based air sampler used to track microbial contamination indoors, such as in hospitals. A normal 90 mm Petri dish filled with a culture medium is impacted by airborne particles after a known volume of air is drawn (30/60 /100 Litres/min) into it (Figs 10 &11). The 380 holes are intended to maximize colony dispersal on the agar and minimize overlapping (HiMedia,https://www.himedialabs.com/la637-air-petri-sampling-system-mark-ii.html).

Using two techniques—the exposure petriplate method and the HiMedia Air Sampler Mark-II method—air samples were taken from three sections of the hospital: the General Ward, the Outdoor Patient Department (O.P.D.), and the Operation Theatre (O.T.). The Hi-media air

Fig 12. Burkard Personal volumetric air sampler
Source: Burkard Manufacturing Co Ltd

Fig 13. Tilak sampler

Fig 14. Image recognition systems (BAA500)
Source:https://www.faulhaber.com/en/motion/automatic-pollen-monitors/

Fig 15. Optical/Light-scattering monitors (WIBS)
Source: https://benchmarkmonitoring.com.au/wibs-5

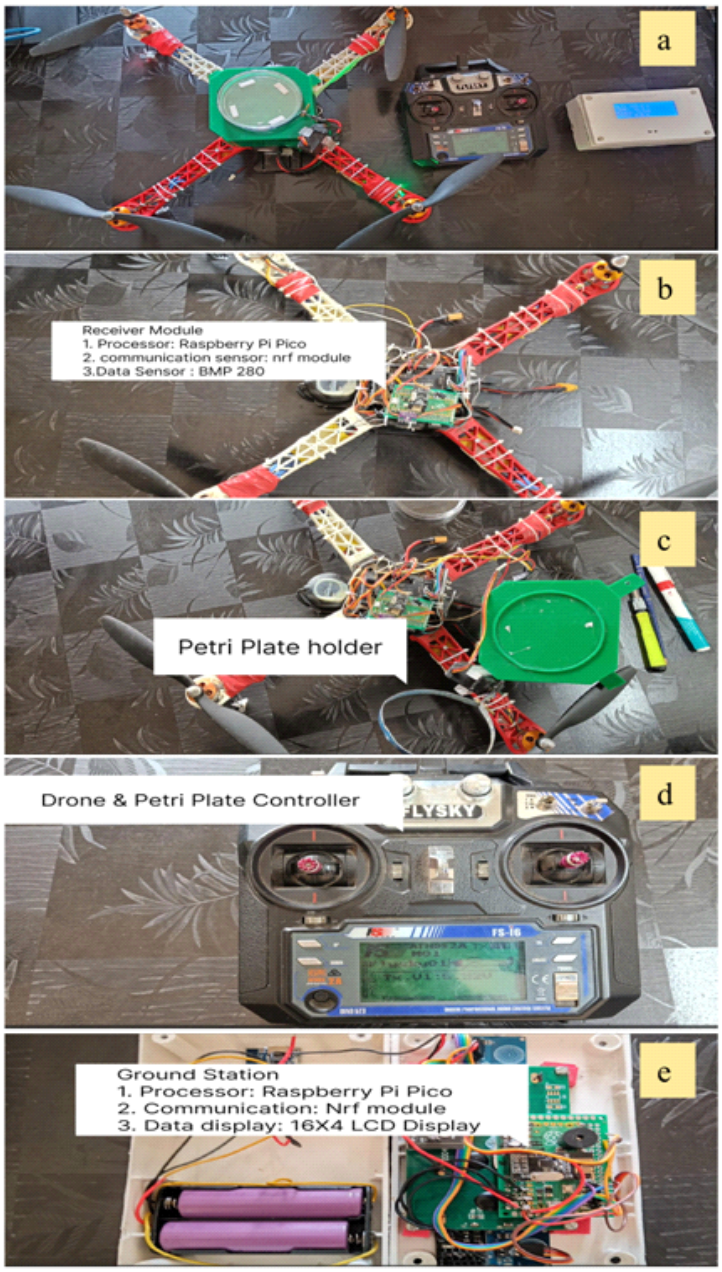

Fig 16. a. Chanda Air Sampler; b. Designed receiver module; c. Petri plate holder with a servo motor connected; d. Drone and Petri plate controller; e. Ground station

sampler method shows a total of 6990 CFU/m^3. The O.P.D. portion had 2575 CFU/m^3, whereas the General Ward had 2370 CFU/m^3 and the O.T. part had 2045 CFU/m^3. *Aspergillus, Cercospora, Mucor, Penicillium, Rhizoctonia, Cladosporium, Rhizopus*, and *Alternaria* are among the fungi found indoors in hospitals (Kukreja *et al*. 2025).

Burkard personal volumetric air sampler: A compact, volumetric air sampler that weighs just 590 grams and gathers airborne particles straight onto glass slides (Fig 12). Specifically made for short-term sampling in industrial or residential settings without power supplies. The instrument operates at a nominal air throughput of 10 litres per minute, and the impaction orifice is positioned in the vertical plane. The sampler, which is powered by a highly accurate DC motor, can run on batteries or the mains and is totally safe in both residential and dangerous environments. The knurled upper ring, which may be moved to the "open" position indicated by the alignment of the red dots, makes changing the glass slide quick and easy. Glass slides that are standard 76 x 26 mm or 3 x 1 inch can be used (Burkard Manufacturing Co Ltd, https://burkard.co.uk/product/personal-volumetric-air-sampler/).

For two years in a row, two portions of a sizable rural indoor cattle shed in West Bengal, India, underwent volumetric measurement of airborne culturable and nonculturable fungal spores. Culturable fungi were sampled using an Andersen Two-Stage Viable Sampler, and nonculturable fungi were collected using a Burkard Personal Slide Sampler. There were 35 different types of viable colony-forming units and 31 different types of spores. The concentration of viable colony-forming units ranged from 165 to 2225 CFU/m^3, whereas the average concentration range of total fungal spores was 233–2985/m^3. Aspergilli/Penicilli, *Cladosporium, Alternaria*, and smut spores were more common in the Burkard Sampler. *Aspergillus niger, Aspergillus flavus*, and *Cladosporium cladosporioides* colonies were prevalent in the Andersen Sampler (Adhikari *et al*. 2004).

Pyrri and Kapsanaki-Gotsi (2007) conducted a comparative study of airborne fungi in Athens, Greece, using viable and non-viable sampling methods. They captured the culturable part of the mycobiota using a portable Burkard air sampler with agar plates. A total of 19 genera of fungi (*Alternaria, Arthrinium, Aspergillus, Aureobasidium, Botrytis, Chrysonilia, Cladosporium, Drechslera, Epicoccum, Fusarium, Mucor, Nigrospora, Paecilomyces, Penicillium, Rhizopus, Sclerotinia, Scopulariopsis, Trichoderma*, and *Ulocladium*) were identified. The whole mycobiota, including the non-culturable and non-viable fraction, was detected concurrently using a volumetric Burkard air sampler for glass slides. Conidia of the genera *Curvularia, Helminthosporium, Periconia, Pestalotiopsis, Pithomyces, Polythrincium, Stachybotrys, Stemphylium,* and *Torula* were also noted, along with ascospores, basidiospores, spores of Myxomycetes, Ustilaginales, Uredinales, and Erysiphales, and teliospores of *Puccinia*. Both samplers were only able to recover seven of the genera. The viable method underestimated the total number of fungal spores, which had a maximum concentration of 3,175 spores/m^3, as well as the spore concentrations of the genera *Alternaria* (280 spores/m^3) and *Cladosporium* (2,565 spores/m^3).

Research utilizing the Burkard personal volumetric air sampler has demonstrated that 'Aspergilli' were the predominant contributors in the air of the storage area, succeeded by *Curvularia* and *Alternaria* spores. In terms of months, August was the predominant contributor to the total spore count (Gorai *et al*. 2022).

Tilak sampler: In aerobiology, the Tilak sampler, also known as Tilak's Continuous Air Sampler (Fig 13), is a form of active, volumetric air sampler that is widely used to gather pollen and fungal spores for microscopic examination. The apparatus continuously and steadily sucks in a predetermined amount of air, usually 5 litres per minute (L/min). This makes it possible to quantify the amount of bio-components in the air (such as spores and pollen per cubic meter). The sampler continuously samples the air using an electric power source (AC-220 V). A translucent cellotaph (1.5 cm in width) is adhered to the slowly revolving drum. The drum offers a trace of microbial and pollen capture in eight days, since it completes one round in that time (Monitoring of airborne microbes, 2012).

Karne (2011) conducted an aeromycological study to assess the qualitative and quantitative prevalence of fungal air pollutants over maize. Environmental surveillance was conducted using a continuous volumetric Tilak air sampler, which provided ongoing air sampling for atmospheric aerobiopollutants. In addition to dust particles, a total of 44 varieties of aerobiopollutants were captured in the sampler, with 39 classified as fungal spore kinds. Out of these, 25 were classified under Deuteromycotina, 9 under Ascomycotina, 2 under Basidiomycotina, 2 under Mastigomycotina, and 1 under Zygomycotina, with the other 5 types categorized as non-fungal spore groupings. Aerobiopollutants reached their zenith in February, recording 29582/m^3 of air and 37.7% spore concentration, coinciding with 4.6 mm of precipitation, an average temperature of 21.3°C, and 54.6% relative humidity. Chate and Gaikwad (2022) examined the aeromycoflora during the Kharif Season in a Groundnut Field located in Ausa District, Latur, utilizing Tilak's continuous air sampler and the Petri Plate exposure technique. The data collection occurred from June 6, 2018, to October 4, 2018.The Deuteromycetes represent the predominant category, encompassing 31 varieties of fungal spore, accounting for 62.14%, succeeded by Ascomycetes with 14 types of fungal spores at 17.34%, while Zygomycetes comprise 4 types of fungal spores at 2.39%, and Basidiomycetes also consist of 4 types of fungal spores at 10.78%. Oomycetes comprise two categories of spores (0.65%), while other classifications consist of four types contributing (6.67%).The overall spore concentration recorded during the investigation at Wagholi was 284310/m^3.

Image recognition systems (BAA500): These devices gather pollen (Fig 14) onto a surface using a volumetric sampling mechanism, such as an impactor, and then automatically identify and count the different types of pollen in real-time or almost real-time using an integrated camera and image recognition software (Oteros *et al*. 2020).

Prompt surveillance is essential, as spores can swiftly trigger infections or allergic reactions. Traditional Hirst-type samplers depend on laborious microscopic examination, constraining near real-time reporting. Automated measurement techniques present a viable option; however, their efficacy in counting various fungal spore sizes and shapes is still uncertain. This research assesses the efficacy of the BAA500 and Hirst-type samplers for five categories of fungal spores classified by size: tiny (*Cladosporium, Ganoderma*), medium (*Epicoccum, Polythrincium*), and large (*Alternaria*). Following the classification of genus data, the BAA500 successfully differentiated all categories. The BAA500 exhibited peak capture efficiency for medium-sized spores, achieving concentrations of *Epicoccum* and *Polythrincium* that were 2.1 and 3.4 times higher, respectively, whereas small spores were significantly overestimated by over tenfold in comparison to the Hirst-type sampler (Žilka *et al*.2026).

Despite the widespread acknowledgement of *Alternaria* spores as allergenic fungal particles, automated bioaerosol detection systems have yet to be trained to identify these entities. González-Alonso *et al*. (2023) documented the creation of a novel algorithm capable of categorizing *Alternaria* spores utilizing BAA500 automatic bioaerosol sensors.

Optical/Light-scattering monitors (e.g., WIBS): Without the need for physical collection, these sensors continuously analyse airborne particles in real time using light scattering and fluorescence, classifying them according to size, shape, and optical characteristics (Fig 15). TheWIBS-5/NEO is the world's only instrument for real-time, single-particle measurement of atmospheric bacteria, moulds, pollen, and other bioaerosols. WIBS-5 measures fluorescence to infer the presence of biological material in particles and provides detailed data on size, relative measure of shape, and fluorescent properties to enable classification of pollen, bacteria, and fungi (Droplet Measurement Technologies).

The Hirst-type impactor/optical microscope combo was found to exhibit lower daily concentrations than the WIBS-4 equipment on average.In actuality, the number concentrations reported by the WIBS-4 were around double that of impaction. It should be emphasized again,

nevertheless, that the methods are founded on very distinct ideas. Because only a fraction of the sample is actually analyzed and counted by eye with a lower size limit of about 2 µm, the traditional approach is therefore operator-dependent.On the other hand, all fluorescent particles larger than 2 mm are directly counted by the WIBS-4 (Fernández-Rodríguez*et al.* 2017).

IDENTIFICATION OF RESEARCH GAP IN AIR SAMPLING

Researchers face significant challenges in collecting viable airborne microbiome from:

- Remote locations
- Different altitudes
- Places with high risk of infectious diseases.

It is also difficult to assemble meteorological information from these remote places (variations in microclimate).

Chanda Air Sampler: A UAV integrated system for bioaerosol monitoring in remote locations and atmospheric layers

To address this limitation, an attempt has been made to design and develop a drone-based airborne microbial collection system capable of sampling microorganisms at different altitudes and localities (Fig 16a).

The system incorporates a mechanically actuated paired Petri plate assembly mounted exclusively on the upper surface of a multirotor aerial platform. Each sterilized, culture-media-containing Petri plate is operated through a servo-driven hinge mechanism that enables precise opening and closing, remotely controlled by the pilot via a dedicated transmitter switch. This configuration ensures controlled exposure duration during sampling while reducing contamination during ascent, descent, and landing.

The unmanned aerial vehicle (UAV) is built around an APM 2.8 flight controller, integrated with a six-channel PWM receiver–transmitter system for real-time manual and auxiliary control. A GPS module provides accurate positional and altitude data, allowing systematic microbial sampling at predefined atmospheric layers. Altitude control is managed by the pilot to facilitate targeted aerobiological investigations.

The instrument is composed of the following units :

- ❑ Receiver module fixed to the drone (Fig 16b)
- ❑ Processor
- ❑ Communication sensor
- ❑ Data sensor
- ❑ Casing and platform with petriplate holder and servo motor (Fig 16c)
- ❑ Drone and petriplate control unit (Fig 16d)
- ❑ Ground station (Fig 16e)

The proposed system shows strong potential for applications in aerobiology, atmospheric microbiology, environmental monitoring, public health research, and ecological studies, offering a scalable alternative to conventional ground-based sampling techniques.The integration of mechanical, electronic, and navigational subsystems results in a compact, reliable, and cost-effective platform for airborne microbial surveillance.The authors propose naming the sampler “Chanda Air Sampler” in remembrance of the renowned aerobiologist, late Prof. Sunirmal Chanda. The patent publication number IN202631096081A1 dated 14.08.2026, Journal number 33/2026.

ACKNOWLEDGEMENT

I owe my deepest gratitude to Prof. Balen Nandi, Retired Professor, The University of Burdwan, whose charismatic personality and profound knowledge inspired me to pursue a career in mycology and plant pathology.

I express my sincere gratitude to Prof. Kashinath Bhattacharya and Prof. Swati Gupta Bhattacharya, for providing me with important information.

I am thankful to Dhrubajyoti Chattopadhayay, District Science Officer and Subhradeep Karmakar, Mentor (Electronics), District Science Centre, Purulia for developing the prototype of the sampler.

DECLARATION

Conflict of Interest. Authors declare no conflict of interest.

REFERENCES

Adhikari, A., Martuzevicius, D., Reponen, T., Grinshpun, S.A., Cho, S.H., Sivasubramani, S.K., Zhong, W., Levin, L., Kelley, A.L., Clair, H.G.S., LeMasters, G. 2003. Performance of the Button Personal Inhalable Sampler for the measurement of outdoor aeroallergens. *Atmosph. Environ*. **37**:4723-4733.

Adhikari, A., Sen, M. M., Gupta-Bhattacharya, S., Chanda, S. 2004. Volumetric assessment of airborne fungi in two sections of a rural indoor dairy cattle shed. *Environ. Intern*. **29**: 1071-1078.

Boehm, G., Leuschner, R. M. 1987. Experiences with the 'Individual Pollen Collector' developed by G. Boehm. In:*Advances in aerobiology* (Eds. G. Boehm and R. M. Leuschner) **51**: 87–88. Birkhäuser.

Chate, D. B., Gaikwad, U. A. 2022. Study of Aeromycological investigation of Kharif Season over the Groundnut Field from Ausa District Latur. *Inter. J. Adv. Res. Sci. Commun. Technol.* **2**: 513-516.

Crisp, H. C., Gomez, R. A., White, K. M., Quinn, J. M. 2013. A side-by-side comparison of Rotorod and Burkard pollen and spore collections. *Ann. Allergy, Asthma Immunol*. **111**: 118-125.

Dananché, C., Gustin, M. P., Cassier, P., Loeffert, S. T., Thibaudon, M., Bénet, T., Vanhems, P. 2017. Evaluation of a Hirst-type spore trap to monitor environmental fungal load in hospital. *PLoS One*. **12**: e0177263.

Das, S., Gupta-Bhattacharya, S. 2012. Monitoring and assessment of airborne fungi in Kolkata, India, by viable and non-viable air sampling methods. *Environ. Monitor. Assess*. **184**: 4671–4684.

Ezike, D. N., Nnamani, C. V., Ogundipe, O. T., Adekanmbi, O. H. 2016. Airborne pollen and fungal spores in Garki, Abuja (north-Central Nigeria). *Aerobiologia*. **32**: 697-707.

Fernández-Rodríguez, S., Tormo-Molina, R., Lemonis, N., Clot, B., O'connor, D. J., Sodeau, J. R. 2018. Comparison of fungal spores concentrations measured with wideband integrated bioaerosol sensor and Hirst methodology. *Atmosph. Environ*. **175**: 1-14.

Fernández-Rodríguez, S., Tormo-Molina, R., Maya-Manzano, J. M., Silva-Palacios, I., Gonzalo-Garijo, Á. 2014. Outdoor airborne fungi captured by viable and non-viable methods. *Fungal Ecol*. **7**: 16-26.

Fiorina, A., Scordamaglia, A., Mincarini, M., Fregonese, L., Canonica, G. W. 1997.Aerobiologic particle sampling by a new personal collector (Partrap FA52) in comparison to the Hirst (Burkard) sampler. *Allergy* **52**: 1026–1030.

González-Alonso, M., Boldeanu, M., Koritnik, T., Gonçalves, J., Belzner, L., Stemmler, T., Gebauer, R., Grewling, £., Tummon, F., Maya-Manzano, J.M.,Ariño, A.H. 2023. *Alternaria* spore exposure in Bavaria, Germany, measured using artificial intelligence algorithms in a network of BAA500 automatic pollen monitors. *Sci. of the Total Environ*. **861**:160180.

Gorai, S., Bhattacharya, K., Raha, S.2022. Aeromycological study of storage place with reference to fungal succession and deterioration of rice grains. *Ind. J.Aerobiol*. **35**: 25-33.

Hirst, J.M. 1952. An automatic volumetric spore trap. *Ann. Appl. Biol*. **39**: 257-265.

Kakde, U. K., Kakde, H. U. 2012. Incidence of post-harvest disease and airborne fungal spores in a vegetable market. *Acta Botanica Croatica*. **71**: 147-157.

Karne, A. V. 2011. An investigation of fungal aerobiopollutants in the ambient air over maize fields. *Nature, Environ.Pollution Technol*. **10**: 609-612.

Krzywinski, K. 1977. The Tauber pollen trap, a discussion of its usefulness in pollen deposition studies. *Grana*.**16**: 147–148.

Kukreja, S., Katre, N. B., Mungole, A. 2025. Aeromycological indoor environmental study of KTS General Hospital Gondia (Maharashtra), India. *The Bioscan*. **20**: 39-44.

Oteros, J., Weber, A., Kutzora, S., Rojo, J., Heinze, S., Herr, C., Gebauer, R., Schmidt-Weber, C. B., Buters, J. T. M. 2020. An operational robotic pollen monitoring network based on automatic image recognition. *Environ. Res*. **191**: 110031.

Pyrri, I., Kapsanaki-Gotsi, E. 2007. A comparative study on the airborne fungi in Athens, Greece, by viable and non-viable sampling methods. *Aerobiologia*. **23**: 3–15.

Tilak, B.S.2012. Monitoring of airborne microbes (Practical Manual). 2nd edition.

Wang, C. H., Chen, B. T., Han, B. C., Liu, A. C. Y., Hung, P. C., Chen, C. Y., Chao, H. J. 2015. Field evaluation of personal sampling methods for multiple bioaerosols. *Plos One*. **10**: e0120308.

Yang, Y., Yang, Z., Ren, Z., Feng, W., Li, Z., Lu, Y., Yan, M., Liu, Z., Zhu, R., Liu, M., Chen, X., Zhang, C., Dong, S., Cui, H., Liu, H. 2025. Fungal Aerosol Exposure and Stage-Specific Variations in Taihang Chicken Houses During Winter. *Microorganisms*. **13**: 2856.

Žilka, M., Alashhab, S., Šèevková, J., Schmidt-Weber, C. B., Wessels, I., Buters, J., González-Alonso, M. 2026. Advances in automatic airborne fungal spore monitoring: detection-efficiency test of the BAA500. *Environ. Pollution*. 128148.