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Biodegradation of Chlorinated Organic Compounds by White-Rot Fungi

M. Arisoy

Department of Basic Health Science, Faculty of Health Education, University of Ankara, Keçiören, Ankara, Türkiye

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The white-rot fungi that cause white-rot of wood have recently become the object of increasing attention from workers in the hazardous waste field. These fungi normally grow on decaying wood and forest litter, and appear to be unique among microorganisms in that they can rapidly depolimerize and mineralize lignin to carbon dioxide (Hammel 1989; Fernando et al. 1989). White-rot fungi are also able to degrade a wide variety of environmentally pollutants to carbon dioxide, including a number of chlorinated pollutants such as DDT[1,1,1-trichloro-2,2-bis (4-chlorophenyl) ethane], Lindane (1,2,3,4,5,6-hexachlorocyclohexane), chlordane (1,2,4,5,6,7,8,8 - octachloro - 3a,4,7,7a-tetrahydro - 4 - 7,methanoindan) poly-chlorinated biphenyls , 2,3,7,8-TCDD (2,3,7,8-tetrachlorodibenzo-p-dioxin) and 3,4 dichloroaniline (Aust and Bumpus 1987; Sutherland et al. 1991; Yadav and Reddy 1993; Barr and Aust 1994; Fernando et al. 1989). Biodegradation of the pollutants was observed only during secondary metabolism, occuring at high rates only under conditions of nutrient limitation, and is cometabolic, i.e., a primary growth substrate such as cellulose or glucose is required (Bumpus et al. 1988; Bergbauer et al. 1991).

In this paper, various white-rot fungi species effective on biodegradation of pp'DDT [para-para'1,1,1-trichloro-2,2-bis-(p-chlorophenyl) ethane], lindane and heptachlor (1,4,5,6,7,8 -Heptachloro-3a,4,7,7a-tetrahydro-4,7-methanoine) have been investigated.

MATERIALS AND METHODS

Phanerochete chrysosporium, Pleurotus sajor-caju, Pleurotus florida, Pleurotus eryngi were used in the experiment. The stock cultures of the organisms were maintained on the malt agar slants. The culture medium is a modification given by Eaton (Eaton 1985). Culture medium contained (g/L) 0,12 NH_4CI; 2,6 K_2HPO_4; 0,5 $MgSO_4$; 0,1 $CaCI_2$; 10 Glucose; 0,001Thiamine. The culture medium was prepared in either 0,l M citrate buffer or 01M tris buffer. After dissolving (1:1) in acetone, pp'DDT, lindane or heptachlor were added to the medium. The growth of the organism in the culture was determined gravimetricaly by measuring the dry weight of mycelia.

Process of extraction of heptachlor is a modification described by Kaya (Kaya 1982). Obtained extracts were analyzed by using chrompack 438: a model gas chromatography system equipped with an CP-SIL- 5CB column and E.C.D (Electron Capture Detector). The temperature of the injection port was 160°C , exit port was 80°C and nitrogen (40 mL/min) was used as carrier gas. The decrease in the initial and final value of pp'DDT, heptachlor lindane were determined at the end of the analysis.

RESULTS AND DISCUSSION

In the studies, it was found that *Pleurotus sajor-caju* was effective in the degradation of pp'DDT and lindane, while *Phanerochete chrysosporium* was responsible for the degradation of heptachlor (Table 1, Table 2, Table 3).

Table 1. Effects of white-rot fungi on biodegradation of pp'DDT.

White-Rot Fungi	Biodegradation of pp'DDT (%)		Growth (mg. dry weight of mycelia/mL .media)	
	A	B	A	B
Phanerochaete chrysosporium	68.99	77.75	1.314	2.716
Pleurotus sajor-caju	78.23	91.70	2.086	2.438
Pleurotus florida	74.74	77.97	0.616	1.220
Pleurotus eryngii	46.92	65.98	2.970	3.810

A: 50µM of pp'DDT was added into the incubation medium at the middle of incubation time.

B: 50µM of pp'DDT was added into the incubation medium at initial stages of growth.

Culture was incubated at 30°C 150 r.p.m., pH:5, 50µM pp'DDT concentration for 20 days.

Maximum degradation rates were found to be 91.70 % for pp'DDT, 85.78 % for lindane and 97.30 % for heptachlor by effective white-rot fungi.

Table 2. Effects of white-rot fungi on biodegradation of lindane

White-Rot Fungi	Biodegradation of Lindane(%)		Growth (mg. dry weight of mycelia/mL media)	
	A	B	A	B
Phanerochaete chrysosporium	10.57	34.34	2.912	3.910
Pleurotus sajor-caju	20.68	89.11	2.676	2.690
Pleurotus florida	17.76	28.90	2.950	2.970
Pleurotus eryngii	67.13	82.40	0.616	0.888

A: 50µM of lindane was added into the incubation medium at the middle of incubation time.
B: 50µM of lindane was added into the incubation medium at initial stages of growth.
Culture was incubated at 30°C 150 r.p.m., pH:5, 50µM lindane concentration for 20 days.

Also enhancing effects of the addition of the mentioned substances to the incubation medium at initial stages of growth, on degradation were observed.

Although, according to Aust *Phanerochete chrysosporium* does not have to be adapted to the chemicals our results indicate that addition of these substances to the incubation medium at the beginning of the incubation may be effective in improving enzyme or enzyme systems of white-rot fungi for degradation (Aust 1990).

Besides *Phanerochete chrysosporium* which was studied on degradation of chlorinated organic pollutants before, *Pleurotus sajor-caju* has also the ability to degrade some chlorinated organic compounds more effectively.

It is suggested that the ability of white-rot fungi to degrade these compounds may make these fungi useful microorganisms for use in the biological treatment of contaminated soils, sediments and aqueous wastes when used in appropriate aerated waste treatment systems.

Table 3. Effects of white-rot fungi on biodegradation of heptachlor.

White-Rot Fungi	Biodegradation of Heptachlor (%)		Growth (mg. dry weight of mycelia/mL. media)	
	A	B	A	B
Phanerochaete chrysosporium	92.13	97.30	2.542	2.596
Pleurotus sajor-caju	59.53	84.76	0.530	0.650
Pleurotus florida	66.25	80.00	2.020	2.224
Pleurotus eryngii	85.85	95.15	0.784	1.314

A: 50µM of heptachlor was added into the incubation medium at the middle of incubation time.

B: 50µM of heptachlor was added into the incubation medium at initial stages of growth.

Culture was incubated at 30°C 150 r.p.m., pH:5, 50µM heptachlor concentration for 20 days.

REFERENCES

Aust SD (1990) Degradation of Environmental Pollutants by *Phanerochete chrysosporium:* Microb Ecol 20: 197-207.

Aust SD and Bumpus JA (1987) Biodegradation of the Halogenated Hydro carbons: EPA Environmental Research Brief 1-5,

Barr DP and Aust SD (1994) Pollutant Degradation by white- rot Fungi: Rewiews of Environmental Contamination and Toxicology vol 138 49-73.

Bergbauer M, Eggert C and Kraepelin G (1991) Degradation of Chlorinated Lignin Compounds in a Bleach Plant Effluent by White- Rot Fungus: Trametes versicolor: Applied Microbiology Biotechnol 25 105-109.

Bumpus JA, Mileski GR, Brock B, Ashbaugh W and Aust SD (1988) Biological Oxidation of Organic Compounds by Enzymes from a White Rot Fungus: Proceedings of the Fourteenth Anual Research Symposium 1-16.

Eaton DC (1982) Mineralization of Polychlorinated Biphenyls by *Phanerochete chrysosporium:* a lignilogytic Fungus: Enzyme Microb Technol 7 194-196.

Fernando T, Aust SD and Bumpus JA (1989) Effects of Culture Parameters on DDT [1,1,1-trichloro-2,2-bis (4-chlorophenyl) ethane] Biodegradation by *Phanerochete chrysosporium:* Chemosphere vol. 19 1387-1398.

Hammel KE (1985) Organopollutant Degradation by Ligninolytic Fungi: Enzyme Microb Technol vol. 11.

Kaya S (1982) Süt Yemi ve Çig Sütte Aflatoksin Kalintilarinin Kromatografik Yöntemle Arastilirmasi: AÜ Vet Fak Dergisi vol. 29 Sayi (3-4).

Sutherland JB, Selby AL, Freeman JP, Evans FE and Cerniglia CE (1991) Methabolism of Phenetrene by *Phanerochete chrysosporium* App and Environ Microb 3310-3316.

Yadav JS and Reddy CA (1993) Degradation Benzene Toluene Ethylbenzene and Xylenes (BTEX) by the lignin degrading Basidiomycetes *Phanerochete chrysosporium* App and Environ Microb 756-762.