CHAPTER 8

CONCLUSIONS AND RECOMMENDATIONS

8.1 Summary

Tanneries in India play a significant role in the national economic development programme. Leather tanning units are however identified as major segment of environmental pollution and included in the category of hazardous industries. Large quantities of solid wastes are generated during leather processing and subsequently during effluent treatment. Only some of the wastes generated find applications, most of the solid wastes had serious problems in their safe disposal.

Chapter 1 highlights profile of tanning industry in India and the environmental related issues affecting the leather industry. Leather making process and sources of pollution are discussed. The efficacies of the existing facilities for controlling pollution along with technologies of solid waste management adapted by tanneries are analysed. The need for anaerobic digestion process, objective and scope of the study are presented.

Chapter 2 is devoted to review of the past studies in the area of environment, scientific and technological advances in anaerobic digestion process more particularly on solid wastes which favoured the current research. The major focus is to draw inferences towards anaerobic digestion process of tannery solid wastes treatment.

Chapter 3 describes in general generation of tannery solid and liquid wastes. The information on source of generation of flesh and primary sludge which are the substrates taken up for the present study, materials and methods followed in characterisation of the solid wastes are described. The composition of fleshing and primary sludge determined have been analysed to assess their potential for the anaerobic digestion process.

Chapter 4 gives detailed information on the design of anaerobic digesters. The major focus is to draw inference towards planning, design and operation of various
types of anaerobic reactors. The design and construction of laboratory scale experimental set-up for batch and two phase studies specific for tannery solid wastes are described.

Chapter 5 presents the studies on Biochemical Methane Potential (BMP) and Anaerobic Toxicity Assay (ATA) by co digestion of tannery solid waste and effluent treatment plant sludge in batch systems. The results of batch kinetics are presented in detail. The significance of refractory component present in the wastes with reference to BMP and ATA has been highlighted.

Chapter 6 highlights studies on two-stage fed batch system. The performance of stage separation systems on volatile solids destruction, rate of gas production, specific gas production, gas composition, etc., has been reported. The evaluation of overall performance of the two stage system has been reported and the advantages of digesting in two-stage system especially protein rich substrates have been highlighted.

Chapter 7 focuses on the microbial aspects of anaerobic digestion, isolation, identification and characterisation of predominant methanogen present in anaerobic digester system of tannery solid wastes.

8.2 Conclusion

The following conclusions have been drawn from the experimental studies conducted under BMP, ATA, single phase, two phase and methanogenic activity of isolated strain.

8.3 Batch Experiments

8.3.1 BMP studies

- Acclimatized sludge used as inoculum for the study was sufficient and contained active biomass which achieved easy startup of the digestion process.

- Based on the VS destruction efficiencies and specific gas production, the tannery solid and primary sludge are amenable for anaerobic treatment for the recovery of biogas with high methane content.
The rapid consumption of VFA observed in the digester system confirms the adequacy of methanogenic activity of methanogens present in the reactor.

The kinetic analysis of the data fit in first order reaction mechanism.

The kinetic data generated in this study formed the basis of the design criteria for the management of tannery solid wastes or similar types of industrial or municipal solid wastes with high organic contents by anaerobic digestion process.

It is observed that larger the refractory fraction present in the feed mixture longer the lag time for the onset of biogas generation.

8.3.2 ATA studies

The feed mixture of tannery solid and primary sludge is found to contain very low concentration of easily biodegradable volatile solids. This is confirmed by the low VS destruction efficiency and specific gas yields.

Even though on higher VS load a rapid increase in VFA concentration was observed, higher gas production rate is achieved due to the presence of higher fraction of available biodegradable organic matter in feed mixture.

It is more appropriate to consider available biodegradable fraction of VS rather than total VS for evaluating biomethanation potential.

8.3.3 Two-Stage System

Fleshing material rich in protein and C/N ratio of 3 has been anaerobically digested at a OLR of 3.47 gm VS/l.d and overall VS conversion efficiencies of 67% has been achieved.

Co-digestion of fleshing material with liquid wastes minimizes ammonia toxicity in two stage process as the bacteria cultures in the two stage process are more robust against high ammonia concentration.
The higher methane content in the second stage indicates presence of highly active methanogens in the reactor and the dynamic balance prevailing between VFA concentration and biogas generation rate.

It is concluded that the two stage digestion system can be operated with protein rich substrates at higher organic loading rates without any process instabilities of fatty acid accumulation.

### 8.3.4 Microbiology and Methanogenic Activity of the Isolate

- Pure culture of predominant methanogen present in the digester was isolated under strict anaerobic condition.
- The performances of isolated methanogenic strain were acetoclastic in nature, which can withstand higher concentration of acetate.

### 8.4 Recommendations

In the present study batch kinetics and biodegradability nature of fleshing have been studied which formed the basis for selection of appropriate system design for the fed batch system. It is concluded that two-stage fed batch system is the most appropriate system design for the anaerobic treatment of fleshing material which is rich in protein and having C/N ratio of 3. The overall performance of the two-stage digestion indicates that the VS destruction efficiency has to be enhanced to a higher level. It is realised that improvement in the system design engineering alone will not help to increase VS conversion efficiency and to achieve higher specific gas production in terms of VS in the feed and VS eliminated. In view of this following recommendation are made for further research in the field of anaerobic digestion of protein and lipids rich wastes.

- In order to improve the overall performance of the two-stage system for flesh material, specific enzymes assisted acidogenesis process has to be developed to improve the efficiency of volatile fatty acid production at a higher organic loading rate with lower hydraulic retention time.
As the C/N content for tannery solid waste is low, development of co-digestion process has to be studied by mixing with suitable industrial wastes with a view to maximize the biogas production with higher methane content.

The role of genetically engineered micro organisms specifically for two stage system has to be studied for improving the anaerobic treatment process with a view to enhance the biomethanation capacity of existing units and to lower the capital and operating cost of the biomethanation plant.