

Table of Contents

List of Figures.....	i
List of Tables.....	ii
List of Abbreviations.....	iii
1. Introduction.....	1 - 9
1.1. Forms of Energy and Sectors of energy consumption	1
1.2. Biogas: a proven renewable fuel.....	2 - 3
1.2.1. Floating drum type plants.....	2
1.2.2. Fixed dome type plants.....	2 - 3
1.3. Anaerobic Digestion - Process Overview.....	3 - 5
1.4. Operational Parameters affecting Biogas Production.....	5 - 9
1.4.1. Temperature.....	5 - 6
1.4.2. pH.....	6
1.4.3. Pre-treatment.....	6
1.4.4. Particle size.....	6
1.4.5. C:N ratio.....	6 - 7
1.4.6. Agitation.....	7
1.4.7. Organic loading rate (OLR).....	7
1.4.8. Hydraulic retention time (HRT).....	7
1.4.9. Type of Substrates.....	8
1.5. Rationale of study.....	8 - 9
1.6. Objectives.....	9
2. Review of literature.....	10 - 14
2.1. Study of anaerobic digestion with various feedstocks.....	10 - 12
2.2. Study of various parameters affecting biogas yield.....	12
2.3. Study of Anaerobic digestion using Food waste as Substrate.....	13
2.4. Study of Anaerobic Digestion by co digestion Food waste and other substrates.....	13 - 14
3. Materials and Methods.....	15 - 20
3.1. Study of the Energy consumption pattern of the Tezpur University Campus.....	15
3.2. Installation of the Biomethanation plant.....	15 - 16
3.3. Feedstock characterization.....	16 - 18
3.3.1. Total Solids (TS).....	16
3.3.2. Ash content (AC).....	16

3.3.3.Total Suspended Solid (TSS).....	16 - 17
3.3.4.Volatile Suspended Solid (VSS).....	17
3.3.5.Total Organic Carbon (TOC).....	17
3.3.6.Total Nitrogen.....	18
3.4. Determination of gas yield, pH, methane content and H ₂ S.....	18 - 19
3.4.1.Determination of biogas yield.....	18
3.4.2.Determination of change in pH.....	18 - 19
3.4.3.Determination of composition of biogas produced.....	19
3.5. Determination of equivalent amount of LPG.....	19
3.6. Economic analysis of the 50 cum Biomethanation plant.....	19 - 20
4. Results and discussions.....	21 - 35
4.1. Present and future Energy Projections.....	21 - 23
4.1.1.Energy consumption pattern in Hostels.....	21 - 22
4.1.2.Future energy demand projection.....	22 - 23
4.2. Observation during the installation of Biomethanation Plant.....	23 - 26
4.3. Performance of the Biomethanation plant.....	26 - 35
4.3.1.Feedstock Characterization.....	27
4.3.2.Determination of Biogas yield.....	27 - 28
4.3.3.Variation of pH of the digestate and ambient Temperature during the observation period.....	29 - 30
4.3.4.Comparative analysis between gas production and pH.....	30 - 31
4.3.5.Variation of CH ₄ content.....	31 - 32
4.3.6.Variation of H ₂ S.....	32
4.3.7.Variation of CH ₄ with pH.....	33
4.3.8.Variation of CH ₄ (%) and H ₂ S(ppm) during the day.....	33 - 34
4.3.9.Determination of equivalent amount of LPG.....	34
4.3.10. Economic analysis of the Biomethanation plant.....	34 - 35
5. Conclusions.....	36
6. References.....	37 - 38
Appendix I.....	39 - 41
Appendix II.....	42
Appendix III.....	43

List of Figures

Figure No.	Figure Title	Page No.
Fig 1.2	Process flow diagram of Anaerobic Digestion process	5
Fig 3.1	TOC analyzer used to measure total organic carbon of feedstock	17
Fig 3.2	Kjeldahl Apparatus used to measure total nitrogen of feedstock	18
Fig 3.3	Gas Analyzer used to measure biogas composition	19
Fig 4.1	Increase of population of students of Tezpur University	23
Fig 4.2	0.5 m ³ Digester at Guest House	24
Fig 4.3	Phase 1- Civil construction	24
Fig 4.4	Phase 2: Construction of the Gas Holder	25
Fig 4.5	Phase 3: Completion of the plant and commissioning	25
Fig 4.6	Gas production in m ³ for a period of 54 days (23 January, 2014 to 9 May, 2014)	28
Fig 4.7	Gas production in m ³ /kg Total solid for a period of 54 days (23 January, 2014 to 9 May, 2014)	28
Fig 4.8	Variation of pH and temperature (22 January, 2014 to 20 February, 2014)	29
Fig 4.9	Variation of pH and temperature (21 February, 2014 to 22 March, 2014)	30
Fig 4.10	Variation of pH and temperature (23 March, 2014 to 9 May, 2014)	30
Fig 4.11	Variation of Gas production with pH (23 January, 2014 to 22 March, 2014)	31
Fig 4.12	Variation of gas production with pH (23 March, 2014 to 9 May, 2014)	31
Fig 4.13	Variation of CH ₄ (%) (12 March, 2014 to 25 April, 2014)	32
Fig 4.14	Variation of H ₂ S (12 March, 2014 to 25 April, 2014)	32
Fig 4.16	Variation of CH ₄ with pH (12 March, 2014 to 25 April, 2014)	33
Fig 4.17	Hourly variation of CH ₄ and H ₂ S (ppm)	33
Fig 4.18	Hourly variation of CH ₄ and H ₂ S (ppm)	34
Fig 4.19	Hourly variation of CH ₄ and H ₂ S (ppm)	34

List of Tables

Table no.	Title	Page no.
Table:4.1.	LPG energy consumption pattern in different hostels	22
Table 4.2:	Characteristics of the feedstock	27
Table 4.3:	Overall benefits and costs for 20 years	35

Abbreviations

KVIC	Khadi & Village Industry Commission
AFPRO	Action for Food Production
EPA	Environmental Protection Agency
ASTM	American Society for Testing and Materials
TU	Tezpur University
VK NARDEP	Vivekananda Kendra – Natural Resources Development Project
LPG	Liquefied petroleum gas
AD	Anaerobic Digestion
W-AD	wet anaerobic digestion
HSS-AD	Hemi-solid state anaerobic digestion
SS-AD	Solid state anaerobic
L-AD	Liquid anaerobic digestion system
FRP	Fibreglass reinforced plastic
OLR	Organic loading rate
HRT	Hydraulic retention time
COD	Chemical oxygen demand
VFA	Volatile fatty acids
LCFAS	Long-chain fatty acids
MC	Moisture content
TS	Total solid
VS	Volatile solid
AC	Ash content
TSS	Total Suspended Solid
VSS	Volatile Suspended Solid
TOC	Total Organic Carbon
TIC	Total inorganic carbon
NPOC	Non purge able organic carbon
TC	Total carbon
FVW	Food and vegetable waste
FW	food waste
FSW	Food solid waste
FLW	Food liquid waste
RFW	Raw food waste
PER	Phyllanthus emblica residues