It is important to note that geography and climate play an important role in determining the microbial concentrations because the transport of bioaerosol is primarily governed by hydrodynamic and kinetic factors, while their fate is dependent on their specific chemical makeup and the meteorological factors to which they are exposed. The presence of people is the most significant parameter resulting in elevated indoor bioaerosol counts in the absence of significant indoor or outdoor sources. Hence, it is essential to evaluate the quality of air we breathe, whether indoor or outdoor. The number of airborne microorganisms can indicate the degree of cleanliness and may be a source of human discomfort. The results of the present work have clearly demonstrated various outdoor and indoor microorganisms at different microenvironments and found that bioaerosol counts are an integral part of the indoor pollution characterization puzzle and important for quantification of airborne allergens and pathogens.

The present study measured the total bacterial and fungal concentrations in the outdoor and indoor air of various microenvironments under uncontrolled environmental conditions from January 2007 to December 2008. A total of 10 microenvironments (Outdoor – bus stand, railway station, recreation ground, sewage treatment plant and vegetable market; Indoor – home, hotel, office premise, public toilet and theatre) were selected for the study. In a microenvironment, 12 samples were surveyed at regular intervals of a month in a year. A total of 5495 cfu/m³ of bacteria was obtained in outdoor environment, of which 3032.5 (55.2%) and 2462.5 (44.8%) were observed during the year 2007 and 2008 respectively. Air samples in an outdoor microenvironment of recreation ground were observed a highest number of total bacteria (1332.5; 24.2%) in the two year study period.

A total of 4845 cfu/m³ of fungi was obtained in outdoor air, of which 2347.5 (48.4%) and 2496.5 (51.5%) were observed during the year 2007 and 2008 respectively. During the study period, air samples in a microenvironment of bus stand were observed a highest number of fungi (1045; 21.6%). In general, the outdoor air concentrations of total fungi were lower than the concentrations of the total bacteria. Of 4902.5 (cfu/m³) total bacteria in indoor air 2787.5 (56.8%) and 2115 (43.1%) were obtained in the year 2007 and 2008 respectively. In the microenvironment of home, a highest number of bacteria (1200; 24.5%) was obtained throughout the study period.
About 5055 cfu/m³ of fungi was obtained from the indoor environment, of which 2837.5 (56.15%) and 2217.5 (43.9%) were obtained during the year 2007 and 2008 respectively. A total of 1145 cfu/m³ (22.7%) was the highest in home among the indoor microenvironments. In general, indoor fungal concentrations were higher than the concentration of the indoor bacteria.

The month wise distribution of bacterial and fungal concentrations was noted to vary during each month in all the sampling environments and was not uniform throughout the study period. There was a less difference between outdoor and indoor bacterial counts in month wise distribution, ranging from 10.4% to 6.5% (outdoor) and 10.0% to 7.1% (indoor).

In extramural air, 8 different bacterial genera were studied, of which 3 of Gram positive (3125; 56.9%) and 5 were Gram negative (1510; 27.5%) types. Species of *Staphylococcus* and *Bacillus* were found to be the most prevalent bacteria and others such as species of *Micrococcus*, *Aeromonas*, *Escherichia*, *Pseudomonas*, *Klebsiella* and *Serratia* were also identified. In general, the concentrations of species of *Staphylococcus* and *Micrococcus* were significantly (P<0.05) greater in outdoor microenvironments. *Staphylococcus* was the predominant bacterial type in almost all outdoor air studies and had the highest count, constituting 21.6% of the total bacterial genera whereas the second predominant group was *Bacillus*, constituting 18.5% and the third *Micrococcus* of 17.2% of total.

A total of 9 different bacterial genera were identified in intramural air, of which 3 and 6 were Gram positive (3060; 62.4%) and Gram negative (1147.5; 24.2%) bacterial types respectively. Species of *Staphylococcus* and *Micrococcus* were the predominant bacterial groups. Species of *Bacillus*, *Aeromonas*, *Escherichia*, *Pseudomonas*, *Klebsiella*, *Serratia* and *Proteus* were also identified among the genera.

Species of *Staphylococcus* were present in almost all the indoor microenvironment studies; these bacteria had the highest count, constituting 26.6% of the total bacterial genera followed by *Micrococcus* constituting 24.1% of the total indoor concentration. These two bacterial genera were found to be significant (P<0.05) in indoor air.

Of the 9 different fungal genera studied, species of *Aspergillus* (1600; 33.0%) were found to be the most prevalent organisms in the outdoor air. Species of *Penicillium* and *Alternaria* were also found to be the second and third respectively. Organisms such as species of
Cladosporium, Curvularia, Fusarium, Mucor, Rhizopus and Trichoderma were also identified among the examined groups.

The outdoor fungal concentrations (Mean ± SD) of Aspergillus in 2007 and 2008 was significantly (P<0.05) greater than those of other organisms in the corresponding years from the microenvironment of bus stand, railway station, recreation ground, sewage treatment plant and vegetable market. Aspergillus seems to be the predominant fungus followed by Penicillium in 2007 and 2008 which were significantly (P<0.05) greater than those of the other species in the microenvironment of bus stand, sewage treatment plant and vegetable market.

The type and total number of fungal isolates were identified and grouped into 9 different genera from the intramural environment. A total number of 1865.5 cfu/m³ (36.8%) of Aspergillus spp. and 647.5 cfu/m³ (12.8%) of Penicillium spp. were found to be the most prevalent groups. The indoor fungal concentration of Aspergillus spp. differs significantly (P<0.05), the mean concentration of 2007 being significantly higher than that of 2008. Like outdoor environments, indoor concentration (Mean ± SD) of Aspergillus significantly greater than (P<0.05) than those of other species from the microenvironments of home, hotel, office premise, public toilet and theatre.

Correlation between monthly bacterial and fungal loads with various meteorological factors such as temperature (ºC), relative humidity (%), total rainfall (mm) and wind speed (km/h) were studied. No statistically significant difference was observed in the total overall yearly concentrations. The possible reason might be the insignificant changes of environmental factors during the sampling years.

The distribution percentage and total number of Aspergillus in various microenvironments were analyzed and a total of 1600 cfu/m³ in outdoor and 1862.5 cfu/m³ in indoor air were obtained. Among the outdoor microenvironments, vegetable market showed the highest percentage of 25.32 cfu/m³ and home environment had the highest percentage of 29.93 cfu/m³ of Aspergillus among the indoor microenvironments. There was no much difference in percentage distribution of Aspergillus in other microenvironments.

The highest monthly mean Aspergillus concentration (cfu/m³) of 18.3 ± 8.4 was observed during the month of June (summer) in 2007 and 17.5 ± 5.1 (cfu/m³) in February (spring), 2008. The annual concentrations of 26.7 ± 7.5 (2007) and 19.8 ± 9.2 (2008) were noticed the highest
and found to be significant (P<0.05) in home environment. In general, *Aspergillus* was the only predominant fungus present in almost all the microenvironments.

The relation between the microbial air quality and allergic status of the selected population in the sampling site (home) were evaluated. A total of 115 individuals (46 males and 69 females) from the volunteers in home environment were recruited as case study for the total immunoglobulin E level. 25 healthy individuals (11 males, 14 females) were included as control study.

Majority (32.2%) of case study subjects were studied from the age groups ranging between 21 and 30, and between 31 and 40 years, whereas a highest total of male (15 of 115; 13%) subjects were found to be the age group ranging between 21 and 30 years and female subjects (24 of 115; 20.9%) were observed in the age group between 31 and 40 years.

The percentage distribution of eosinophil was analyzed for the preliminary identification of allergic status. About 92.2% showed peripheral blood eosinophil counts within the normal range whereas 6.1% and 1.7% showed an elevated and a high eosinophil range respectively. The general presumption that fungi induced allergy is associated with peripheral blood eosinophil did not correlate with the present findings.

The most common *in vitro* test for assay of allergen activity is Enzyme Linked Immuno Sorbent Assay (ELISA) and was performed to study the immunoglobulin E antibody level as the serological index to relate with the allergic status. About 18.3% of the subjects had an elevated level of total IgE (> 160 IU/ml) whereas about 81.7% of the subjects showed no significant difference between the means of the different groups (< 160 IU/ml). The total IgE levels obtained here as reference ranges in individuals from a microenvironment of home might be useful for the diagnosis of fungal allergic disease.

The potential role of specific IgE antibody against *Aspergillus* was estimated by ELISA quantification method to study the fungal allergic status in study population. About 2.6% of the subjects had specific IgE level and the highest level of specific IgE was found to be ranging between 641 and 800 IU/ml. There are no internationally standardized species specific control sera available.

A mouldy home, the risk of asthma for its residents, associated with an exposure to the total mould or to some specific genera, probably increases with the inhalation of fungal particles
as well as their products. To remediate the high risk site (home), a suitable method was employed by appropriate air sanitation method to check its efficacy. Bacillocid is the commonly used, commercially available surface and environmental disinfectant that has very good cleansing property along with bactericidal, fungicidal, viricidal and sporicidal activity. The application of Bacillocid does not require shut down of the contaminated areas for 24 h with a viable count reduction of 99.9% over the parallel untreated control, after correcting for settling rates, in the air of the test enclosure.

The likelihood that a given individual will develop an allergic disease reflects a combination of genetic and environmental factors. But then, the knowledge on the presence of mould within indoor air is important to take remedial measures and provide relief to the people involved in the environments.

The present study suggests that the city of Chennai harbours various species of bacteria and fungi due to its warm and slight rainy climate and very rich flora. It is of significance that our findings may be of use with regard to the diagnosis and prophylaxis of allergic diseases thought to be resulting from air borne fungi, when using allergic tests the spectrum of the fungal genera examined in the selected environments (Home). This study may thus be of considerable assistance to scientist and clinicians working in this field in adopting preventive measures and/or selecting an appropriate antigen for diagnostic purposes.

The complexity of carrying out similar studies highlights the need for establishing valid approaches that would contribute and add to our aerobiological, epidemiological and clinical knowledge. The following recommendations are the outcome of the present study.

- A routine programme of building inspection and assessment can identify problems before complaints and building related symptoms occur.

- Monitoring of indicators other than concentrations may be helpful, for instance ventilation rates, general cleanliness and signs of dampness. In addition, it is necessary to investigate how people are exposed to pollutants in indoor air and how the exposure levels could be measured or estimated using computer models.

- Persons residing in air conditioned homes may have a higher frequency of respiratory complaints than those living in naturally ventilated homes.
• The air conditioning ducts should be kept free from dirt and spores. Any leaks in air conditioning ducts which might introduce dirt and should be checked and repaired.

• Manual scrubbing with brushes and flexible rods and whips and can assist in cleaning hard to reach dirt build up in air handling systems.

• Some commercial air duct cleaners are equipped with tiny fibre – optic cameras to assist in locating dirt build up and to confirm cleaning effectiveness.

• The exhaust ventilation fans could reduce the microbial counts and other air borne contaminants including volatile organic compounds and gasoline vapour, which directly or indirectly affects health. This intervention is simple and easy to implement because it does not require more resources or skills.

• Concentrations can be achieved by installing this new generation of hybrid air filters. Engineering control methods must be balanced with constraints such as occupant comfort, economic factors and building management strategies to ensure that the health risks associated with bioaerosol exposure are as low as practical.

• The use of HEPA filtration can be used to trap very small particles.

• Chemicals should also be applied to indoor air. The use of sanitizing solutions to kill mould and bacteriological growth opens the question of safety for humans and pets in the air conditioned area.

• Visible mould can be removed by disinfection with a chlorine bleach solution. The area being cleaned should be well ventilated, as chlorine itself is volatile and irritating.

• Proper identification and elimination of the microbial sources in occupational and house hold settings, maintenance of equipment, humidity control, natural ventilation, use of filters in ventilation and air cleaning by the use of disinfectants and biocides.

• More research and data are needed, particularly on particles and microbes, volatile organic compounds from consumer products, building dampness, levels of exposure and effects on vulnerable populations.

• All possible routes of exposure should be considered. Health based guideline values for key pollutants and other practical guidance should be developed.
• The impact of indoor exposure should be considered when evaluating the health effects of outdoor air pollutions. All relevant sources known to contribute indoor air pollution should be evaluated. A reasonable reduction in the bioaerosol adds to our aerobiological, epidemiological and clinical knowledge.