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Timber Degrading Fungi in Sawmills of Gujarat, India

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ABSTRACT

Timer decay is caused by primarily enzymatic activities of microorganisms. For the first time fungal diversity of timber degrading fungi was studied in Gujarat, India. Timber Degrading Fungi belonging to Aphyllophorales are economically important as many of these cause serious damage in sawmills of Gujarat. To find out the association of the timber degrading fungi and timber decay problems in sawmills a survey was conducted during 2007 to 2011 in different sawmills of 5 districts of Gujarat i.e. Vadodara, Ahmedabad, Bharuch, Rajkot and Jamnagar. In the present study teak wood present in sawmills was infected with 14 types of fungi in which *Lenzites sterioides* and *Trametes versicolor* damaged the wood severely was reported for the first time. In all 94 sawmills were surveyed, the 28 sawmills were from Vadodara, 29 from Ahmedabad, 12 from Bharuch, 21 from Rajkot and 4 from Jamnagar. Out of 94 sawmills survyed, 84 sawmills were having timber rotting fungi associated with wood. Maximum fifteen and thirteen fungal species were observed in saw mills of Chhani road, followed by 11 in Station road, 7 in Dhabhoi road and 6 in Harni, Vadodara. Fours woods uninfected are Beyo, Marinty, Ash, and Arjun. Fourteen different types of fungi were found associated with teak, followed by seven in pinus, madhuca, *Acacia nilotica,* six in babul, neem, four in tamarind, *Pithacoelobium* and three in mango, Eucalyptus, African Mahagoni, Kapoor, *Peltophoram rouxburghii, Derris pinnata* wood respectively. The commonly observed timber decaying fungi were *Schizophyllum commune*, *Flavodon flavus* and *Ganoderma lucidum* belonging to Basidiomycota. Ascomycota members included was *Daldinia concentrica* and *Xylaria polymorpha.*

***Keywords*:** Wood decay fungi; sawmills; Teak, Beyo; Marinty; *Schizophyllum commune; Flavodon flavus; Daldinia concentric*; Gujarat

1. INTRODUCTION

The total forest cover in India according to the latest State of Forest Report 2003 is 67.83 m ha and this constitutes 20.64 % of the geographic area. The state of Gujarat is one of the progressive states in the western part of India with an area of 196,024 sq. km. While the recorded forest area is 19,393 sq.km, which is 9.89 % of the total geographical area. The

production of fuel and timber is much less than the demand. The forest area which produces timber and fuel wood is only 63.5 % of the recorded area. 90 percent of forest raw material is processed by 25,000 saw mills and a larger number of cottage units, who would also lay claims on forests.

Natural teak forest in India covers about 8,900,000 ha (Tewari, 1992); The more important teak forests, however, occur in Hoshangabad Betul (Madhya Pradesh), Chanda and Melghat (Maharashtra) Wynaad (Kerala), Anamalai hills (Tamil Nadu) and North Kanara (Karnataka). Timber degrading fungi belonging to Aphyllophorales (Basidiomycetes) are economically important as many of these are pathogens of forest trees and cause serious damage. These wood-rotting fungi are also important in the forest ecosystem as they are active decomposers of organic matter (Natarajan, Kolandavelu 1998). They can be a valuable resource for few pharmaceuticals, food production, bioremediation of toxic chemical spills (Kirk *et al.* 1992a), biopulping and other industrial uses (Akhtar *et al.* 1993, Kirk *et a*l. 1992b).

2. MATERIALS AND METHODS

Ninety four saw mills were surveyed in Vadodara, Ahmedabad, Jambusar, Bharuch, Rajkot and Jamnagar during June 2006 to February 2011 to find out timber degrading fungi and problems related to the wood decay in 5 districts. The infected wood along with sporophores were brought to the laboratory to identify the associated fungi.

2. 1. Identification of Fungi

Basidiomes were studied using macroscopic (eg: size, colour, number of pores/mm, length of tubes) and microscopic (presence/absence of structures, dimensions, vegetative and reproductive characters (Ryvarden 1991). Measurements were made from slide preparations. Fungi were stained with 1 % aqueous Pholoxine and 5 % KOH. Specimens were identified to species level using specialized references (Eriksson, Ryvarden 1975) and CBS Aphyllophorales database (www.cbs.knaw.nl/databases/). Certain specimens were sent to The Forest Research Institute, Dehradun for final confirmation. These fungi are kept in fungal collection of Botany Department of The Maharaja Sayajirao University of Baroda, Gujarat, India.

3. RESULT AND DISCUSSION

3. 1. Survey of Saw Mills

To find out the association of the timber degrading fungi and study the timber decay problems in sawmills a survey was conducted during last 5 years in different sawmills of i) Vadodara, ii) Ahmedabad, iii) Bharuch, iv) Rajkot and v) Jamnagar. In all 94 sawmills were surveyed from the Gujarat state, in which 28 sawmills were from Vadodara, 29 from Ahmedabad, 12 from Bharuch, 21 from Rajkot and 4 from Jamnagar. The location of these 5 districts is depicted in (Figure 1) and results are recorded in Tables 1, 2 and 3. The survey revealed that the economically important woods present in the saw mills included were a) Arjun (*T. arjuna* W.A.), b) Baheda (*Terminalia bellerica* Roxb.), c) Biyo (*Pterocarpus marsupium* Roxb.) d) Devdar (*Cedrus deodara* (Roxb. ex D. Don.) G. Don, e) Haldar (*Adina cordifolia* Roxb), f) Kapur (*Dryobalanops aromatica* Gaertn. F., Nom Cons.), g) Marinty (*S.*

contorta Vidal), h) Pine (*Pinus longifolia* Roxb. Sans.), i) Sal (*Shorea robusta* Gaertn. j) Sevan (*Gmelina arborea* Roxb.), k) Sisoo (*Dlabergia sissoo* Roxb.), l) Steam Beech (*Fagus grandifolia* Ehrh.), m) Sycamore (*Platanus occidentalis* L.) n) Teak (*Tectona grandis* L.f.), f.), and. Locally available, common woods present were a) Amli (*Tamarindus indica* L.), b) Aonla (*Emblica officinalis* Gaertn.). c) Babul (*Acacia arabica*) d) Gorus amli (*Pithecellobium dulce* (Roxb.) Benth.), e) Gulmohar (*Delonix regia* (Bojer ex Hook.) Raf) f) Mango (*Mangifera indica* L.), g) Neem (*Azadirachta indica* A.Juss), and These woods are commonly used in making planks for furniture, decorative items, and making packaging boxes etc.

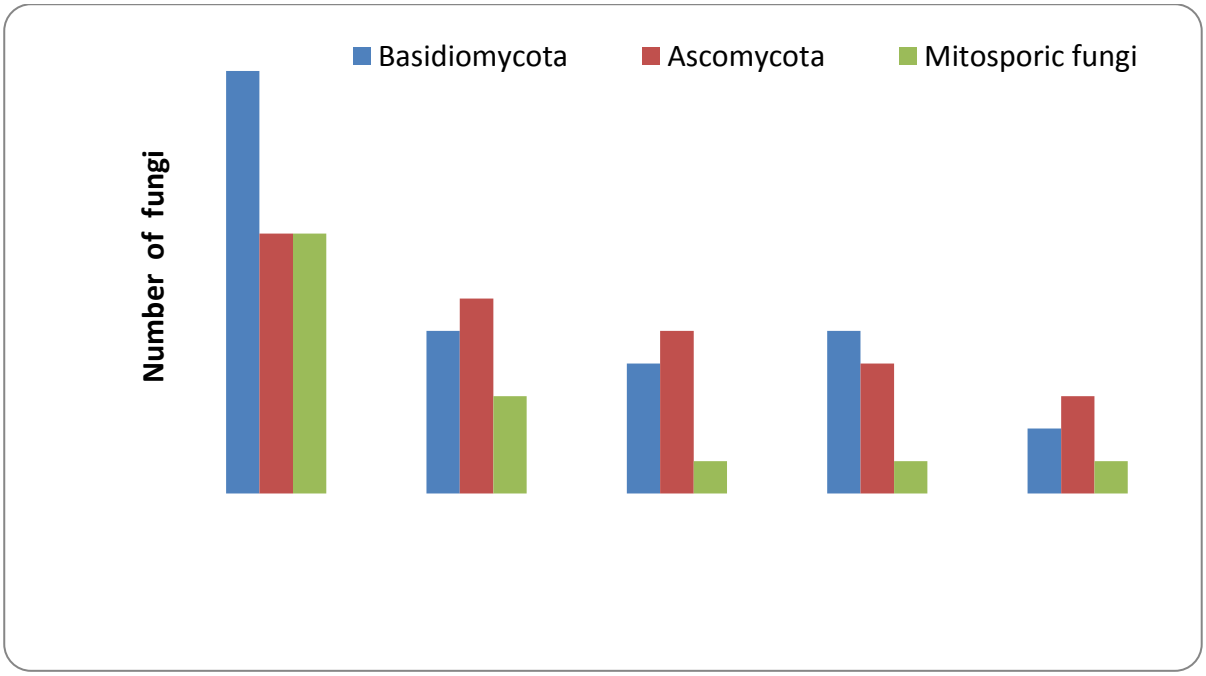

Figure 1. Showing the occurrence of wood decay fungi and their groups in different sawmills of Gujarat.

Table 1. Showing occurrence of different wood deteriorating fungi in Saw mills of 5 different districts of Gujarat.

Place	Total No of Saw mills	Samples with Associated Fungi	Occurrence of Fungal Deteriogens		
			Basidiomycota	Ascomycota	Mitosporic fungi
Vadodara	28	119	13	8	8
Ahmedabad	29	56	5	6	3
Rajkot	21	29	4	5	1
Bharuch	12	20	5	4	1
Jamnagar	4	10	2	3	1

Table 2. Occurrence of different wood decay fungi in sawmills of Gujarat.

S. No	Fungi	Group	Family
1	*Aspergillus flavus* Link.	Ascomycota	Trichocomaceae
2	*A. niger* van Tieghem	"	"
3	*Chaetomium globosum* Kunze.	"	Chaetomiaceae
4	*Daldinia concentrica* (Bolton) Cesati and de Notaris	"	Xylariaceae.
5	*D. sacchari* Dargan & Thind	"	"
6	*Hypoxylon rubignosa* Pers. ex. Fr.	"	"
7	*Xylaria feejeensis* (Berk.) Fr.	"	"
8	*X. polymorpha* (Pers.) Grev.	"	"
9	*X. allantoidea* (Berk.) Fr.,	"	"
10	*Agaricus*	Basidiomycota	Agaricaceae
11	*Auricularia aricula* (L.) Underwood	"	Auriculariaceae
12	*Coriolus versicolor* (L.ex Fr.) Quel.	"	Plyporaceae
13	*Daedaleopsis confragosa* (Fr.) Schroet.	"	"
14	*Flavodon flavus* (Klotzsch) Ryv.	"	Steccherinaceae:
15	*Ganoderma applanatum* (Pers. ex. Wallr.) Pat.	"	Ganodermatacease
16	*Ganoderma lucidum* (Fr.) Karsten.	"	"
17	*Lenzites betulina* (Fries.) Donk.	"	Polyporaceae
18	*L. sepiarum* (Wulfen) Fr.	"	"
19	*L. sterioides* (Fr.) Ryv.	"	"
20	*Phellinus badius* (Berk.: Cke) Cunn.	"	Hymenochaetaceae
21	*P. noxius* (Corner) Cunningham	"	"
22	*Trametes hirsutum* (Wulfen) Pilát,	"	Polyporaceae
23	*Sterium* hirsutum (Willd.) Pers.	"	Stereaceae
24	*Colletotrichum gloeosporioides* (Penz.) Penz. & Sacc	Mitosporic Fungi	Phyllachoraceae
25	*Fusarium moniliforme* J. Sheldon	"	Hypocreaceae
26	*F. pallidoroseum* (Cooke) Saccardo	"	"
27	*Lasiodiplodia theobromae* (Pat.) Griffon & Maubl.	"	Botryosphaeriaceae.
28	*Nectria cinnabarina* (Tode) Fr.,	"	Nectriaceae
29	*Phomopsis salmalica* A.H. Khan	"	Valsaceae
30	*Trichoderma harzianum* Rifai.	"	Hypocreaceae
31	*T. viride* Pers.	"	"
32	*Trichoderma* sp.	"	"

Table 3. Occurrence of timber and wood decay fungi in sawmills of Gujarat.

S. No	Wood	Fungi	V	A	B	R	J
1	*Tectona grandis*	*Lenzitesbetulina*	+	--	--	--	--
		L. sterioides	+	+	+	--	--
		Coriolus versicolor	+	--	--	--	--
		Trametes hirsutum	--	--	+	--	--
		Phellinus badius	+	--	--	--	--
		P. noxius	+	--	--	--	--
		Stereium hirsutum	+	--	--	--	--
		Ganoderma lucidum	+	--	--	--	--
		Flavodon flavus	+	+	--	--	--
		Schizophyllumcommune	+	+	+	+	--
		Xylaria allantoidea	+	--	--	+	--
		X. polymorpha	+	--	--	--	+
		Daldinia sacchari	+	--	--	--	--
		D. concentric	+	+	+	+	--
2	*Shorea robusta (sal)*	*S. commune*	+	--	--	--	--
		L. betulina	+	--	--	--	--
3	*Pinus longifolia*	*F. flavus*	+	--	--	--	--
		T. hirsutum	+	--	--	--	--
		D. concentrica	--	+	--	--	--
		D. sacchari	--	+	--	--	--
		S. commune	--	--	+	--	--
		X. polymorpha	+	--	--	--	+
		Agaricus sp.	--	--	--	+	--
4	*Mangifera indica*	*S. commune*	+	+	--	--	--
		L. betulina	--	+	--	--	--
		F. flavus	+	--	--	--	--
5	*Azadirachta indica*	*S.commune,*	+	+	+	+	+
		F.flavus	--	+	--	--	--
		D. concentrica	+	+	--	--	--
		X. feejeensis	+	--	+	--	--
		X. polymorpha	+	+	--	+	--
		Hypoxylon rubignosa	+	--	--	--	--
6	*Acacia nilotica*	*S. commune*	+	+	--	--	--
		G. applanatum	+	--	--	--	--
		G. lucidum	--	+	--	--	--
		D. concentrica	+	--	--	--	--
		X. Allantoidea	+	--	--	--	--
		X. polymorpha	+	+			
		F. flavus	--	--	--	+	--
7	*A. arabica*	*F. flavus*	+	--	--	--	--
		G. lucidum	+				
		D. concentrica	+	+	--	--	--
		P. badius	+	--	--	--	--
		X. polymorpha	--	--	+	--	--

		S. commune	--	+	--	--	--
8	African Mahagoni	*L. betulina*	+	--	--	--	--
		Daedaleopsis confragosa	+	--	--	--	--
		X. polymorpha	+	--	--	--	--
9	*Dryobalanops* spp (Kapoor)	*D. concentrica*	+	--	--	--	--
		S. commune	+	--	--	--	--
		X. Allantoidea	+	--	--	--	--
10	*Platanus occidentalis (Shaikamoor)*	*F. flavus*	+	--	--	--	--
11	*Tamarindus indica*	*D. concentrica*	+	--	--	--	--
		G. lucidum	+	--	--	--	--
		S. commune	--	--	+	+	+
		F. flavus	+	--	--	--	--
12	*Pongamia pinaeta*	*S. commune*	+	--	--	--	--
13	*Cedrus devodara*	*S. hirsutum*	+	--	--	--	--
		X. polymorpha	+	--	--	--	--
14	*Terminalia myriocarpa*	*F. flavus*	+	--	--	--	--
15	*Dlabergia sisoo*	*D. concentrica*	+	--	--	--	--
		S. commune	--	--	--	+	--
16	*Derris pinnata*	*S. commune*	--	+	--	+	--
		D. concentrica	+	+	--	--	+
		D. sacchari	--	+	--	--	--
17	*Ficus bengalensis*	*S. commune*	+	--	--	--	--
18	*Peltophoram rouxburghii*	*F.flavus*	+	--	+	--	--
		G. lucidum	+	--	--	--	--
		D. concentrica	+	--	--	--	--
19	*Pithacoelobium dulce*	*X. polymorpha*	+	+	--	--	--
		S. commune	--	+	--	--	--
		G. lucidum	+	--	+	--	--
		F. flavus	--	+	--	--	--
20	*Emblica officinalis*	*F. flavus*	+	--	--	--	--
21	*Eucalyptus globulus*	*L. betulina*	--	+	--	--	--
		S. commune	--	+	--	--	--
		F. flavus	--	--	--	+	--
22	*Adina cordifolia*	*S. commune*	--	--	+	--	+
23	*Terminalia bellerica*	*F. flavus*	--	+	--	--	--
24	*Bombax ceba*	*S. commune*	--	+	--	--	--
25	*Leucinia leucocephala*	*F.flavus*	--	--	--	--	--
26	*B. arudinacea*	*S. commune*	--	--	+	--	--
27	*Fagus grandifolia*	*X. polymorpha*	+	--	--	--	--
28	*Delonix regia*	*S. commune*	+	--	--	--	--
29	*Madhuca indica*	*G. applanatum*	+				
		G. lucidum	--	+	--	--	--
		S. commune	--	+	--	--	--
		F. flavus	--	+	--	--	--
		Auricularia aricula	+	--	--	--	--
		H. rubignosa.	+	--	--	--	--

		X. polymorpha	--	+	--	--	--
30	*Prosopis juliflora*	*F. flavus*	+	--	--	--	--
		Agaricus sp	+	--	--	--	--
31	*Aspidosperma* spp (Beyo)	--	--	--	--	--	--
32	*Shorea contorta (Marinty)*	--	--	--	--	--	--
33	*Fraxinus americana (Ash)*	--	--	--	--	--	--
34	*T. arjuna*	--	--	--	--	--	--

V = Vadodara, A = Ahmedabad, B = Bharuch, R = Rajkot, J = Jamnagar, + = Present, -- = Absent

3. 2. Diversity of fungal flora in saw mills

Out of the 94 sawmills surveyed, 84 sawmills showed the presence of timber degrading fungi. The 10 sawmills where no association of any fungi was found in Siva Shakti Sawmill in Vadodara, P. K. Patel and Co and Bhavani saw mill in Ahmedabad, K.K. Patel and Company and Patel A.Y. Lakadawala in Baruch Silicon Timber Mart, J.M. Patel Sawmill, Bagavan Timber Mart, Narayan Traderes and Maruthi Timber Mart in Rajkot. Only one timber decaying fungi was found in sawmills of Shri Mahadev Sawmill and Shiv Shakti timbers in Vadodara, Pavi Timber Mart, Sreelakshminarayan Saw mill, Shree Ganesh saw mill, Shree Vishnu saw mill and Shree Krishna saw mill in Ahmedabad, Lalit Timber Mart, Haji Abhdul Rahim Mahamadbhai Lakadawala, and Dhanlakshmi Sawmill in Bharuch, Shankar Vijay timber mart, Jyoti timber mart, D.K Patel and Co, Visal Timber Traders and Shankar Vijay Timber mart in Rajkot and Krishna Sawmill in Jamnagar.

Fifteen and thirteen fungal species were observed in two different saw mills situated in Chhani road, Vadodara, followed by 11 fungi in a saw mill of Station road Vadodara. Fours woods uninfected are Beyo, Marinty, Ash, and Arjun. Fourteen different types of fungi were found associated with teak, followed by seven in pinus, madhuca, *Acacia nilotica,* six in babul, neem, four in tamarind, *Pithacoelobium* and three in mango, Eucalyptus, African Mahagoni, Kapoor, *Peltophoram rouxburghii, Derris pinnata* wood respectively. The commonly observed timber decaying fungi were *Schizophyllum commune*, *Flavodon flavus* and *Ganoderma lucidum* belonging to *Basidiomycota*. *Ascomycota* members found associated were *Daldinia concentrica* and *Xylaria polymorpha.*

The timber decaying fungi associated with different woods in 94 sawmills produced huge amount of fungal spores dispersed in that area. The workers of sawmills surveyed were facing some respiratory problems. This may be because of the fungal spores inhalation which might be present in the air.

In most sawmills around the world, trees are harvested into logs and stored in the forest or in a log yard for a period of time before being sawn into lumber. These logs may be attacked by various pigment producing fungi. Since hardwood species are used to a great extent in furniture manufacturing and in the making of other valuable wood products, the reduction of wood staining fungi, molds, and decay fungi in these species has a significant economic impact. Studies on airborne fungal spores which are produced from different wood inhabiting fungi are undertaken by various scientists (Verhoeff and Burge, 1997). People who are constantly exposed to an indoor environment where works on organic substances and their byproducts are dealt with, may often develop respiratory disorders. Sawmill workers may be exposed at work to the inhalation of various allergenic and immunotoxic agents, comprising of wood derivatives (e.g. terpenes, resin acids) and microorganisms associated with timber (Dennekamp *et al.,* 1999). In the present sudy also different fungi like *Aspergillus niger, A.*

flavus, A. fumigatus, A. awamorii, producing toxins were studied. Inhalation of fungal spores may result into decrease in lung function, bronchial hyperresponsiveness and respiratory disorders, such as: organic dust toxic syndrome (ODTS), allergic alveolitis, asthma, non-asthmatic chronic airflow obstruction, chronic bronchitis, mucous membrane irritation syndrome (MMI) and rhinitis (Mandryk, 2000). in the present paper also the workers working in sawmills of gujarat were suffereing from allergic, chronic, respiratory problems
According to Wealth of India, Kerala has largest number of sawmills. A recent estimate shows more than 25000 registered sawmill presenting Gujarat. Airborne fungi occurring in different indoor environments such as libraries, markets, flour mills, hospital wards etc., have been reported from different parts of India (Sharma and Datta, 2001). But no such data is available for number and type of fungi occurring in the environment of saw mills. Few reports of such studies are however available from countries like Scandinavia, France, Canad and Poland (Dutkiewicz *et al.,* 2001). The studied conducted in Poland showed that the greatest concentrations of microorganisms in sawmills processing coniferous wood was noted at debarking stage of pine logs (Dutkiewicz *et al.,* 2001). In the present study also gratest concentration of fungal spores, decay fungi was identified from the sawmiils of Gujarat, Inida.

3. 3. Diversity of Mitosporic Fungi in saw mills

In the present study *Aspergillus flavus, A. niger, Chaetomium globosum, Colletotrichum gloeosporioides, Fusarium moniliforme, F. pallidoroseum, Lasiodiplodia theobromae, Nectria cinnabarina, Phomopsis salmalica, Trichoderma harzianum,* and *T. viride* were found associated with different timbers present in five district of Gujarat. Most dominant invaders of woods were *A. niger A. flavus, T. harzianum* and *T. viride*. The high risk genera like *Aspergillus* and *Trichoderma* were observed. In the present study it was found in a number of woods which were infected by the timber decaying fungi, dehisces different concentration and composition of fungal spores. The study revealed high prevalence of predominantly allergenic fungal spores in certain sawmills of the five districts of Gujarat.

Padmanabhan and Naya (2004) found association of *Aspergillus, Penicillium, Cladosporium, Nigrospora*, *Ganoderma*, „other basidiospores" and ascospores in air. They further found that *Aspergillus,* and *Penicillium* were the two most dominant spore types in the indoor air, which contributed 51.19% and *Cladosporium*, the most dominant spore type in the outdoor contributed 44.75% of the total spores. In a similar survey conducted in Eastern Canadian sawmills by Caroline and Anne (2000) found that *Penicillium* spp were the most frequently isolated microfungi. Aerobiologists have found that the two high allergy risk genera like the presence of *A. fumigatus* and various species of *Mucor, Trichoderma* and *Phoma* could adversely affect the man power working in these establishments (Simeray *et al.,* 1997). The concentration and composition of airborne microflora in sawmills may vary to a great degree depending on the kind of timber being processed and the technology of production (Mandryk, 2000). The type of wood processed may influence the composition of the mycoflora present in the atmosphere. *Penicillium* spp predominated in conifer and *Cladosporium* spp in hardwood sawmills (Simeray *et al.,* 1997). The pollution of air with microorganisms has been reported from the primary or secondary infection of timber (Rask-Andersen 1994). The primary infection develops in timber logs stored in forests and in lumber yards, initially with bacteria (described as "pioneer organisms") and then with fungi which may eventually cause wood decay (Käärik 1975).

It is evident from the table 2 and histogram 1, that in 5 different districts of Gujarat, 119 samples from vadodara, 56 samples from Ahmedabad, 29 samples from Rajkot, 20 samples

from Bharuch and 10 samples from Jamnagar were associated with timber decaying fungi. 29 species of timber deteriorating fungi were identified from vadaodara in which 13 belonged to group *Basidiomycota*, 8 belongs to group *Ascomycota* and Mitosporic fungi. Timber deteriorating fungi identified from Ahmedabad, Rajkot, Bharuch, and Jamnagar was 14, 10, and 6 species respectively.

According to an old survey there were 1643 sawmills in Gujarat in 1977 which increased to 4079 in 1996 (Jose and Shah 2001). But in the present paper different sawmills were identified with fungal infection, in which Fifteen and thirteen fungal species were observed in Chhani road, Vadodara. 5 fungal species were recorded in Jambhusar and 3 fungal species were observed in Ahmadabad. Teak wood is highly valued due to appearance and its wood properties including high durability and resistance to chemicals (Sandermann and Dietrichs, 1951). But in our survey reveled that teak wood was infected with 14 types of fungi in which *Lenzites sterioides* and *Trametes versicolor* damaged the wood severely. Commonly used timbers infected with seven types of fungi in Pinus, Madhuca, *Acacia nilotica,* six in Babul, Neem, four in Tamarind, *Pithacoelobium* and three in Mango, Eucalyptus, African Mahagoni, Kapoor, *Peltophoram rouxburghii, Derris pinnata* respectively.

4. CONCLUSIONS

For the first time fungal diversity of timber degrading fungi was studied in Gujarat, India. In the present study teak wood present in sawmills was infected with 14 types of fungi in which *Lenzites sterioides* and *Trametes versicolor* damaged the wood severely was reported for the first time. Gratest concentration of fungal spores, decay fungi was identified from the sawmiils of Gujarat, Inida. *Aspergillus niger, A. flavus, A. fumigatus, A. awamorii* producing toxins were reported from sawmills of Gujarat studied. The workers working in sawmills of gujarat which contain teak woods were suffereing from allergic, chronic, respiratory problems was reoprted for the first time.

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