Foldscopic visualization and identification of Airborne Fungi in Museum and Library Environment

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Abstract: Tagore's Museum and Central library of Jadavpur University in Kolkata were selected for the monitoring of bioaerosols during the monsoon period from July 2018 to September 2018 by Two-Stage Viable Andersen Cascade Impactor. A total of 6 different fungal species were obtained. Each fungal species were viewed under Foldscope Microscope with 140x magnification. The most dominated fungal species were *Aspergillus* sp. (56.75%) followed by *Penicillium* sp. (27.02%), *Curvularia* sp. (5.40%), *Trichoderma* sp. (5.40%), *Cladosporium* sp. (2.70%) and *Diasporium* sp. (2.70%). These fungi were thought to be responsible for the biodeterioration of paper, paintings, and wooden sculptures, building materials and also allergen for the people working in the sampling location. The total fungal load (176 CFU/m^3) was above the recommended level of microbial contamination given by American Conference of Governmental Industrial Hygienists Guidelines (100 CFU/m^3) but below the World Health Organization Guidelines (500 CFU/m^3). Application of Foldscope for regular monitoring in both museum and library may be helpful for assessment of indoor environment quality.

Keywords **- Biodeterioration, museum, library, Foldscope, spot monitoring, fungal loads.**

I. INTRODUCTION

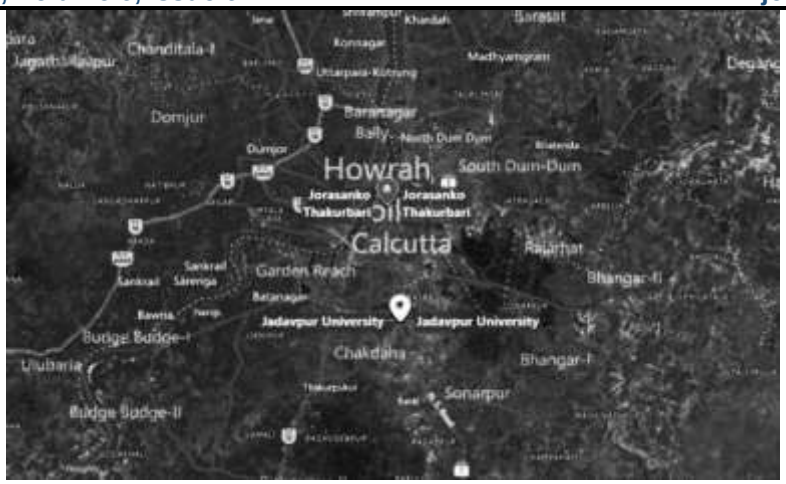
Biodeterioration risk of museum and library objects by fungi has attracted attention in recent years (Bhattacharyya et al. 2016). Fungal deterioration of museum and library objects causes various kinds of damage depending on the species of organism responsible for the attack as well as the characteristics of the substratum. Most of the fungal species that attack library materials come from dust and dust inhabitants (Florian, 2002). Due to their ability to form hyphal networks they penetrate materials deeply, resulting in material loss due to acid corrosion, enzymatic degradation and mechanical attack. Inappropriate ventilation or air-conditioning systems is one of the vital issues for supporting fungal growth which may cause fluctuations of temperature and humidity in cultural heritage environments (museums, libraries, archives). Fungi use organic substances as a source of nutrients and can utilize moisture present in the air (Naji et al. 2014). *Aspergillus*, *Penicillium*, *Alternaria*, *Aureobasidum* are the most common genera isolated from libraries/archives and museum environments (Mesquita et al. 2009).

Foldscopes is a portable and versatile origami microscope invented by Manu Prakash and Jim Cybulsky from Stanford University that has the potential to bring microscopy out of laboratories and into the hands of people around the world (Cybulsky et al. 2014).Its magnification power is enough to enable the spotting of different fungal species. Presently in India few institution has 'on spot' facilities to detect fungal spore and biodeterioration status of museum exhibit, archival documents and library materials. The low cost, user friendly Foldscope microscopic techniques may help to detect fungal contamination in the gallery or preservation room. Fungi in libraries, museums and their storage rooms can seriously threaten the health of the restorers, the museum personnel and the visitors due to their allergic potential, due to the production of mycotoxins and also due to their ability to cause systemic infections in humans (Crook and Burton, 2010).Hence, the present study was attempted to identify different airborne fungal species under foldscope microscope to attach it to a smart phone (Samsung Galaxy On Max) and also to determine the fungal loads (CFU/m^3) in museum and library environments.

II. MATERIAL AND METHODS

2.1 Study area

The Tagore museum at Jorasanko, North of Kolkata and Central library at Jadavpur University, South of Kolkata (Figure 1), West Bengal, India, were selected for the monitoring of airborne micro-fungi to access their availability using Two-Stage Viable Andersen Cascade Impactor. The museum and library conserve books, photograph, newspapers, oil paintings, manuscript, fabrics, furniture, etc.



(Source: http://www.bing.com/mapspreview)

Fig 1: Location map of study area: Tagore′s museum at Jorasanko and Central library at Jadavpur University

2.2 Culture media for fungi

Potato Dextrose Agar (PDA) media was used for isolation and quantification of total fungi. The composition of the Potato Dextrose Agar (Hi-Media, Mumbai, India) was 200 gm/l potatoes infused, 20 gm/l Dextrose (Glucose), 15 gm/l Agar. pH of the media was maintained at 5.6. The media was dissolved in distilled water, sterilized at 15 pounds per square inch (1.0546 Kg/cm²) pressure for 15 minutes using autoclave (G.B. ENTERPRISES), distributed in sterile petri dishes and solidified after cooling.

2.3 Sampling Strategies

Two-Stage Viable Andersen Cascade Impactor was used to collect the viable fungal spore. Before setting out for air sampling, the plates were acclimatized at room temperature and marked properly. They were carried out in an ice box, taped to each other. The sampler was installed at a relatively undisturbed location, not isolated from the rest of the room and at one meter height from the ground. The sampler was run for 10 minutes. After completion, each stage was opened carefully and the plates were taken out and its lid placed before it would have been contaminated by the air. The lids of the plates were tapped to eliminate the chances of reopening during transportation and then taken to the laboratory where they were kept in an incubator at 27°C for 7 days. After 7 days of incubation observed configured colonies were counted and identified based on their morphological features. Different fungal species produce different-kind of colony pattern, some colonies either by coloration or in different shapes (irregular to circular).

2.4 Microscopic identification

Slides were prepared for each colony after staining with Lacto phenol Cotton Blue and observed under Foldscope Microscope under 140x magnification. The fungi were then identified using its colonial morphology and microscopic appearance.

2.5 Determination of fungal load

Qualitative fungi concentrations were only estimated referring to culturable fungal colonies as CFU/m^3. The concentration of fungi per cubic meter of air was calculated from the following equation:

$$\text{Colony Forming Unit} = \frac{1000P}{RT} \text{CFU/m}^3$$

Where, P= number of colonies counted on the sample plate after correction using positive hole conversion table, T= duration (15 minutes) and R= air sampling rate (14 litre/minute).

III. Results and Discussions

Six different fungal species were collected from museum and library by Andersen two-stage viable (microbial) particle sampler during the monsoon period from July 2018 to September 2018and identified under foldscope microscope (Figure 2) because most of the fungi were encountered in this time interval.

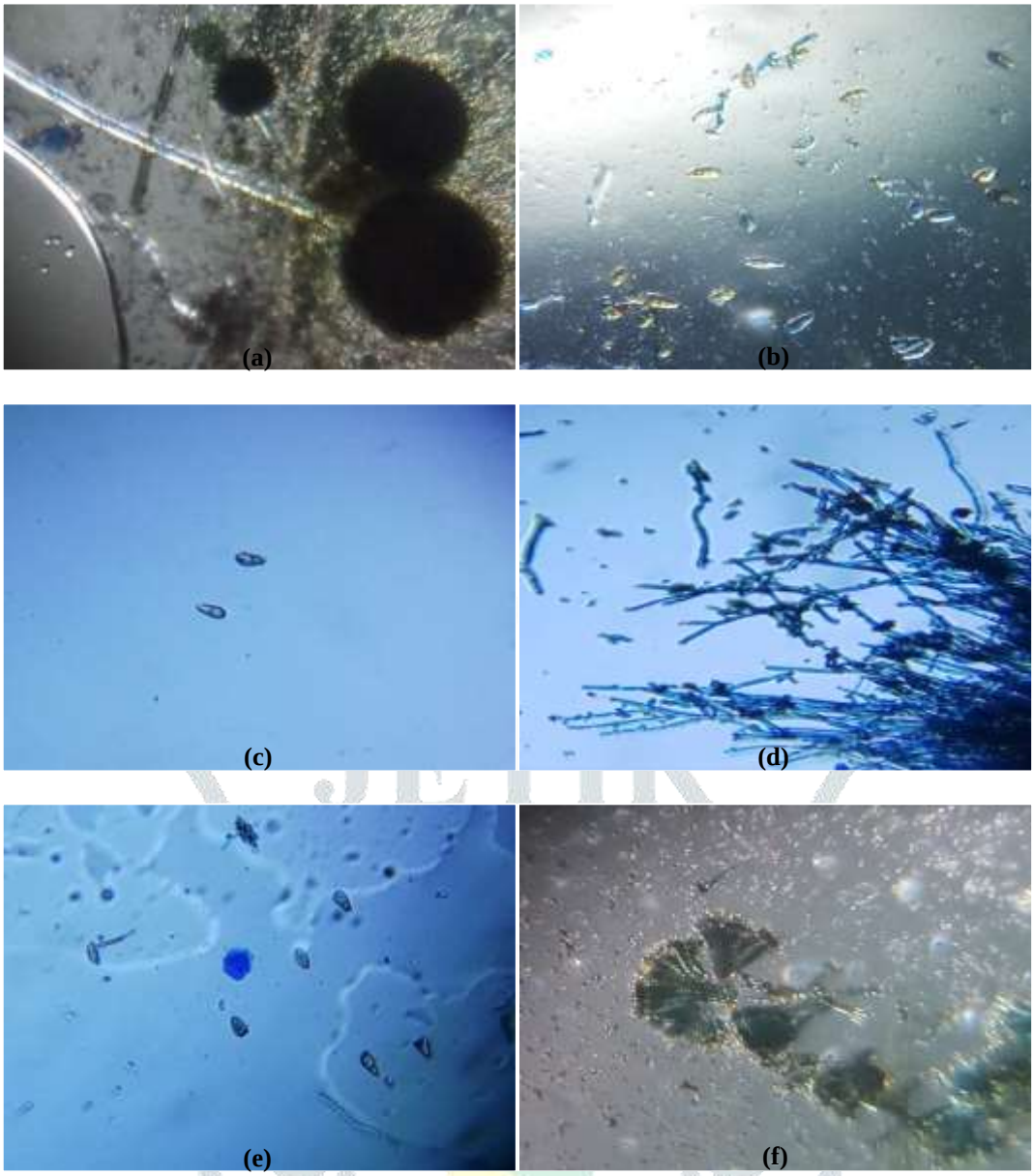


Fig 2. Foldscope images (140x) of some fungal species (a) *Aspergillus* sp. (b) *Cladosprium* sp. (c) *Curvularia* sp. (d) *Trichoderma* sp. (e) *Diasporium* sp. (f) *Penicillium* sp.

This can be explained by the climate of this city, where the outdoor daily maximum and minimum air temperatures are 32°C and 26°C respectively, and the daily average relative humidity near about 83%. The results of atmospheric sampling revealed that *Aspergillus* was consistently the most abundant one with 21 colonies (56.75%) followed by *Penicillium* sp. with 10 colonies (27.02%), *Curvularia* sp. (5.40%), *Trichoderma* sp. (5.40%) and *Cladosporium* sp. (2.70%), *Diasporium* sp. (2.70%) (Table 1) because *Aspergillus* sp. produces small, globose or subglobose conidia up to 5 µm in diameter which was easily dispersed through the air and settle on different surfaces (Florian, 2002).

Table 1: Diversity and Density of micro-fungi

Isolated aeromycoflora	**Museum and Library**			
	Colonies	**Percentage Occurrence (%)**	**Density (CFU/m^3)**	**Total (CFU/m^3)**
Aspergillus sp.	21	56.75	100	176.17
Penicillium sp.	10	27.02	47.61	
Curvularia sp.	2	5.40	9.52	
Trichoderma sp.	2	5.40	9.52	
Cladosporium sp.	1	2.70	4.76	
Diasporium sp.	1	2.70	4.76	

Bortoletto (1998) reported that fungal cells of *Aspergillus*, *Penicillium*, *Cladosporium* and *Trichoderma* were isolated from the large library, with populations of about 800 CFU/m^3 respectively.

All the items present in the room are cellulosic in nature. A variety of factors affect the growth of molds within the museum and library like papers, paintings, photographs, leathers, book cloths, curtains, wooden sculptures are more susceptible to mold growth than others. Fungi attack museum exhibit when it finds a suitable environment for growth. Most of the wood-degrading fungi that digest cellulose and lignin require a long period of wet conditions in order to colonize successfully wooden substrata (Florian, 2002). The most biosusceptible photographic materials are the gelatin and the paper, because they are organic and hygroscopic (Lourenço and Sampaio, 2009).So, the ingredients of the exhibit are used as substrate (Sterflinger and Pinzari, 2012). So the nature of the exhibit in indoor environment is a vital factor of object biodeterioration.

Fungal concentrations in museum and library are shown in Table 1. Total concentrations of museum and library (176.17CFU/m^3) were higher than the recommended level of microbial contamination given by American Conference of Governmental Industrial Hygienists Committee (100 CFU/m^3) and lower than the guidelines provided by WHO (500 CFU/m^3). Bioaerosols in the indoor environment may be transported from outdoor through ventilation systems, workers and visitors via their bodies, clothes, carried items, doors and windows etc. The presence of few numbers of airborne microorganisms in such places is a normal condition, but an increase of their concentration level can represent a disease risk factor. Exposure to indoor bio aerosols would raise a number of adverse health effects, such as primary irritation, infections, allergies, cancer, respiratory symptoms and diseases and sick building-syndromes respectively (Burge, 1990; Levetin, 1995; Pejtercen, 1999). Some curators suggest that an improved ventilation system can combat fungal problems and preserve the books in a better way (Hayleeyesus and Manaye, 2014). Regular periodic assessment of fungal infestation in cultural heritage can be helpful to control biodeterioration of museum and library objects.

IV. CONCLUSIONS

The detection and identification of aeromycoflora related to bideterioration are the first step for understanding the effects of microorganisms on cultural heritages objects. In this work, we emphasize the use of this foldscope microscope as an effective tool for museum and library authorities for concerning about their indoor air quality regarding health of worker and also to protect biodeterioration of museum and library objects and conserving the paper documents, paintings, photographs, wooden sculptures, building materials.

V. ACKNOWLEDGEMENT

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REFERENCES

[1] Bhattacharyya S., Mukherjee D., Chaudhuri P. 2016.Biodeterioration risk index of exhibit present in museum galleries of tropical climate, Museum Management and Curatorship

[2] Bortoletto ME. 1998. Fungal contaminations in indoor environments: the case of Manguinhos Library (In Portuguese). Rev Brasindoor 2:1-7.

[3] Burge H. 1990. Bioaerosols: prevalence and health effects in the indoor environment. Journal of Allergy and Clinical Immunology, 86(5), 687-701.

[4] Crook, B., and Burton, N.C. (2010) Indoor moulds, sick building syndrome and building related illness. Fungal Biol Rev 24: 1–8.

[5] Cybulski JS, Clements J, Prakash M. 2014. Foldscope: Origami-Based Paper Microscope. PLoS ONE 9(6): doi:10.1371/journal.pone.0098781.

[6] Florian, M.-L.E. 2002. Fungal Facts. London, UK: Archetype publications, p.146.

[7] Hayleeyesus, S. F., and A. M. Manaye. 2014. "Microbiological Quality of Indoor Air in University Libraries." Asian Pacific Journal of Tropical Biomedicine 4: S312–S317. doi:10.12980/APJTB.4.2014C807.

[8] Levetin E. 1995. Fungi. In: H. Burge (Ed.) Bioaerosols. CRC Press, USA, 87-120.

[9] N. Mesquita, N.M.A. Portugal, S. Videira, S.R. Eccheverria, A.M.L. Bandeira. 2009. Fungal diversity in ancient documents. A case study on the Archive of the University of Coimbra, IntBiodet&Biodegr, Vol. 63, 626-629.

[10] Naji, K. M., Q. Yusuf, M. Abdullah, A. M. Qaseem, A. Zaqri, M. Saeed, and M. Alghalibi. 2014. Evaluating the Biodeterioration Enzymatic Activities of Fungal Contamination Isolated from Some Ancient Yemeni Mummies Preserved in the National Museum. Biochemistry Research International. Doi.org/10.1155/2014/481508.

[11] Pejtersen J. 1999. Sensory pollution and microbial contamination of ventilation filters.Indoor Air, 6(4), 239-248.

[12] Sterflinger, K., and F. Pinzari. 2012. The Revenge of Time: Fungal Deterioration of Cultural Heritage with Particular Reference to Books, Paper and Parchment. Environmental Microbiology 14 (3): 559–566.