Research Journal of Recent Sciences _____ ISSN 2277-2502
Vol. 4**(IVC-2015),** 42-46 **(2015)** *Res. J. Recent. Sci.*

Biodeterioration of Art objects on Paper and their Conservation

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Available online at: www.isca.in, www.isca.me
Received th 2015, revised th 2015, accepted th 2015

Abstract

The Botanical specimens, manuscripts, books paintings, paper craft and various other material of cultural heritage provides an ideal substrate for the growth and proliferation of several fungi and probably in most of the cases they get liberated in the ambient air. Biodeterioration is any undesirable changes in the properties of materials caused by vital activities of microorganisms. The present paper deals with the microbes present of the paper paintings with great emphasis on their role in damaging paintings as well as measures for control. The airspora present on the paper paintings from different places visited has been studied and the record for entire year prepared. Over 20 fungal species were identified several fungal species of Aspergillus and Alternaria were found dominating from all the experimental sites, followed by species of Cladosporium, Fusarium, Curvularia, Chaetomium, mycelia sterillia, Penecillium, Trichoderma, Phoma and Cephalosporium showed their presence during several months. Deterioration of paintings cause by microbes is a serious problem throughout the world. Fungi are abundant on the earth with high ecological adoptability. Fungal activity damage paintings through discoloration, colored stains and flaking of paint layers. One of the biggest problem in the control of microbial deterioration of paper paintings is not only to prevent the growth of microbes, but also to kill them without damaging the paintings, keeping this in view, out of various biocides α-aminoisobulyric acid (AIB) showed inhibitory action and preventing growth of hyphal stage and it is suggested that this may be used as effective biocide for control of microbial growth on paper.

Keywords: Biodeterioration, ecological adoptability, microorganisms.

Introduction

Biodeterioration of cultural properties and ethnographical object is an entirely new field of research. The valuable articles such as manuscripts, books, wall paintings etc. get deteriorated due to the attack of multiple organisms. This problem is more detrimental in tropical humid climate like India. In that climate fungi constitute a major threat to the preservation of archival material composing of paper causes considerable economic and cultural loss. More than hundred species of fungi attack paper and paper material[1].

Paper art is mostly made up of fibrous material like cotton, wood, bamboo, rice straw and similar materials. The basic component of paper is cellulose. The other constituents are starch, sugar and some other carbohydrates. Lignin also forms a major component of paper[2]. Because of its cellulose constituent paper is susceptible to a wide range of biological agents which include bacteria, fungi and insects of these fungi have a remarkable capacity of dissolving cellulose as it provides a satisfactory medium for mould growth[3]. Stains and weakening of paper are the obvious results of fungal activity[4]. Attack by micro-organisms on paintings mostly result in deterioration of the whole of the object, generally starting from the support and then penetrating through all the layers. (Plate 1, 2,)

So it is very important to do scientific research in this field of biodeterioration and identity the microbial flora present on it to prevent its evil consequences on mankind. Thus the following study was designed with the objective to determine the correlation of airborne fungal spores in air and their impact on the properties of cultural heritage with special reference to paper art and to find the less toxic alternative to the toxic fungicides currently in use for microbial deterioration of paper art.

Material and Methods

The areas have been selected for present study within and around the boundaries of the Bhopal Township, A historical and industrial city of central India. Though survey of different localities in Bhopal and its neighboring areas will be conducted as well as other parts of the countries will also included for study which are famous for paper arts i.e., paper paintings, manuscripts etc.

Two aspects that have been dwelt in the present study are as follows:

Isolation and Identification of fungal flora: Fungal colonies appearing on paintings were studied and their colors etc. were recorded. Identification of fungal colonies, grown on petriplates was made with the help of reference culture isolates

and literature. Colonies were identified on the basis of colony characteristics and spore morphology.

Most of the cellulolytic fungi grow best of the potato dextrose Agar (PDA) medium, although other media like wart agar, subouraud medium have also been employed. The samples were collected by thumb impression from painting then on prepared PDA plates or by inoculation needle to transfer microorganisms. Following inoculation, the cultures plates were incubated in an incubator under suitable conditions.

The metrological parameters viz, temperature, rainfall and humidity were also recorded during the study period.

Selection of suitable Biocides: Selection of a suitable biocide, as a practice, depends on its biocidal efficacy, environment and user friendliness etc.

In the preliminary studies, related to selection of less toxic preservative against fungal attack, out of the 5 commonly used biocides viz Thymol, Orthophenyphenol and its Sodium salts, quaternary Ammonium compound, Formaldehyde and α-amino-isobutyric acid tested for common fungal species i.e. *chaetomium globosum* and α-amino-isobutyric acid (AIB) tested for common fungal species was found most effective.

The toxic efficacy of different quantities of the selected biocide was assessed by the following procedures. The experiment was repeated five times with each quantity to determine the lethal dose value[5].

5 strips of handmade paper were taken and numbered 1 to 5. No.1 strip was treated with 1% solution of AIB in water, 2nd was treated with 2% solution of AIB in water-ethanol mixture. No. 3rd strip was treated with 2% solutions of AIB in water. 4th strip was treated with 5% solution of AIB in water and No. 5th strip was control and was not treated with any biocide.

All the five strips then infected with commonly found fungal species of *chaetomium.* These strips kept on a watch glass containing moist paper covering then with inverted watch glass making small humidity chamber and sealed temporarily with rubber bands and were inspected daily for fungus growth if any and the observations were recorded.

Results and Discussion

Most of the fungal species found damaging papers were found belonging to *Ascomycata* and *Deuteromycota*. The fungal flora isolated has been shown in table-1. It may be concluded that there are wide variety of fungus forms present on paper paintings but *Aspergillus* and *Alternaria* sps were found dominating from all the experimental sites followed by *Cladosporium Fusarium oxysporum, Curvularia luneta Chaetomium* sp. *Mycelia sterila, Penecillium Stachybotrys, Trichoderma sp. Phoma, Mucor, Rhizopus,* V*erticillium* and *Cephalosporium* showed their presence during several months. (table-1).

Growth of fungi is attributable to dampness of the walls, high ambient humidity and presence of organic compounds derived from dust deposits, by infiltration from paints, binders etc. The fungal flora has been well studied by number of scientists abroad from different types of paintings[5-8].

Fungal flora may produce various colored superficial stains chromatic and aesthetic appeal of the paintings. (Plate 8, 9, 10, 11). *Alternaria a*lterneta was isolated from completely blackened surface of the paintings, whereas *Cladosporium* was isolated from brown and grey spots, *Aspergillus nidulence, A. flavus Chaetomium* sp and phoma sp. forms hard fruiting bodies, with little increase in humidity may cause swelling in the paint film, finally fungi grow profusely beneath and over the surface and powdering of the weakened paint was notes. Species of Aspergillus were found from all the paintings and during all the seasons. This could be due to its versatile nature as it can survive under abnormal and certain extreme conditions[9]. Cellulytic activity of *Alternaria alterneta, Aspergillus niger, Fusarium oxysporum penecillium, Phome sp. and Trichoderma sp*. was studied at different pH and temperature.

As a result of this study, α-amino- isobutyric acid (AIB) has been found to be an effective biocide in low concentration for control of microbial growth on paper paintings. (table-2). The results obtained in the present study suggest that AIB can be used as a preservative and curative agent. However, its effectiveness against other species of paper infecting fungi as a broad spectrum biocide is yet to be established.

Biodeterioration has direct link to our economy, as object of historical importance causes considerable economic and cultural loss. Studies on Biodeterioration aspects of conservation of cultural properties need to be expended and strengthened in order to save the cultural heritage.

Conclusion

It is concluded that there are wide range of fungal forms present on paper paintings. Microbial growth on the painting`s surface, causes deterioration of all components of the object by filamentous spreading and forming fruiting bodies. Fungal metabolism also produces colored stains on the paintings. Selection of broad spectrum biocide, which is non-toxic for human beings and having both fungicidal as well as insecticidal property. All these data has been successfully utilized for control of microbial growth which were responsible for deterioration of cultural properties.

Table-1
Fungal flora of paper paintings from different sites

Sl. No	Place		Fungi	Jan- Mar	Apr-Jun	Jul-Sep	Oct-Dec
1	Bharat Bhawan, Bhopal	1	*Alternaria alternata*	+	+	+	+
2	Manav Sangrahalaya, Bhopal	2	*Aspergillus flavus*	-	-	+	+
3	Tribal Art Musium, Bhopal	3	*Aspergillius niger*	+	+	+	+
		4	*Aspergillus nidulans*	-	+	+	-
		5	*Aspergillus terreus*	-	-	+	+
		6	*Aspergillus versicolor*	-	-	+	-
		7	*Cladosporium cladosporioides*	+	+	+	+
		8	*C. herbarum*	-	-	+	+
		9	*Chaetomium globosum*	+	+	+	+
		10	*Curvularia lunata*	+	+	-	+
		11	*Emericella nidulans*	-	+	+	-
		12	*Fusarium Oxysporum*	-	+	+	+
		13	*Fusarium solani*	+	-	+	-
		14	*Mycelia sterila*	+	+	+	+
		15	*Rhizopus nigricans*	-	+	+	+
		16	*Stachybotrys*	+	+	+	-
		17	*Trichoderma sp.*	+	+	+	+
		18	*Phoma sp.*	+	+	+	+
		19	*Penicillum*	+	+	+	+
		20	*Monodictys sp.*	-	+	-	+
		21	*Aureobasidium globosum*	+	-	-	-
4	National Art Musium New Delhi	1	*Alternaria alternata*	+	+	+	+
		2	*Aspergillus flavus*	+	+	+	+
		3	*Aspergillius niger*	+	+	+	+
		4	*Cladosporium cladosporioides*	+	+	+	+
		5	*Mycelia sterila*	-	-	+	+
		6	*Rhizopus nigricans*	-	+	+	-
5	Jaliyana wala Bag, Amritsar	1	*Aspergillius niger*	+	+	+	+
		2	*Alternaria terrerus*	-	+	+	-
		3	*Mycelia sterila*	-	+	+	+
		4	*Penicillum sp.*	+	+	+	+
		5	*Emericella sp.*	-	+	+	+
		6	*Fusarium oxysorium*	-	+	+	+
		7	*Stachybotrys sp.*	+	+	+	-
6	Kangra Art Musium, Kangra (Dharmshala)	1	*Alternaria alternata*	-	+	-	+
		2	*Alternaria longipes*	+	-	-	-
		3	*Aspergillus fumigatus*	-	-	+	+
		4	*Aspergillus nidulans*	-	+	+	+
		5	*Cladosporium cladosporioides*	+	+	+	-
		6	*Cladosporium herbarum*	-	+	+	+
		7	*Curvularia lunata*	+	+	-	-
		8	*Fusarium Oxysporum*	-	+	-	-
		9	*Monodictys sp.*	-	-	+	+
		10	*Penicillum sp.*	+	+	+	+
		11	*Phoma sp.*	+	+	+	+
7	Tibbatian Tample Dalhousi	1	*Alternaria alternata*	+	+	+	+
		2	*Chaetomium sp.*	+	+	+	+
		3	*Curvularia lunata*	-	+	+	+
		4	*Drechslera sp.*	-	-	+	-
		5	*Fusarium culmorum*	-	-	-	+

		6	*Penicillum species*	+	+	+	+
		7	*Penicillum granulatum*	-	-	+	+
8	Rani Durgawati University Jabalpur and National Art Musium	1	*Alternaria alternata*	+	+	+	+
		2	*Alternaria tenuis*	+	+	+	+
		3	*Aspergillus flavus*	-	+	+	+
		4	*Aspergillius niger*	+	+	+	+
		5	*Aspergillus versicolor*	-	+	+	-
		6	*Aureobasidium pullulans*	+	+	-	-
		7	*Aureobasidium globosum*	+	+	-	-
		8	*Curvularia lunata*	-	+	+	+
		9	*Fusarium culmorum*	-	-	-	+
		10	*Phoma sp.*	+	+	+	+
9.	Art Gallery, Lucknow	1	*Alternaria alternata*	-	+	+	+
		2	*Aspergillius niger*	+	+	+	+
		3	*Clodosporium sp.*	+	+	+	+
		4	*Chaetomium sp.*	+	+	+	+
		5	*Curvlaria lunata*	-	+	+	-
		6	*Fusarium Oxysporum*	+	+	+	++
		7	*Penicillum sp.*	+	+	+	+
		8	*Phoma sp.*	+	+	+	+
10.	National Art Musium New Delhi	1	*Aspergillius sp.*	+	+	+	+
		2	*Alternaria tenuis*	+	+	+	+
		3	*Chaetomium sp.*	-	+	+	-
		4	*Fusarium Oxysporum*	-	+	+	+
		5	*Clodosporium sp.*	+	+	+	+
		6	*Curvlaria*	-	+	+	+
11.	National Art Musium, Lucknow	1	*Aspergillus niger*	+	+	+	+
		2	*Alternaria alternata*	-	+	+	+
		3	*Clodosporium sp.*	+	+	+	+
		4	*Mucor*	-	+	+	+
		5	*Rizopus nigricans*	-	+	+	-
		6	*Pencillum sp.*	+	+	+	+
		7	*Phoma sp.*	+	+	+	+
		8	*Colletotrichum sp.*	-	+	+	-

Table-2
Effect of Aminoisobutyric acid (AIB) *on Chaetomium globosum* a paper infecting fungi

STRIPS	**1**	**2**	**3**	**4**	**5**
Duration (in Days)	**1% AIB in water**	**1% AIB in Water ethanol mixture**	**2% AIB in water**	**5% AIB in water**	**Control**
Day 1	+	-	-	-	+
Day 2	++	-	+	-	++
Day 3	++	-	++	-	++
Day 4	++++	-	++++	-	++++
Day 5	++++++	-	++++++	-	++++++

- Sign indicates the absence of fungal growth. + Sign indicates the extent of fungal growth.

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