Ecol. Env. & Cons. 12 (2) : 2006; pp. (223-226)
Copyright © Enviromedia

Decolourization and dechlorination of a pulp and paper industry effluent by *Thelephora* sp.

K. Selvam*, K. Swaminathan , K.Rasappan***, R. Rajendran* and S. Pattabhi******
**Department of Biotechnology, Dr. NGP Arts and Science College, Coimbatore 35, India*
***Department of Biotechnology, Bharathiar University, Coimbatore 46, India*
*** *Department of Civil Engineering, Coimbatore Institute of Technology, Coimbatore 14, India*
*****Department of Environmental Sciences, PSG College of Arts and Science Coimbatore 14, India*

ABSTRACT

The white rot fungus *Thelephora* sp. was newly isolated from the Western (Ghats region of Tamil Nadu, India, and used to treat pulp and paper industry effluents in a laboratory scale and in a pilot seale. This fungus has been shown to degrade a variety of persistant environmental pollutants. To develop in the laboratory scale, a maximum decolorization by 43.1% was achieved on the fourth day. Inorganic chloride at the concentration of 751 mg/L. which corresponded to 220.9% of that in the untreated effluent, was liberated on the tenth day. The chemical oxygen demand (COD) was also reduced to 1,840 mg/L (45.0%). In the pilot scale, a maximum decolorization by 23.6% was obtained with the one day incubation, inorganic chloride 361 mg/L (54.3%) was liberated on the sixth day and the COD was reduced to 2,000 mg/L corresponding to 40.2%. From the results, it seems to be one of the efficient candidates for dechlorination of wastewater.

Key word's : Chemical Oxygen Demand (COD), Dechlorination, Decolorization, *Thelephora* sp.

Introduction

Bleaching of kraft pulp uses large amounts of chlorine and/or chloride chemicals. Byproducts produced from using these chemicals are chlorinated organic substances, some of which are toxic, mutagenic, persistent, and bio-accumulating and cause numerous harmful disturbances in biological systems (Bajpai and Bajpai, 1997). Discharge of an untreated effluent from the industry into water bodies causes a poor water quality and the colour from an untreated effluent is detectable over long distances. The pulp and paper mill effluent is highly coloured, imparting a black/brown colour to receiving water bodies. The effluent colour may increase in water temperature and decrease photosynthesis, both of which probably lead to a decreased concentration of dissolved oxygen (Kingstad and Lindstrom, 1984).

White rot fungi can degrade lignin and its derivatives and therefore have potentials in the lignin/phenolic wastewater treatment (Eaton, *et al.* 1980). They have been proved to be ideal organisms for decolorization as well as for the reduction of adsorbable organic halides (AOX) and the chemical oxygen demand (COD). *Trametes versicolor* is one of the white rot fungus known to decolorize kraft mill effluents from sulphate pulping (Livernoehe *et al.*1981,1983). Colours in such effluents can be removed with mycelial pellets or calcium alginate-immobilized mycelium in batch cultures or in a continuous process (Livernoehe 1981; Rover 1983 and Archibald 1990). The maximum colour removal of baggasse-based paper mill effluent has been achieved by *T. versicolor* (Modi, *et al.*1998). Another white rot fungus, *Phanerochacte chrysosporiumn,* produces isoenzymes, including lignin peroxidases (LiPs) and Mn-depen-

dent peroxidases (MnPs) which are capable of degrading not only lignin, but also chlorinated lignins found in pulp-bleaching effluents (Kirk, *el al.* 1986 and Lankinen, *et al.* 1990). Upon screening of 12 basidiomycetous fungi, the most efficient strains for decolorization of paper mill wastes have been identified as *P. chrysosporium* strains and *P.flavidoalba* strains that produce extracellular ligninases. LiP and MnP (Pereze, *et al.* 1997). In this work, a newly isolated white rot fungus. *Thelephora* sp. was examined in laboratory scale and a pilot scale to evaluate the organism for application to the treatment of bleach plant effluent from a large paper mill, since different scales can show different efficiencies in the treatment. In particular, its potentials in decolorization, the reduction of the COD and the increase in the inorganic chloride content were analysed.

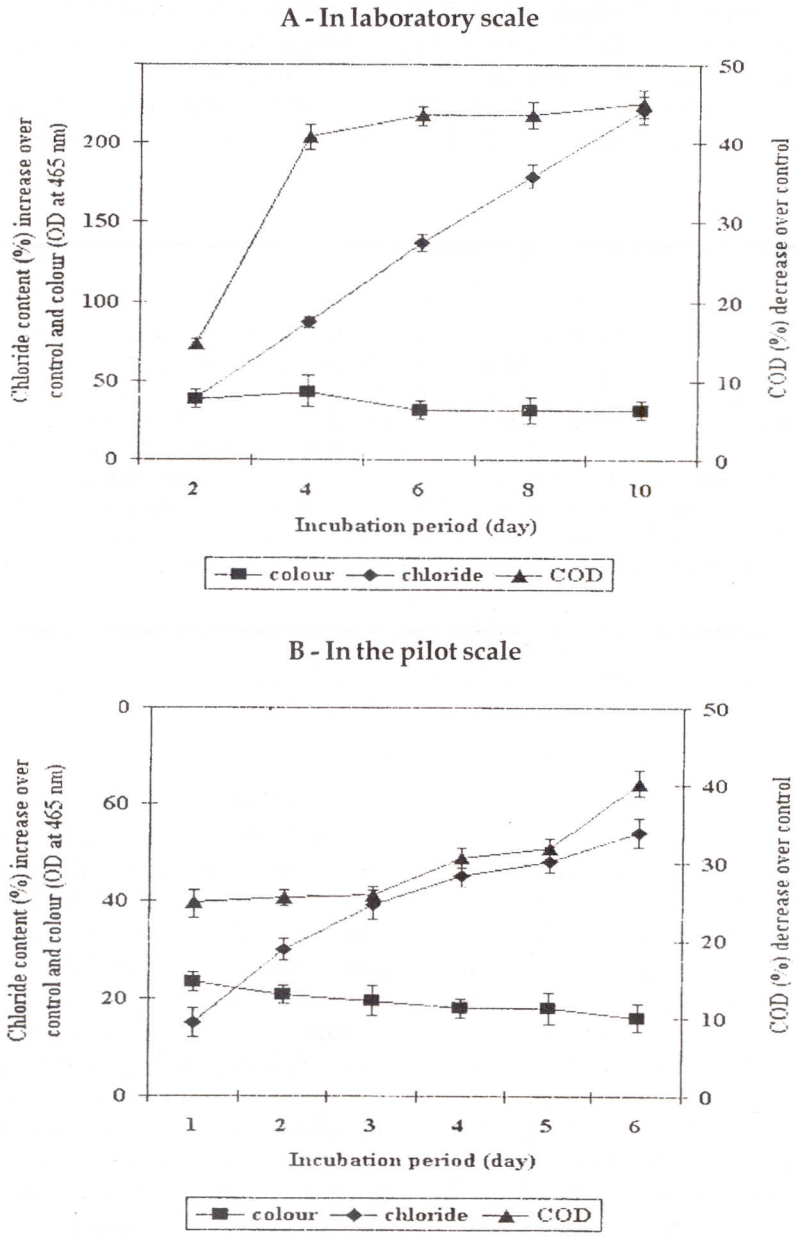

Fig.1 Treatment of pulp and paper mill effluent by *Thelephora* sp.
Colour %(OD at 465nm) - values decrease over control, Chloride content (%) - values increase over control, Chemical oxygen demand (COD, %) - values decrease over control Values are mean of three replicates and standard deviation.

Materials and Methods

A white rot fungus *Thelephora* sp. used in this study was isolated from a stump of a burnt tree collected from the Western Ghats region of Tamil Nadu, India. The fungus was identified based on the keys provided previously (Bakshi, 1971; Gilbertson and Ryvarden 1986). The fungus on the logs were cut out, sterilized with 1% mercuric chloride solution, repeated washed with sterile distilled water as described previously and cultured on 2% malt agar medium for 6 days at 37°C (Watling, 1971). Spores were harvested using a filter-sterilized camel hair brush. The spore concentration was adjusted to 10^5 spores/mL and used as an inoculum for further studies. The effluent from the first extraction of the bleaching sequence was a sewage from a paper mill, in Tamil Nadu, India, utilizing eucalyptus as a main raw material, stored at 4°C and filtered through a 0.5 mm sieve to remove large suspended particles. Production paper involves chemical digestion of wood and allied materials to convert them to pulp and chemical refining of the pulp. For these processes high amounts of alkaline and chlorine compounds are used. Hence the wastewater produced in this process was dark brown in color with charring wood and chemical odour. Moreover, since chlorine compounds are used, the wastewater contained high amounts of COD and carcinogenic organic chlorides. To analyse the efficiency of the wastewater treatment, *Thelephora* sp. was grown in media described elsewhere (Pellinen *et al.* 1988). The solution pH was adjusted to pH 4.5 with H_2SO_4. and the reactor was maintained at 39°C and continuously flushed with oxygen. After treatment, the mycelia were harvested and their efficiencies for reducing the color, increasing the inorganic chloride content, and the COD were analysed according to the methods reported previously (NCAS1, 1971). In the laboratory scale, the activities were measured every other day and in the pilot scale everyday for 6 days.

Results and Discussion

Colour, the chloride content and the COD in effluents are regarded as important factors to evaluate the water quality. Therefore, those factors in a pulp and paper effluent were measured during the treatment of the ligninolytic fungus, in a laboratory scale and in a pilot scale. In the laboratory scale, colour was reduced to 43.1% of that in the untreated effluent by the four day incubation. The liberation of inorganic chloride was increased up to 227% (751 mg/L) of that in the untreated effluent during ten days and the COD was reduced to 1.840 mg/L (45.0%) (Fig. 1 A). In the pilot scale, the colour was removed to 23.6% by first day incubation, 54.3% (361 mg/L) of inorganic chloride was liberated on the sixth day and the COD was reduced to 2.000 mg/L (40.2%) (Fig IB). These results revealed that the pilot scale experiment is not as efficient as the laboratory scale treatment and that the pilot scale experiment needs to be improved further. In the previous studies, *P. chrysosporium* and *T. versicolor* decolorized a pulp and paper mill effluent by 40 to 80 % (Pellinen, *et al.*1988; Bergbauer *et al.*1991; Fuki *et al.*1992; Manzanares, *et al.* 1995; Lee *et al.* 1995a, b and Modi *et al.* 1998) while *P. chrysosporium* increases inorganic chloride content by 34% (Pellinen, *et al.* 1988) and the COD of 32 to 70% was reduced with *P. chrysosporium* and *T. versicolor* (Pellinen *et al.* 1988 and Martin & Manzanares 1994). When compared with previous results, the newly isolated *Thelephora* sp. has a superior potential to dechlorinate lignin and/or lignin derivatives. This study is the first to report that *Thelephora* sp. seems to be best organism for dechlorination of lignin in pulp and paper mill effluent and therefore, using this organism may prove to be a very simple and inexpensive agent to remove organic chloride compounds in wastewater efficiently.

References

APHA, 1976. *Standard Methods for the Examination of Water and Wastewater.* American Public Health Association, New York.

Archibald, F.S., Paice, M.G. and Jurasek, L. 1990. Decolourization of kraft bleachery effluent chromophores by *Coriolus (Trametes) versicolor. Enzyme and Microh. Tcchnol.* 12 : 846 -853.

Bakshi, B.K. 1971. *Indian Polyporaceae - OnTrees and Timbers.* Indian Council for Agricultural Research (ICAR) publications, New Delhi, p. 80-81.

Bajpai, P. and Bajpai, P.K. 1997. In : *Advances in Biochemical Engineering/Biotechnology,*(ed.Eriksson,K.E.), Springer-Verlag : Berlin. 57 : 213-259.

Bergbauer, M., Eggert, C. and G. Kraepelin. 1991. Biodegraciation of chlorinated lignin compounds in a bleach plant effluent by white-rot fungus *Trameles versicolor. Appl. Microbiol. and Biotechnol.* 35 : 105-109.

Eaton, D. C., H. M. Chang, and T. K. Kirk. 1980. Decolourization of kraft bleach plant effluent. *TAP PI. Journal* 63 : 103-106.

Fukui, H., Presnell, T.L., Thomas, W.J. and Chang, H.M. 1992. Dechlorination and detoxification of bleach plant effluent by *Phanerochaeie chrysosporium. J.Biotechnol.* 24 : 267-275.

Gilbertson,R.L. and Ryvarden, L. 1986. *Norlh Americctnpo-Iyporefi. Qslo-.Funglftoni.* 1 : 43 3 p.

Kirk, T.K., Tien, M., Johnstucl, S.C. and Eriksson, K.E. 1986. Lignin degrading activity of *Phanerochaete chrysosporiuin* Burds : Comparison of cellulase negative and other strains. *Enzyme and Microb. Technol.* 8 : 75-80.

Kingstad, K. P. and K. Lindstrom. 1984. Spent liquors from pulp bleaching. *Environ. Science Technol.* 18 : 236A - 248A.

Lankinen, V.P., Inkeroinen, M.M., Pellinen, J. and Hatakka, A.I. 1990. The onset of lignin modifying enzyme, deerease of AOX and color removal by white rot fungi : Growth on bleach plant effluent. *Wat. Science and Technol.* 24 : 189-198.

Lee. S. H., Kondo, R. and Sakai, K. 1995a. Treatment of kraft bleaching eflluents by lignin degrading fungi. IV. An accelerating effect of glucono-deltalactone on the fungal decoloriziation of the El efflulent. *Journal of Japan Wood Research Society.* 41 : 110-113

Lee, S.H., Kondo, R., Sakai, K. and Sonomoto, K. 1995b. Treatment of kraft bleaching efnuents by lignin degrading fungi. V. Successive treatments with immobilised mycelium of the fungus KS-62. *Journal of Japan Wood Research Society.* 41 : 63-68.

Livernoche, D., L. Jurasek, M. Desrochers, and J. Dorica. 1981. Removal of color from kraft mill wastewaters with cultures of white rot fungi and with immobilized mycelium of *Coriolm versicolor. Biotechnol. and Bioengine.* 25 : 2055-2065.

Livernoche, D., Jurasek, L. Desrochers, M. and Veliky, I.A. 1983. Decolourization of a kraft mill effluent with fugal mycelium immobiliztion in calcium alginate gel. *Biolechnol. Lett. 3 :* 701-706.

Manzanares, P., Fajardo, S. and Martin, C. 1995. Production of ligninolytic activities when treating paper pulp effluents by *Trameles versicolor. Journal of Biolechnol.* 43 : 125-132.

Martin, C. and Manzanares, P. 1994. A study of the decolourization of straw soda pulping effluents by *Trametes versicolor. Bioresource Technol.* 47 : 209-214.

Messner, K., Ertler, G., Jaklin-Farcher, S., Boskovsky, P., Regensberger, V. and Blaha, A. 1990. In : *Biotechnology in Pulp and Paper Manufacture* (eds. Kirk,T.K. and II. M. Chang) Bufferworth-Heincmann, Stoneham, 245-253.

Modi, D.R., Chandra, H. and Garg, S.K. 1998. Decolourization of baggasse based paper mill effluent by the white rot fungus *Trametes versicolor. Bioresource Technol.* 66 : 79-81.

NCASI (National Council of the Paper Industry for Air and Stream Improvement). 1971. An investigation of improved procedures for measurement of mill effluent and receiving water color. *Technical Bulletin,* No. 253.

Pellinen, J., Joyce, T.W. and Chang, H.M. 1988. Dechlorination of high molecular weight chlorolignin by the white-rot fungus *Phanerochaele chrysosporium. TAP PI. Journal.* 71 : 191-194.

Pereze, J., Saez, L., Rubia, T.D.L. and Martinez, J. 1997. *Phanerochaele Jlav'uloalha* ligninolytic activities and decolorization of partially bio-deporated paper mill wastes. *Water Research.* 31 : 495 -502.

Royer. G., Livernoche, D., Desrochers, M., Jurasek, L., Rouleau, D. and Mayer, R.C. 1983. Decolourization of kraft mill effluent: Kinetic of a continuous process using immobilised *Coriolm versicolor. Biotechnol. Lett.* 5 : 321-326.

Watiing, R. 1971. Basiodiomycetes : Homobasidiomycetidae. In : *Methods in Microbiology.* V. 4. (ed. Booth. C.). Academic Press, London and New York, 219-236.