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Forms and Distribution of Fungi in Paper and Pulp Manufacture Waste Water

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Sixtyeight different species of filamentous and yeast fungi were obtained from two sources of paper mill waste waters manufacturing pulp from straw and bamboo-soft wood mixture by hydroxide and sulfite pulping methods. The pulp manufacture waste water systems provided a high osmotic, lymaphilic, organic environment characteristically rich in sodium, potassium and phenolic substances Total quality of fungi in raw effluents was low but there was evident increase with self purification during the course of disposal. *Aspergillus, Penicillium, Fusarium, Acremonium, Preussia, Trichosporon* and to a lesser extent *Trichoderma, Gliocladium, Phoma* spp. predominated in these waste systems. Although majority were lymaxenes, a large number of lymaphilic fungi known for their characteristic decomposer functions for plant structural polymers and aromatic hydrocarbon residues were obtained.

Key words : Ecology, Waste water, Fungi, Pulp waste, Pollution.

INTRODUCTION

Paper and pulp manufacturing industries generate a high organic waste load and put a heavy burden on the fresh water disposal systems (Eriksson and Kirk, 1985). In the estuarine section of the river Ganges, in West Bengal. approximately 18.2 kg BOD load is generated per sq. km of the basin, much of which finds its way to the river (Dasgupta, 1984). Paper mill wastes contribute about 25% of the industrial BOD load discharged to the river. Fungi are important community segments of organic waste waters and play a significant role in self purfication of waste water disposal system (Cooke, 1979 ; Streit *et al*, 1987). In the context of an investigation on self purification of waste waters discharged to the river Hooghly in West Bengal, forms and distribution of fungi in paper and pulp manufacture waste waters was studied. The investigation has relevance to attempts for bioconversion and recycling of such wastes, results of which will be presented later.

MATERIALS AND METHODS

Paper and pulp manufacture waste was collected from Kalyani Paper Factory, Kalyani and Indian Paper Pulp, Hazinagar, processing pulp respectively from straw and bamboo-soft wood mixture by hydroxide and sulfite methods respectively. Replicate samples of water and soil or sludge were collected from suitable locations of waste water disposal systems of these units following standard methods of water and waste collection for bacteriological analysis (Anonymous, 1975). As far as practicable, soil and water samples were analysed immediately. Physical and chemical properties of water and solid matter were analysed using standard methods of analysis (Jackson, 1960 ; Anonymous, 1975, 1985 ; Hortwitz, 1960). Fungi were enumerated and isolated by conventional serial dilution plate count method in Dextrose-Peptone-Rose Bengal-Aureomycin Agar medium (Cooke, 1954) using suitable replications and identified with reference to standard descriptions (Thom and Raper, 1945 ; Raper *et al.*, 1949 ; Lodder snd Kreger-Van Rij, 1970 ; Domsch *et. al.*, 1980).

RESULTS AND DISCUSSION

Waste waters from both the paper and pulp manufacturing industries contained very high organic load (low DO), a large part of which appeared to be not easily biodegradable, as the BOD/COD ratio were very low (Table 1). There was evidence for partial self purification with consequent reductions in concentrations of oxidizable carbon matter of the wastes before those were discharged to the river (Table 1). Physico-chemical analysis of waste waters (Table 2) revealed a high ionic concentration particularly of sodium and potassium in the effluents. Chlorides, phosphates and sulfates were also present in very high concentrations. Sugar and nitrogen concentrations were very low and concentration of free phenolics was very high. Chemically, the pulp manufacture waste waters presented a highly saline, high osmotic environment, rich in oxidizable organic substances. Alkali digestion of lignocellulosic matter provided the saline organic substances in the waste systems.

Analysis of waste waters for fungi in specific medium revealed the presence of a population of filamentous fungi and some yeasts in varying quantities (Table 1). Population values of the raw effluents were generally low, but with lowering of BOD due to self purification population of fungi increased in flowing waste waters. Basin soil had higher population than that of the submerged and cleared sludge but among the latter two, submerged sludge had a little higher population than the cleared sludge. High ionic concentration and low availability of oxygen appeared to be the possible impediments for the fungi in raw effluents.

Table 1 : Organic pollution load and total count of fungi of paper and pulp manufacture of waste waters.

Source	pH	DO	BOD	COD	Organic carbon (%)	BOD/COD	Total count per g/ml
			(ppm)				
a) Effluent at source	6.0 7.8	0.25 0.50	186 243	268 370	0.214 0.227	0.65 0.69	$1.4_{10.0} \times 10^2$
b) Effluent at 300 mt from source	6.0 7.0	0.3 1.2	128 165	176 325	—	0.5 0.72	$4.0_{18.0} \times 10^2$
c) Effluent when mixed with river water	7.0	3.0 5.2	8 21	20 74	— —	0.28 0.40	$8.0_{32.0} \times 10^2$
d) Submerged soil/sludge	7.0	—	—	—	0.946 1.410	—	$2.8_{9.1} \times 10^4$
e) Cleared sludge	8.0	—	—	—	2.82 3.31	—	$0.2_{1.7} \times 10^4$
f) Basin soil, not influenced by waste water	7.0	—	—	—	0.481 1.130	—	$32.0_{130.0} \times 10^4$

Values are range for 5X2 determinations of two different sources, straw-hydroxide and bamboo-sulfite manufacture processes, during two seasons.

Table 2 : Physical and chemical properties of waste waters from paper and pulp manufacture.

Parameters	Values	
	Sulfite pulping	Hydroxide pulping
pH	7.5	7.8
TDS (g %)	0.112	0.118
TSS (ppm)	0.200	0.280
ECe (m. mhos/cm)	4.100	4.710
Colour	Violet brown	Brown
Carbonte	Nil	Negligible
Bicarbonate (meg/1)	—	2.25
Chloride (meg/1)	18.20	16.25
Sulfate (meg/1)	68.0	62.50
Na^+ (ppm)	186.0	170.0
K^+ (ppm)	102.0	83.70
Ca^{++} (meg/1)	8.20	5.40
Mg^{++} (meg/1)	4.80	1.60
Phosporus (ppm)	20.32	23.81
Sodium Adsorption ratio (SAR)	4.20	3.95
Total phenolics (ppm)	283.0	310.0
Total sugars (ppm)	8.0	5.0
Total nitrogen (%)	0.007	0.005

The species composition (Table 3) of pulp waste water fungi was predominated by mainly *Aspergillus*, *Penicillium*, *Fusarium*, *Acremonium*, *Preussia* yeast

Table 3 : Species frequency of fungi of paper and pulp waste waters population count as % of total

Organism	Source					
	Effluent water		Sludge		Soil	
	1	2	1	2	1	2
Yeast *(Trichosporon* spp *)*	59 7	8.6	10.8	4.2	2.8	—
Aspergillus spp.	10.8	41 8	22.3	43.4	17.6	64.6
Penicillium spp.	8.6	20.0	14.8	18.6	26.5	14.2
Fusarium spp.	7.2	11.0	12.8	8.2	16.5	6.2
Acremonium spp.	3.4	8.4	6.0	3.7	6.5	1.3
Trichoderma spp.	2.4	+	8.4	+	10.2	+
Gliocladium spp.	2 4	—	6.1	—	5.2	—
Preussia spp.	2.1	4.7	9.2	6.5	6.4	2.2
Arthrosporic isolates, possibly anamorphs of basidiomycetes	—	2.6	—	1.8	—	—
Other spp.	3.4	2.9	9.6	6.7	8.3	6.9

1—Hydroxide pulping 2—Sulfite pulping, (+)/(—) —Signs indicate presence/absence in very low frequency and inc uded among the other species.

(*Trichosporon*) and to a lesser extent by *Tri hoderma*, *Gliocladium*, *Phoma* and others. Straw based hydroxide pulp waste liquor supported more number of fungal species than wood based sulfite pulping waste. Yeasts, particularly *Trichosporon cutaneum* predominated in hydroxide pulp waste but not in sulfite liquor. Variation in species composition between the two sources was caused by possible variations of primary substrate (straw and wood) and chemical process of digestion (hydroxide and sulfite).

In spite of high ionic concentration and low DO, paper and pulp manufacturing waste waters, particularly in flowing systems, had a reasonable diversity of fungal species.

Among the fungi isolated excluding the 3-4 species of casual invadors (e. g. *Bipolaris sorokiniana*, *Nigrospora oryzae* etc.) majority were lymaxenes-fungi of other environment tolerating high ionic waste water environment. Characteristically, however, there were a few lymaphiles also (Cooke and Pipes, 1970). Notable among them were *Trichosporon* spp. and other yeasts, most possibly *Candida* and *Rhodotorula* spp., *Geotrichum candidum*, *Phoma* spp., *Preussia* spp., *Sporotrichum pruinosum* and a few *Aspergillus* and *Penicillium* spp. These species represent the characteristic mycoflora of the pulp manufacture

waste water systems. A rich concentration of degradable organic substances was obviously the reason for such high collection of species and apparently they were tolerant to high ionic concentration and low 0_2 saturation of the environment.

Among the species obtained, few are characteristically known for their exclusive decomposer functions for plant structural polymers including lignin matter (e.g. *Trichoderma*, *Sporotrichum*, *Humicola*, *Paecilomyces*, *Gliocladium* etc.). Yeast like *Trichosporon* spp. with their particular preference to straw based waste water can be considered as important decomposer-consumer segment of such waste matter. Species of *Aspergillus*, *Penicillium*, yeast, *Fusarium*, *Acremonium* and *Paecilomyces* as isolated here are ecologically consumers but are known for their utilization of complex ligno-cellulosic hydrocarbons and aromatics of synthetic origin (Domsch *et. al.*, 1980)

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