5. SUMMARY

Prehistoric man had dyed furs, textile and other objects with natural substances, mainly of vegetable, but also of animal origin. In the 19th and the 20th century many dyes were discovered and their chemical constitutions elucidated. Currently, thousands of dyes of different constitutions are commercially available to meet global demands. In the dyeing industries, about 30 to 60L of water is consumed per kilogram of cloth dyed and large quantities of effluents are released during processing. Comprising over 70% of the earth's surface, water is undoubtedly the most precious natural resource that exists on our planet. When it is unfit for its intended use, water is considered polluted. Effluents containing dyes destroys scenic beauty of water bodies and contaminates groundwater. Soil pollution in the surrounding areas is also noticed. Most dyes are known to be mutagenic, teratogenic or carcinogenic in humans and animals. Dyeing industries use various technologies to treat their effluent. Some conventional technologies have not been very effective in removing dyes, while others have not been economically feasible. Therefore most industries use a combination of chemical and biological technologies to remove dyes from their wastewater. However, the search for a cost effective, sludge-free technology to remove dyes from dyeing industry effluent is still underway.

The present study was carried out to investigate the removal of color from textile dyeing effluent sample collected from Tube Knit Fashion Processing Unit, Tirupur, India using a suitable fungal strain.

Among the 54 fungal strains isolated from their natural habitats in Western Ghats, Trametes versicolor was found to have good adsorption capacity towards the dyes studied. The efficiency of this fungal species to remove Reactive Red, Reactive Blue and Congo Red dyes from aqueous solutions was studied in batch and fixed bed modes. In batch studies three different modes, agitated, aerated and rotating biological contactor were employed. The fungal biomass was
subjected to various pretreatments viz. autoclaving, autoclaving followed by acid pretreatment and alkali pretreatment to enhance their adsorption efficiency. In batch studies, autoclaved biomass of *T. versicolor* was found to be most effective in removal of dyes from aqueous solutions. At lower concentrations, complete removal of all the dyes studied was observed in this treatment process, 100% removal was noticed at 20, 10 and 30 mg/L of Reactive Red, Reactive Blue and Congo Red, respectively in agitated mode. In batch studies, equilibrium time slightly varied with initial dye concentrations and type of adsorbent used. In case of Reactive Red, the equilibrium time ranged between 70 to 110 min, whereas for Reactive Blue it was between 90 to 110 min and for Congo Red 30 to 90 min. For further studies, 120 min was considered as optimum contact time for Reactive Red and Reactive Blue and 90 min for Congo Red. Optimum adsorbent dosage was 2.0 g/50 mL of dye solution. Adsorption was pH dependent and maximum adsorption was noticed at acidic pH. Studies on adsorption isotherms revealed that adsorption of dyes by the fungal biomass follow the Langmuir, Freundlich and Tempkin models. Lagergren constants obtained in the present study revealed that dye concentration did not have significant effect on the rate of adsorption. Second order kinetics fitted well than the first order or Lagergren kinetics model.

Desorption studies revealed that alkaline medium favoured desorption of the dyes. Percent desorption was 29.2, 36.4 and 40.0 for Reactive Red, Reactive Blue and Congo Red, respectively. Desorption was attempted in industrial ethanol (70%) which yielded 40.6, 42.6 and 50.9% removal of these dyes at initial 5 min. Complete desorption (100%) of all the dyes was achieved within 30 min.

In column mode adsorption studies, autoclaved biomass which showed better adsorption in batch mode was used. The flow rate and bed volume were optimized using aqueous dye solutions. Flow rate of 2.5 mL/min and bed volume of 49 cm³ were found to be optimum for removal of dyes studied. The data
obtained in the fixed bed studies revealed that adsorption of dyes by the fungal biomass obeyed the BDST model. $N_0$ and $K_a$ values were calculated from the BDST (Bed – Depth – Service – Time) curves. Comparison of $Q_0$ from batch studies and $N_0$ from column studies revealed that agitated batch mode was more efficient and so the same was employed for effluent treatment.

The textile dyeing effluent collected from Tube Knit Fashion Processing Unit, Tirupur, India was subjected to fungal treatment. The physico-chemical properties of the effluent were determined. The pH of the effluent was found to be slightly alkaline (8.6). But the pH was unaltered for further treatment, because it is not either practical or economical to alter the pH of a large quantity of effluent. The effluent contained 1042 mg/L of total suspended solids (TSS), 6336 mg/L of total dissolved solids (TDS), 402 mg/L of calcium, 154 mg/L of magnesium, 3051 mg/L of chlorides, 331 mg/L of sulphates, 0.2 mg/L of iron, 78 mg/L of silica and 0.21 mg/L of fluoride. The biochemical oxygen demand (BOD) at 20 °C for 5 days was 95 mg/L and the chemical oxygen demand (COD) was 650 mg/L. The preliminary studies revealed that adsorbent dosage of 2.5 g/50 mL of effluent and treatment period of 90 min were optimum for effluent treatment. The fungal treatment reduced color, odour, iron, silica and fluoride completely. TSS, TDS, BOD, COD, chlorides, sulphates, calcium and magnesium were reduced by 2.3, 34.86, 37.89, 25.28, 53.65, 58.31, 48.26 and 41.56 per cent, respectively. The treated and untreated effluent samples were plated on Czapex - Dox agar plates to check for the presence of *Trametes versicolor*. The culture plates did not show any growth of *T. versicolor*. It may be due to the use of autoclaved biomass as adsorbent in which the mycelium was already killed. This validates the use of autoclaved biomass as a safe adsorbent for treatment of textile dying effluent.

Results obtained in the effluent toxicity studies showed that raw effluent was not acutely toxic to seed germination, but affected the development of embryonic axis by about 31 per cent and inhibited the development of root and shoot by 32
and 30 per cent, respectively. Total biomass production was inhibited by 42.08 per cent. But the treated effluent increased the root length, shoot length, root biomass and shoot biomass by 72, 77, 95 and 39 per cent, respectively when compared to untreated effluent. Phytotoxicity of untreated effluent was 31.55, which was reduced to 8.95 in treated effluent. Vigour index of untreated effluent (1995) was increased after the fungal treatment (2657). The tolerant index towards untreated effluent was 0.685 but for treated effluent it was 0.911, which was nearer to control (1.000). These phytotoxicity parameters revealed that the treatment of dye industry effluent with autoclaved biomass of T. versicolor could reduce the toxicity of the effluent significantly.

The IR studies exhibited the presence of C=C, N-H, C-H, C-N and C=O groups on the surface of live and other pretreated biomasses. IR studies also revealed that acid and alkali pretreatment caused hydrolysis of the wall polysaccharides, accompanying increased exposure of hydrophilic functional groups from polysaccharides resulting in low adsorption affinity of the hydrophobic dyes onto the surface of the treated fungal biomass. SEM images depicted the change in morphology and texture of the fungal biomass due to various pretreatments. Image analysis revealed the uptake of dyes by the fungal biomass.

As the fungus, Trametes versicolor is easily cultivable and is also available as waste from various industrial processes, its utility as a biosorbent for dyes will be economical and can be viewed as a waste management strategy. Since the dye adsorbed on the surface of the fungal biomass can be easily desorbed, it can be reused as a low grade dye. Moreover, as the fungal biomass is easily biodegradable, the biomass can be easily composted thereby avoiding sludge accumulation.