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DISCUSSION

Biodeterioration is any undersirable change in the properties of a material of economic importance caused by vital activities of organisms. The biodeterioration includes mildewing or rotting, mechanical damage, staining or spoilage of materials. The biological agents and their role in deterioration of economically important material has become a matter of great concern. The investigations of Alexander (1965), Hyeck (1968), Eggins (1968), Wessel (1954), Bassi and Giacobini (1969), Ionita (1973), Lazer and Dimitra (1972), Mukherjee (1973) and Tilak and his associates (1972,1976,1977) have greatly contributed to this enterprising aspect. The analysis of the composition of indoor air , the concentration of various types of biodeteriorating micro-organisms there-in, their seasonal variation are gaining greater importance. An entirely new field of research of the application of aerobiology has emerged in relation to biodeterioration of materials in stores, equipments, paintings and frescoes and library materials in which the substrates and organisms interact. Such studies have proved that fungi, bacteria and actinomycetes are the major agents of biodeterioration of various types of material. Materials such as clothing, paper goods ,plastic objects, photographic films, optical equipment, electronic equipment are all subjects to fungal growth and rendered unfit for use.

Fungi are capable of causing mildew of cotton fabrics and several species of fungi were isolated and identified from mildewed cotton material (Davis, Drewgus, Gray and Holland (1880). The effect of fungi on textile fiber can be roughly classified as 'mildew' and 'rots'. In mildews fungi that grow on textile do not actually attack the textile fiber and hence do not cause weakening or failure of the fiber. They make them unsightly and unfit for many purposes.

Rot fungi actually digest the textile fibers, causing a loss of fiber strength or complete destruction of the fabric. Prindle (1935) has found that species of the genera Alternaria, Stemphyllium, Oospora and Penicillium are specially destructive to wool. Silk and rayon fabrics are less affected by mildew. Marsh and Duske (1943) stated that the chief textile mildewing fungi are species of Penicillium, Mucor, Aspergillus, Fusarium and Trichoderma but Chaetomium globosum causes the greatest amount of damage to the textile material.

Mcbeth and Scales (1913) studied the destruction of cellulose by both bacteria and filamentous fungi. The paper is made up of plant fibers like cotton, flax, hemp, straw and wood. In raw state all except cotton are improved form of cellulose, usually lignocellulose. The organisms causing decomposition of cellulose included Chaetomium, Myxotrichum, Epidamella, Aspergillus, Spicaria, Cephalothecium, Torula, Stachybotrys, Cladosporium, Alternaria and Fusarium. They stain the paper yellow, brown and black due to destruction of cellulose.

In electric goods the fungi attack the insulation materials, impregnating compounds such as waxes, laminated plastic materials and cork packing. Though there is no actual destruction of such materials, fungus growth leads to leakage and short-circuiting via moist fungus hyphae. This is particularly observed in unused equipments.

Due to growth of molds in or on optical equipments such as microscopes, binoculars, telescopes etc. they become unfit for further use. The organic matter on glass lenses or prisms though in minute quantity serves as substrate for fungus growth, which spread over the glass surface occasionally etching the glass surface.

The molds growing on the surface of leather make it unpleasant to handle and require frequent cleaning. Furthermore, mold growth on leather instrument cases can spread to and possibly damage the enclosed instruments.

Study of airspora inside the caves at Ajanta and Ellora by Tilak and Kulkarni (1972) clearly indicate a close relationship between occurrence of fungal spores on the paintings and in the air and indicate that fungal spores were responsible in spoiling the wall paintings during favourable meteorological factors. *conditions.*

The house dust has been under investigation mainly because of the allergenic constituents and their origin. It has been established long back that the inhalation of fungal spores along with the house dust causes acute symptoms in allergic individuals. Aspergillus, Rhizopus, Cladosporium, Fusarium, Curvularia, Helminthosporium, Epicoccum along with hyphal fragments and insect scales are common members of house dust. The intramural studies in the dwellings of man would serve a very useful purpose in the treatment of allergenicity.

In indoors the most important source of air borne mold spores is the outside air. In indoors relatively few spores are produced and released into the air. According to Gregory (1973) the microbial concentration of indoors vary greatly with the amount of mechanical and human activity. The microbial flora of the indoor air depends on the number and kind of organisms present and the mechanical movements within the enclosed space. (Madeline and Linton 1974). The contamination of indoor environment with the presence of microbial population and other contaminants certainly constitutes a major problem of hazards.

Library is an institution charged with the function of preserving and disseminating human culture and civilization contained in the books. The books, the wares of library are to be preserved for posterity as they represent the life long labours and researches undertaken by Philosophers, sages, Scientists and literatures. The paper, parchment tracing cloth, leather, binding material and ink are the main constituents of books. The paper of which the books are made is a perishable and delicate material. So also, Parchment, cloth, leather and other binding materials like card board thread glue etc. are perishable articles like papers.

Depending upon the nature and the environmental conditions, the paper is subjected to the attack from several sources which can be broadly classified as physical, chemical and biological. Heat, sunlight, moisture dust and dirt are the physical sources, which are known to damage paper and cause deterioration. Similarly acidic and other gases present in the atmosphere and deleterious chemicals added during manufacture of paper are responsible for affecting storage life of paper. However, the most important agents for deterioration judging from the bulk of damage caused annually to paper and paper products are the biological agents.

The chief constituents of paper are the plant fibres. The chief fibers in use today are cotton, flax (lignen), hemp, esparto, straw and wool. In raw state all except cotton are improved form of cellulose, usually lignocellulose. Some chemical treatment is needed for these fibres to make them suitable for making a good quality paper. To make it more attractive, some glue is used on the surface. The long fibres make good quality paper.

Certain fungi possess the cellulose digesting enzyme commonly referred to as cellulase. De Barys (1886) finding of the enzyme having capacity to dissolve the plant cell walls was later confirmed by Ward (1888) and Behrens (1898). though it is not possible to isolate this enzyme actually from the fungi, its occurrence in many fungi is an established fact. Gallow (1963) have reported that about half of the commonly occurring fungi possess this capacity to digest cellulose. White et al (1948) in the survey of cellulolytic activity in 453 cultures of fungi, majority of which were fungi imperfecti, obtained similar findings.

Today this activity of cellulose digestion has been demonstrated in large number of fungi among which Ascomycetes (example species of Chaetomium) and Basidiomycetes digest the cellulose most rapidly.

As the cellulose is main constituent of paper, the books which are made up of paper are affected by the fungi. See (1919) isolated fungi from paper and books. They were found to be species of Chaetomium, Myxotridium, Eidamella, Aspergillus, Acrostalagmus, Spicatia, Cephalothecium, Stachybotrys, Dematium, Cladosporium, Stemphyllium, Alternaria, Stysanus and Fusarium.

According to Greathouse (1950), Gallow (1963) and Flyate (1968) fungi, bacteria, and actinomycetes are the major agents of biodeterioration of library materials. Due to their activity they form pigments and stain the paper usually with yellow, brown and black spots. Saffory et al (1935) reported species of Cladosporium, Fusarium, Aspergillus, Monilia and an actinomycetes responsible for 'foxing' of the paper. Verona (1938) added species of Phoma, coniosporium and Cephalosporium to this list of paper deteriorating fungi.

The papers coated with asphalt which is fungicidal are even damaged by fungi. Gray and Martin (1947) have reported 19 species of fungi belonging to Penicillium, Aspergillus, Chaetomium, Sepedomium and Trichodesma from such damaged papers.

The books in the libraries are not only damaged by paper deterioration but Armitage (1949), Kowalik and Sadurska (1956) and Niuksa (1961) have observed that fungi play an important role in spoilage of binding material, leather and plastic materials.

Although extensive work has been done on the qualitative and quantitative incidence of pollen and fungal spores in outdoor environment, scant attention has been paid to airborne fungal spores as environmental pollutant in indoor environment. Among enclosed spaces libraries offer unique substrate characteristics such as bindery glue, dust, old papers, binding fibrics etc. for fungal growth.

The presence of actinomycetes in the library have been reported by Kowalik and Sadursha (1956), Beljakova (1961) Aleksi (1965) reported speices of 18 fungi on stored manuscript. In general the fungi reported on books and papers belong to species of Alternaria, Monilia, Fusarium, Chaetomium, Sporidomium, Rhizopus, Epicoccum and Paecilomyces. Most of them are active decomposing fungi. They spoil the paper by yellow, brown and black spot formation. Their action is very slow and hence require several months for detection of damage caused to the paper.

Lydenberg and Archer (1931) first reported that the indoor air contain the fungal spores which are responsible for biodeterioration of library books. Increase in the humidity favours the growth of molds and mildews which causes loosening of paste and glue, weakening of fibres of paper and leather thus causes damage to the stored books.

In India, the aeromycoflora inside library and the investigations on deterioration of paper by activity of micro-organisms were known by the works of Kathapalia (1960), Mukherjee (1973), Tilak and Vishwe (1978), Tilak et. al. (1982), Tilak and Saibaba (1984), Tilak et. al. (1985), Tilak and Pillai (1988), Vaidya (1990), Pandey et al (1994), Ahuja and Pandey (1994), Saoji and Giri (1994) etc.

The present investigation is on aeromycoflora inside library building of Shivaji University, Kolhapur M.S. The aeroflora includes 36 types of fungal spores, the other types include insect parts, mycelia, scales and hyaline threads.

The survey indicates that the genus Cladosporium is the dominant contributing 86.908% that is major part of the aeroflora. Among the other genera Aspergillus (6.028%), Smut spores (2.149%), Alternaria (1.052%), Curvularia (1.398%), Nigrospora (1.398%) are the next abundant. The genera Alternaria, Corynespora, Curvularia, Helminthosporium, Nigrospora, Pithomyces, Spegazzinia, Torula, Tetraploa, Drechslera, Bispora, Pleospora though in low concentration are constantly associated with the aerospora. Thus Deuteromycetes contributing 95.368% to the total aerospora form the dominant group inside the library building. The very high number of Deuteromycetes may be well explained by the presence of a few prolific spore producers with ubiquitous habit such as Cladosporium spp. Alternaria spp. Aspergillus spp.

The high prevalence of Cladosporium spp. and Alternaria spp are in agreement with the studies of Tripathi (1987), Tilak and Pillai (1988). The occurrence of Curvularia, Aspergillus spp. Helminthosporium inside library building is reported by Vittal and Glory (1985), Tilak and Vishwe (1975). The peak of the incidence was recorded in the autumn season particularly in the month of January. The high humidity and optimum temperature favours the growth of fungi. The decrease in the spore incidence started with on set of summer and reached to minimum in the months of April and May. The low relative humidity and high temperature is unfavourable for growth of fungi and hence decrease in the incidence of aeroflora is observed. In the year 1994 in the month of May though the relative humidity is high the temperature being high the spore concentration is found to be low. With on set of rainy season the relative humidity increased, the temperature lowered down to optimum and hence increase in the spore concentration is observed.

Among the 36 types of spores recorded in the aerospora inside library building of Shivaji University, Kolhapur, 7 types are known to have paper deteriorating activity. These are Chaetomium, Alternaria (1.052%), Cladosporium (86.908%), Epicoccum (0.653%), Fusarium (0.031%) Sporidesmium (0.059%) and Torula (0.358%). Among them Cladosporium is the most dominant contributing 86.908% to the total aerospora and form the major constituent of the aerospora for seven months out of ten months of observation. It is absent during the summer months (March-May). The other paper deteriorating members occur in very small proportion. Chaetomium contributing (0.329%) to the total aerospora is recorded during summer and monsoon season

and is absent during autumn Alternaria contribute (1.052%) to the total aerospora and is a constant member of the aerospora recorded for the 10 months period of observation. Torula contributing (0.358%) to the total aerospora is recorded during all the ten months of investigation. Epicoccum adds (0.653%) to the total aerospora and is recorded during summer and monsoon while during autumn it is absent. Fusarium (0.031%) and Sporidesmium (0.059%) are inconsistently occurring.

Cladosporium showed two major seasons :

1) December-February and (2) June-July. During summer they are altogether absent. Alternaria and Torula the two constant members of aerospora are particularly recorded during hot months (March-May) and also early part of autumn (October-November).

Microbes in indoor air may come from the outdoor by ventilation or they may originate within (Gregory 1961). Because of this exchange the microbial contents of indoor air tend to change in unison with that of outside. The extramural aerobiological studies of Shivaji University, Kolhapur campus were made earlier by Kulkarni (1979). He has recorded 74 biopollutants from the campus atmosphere. The aerospora is dominated by Deuteromycetes followed by Phycomycetes, Basidiomycetes and Ascomycetes. The percentage of Deuteromycetes spores inside library building is more (95.368%) than that of outside the building (47.69%). This may be because the source of the spores belonging to Cladosporium is mainly from within the library building. The samples of the deteriorated papers and the humid walls after critical examination indicated the presence of Cladosporium mainly along with Aspergillus, Alternaria, Torula etc. There are twelve spore genera newly recorded from the

air within the library building. They are Bagnisiella, Didymospharea, Massaria, Arthrinium, Ceratophorum, Cordana, Corynespora, Dendryphiopsis, Drechslera, Exosporium, Oidium, Sporidesmium.

Allergy is one of the most ancient and common human ailments. It has been estimated that in India over 10% of population suffer from the allergic disorders which are attributed to several causative agents like Pollen, fungal spores, house dust, danders, dust mites etc. As we breath, the components of airspora enter the respiratory tract. These inhaled particles are not exhaled again. Most of the inhaled particles are deposited in the respiratory tract. These particles may act as irritants, pathogens, allergens or antigens. The common indoor fungal spores are Aspergillus, Penicillium, Cladosporium and Alternaria. among the enclosed places like libraries offer unique substrate characteristics such as bindery glues, dusts, old papers, binding fabrics for fungal growth. The role of fungi as causitive agent of allergic rhinitis and bronchial asthma from library dust and book collection is well documented. Cladosporium, Alternaria are common members of allergenic fungi. The indoor atmosphere of library building especially where the old books and periodicals are stored is rich in these spore contents. They are not in circulation frequently. Hence, whenever these books were agitated the persons visiting this section were found to be suffering from skin irritation, bronchial asthma. Out of 100 people interviewed 30% showed positive reaction to these spores.

The survey of aerospora inside library building indicates that the air inside is never free from biopollutants. Fluctuations in the concentration of total and individual types were observed in different months during the course of investigation. The present library is well ventillated and hence needs no air

conditioning. The spore concentration was minimum in the areas where the books are in circulation. In areas where older book^s were stored or not handled frequently the spore concentration were high after agitation. The concentration of indoor pollutants was more than outdoor. Hence the source of biopollutant is from within the affected books which probably aggravate^a fungal colonization. The Kolhapur city has got the environmental conditions favourable for fungal growth. The humid climate help them to grow more and more. To keep them away, proper ventilation, loose shelving of books is very useful. Artificial heat may also drive them away. Hetherington. D. E. (1947) has recommended a solution which has been used successfully to prevent growth of mold. The ingredients of his formula are Thymol Crystals(100gm), mercuric bichloride (4 gms), ether(200 cc) and benzene (400 cc). Even one application of this solution has proved to be sufficient to stop the growth of mold.

In addition to the fungi insects, water, fire, dust and human beings are the other enemies of books responsible for deterioration. Books are the life blood of great thinkers of the past and present. They represent the life-long labours and researches. It is a very pleasant , though difficult, task of Librarian to preserve the treasure of knowledge which is found in the form of books and document. It is rather his religious duty to conserve this knowledge in an appropriate manner.