## ABSTRACT

In a world of diminishing resources and increasing needs, each opportunity for the sustainable reuse of waste materials must be examined. Organic refuse from household, agriculture and agro-industrial processing can help to fulfill the requirements for fuel and fertilizer. Biomethane production from organic wastes through anaerobic digestion is perceived as one of the viable options for the safe disposal of wastes without hindering the natural ecosystem. Despite its numerous advantages, anaerobic digestion at times tends to be ineffective due to certain bottlenecks associated with the inoculum and process instability owing to inhibitory products. The present study is an attempt to mitigate the aforementioned constraints thereby a stable and economically viable anaerobic process can be implemented without any limitations.

Firstly, inorder to overcome the problem of non-availability of inoculum in a required quantity at a particular place and duration an attempt has been made to utilize specifically isolated microbial consortia (MAC) which consists of six facultative anaerobes and two methanogenic strains as an inoculum for anaerobic digestion of organic wastes. All the strains were characterized for its growth kinetic behavior and methane production potential. Specific methanogenic activity (SMA) of the developed inoculum was found to be 0.41 $\frac{g\ COD_{CH_4}}{g\ VSS*d}$ which is comparable to the conventional inoculum sources applied for biomethane production.

Organic wastes such as Kitchen wastes (KW) and Potato wastes (PW) were selected as a main stream substrate for anaerobic digestion. Since these wastes, being characterized as having varied C: N (26:1 to 36:1), high moisture (<84% w/w) and carbohydrate content (43-45%, w/w) could undergo rapid degradation leading to accumulation of volatile fatty acids (VFA). This causes decline in pH to acidic range which is quite detrimental to methanogens thereby causing cessation of methane production. To overcome these difficulties, anaerobic codigestion was adopted in the present study as an alternative strategy using *Pistia stratiotes* as cosubstrate for PW and KW digestion. Preliminary biomethane production studies revealed that codigestion of PS with KW and PW resulted in enhanced methane production by exerting positive synergistic effect during the digestion process leading to stability in pH

amenable for methanogenesis. Further, optimization of process parameters for KW+PS and PW+PS digestion was conducted using statistical approach CCD-RSM and artificial intelligence models ANN-GA. Upon comparison of these two optimization techniques, ANN-GA model obtained through feed forward back propagation methodology was found to be efficient and yielded 447.63±24.4 L $CH_4$/kg $VS_{fed}$ and 362.17±17.85 L $CH_4$/kg $VS_{fed}$ for PW+PS and KW+PS respectively.

In order to examine the process behavior of anaerobic codigestion process, kinetic modeling using first order, modified Gompertz and unstructured segregated model was carried out. First order and modified Gompertz models were found to fit well with the observed methane profile with $R^2$ of ~0.97-0.99. In case of unstructured segregated model important kinetic constants such as $K_{hs}$, $K_{SS}$, $K_a$, $K_{VFA}$ were derived and the simulated cumulative methane production was found to match well with the observed methane yield within the error band of ±20% and ±12.5% for KW+PS and PW+PS respectively. This showed that the developed model could represent the overall process behaviour of this novel anaerobic codigestion using mixed anaerobic culture as an inoculum.

Finally, an approach for carbon utilization as well as valorization of waste residues obtained after biomethanation was attempted through biotechnological means by subjecting it for treatment with six cyanobacterial cultures and two free living nitrogen fixing bacteria which utilize the organic matter present in the residue and simultaneously enhance the N, P and K content thereby reduce the waste strength making it suitable for application as biomanure. The biomanure enriched with nutrients through aforementioned process was applied to the soil to evaluate the influence of it towards soil quality parameters and crop (Bhendi) production. The plant growth from biomanure treated plot was at par with the urea supplemented soil which advocates that synthetic fertilizer can be potentially replaced with this enriched residual slurry.

**Keywords**: Anaerobic codigestion; Kitchen waste; Potato waste; *Pistia stratiotes;* Mixed anaerobic consortia (MAC); Modeling; Biomanure.