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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%.

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- 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

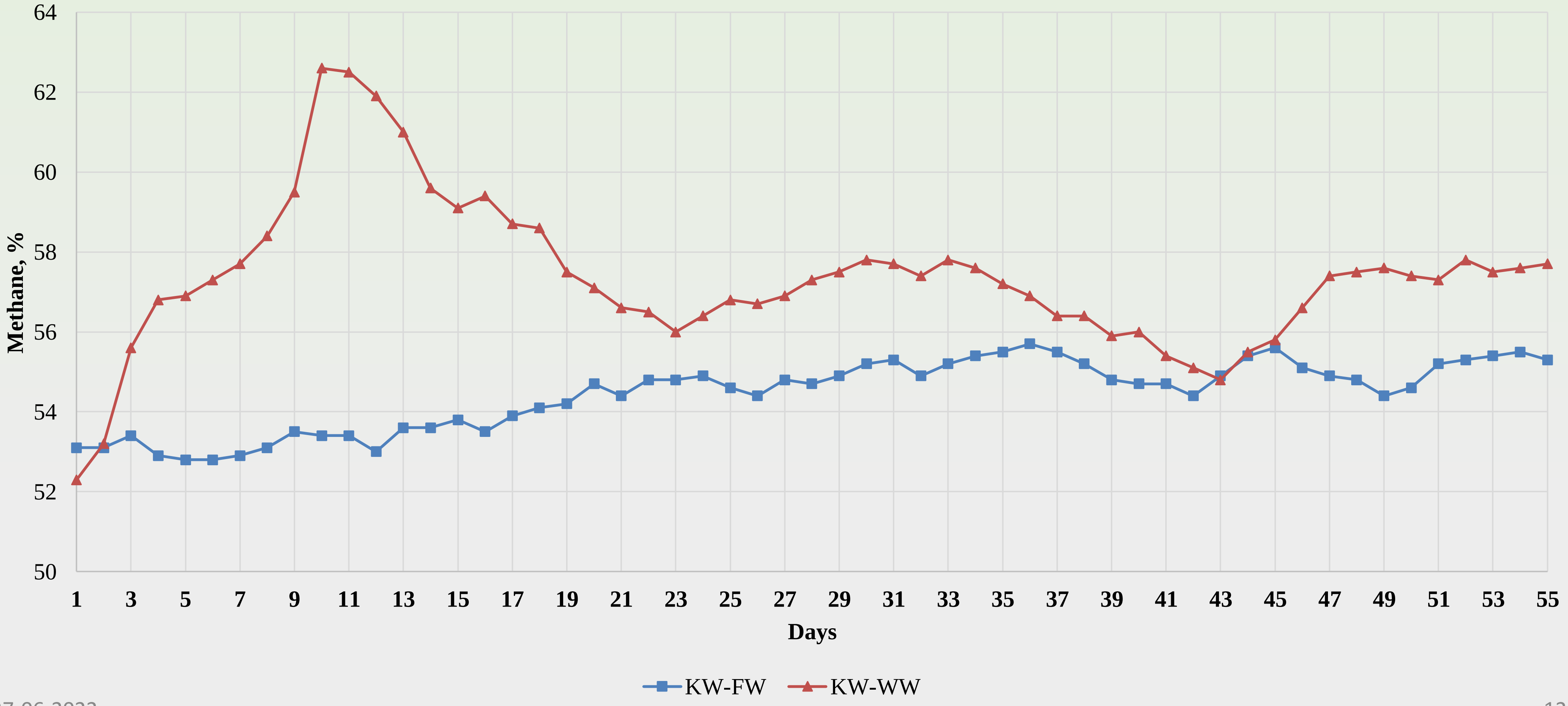
- The proximate analysis revealed that the total solids (TS) and volatile solids (VS) content in kitchen waste substrate on a wet basis was 10% and 90%, respectively.

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

Results

Digester	CH4,%	CO2,%	Biogas Production, L	Specific Biogas yield, L/kg VS	Specific Biogas yield, L/kg TS	Specific Methane yield, L/kg VS	Specific Methane yield, L/kg TS	TVSMRE,%
KW-WW (I)								
Min	52.3	33.1	14.83	51.48	46.34	26.93	24.23	5.22
Max	62.6	47.7	130.06	371.69	334.52	213.47	192.12	43.0
Avg.	57.4	37.8	107.05	273.48	246.13	158.48	142.63	35.17
KW-FW (II)								
Min	52.8	37.9	8.90	30.89	27.80	16.40	14.76	3.11
Max	54.2	43	118.62	346.26	311.64	189.15	170.24	40.49
Avg.	55.7	40.4	99.72	258.37	232.53	139.76	125.79	33.65

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

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Thank you