# Abstract

This thesis proposes efficient anaerobic treatment processes for recovering methane and Volatile fatty acids (VFAs) from domestic wastewater, which is often discharged untreated into water bodies in India, leading to deterioration of water quality. Little research has been conducted on recovering valuable resources from this wastewater in Indian context. Firstly, the applicability of inexpensive materials, including Granular activated carbon (GAC), Powdered activated carbon (PAC), Biochar (BC-550), Mine tailing sludge (MTS), Acid mine drainage sludge (AMDS), Zerovalent nano iron (ZVNI), and Laterite soil (LS), for enhancing anaerobic treatment of domestic sewage were examined. Results showed that carbon-based additives perform better than iron-rich additives, and the enhancement effect induced by conductive additives is correlated with surface area and surface charge. The study concluded that GAC, PAC, and BC-550 exhibited high efficiency performance and were recommended for subsequent studies. Secondly, the impact of different OLRs on the anaerobic treatment of wastewater incorporated with biochar as conductive additives in a lab-scale simulated septic tank was investigated. Biochar synthesized at different temperatures was evaluated for its effectiveness in developing high-rate septic tanks. Results showed that biochar addition reduced start-up time and improved methane production at increasing organic loading rates (OLRs), while establishing a robust microbiome. However, the effluent showed increasing accumulation of total ammonia nitrogen (TAN) at higher OLRs. Thirdly, the effects of different mixing conditions viz. continuous, intermittent and no-mixing, with incorporation of various sizes of conductive additives on anaerobic treatment performance using high strength wastewater was investigated. The results showed that non-mixed systems with GAC amendment provided the highest methane yield and increased microbial richness and diversity. However, continuous and intermittent mixing increased microbial diversity and richness in control reactors while reducing the same in GAC and PAC amended reactors. Overall, mixing conditions affected the microbial community and influenced methane recovery. The study suggested that evaluating methane production efficiency solely based on species richness of bacterial communities may not provide an accurate reflection, especially during mixing. Fourthly, production of VFAs from anaerobic treatment of kitchen wastewater in presence of different salt and surfactant concentration was investigated. VFA production decreased with increasing salt concentration and increased with increasing surfactant concentration. The presence of surfactant improved VFA production in all salt concentrations. The presence of surfactant appeared to shield the inhibitory effect of salinity in wastewater. Acetates and propionates were the major components of VFA, with the percentage of propionates increasing with increasing surfactant concentration. *Enterobacteriales* were the most dominant bacteria present in salt concentrated wastewater, whereas *Lactobacillales* were most prominent in surfactant concentrated fermentation products. Finally, fecal sludge (FS) was anaerobically treated for VFA production after thermal treatment at 100-180°C for 2 hours. Thermal pretreatment significantly enhanced fermentation performance, with maximum VFA produced at 140°C. Methane generation was notice after prolong methanogenic lag phase and it increased over time, with *Bacteroidetes* and *Firmicutes* as the major fermentative bacteria and *Methanosarcina* as the only methanogen present.


**Keywords:** Conductive additives, wastewater, anaerobic treatment, methane, volatile fatty acid, microbial communities.