

FUNGAL DETERIORATION OF CELLULOSIC MATERIALS

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ABSTRACT

Different cellulosic materials like wood, paper and fabric were collected from different localities of Karachi for the observation of degradable fungi. Maximum number of fungi were recorded from wood samples followed by paper materials. All the samples of wood, paper and fabric were contaminated with *Aspergillus flavus* followed by *A. niger*. However, *Chaetomium globosum*, *Macrophomina phaseolina*, *Mucor* sp., and *Rhizopus* sp., were isolated from all the cellulosic materials.

KEYWORDS: Agar plate method, Cellulosic materials, Degradation, Fungi, Samples.

INTRODUCTION

Deterioration, a natural process, leads to decay organic or inorganic material by breaking down material into simpler forms which can be used by other organisms like bacteria, fungi and insects (Kransy *et al.*, 2003). Degradation requires specific enzymes which are secreted by the organisms that are responsible to convert complex substances into simpler ones either organic or inorganic products. According to Sims and Cupples (1999) biodegradable materials are generally organic material like fabric, leather, paper, wool, wood etc but sometimes organisms also deteriorate inorganic materials like plastic, paints, glass, metal etc.

Paper is an organic biodegradable material the chief composition of which is lignin and cellulose. Many fungi have been reported on paper like genera of *Acremonium*, *Alternaria*, *Aspergillus*, *Aureobasidium*, *Botrytis*, *Candida*, *Chaetomium*, *Cladosporium*, *Curvularia*, *Drechslera*, *Epicocum*, *Fusarium*, *Geotrichum*, *Humicola*, *Mucor*, *Myrothecium*, *Neurospora*, *Penicillium*, *Phoma*, *Rhizopus*, *Rhodotorula*, *Scopulariopsis*, *Stachybotrys*, *Syncephalastrum*, *Trichoderma*, *Trichosporon* (Pinzari *et al.*, 2006; Arroyo, 2009; Chadeganipour *et al.*, 2013).

Wood is hard, fibrous structural tissue found in stems and roots of trees and woody plants. Main composition of wood consists of cellulose, lignin, pectin and hemicelluloses. Some of the reported fungi which deteriorate wood using enzymatic activities includes *Serpula lacrymans*, *Coniophora puteana*, *Anrodia vaillantii*, *Phellinus contiguus*, *Asterostroma* spp., *Phellinus pini*, *Ganoderma applanatum*, *Armillaria mellea*, *Ganoderma lucidum*, *Laetiporus sulphureus*, *Schizophyllum commune*, *Chaetomium* spp., *Xylaria* spp., *Alternaria* spp., *Merulius lacrymans*, *Fomes* spp., *Coriolus versicolor* (Lee *et al.*, 2004; Bravery *et al.*, 1992; Arroyo, 2009).

Textile or cloth, another important degradable material, obtained from different sources like animal (wool, silk), plant (cotton, flax, jute), minerals (asbestos, glass fiber) and synthetic (nylon, polyester, acrylic). According to Arroyo (2009) and Jain (2006), fungi deteriorating cellulosic textiles are *Curvularia* spp., *Cladosporium* spp., *Aspergillus oryzae*, *Mucor* spp., *Rhizopus oryzae*, *Penicillium caseicolum*, *P. citrinum*, *Chaetomium* spp., *Fusarium* spp., *Myrothecium* spp., *Alternaria* spp., *Stachybotrys* spp., and *Trichoderma* spp. This study aims to isolate the degradable fungi from some cellulosic materials of different locations of Karachi.

MATERIALS AND METHODS

Collection of cellulosic materials: Twenty four samples of each cellulosic material including paper (pages of old books), wood (pieces of wood) and fabric (cottony) were collected randomly from different areas of Karachi. Paper samples were collected from Nazimabad (1), Rizvia society (2), Golimar (3), University of Karachi (2), Gulshan-e-Iqbal (1), Shadman Town (1), Orangi Town (1), Saddar (1), Bismillah Hotel (1), Suhrah Goth (1), Garden (1), Malir (1), Banaras (2), Landhi (3), Mehmoodabad (2), North Karachi (3), and Karimabad (1). However, wood samples were collected from wood working shops around Landhi (2), Gulbahar (5), University of Karachi (3), Gulshan-e-Iqbal (1), Gulistan-e-Johar (1), Surjani (1), Dastagir (1), Gulberg (1), Liaquatabad (1). Twenty three samples of fabric were collected from different regions of Karachi like Airport (2), Golimar (1), Nazimabad (4), Landhi (2), Garden (1), University of Karachi (2), Gulistan-e-Johar (1), Tower (1), Surjani Town (3), Bufferzone (2), Liaquatabad (3) and Lazbella (1).

Isolation of fungi: Agar plate method was used for the detection of fungi in which pieces of cellulosic materials (1 mm³ for wood pieces and 1 mm² for paper and fabric pieces) were cut, surface sterilized with 1 % Ca(OCl)₂ for 5 minutes and then plated on Potato Dextrose agar (PDA), 10 pieces per Petri plate. A set of non surface sterilized cellulosic materials were also plated. All the plated materials were incubated for 5-7 days at room temperature (30 ± 2°C), alternating cycles of artificial day light (ADL) and darkness.

Table 1. Fungi isolated from cellulosic materials.

Fungi	*Relative colonization (%) of fungi from cellulosic materials					
	Wood		Fabric		Paper	
	Sterilized	Non-sterilized	Sterilized	Non-sterilized	Sterilized	Non-sterilized
<i>Absidia corymbifera</i> (Cohn) Sacc. & Totter	0	2.083	0	0	0	0
<i>Absidia cylindrospora</i> Hagem	0	0	0	0	4.735	2.541
<i>Absidia glauca</i> Hagem	0	0	0	1.351	4.953	3.292
<i>Alternaria sonchii</i> Davis	0	1.528	0	0	0	0.990
<i>Arthrotrichum oligospora</i> Fresen	0	0.805	0	0	0	0
<i>Aspergillus candidus</i> Link ex Link	0	0.903	0.719	1.186	0	3.292
<i>Aspergillus flavus</i> Link ex Gray	25.344	22.612	37.405	23.348	23.614	12.464
<i>Aspergillus fumigatus</i> Fres.	1.375	10.903	4.349	15.126	3.676	7.318
<i>Aspergillus niger</i> Van Tieghem	31.596	19.598	27.492	20.497	18.941	11.984
<i>Aspergillus terreus</i> Thom	0.750	6.708	0	1.878	1.059	0.975
<i>Aspergillus wentii</i> Wehmer	4.543	2.861	1.695	1.038	6.417	0.927
<i>Aspergillus versicolor</i> (Vull.) Tiraboschi	3.959	3.097	0	0	0	0
<i>Botryotrichum piluliferum</i> Sacc. & March.	0	2.233	0	0	0	0
<i>Chaetomium elatum</i> Kunze ex Steud.	0	1.375	4.496	0	0	0
<i>Chaetomium funicola</i> Cooke	0	0.930	0	0.988	0	0
<i>Chaetomium globosum</i> Kunze ex Steud	3.251	1.611	4.606	3.658	4.859	14.541
<i>Drechslera australiensis</i> (Bugnic.) Subram. & B.I. Jain	0	0.778	0	0	2.087	1.853
<i>Drechslera miyakei</i> (Nisikado) Subram. & Jain	0	0	0	0.326	0	0
<i>Drechslera siccans</i> (Drechsler) Shoemaker	0	0.889	0	0	0	0
<i>Fusarium oxysporum</i> Schlecht.	0	0	2.985	1.796	1.807	1.374
<i>Macrophomina phaseolina</i> (Tassi) Goid	3.585	6.695	1.658	1.796	15.233	21.253
<i>Monilia</i> sp. Fresen.	0	0	0	0.313	1.277	2.061
<i>Mucor</i> sp. Fresen.	15.215	3.125	3.353	2.669	2.679	3.851
<i>Myrothecium roridum</i> Tode ex Steudel	0	0	0	0	1.900	0.895
<i>Myrothecium verrucaria</i> (Alb. & Schw.) Ditm. Ex Steudel	7.378	4.736	0	0	0	0.783
<i>Penicillium</i> sp. Link ex Fr.	0	0	0	0.313	0	0
<i>Rhizoctonia solani</i> Kuhn	0	0	0	1.417	0	0
<i>Rhizopus</i> sp. (Ehrenb.)	1.500	3.013	11.240	21.915	6.760	6.903
<i>Syncephalastrum</i> sp. Schrot.	0	0.722	0	0	0	1.358
<i>Trichoderma hamatum</i> (Bonord.) Bain	1.500	1.791	0	0.395	0	0.511
<i>Trichoderma polysporum</i> (Link ex Pers.) Rifai	0	1.014	0	0	0	0.831

Detection of mycoflora: Fungal colonies appearing on plates (3 plates for each sample) after 5-7 days of incubation were identified on the basis of different morphological characters by using standard literature (Barnett, 1960; Booth, 1971; Ellis, 1971; Nelson *et al.*, 1983, Domsch *et al.*, 1980; Raper *et al.*, 1965). Data showing relative colonization (%) of identified fungal species were summarized in Table 1.

RESULTS AND DISCUSSION

Biodeterioration is a naturally occurring process in which microorganisms convert complex materials into simpler one to obtain energy for survival and continuity of life. Wood is a renewable material. In the present studies, twenty three fungal species were isolated from non-sterilized while 12 species were isolated from sterilized wood material namely *Absidia corymbifera*, *Alternaria sonchi*, *Arthrotrichum oligospora*, *Aspergillus candidus*, *A. flavus*, *A. fumigatus*, *A. niger*, *A. terreus*, *A. wentii*, *A. versicolor*, *Botryotrichum piluliferum*, *Chaetomium elatum*, *Chaetomium globosum*, *C. funicola*, *Drechslera australiensis*, *D. siccans*, *Macrophomina phaseolina*, *Mucor* sp., *Myrothecium verrucaria*, *Rhizopus* sp., *Syncephalastrum* sp., *Trichoderma hamatum* and *T. polysporum* (Table 1). Not all fungi attack on wood and cause degradation, some of them cause discoloration or stain the wood; these are wood staining or mildew fungi. These fungi typically develop due to poor timber-drying practices or extreme wet conditions (Todd *et al.*, 2008). Some fungal species of basidiomycetes are ineffective on wood but when wood is applied with preservatives like ammonical copper arsenate, fluor-chrome-arsenate-dinitrophenol, creosote or pentachlorophenol, fungi become effective to cause it decay (Duncan and Deverall, 1964).

Total 21 species (13 genera) were isolated from paper material like *Absidia cylindrospora*, *A. glauca*, *Alternaria sonchi*, *A. candidus*, *A. flavus*, *A. fumigatus*, *A. niger*, *A. terreus*, *A. wentii*, *Chaetomium globosum*, *Drechslera australiensis*, *Fusarium oxysporum*, *Macrophomina phaseolina*, *Monilia* sp., *Mucor* sp., *Myrothecium verrucaria*, *M. roridum*, *Rhizopus* sp., *Syncephalastrum* sp., *Trichoderma hamatum* and *T. polysporum* (Table 1). Shamsian *et al.* (2006) observed historical manuscripts at Astan Quds Museum Library and found fungal contamination of mainly *Aspergillus*, *Penicillium*, and *Mucor* spp. He recorded maximum number of fungi from those papers that contain high amount of cellulose while those with slippery in touch and lacking or less amount of cellulose resulted in least number of fungi. Different ingredients used for repairing old and damaged books like glues with animal and vegetable sources, wax seals and inks are considered to be good nutritional resources for fungal growth (Shamsian *et al.*, 2006).

From fabric material, seventeen fungal species (12 genera) were isolated that included *Absidia glauca*, *A. candidus*, *Aspergillus flavus*, *A. fumigatus*, *A. niger*, *A. terreus*, *A. wentii*, *Chaetomium funicola*, *C. elatum*, *C. globosum*, *Drechslera miyakei*, *Fusarium oxysporum*, *Macrophomina phaseolina*, *Monilia* sp., *Mucor* sp., *Penicillium* sp., *Rhizopus* sp. and *Trichoderma hamatum* (Table 1).

Microorganisms are great threat to textile materials at all stages of their production, transportation and storage of raw material. Fabrics are made up of natural fibers particularly more susceptible to attack of microorganisms due to both cellulosic and non cellulosic compounds (Arroyo, 2009). Pekhtasheva *et al.* (2012) reported *Aspergillus*, *Penicillium*, *Alternaria*, *Cladosporium*, *Fusarium*, *Trichoderma* from different textile materials. *A. flavus* was the most dominant fungi recorded from all samples of cellulosic materials followed by *A. niger*. Other than species of *Aspergillus*, *Chaetomium globosum*, *M. phaseolina*, *Mucor* sp., and *Rhizopus* sp., were isolated from all the samples of cellulosic materials. Sterilization using $\text{Ca}(\text{OCl})_2$ can significantly reduce the number of fungi. However, comparatively all the three cellulosic materials, maximum number of fungi were detected from wood followed by paper and fabric. Biodegradation is an uncontrolled process but can be controlled by altering environmental conditions so that the atmosphere is not suitable for the growth of microorganisms.

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