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Mesophillic Anaerobic Co-Digestion of Organic Fractions of Municipal Solid Waste with Wastewater Sludge and Enhancement of its Performance using Jaggery as an Additive

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Abstract - *This study used to evaluate the feasibility of the Anaerobic Co-Digestion (ACoD) of Organic Fractions of Municipal Solid Waste with Wastewater Sludge and the influence of Additive on it. Results indicated that ACoD to have more environmental benefits for sustainable management of municipal solid waste as well as sludge from sewage treatment plants. Meanwhile the usage of additives such as Jaggery may have enhanced the biogas production of about 50.65% more biogas at 10% than that produced by OFMSW:WWS:1:1 mix and higher removal of Volatile Solids. ACoD built more confidence to cause a reduced effect than current waste management scenario in Indian cities and lowering the probability of Emission of GHGs, acidification and degradation of fossil energy.*

***Key Words*: Anaerobic Co-digestion, Biogas, Jaggery, Organic Fractions of Municipal Solid waste, Wastewater Sludge.**

1. INTRODUCTION

Anaerobic Co-Digestion is the one of the way to treat various organic or fermentable wastes; these wastes are combined together in an anaerobic condition and allow decomposing together to increases the Yield of Biogas. This is also called as Co-Fermentation and this type of treatment of organic-wastes has plenty of advantages. The benefits of ACoD are:

- Toxic elements dilution
- Decomposable-Organic-Wastes load increases
- Nutrient-Balance improves
- Microbes Co-operative activity
- Improved Yield in Biogas
- Increases Digestion-Rate & Stability
- Produces good quality of Digestate
- Improves C/N ratio
- Reduces issues regarding accretion of VS content

By-products of this ACoD are CH_4 and CO_2 and Digestate remaining as integral profitable-value, can be used as fertilizer for soil-conditioning.

ACoD-Process of OFMSW and sewage sludge is illustrated in Fig-1 as follows:

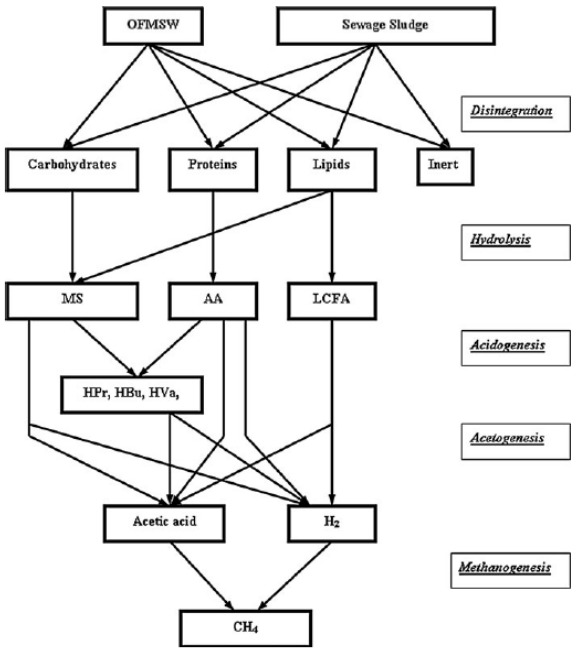

Fig-1: Flow Chart of ACoD Process (MS monosaccharides, AA- amino acids, LCFA-long chain fatty acid, HPr-propionic acid, HBu-butyric acid, HVa-valeric acid)

1.1 Research Objectives

- To analyze Physical Characterization of Freshly generated municipal solid waste along with physical composition of the OFMSW.
- To analyse Wastewater sludge quantity and characteristics.
- To determine the optimal mix ratio of OFMSW:WWS of ACoD
- To evaluate Performance of ACoD using Jaggery as an additive
- To analyze the Characteristics of Digestate

2. MATERIALS AND METHODOLOGY

This study accomplished by using following materials:

2.1 Study area

Davanagere is the 6th largest city in Karnataka state and having population of 4.35 Lack according to 2011 census.

And city's municipal establishment is overseen by Davanagere city Municipal Corporation. This city is selected as being one of the 100 urban Indian towns to be formed under the Smart City Mission as a smart city.

2.2 Materials, Collection and their Preparation

a) OFMSW: Freshly generated Municipal Solid Waste was collected from different Transfer stations located in study area, and then it is segregated to obtain OFMSW, manually crushed and sieved for experimentation.

b)Waste Water Sludge: Wastewater sludge was collected from the Sewage Treatment Plant located near Dodbudhihal Village, Davanagere, Karnataka.

c)Jaggery: Jaggery is a good source of carbon and energy, addition of this will enhance the biogas production. It may stimulate the metabolic activity of microflora. So, jaggery can be used as an additive for increased biogas production to overcome fuel requirement for growing population and also to stabilize the wastewater sludge.

2.3 Experimentation

a)Experimental setup: Mesophillic Batch ACoD experiment has been conducted in a 20L capacity plastic container as a digester with a proper provision of feedstock inlet, Biogas collection system and digestate removal facility. Generated Biogas is collected into rubber tube. Overall setup of experimentation is demonstrated in Plate 1.

Plate-1: Setup of Experimentation of ACoD

b) Experimental procedure: Prepared materials of required quantity are mixed together and fed into the container, properly sealed to maintain anaerobic condition then allow stabilize for the period (HRT) of 30Days and at every 5days Biogas production was noted down.

2.4 Methodology

Methodology adopted for research is as represented in Fig -2.

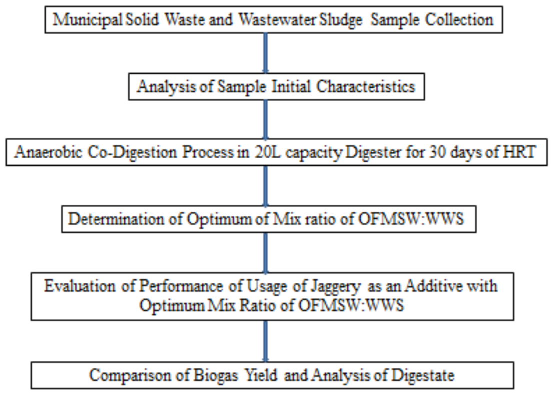

Fig-2: Methodology Flow Chart

3. RESULTS AND DISCUSSION

3.1 Initial Characteristics Analysis

a)Municipal-Solid-Waste: The municipal-solid-waste was collected and examined for determining initial characteristics. The physical characterization of MSW and physical composition of OFMSW were tabulated in Table-1 and Table-2 respectively. Moisture content, Total Solids and Volatile Solids contents of the OFMSW were tabulated in Table-3.

Table-1: Physical Characterization Of Fresh Municipal Solid Waste

Waste composition	Results	Units
Organic fractions	68.36	%
Paper	7.10	%
Plastic/ polythene	22.80	%
Glass/ceramics	0.30	%
Metals	0.14	%
Miscellaneous	1.30	%

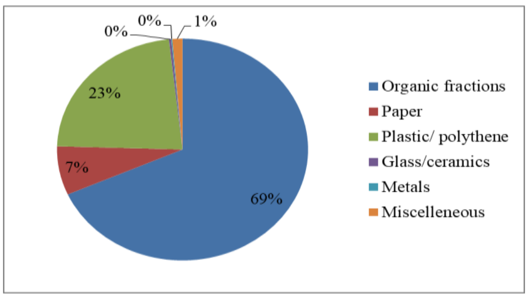

Fig-3: Physical Characterization Of Fresh Municipal Solid Waste

Table-2: Physical Composition of OFMSW

Waste composition	Results	Units
Vegetables/ Fruits	76.65	%
Rice/Food waste	11.94	%
Dried leaves/Yard waste	7.61	%
Other	3.80	%

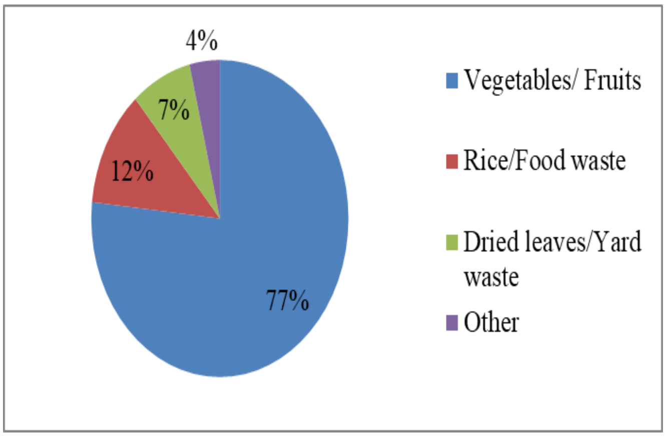

Fig-4: Physical Composition of OFMSW

Table-3: OFMSW's Initial Characterization

Sample	Moisture Content	Dried Total solids	Volatile Solids
OFMSW	44.12 %	55.88 %	47.02 %

b)Wastewater Sludge: The quantity and initial characterization of wastewater sludge were tabulated in Table-4.

Table-4: Wastewater Sludge Quantity and Characteristics

Sample	Process	Specific production	Moisture Content	Dried Total Solids	Volatile Solids
		Kg/MLD	%	%	%
Dewatered sludge	S-B-R Technology	200	57.10	42.90	11.24

3.2 Experimentation for ACoD Process:

a) Optimum Mix Ratio: Optimum mix ratio is evaluated by conducting 3 different trial ratios, say 1:1, 1:0.5 and 0.5:1 based on volatile solid (VS) content, then these samples were fed into the 3 sets of anaerobic digester and allow to stabilize for 30 days of HRT, results were tabulated in Table-5. ACoD experimentation indicated that OFMSW:WWS:1:1 produces comparatively better results in terms of Biogas production. Graphical representation of performance of ACoD is as shown in Fig-3.

Table-5: Cumulative Biogas Yield for Varying Mixing Ratios

Samples	Cumulative Biogas Yield, Kg/Kg of VS						
HRT in Days	0	5	10	15	20	25	30
OFMSW:WWS: 1:1	0	0.023	0.056	0.127	0.169	0.201	0.222
OFMSW:WWS: 1:0.5	0	0.010	0.023	0.046	0.060	0.077	0.103
OFMSW:WWS: 0.5:1	0	0.027	0.077	0.143	0.170	0.190	0.200

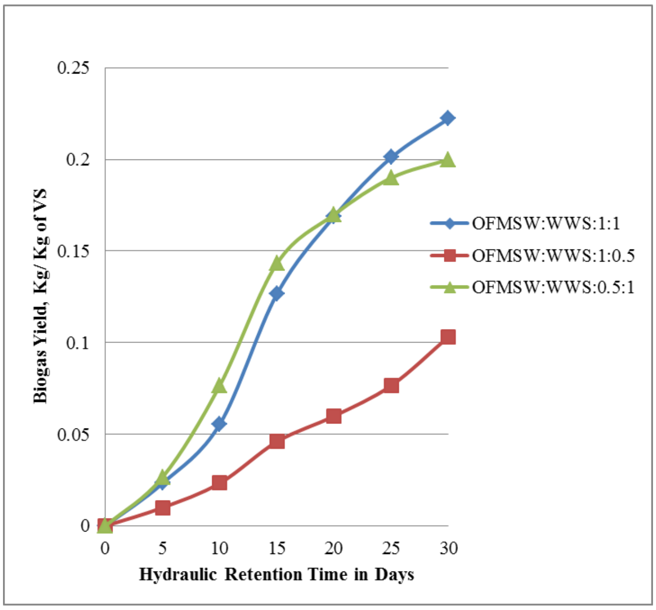

Fig-5: Performance of ACoD

b) Using Jaggery as an additive: Optimum dosage of Jaggery was determined by conducting experiment using 3 different varying dosages of Jaggery, say 5%, 10% and 15% of total volatile solid (VS), then the additive was mixed to the optimum mixing ratio of OFMSW:WWS:1:1 and fed into the 3 sets of anaerobic digester and allow to stabilize for 30 days of HRT, results were tabulated in Table-6. ACoD with Jaggery experimentation indicated that OFMSW:WWS:1:1 with 10% of Jaggery produces comparatively better results. Then the Digestate was analysed to determine VS content and the results were tabulated in Table-7. Graphical representation of performance of ACoD with Jaggery is as shown in Fig-4 and Fig-5.

Table-6: Cumulative Biogas Yield from ACoD of OFMSW:WWS:1:1 Using Jaggery as an Additive

Samples	Cumulative Biogas Yield, Kg/Kg of VS						
HRT in Days	0	5	10	15	20	25	30
OFMSW:WWS:1:1	0	0.023	0.056	0.127	0.169	0.201	0.222
5% Jaggery	0	0.063	0.153	0.200	0.256	0.267	0.275
10% Jaggery	0	0.064	0.177	0.248	0.280	0.321	0.334
15% Jaggery	0	0.083	0.128	0.224	0.262	0.292	0.303

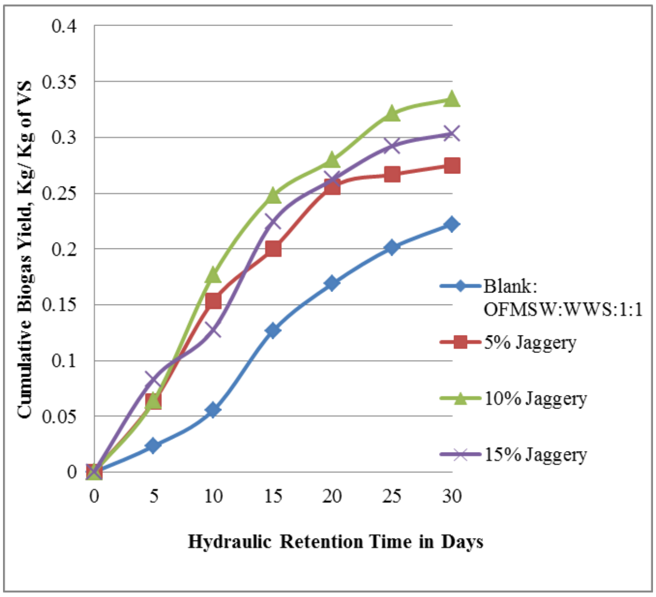

Fig-6: Performance of ACoD of OFMSW with WWS using Jaggery as an Additive

Table-7: Details of Percentage of MC, TS and VS with Jaggery as an Additive

Samples	% MC	% TS	% TVS
OFMSW	44.12	55.88	47.02
WWS	57.1	42.9	11.24
Blank(1:1)	60.86	39.14	14.80
5% Jaggery	62.50	37.50	11.91
10% Jaggery	57.14	42.86	15.30
15% Jaggery	63.64	36.36	7.65

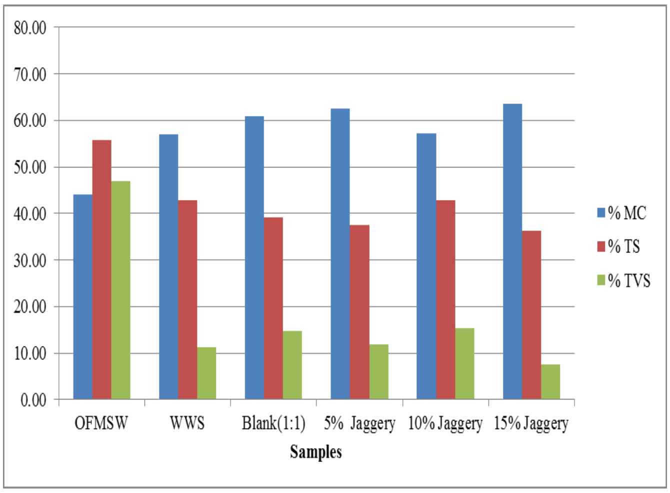

Fig-7: Details of MC, TS and VS before and after ACoD with Jaggery as an Additive

4. CONCLUSIONS

- Optimum mixing ratio of OFMSW:WWS was found to be at 1:1based on Volatile solid content, and the Biogas yield was 0.222 Kg/Kg of VS.
- Optimum dosage of Jaggery was found to be at 10% with OFMSW:WWS:1:1, the Biogas yield was 0.334 Kg/Kg of VS. And it produces 50.65% more biogas than that produced by OFMSW:WWS:1:1 mix.
- Maximum removal of VS of about 83.73% is achieved with 15% of Jaggery compared to untreated OFMSW.

4.1 Advantages

Anaerobic Co-Digestion of Sludge from MWWTP with OFMSW is having numerous beneficial consequences:

- Increases stability in AD process.
- Increases Biogas production/ Yield.
- Possible choice for handling of OFMSW as well as WWS.
- Significantly lesser utilization of Dumping Yard.

4.2 Disadvantages

- Handling of produced sludge is necessary subsequently.
- Great care should be taken while collecting and Storage of Biogas.
- Importantly, accuracy is needed in dosing, mixing and temperature.

4.3 Scope of Future Study

- Work has been conducted in the context of the theory of co-digestion that eventually generates biogas through co-digestion of OFMSW with WWS. Thus, other problems that may arise which need to be addressed may include influence of pathogen concentrations present in Sludge on heavy metals or concentration of scum that may have a serious impact on anaerobic digestion. Further studies not only concentrate on stabilization of waste and also on removal of pathogen and its regrowth after direct disposal of sludge.

- Batch or continuous ACoD reactor performance reflects the real field feasibilities. Such research can be utilized for the analysis of economic feasibilities and also for the restriction to the digester about loss-gain analysis.
- Adjustment of pH is a complicated matter in ACoD study, so 2-Separated phase (acid and methane phase) digester analysis will be fascinating, more reflective and useful to model plausible scenario.

REFERENCES

[1] Baier U & Schmidheiny P (1997),"Enhanced Anaerobic Degradation of Mechanically disintegrated sludge", Water Science and Technology 36 (11), 137-143.
[2] Davis.M, & Cornwell. D (1998)," Introduction to Environmental engineering", New York: Mc.Graw-Hill.
[3] EPA(2011), Retrieved February 20, 2012, from US EPA www.epa.gov/osw/conserve/rrr/reduce.htm
[4] Eskicioglu C, Kennedy K. J & Droste R. L (2007a)," Enhancement of Batch Waste Activated Sludge Digestion by Microwave Pretreatment", Water Environment Research , 79, 2304-2317.
[5] Eskicioglu C,Terzian N,Kennedy K,Droste R.L & Hamoda M.(2007b),"A thermal Microwave Effects for Enhancing Digestibility of Waste Activated Sludge", Water Resourse , 41, 2457-2466
[6] Esposito G,Frunzo L,Giordano A,Liotta F,Panico A,Pirozzi F(2012)," Anaerobic co-digestion of organic wastes", DOI 10.1007/s11157-012-9277-8, Springer Science+Business Media B.V. 2012.
[7] Fathi Aghdam E,Kinnunen V,Rintala J(October 2015)," Mesophilic anaerobic co-digestion of municipal solid waste and sewage sludge"
[8] Gujer W& Zehnder A(1983),"Conversion Processes in Anaerobic Digestion", Water Engineering and Tecnology , 15, 127-167.
https://www.researchgate.net/publication/306132600
[9] Harnzawi N, Kennedy K. J. and McLean D. D (1998), "Anaerobic digestion of co-mingled municipal solid waste and sewage sludge" by Elsevier Science LId., PH:S0273-1223(98)00438-7
[10] Harris.k (2004)," Residential Waste Flow, Personal Communication,Waste Diversion and Processing. The City of Ottawa, ON
[11] Hartmann H, Angelidaki I & Ahring B(2003),"Co-digestion of the Organic fraction of Municipal Waste with Other Waste Types",In J. Mata- Alvarez, Biomethanaization of the organic fraction of municipal solid wastes (pp. 182-186). IWA,UK.
[12] Horan, N (2003),"Anaerobic Treatment Processes",In M. D, & H. N, Handbook of Water and Wastewater Microbiology (pp. 391-397). London, England
[13] HNB technical note
[14] Manariotis, I, Grigoropoulos.S & Hung.Y (2010)," Anaerobic Treatment of Low -Streanth Wastewater by a Biofilm Reactor", In L. Wang, Handbook of Environmental Engineering (Vol. 11, pp. 445-496). Environmental Bioengineering.
[15] Maria F. Di, Micale C,Sordi A and Cirulli C(June 2012)," Co-digestion of sewage sludge and organic fraction of municipal solid waste" https://www.researchgate.net/publication/281933373
[16] Meghanath Prabhu, Sachin Waigaonkar, Regina Dube, Dirk Walther, Srikanth Mutnuri(2014)," Anaerobic co-digestion of food waste and septage – a waste to energy project in nashik city", ISSN 0974 – 0546 http://www.applied-science-innovations.com
[17] Meghanath Prabhu S and Srikanth Mutnur (2016)," Anaerobic co-digestion of sewage sludge and food waste", DOI: 10.1177/0734242X16628976,wmr.sagepub.com
[18] Mohana S, Acharya B, & Madamwar D (2010),"Distillery Spent Wash: Treatment Technologies and Potential Applications", Journal of Hazardous Materials , 163, 12-25.
[19] Pranshanth S, Kumar P & Mehrotra I (2006),"Anaerobic biodegradability Effect of Particulate COD". Journal of Environmental Engineering, 132 (2), 488-496.
[20] Schaefer S & Sung S (2008),"Retooling the Ethanol Industry: Thermophilic",Water Environment Research , 80 (2), 101-108.
[21] Schink B (1997)," Energetics of Syntrophic Cooperation in Methanogenic Degradation", Microbiology and Molecular Biology Reviews , 61 (2), 262-280.
[22] Schmit K & Timothy G (2001),"Comparison of Temperature-Phased and Two-Phase Anaerobic Co-Digestion of Primary Sludge and Municipal Solid Waste",Water Environment Research , 73 (3), 314-321.
[23] Shravan B.M and Dr. D.P. Nagarajappa(2018)," Solid Waste Management in Davangere" Volume: 05 Issue: 09, International Research Journal of Engineering and Technology.
www.irjet.net
[24] Sosnowski.P, Wieczor ek K,Ledakowicz S(2003), "Anaerobic co-digestion of sewage sludge and organic fraction of Municipal solid wastes" Advances in Environmental Research 7 (2003) 609–616
[25] Speece, R. (2008)," Anaerobic Biotechnology for Iindustrial Wastewater", Nashville: Tennesse:Archae Press.
[26] Stroot P, McMahon K, Mackie R, & Raskin L. (2001),"Anaerobic Codigestion of Municipal Solid Waste and Bio solids under Various Mixing Conditions Digester Performance",Water Research , 35 (7), 1804-16.
[27] Tchobanoglous, G., Thiesen, H., & Vigil, S. (1993),"Intregrated Solid Waste Management- Engineering Principles and Managament Issues", Boston: McGraw-Hill Inc.
[28] Vigneswara S, Sundaravadivel M and Chaudhary D S (2007), "Sequencing Batch Reactors: Principles, Design/Operation and Case Studies", University of Technology Sydney, Australia: Page no. 77-86.