CHAPTER 7

SUMMARY AND CONCLUSIONS
In the present day society when people are more aware about environmental impact of pollution, it is utmost necessary to provide adequate treatment of effluents from industrial sources. There are various methods of effluent treatment. Anaerobic treatment is the important treatment process in use. It is also economically attractive alternative for treatment. Dairy waste is a major source of high strength pollutant in country like India, where huge amount of milk based industries are thriving and pumping large amount of organic pollutants in the environment. This wastewater is highly degradable with acidic pH. Thus, causing problems for disposal. Several studies have been extensively carried out to treat this wastes. Aerobic treatment, lagoon treatment trickling filters are prominently used. Majority these methods are either unsuitable or economically unfeasible. However, anaerobic digestion offers an excellent alternative to both energy conservation and pollution control consideration. This has potential of energy production as well as it generates very less amount of sludge. The major advantage of this process are low cost, high energy efficient process and simple compare to other waste treatment methods.

The present study provides the means to control environmental pollution by utilizing dairy wastewater of moderate strength to high strength cheese whey. These wastes contain highly biodegradable matter which can be efficiently scavenged by anaerobic bacteria. But anaerobic digestion is a stringent process where many different factors have adverse effect on functioning of anaerobic microbial ecosystem. To solve these problems, and to make an energy efficient process, our study optimized various conditions like organic loading, hydraulic retention, temperature, addition of metal ions and design of bioreactor for increased efficiency of load reduction as well as
methane production. Our study analyzed the effect of various anaerobic
treatment modes such as batch, semi continuous, continuous, continuous fixed film reactors employing various support materials and separation of acid and methane producing stages.

Anaerobic digestion was performed in laboratory scale anaerobic upflow reactors for batch and semi continuous and upflow fixed film reactors for continuous and optimization study. Our results suggested best performance with furnace coal as support material with high biomass retaining capacity. If the study is seen in comparative aspects the batch scale studies are unfeasible due to long duration for efficient treatment process.

- It took around 40 days for low strength and eighty days for high strength dairy waste to achieve 94 and 93% COD reduction in batch mode.
- In semi continuous study without fixed film it took 72 and 68 days to achieve 91 and 89% reduction at 10 days HRT for low and high strength and the high strength reactors was very unstable during the operation due to wash out of microbial mass.
- Semi continuous fixed film reactors achieved 94 and 93% COD reductions with 10 days HRT for low strength and high strength respectively.
- Continuous fixed film reactors could achieve 96.6 and 95.9% COD reduction at 10 days HRT for low and high strength.
- Different support material i.e. coal, bonechar and PVC beds were used for optimization of the results obtained in preliminary studies.
- Start up and study state profile was analyzed for all support materials at different organic loads and hydraulic retention
time. Coal was found to be best support material probably due to high surface immobilization.

- Experiments were carried out at HRTs ranging from 10 days to 1 day. 4 day period was found to be the most suitable for treatment of high strength cheese whey as the reactor could achieve 80% treatment efficiency with no pH neutralization required at this organic load given which accounts to 26 Kg COD/M$^3$/d. At this HRT 87% as COD reduction could be obtained with 5.37 M$^3$/M$^3$/d with 63.07% methane content.

- At 4 days HRT the system was further optimized at different temperatures. It was found that in mesophilic range 40°C was optimum giving 80.07% COD reduction and stabilized pH at 6.02 in study state.

- Different metal ions i.e. Fe, Co, Ni and their combination were optimized for improvement in digestion efficiency. It was observed that at 50 Mu mole concentration of Fe, the COD reduction efficiency was increased by 5% i.e. reaching to 85.46 with improved methane content i.e. 65.4% pH was stabilized at 6.65 with lowest effluent VFA content i.e. 0.92 Kg/ M$^3$. Similarly, Co and Ni were also able to improve the digestion efficiency. Their concerted effect was seen at lower concentration proportion i.e. at 25 Mu mole each. These proportion when added to influent at 4 days retention time could achieve 86.14% COD reduction and 66.3% methane content. This was the best result obtained for a combination of HRT, Mesophilic Temperature and metal ion addition.

- Optimization of fixed film reactor was also done with respect to recirculation of digester fluid. It was observed that with a recirculation frequency of one recirculation per 48 hrs. was able to increase the digestion efficiency by 4% i.e. to 84.23% COD
reduction compared to control 80.55%. In this case methane content also improved to 64.47% compared to 62.30 of control.

- The optimization of anaerobic process was done by changing the reactor design. Two fixed film reactors were operated in series thereby separating acidogenic and methanogenic stages of anaerobic digestion. It was found that this system could achieve very high COD reduction in short period of time. 81.42% COD reduction and 88.15% SCOD reduction could be achieved in 2 days retention time which is half the time taken by a single stage fixed film reactor. Moreover, high methane content i.e. 63.12% could be achieved with such low retention. At higher retention of 6 days 73% methane content could be achieved in the system.

Thus, our study has provided an efficient and optimized condition for treatment of high strength dairy waste in less time under high organic loading and shorter retention time with COD reduction above 85% with anaerobic process. On the basis of overall finding it could be suggested that the process could be applied at field level after one more stage of scale up study. On the basis of overall findings, it could be suggested that the process could be applied at field level after one more stage of scale-up study.