Biogas production by pine needles co-digested with food waste through anaerobic digestion

A

THESIS

Submitted in partial fulfillment of the requirements for the award of the degree of

Bachelor of Technology

in

Civil Engineering

By

Piyush Pathania (161620)

Gunjan Katoch (161640)

Nitin Thakur (161671)

Under the Guidance of

Prof. Dr. Ashish Kumar

to

Department of Civil Engineering

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY, WAKNAGHAT

May-2020

Student’s Declaration

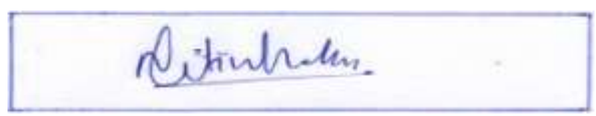
We hereby declare that the work presented in the Project report entitled **“Biogas production by pine needles co-digested with food waste through anaerobic digestion ”**submitted for partial fulfillment of the requirements for the degree of Bachelor of Technology in Civil Engineering at **Jaypee University of Information Technology, Waknaghat** is an authentic record of my work carried out under the supervision of **Dr. Ashish Kumar**. This work has not been submitted elsewhere for the reward of any other degree/diploma. I am fully responsible for the contents of my project report.

Signature of Students

Piyush Pathania (161620)

Gunjan Katoch(161640)

Nitin Thakur(161671)



Department of Civil Engineering

Jaypee University of Information Technology, Waknaghat, India

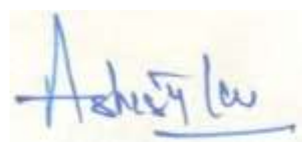
Date…27/May/2020

Certificate

This is to certify that the work which is being presented in the project report titled **"Biogas production by pine needles co-digested with food waste through anaerobic digestion"** in fulfillment of the requirements for the award of the degree of Bachelor of Technology in Civil Engineering submitted to the Department of Civil Engineering, **Jaypee University of Information Technology, Waknaghat is** an authentic record of work carried out by **Piyush Pathania(161620),Gunjan Katoch(161640), Nitin Thakur(161671)** during a period from June 2019 to May 2020 under the supervision of **Dr. Ashish Kumar** Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat.

The above statement made is correct to the best of our knowledge.

Date: 27 May 2020



Dr. Ashok Kumar Gupta

Professor and HOD Civil

Engineering Department

JUIT Waknaghat

Dr. Ashish Kumar

Professor

Civil Engineering

Department JUIT

Waknaghat

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Piyush Pathania

Gunjan Katoch

Nitin Thakur

Date: 27 May 2020

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Abstract

We all know that the population of the world is increasing day by day with increase in the population the energy demand is also increasing. Our current energy resources like coal, fossil fuel, natural gas etc are depleting at very fast rate. Therefore we need to shift our focus to some other energy resources . Anaerobic digestion process could be one of our option . Anaerobic digestion is a process in which micro-organism break down organic material in the absence of oxygen resulting in the formation of gas which can be used as the source of clean energy. The objective of this research is to identify the credibility of food waste and pine needles co digested with each other at organic loading rate of 0.05, 0.1, 0.15, 0.2 and 0.25 and at ratios of 25%(PN):75%(FW) by mass , 75%(PN):25%(FW) by mass and 50%(PN):50%(FW) by mass and to identify the best biogas yield at different organic loading rate and at different ratio and to study the effect of temperature variations on biogas production. For this study six continuous flow digesters were set up three at controlled temperature of 25^{O}C and three are exposed to atmospheric conditions. The digesters placed at fix temperature are named as D2 , D4 and D6 of ratios25(PN):75(FW),75(PN):25(FW)and 50(PN):50(FW) and the digesters placed at atmospheric conditions are named as D1,D3 and D5 of ratios25(PN):75(FW) , 75(PN):25(FW) ,50(PN):50(FW) . HRT (Hydraulic Retention Time) for the digesters was of 6 days . On every 7th day feed was changed and the different parameters like pH , Temperature and biogas yield was measured . The biogas production at different OLR(Organic Loading Rate) and at different ratios for all the digesters was measured and compared. After comparing the results it was found out that the biogas production of digesters which are kept at controlled temperature is high then that of those who are placed at ambient temperature. The digesters of ratio D2 25(PN):75(FW) by mass placed at incubated temperature has given maximum biogas yield.

Chapter-I

Introduction

Consumption of petroleum derivatives is an enormous danger to the vitality gracefully all through the world. Petroleum products likewise cause various issues with its ignition and poisonous contaminations which is driving us towards look into in changed corners to accomplish effective and non-thorough vitality sources like sustainable power source. Sustainable power source comprise of various sources like sun oriented vitality, geothermal vitality, flowing vitality, hydro wellsprings of vitality, geothermal vitality, and biogas.

It is a yield of anaerobic assimilation process. Biogas is unique in relation to other vitality sources on the grounds that the procedure uses natural waste as a fuel/substrate to produce biogas like extra food squander, rural straw, and backwoods waste and trimmings from gardens and nursery. The elite highlight of biogas is its all out waste administration/management. Through its start, it uses natural waste material as its feed which results in a gas used for cooking and power and the waste aged slurry which withdraws in fluid state is acceptable/valuable for the dirt and don't harm like cruel concoction composts. It originates from original bio fills and assumes a significant job in satisfying rustic vitality requests.

Deforestation causes a tremendous quantity of issues worldwide. Today there are many nations where many people's/populace are legitimately dependant on wood for vitality cooking and warmth purposes. Cutting down of trees cause soil disintegration as well as is one of the significant reasons for indoor contamination. Smoke emerges by the burning of wood comprises of carbon dioxide and airborne particulates which are very deadly/damaging for wellbeing. In Dev Bhoomi Himachal Pradesh, wood utilization is routine because of its plentiful accessibility and most country family units utilizes/devour 7-8 Kg wood every day to meet their vitality needs.

Directly speaking the globe is in more prominent need of an eco-accommodating, inexhaustible wellspring of vitality. Out of various sustainable power sources, anaerobic assimilation gives a spotless; better propellant/fuel for power and for the purposes of cooking and just uses squander natural, organic waste material as a fuel to power it or we can say as a substrate. CH_4 also known as methane is considered as a perilous ozone harming substance contributing its terrible impact in type of a dangerous atmospheric deviation and yet, it is additionally utilized as a decent fuel for vitality age purposes.

Natural waste like kitchen/food squander in India is expanding step by step with quick increment/development in populace. City squander in provincial and most urban zones are improperly overseen or dealt with and the greater part of the waste are moved and arranged in landfills or dissipated all through open spots which cause lethal sicknesses like Cholera, Jaundice, dengue, intestinal sickness and Typhoid. The landfill isn't an approach to look further. Substrates like food squander, rural straw, woods waste and nursery trimmings contains higher/larger amount of natural organic material with great calorific worth and nutritive incentive for microscopic living beings or bacterial application.

Utilization of food squander in the digester may prompt better return/creation of biogas which can fills in as a decent waste administration approach. Rare administration of waste and numbness of removal receptacles will just prompt contamination of condition and will likewise advance sicknesses by bugs and creatures. Open anaerobic assimilations in landfills are the significant reason for a dangerous atmospheric deviation and environmental change. Be that as it may, kitchen squander is normally disregarded in creating nations. Many of the biogas digesters in the world operates on low calorific fills like dairy animals compost, profluent, sewage slime and food waste which brings about low CH_4 creation/yield. Utilizing municipal waste could turn tables with the nearness of higher sugar, nutritive and calorific worth. Productivity could likewise be accomplished by Co-absorption of Municipal strong waste with different substrates.

Advancement of Appropriate Rural Technology Institute Biogas structure in year 2003 altered the effect of biogas creation/yield on ordinary models. The use of starch and sugar based substratum has increased the latent capacity of digesters. The capacity has multiple times more. The new substrate is more capable than that of out of date substrates with co-assimilation.

Structure of Appropriate Rural Technology Institute – biogas plant is very straightforward, convenient and substance utilized for building was 1/4th the customary plan cost

There are main considerations answerable for the exhibition of reactors. The greater part of the reactors execution is upset by the sloppy contribution of feedstock, the plan of the reactor and ecological components. Physical and compound attributes of the natural squanders, synthesis of waste are significant for running plant since they impact the creation of biogas and procedure solidness in the course of the processing. Natural waste comprises of dampness, TS, VS, carbon and nitrogen with many follow metals. The biodegradability of natural organic waste is determined by decrease in introductory/composition of TS and VS content. The yield of biogas depends on contribution of VS per unit content in the digester and affected by the temperature outside the digester. A great deal of alteration on innovative and operational condition is done to lower down the cost of the digester. Brand new techniques has been developed for fast aging of microscopic organisms with decrease in size and convey ability of biogas digester and regarding the substrate, ton of new natural waste, organic waste has tried to approve higher biogas creation. Through advancement in plan of biogas plants, there have been numerous changes and one of them is presentation of brand new reduced structure/biogas reactor for both provincial and urban. The significant advantage of utilizing biogas innovation is that it utilizes natural waste which is created on regular routine and freely delivering your own gas from produced squander. Proposed methodology of biogas could take care of vitality emergency issue.

1.1 Biogas characteristics

It is the mix of gases made by the disintegration of organic matter, waste, substrate without oxygen. Biogas is a maintainable and non-exhaustive wellspring of imperativeness. Biogas is conveyed by the method of anaerobic preparing with methanogens or anaerobic living creatures, which breakdown or disintegrates organic matter inside the shut structure/plant. This shut system is known as anaerobic digester. Biogas is made with mixture of gases out of which methane (CH_4) and carbon dioxide (CO_2), hydrogen sulphide (H_2S) and dampness. Gases like CH_4 and H are combustible in nature.

Gases encircled during anaerobic ingestion process vacillate from feedstock to feedstock yet CH_4, CO_2 are made in increasingly unmistakable number and rest of gases are accessible in little sum.

Table 1.1:- Biogas composition

S. No.	Constituent	Unit	Composition
1	CH_4	%	50 to 80
2	CO_2	%	15 to 45
3	H_2S	mg/m^3	0 to 5000
4	NH_3	mg/m^3	0 to 450
5	Humidity	-	Saturated

Table 1.1 is speaking to dispersion of various sorts of gases created at the last phase of anaerobic absorption process. Methane and carbon dioxide rules whereas different gases are in modest quantity. Methane being primary constituent will fluctuate from substrate to substrate.

Table 1.2:- Biogas, Bio methane and Natural Gas composition

CONSTITUENTS	BIOGAS	BIOMETHANE	NATURAL GAS
	UNITS		
METHANE	45-70%	94-99.9%	93-98%
CARBON DIOXIDE	25-40%	0.1-4%	1
NITROGEN	<3%	<3%	1%
OXYGEN	<2%	<1%	-
HYDROGEN	TRACES	TRACES	-
HYDROGEN SULFIDE	<10 ppm	<10 ppm	-
AMMONIA	TRACES	TRACES	-
ETHANE	-	-	<3%
PROPANE	-	-	<2%
SILOXANES	TRACES	-	-

Table 1. 3:- Features of biogas

S no.	Features	Units
1	Energy content	6-6.5 kWh/m^3
2	Fuel Equivalent	0.6-0.65 l oil/m^3 biogas
3	Explosion Limits	6-12 % biogas in air
4	Ignition Temperature	650-750 ^{0}C
5	Critical Pressure	75-89 bar
6	Critical Temperature	-82.5 ^{0}C
7	Normal Density	1.2 Kg/m^3
8	Smell	Rotten eggs

1.2 Different stages of digestion process

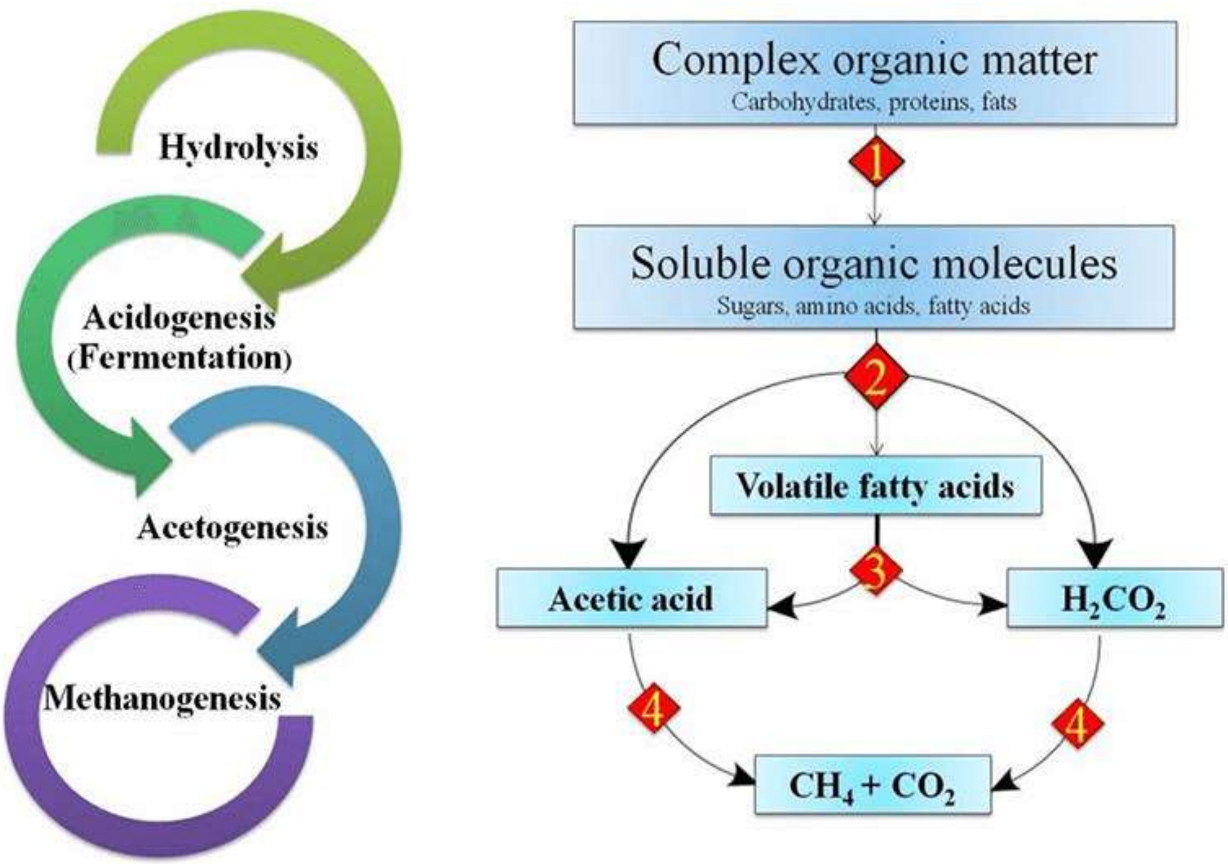

Figure 1.1:- Anaerobic digestion process stages.

Hydrolysis

Hydrolysis is essentially a parting of huge mixes in nearness of water. Hydrolysis additionally represents breaking down of complex mixes/matter like proteins (condition I), carbohydrate, lipids and cellulose (condition II) into easier structure which may further effectively devoured by micro-organisms.

Condition I: Proteins + H_2O hydrolysis a dissolvable amino acids

Condition II: Cellulose + H_2Ohydrolysis a dissolvable sugars

Hydrolysis of complex mixes/matter prompts less difficult particles:

Hydrolysis of cellulose

(1.3): $(C_6H_{12}O_6)$ n + H2O - > $nC_6H_{12}O_6$

Microscopic organisms associated with hydrolysis process: The significant micro-organisms required at this stage are Bacillus, Micrococcus, Clostridium, Vibrio etc.

Acidogenesis

Second step of AD process is acidogenesis .In this stage fundamental molecule is separated into volatile fatty acids like capricious acids, ketones, alcohol, carbon dioxide and hydrogen. Carbon dioxide and hydrogen will overlook the Acetogenesis step which is the third step of AD and will direct coordinate with fourth step. Reaction incorporates change of glucose into ethanol and carbon dioxide (condition III). Another reaction included Conversion of glucose and hydrogen into Propanoic destructive and water (condition IV) or direct change of glucose into acidic destructive.

Condition III: $C_6H_{12}O_6 \leftrightarrow 2CH_3CH_2OH + 2CO_2$

Condition IV: $C_6H_{12}O6 + 2H_2 \leftrightarrow 2CH_3CH_2COOH + 2H_2O$

Condition V: $C_6H_{12}O_6 \rightarrow 3CH_3COOH$

Acetogenesis

The 3rd stage in the process of anaerobic digestion pivots to the changes in Acetogenesis things (Propanoic destructive and alcohol) into acidic destructive, H and CO_2. Hydrogen plays an essential limit of a go between as the reaction will conceivably process if the hydrogen midway weight is satisfactory and allow the change of acids present in Acetogenesis stage. This system of cutting down hydrogen midway weight is finished by minuscule life forms and hydrogen pressures moreover go about as a pointer of digester's health. Glucose (condition VI) and ethanol (condition VII) among others are moreover changed over to acidic corrosive induction during the third period of anaerobic development.

Condition VI: $C_6H_{12}O_6 + 2H_2O \leftrightarrow 2CH_3COOH + 2CO_2 + 4H_2$

Condition VII: $CH_3CH_2OH + 2H_2O \leftrightarrow CH_3COO^- + 2H_2 + H^+$

Methanogenesis

The last process of the digestion is methanogenesis. In this process methane is made by 2 specific bacterial social events where lithotrophs minute life forms use/uses H_2 as electron supplier and decrease carbon dioxide to methane and water (condition VIII). The second kind of microbial living thing named organotropicacet oclastic Methanogens basically age regular destructive like acidic destructive to methane and carbon dioxide (condition IX). An enormous bit of the methane is removed from acetoclastic methanogens. Methanogens have a tremendous activity in ejection of sharpness. Employment of syntrophic infinitesimal life forms is excellent as they convert other normal acids like butyrate and propionate to acidic corrosive determination and in the nonattendances of these microorganisms short chain of characteristic acids total inside reactor inciting lowering down in pH.

Condition VIII: $4H_2 + CO_2 \rightarrow 2H_2O$

Condition IX: $CH_3COOH \rightarrow CH_4 + CO_2$

1.3 Factors affecting biogas production

C/N (carbon/nitrogen) ratio

Carbon: Nitrogen ratios the important factor affecting the biogas yield. C:N in the digester should to be adjusted to support biogas creation. The ideal range of C:N ratio in the biogas digester should be around 25-30: 1 for better productivity of gas. Food squander is different in creation as food wastes have low nitrogen content and high degradability. Then again, lignocellulos waste has inflexible structure and has higher nitrogen content and lower degradability. If both are Co-processed with each other it could result in improved/higher biogas creation/production. Increased value of C: N have various outcomes as nitrogen is quickly devoured by microorganisms to satisfy their protein necessities and this prompts unused carbon in digester, bringing about lower biogas creation. Lowering down of C: N proportion in the digester might free alkali which hoists the pH worth and its amassing could obstruct the biogas creation. Increment in temperature might repress alkali collection.

OLR (Organic Loading Rate)

OLR or we can say Organic loading rate is a basic constituent influencing biogas creation. Loading rate is commonly communicated regarding VS (Volatile Solids). Weakening then again is mandatory for working of biogas process. On the off chance that there is high weakening the more quickly the strong substance will settle down at the base of digester. If there should arise an occurrence of high strong substrate lower weakening could hinder biogas creation. The ideal loading rate of the digester should be around 6.5% to 9.5% of all out solids of substrate. Organic loading rate change from substrate and their organization. Organic Loading Rate resilience when augmented can be seen in numerous AD and change in Organic Loading Rate might incite change of microbial network structure and bounty and elements in micro-organisms. The OLR of continuous digester is lower as compare to batch digesters.

pH value

pH is a important factors affecting anaerobic digestion process. Ideal range of pH lies between 6.8 to 7.2. Mesophilic temperature is generally utilized and for negligible operational qualities ranges from 6.5–6.8 and 7.2–7.5. On the off chance that pH estimation of digester is beneath 7.2, at that point the nearness of NH_4^+ is supported and comparably on the off chance that it is more noteworthy than 7.2, at that point the nearness of NH_3 is supported. Despite the fact that pH worth can be balanced utilizing assortment of synthetic concoctions like Ammonia anhydrous (NH_3), Lime, Quick lime (CaO), Caustic pop (NaOH), Hydrated Lime ($Ca(OH)_2$), Soda debris (Na_2CO_3), Sodium Bicarbonate ($NaHCO_3$). The process starts the pH is normally settled however during Acetogenesis stage the pH decreases due to the production of organic acids.

Temperature

Temperature is a principal factor affecting biogas creation. Perfect range of temperature for different organisms are Psychrophiles (5-20 ^{0}C), mesophiles (30-35 ^{0}C), thermopiles' (50-60 ^{0}C) and hyperthermophiles (>65 ^{0}C). Accomplishing perfect temperature requires extern l heat source. Biogas is so far producible at insignificant temperature run for mesophilic is 20-30 ^{0}C and 35 – 40 ^{0}C. Temperature similarly impacts hydrolysis of substrate as thermophilic organisms have higher temperature and the time taken by thermophilic microorganisms to crumble natural issue is faster when diverged from mesophilic. Low temperature moves down the biogas creation basically. A CH_4 confining microorganism goes after different temperature for improved methane creation Table1.4.

Table 1. 4:- Methanogens with of wide optimum temperature range

S No.	Species	Temperature in ^{0}C
I	*Methanobacterium bryantii*	37
II	*Methanobacterium formicicum*	37–45
III	*Methanobacterium thermoalcaliphium*	58-62
IV	*Methanothermobacterb thermoautotrophicum*	65-70
V	*Methanothermobacter wolfeii*	55-65
VI	*Methanobrevibacter smithii*	37-39
VII	*Methanobrevibacter ruminantium*	37-39
VIII	*Methanothermus fervidus*	83
IX	*Methanothermococcus thermolithotrophics*	65
X	*Methanococcus voltae*	35–40
XI	*Methanococcus vannielli*	65
XII	*Methanomicrobium mobile*	40
XIII	*Methanolacinia paynteri*	40
XIV	*Methanospirillum hungatei*	30–40
XV	*Methanosarcina acetivorans*	30–40
XVI	*Methanosarcina barkeri*	35–40

Hydraulic Retention Time (HRT)

HRT is portrayed should be expected time for a picked substrate to process in a reactor. Hydraulic Retention Time vacillates by sort of substrate, pH worth and temperature on which a digester is functioning.

HRT = "V"/"Q"

V = volume of system (m^3)

Q = influent flow rate (m^3/day)

If the loading rate per unit volume is low then it leads to higher Hydraulic Retention Time.

Table 1. 5:- Generation time of a bacterial group

S NO.	Bacterial Group	Function	Approximate Generation Time
1	Aerobic organotrophs	Floc formation and degradation of soluble organics in the activated sludge and trickling filter process	15–30min
2	Facultative anaerobic organotrophs	Floc formation and degradation of soluble organics in the activated sludge and trickling filter processes,	15–30min
3	Nitrifying bacteria	Oxidation of NH4 + and NO2 - in the activated sludge and trickling filter processes	2–3 days
4	Methane-forming	Production of methane in the anaerobic digester bacteria	3–30 days

1.4 Substrates used

There are various assortments of substrates used for gas creation however creature compost is for the most part utilized around the world, different potential of waste varying from food preparing ventures, farming waste, squander sludge and organic biodegradable portions of Municipal Waste. Biogas creation is novel on use of organic throw away substrates like garden waste, nursery trimmings, waste from farming field; hindered crops are effectively processed by anaerobic reactor.

1.4.1 Cow manure

Dairy animals' compost is noteworthy, modest and effective decision for kick starting biogas plant. Heaps of methane shaping microbes are available inside excrement. It is commonly favoured not to uncover or disintegrate dairy animals compost in outdoors during fire up as methane framing microorganisms are exacting anaerobes and uncovering them could cause unexpected demise in microbial populace and methane shaping microscopic organisms are significant hotspot for gas creation. Bovine excrement is installed with differing quantity of bacteria's and is a huge hotspot for inoculants and firing of digester.

1.4.2 Food squander

Food squander consists of the opposite parts, and each nuclear family has a high number of food squander on the regular calendar. Food waste that shows countries like India under natural waste mix the natural parts with other inorganic waste and dump it into landfills leading to the release of methane. Biogas may be the most appropriate response to solving a food squander problem. Food squander has a balanced production of starch, lipids and fats, which are successfully hydrolyzed and controlled by microorganisms. Theoretically highly depleted methane yield from sugar is 0.37 m^3 CH_4 / kg natural drought problem. The problem with sugar is that it is isolated by small organisms and has a high carbon dioxide and low methane content. Proteins and lipid proteins, on the other hand, provide a climb to theoretical optimization of methane yield. The methane yield is 1.0 m^3 CH_4 / Kg and the lipid is 0.58 m^3 CH_4 / Kg.

Food Destruction, Extravagance and Blowout in India contain a wide variety of foods and are usually in liquid composition. It is difficult to separate and concentrate each cluster because the classification is unusual for the experience. A mixture of sugar, lipids, and fats gives classification in the gas scheme. Food waste is discrete in nature and the problem is growing slightly. Biogas opens another window for understanding food waste.

1.4.3 Agriculture & forest residues

One of the biggest scope issues is the horticultural waste boards. In creating a nation like India, the rest of the waste is grain and the rest of the waste is scattered on the farm. There are various issues related to grass waste and the cost of using it to save large quantities of deposits and drilling stubble. Woodland construction includes leaves, twigs, bark, needles and sauce dust. Pine needles have been used as a substrate in our research, because of the extraordinary threat of tannins from pine needles that cause soil growth in Himachal Pradesh. The growth of pine needles additionally promotes woodland fire risk.

Co-digestion:

Co-processing is a process where organic waste material is digested with other waste material to increase the biogas yield. A primary benefit of co-digestion is that it uses existing infrastructure for the purpose of biogas production. It has different focal points, for example,

A) This aggregation can disrupt ammonia.
B) It balances the anaerobic processing Carbon: Nitrogen ratio required for methanogens.

1.5 Type of anaerobic digester

Two types of anaerobic digester-

1. Batch digesters
2. Continuous flow digester

1.5.1 Batch digester

Batch digester-In this feed stock are stacked into digester at the same time. There is a set timeframe for processing to happen. Following this time digester is physically purged and reloaded. Feed is changed at 40-50 days interim. Gas creation is lopsided on the grounds that bacterial absorption starts gradually, pinnacle and afterward tighten.

1.5.2 Continuous flow digester

In continuous digester, organic issue is continually included (continuous complete blended) or included stages to the reactor (continuous attachment stream; first in – first out). Here, the results are continually or occasionally evacuated, bringing about consistent creation of biogas. A solitary or various digesters in succession might be utilized. They void naturally through the flood at whatever point new material is filled in. Along these lines, the substrate must be liquid and homogeneous. Continuous plants are reasonable for rustic family units as the important work fits well into the day-by-day schedule. Gas creation is steady, and higher than in batch plants.

Continuous flow digester is of two types-:

(a) Floating Drum Type

Floating drum plants include an underground digester (tube shaped or encased) and a moving gas holder. The gas-holder glides legally on a mature solution or in its own water coat. The gas is collected in the gas drum, which is known by the measurement of the gas. The gas drum is kept by tilting from the direct edge. When biogas is produced, the drum goes up and when it eats, the drum goes down.

When the drum jumps into the water coat, it does not even exit the surface with a strong material. After the appearance of the nominal fixed-arc model, gliding drum plants become old because they have high elation hazards and support costs, along with other structural defects.

Currently there are two types of floating arc sort biogas plants in India.

KVIC (Khadi and Village Industries Commission) Biogas Plant

The floating dome type design originally consisted of underground tank and gas holder mounted on top of the digester tank. The abundance of the tank can be changed from 3 - 7 meters and the volume of the digester tank can vary from 1.2 - 16 meters. The surface is placed in a blending tank, connected directly to the base of the underground tank, and similarly to a slurry pipe outlet chamber. Both the blending and outlet rooms are set at ground level. The structure of the two gas holders and the digester tank is rounded and hollow, as it contains a fiddle and gas holder material steel sheet. To assist the gas holder, an iron strip is installed at the base of the digester and attached to the gas holder. Once the process begins, the gas holder will sprout openly over the hip.

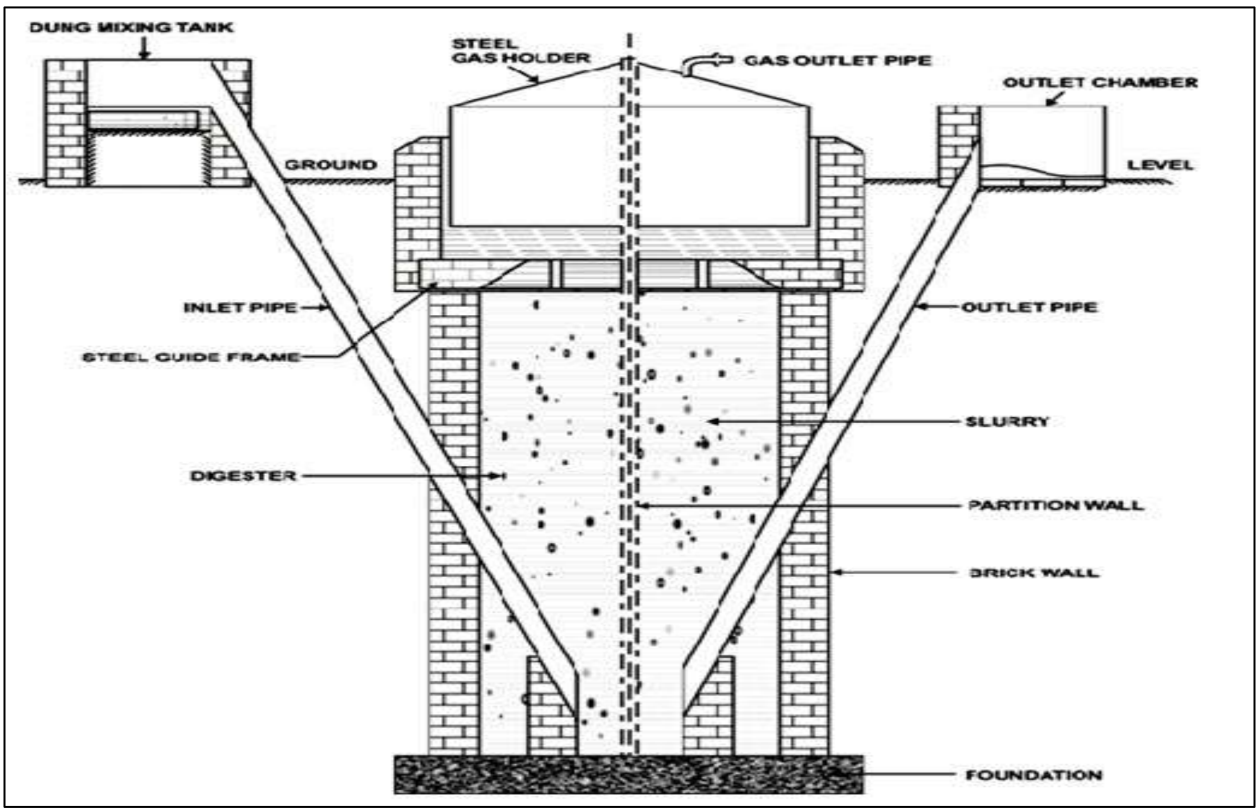

Figure 1.2:- Portrayal of KVIC Biogas plant

ARTI (Appropriate Rural Technology Institute)

The plan was brought about by a NGO in Pune, Maharashtra. The arrangement incorporates HDEP water tanks, where the digester tank is generous and the gas holder tank is 1/third of the digester. The upper piece of the digester tank was exhausted. The gas holder top is generally unfilled and the gas valve is created at the base of the gas holder tank. One of the benefits of an ARTI biogas plant is cost attainability, since the improvement cost is one-fourth of the general structure and conservativeness of the material and plan.

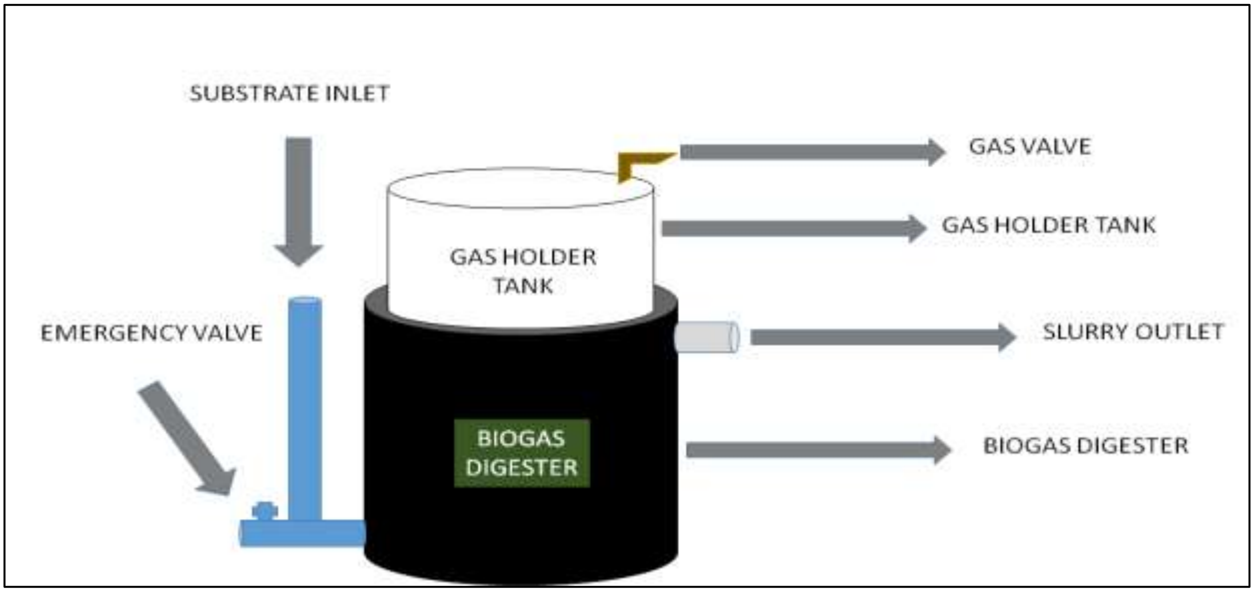

Figure 1.3:- Representation of ARTI type biogas plant.

(b) Fix dome type

A fixed-vault plant includes a digester with a fixed, non-versatile gas holder, which sits on the digester. Right when gas creation starts, the slurry is removed into compensation tank. Gas pressure increases with volume of gas set aside and the stature differentiate between the slurry level in the digester and the slurry level in compensation tank. The costs of fixed-curve biogas plant are tolerably low. Its direct as no moving parts exist. There are also no rusting steel parts and thus a long presence of the plant (20 years or more) can be typical. The plant is fabricated underground, protecting it from physical damage and saving space. While the underground digester is protected from low temperatures around night time and during cold seasons, sunshine and warm seasons set aside more effort to heat up the digester. No day/night instabilities of temperature in the digester earnestly sway the bacteriological systems. The advancement of fixed curve plants is work genuine, as such creation neighborhood business. Fixed-curve plants are hard to produce. They should simply be created where advancement can be controlled by experienced biogas experts. Regardless plants may not be gas-tight.

Two kind of fix arch sort utilized in India

Janata type biogas plant

The structure of this plant is balanced from Chinese curve formed biogas plant. The structure of this plant relies upon building material (usage of cement and squares). It is underground and involve mixing pit which is arranged at ground level and the condition of the digester is vault at the top and rest of the structure is tube moulded and there is an exit for slurry which is also connected with ground level and made sure about by strong segment. The cut off is proportionately higher than KVIC plan. The gas creation standard takes after KVIC plant structure.

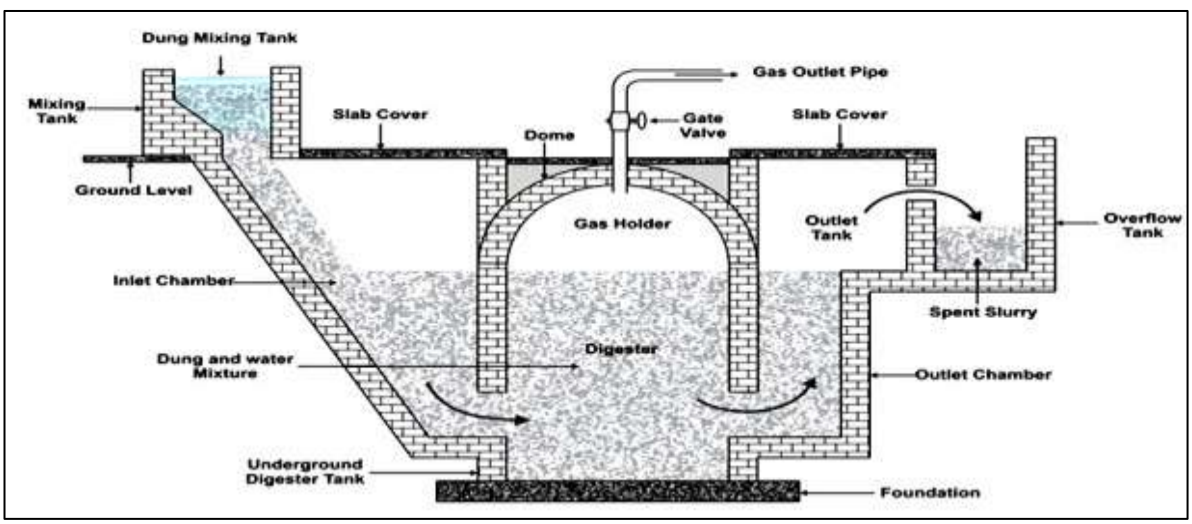

Figure 1.4:- Portrayal of Janata type biogas plant.

Deenbandhu plant design.

The arrangement was made by AFPRO (Action for food creation) . It reduces the expense of the plant to half of KVIC model. The condition of the plant is hemispherical and it is fixed underground. The substrates are stacked from the channel pipe which is related with a mixing pit at ground level. The vault is based on braced cement and attached to the base of the digester. The slurry is left from the outlet pipe which is related through an opening on the contrary side of the digester. Deenbandhu is one the typical created plant in India.

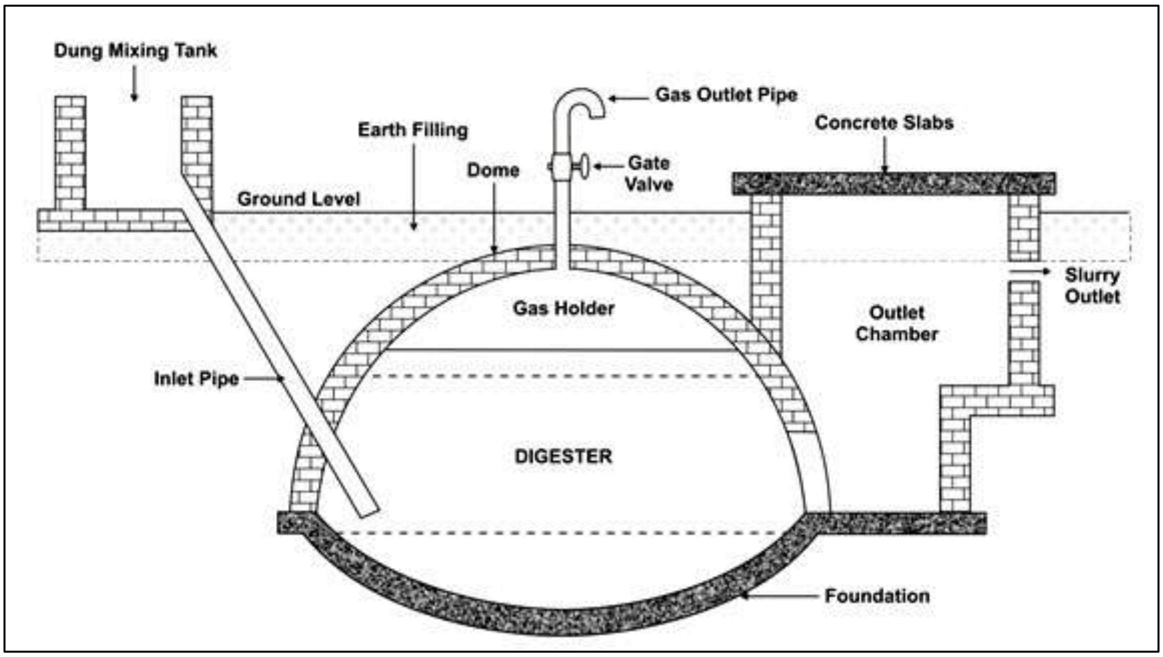

Figure 1.5:- Representation of Deenbandhu type plant

1.6 Waste generated in Himachal Pradesh

State of Himachal Pradesh was estimated to be 304.3 tons per day in 2011. The per capita waste generation rate in Himachal Pradesh is around 0.413 kg/day. It is also estimated that 60% of the waste generated ends up in landfills. Dumping of waste in unscientific manner creates anaerobic condition at the disposal site which leads to uncontrolled emission of methane which is a greenhouse gas (GHG) like methane.

1.7 Benefits of the biogas technology

The financial advantages got are:

1. The waste material is processed and decreased without contaminating the earth as air, land and water contamination.
2. Bio-Fertilizers are gotten as fluid slurry and it is wealthy in supplements and can be utilized as excrement in ranches to improve soil fruitfulness.
3. Biogas delivered is sustainable wellspring of vitality and substitute of LPG and can be utilized to create power.
4. It spares land contamination not at all like land filling as the digester is compact fit as a fiddle.

The social and medical advantages got are:

1. People are required for the activity/working of bio digesters along these lines making openings for work.
2. The compost got is modest in this manner can be promptly accessible to the ranchers with ease.
3. The odds of dispersal of diseases causing small scale life forms are decreased.
4. It requires squander for its activity which is produced on consistent schedule

Chapter-II

Literature review

2.1 General

Biogas creation is a huge hot research subject currently day by day's thusly there is tremendous proportion of composing is open. The composing review is a combination of study done regarding the matter, consolidating research articles appropriated in national and overall journals. This assessment is on;

1. To consider the effect of temperature on biogas creation

2. To find the most fitting proportion of unsteady solid of cow compost and pine needle for most prominent creation of methane.

3. To find the most fitting proportion of unsteady solid of food waste and pine needle for most prominent creation of methane.

2.2 Literature on biogas production

Paul Thomas et al.,(2017) this paper assess the extent of biomass in Indian economy. Being an agribusiness nation, India has an awesome degree and potential assets from agronomics segment like harvest build up, creature squander, food squander and so on. At which rate the populace increasing in India the interest for vitality is additionally developing at quick rate, so to beat this interest biogas creation from squander is generally excellent other option. The quicker development of economy of India lead to urbanization which thusly the expands the age of metropolitan strong waste. The city strong waste is a rich wellspring of biomass, so it tends to be utilized from multiple points of view for transformation to vitality like biogas age.

E.Fathi Aghdam et al.,(2015)conduct an examination on mesophilic anaerobic processing of natural piece of common solid waste, bio squander, sewage ooze and co-assimilation of bio waste and sewage ooze. Combined biogas age from natural portion of city strong waste, bio squander, sewage slop and co-absorption of bio waste and sewage muck was about 385±55, 384±83, 197±15 and 317±60 L CH_4/kg Vs. The natural stacking rate for digester was 1 to 2 kg VS/m^3d. By co-absorption of sewage slime and bio squander the normal biogas creation was expanded by 61%. By result assessment, the methane yield alone by bio squander is 12% more than methane creation by precisely treated natural portion of civil strong waste.

Abhilash Kumar Tripathi (2015) - Biogas is produced from anaerobic absorption of complex natural squanders. The current investigation centres around proficient and practical utilization of biogas digester for the creation of biogas from hard-headed lignocelluloses squander (pine needles). In spite of the fact that creation of biogas utilizing anaerobic assimilation has been utilized in Himachal Pradesh however it isn't up 'til now an effective innovation because of different confinements. In the current examination attainability of a smaller structure of biogas plant is confirmed with the help of biogas plant introduced in our faculty grounds. it's discovered that biogas plant used for the examination is suitable for places with low world thickness. The polysaccharide content in pine needles is seen as around 55% creation it cheap biomass for vitality age. Pine needles used here as substrate were exactly crunch to very fine live (1-2mm) before being co-processed with waste material squander water. it's seen that biogas creation crested from1.4 l\day to1.9 l\day throughout winter month, wherever because it was7.3 l\day throughout long stretches of March and Gregorian calendar month. The decrease in unpredictable solids was to boot seen throughout the long periods of March and Gregorian calendar month that was close to 64% during April higher contrasted with its incentive in winters. The structure of biogas plant was discovered cheap to a big piece of Himachal Pradesh.

Ruchi Devi,(2016)- This paper depicts the after effects of a trial examination taken up to check the reasonableness and capability of the pine needles as substrate in biogas creation under group digester. There are different lignocelluloses biomasses for bio fuel creation yet the utilization of pine needles has not been acknowledged so a lot yet. In the current investigation two cluster digesters (each having two plastic made containers: one for aging and second as gas holder) was utilized. In the principal digester bovine waste named as DIGESTER1 and in the subsequent digester named as DIGESTER2 ground pine needles were co-processed with dairy animals compost was utilized as a substrate. The feed material was gathered from neighbourhood sources. In both the digesters; inoculum arranged from cow manure was utilized. Biogas creation utilizing bovine excrement and pine needles under cluster digester has been analyzed under comparative field conditions. In the two digesters faucet water was utilized to make slurry in a proportion of 1:15 by weight. The various parameters like Total strong, unstable strong are estimated and pH, biogas creation and temperature are estimated on regular routine. The encompassing temperature run during the testing time frame was between 15^0C-23^0C and slurry temperature inside the digester was in scope of 17^0C-26^0C. The absolute volume of biogas creation of the 70 days in DIGESTER1 and DIGESTER2 was 2.47 and 5.30 litres separately and subsequently saw that pine needles are better substrate in contrast with bovine manure.

Chua yang Liu,(2015)studied the co-processing of food squander with sewage slop at two distinctive complete strong fixation. The biogas creation in low-strong gathering of absolute strong 4.8% increments as the level of food squander in feedstock expanded from 0 to 100%, however in this there is no synergetic impact see between the two substrate. Additionally, the option of more food squander brings about amassing of unstable unsaturated fats by consequence of which biogas creation decline. While the blending proportion in with half or less food squander in high strong gathering with all out 14% is liked. It additionally helps in debilitate the basic condition with pH 7.5-8.5 keeping away from the exorbitant fermentation however high smelling salts fixation is a potential hazard. In any case, in high strong gathering great synergetic impacts was found between the two substrate in view of expansion of more food squander. Consequently, half of food squander is the most best proportion for the best synergetic impact.

Muhammad Rizwan Haider,(2015)studied the amount co-processing proportion of waste material and rice husk to defeat the aggregation of unstable unsaturated fats in absorption of food squander alone. during this examination four mixing proportions of waste material and rice husk with C/N proportion estimation of twenty, 25, thirty was taken. Anaerobic cluster autoclave was used during this examination at mesophilic temperature. The feedstock with C/N proportion of twenty offers the simplest come back of biogas of 584L/kg VS. the end result expand that because the food squander extent within the mix builds the biogas yield diminishes. Further, new cow compost was used as inoculants to come to a decision the foremost applicable proportion of feedstock and inoculum. within the resulting investigation, substrate with C/N proportion of twenty was exposed to anaerobic absorption for 5 distinct proportions of chosen feedstock and inoculants of 0.25, 0.5, 1.0, 1.5 and 2.0 separately. the best yield of biogas age of 557L/kg VS was given by the S/I proportion of zero.25. The amassing of unstable unsaturated fat was led to by higher S/I proportion in lightweight of the very fact that to higher natural stacking.

Bodius Salam, (2015) conducted study on biogas creation to assess the biogas age by dairy farm animals.manure.in.mesophilic.temperature.utilizing colloid asimpetus. Two Anaerobic clust er sterilizer used for analyze one with impetus and one while not impetus. The digesters are factory-made with glass funnel formed jar of 1liter. 390gm of dairy farm animals' compost was mixed with310gm of water to induce prepared suspension for sterilizer.The biogas made by sterilizer while not impetus was twenty seven.3 L/kg of bovine manure and sterilizer with.impetus.was three0.5L/kg.of dairy.farm animals waste .The upkeep timeframe for strive was seventy six days at encompassing temperature27-31°C.

Sanctum Brown, (2013) determined the most effective proportion of feedstock and emanating for waste product and yard squander mixing proportion for greatest biogas age. during this examination co-absorption of yard waste and food squander were done at feedstock and emanating for varied proportion of one, 2, and three singly. The extent of food squander on the bases of dry unpredictable sturdy is 0%, 10% and 20% consequently, methane series age dilated, the most effective gas age accomplished in mix in with 10% and 20% level of food squander. Co-absorption of waste product and yard squander at express proportion upgrade the sterilizer operating attributes.and raise the.biogas.creation.

Ruihong Zhang et al.,(2007) direct AN examination for the portrayal of food squander for the feedstock for the anaerobic sterilizer. during this trial, the variability completely different properties of food squander on day by day and week when week assessed. The anaerobic cluster sterilizer used at 50°C for process and biogas age. traditional of day by day moistness substance and proportion of unstable sturdy to feature up to strong determined over the long inspecting were 70% and 80%, and week when week traditional of moistness substance and proportion of unpredictable sturdy to feature up to strong were 74% and 87%. Food squander could be a tight in supplement for anaerobic microorganisms as assess by the supplement content examination. Methane series age when tenth and twenty eighth long stretch of process is around 348 and 435mL/g VS. 81%, of unstable sturdy was exhausted when assimilation for twenty eight days. during this approach, food squander is impressive substrate for anaerobic assimilation with high biodegradation.

Hamed El-Mashad et al., (2010) study to make your mind up the biogas creation of assorted mix of dairy farm fertilizer and food squander and moreover assess biogas creation alone by food squander. Likewise decide the excellence afoot by co-absorption and alone by waste product and dairy farm compost. Bunch sterilizer used for anaerobic process. The natural stacking pace of food squander and also the mix is two, three and 5gVS/L. the upkeep time for absorption is thirty days. the conventional level of gas created was 62% and 59% severally. The food squander co-processed with dairy farm waste product raise the methane series age. The active model grew likewise applied to make your mind up the biogas age for varied mix of waste product and dairy farm waste product. The mix with 60% of waste product and 40% of dairy farm waste product offers the best biogas creation.

DenBrown etal., (2013)determine the most effective proportion of feedstock and gushing for waste product and yard squander mixing proportion for many extreme biogas production. During this examination co-absorption of yard waste and food squander were done at feedstock for varied proportion of one, two, and three severally. The extent of food squander on the bases of dry unstable sturdy is 0%, 10% and 20%. Therefore, methane series age dilated. the most effective gas age accomplished in mix in with 10% and 20% level of food squander. Co-absorption of waste product and yard squander at express proportion improve the sterilizer operating attributes.and raise the.biogas.creation.

Xumeng Ge etal., (2014) conduct AN examination for biogas age from tropical biomass squander by anaerobic process. In tropical space anaerobic assimilation is a very valuable innovation for age of biogas from bountiful biomass in tropical locus which might in addition used afoot of heat, power. The reassurance of anaerobic absorption for tropical ranger service squanders. This examination, tropical biomass was assessing for biogas age by fluid anaerobic process or sturdy state anaerobic absorption, contingent the feedstock's attributes. Like once alibizia leaves and chips were used as substrate, fluid anaerobic process would be wise methane series creation (161 and 113 Lkg-1VS) than sturdy state anaerobic assimilation (156.8 and59.6 Lkg-1VS), whereas sturdy state anaerobic absorption accomplished five time higher estimation of methane series creation than fluid anaerobic assimilation. The Co-assimilation and mono process of taro skin, taro substance, papaya and yam accomplish biogas creation of 345 to 411 Lkg-1VS; uncover the durability of anaerobic absorption innovation.

2.3. Summary

Resulting to focusing stores of analysis papers on biogas creation from variety completely different substrate. Clearly huge proportion of composing is open on biogas creation from cow compost, food squander, farming waiting, and furthermore on co-osmosis with completely different substrate. Regardless, there's terribly assessment is finished on co-preparing of bovine waste with pine needles and pine needles. Therefore, the essential purpose of read of this assessment work was to get information regarding biogas creation and giving restoration wellspring of essentiality.

Chapter-III

Experimental setup and methodology

3.1 General

Here clarified regarding the trial configuration utilized, just the same as the portrayal of substrate utilized in AD process. The assurance of physical and chemical qualities of substrate for example food squander, pine needle and cow waste was finished. Consistent stream digesters utilized for performing biogas creation. Physical and chemical parameter of reactor slurry beginning and last was determined. Day by day perusing on pH, temperature and gas assortment noted. The point by point test plan and strategy clarified in this part.

3.2 Sample and material collection and preparation

The fundamental reason for this examination is the assurance the biogas capability of co-processing of 2 substrates to rise in the production of biogas. The choice matter utilized as substratum in the production of biogas is for the most part relying upon the accessibility and is of no utilization. Pine needle was assembled from woods fallen. The food waste is taken from the college mess Annapurna. Cow dung is gathered from the close by town. Inoculum is set up from the biogas plant introduced in college.

3.2.1 Source for inoculum

The gathering of inoculum was done from the functional digester placed near to the workers mess at Jaypee University of Information Technology. Biogas digester comprises of 2 tanks. One act as digester and other as gas gatherer. First mix the digester tank for homogenous example at that point gathers the example in shut compartment. At that point perform test on it investigate the attributes of inoculums. Expansions of inoculum to reactor slurry help up the turn of events or development of microorganism. It additionally helps in biogas creation.

Figure 3.1:- Inoculum source (Biogas plant at JUIT)

3.2.2 Pine needle

Pine needles co-processed with food waste. Pine needles gathered from encompassing of JUIT grounds. Pine needles assembled from the backwoods encompassing the JUIT and the debasements expelled. Pine trees are around 98-160ft tall and remain green through the year. Its bark is commonly red earthy colored. It has many medications esteem found in many south east Asian countries. Pine needles have extremely high lignin, cellulose and hemicelluloses content for example it requires some investment to debase. Pine needles are dried in sun and afterward changed over into powder form with the help of a grinder. Crushed/grinded pine needles are then used as substrate in the digester.

Figure 3.2:- Pine needles

3.2.3 Food waste

Food waste is gathered /assembled from JUIT mess. Food squander covers exceptionally huge fraction in our waste stream. The food waste essentially comprises of organic waste so it is effectively debase in anaerobic digester. In India huge segment of food throw away each day, discarded into landfills with no vitality recuperation and builds the heap on landfill destinations. The food waste for the most part made out of unconsumed food, extra food prepared from houses, and other sources like school's flask, eateries, lodging and modern sources like industrial facility mess. As fast increment in the expense related with the vitality gracefully and waste removal and expands open worry with ecological corruption, change of food waste to vitality is awesome and financially in creating nation like India. As the dampness content in food waste is high it is generally excellent substrate in anaerobic processing. The C/N ration is likewise awesome in food waste. That is awesome in addition to point for biogas generation. The methane production relies on the estimation of unstable strong in food waste.

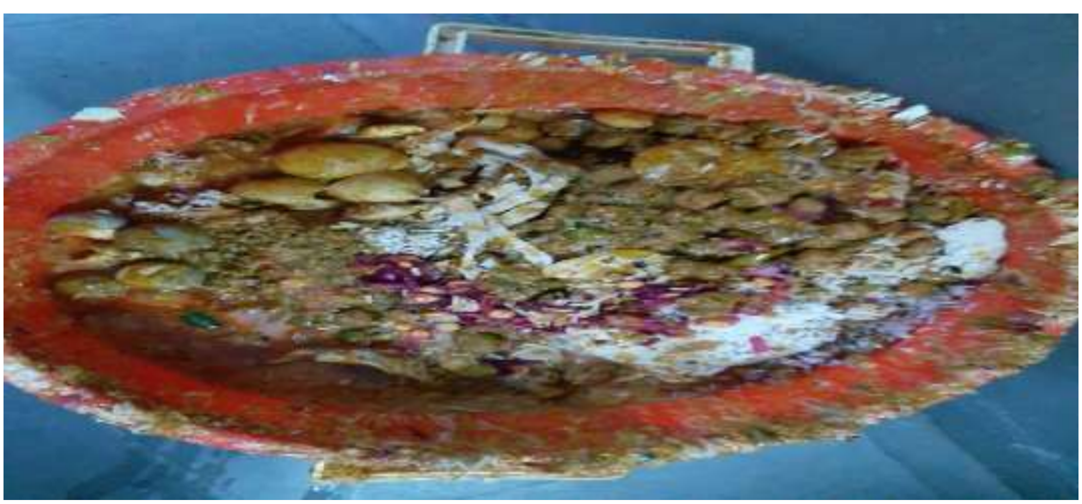

Figure 3.3:- Food waste from JUIT mess

3.2.4 Cow dung

Cow manure accumulated from the nearby village. Dairy animals' dung act as a marvelous substrate for biogas plant. This source is cheap and easily available. Dairy animals manure is commonly phenomenal source supportable force source as natural gas petroleum's costs increase rapidly in now a days. The earth in like manner get degraded by the pollution realized by dairy animals compost as it is organized straightforwardly like fragrance, air imagined smelling salts, green house gases. These green house gases are responsible for the increase in the temperature of the earth causing global warming and many other environmental problem. Dairy animals waste is well off in natural issue. Carbon/Nitrogen proportion is in like manner great in dairy animals compost. The anaerobic ingestion is generally proper for cow fertilizer evacuation. In India where critical section of people depends on cultivating and creature development, dairy animals manure is successfully open. As such, cow compost is a superb substrate for the gas creation. Co-processing of dung and other substrate raise the methane yield.

3.3 Experimental setup details

3.3.1 Design 1

Continuous flow reactors are utilized for anaerobic absorption for lab scale study. The digester was made from buckets. The investigation was made out from two digesters named as D1 placed at ambient temperature and D2 placed at controlled temperature and comprised of two plastic buckets, one go about as the digester and the different as gas assortment. Slurry in the digesters D1 and D2 was made out of dairy animal's fertilizer, pine needles and food squander in the proportion of 25:75 for example 25 % pine needles and 75% food squander. Digester D1 is presented to environmental temperature though digester D2 is kept in controlled temperature of 25 degree Celsius. Every after six days this slurry was tried for various physical and chemical parameters like temperature, pH., Alkalinity. Basin limit of the digesters was 38L and the gas-gathering container was 20l. Inner breadth of the digester basin was 0.46m and 0.35m for the gas gatherer. Exploratory time for the study of digester is 35 days and the Hydraulic Retention Time (HRT) of the digester were 6 days it implies new feed is included the digesters each following 7 days. The digester was put inside and outside the fluvial power through pressure research center at structural building office in JUIT, Waknaghat (H.P).

The structure for OLR(Organic Loading Rate)/Feed for the digester D1 and D2 is given beneath in the table 3.1.

Table 3.1:- Design for digester D1 and D2 at different OLR.

									Total solids	Total solids
	S.no.	OLR(VS/l/day)	Days	vol.(litre)	Feed (gm vs.)	PN 25%	PN(gm vs.)	FW 75%	FW(gm vs.)	PN (gm TS)
	1	0.05	6	38	11.4	0.25	2.85	0.75	8.55	4.0755
	2	0.1	6	38	22.8	0.25	5.7	0.75	17.1	8.151
	3	0.15	6	38	34.2	0.25	8.55	0.75	25.65	12.2265
	4	0.2	6	38	45.6	0.25	11.4	0.75	34.2	16.302
	5	0.25	6	38	57	0.25	14.25	0.75	42.75	20.3775
	6	0.3	6	38	68.4	0.25	17.1	0.75	51.3	24.453
	7	0.35	6	38	79.8	0.25	19.95	0.75	59.85	28.5285
	8	0.4	6	38	91.2	0.25	22.8	0.75	68.4	32.604
	9	0.45	6	38	102.6	0.25	25.65	0.75	76.95	36.6795
	10	0.5	6	38	114	0.25	28.5	0.75	85.5	40.755
	11	0.55	6	38	125.4	0.25	31.35	0.75	94.05	44.8305
	12	0.6	6	38	136.8	0.25	34.2	0.75	102.6	48.906
	13	0.65	6	38	148.2	0.25	37.05	0.75	111.15	52.9815
	14	0.7	6	38	159.6	0.25	39.9	0.75	119.7	57.057
	15	0.75	6	38	171	0.25	42.75	0.75	128.25	61.1325
	16	0.8	6	38	182.4	0.25	45.6	0.75	136.8	65.208
	17	0.85	6	38	193.8	0.25	48.45	0.75	145.35	69.2835
	18	0.9	6	38	205.2	0.25	51.3	0.75	153.9	73.359
	19	0.95	6	38	216.6	0.25	54.15	0.75	162.45	77.4345
	20	1	6	38	228	0.25	57	0.75	171	81.51

3.3.2 Design 2

Continuous flow reactors are utilized for anaerobic absorption for lab scale study. The digester was made from buckets. The investigation was made out from two digesters named as D3 and D4 and comprised of two plastic buckets, one go about as the digester and the different as gas assortment. Slurry in the digesters D3 kept at ambient temperature and D4 kept at controlled environment were made out of dairy animals fertilizer, pine needles and food squander in the proportion of 75(PN):25(FW) by mass for example 75 % pine needles and 25% food squander by mass. Digester D3 is presented to environmental temperature though digester D4 is kept in controlled temperature of 25^0C. Every after six days this slurry was tried for various physical and chemical parameter like temperature, pH., Alkalinity. Basin limit of the digesters was 38L and the gas-gathering container was 20l. Inner breadth of the digester basin was 0.46m and 0.35m for the gas gatherer. Exploratory time for the study of digester is 35 days and the Hydraulic Retention Time (HRT) of the digester was 6 days it implies new feed is included the digesters each following 7 days. The digester was put inside and outside the fluvial power through pressure research center at structural building office in JUIT, Waknaghat (H.P).

The design for OLR(Organic Loading Rate) / Feed for the digester D3 and D4 is given below in the table 3.2.

Table 3.2:- Design for digesters D3 placed ambient temperature and D4 placed at incubated temperature

S.no.	OLR(VS/l/day)	Days	vol. (litre)	Feed(gm vs.)	PN 75%	PN(gm vs.)	FW 25%	FW(gm vs.)	Total solid PN (gm TS)	Total solid PN (gm TS)
1	0.05	6	38	11.4	0.75	8.55	0.25	2.85	12.2265	19.0095
2	0.1	6	38	22.8	0.75	17.1	0.25	5.7	24.453	38.019
3	0.15	6	38	34.2	0.75	25.65	0.25	8.55	36.6795	57.0285
4	0.2	6	38	45.6	0.75	34.2	0.25	11.4	48.906	76.038
5	0.25	6	38	57	0.75	42.75	0.25	14.25	61.1325	95.0475
6	0.3	6	38	68.4	0.75	51.3	0.25	17.1	73.359	114.057
7	0.35	6	38	79.8	0.75	59.85	0.25	19.95	85.5855	133.0665
8	0.4	6	38	91.2	0.75	68.4	0.25	22.8	97.812	152.076
9	0.45	6	38	102.6	0.75	76.95	0.25	25.65	110.0385	171.0855
10	0.5	6	38	114	0.75	85.5	0.25	28.5	122.265	190.095
11	0.55	6	38	125.4	0.75	94.05	0.25	31.35	134.4915	209.1045
12	0.6	6	38	136.8	0.75	102.6	0.25	34.2	146.718	228.114
13	0.65	6	38	148.2	0.75	111.15	0.25	37.05	158.9445	247.1235
14	0.7	6	38	159.6	0.75	119.7	0.25	39.9	171.171	266.133
15	0.75	6	38	171	0.75	128.25	0.25	42.75	183.3975	285.1425
16	0.8	6	38	182.4	0.75	136.8	0.25	45.6	195.624	304.152
17	0.85	6	38	193.8	0.75	145.35	0.25	48.45	207.8505	323.1615
18	0.9	6	38	205.2	0.75	153.9	0.25	51.3	220.077	342.171
19	0.95	6	38	216.6	0.75	162.45	0.25	54.15	232.3035	361.1805
20	1	6	38	228	0.75	171	0.25	57	244.53	380.19

3.3.3 Design 3

Continuous flow reactors are utilized for anaerobic absorption for lab scale study. The digester was made from buckets. The investigation was made out from two digesters named as D5 and D6 and comprised of two plastic buckets, one go about as the digester and the different as gas assortment. Slurry in the digesters D5 places at ambient temperature and D6 placed at incubated temperature were made out of dairy animals fertilizer, pine needles and food squander in the proportion of 50(PN):50(FW) by mass for example 50 % pine needles and 50% food squander. Digester D5 is presented to environmental temperature though digester D6 is kept in controlled temperature of 25^{0}C. Every after six days this slurry was tried for various physical and chemical parameters like temperature, pH., Alkalinity. Basin limit of the digesters was 38L and the gas-gathering container was 20l. Inner breadth of the digester basin was 0.46m and 0.35m for the gas gatherer. Exploratory time for the study of digester is 35 days and the Hydraulic Retention Time (HRT) of the digester was 6 days it implies new feed is included the digesters each following 7 days. The digester was put inside and outside the fluvial power through pressure research center at structural building office in JUIT, Waknaghat (H.P).

The design for Organic Loading Rate (OLR) / Feed for the digester D5 and D6 is given below in the table 3.3.

Table 3.3:- Design for digesters D5 and D6

									Total solid	Total solid
S.no.	OLR(VS/L/d)	Days	vol. (litre)	Feed(gm vs.)	PN 75%	PN(gm vs.)	FW 25%	FW(gm vs.)	PN (gm TS)	PN (gm TS)
1	0.05	6	38	11.4	0.75	8.55	0.25	2.85	12.2265	19.0095
2	0.1	6	38	22.8	0.75	17.1	0.25	5.7	24.453	38.019
3	0.15	6	38	34.2	0.75	25.65	0.25	8.55	36.6795	57.0285
4	0.2	6	38	45.6	0.75	34.2	0.25	11.4	48.906	76.038
5	0.25	6	38	57	0.75	42.75	0.25	14.25	61.1325	95.0475
6	0.3	6	38	68.4	0.75	51.3	0.25	17.1	73.359	114.057
7	0.35	6	38	79.8	0.75	59.85	0.25	19.95	85.5855	133.0665
8	0.4	6	38	91.2	0.75	68.4	0.25	22.8	97.812	152.076
9	0.45	6	38	102.6	0.75	76.95	0.25	25.65	110.0385	171.0855
10	0.5	6	38	114	0.75	85.5	0.25	28.5	122.265	190.095
11	0.55	6	38	125.4	0.75	94.05	0.25	31.35	134.4915	209.1045

12	0.6	6	38	136.8	0.75	102.6	0.25	34.2	146.718	228.114
13	0.65	6	38	148.2	0.75	111.15	0.25	37.05	158.9445	247.1235
14	0.7	6	38	159.6	0.75	119.7	0.25	39.9	171.171	266.133
15	0.75	6	38	171	0.75	128.25	0.25	42.75	183.3975	285.1425
16	0.8	6	38	182.4	0.75	136.8	0.25	45.6	195.624	304.152
17	0.85	6	38	193.8	0.75	145.35	0.25	48.45	207.8505	323.1615
18	0.9	6	38	205.2	0.75	153.9	0.25	51.3	220.077	342.171
19	0.95	6	38	216.6	0.75	162.45	0.25	54.15	232.3035	361.1805
20	1	6	38	228	0.75	171	0.25	57	244.53	380.19

Given below are the images of all the digesters i.e. D1,D2,D3,D4,D5and D6 placed at controlled temperature and at environmental/atmospheric conditions.

Figure 3.4:- Digesters D1, D3 and D5 placed outside at atmospheric conditions.

Figure 3.5: –Digesters D2,D4 and D6 placed at controlled temperature of 25 ^{0}C

3.4. Testing methods:-

3.4.1Temperature

The estimation of temperature is be finished with the assistance of an advanced thermometer.

Figure 3.6:- Thermometer

3.4.2 pH

pH is measured with the help of pH meter and pH strip.

Figure 3.7:- pH meter

3.4.3 Determination of Alkalinity

1. Take one funnel shape flagon and fill it with 25/50ml of sample

2. After this add 2 to 3 drops of phenolphthalein, if colour of the sample changes to pink by expansion titrate it with 0.02 N of Sulphuric acid (H2So4) solution .

3. If colour of test doesn't change at that point include two drops of methylorgane indictor. At that point titrate it with 0.02 N Sulphuric solution..

4. Titrate the solution unto that point when the colour changes from yellow to orange.

5. Note down the readings.

Alkalinity = Normality of Sulfuric acidx1000x500 x corrosive utilized/Volume of test taken

3.4.4 Biogas analyzer

Biogas Analyzer was utilized for ascertaining constant biogas creation. Biogas sensor/Analyzer was bought from HIMCOSTE venture reserves. Unlike Gas chromatography, biogas analyzer is portable with automatic calibration system, which provides accurate results over time. Gas sensor information for MSW uncovered Average methane content, Average Carbon Dioxide content, Average Oxygen substance and Hydrogen Sulfide content

Variety in graph is because of various kind of food squander took care of in digester. High measure of Methane is created with higher protein and lipid squander. Starch was for the most part prompts higher Carbon Dioxide content in biogas.

Food squander took care of fundamentally shape the microbial decent variety of the digester. Food squanders produced from mess have high measure of starch followed by proteins and lipid squander. With expansion of flavors fundamentally influences the pH of digester.

Figure 3.8:- Biogas analyzer

3.4.5 Determination of Biological oxygen demand

1. Completely fill two BOD bottles with weakening water.
2. Into extra BOD bottles, somewhat loaded up with weakening water, cautiously blend the best possible volume of test.
3. Add weakening water until the containers are totally filled.
4. Stopper each container taking consideration to abstain from catching air bubbles inside the containers as the jug plugs are embedded.
5. Fill the highest point of each container neck around the plug with weakening water.
6. Determine the underlying DO substance of each arrangement of copy bottles, including the weakening water clear
7. Place the rest of the containers in the hatchery at 20°C and brood for five days.

8. At the finish of five days test the DO content for the brooded bottles.

9. Calculate the BOD of every weakening.

10.CALCULATIONS

$$\text{Body, mg/L} = \frac{\text{(Initial DO - Final DO) x bottle volume}}{\text{Test volume}}$$

11. Major interferences of BOD test are substances that hinder the development of the microorganisms' viz. chlorine, mineral acids, and overwhelming metals

12. Excessive nitrites can meddle with the BOD assurance.

13. Growth of green growth within the sight of light can build the DO

14. Artifacts in BOD testing results from deposits developing in the BOD and weakening water bottles.

Varieties in BOD test is dependent upon various elements temperature, climate and so forth results can shift generally from everyday, or even hour to hour.

3.4.6 Flame test

Flame test is the simplest way to identify the quality and quantity of biogas in the digester. This test was performed at the end of retention time to check the presence/quality of methane gas in the digester. Colour of flame indicates the presence of methane in the digester. Blue colour flame means the methane is present in the digester in good quantity and orange colour flame means the concentration of methane is slightly less in the biogas.

Figure 3.9:- Blue colour flame

Chapter- IV
Result and Discussion

4.1 General

In this chapter the outcomes of investigation was made by Assessments of different physical and chemical parameters of substrates are accessed.

4.2 Characterization of substrate

Characterization of substrate was already done in previous research on anaerobic digestion process.

For characterization, we have studied and compared various research papers on an anaerobic digestion in which pine needles or food waste or both are used as substrate. On comparing the results of characterization of substrates, we found that the readings are almost similar on every research papers we have studied and compared so far.

Given below in the table are the results of characterization of substrate from one of those research papers.

Table 4.1:- Characterization of substrate taken from previous research paper on anaerobic digestion.

S.no	Parameters	(FW)Food residue	PN(pine needles)
1.	TS %	28.3	81
2.	VS%	13.3	69
3.	pH	6.6	6.4
4.	VS/TS %	47.9	85.4
5.	TOC %	46	49.1
6.	Carbon/nitrogen ratio	41	48

4.3 Variation of temperature

Temperature plays an important role in biogas creation since the metabolic activities of microscopic organisms relies on this parameter. Best outcome of gas creation is between mesophilic temperature ranges. With increase in temperature the gas creation likewise increments. A portion of the procedures in biogas creation are a lot of touchy to temperature so consistent temperature required like Methanogenesis. Temperature for most days of digester inside is steady conditions for example 25*C and for out the temperature changes from 8°C to 20°C in winter. A temperature variation is given below in the tables.

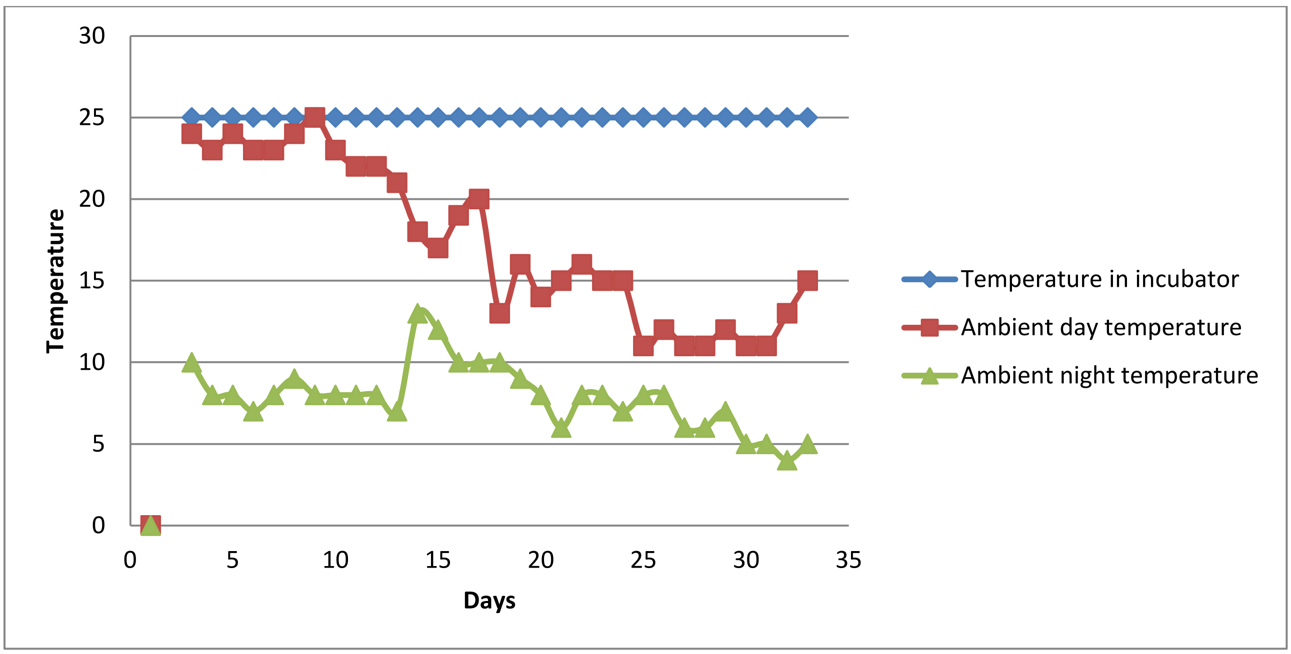

Figure 4.1:- Variation of Temperature around corresponding digesters in the month of December, 2019

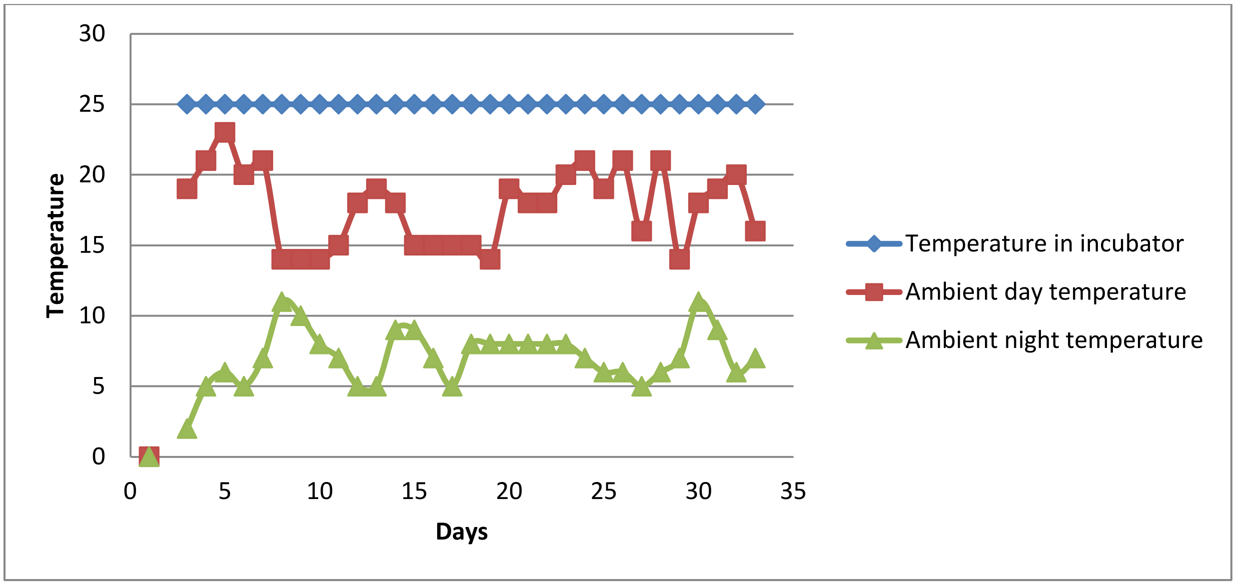

Figure 4.2:- Variation of Temperature around corresponding digesters in the month of January, 2020

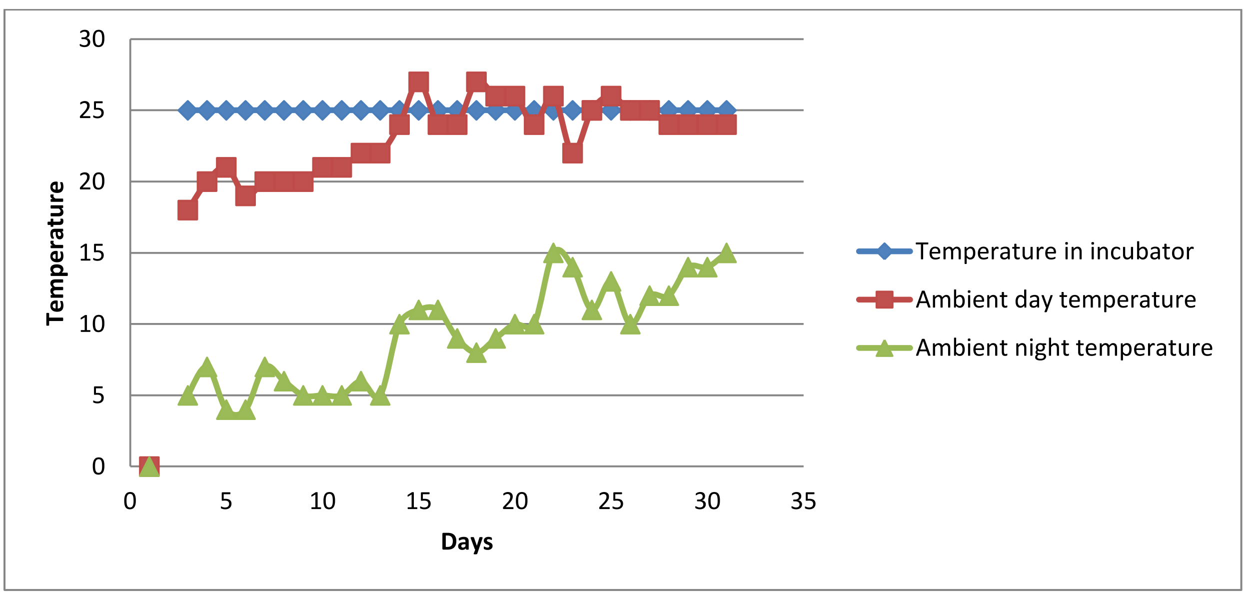

Figure 4.3:- Variation of Temperature around corresponding digesters in the month of February, 2020

4.4 Variation of pH

pH is a significant parameter which influence the biogas creation. The ideal pH range foe the digester should lies between 6.8-7.2.If the pH is more are less all the micro-organisms in the digester dies which ultimately affect the yield of biogas The pH acquired from slurry of digesters D1, D2,D3,D4,D5,D6 placed at incubated temperature lies between 5-6 and the pH of inoculums lies between 8 to 8.5.

The variation in pH of different digesters are given below

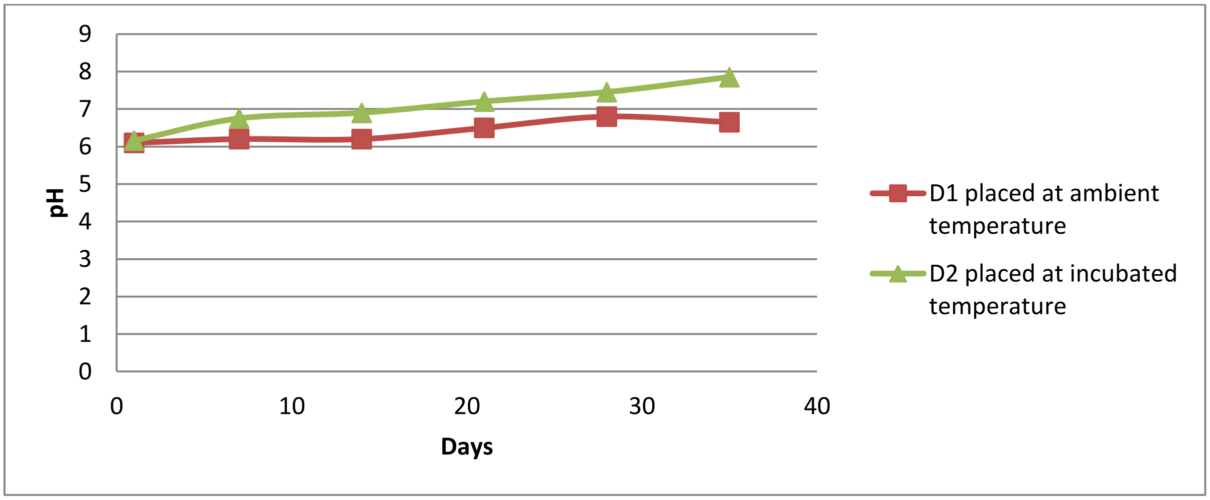

Figure 4.4:- Variation of pH in Digesters D1 and D2 in the month of January and February, 2020

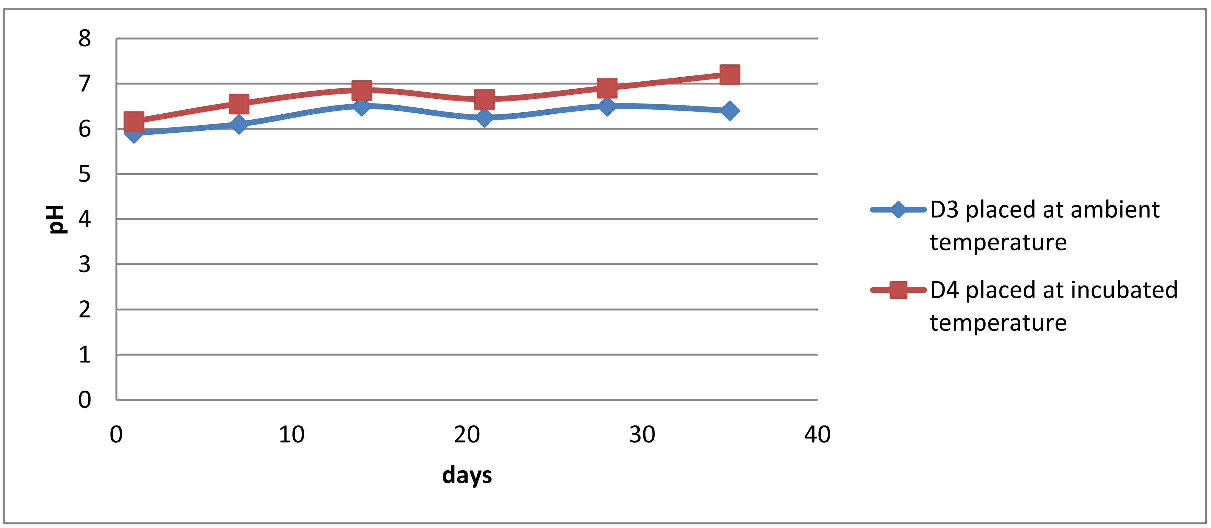

Figure 4.5:- Variation of pH in Digesters D3 and D4 in the month of January and February, 2020

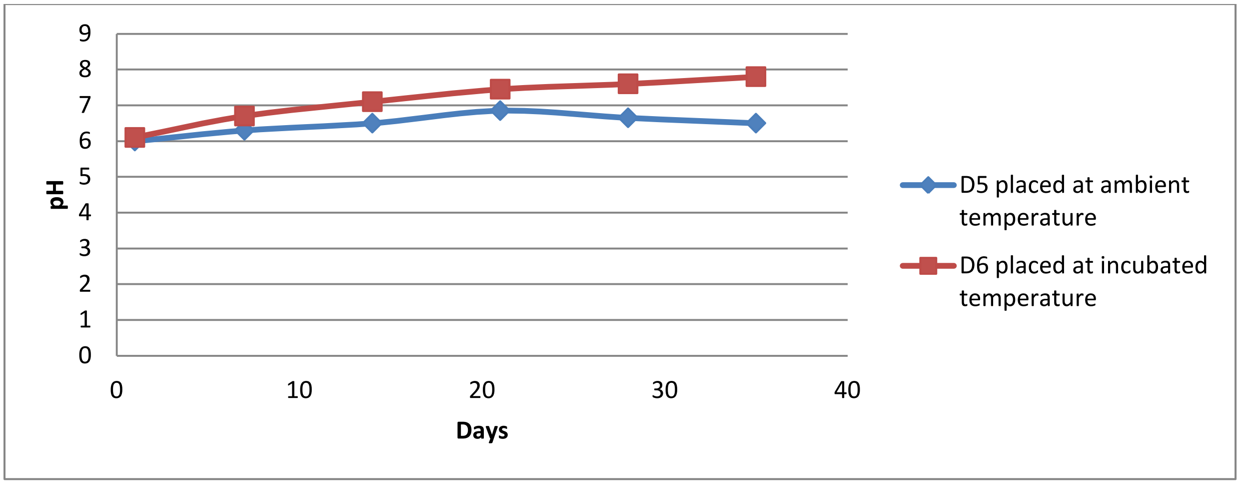

Figure 4.6:- Variation of pH in Digesters D5 and D6 in the month of January and February, 2020

We can see from above figures that the pH of digesters which are kept at fixed incubated temperature i.e. (D2,D4 and D6) are slightly higher than the pH of digester which are placed outside . This is due to the temperature at low temperature the metabolic activities of micro organisms slow down resulting in the lowering of pH and bio gas production.

4.5. Alkalinity variation

The alkalinity of the substrate is because of essence of calcium, magnesium and ammonium bicarbonate. The alkalinity helps in keeping up or maintaining of buffering limit of digester. Alkalinity framed by breaking down of substrate by smaller scale living being. The alkalinity focus relies on the centralization of strong feed to a decent degree. The perfect alkalinity run in the anaerobic digester is in between 1500-5000 mg/l for keeping up enough measure of consuming limit of slurry. With increase in digestion process Alkalinity of the digester increases, additionally .It also increases with increment in organic loading rate. The alkalinity of the slurry for digesters D1,D3 and D5 placed at ambient temperature and D2,D4 and D6 placed at controlled temperature at various OLR is given beneath in the table.

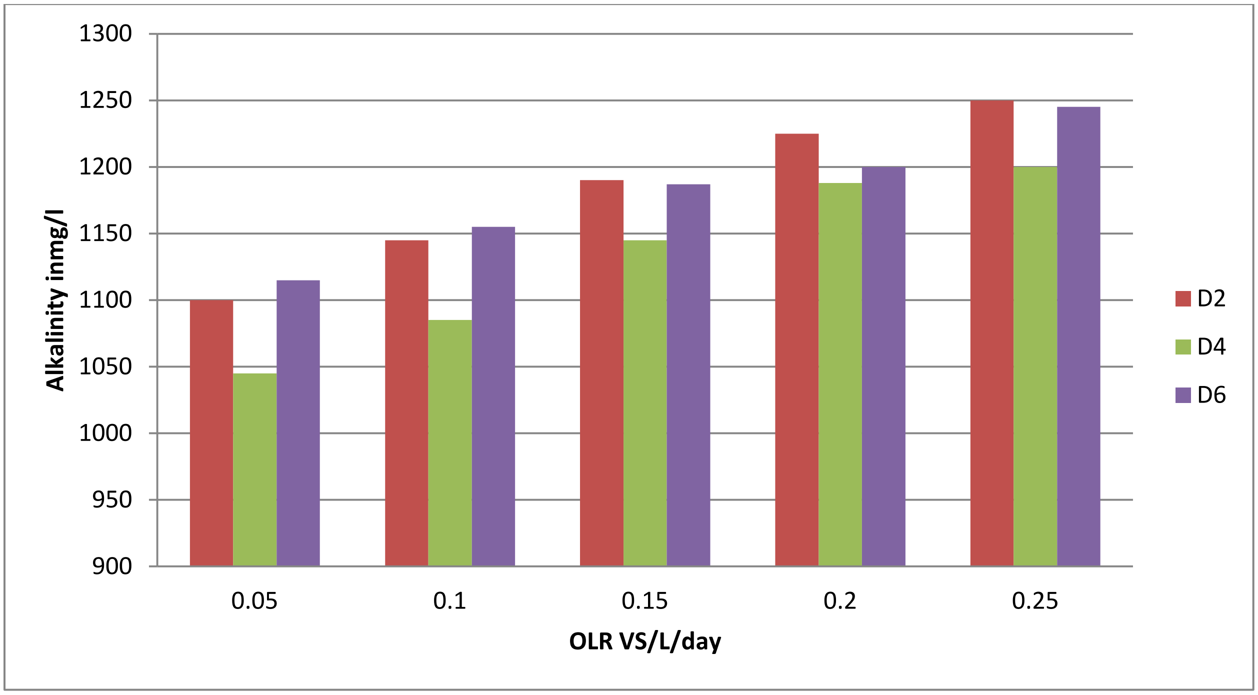

Figure 4.7:- Alkalinity variation in Digesters D2, D4, and D6 placed at incubated temperature at different OLR

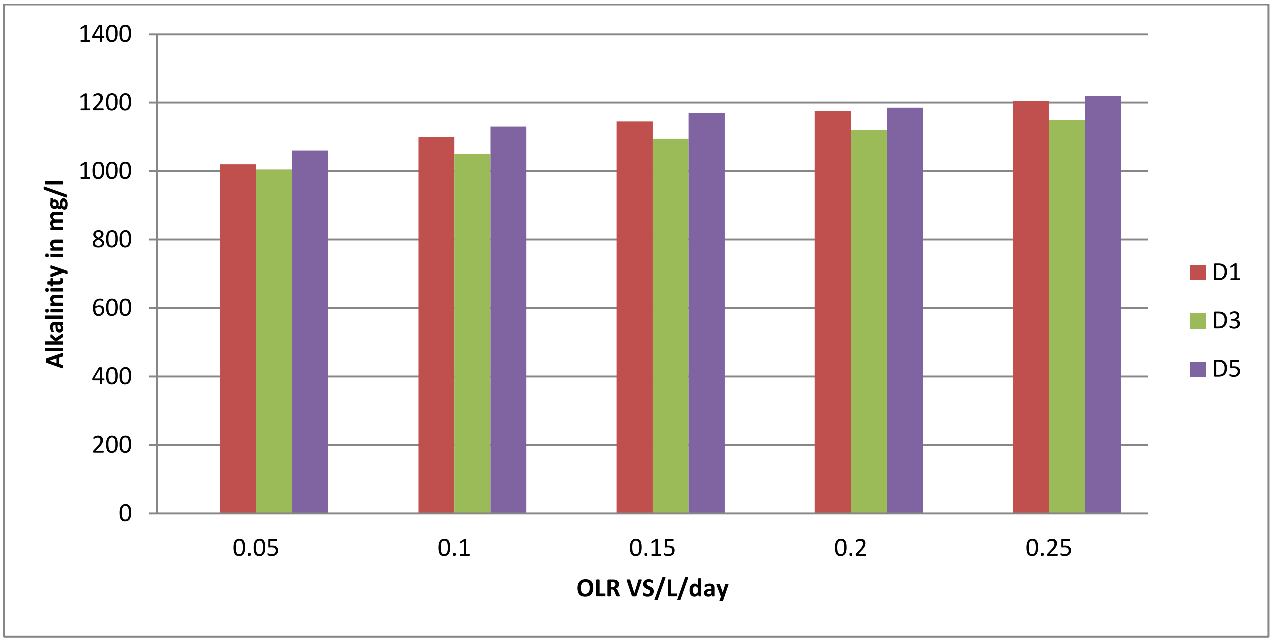

Figure 4.8.Alkalinity variation in Digesters D1, D3 and D5 placed at ambient temperature at different OLR

From table we can observe that the alkalinities of the digesters which are kept at ambient temperature i.e. (D1, D3, D5) are lower than the alkalinity of the digester which are kept at controlled temperature. We can also see that with increase in OLR the alkalinity is also increasing. Alkalinity of digesters of ratios75(PN):25(FW) by mass i.e. D2 and D3 are lesser then other digesters this is due to the presence of more dry mass then wet mass in the digesters.

4.5 Biogas production

Methane and Carbon dioxide production at different OLR(organic loading rate) is given below in the table. The gas generation in all the digesters was checked after 6 days time interval. The gas production at 0.05OLR is very less and was checked by doing flame test. That is why the readings of 0.05 OLR is not in the table. Biogas generation in all the digesters started immediately once the feed is added. The results show us the increase in quantity and quality of biogas production with increase in time and organic loading rate. The biogas production of D2,D4 and D6 digesters which are kept at controlled temperature of 25 degree C is higher than the digesters which are kept at ambient temperature i.e. D1, D3 and D5. Both digesters of ratio 25(PN):75(FW) by mass i.e. D1placed at ambient temperature and D2 placed at incubated temperature has given best results and digesters ratio 75(PN):25(FW) by mass i.e.D3 places at ambient temperature and D4 placed at incubated temperature has given poor results. Overall digester D2 which is placed at incubated temperature has given maximum result.

The variation in methane production at different OLR(organic loading rate) for digesters D1,D3 and D5 placed at ambient temperature and for digesters D2,D4 and D6 placed at incubated temperature in the month of January and February at different organic loading rate is shown below in figure 4.9

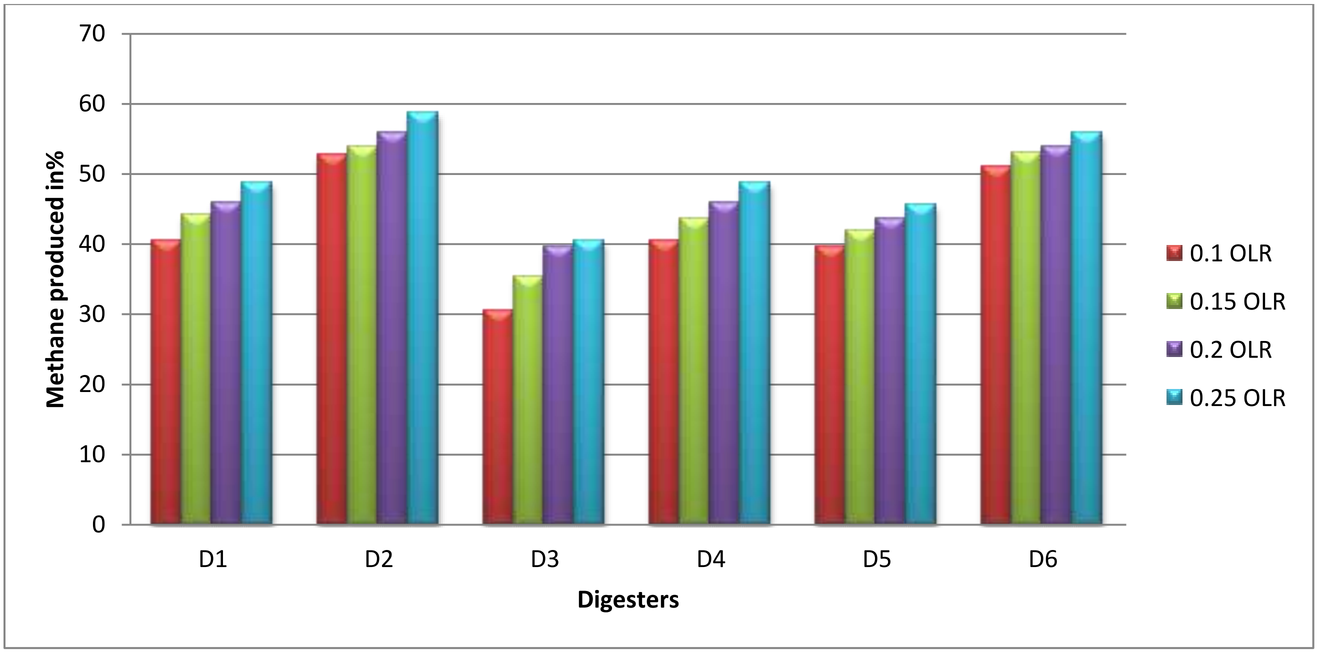

Figure 4.9:- Methane produced at different OLR

Chapter-V
Conclusions

5.1 General

Assessment of results done from test studies states that the digestion of pine needle, cattle waste and food staying/extra is an awesome wellspring of sustainable power source. In addition, it additionally helps in shielding condition from unsafe gases created/delivered during processing of these biomasses in open. Co-processing of substrates likewise improves the biogas production.

The substrate utilized in this examination was gathered from JUIT campus and woods next to the campus. A lot of food is dumped at dumping location without any utilization and some is used in working digester close to laborer mess. Moreover, with the disintegration of this loss in open produce unsafe gases prompting gathering of contaminants in the earth. Then again, pine needles have no utilization, in addition Pine Needles are likewise liable for promoting backwoods fire which prompts ascend in contamination and liable for destruction/obliteration of untamed life. Subsequently, this examination gives us elective choice for the utilization of pine needles and food waste to change over them into helpful and sustainable power source as biogas yield. Moreover, this investigation additionally helps in deciding the most great proportion substrate in anaerobic digestion process and helps us in identifying the best organic loading rate(OLR) among (0.05,0.1,0.15,0.2 and0.25) and best ratios for biogas production. For this study six continuous flow digesters were set up three at controlled temperature of 25^{O}C and three are exposed to atmospheric conditions. The digesters placed at fix temperature are named asD2,D4andD6 of ratios25(PN):75(FW),75(PN):25(FW)and 50(PN):50(FW) by mass and the digesters placed at atmospheric conditions are named as D1,D3 and D5 of ratios25(PN):75(FW) , 75(PN):25(FW) ,50(PN):50(FW) by mass . HRT (Hydraulic Retention Time) for the digesters was of 7 days . On every 7th day feed was changed and the different parameters like pH , Temperature , BOD and biogas yield was measured and compared with each other.

5.2 Conclusion on biogas generation

(1). Once we start adding feed to digesters the pH of the digesters kept inside controlled temperature i.e. D2,D4 and D6 keeps on increasing with increase in OLR whereas the pH of digesters D1,D3 and D5 which are exposed to atmospheric condition keeps on fluctuate and remain to slightly acidic side .

This is due to the temperature outside is very low and keeps on fluctuating which affect /slows down the metabolism of the micro-organisms resulting in the slow or low gas production and decrease in pH.

(2). The alkalinities of the digesters, which are kept at ambient temperature i.e. (D1, D3, and D5), are lower than the alkalinity of the digester, which are kept at controlled temperature. We can also see that with increase in OLR(organic loading rate) the alkalinity is also increasing. Alkalinity of digesters D2 and D3 of ratios 25(FW):75(PN) by mass is lesser then other digesters this is due to the presence of more dry mass then wet mass in the digesters and also due to low temperature whereas the alkalinity of digesters D1 and D2 of ratio 75(FW);25(PN) by mass is more. Overall digesters that are kept incubated temperature has more alkalinity then their respective counterpart.

(3). Results show us the increase in quantity and quality of biogas production with increase in time and OLR. The biogas production of D2,D4 and D6 digesters which are kept at controlled temperature of 25 ^{0}C is higher than the digesters which are kept at ambient temperature i.e. D1, D3 and D5 this is due to the temperature which affects the metabolic rate of micro-organism ultimately affecting the biogas production . Both digesters of ratio 25(PN):75(FW) by mass i.e. D1 and D2 has given best results and digesters of ratio 75(PN):25(FW) by mass i.e.D3 and D4 has given poor results.

(4). Overall digester D2 of ratio 25(PN):75(FW) by mass placed at incubated temperature of 25^{0}C has given maximum result.

(5). With increase in OLR(organic loading rate) the rate of biogas production has also increases.

References

1. Department of Environment, Science & Technology Government of Himachal Pradesh 2003,The State of Environment Report (SoER).

2. http://www.hindustantimes.com/delhi/delhi-chokes-on-smoke-from-neighbouring-states/story- zAkXkflle5MoUXLNYfZa0H.html (Accessed on 22 March 2020)

3. Yong, Z., Dong, Y., Zhang, X., & Tan, T. 2015. Anaerobic co-digestion of food waste and straw for biogas production. Renewable Energy, 78, 527-530.

4. Karve .A.D. (2007), Compact biogas plant, a low cost digester for biogas from waste starch.

5. Drapcho, C.M., Nhuan, N.P. and Walker, T.H., 2008.Biofuels engineering process technology pp. 334-335. New York, NY, USA:: McGraw-Hill.

6. Fig cite Pomykała, R. and Łyko, P., 2013. Biogaz z odpadów (bio) paliwemdlatransportu–barieryiperspektywy. Chemik, 67(5), pp.454-461.

7. Monnet, F., 2003. An introduction to anaerobic digestion of organic wastes. Remade Scotland, pp.1-48.

8. Bennett, G.F., 2004. The Microbiology of Anaerobic Digesters: Michael H. Gerardi, Wiley, Somerset, NJ, 2003, 186 pp., US $49.95 (Paperback), ISBN 0-471-20693-8.

9. Ostrem, K. and Themelis, N.J., 2004. Greening waste: Anaerobic digestion for treating the organic fraction of municipal solid wastes.Earth Engineering Center Columbia University, pp.6-9.

10. Poul Thomas, Nirmala Soren, Nelson, Pyanadathu Rumjit, jake George James, M.P. 2017 Saravanakumar, Biomass resource and potential of anaerobic digestion in Indian Scenaria, *Renewable and sustainable energy reviews,*

11. Sihuang Xie, Faisel.I. Hai, xinmin Zhan, Wenshan Guo, Hao H Ngo, William E Price, Long D.Nghiem, (2017) Anaerobic co-digestion: A critical review of mathematical modeling for performance optimization, *Bioresource technology,*

12. Balasubramaniyam, U., Zisengwe, L.S., Meriggi, N. and Buysman, E., 2008. Biogas production in climates with long cold winters. Documentation Prepared by Wageningen University, the Netherlands for Women in Europe for a Common Future, WECF The Netherlands, pp.1-68.

13. Tripathi, A. K., Kumari, M., Kumar, A., & Kumar, S. 2015. Generation of biogas using pine needles as substrate in domestic biogas plant. International Journal of Renewable Energy Research, 5(3), 716-721.

14. Alvarez, R. and Lidén, G., 2008. Semi-continuous co-digestion of solid slaughterhouse waste, manure, and fruit and vegetable waste. Renewable Energy, 33(4), pp.726-734.

15. Mata-Alvarez, J., Llabres, P., Cecchi, F. and Pavan, P., 1992. Anaerobic digestion of the Barcelona central food market organic wastes: experimental study.Bioresource Technology, 39(1), pp.39-48.

16. Nguyen, P.H.L., Kuruparan, P. and Visvanathan, C., 2007. Anaerobic digestion of municipal solid waste as a treatment prior to landfill. Bio resource Technology, 98(2), pp.380-387.

17. De Laclos, H.F., Desbois, S. and Saint-Joly, C., 1997. Anaerobic digestion of municipal solid organic waste: Valorga full-scale plant in Tilburg, the Netherlands. Water science and technology, 36(6-7), pp.457-462.

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