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Extraction of Bio Gas from Vegetable Waste

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ABSTRACT
As fossil fuels like coal and petroleum are depleting in India, so alternativesources of energy is the requirement of the present day. One amongst the majorchallenging source of energy is biogas being produced from biomass. At the sametime, enormous amount of garbage producedinIndiaisahugeproblemintermsofdisposalandhandling.Therefore,an effort have been made here to utilize vegetablewastefor generation of biogas by anaerobic digestion method.
The reactor of 5L capacitywas seeded with concentrated sludge taken from outlet of an anaerobic reactor inPeriyarManiammaiUniversity, Vallam. Mixing in reactor system of magneticstirring for one hour. The vegetable waste was obtained from Sengipatti market of Thanjavur.The waste was analyzed for it's physical and chemical composition as per standardmethods. The reactor was operated by batch mode, without with drawl of effluent.
Daily evolution of gas and pH were monitored. Experiments have been performedby anaerobic digestion basis and some activated sludge have been added to promotethe digestion process. Fromthis study, it is in termed that process with 40% slurryconcentration at 32°C gave test result of all process. Production of biogas yield, havebeen presented.

I. INTRODUCTION

1. GENERAL

Due to scarcity of petroleum and coal, it threatens supply of fuel throughout the world. Also problem of their combustion leads to research in different corners to get access the new source of energy,like renewable energy resources. Solar energy, wind energy, different thermal and hydro sources of energy, biogas are all renewable energy sources. But, biogas is distinct from other renewable energies because of its characteristics of using, controlling and collectingorganicwastesandatthesametimeproducing fertilizerandwaterfor use in agricultural irrigation. Biogas does not have any geographical limitations and doesn't require advanced technology for producing energy, also it is very simple to use and apply.

Deforestation is a very big problem in developing countries like India most of the part depends on charcoal and fuel-wood supply which requires cutting of forest. Also, due to deforestation it leads to decrease the fertility of land by soil erosion. Use of dung, firewood as energy is also harmful for the health of the masses due to the smoke arising from them causing air pollution. We need an Eco friendly substitute for energy.

STUDYAREA

In Thanjavur 560 Kg/m^3 density of municipal solid waste is generated. This municipal solid waste is composed of 44.88% vegetable waste. There are more than 300 vegetable stalls in Thanjavur. The daily waste generation in Thanjavurcorporation is20tonnes.Out ofthis,thevegetable wastegeneratedis8tonnes.Atpresent,landfilldisposalistheprocessofdisposingmunicipalsolid waste.Thevegetablewasteisalsodisposalalongwithmunicipalsolidwaste.

S.No:	Characteristicsofwaste	Values(%)
1.	VegetableWaste	44.88
2.	Paper	5.59
3.	Plastic	5.79
4.	Cloth	0.06

5.	Wood	0.89
6.	Metals	0.06
7.	Glass	0.01
8.	Leather	0.05
9.	Rags	0.4
10.	Rubber	0.02
11.	Pebbles	11.45
12.	Fine sand	15.21
13.	AshandFineEarth	5.86
14.	Moisture	9.72
Density		560Kg/m^3

Table1:WasteGenerationRatesinThanjavur

DEMANDSFORRENEWABLEENERGY

The world population in the year 2100 will be in excess of 12 million. If the current trends in technological progress and innovation continue, the demands for energy then will be five times greater than what it is now.

Ifwecontinuethepolicyofusing coal,oiland gas at thepresentratethen by the year 2030 the global temperature will have increased by 2 degrees Celsius.Andwillcausegreenhouseeffectwhichinturnleadstoriseofsealevel and submerge of the land portion.

Over use of coal and natural gases not only increase the global temperature but also get drained out and will leads to us empty handed with source, hence an alternate renewable energy source must produced for outfuture use.

IMPACTDUETOVEGETABLEWASTE

Million tonnes of solid waste are generated each year from municipal, industrial and agricultural sources. Unmanaged organic waste fractions from farming,industryandmunicipalitiesdecompose intheenvironment,resulting in large scale contamination of land, water and air. Out of those 40% is vegetable waste.

These waste not only represent a threat to environmental quality, but also possess a potential energy value is not fully utilized despite the fact they are cheap and abundant in moist parts of the world.

Methane (CH_4) and carbon dioxide (CO_2) emitted as result of microbial activity under uncontrolled anaerobic conditions at dumping sides are released into the atmosphere and contribute to global warming.

Vegetable waste can be defined as part of vegetable that does not go into the finish product. The characteristics of vegetable waste are

- Highmoisturecontent
- Naturalbiomass
- Highlybio degradable
- Causetheoffsmellduetopurification

Thiscausesthefollowingproblems

- Itishighbiodegradablesocausesofsmelldueto purification.
- Sum of the vegetables also has a tanning eg; seeds of mango that may impact colour to ground water and surface water if percolated along with water.
- Itcanalsoattractfliesandotherinsectsand cattle.
- Badaestheticandunhygieniccondition.

BIOGAS

Biogastypicallyrefers to agas producedbythebiologicalbreak downof organic matter in the absence of oxygen. One type of bio gas is produced by anaerobic digestion or fermentation of biodegradable such as bio mass, manure or sewage, municipal waste, green waste and energy crops. This type of bio gas comprises primarily methane and carbon dioxide.

Bio gas is about 20% lighter than air and has on ignition temperature in the range 650^o C to 750^0 C. it is an odourless and colourless gas that burns with clear blue flame similar to that of LPG gas. Its calorific value is

20 mega joules (MJ)per m and burns with 60% efficiency in a conventional bio gas stove.

Component	Concentration(byVolume,%)
Methane,CH_4	50-75
Carbondioxide, CO_2	25-50
Nitrogen,N_2	0-10
Hydrogen,H_2	0-1
Hydrogensulphide,H_2S	0-3
Oxygen,O_2	0-2

Table2:TheTypicalCompositionofBiogasisgivenbelow

Applicationsofbiogas:
Biogasmaybeusedinthefollowingfourways

- Purificationandexportascompressedgasorinliquidform.
- It may be used to heat green house, boilers, furnaces, fire brick or cement kilns, for household work like cooking.
- Directcombustion
- Generationofelectricity

Benefitsofbiogasproduction:
Biogasproductionhasmanybenefitssuchas

- Itisaclosedloopsystem.
- Itcontributestoasustainabledevelopment.
- Renewableenergyproduction.
- Sustainablewastemanagement.
- Fertilizerproduction.
- Odourreduction.
- Removalofweedseedsandpathogens.

ANAEROBICDIGESTION
Anaerobic digestion (AD) or fermentation is a biological process inwhich microorganism break down biodegradable material in the absence of oxygen. That produces a gas principally composed of methane (CH_4) andcarbon dioxide (CO_2) otherwise known as biogas.
Anaerobic processes could either occur naturally or in a controlled environment such as biogas plant. Organic waste such as livestock manure and various types of bacteria are put in an airtight container called digester so the process could occur. Depending on the waste feedstock and the system design, biogas is typically 55 to 75 percent pure methane.
Almost any organic material can be processed with anaerobic digestion. Thisincludesbiodegradablewastematerialssuchaswastepaper,grassclipping, leftover food, vegetable waste, sewage and animal waste.
Anaerobic digestion is a renewable energy source because the process produces a CH_4 and CO_2 rich biogas suitable for energy production helping replace fossil fuels. Also, the nutrient rich solids left after digestion can be used as fertilizer.

ModesofOperation
Anaerobic digestion can be designed and engineered to operate using anumber of process configurations.

- Batchmode
- Continuousdigestionmode
- Semi-continuousdigestionmode

A **Batch system** is the simplest form of digestion. Biomass is added tothe reactor at the start of the process in a

batch and is sealed for the duration process.Batchreactorsuffersfromodourissuesthatcanbeasevereproblemwhen they are emptied. Typically biogas production will be formed with a normal distribution pattern over time. The operator can use this fact todetermine when they believe the process of digestion of the organic matter has completed.
In **Continuous digestion process** organic matter is constantly added to the reactor. Here the end products are constantly removed resulting in constant production of biogas.
In **semi-continuous digestion process** organic matter is periodically added to the reactor. Here the end products are periodically removed resultingin periodic production of biogas.

MethodsofAnaerobicDigestion
Anaerobic decomposition is a complex process. It occurs in three basic stages as the result of the activity of a variety of microorganisms.
Initially, a group of microorganisms converts organic material to a form that a second group of organisms utilizes to form organic acids. Methane producing (methanogenic) anaerobic bacteria utilize these acids and complete the decomposition process.
A variety of factors affect the rate of digestion and biogas production.The most important temperature. Anaerobic bacteria communities can endure temperatures ranging from below freezing to above (57.2^0C), but they thrivebest at temperatures of about (36.7^0C) (mesophilic) and (54.4^0C) (thermophilic) Bacteria activity, and thus biogas production, falls off significantly between about (39.4^0 and 51.7^0C) and gradually from (35^0 to 0^0C).

ThermophilicDigestion
In the thermophilic range, decomposition and biogas production occur morerapidlythaninthemesophilicrange.Thermophilicdigestionislesscommon and not as mature a technology as mesophilic digestion. The digesteris heated to 55^0C and held for a period of 12 to 14 days.
Thermophilic digestion system provides higher biogas production, faster throughput and an improved pathogen and virus kill, but the technology is more expensive, more energyis needed and it is necessaryto have more sophisticated control and instrumentation.

MesophilicDigestion
Mesophilic digestion is the most commonly used process for anaerobic digestion, in particular waste sludge treatment. Decomposition of the volatile suspended solids (VSS) is around 40% over a retention time of 15 to 40 days at a temperature of 30 to 40^0C, which requires larger digestion tanks.
It is usually more robust than the thermophilic process, but the biogas production tends to be less, and additional sanitization is usually required.
To optimize the digestion process, the digester must be kept at a consistent temperature, as rapid changes will upset bacterial activity.

StagesofAnaerobicDigestion
Thisnatural,biologicalprocesstakesplaceinfourstages.

- Hydrolysis
- Acidogenesis
- Acetogenesis
- Methanogenesis

Hydrolysis
In the first stage anaerobic bacteria reconstructs high – molecular substances (protein,carbohydrates,fats,cellulose)bymeans ofenzymes to low- molecular compounds like monosaccaride, amino acids, fatty acids and water. Enzymes assigned by hydrolysis bacteria decompose substrate components to small water-soluble molecules. Polymers turns into monomers (separate molecules). This process is called Hydrolysis.

$$C_6H_{10}O_5+2H_2O \rightarrow C_6H_{12}O_6+H_2O$$

Acidogenesis
In the second stage further break down of the remaining components is takes place by acidogenic (fermentative) bacteria. Here volatile fatty acids are created along with ammonia, carbon dioxide and hydrogen sulphide as well as other by products. This process is called Acidogenesis.
$C_6H_{12}O_6 \leftrightarrow 2CH_3CH_2OH + 2CO_2$ $C_6H_{12}O_6+2H_2 \leftrightarrow 2CH_3CH_2COOH+2H_2O$

Acetogenesis

The third stage anaerobic digestion is Acetogenesis. In this acid forming bacteriaforminitial products formethane formation: aceticacid,carbon dioxide and hydrogen. These products are formed from organic acids. For vital function of these bacteria that consume hydrogen, stable temperature mode is very important.

$$CH_3CH_2OH+2H_2O\leftrightarrow CH_3COO^-+2H_2O+H^+$$

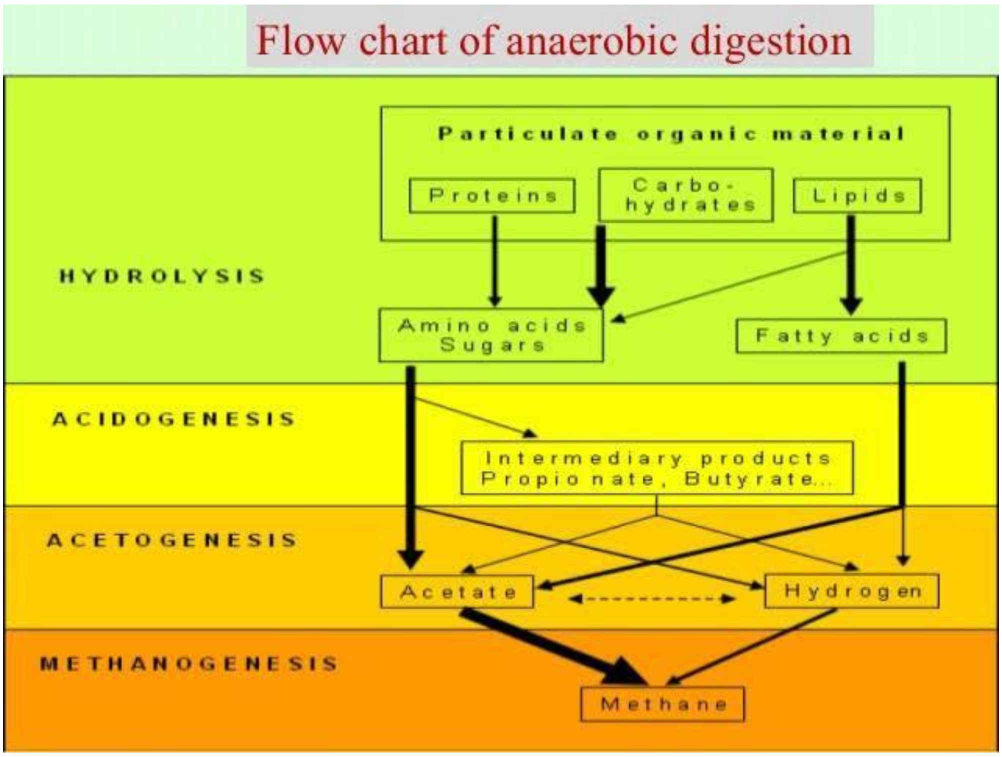
Metanogenesis

The terminal stage of anaerobic digestion is the biological process of Methanogenesis. Here methanogens utilize the intermediate products of the proceeding stages and convert them into methane, carbon dioxide and water. It is these components that make up the majority of biogas emitted from the system. Methanogenesis is sensitive to both high and low pH and occurs between pH 6.5 and pH 8.
The simplified generic chemical equation for the overall process outlined above is as follows.

$CH_3COOH\rightarrow CH_4+CO_2$ $C_6H_{12}O_6 \rightarrow 3CO_2 + 3CH_4$

SymbiosisofBacteria

Methane and acid producing bacteria act in a symbiotical way. Acid producing bacteria create an atmosphere with ideal parameters for methane producing bacteria (Anaerobic conditions, compounds with a low molecular weight). On the other hand, methane producing microorganisms use the intermediate of the acid producing bacteria. Without consuming them, toxic condition for the acid producing microorganisms would develop. In real time fermentation processes the metabolic actions of various bacteria acts in adesign. No single bacteria is able to produce fermentation products alone as it requires other too.



FactorsAffectingAnaerobicDigestion

Thefollowingarethefactoraffectingthe anaerobicdigestion.

AnaerobicEnvironment

Active functioning of bacteria is possible only in the absence of oxygen free conditions, biogas plant design takes that into consideration.

Humidity

Bacteriacanlive,feelandpropagateonlyinmoistconditions.

Temperature
Anaerobicdigestionhasbeenclassifiedintothreetemperatureranges Psychrophilic (0-20^{0}C), mesophilic (20-42^{0}C) and thermophilic (42-75^{0}C).

Thermophilic digester are more efficient in terms of retention time, loading rate and nominally gas production but they need a higher heat input and have a greater sensitivity to operating and environmental variable which makes the process more problematic than mesophilic digestion.

Fermentationperiod

The quantity of produced biogas is different within the fermentation period.Inthebeginningoffermentationitismoreintensivethen attheendofit. Then comes the moment when further biomass presence in the digester is economically unfeasible.

pH Level

Methane and acetic acid formationbacteria can exitonlyinlow alkalinity environment with pH 6.8-8. All the bacteria kinds have tendency to suspend their activity in case pH level is higher of the optimum hence the biogas production suspends as well. That is why the best pH level 7 should be maintained.

OrganicLoadingRate

The chemical oxygen demand (COD) corresponds to the concentration of oxygen required for the full oxidation of all organic carbon to carbon dioxide and water. A high COD removal efficiency is desired, signifying a high conversion of carbon containing compounds to biogas.

ParticleSize

Bacteria size 1/1000mm the smaller the substance particles the easier the decompositionmadebybacteria.Fermentationperiodbecomesshorterandbiogasproductionbecomesfaster.Itisanecessaryadditionalsubstratedisintegration should be done before substrate feed into reactor.

Mixing

It is important not only to avoid floating cork and sediment formation but also for biogas extraction (mixers help bubbles to go up the digester). Mixers work constantly in a bacteria preserving mode.

ProcessStability

Microorganisms are used to feed other modes. Any changes should be done smoothly.

TotalSolidContent

There are three different ranges of solid content: low solid anaerobic digestion system contain less than 10% total solid, medium solid from 15-20% and high solid systems range from 22-40%, when increasing the total solid content, the volume of the digester decreases, due to lower water requirements.

EvenSubstrateFeed

The by-products of each group of bacteria lifecycle are the nutrients for otherbacteriagroup.Theydo all work with different speed. The bacteriashould not be over feed as they hardly be able to produce nutrients for another group. That is why the substrate feed is calculated and programmed for each project carefully.

NutrientsSupply

Bacteria provide with all necessary nutrients that are contained in substratesotheonlythingneededisconstantsubstratesupplysubstratecontains vitamins,solubleammoniacompounds,microelementsandheavymetalsinsmallquantities.Nickel,Cobalt,Molybdenum,WolframandFerrumarerequired by bacteria for enzyme formation and are also present in substrates.

BenefitsandAdvantagesofAnaerobicDigestion:

Thebenefitsandadvantagesofanaerobicdigestioninclude:

- Odourreduction
- Reduction in the biological oxygen demand of treated effluent by up to 90%, reducing the risk for water contamination.
- Improve nutrient application control, because up to 70% of the nitrogenin the waste is converted to ammonia, the primary nitrogen constituent of fertilizer.
- Reduced pathogens, virus, protozoa and other disease causing organisms in lagoon water, resulting in

improved herd health and possible reduced water requirements.

- Reductionofuncontrolledmethaneemissionsfromlandfills.
- The production of electricity and heat may provide income for the user of this technology.
- Decreasedsludgeproductionasopposedtoaerobicdigestion.
- Anaerobicdigestionsdonotrequireenergyformechanicalmixingin other to maintain adequate aeration.
- Biomassproductionisreducedinanaerobicdigestionascomparedto aerobic digestion.
- Preventing the uncontrolled emissions of CH_4(22 timesmore powerfulthan CO_2) from landfill.

II. LITERATUREREVIEW

1. Daniel Manaye Kabtamu – "Production of Biogas from Vegetable and Vegetable wastes mixed with different wastes" published on Environmentand Ecology Research, Jan-2015.

This work explores the production of biogas from vegetable and vegetable wastes mixed with cow manure in an anaerobic digester. The anaerobic digestionof vegetable and vegetable wastes mixed withdifferent wastetook 55 days to produce biogas. Anaerobic digestion is very sensitive to changein pH and it is important to maintain pH of 6.7-7.4 for healthy system.

From this journal, we have planned to add cow manure with vegetablewaste. Apart from this slaughter waste can also be added to increase the yield of biogas. We are trying to do this process naturally without any addition of chemicals.

2. Yasini Nalinga, Isack Legonda – **"The effect of particle size on biogas production"** publishedonIJIRTS(InternationalJournalofInnovativeResearch in Technology of Science), March-2016.

The study on the effect of particle size on biogas production has been conducted. Substrates consisted of pre-treated water hyacinth with drying and grounded to fine particles and chopped water hyacinth to smallparticles. The reactor digesters were operated at mesophilic temperature ranges of 25^o C to 32^o C. Further observation revealed that methane yields increasedby21%when thesubstrateswerepre-treatedbygrindingintovery fine particles compared with the chopped substrate.

Hence, we decided to dry and grind the vegetable wastes to small particlesto increase the yield of biogas.

3. Sharma, SK, Mishra, I.M, sharma, M.P and saini J.S,. Effect of particlesize on biogas generation from biomass residues, Biomass, 1988, 17,251- 263.

They demonstrated the anaerobic digestion potential of banana peeling (Musaparadisiaca). According to them, particle size of 0.008 and 0.4 mm produced an almost equal quantity of biogas, thus grinding below 0.4 mm would seem to be uneconomical.

So, if we grind and sieve the vegetable waste powder more residues may be left as waste. This may result in the reduction of quantity of biogas. We decidedtogrindandusealltheveg etablewasteevenitmay0.5mmor more.

4. Stewart, DJ, Bogue, MJ and Badger, DM, Biogas production from crops andorganicwaste.Resultofcontinuous digestion tests. New Zealand J.Sci., 1987, 27,285-294.

They measured biogas yields from anaerobic digestion of banana in continuous digesters at 35^0c.Thehigh CH_4 yields obtained fromthedigested waste resulted from almost complete destruction of the Volatile solids.

Thisshowsthatroomtemperatureisenoughforthedigestion process.

The volume of volatile solids can be used almost completely for the gas production as they are in small particles.

III. OBJECTIVESANDMETHODOLOGY

OBJECTIVES

Todeterminethegasyieldfromvegetable waste.

Tostudytheprocessofanaerobicdigestionbyconducting experiment.

Todeterminetheefficientyieldofbiogasondifferentcombinationof vegetable waste.

PRINCIPLESFORPRODUCTIONOFBIOGAS

Organic substance exist in wide variety from living begins to dead organisms. Organic matters are composed of

Carbon (C), combined with elements such as Hydrogen (H), Oxygen (O), Nitrogen (N) and Sulphide (S) to form variety of organic compounds such as carbohydrates, proteins and lipids. In nature microorganisms through digestion process breaks the complex carbon into smaller substances.
Therearetwotypesofdigestionprocess

- Aerobicdigestion
- Anaerobicdigestion

The digestion process occurring in presence of oxygen is called Aerobic digestion and produces mixtures of gases having carbon dioxide (CO_2), one of the main “Greenhouses” responsible for global warming.
The digestion process occurring without (absence) oxygen is called AnaerobicDigestionwhichgeneratesmixturesofgases.Thegasproducedwhich is mainly methane produces 5200-5800 KJ /m^3 when burned at normal room temperature which produce a variable environmentally friendly energy source to replace fossil fuels (non-renewable).

METHODOLOGY

a) CollectionOfVegetableWaste

b) DryingAndGrinding

c) ConstructionOfAnaerobicDigester

d) SamplePreparation

e) FeedingAndOperating

f) MeasurementOfBiogasProduced

IV. MATERIALSANDMETHODSUSED

MATERIALS

Biomassmaterial:

Populations of anaerobic microorganisms typically take a significant period of time establish themselves to be fully effective. It is therefore common practice to introduce anaerobic microorganisms from materials with existing populations.Thisprocessiscalled“SEEDING”thedigestersandtypicallytakes place with the addition of sewage sludge or cattle slurry.
The collected vegetable wastes were segregated and their wet and dry weights were found. The physical and chemical composition of vegetable waste was determined by standard methods.

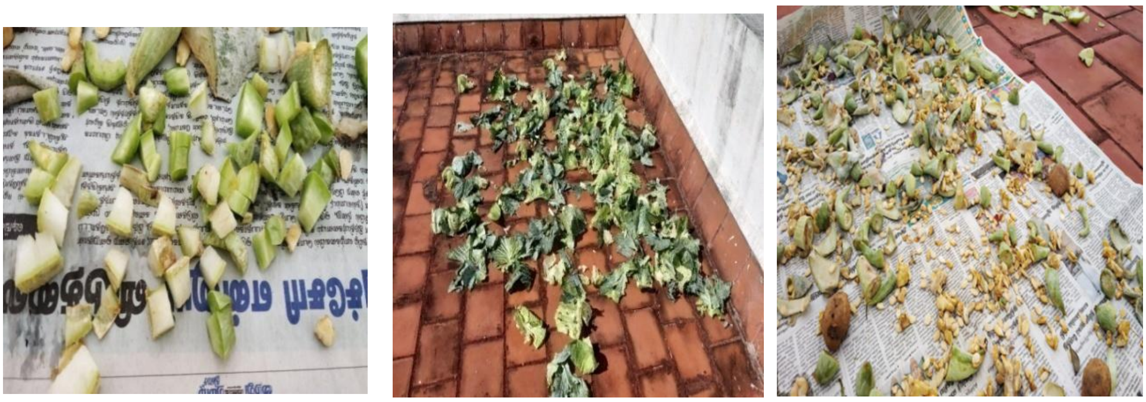


Fig.1:DryingUnderSunlight

Fig.2:Driedsampleofvegetablewaste

Bacteria size 1/1000 mm the smaller the substrate particles the easier the decomposition made by bacteria. Fermentation period becomes shorter and biogas production faster. Hence to make the feedstock for the experiments, raw friuts waste was shredded in a mill and then diluted with tap water.

SEEDINGSLUDGE

Any organic material can be used as a seeding sludge material.Production rate of biogas depends on type of sludge used. The distillery sludgefromanaerobicdigestionplantofPeriyarManiammaiUniversityisusedas seeding material.

Itwasthenfedintotheairtightdigesterwhereanaerobictreatmenttakesplace.

Fig.3:Powderedformofdryvegetablewastes

METHODS
A batch system is the simplest form of digestion. Batch reactors suffer from odour issues when they are emptied.
The operator can use this fact to determine the completion of the process, the batch digester where the organic waste stays in the tank for some time an is then replaced after gas production.

Almost any wet organic material can be processed with anaerobic digestion. So in this project also vegetable waste is treated by the same method.

EXPERIMENTALSETUP:
Materialsusedare,

- Gasstoragechamber(Borosilbottle -2litres)
- MagneticStirrer
- Displacementjar–1litre
- Digestionchamber(PVCcan–10litres)
- Stopper
- Rubbertubes

The digester is filled with seeding sludge. The digester is connected with borosil bottle through rubber tube. The borosil bottle collects the biogas at the top. The amount of gas collected will be measured by the raise of water level in the displacement jar connected with the borosil bottle.

The reactor of 5L capacity was seeded with concentrated sludge taken from outlet of an anaerobic reactor treating distillery waste concentrated sludge taken from outlet of an anaerobic reactor treating slaughter waste water of Periyar Maniammai University. Mixing in reactor systemis ofmagnetic stirring for 1 hr. The reactor was fed two times with 2ml of ethanol as soal source of carbon and energy to check the activity of sludge. The vegetable waste was obtained from a vegetable stall of sengipatti.

Fig4:Experimentalsetup

WORKPLAN:
At the beginning 75% biomass is added to the reactor in a batch modeand is sealed for the duration of the process. The reactor was operated by batch mode, without removing the feed stock. Daily gas evaluation and pH were monitored.
With the vegetable waste in a batch mode, the digester was operated for 15 days to find the maximum methane yield. Total solids reduction, dissolved solids reduction, volatile solid reduction, COD reduction and a

maximum gas yield were also found.
Gas started yieldingonthefirst dayitselfwith 40ml ofgas.DailypH,gas evolved were monitored. The sample of the influent and effluent were collected weekly and monitored for its TS reduction, and COD reduction.

Seeding Procedure
Volume of vegetable waste (Density = 450g/l)=**1500ml** Volume of Abattoir Waste or Slaughter Waste=**1000 ml** Combination of Main source[vegetable waste+Slaughter]=**2500 ml** Anaerobic Sludge added for Seeding=**500 ml** Total Volume of waste taken for production of biogas=**3000 ml**

InitialValues
pHvalueduringinitiationoftheprocess=**8.5**

[pH value of the waste will be in the range of alkaline, as the process of decomposition continues fatty acids will be produced which will make the source into acidic and reduce the production of biogas]
Magneticstirrerismadetorotateatthespeedof85rpm.

Initialtemperatureinsidethesetupis35^{0}C[RoomTemperature].

Fig.5:Mixingpowderedwastewithsludge

CHEMICALANALYSIS:

pH

Anaerobic bacteria, specially the methanogens are sensitive to the acid concentration within the digester and their growth can be inhibited by acidic conditions.
As digester reaches the methanogenesis stage, the concentration of Ammonia Increases and the pH value can increase to above 8.
Once methane production is stabilized, the pH level stays between 7.2and 8.2
The pH meter is standardized with known standard pH by using Electrodes in a beaker containing standard buffer solution.
The instrument is standardized by the adjustment of the control knobs so that the pH meter cords the exact pH of the standard solution.
The pH of the sample is determined by placing the electrode in it. The reading is taken after the indicated value remains constant for about a minute.

Thereadingsaretabulatedbelow:

Date	Day	pH Value
03.03.2020	1	8.02
04.03.2020	2	7.9
05.03.2020	3	7.4
06.03.2020	4	6.85
07.03.2020	5	6.95
08.03.2020	6	7.02
09.03.2020	7	7.1
10.03.2020	8	7.42
11.03.2020	9	7.22
12.03.2020	10	7.15
13.03.2020	11	7.13

Table 3:pHValues

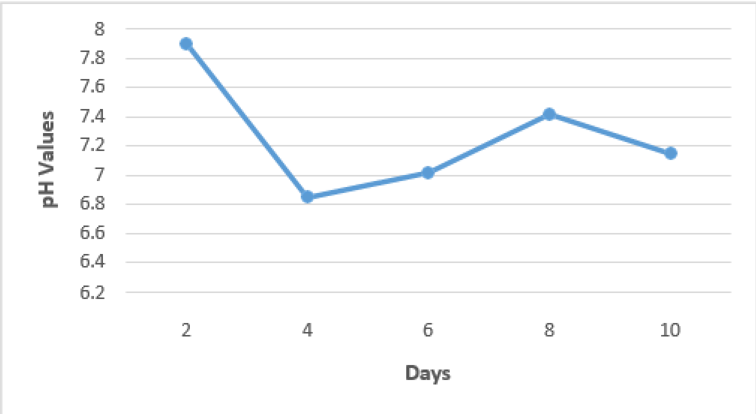


Fig.6: GraphforpHValues

TotalGas Production
Gas started yielding on the first day itself with 40ml of gas daily pH gas evolved monitored. The sample of the influent and effluent were collected weekly and monitored for its TS reduction and COD reduction.

Theobservedreadingaretabulatedasbelow.

DATE	DAY	AMOUNTOF GAS (ml)
03.03.2020	1	40
04.03.2020	2	48
05.03.2020	3	64
06.03.2020	4	38
07.03.2020	5	30
08.03.2020	6	28
09.03.2020	7	25
10.03.2020	8	23
11.03.2020	9	20
12.03.2020	10	05
13.03.2020	11	03
14.03.2020	12	-

Table4:AmountofGasProduction

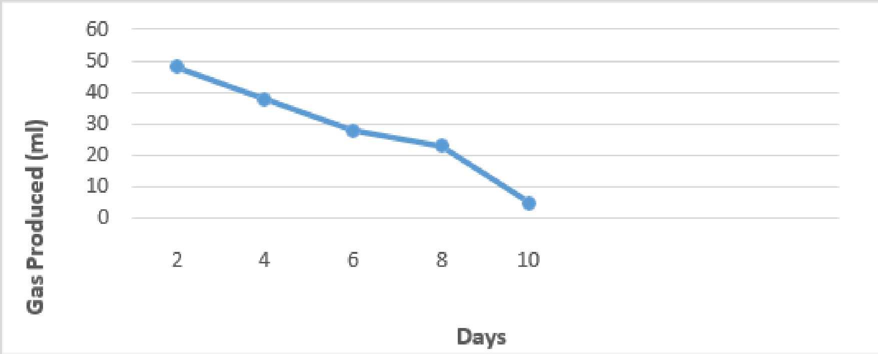


Fig.7: GraphforGas Production

TotalSolids

Acleancrucibledishisignitedinanovenandafterpartialcoolingits empty weight is taken as W1.
5ml of feedstock is taken in the dish and it is kept in oven at 100^0 C after that the weight of dish is taken as W2.
Theamountoftotalsolidsiscalculatedbyusingtheformula,

$$TotalSolids = \frac{W2 - W1 X1000}{mlofsample}$$

Thereadindsaretabulatedbelow

Sample Details	Volumeof Sample taken(ml)	Empty Weightof Crucible Dish (gm)	FinalWeight 0f Crucible Dish (gm)	Solids(mg/l)
TS1	5	32.672	32.655	1230
TS2	5	32.054	32.142	1250

Table5:TotalSolids:BeforeDigestion

Sample Details	Volumeof Sample taken(ml)	Empty Weightof Crucible Dish (gm)	FinalWeight 0f Crucible Dish (gm)	Solids(mg/l)
TS 1	5	34.658	34.987	489
TS 2	5	32.152	32.058	485

Table6:TotalSolids:AfterDigestion

DissolvedSolids

5ml of filtered feedstock is taken in thedish and it is kept in water bath at 100^0 C after that the weight of dish is taken W2.
TheamountofTotalSolidsiscalculatedbyusingthis formula,

$$DissolvedSolids = \frac{W2 - W1 X1000}{mlofsample}$$

Thereadingsaretabulatedbelow

Sample Details	Volumeof Sample taken(ml)	Empty Weightof Crucible Dish (gm)	FinalWeight 0f Crucible Dish (gm)	Solids(mg/l)
Day1	5	31.545	32.045	645
Day2	5	34.795	35.115	620

Table7:DissolvedSolids-BeforeDigestion

Sample Details	Volumeof Sample taken(ml)	Empty Weightof Crucible Dish (gm)	FinalWeight 0f Crucible Dish (gm)	Solids(mg/l)
Day1	5	31.985	32.014	260
Day2	5	32.002	32.895	240

Table8:DissolvedSolids -After Digestion

VolatileSolids

The residues left after determining total solids is again divided into volatile suspended solids and fixed solids. VS is the organic fraction that lost as CO_2 and fixed solids are that ash portion that remains.

Thereadingsaretabulatedbelow

SampleDetails	VolumeofSample taken(ml)	Solids(mg/l)
Day1	5	995
Day2	5	1030

Table9:VolatileSolidsBeforeDigestion

SampleDetails	VolumeofSample taken(ml)	Solids(mg/l)
Day1	5	365
Day2	5	402

Table10:VolatileSolidsAfterDigestion

ChemicalOxygenDemand(COD)

A capacity of flat bottom flask, 500ml is taken and 0.4 gm of $HgSO_4$ is added. Then 20ml of sample is added dilute with 20ml distilled water and mixed.

0.25N of potassium dichromate is added depending upon the expe ted COD 30ml of conc. H_2SO_4 + Ag_2SO_4 reagent is added and mixed thoroughly. The slow addition along with swirling prevents fatty acid to escape out due to high temperature.

Then the flash is connected to the condenser and the contents are mixed before heating. Improper mixing will result in bumping and sample may be blown out. It is refluxed for a minimum of two hours.

The sample is diluted for a minimum of 70ml, it is cooled to room temperature, $K_2Cr_2O_7$ remaining after refluxing is titrated against standard ferrous ammonium sulphate using ferroin as an indicator. The colour changes from blue green to wine red indicates the end point.

Blacksampleisalsotitratedinthesamemannerusingdistilledwater.

TheCODiscalculatedbythefollowingtheend point.

$$COD(mg/l) = \frac{A - B X g X 1000}{\text{mlofsample}}$$

Where,

A=mlofferrousammoniumsulphateusedforblank

B=mlofferrousammoniumsulphateusedforsample N = normality of ferrous ammonium sulphate

g=millequivalentweightofoxygen

Sample	PipetteSolution (ml)	Burette Reading		COD(mg/l)
		Initial (ml)	Final (ml)	
Blank	70	0	5.5	72000
Effluent (1in50)	70	0	8.0	25000
Effluent (1in100)	70	0	7.1	26000
Influent (1in50)	70	0	7.3	63000
Influent (1in100)	70	0	8.4	40000

Table11:ChemicalOxygen Demand

V. RESULTSANDDISCUSSION

RETENTIONTIMEVSGASPRODUCTION

A batch mode on anaerobic digestion or fermentation is followed in this project. It is the natural biological process which stabilizes the organic waste in the absence of air transforms it into biogas. The biomass is fed into the digester in a batch mode. Once the digestion is completed, the effluent is removed and the process is repeate.

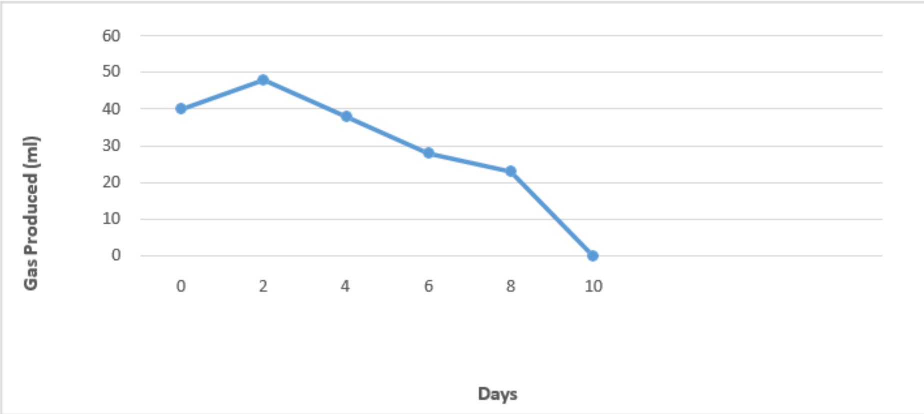


Fig.8:GraphforRetentionTimeVsGasProduction

The gas production will increased with the retention time and after and reaching the peak value it will goes on decreasing. From this graph the maximum gas production and its duration for the batch mode of anaerobic operation can be found.

TOTALSOLIDS

There are three different ranges of solids content low solid anaerobic digestion systems contains less than 10% total solids, medium solids from 15 – 20% and high solid systems range from 22 – 40%.
When increasing the total solid content, the volume of the digester decreases, due to water requirement.

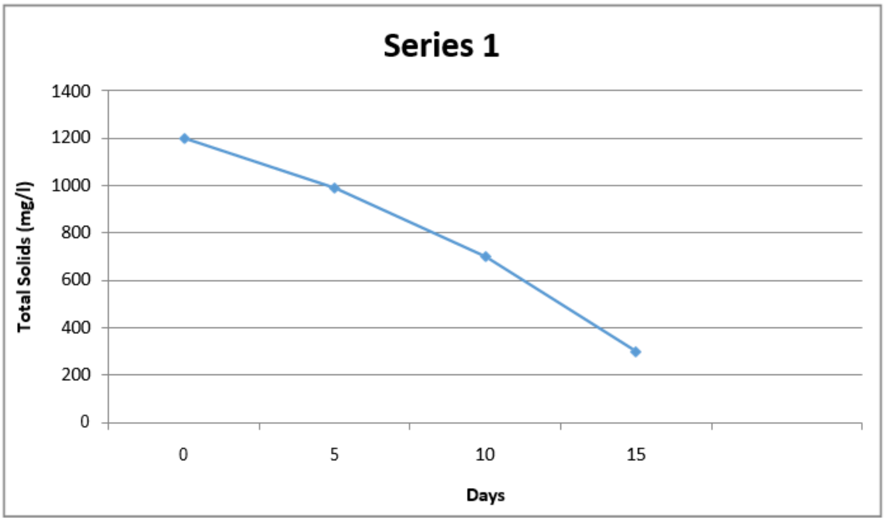


Fig.9: GraphforTotalSolids

Here the result shows that the amount of total solid content before adding the biomass is reduced at the end anaerobic digestion.

DISSOLVEDSOLIDS

Ahighcontentofdissolvedsolidselevatesthedensityofseedingsludge.
Dissolvedsolidsarethosewhichremaindissolvedinsewagejustassaltin water.

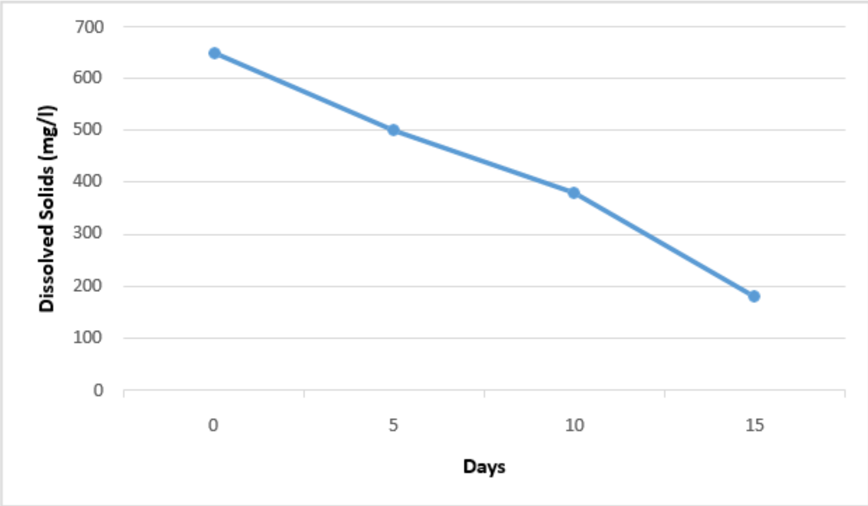


Fig.10:GraphforDissolvedSolids

Here the results shows that the amount of dissolved solid content before adding the biomass is reduced at the end of anaerobic digestion.

VOLATILESOLIDS

Theweight of organic solids burned off when heated to about 538^{0}C is defined as volatile solids. The biogas production potential of different organic materials can also be content unit results higher the gas production.
Here at the initial stage the amount of volatile solids is more than the end stage. That is way the biogas production is goes on increasing at the initialstage.

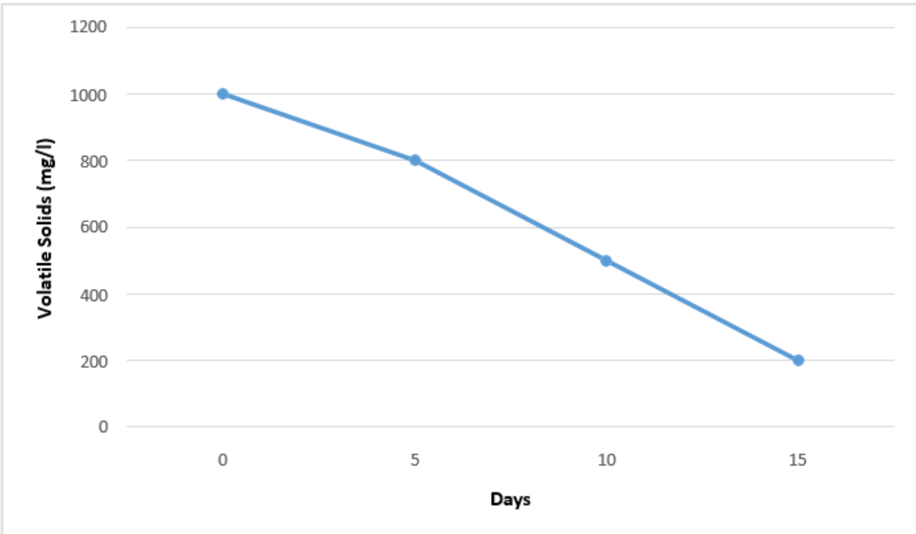


Fig.11: GraphforVolatile Solids

CHEMICALOXYGENDEMAND

COD test determines the oxygen required for chemical oxidation of most organic matter and oxidizable inorganic substances with the help of strong chemical oxidant COD can be obtained in about 3hrs.

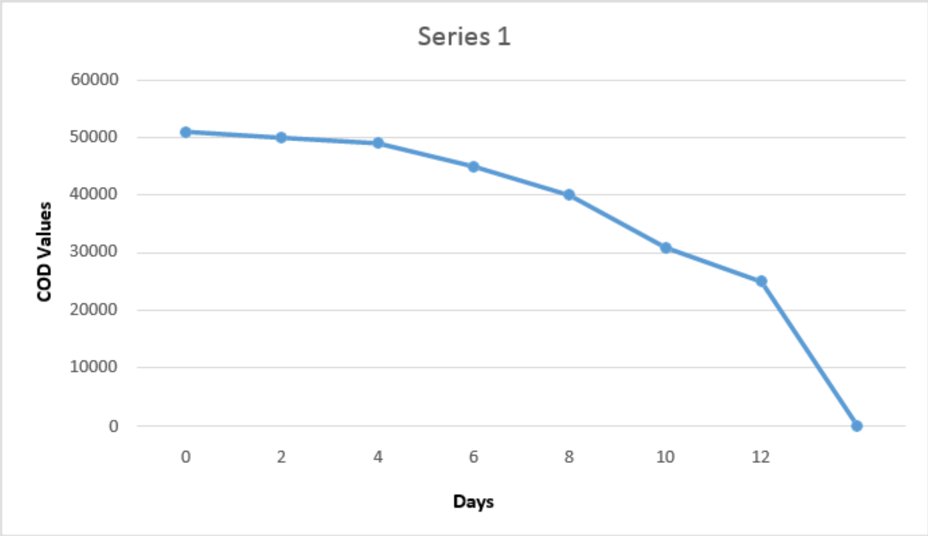


Fig.12:GraphforChemicalOxygenDemand

COD values are too if greater amounts ofbiologicallyresistant organic matterarepresent.ThegraphshowsreductionintheCOD.Hencetheamount of biologically resistant organic matter is less.

Fig.13:BioGasProducedAfter Digestion

VI. CONCLUSION

The project is concerned with the batch study on Anaerobic Digestion of vegetable waste. In this project the process of anaerobic decomposition of vegetable waste by micro organisms have been completely studied.

In this project the digester was operated for 15 days to find the maximum biogas yield. Total solids reduction dissolved solids volatile solids reduction, COD reduction and a maximum gas yield were also found. It was observed that 60ml of maximum gas yield on 3rd day. In practice 75% of sludge is used for seeding.Itwilltakemoretimeto producebiogas.Inthisproject 100%ofsludge is used and hence the maximum COD reduction of 50%, TS reduction of 39.68%, and DS reduction of 40.68%.

The pH of the waste is reduced from 8.5 to 4.5 due to the production of fatty acids by the micro organisms. Then the pH is neutralized and maintained by addition of NaOH and buffer solution. The optimum pH for active decomposition of waste is 6.8 – 7.5.

In Thanjavur MSW is treated by landfill composting method. Theeffluent from this is used as manure. In anaerobic decomposition method of solid waste management, manure production as well as the biogas recovery can be achieved.

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