A comparative study based on anaerobic digestion of kitchen waste with waste water and fresh water

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Introduction

• Waste generation and disposal have become a national as well as a global issues due to increasing population, urbanization, and industrialization.

• India generates around 1,60,038 tonnes of MSW daily [1].

• 51% of total MSW is biodegradable waste, which includes fruits and vegetables[2].

• These wastes are liable for increase in environmental pollution if not managed well.
A case study of IIT Delhi, India

• The campus of IIT Delhi accommodates nearly 15,000 population (9000 students residing in various hostels, and nearly 6000 family members of faculties and staffs in various residential apartments).

• Delhi is a national capital. IIT Delhi campus is an ecological equivalent model of large revenue village.

• Thus, the total amount of organic waste generation is approximately 2.0 tonnes/day.
• Kitchen waste (fruits and vegetables waste) contains a high amount of moisture (75–90%) and a high organic fraction (80–90%), which makes it a suitable feedstock for the anaerobic digestion process.

• Anaerobic digestion is an efficient technique for converting organic waste into biogas with the extra benefits of organic manure.

• Biogas is produced by the degradation of organic matter with a group of microorganisms under anaerobic conditions.

• It contains methane (50–70%) and carbon dioxide (30–50%) as major constituents with traces of moisture, hydrogen sulfide, hydrogen, nitrogen, and carbon monoxide[3].
Water conservation in AD systems

• The AD process requires huge amount of water that is to be fed on a daily basis along with the substrates to maintain the required feeding rate.

• The use of freshwater or groundwater for operating the AD process is not a sustainable option, considering its supply is getting very limited in many regions [4].

• The operation of the AD process has been categorized in wet and dry digestion based on the operational feeding rate of the digester.

• The anaerobic digestion is termed a dry process if the feeding rate stays between 20 and 40% TS, whereas it is considered a wet process if the feeding rate is maintained below 15%.
• The dry versus wet digestion process has shown that the dry process had a more advantageous energy balance and economic performance than the wet process.

• However, complete mixing of the waste is not possible in the dry process, and, thus, the ideal contact of microorganisms and substrate cannot be guaranteed.

• Conversely, the wet process offered several important benefits, including greater flexibility over the type of feedstock accepted, dilution of inhibitory substances by process water, and less sophisticated mechanical equipment [5].

• Hence, water requirement is a necessity for AD operation for stable process stability and enhanced energy yield.

• Lignocellulosic biomass having TS content around 85-95%, that may require huge amount of water to treat using AD.

• Thus, there is a requirement to find alternative options for replacing the freshwater that are abundantly and cheaply available.
Methodology

• The study was conducted on two pilot-scale anaerobic digesters I and II at 5 % total solids.

• Digester I was fed with kitchen waste along with wastewater

• Digester II was fed with kitchen waste along with freshwater to produce renewable methane.

• The study was carried out at mesophilic temperature with a hydraulic retention time of 30 days.

• Two floating drum type anaerobic digesters with each digester having a total volume of 300 L (working volume: 192 L) were used for the experimental study.
Start-up of the digester

• Each digester was fed with cattle manure along with water at a 5% TS level. No feeding was done thereafter, and the biogas production parameters were measured continuously till each digester stopped producing biogas.

• It was observed that the biogas production started from the 2nd day of feeding and almost ceased after 42-44 days recording maximum methane content of 50–55%.

• Later, the digesters were fed with the assigned KW substrates from day 45.
Characterization of IIT Delhi drain wastewater

- pH 7.7-7.8
- COD 150-190 mg/L
- Total ammonical nitrogen (TAN) 25-26 mg/L
- Total dissolved phosphate (TAP) 20-24 mg/L
- Nitrate- Nitrogen (NO3-N) 10-11 mg/L
- Total suspended solids 55-70 mg/L
Characterization of kitchen waste

• The proximate analysis revealed that the total solids (TS) and volatile solids (VS) content in kitchen waste substrate on a wet basis was 10% and 90%, respectively.

• The ultimate analysis revealed the C/N ratio in kitchen waste substrate was 20.54.
## Results

<table>
<thead>
<tr>
<th>Digester</th>
<th>CH4,%</th>
<th>CO2,%</th>
<th>Biogas Productio n, L</th>
<th>Specific Biogas yield, L/kg VS</th>
<th>Specific Biogas yield, L/kg TS</th>
<th>Specific Methane yield, L/kg VS</th>
<th>Specific Methane yield, L/kg TS</th>
<th>TVSMRE,%</th>
</tr>
</thead>
<tbody>
<tr>
<td>KW-WW (I)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Min</td>
<td>52.3</td>
<td>33.1</td>
<td>14.83</td>
<td>51.48</td>
<td>46.34</td>
<td>26.93</td>
<td>24.23</td>
<td>5.22</td>
</tr>
<tr>
<td>Max</td>
<td>62.6</td>
<td>47.7</td>
<td>130.06</td>
<td>371.69</td>
<td>334.52</td>
<td>213.47</td>
<td>192.12</td>
<td>43.0</td>
</tr>
<tr>
<td>Avg.</td>
<td>57.4</td>
<td>37.8</td>
<td>107.05</td>
<td>273.48</td>
<td>246.13</td>
<td>158.48</td>
<td>142.63</td>
<td>35.17</td>
</tr>
<tr>
<td>KW-FW (II)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Min</td>
<td>52.8</td>
<td>37.9</td>
<td>8.90</td>
<td>30.89</td>
<td>27.80</td>
<td>16.40</td>
<td>14.76</td>
<td>3.11</td>
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<tr>
<td>Max</td>
<td>54.2</td>
<td>43</td>
<td>118.62</td>
<td>346.26</td>
<td>311.64</td>
<td>189.15</td>
<td>170.24</td>
<td>40.49</td>
</tr>
<tr>
<td>Avg.</td>
<td>55.7</td>
<td>40.4</td>
<td>99.72</td>
<td>258.37</td>
<td>232.53</td>
<td>139.76</td>
<td>125.79</td>
<td>33.65</td>
</tr>
</tbody>
</table>
Variation in methane content in biogas in digesters I and II
Energy balance

The overall energy efficiency achieved in each digester was 96.67% for digester I and 96.23% for digester II.
References


Thank you