I. INTRODUCTION

Tanning industry is one of the oldest industries in India. India occupies a predominant position in the production of hides and skins and is a major supplier. Annually about 100 million pieces of hides and skins which form 12% of the total output are produced in India (Sastry, 1981). Leather industry is mainly concentrated in Karnataka, Rajasthan, Tamil Nadu, Uttar Pradesh and West Bengal.

Although tanning industry has been in existence in the country for a long time, the problem of environmental pollution from the tanneries has been realised only recently. Of the variety of industrial effluents, the one from tanneries is the most complex and is a serious pollutant (Arora, 1981). The untreated waste water when allowed to stagnate gives rise to unpleasant odour, unsightly appearance besides creating ground water and surface water pollution. The demand for cleaner environment, especially in the context of increasing population necessitates early measures to contain and remove pollution from tanneries (Sastry, 1981).

Tannery effluents

Most of the tanneries in India adopt vegetable tanning process. The important steps followed in a tannery are
a. soaking, b. liming and removal of hair, c. deliming and washing, d. tanning, and e. finishing. 'Beam house waste water' is formed by steps a to c. The waste water from steps d and e is called 'tannery water'. Presence of high amounts of tannin renders the combined waste liquid highly pigmented. The quantity of waste water released from tanneries varies from 3,008 to 3,324 litres per 100 kg of hides processed per day. The wastes from tannin vats are the strongest of all portions which means that these composite wastes are highly polluted with high biochemical oxygen demand. In the tannery liquors, nearly 14.08 g/L of tannin is present for 100 kg of hides processed (Krishnamoorthy et al., 1972).

As early as 1936, the toxicity of tannery effluent was recognized (Krishnamoorthy et al., 1972). The major toxic component of vegetable tannery effluent is tannin (Rao and Mariappan, 1972). It is also toxic to aquatic animals (Mahadevan and Muthukumar, 1980).

The effluents from tanneries have high pollutional potential. The main polluting constituents of the final composite effluent are: a. high pH value, b. high chloride and sulphide content, c. high sodium level, d. high concentrations of chromium and tannin, e. high quantities of total and dissolved solids and f. large amounts of oxidisable organic matter. The various
undesirable effects caused by different polluting constituents of untreated effluent when discharged into environment are the following.

**Effect on streams**

Since the waste water exerts high oxygen demand, both chemical and biochemical, it takes up the dissolved oxygen of receiving water completely, thereby bringing in the process of putrefaction. The suspended organic solids settle at the bottom and form sludge deposits which in turn create benthic oxygen demand. Tannin imparts brown colour to water and exerts chemical oxygen demand. The brown colour exists for long stretches in streams. High concentrations of sodium chloride result in the brackish taste of the receiving waters which become unsuitable for domestic and irrigational purposes.

**Effect on land**

Pores of the soil are clogged by the suspended organic solids of untreated composite effluent. The solids decay and lead to soil sickness. Chlorosis of plants results as a regular phenomenon due to chlorides of waste water. Presence of sodium at high concentrations deleteriously affects the soil structure and growth. Therefore, the use of tannery water for irrigation not only impairs soil productivity but also causes complete infertility.
Effect on sewers

Discharge of untreated tannery effluent into sewers enhances the anaerobicity and consequent increase in the production of carbon dioxide. Lime present in the effluents combines with the carbon dioxide forming calcium carbonate. The calcium carbonate and other suspended particles reduce the carrying capacity of sewers. Furthermore, deposits of calcium carbonate are difficult to dislodge during sewage cleaning.

The problem

Although investigations were started some fifty years ago to study the effect of tannery effluents, the results are not conclusive nor convincing. Only recently has Muthukumar (1980) from this laboratory made a thorough study on the effect of tannins on crops and microorganisms. Subsequently Sivaswamy (1982) studied the effect of tannery effluents on soil and microorganisms.

Other workers analysed the metabolic pathway of various tannin derivatives, but only that of hydrolyzable tannins. Aspergillus flavus, A. fumigatus, A. niger, species of Candida, Fusarium, Penicillium and Trichoderma were the dominant fungi capable of utilizing tannin derivatives. Some species of Achromobacter and Pseudomonas utilized tannins (Benoit et al., 1968; Chandrakantha et al., 1973; Dalvesco et al., 1972;

Metabolic pathways of hydrolyzable tannins such as tannic acid, gallic acid and gallotannin have been well established. Also enzymological aspects of tannic acid, gallic acid and other hydrolyzable tannins have been satisfactorily investigated. Tannase was isolated as early as 1913 and following that several workers have isolated and studied tannase from various organisms (Adachi et al., 1968; Aoki et al., 1974; Badura et al., 1969; Chab and Yu, 1973; Chernyagina, 1971; Dhar and Bose, 1964; Doi et al., 1973; Ganga et al., 1977; Knudson, 1913; Nishira, 1962; Parthasarathy and Bose, 1976; Srivastava and Sharma, 1974; Suseela et al., 1978; Yamada et al., 1968).

However, information on the degradation of condensed tannins is only fragmentary. Only Chandra et al., (1969) presented data that an extracellular enzyme from A. flavus degraded catechin.

A few fungi were isolated from rice field soil and used for in vitro studies. Degradation of various tannins, as sole carbon source, cometabolism of tannins and degradation of tannins by Cooum water and sediment were investigated.
After several trials and preliminary investigations, \textit{Chaetomium cupreum} was found to utilize catechin as sole carbon source. Enzymological aspects of catechin degradation, \textit{homogeneity} of the enzyme, and its characteristics have been studied. Intermediates and end products of catechin degradation have been analysed.

It is thought to be about 12,000 years old (Levis, 1957) and has made many workers unresponsive. Not only substances which are used for leathering hides should be classified as tanning. But this classification is too restrictive because plants contain a variety of substances which have all the properties of tanning except that they have not been selected for tanning ability to leather hides. Moreover, substances (complexes) which have the capacity of leathering hides are not to be found in vegetable extracts.

Any naturally occurring substance of molecular weight between 500 and 3,000 containing a sufficient number of phenolic hydroxyl or other suitable groups (the molecular weight) which enables it to form effective cross-links between protein and the macromolecule, can be regarded as tanning. Lower molecular weight phenolics are too small in size to form effective cross-links. Although these phenolics may be transferred by alcohol into the stability constant of wood components rapidly. In contrast, high molecular weight compounds tend to act as non-tannins.