Treatability studies of MSW landfill leachate using anaerobic batch reactor

A

THESIS

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

of

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IN

CIVIL ENGINEERING

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Under the supervision

of

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May, 2019

STUDENT'S DECLARATION

I hereby declare that the work presented in the Project report entitled **"Treatability studies of MSW landfill leachate using anaerobic batch reactor"** submitted for partial fulfilment of the requirements for the degree of Master 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 **Anirban Dhulia**. 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.

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30/03/2019

CERTIFICATE

This is to certify that the work which is being presented in the project report titled **"Treatability studies of MSW landfill leachate using anaerobic batch reactor"** in partial fulfillment of the requirements for the award of the degree of Master 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 **DIVYA SHARMA (172753)** during a period from August, 2018 to May 2019 under the supervision of **Anirban Dhulia,** Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat.

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

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LIST OF ABBREVIATIONS

BMP	Biochemical Methane Potential
MSW	Municipal Solid Waste
RO	Reverse Osmosis
COD	Chemical Oxygen Demand
VS	Volatile Solids
DS	Dissolved Solids
AMPTS	Automatic Methane Potential Test System
STP	Sewage Treatment Plant
SMA	Specific Methanogenic Activity
VSS	Volatile Suspended Solids
F/M	Food / Mass

ABSTRACT

Leachate has been generated from organic wastes. Biochemical Methane Potential (BMP) test has been used to determine the production of biogas from different Food/Mass (F/M) ratio. Process has been conduct under anaerobic condition, bottles with different F/M ratio was prepared to check the generation of biogas at different temperature, Anaerobic condition was established by applying aluminium cap at top of the bottle and needles were injected to fill the bottles with nitrogen gas. Study was made to check performance of leachate to generate biogas. Test on pH, Alkalinity, COD, VSS, BOD was conducted to analysis characteristics of leachate. The removal efficiencies for Biochemical Methane Potential of leachate were used determined for different substrate. BMP test was performed for batch process by using serum bottles. BMP test was influenced by F/M ratio. Decrease in the production of gas was observed from 1.0 to 0.75 for both temperature conditions. Methane gas was observed to be more for substrate in room temperature than at 19 ℃. F/M ratio 0.75 was found to be more than other ratios due to more content of sludge. Results estimated for the test conduct for different ratios were estimated to be optimum for ratio 0.75 and for ratios 2:1, 1:1 and 0.5:1 results were observed satisfactory and minimum gas production was observed for no-food. Test was performed for two different sets and optimum results were observed for Set-II. Biogas production was comparatively less for Set-I that was performed in winters at 19℃ as compared to production for Set-II that was performed in summers at room temperature.

CHAPTER: 1

INTRODUCTION

1.1 GENERAL INTRODUCTION OF THE TOPIC

Stabilization of biological wastes has been by anaerobic treatment. This treatment has been used, as it has its own significant in form of methane gas. Organic waste can be converted into biogas though the anaerobic treatment, increasing demand for fossil fuels has increased the interest for production of biogas through anaerobic process. There are many process for the production of biogas, but some of those our harmful for the bacteria producing methanogenic process in the production batch and continuous been used for determination of biodegradability.

Continuous process has been used widely for the anaerobic treatment, disadvantages of continuous process can be seen in terms of cost and to provide facilities variables has been provided by the batch process. So batch process does not have such limitation. These variables can be put into different groups with the batch process. Batch process has been used widely for the anaerobic treatment.

There are many difficulties that is been faced during treatment of biodegradibity of waste by anaerobic process. It depends on the substrate that has been treated due to lake of understanding about the preventing action. Chemical procedure has not been used for determination of biodegradable and non-biodegradable organic present in the waste. For determination of non-biodegradable and biodegradable organics present in the waste this technique has been widely used as so for. Methane production from organic waste has been estimates from the BMP test.

Biochemical Methane Potential time for the batch process has been taken as 24 hrs and it has been seen that there has been maximum production of methane. During 24 hrs incubation BMP test has been process that on aerobic treatment is useful through BMP test. The treatment for MSW is although just satisfactory but has been useful from the aspects of methane generation.

Anaerobic Decomposition

This anaerobic degradation follows four steps

1) **Hydrolytic**: in the first steps there is breakdown of organic polymers and it is done by the bacteria. The end product of hydrolytic process is again polymers. Bacteria present in the process break down the chain of carbohydrates and proteins further breakdown into peptides and amino acids.
2) **Acidogenesis:** In this further process the end hydrolytic is being connected into alcohols. And it all depends on the products of hydrolytic step in the formation of biogas.
3) **Acetogenesis**: In this stage by products of acidogenesis are degraded by bacteria to form acetic acid, carbon dioxide and hydrogen.
4) **Methanogenic:** Bacteria further decompose to give final product in form of methane generation.

Objectives

- Characterization of municipal solid waste (MSW) leachate from a landfill site located in District Kullu, Himachal Pradesh.
- To evaluate the anaerobic biodegradability of MSW leachate.
- To devise supplementary treatment methods conforming to permit standards for suitable disposal of leachate.

CHAPTER: 2

LITRATURE REVIEW

REVIEW ON EFFICIENCY OF ANAEROBIC DIGESTION

Anaerobic digestion is process that generates biogas by organic wastes. Wet and dry wastes generally produces biogas with efficiency for particular plant, that system is known as BMP (biochemical methane potential) biogas produced by the process is expressed by Nm^3 /kg methane is expressed per kg of volatile solids. Results are obtained from the physical chemical characterization of BMP test. According to paper results has been obtained for ago food industry. As MSW consist of organic matter so there is absence of unwanted fractions BMP test for the organic waste has become promising way of solving the treatment problem of MSW it was become alternative to energy saving and reuse of organic wastes.

STUDIES ON COMPARISION OF BATCH AND CONTINEOUS PROCESS

During digestion process percentage of degradation can be estimated by anaerobic treatments. Speed with which first step of methane generation takes place can be estimated by anaerobic treatment. To establish the model batch test has been conducted in triplets. First order process and BMP test both has been conducted by batch process. In this paper issue related to the test has been addressed for batch process. Continuous process has been compared to batch process for the anaerobic digestion. It has also addressed issues related to the inoculum to substrate ratio to be fitted for particular sample. New techniques have been established to estimate the different parameters. It has been more preferred than linear regression. The ratio used for the volume ratio has been estimated to 50 % for the production of methane. According to the papers while performing batch test for waste activated sludge and has been noticed no change in terms of degradability. It has been noticed that to evaluate potential of substances BMP test has most capable method in terms of cost effectiveness or conservative.

REVIEW ON THE PROCESS OF FERMENTATION

Municipal solid waste landfill generates biogas and leachate. Waste treatment can be solved by the production of biogas from municipal solid waste. Residuals of wastes can be further used for the fertilizers. Fuel gas is been obtained from anaerobic fermentation. After the decomposition of wet organic landfill gas is been produced and it should be absence of oxygen that is anaerobic condition. There are three stages of the methane generation that is hydrolysis, acidification, and methane formation. The process of degradation of landfill gas production depends on moisture and temperature .These parameters are very important for generation of landfill gas. It varies accordingly the landfill sites.

DRAWBACKS OF TREATMENTS USED FOR ANAEROBIC PROCESS

Land filling has become very common way to solve the treatment of MSW. There are also many disadvantages for generation of land filling. Generation of leachate from land filling is a polluted chemical that is harmful for environment and it should not be dispose without treatment. Because of its chemical composition and volumetric flow it is important to set standards before its dispose. As impact on environment is major issue and is increasing year by year. Its impact has forced government to fix standards. In this paper treatments have been discussed about the landfill leachate. There are drawbacks of treatments that are further discussed for different treatment methods. Operating conditions decides treatment capability for particular substrate. Membrane technology has been used now a day's especially reverse osmosis (RO). Reverse osmosis is been commonly used as main step in landfill leachate treatment. Due to the rejection of standards for land filling conventional landfill leachate treatment are not capable to reach the permit standards or are required by the authorities. So overcome this problem new technologies have been used and they are cost effective technologies.

STUDIES TO CHECK BENEFITS OF BMP TEST

Biochemical methane potential test was carried out to analyze the anaerobic digestion by batch process. To access the waste treatment or the sludge from waste water treatment plant BMP test has been conducted. It involves the three steps and for the enhancement of first step in methane formation from land filling that is hydrolysis some biological and chemical pre-treatment are applied during the process. Enzymes are being used to speed by the process or nutrient solutions are also used as pre-treatment in the same process. To provide most favorable condition pre-treatment is been given for the establishment of reaction. Co-digestion is used for the achievement of the process. To check that BMP test is beneficial, volumetric test is been conducted. Volumetric test is used to convert liquid into the biogas production. Full scale digester is used for the results of the BMP assay in which nutrient solution allowed to sample has been produced for Inoculation with anaerobic digestion. This test has been used to improve removal efficiency of chemical oxygen demand and for optimum biogas production. In order to improve the growth of micro-organisms and biodegradation activities, it is very important to improve the environment where they live. Sample of sludge can be used to enhance the digestion process along with the removal of chemical oxygen demand and volatile solids, especially pre-treatment are required to be given before the start-up of the process. For e.g. the size of animal manure needs to get reduced in order make it soluble and first step of the methane formation that is hydrolytic phase and this step should be the fastest one.

OPTIMIZING THE OPERATION AND DESIGN OF ANAEROBIC PROCESS

For substrate biochemical methane Potential provides the digestibility it also provides the dimensional results as we can repeatable. It gives the results between the substrates that can be various in numbers and to the production of bio gas. It provides the information about the organic carbon content that can be converted into methane in absence of oxygen that is an anaerobic condition. Biochemical Methane Potentials can be used to determine the amount of organic carbon in a given substrate and MSW is more suitable because of much more content of organic waste than the other wastes. For optimizing the design and operation of an anaerobic digester BMP test provides the information and also evaluate the potential anaerobic substrates. Now a days the anaerobic digestion is being used more effectively as it is beneficial than other technologies. Although its onetime expenses costs are high, so the planner should be very careful while designing the system. It should give be the best possible. From waste water BMP assay can generate data. For anaerobic digestion results should be more accurate. Relatively BMP assay are less expensive than other technologies used for the land filling.

STUDIES ON METHANE AS SOURCE PF ENERGY

Landfill industry is being changing the technologies from the conventional land filling to bioreactor landfill. Limited moisture to the municipal solid waste is minimizing biodegradation. The main objective of bioreactor landfill is biodegradation so that is widely used to fulfill the purpose. Due to generation of methane atmospheric pollution can be controlled. Methane can be used as source of energy and is useful for other burning alternative. Recirculation of leachate can help the moisture content and it is helpful for the biodegradation. To accelerate decomposition of waste there are many other operational process that may help the decomposition process. For the enhancement of gas generation there are such operational that can increase the production of gas. Quality of leachate is been imposed by such operational processes. The main purpose of the study is to reduce the treatment cost of leachate and to increase the production with minimal operational cost.

REVIEW ON DEVELOPMENT OF BIOGAS FROM ANAEROBIC DIGESTION

For sustainable energy development production of biogas from anaerobic digestion had become very useful in land filling treatment plant. BMP test is being conducted for different substrates to determine methane generation. The main purpose of the test is to quantifying biochemical potential from organic wastes. Automatic methane potential test system (AMPTS) II machine has been used to carry out biochemical methane potential test. During initial phase of feedstock is low that means the waste is acidic and buffer was used to accelerate the pH up to the range from 6.5 to 7.5. BMP for the waste was obtained to be around 300 ml CH_4/g and methane content is about (60-70) % volume.

STUDIES ON RESOLVING PROBLEM FOR WASTE MANAGEMENT

Generation of Biogas biochemical methane potential is main purpose of this paper .Liquid and solids wastes both assess the biogas in absence of oxygen that is anaerobic condition. The 5g substrate being used and digested with 250 ml. Volume is being not changed and about 60 % methane has been generated is 80 days in moderate temperature. Moisture content VS and COD are the main parameters. According to this paper mild temperature has been set for the experiment. As organic waste generates more biogas than other wastes, BMP test is best method for estimating biogas through wastes. The problem for waste management can be easily solved through this test. The focuses on estimation of anaerobic biodegradability can be analyzed by biochemical methane potential under normal temperature conditions. The experiment was carried out in bottles that were prepared in triplet for the more accurate results.

ALTERNATIVES FOR RENEWABLE ENERGY SOURCE

There are various alternative renewable energy source used for generation of methane from the agricultural waste for e.g. cow duck and harvesting residues, and this the best solution for the agricultural waste management. To obtained optimum biogas from the agricultural waste anaerobic co-digestion is mixed with the agricultural waste during the methane genesis process to reduce the effect of ammonia that is been generated during the process sewage treatment plant (STP) sludge and anaerobic been sludge has been used. BMP test also check the alkalinity and ammonia contents in the substrates. According to this paper substrate should be taken in the ratio of 1:2:1 and is found to be obtained optimum biogas that is 489 ml /day.

STUDIES ON ALGAE ASSISTED MFCS

A summary of various studies involving the biodegradability of municipal solid waste is presented in Table 1.

Table 1. Summary of Studies Related to Biodegradability of Municipal Solid Waste

Sl. No.	Title	Journal Name (Year)	Author	Methodology	Conclusion
1	Bioassay for Monitoring Biochemical Methane Potential and anaerobic toxicity	Applied Science Research (1978)	W.F.Owen,D. C.Stuckey,J.B Healy.Jr,L.Y. Young and P.L.McCarty	System has developed for maximum production of biogas with efficiency of particular plant.	Physical and chemical characterization of sample was used to obtained results for BMP test. MSW consist of organic matter, so there is absence of unwanted fraction of BMP test. Test become alternative to energy saving

					and reuse of organic wastes.
2	Biochemical Methane Potential of Miscanthus Fuscus for anaerobic digestion	International Journal of Scientific and Research (2017)	E.K.Tetteh,K. O.Amano,D. Asante-Sackey and E.K.Armah	Residual of wastes can be further used for the fertilizers. Four stages of methane generation that is hydrolysis, acidogenesis, acetogenesis and methane formation further produces biogas.	The process of degradation of landfill gas production depends on moisture and temperature.
3	Characterization and Biochemical Methane Potential tests of liquid substrates for high rate anaerobic digestion	Chemical and Biochemical Engineering Quarterly (2018)	M.Mainardis, V.Cabbai,G.Zannier, D.Visintini,and D.Goi	Continues process has been compared to batch process for anaerobic digestion. New techniques have been established to estimate the differences.	Batch test for a sludge has been noticed no change in terms of degradability.
4	Anaerobic digestion of landfill leachate: A modified approach	Microbiology and Immunology Research (2013)	Suman Ghosh and Syed E.Hasan	Conventional digester has been used for treatment of land filling.	Modified design used for digestion process worked well and was found to be quite economical.
5	Assessing	Water	P.D.Jensen,H.	Batch digestions	Volume used for

	the role of Biochemical Methane Potential tests in determining anaerobic degradability rate and extent.	Science and Technology (2011)	Ge and D.J.Batstone	were performed for 160mL sample at 38℃.Blank was used consist of inoculum and medium for the test.	the test should at least 50% of inoculum volume ratio. .
6	Evaluating the Biochemical Methane Potential of low organic waste.	Water Management research (2014)	Zi shen Mou	Biochemical Methane Potential test has been conduct for the operation and design for the anaerobic treatments.	Anaerobic digestion results are accurate, Biochemical Methane Potential assay are less expensive than other technologies.
7	Anaerobic digestion of landfill leachate	Water SA Vol.17 No.4 (1991)	C-Y Lin	Test was performed four samples Substrate were fed once daily and was connected to gas cylinder.	Conventional methods resulted in high efficiency. During the process methanogenic process was efficient in Chemical Oxygen Demand and Biochemical Oxygen Demand.
8	Landfill	Journals of	S.Renou,J.G	Attached-growth	Conventional

	Leachate Treatment: Review and Opportunity.	Hazardous Material (2008)	Givaudan,S.Poulain,F.Dirassouyan,P.Moulin	biomass process was used to assess the biogas.	biological treatments are considered as appropriatetechnologies. Physio chemical treatments have been found to be suitable for treatments.
9	Influence of Sewage Sludge and Leachate on Biochemical Methane Potential of Waste Biomass	Bioremediation and Biodegradation (2012)	Kanchan Wakadikar,Rakesh Kumar	Biochemical Methane Potential test was performed in 2 L of plastic bottles for 35 days, consists of vegetable wastes, food wastes, cellulosic wastes and municipal solid wastes.	Test was conduct to assess biogas from different substrates vegetable wastes, food wastes and municipal solid wastes.
10	Biochemical Methane Potential test of residual biomass from the agro food industry	Water Science and Technology (2012)	M.Soldano,N Labartino,C.Fabbri,S.Piccinini	Methane gas has been generated from agricultural waste for e.g (cow dung and harvesting residue).	Biogas production from agricultural waste reduces the effect of ammonia, generated during process of anaerobic digestion.

CHAPTER: 3

MATERIALS AND METHODS

STUDY AREA

General

Kullu district is located about 270 km north of the Himachal Pradesh capital, Shimla. It lies at an average elevation of 4,193 feet and lies on the bank of river Beas. Its altitude ranging from about 1,278 m above mean sea level. The major river system of the region is river Beas. The town is situated at height of 1220 m. The Great Himalayan National Park is also located in Kullu. Park was built in 1984 and spreads over an area of 452 sq mi and it lies between an altitude of 1,500 m to 6,000 m.

Climate

Temperature in Kullu varies from 19 ℃ to -2 ℃ in winter and in summer maximum temperature this time is between 25 ℃ and 35 ℃.The towns enjoys monsoon during July to September and average total annual precipitation is 1,363 mm.

BIOCHEMICAL METHANE POTENTIAL:

For conducting BMP test the serum bottle has been taken of about 250 ml. Aluminium cap is been put above the bottle to avid the leakage of methane gas. Each bottle is been fitted with that aluminium cap of appropriate size. There is mixture of gas 30 % CO_2 and 70 % N_2 temp is been step and media is been defined. The temp is been set to 4 ℃ during the generation of BMP test The media contains the vitamins fatty acids for the anaerobic digestion. Sodium sulfide is been added to provide adequate environment.

Materials and Methods of BMP

Anaerobic Transfer

The inoculum prepared and is transfer in a serum bottle in transfer set to provide the anaerobic condition needles been inserted into the neck of the bottle. This test can be performed by transferring the inoculum into different bottle. For providing anaerobic environment incubation is provided to the sample for a temperature that is set to produce methane ratio of CO_2: N_2 is about 30:70 and the volume in a bottle is filled up to an appropriate level. Gas flushing needles are used provide the nitrogen and CO_2 to the sample.

Gas Measurement

Gas measurement in done with the glass syringes the sample is flushed with the CO_2 and N_2 though the needles, so as to provide anaerobic environment inside the bottles. The syringe used is first lubricated with water and then CO_2 and N_2 is been inject ted though needles. Syringe is been inserted horizontally for the measurement. For the determination of gas the glass syringe has been allowed to move gently to provide equilibrium between atmospheric pressure and to the bottle.

Biochemical Methane Potential

For accurate results liquid to void volume in the inoculum is important farter. The guidelines from authorities has been given that amount of methane production should not exceed the standards. Nutrients present in the waste should not be limited. Toxicity in the process should be eliminated. About 150 mg COD is used for the final product in the bottle for sampling that is for the less toxic organic wastes. The ratio for degradability is kept as 2 g and ratio can be change according to the toxicity of the organics. In case it degradability of any substrate in not know than number of dilution can be perform for the estimation. In this paper volume is taken to be 200 ml and it can be decreased if low gas is to be estimated.

Gas measurement is been conducted on daily bases. Prevention has been taken for the atmospheric pressure greater than 0.5 at to present the leakage of the gas. Gas sample is been determine by the chromatography. Gas syringe is used for measurement atmospheric pressure. During incubation volume is added to the substrate. After volume gas has been measured by BMP test.

To measure methane in small quantities semi continuous seed digester can be used for low organic loadings. Seeds or inoculum and substrate metabolism are important for the accuracy of methane generation. Methane generation from semi continuous seed digester is limited to less than 0.5 ml over a 30 days period. For the typical substrate of other sample methane gas is been estimated to 1 ml resulting for the same period. This period is to around for 30 days. The variation in the process is due to the metabolism rates. More once some organic wastes require more time period for degradation depends on the land fill sites.

Anaerobic Toxicity

Anaerobic toxicity during the process is predominant to methane formation the end product of acetogenesis that is further degraded into methane formation. In this process the bottle are prepared same as BMP test. Acetate and propionate end product of acetogenesis is been added to the prepared bottle. Due to the addition in the sample bottle there is decrease in the production of gas. It required an ambient condition. However in some cases anxiety may occur as should and microorganisms settle at the bottom of the sample. Prepared in the bottle anxiety may occur in such cases if toxicity is associated with the organics and may occurring due to adsorption in the substrate. To conduct a test different condition from non-condition to controlled condition is carried out for different substrates that are toxic in nature. However five to ten concentrations for single substrate is measured along with their sets for each. Samples are prepared in absence of oxygen (anaerobic condition) .Serum bottle are prepared in the controlled conditions. Also for adding the media to the substrates controlled condition is being provided. According to this paper all bottles were prepared by filling to 48ml volume of substrate and volume is estimated to 10% of volume of total liquid. At the end of experiment 2ml of acetate-propionate is added to the solution containing 75mg acetate final product of acetogenesis.

During the first week of experiment incubation was critical. Gas measurement is been conducted as daily bases. After the measurement gas has been expelled. Each sample is been computed for maximum generation of gas. Ratio for the food and microorganism should be such that it will give maximum methane generation. Ratio is suggested to be less than 0.95 for the optimum results by sample all composition results can be interpreted and for varying the ratio of carbon dioxide and methane interpretation helps to determine the final results. Toxicity during experiment is been analyzed in some and for determination of toxicity semi-continuous studies can be conducted analyzing the toxicity.

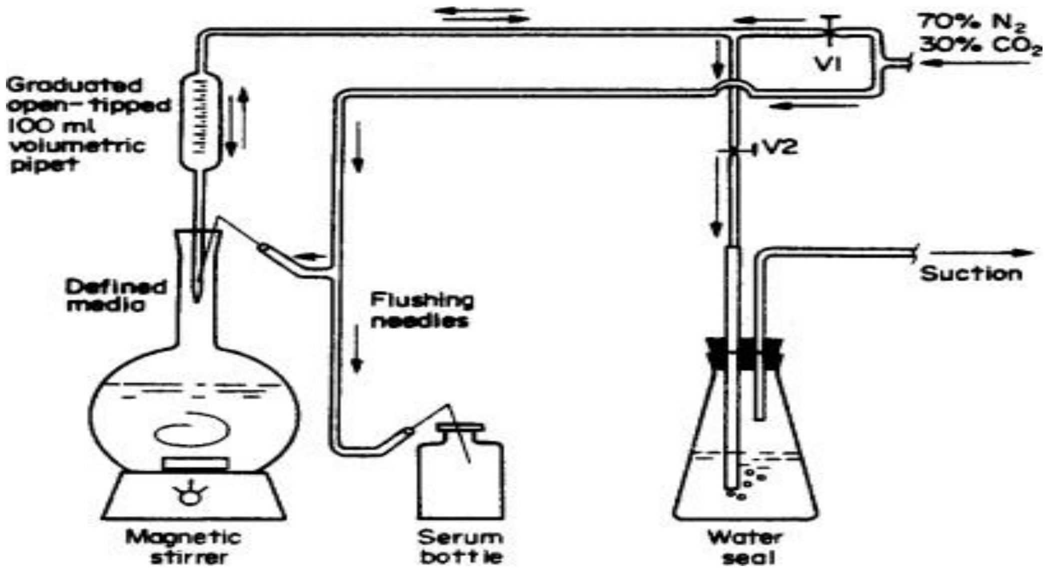

Figure 1. Schematic Diagram of Procedure for the Anaerobic Transfer of Defined Media into Serum Bottles.

Biomass production process step by step:

(a) Hydrolysis (en-biogas)

Bacterias degrade the organic polymers into smaller products in the first step of methane production from leachate. Bacteria decompose the chains of polymers into further smaller products for the generation of biogas.

(b) Acidogenesis

The end product of first step is further breakdown into acids and alcohols. The final products depend on the acids produced in first step of methane formation.

(c) Acetogenesis

Acetogenesis is the nest step in the formation of biogas and end products of acetogenesis further degraded by acetogens to give acetic acids, carbon dioxide and hydrogen.

(d)Methenogenesis

Bacterias producing methane breakdown end product of acetogenesis into biogas. Micro-organisms occur in the process to provide anaerobic condition and for the stabilization of these bacteria suitable temperature is very important factor.

Symbiosis of bacteria

Product of methenogenesis methane and acid producing bacteria refers as diverse organisms acts as together. In production for biogas methane producing bacteria uses the intermediate products under idea condition. End product can't be performing by single bacteria's during the break down of products into further simple form. There are many parameters on which the products of process dose occurs.

Substrate temperature

The process break down of bacteria to produce methane under the absence of oxygen is possible between 3 ℃ to 70 ℃ according to the experiment performed for different substrates of organic waste.

Available nutrient

For degradation bacteria is needed to b provide nutrients. Carbon and energy is not sufficient for degradation or generation of methane. Mineral nutrients like fatty acids, phosphorus are also required for fermentation for the generation of biogas there should be possible supply of nitrogen, sulphur, potassium, magnesium, calcium, iron, manganese etc. Mainly agricultural residue contains these all elements those are mentioned above. Higher concentration of any substance has hindering effects on the production of biogas.

Batch-type and continuous plants

Batch type process has been used in anaerobic fermentation for providing retention time. It varies for individual substrate in the anaerobic process. Substrate that has been used for the process is not only depends on the temperature but retention time is also very important factor for anaerobic fermentation.

pH value

Bacteria that produce methane survive best in range of pH that is slightly alkaline to neutral condition. After the anaerobic fermentation has been take place, its pH has been taken between the ranges from 7 to 8.5. Carbon dioxide and ammonia has the buffer effect, so pH value rarely has been noticed. Digester that has been used for the experiments requires higher than normal pH value if it consists higher volatile acid. Increase if pH drops below 6.2, than it has been noticed than there will be toxic effect on bacteria performing methanogenic process.

Inhibitory factors

Heavy metals detergents and antibiotics present in the waste producing methane have inhibitory effect on the process of anaerobic fermentation. In methenogenesis process lead, zinc and other metal are toxic for the process if so present in the waste. At the particular range concentration of lead present in the waste effect the process. Iron does not have any effect on the process but manganese stimulate the range of methane production. Growth of acetogenic bacteria depends on the toxicity of lead, copper, zinc that is present in organic waste. The effect of manganese has been noticed only on the methanogenic bacteria, but does not have any effect on the bacteria producing non methanogenic and acetic acid.

BATCH STUDIES

Batch studies experiment was conducted for different substance at different temperature in serum bottles of 100 ml capacity rubber cap and aluminum seal is provide anaerobic condition. Batch studies were conducted as:

- Biochemical methane potential BMP of leachate at 19 ℃ (winters)
- Biochemical methane potential BMP of leachate at room temperature (summer)

Inoculum

For BMP of leachate is used as Inoculum. Food to microorganism ratio is taken for BMP test, sludge is taken from sewage treatment plant JUIT Waknaghat, Solan, Himachal Pradesh, India. Preparation of serum bottles are washed and dried before liquid volume of about 100ml is used to maintained liquid to void ratio for maximum generation of biogas. To provide anaerobic condition inside the bottles needle is used for flushing nitrogen, same procedure is used to flush out the oxygen present in the bottles to provide anaerobic condition inside the bottles. Aluminium seal are used to provide the anaerobic conditions to the bottles.

Specific Methanogenic Activity

For this experimental study 15 bottles are prepared to perform test in duplicate. Substrate to sludge ratio varies as 2, 1, 0.5 and 0.75 shown in the tables.

EXPERIMENTAL MATERIALS AND TECHNIQUES IN BATCH STUDIES

For BMP leachate and sludge has been used as Inoculum for preparation of substrates. Sludge was taken from JUIT sewage treatment plant.

Preparation of Bottles

Serum bottles were thoroughly washed in tap water. The bottles were dried and placed in an incubator. Total liquid volume of 100 mL for accuracy of results it is important to maintain appropriate liquid to void ratio. A serum cap was placed after the bottle was filled to the appropriate volume while simultaneously removing the oxygen from the bottle by flushing nitrogen gas in it. The stoppers were fitted with an aluminum crimp seal.

Gas Measurements

Glass syringe was used to measure gas volume present in headspace. The plunger was lubricated with water and serum bottles were shaken properly before gas volume measurements were made. The gas volume measurement from serum bottles using glass syringe is shown in Figure

Specific Methanogenic Activity

Specific Methanogenic Activity (SMA) was estimated to analyse potential of leachate and sludge. Each SMA study consisted of 10 bottles with experiments performed in duplicate. The bottles were prepared with different ratios as 1:1, 2:1, 0.75:1 and 0.5:1 for the formation of biogas.

CHAPTER: 4

RESULTS AND DISCUSSIONS

LEACHATE CHARACTERISTICS

pH

It is observed that leachate obtained from Mohal district Kullu was basic in nature. Ph value of landfill site ranges from 4.5 to 9 and it depends upon the age of landfill site. Younger landfill has an acidic pH up to 6.5 and mature landfill has been estimated pH value greater than 7.5 (Figure 2).

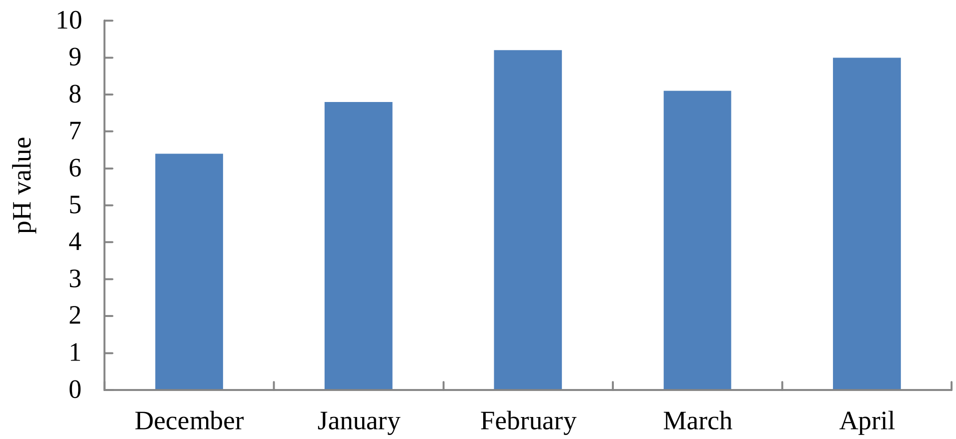

Figure 2. Seasonal Variation of pH Value for Leachate

Results show that leachate obtained from landfill site was basic in nature. In early stages it was observed to be 6.4 because leachate was younger and it in April it was observed to be 9 and mature landfill has been observed to have pH value greater than 7.5. Concentration of volatile fatty acids is optimum for landfill leachate in its initial stages, for mature landfill leachate these volatile fatty acids have been converted into biogas.

Hardness

Hardness of leachate sample of landfill MSW were (700, 750, 780, 850 and 970) mg/L respectively values was higher than the standard limits (Figure 3).

Biological Oxygen Demand at 20 ℃

BOD measure biodegradability of organics maturity of leachate that decrease with time. In the initial stage of experiments the value of BOD has been found to be as follows:

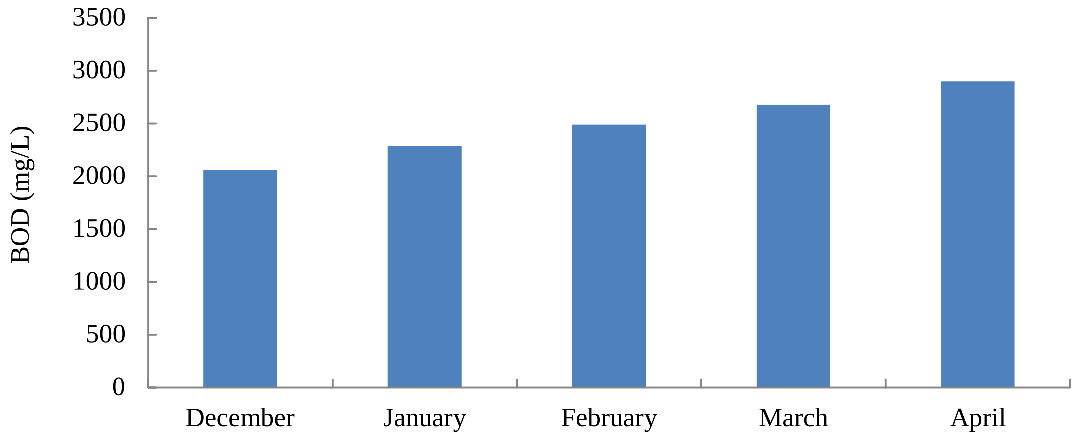

Figure 3. Seasonal Variations of BOD Concentration for Leachate

The average BOD concentration for leachate were observed to be 2500 mg/L (Figure 3). That is due to effect of low temperature on the concentration of BOD. Results are shown in above figure indicates the variation in BOD concentration due to temperature variation.

Chemical Oxygen Demand

It represents the oxygen demand for decomposition of organic matters. The COD value for leachate samples were measured as shown in Figure 4 below.

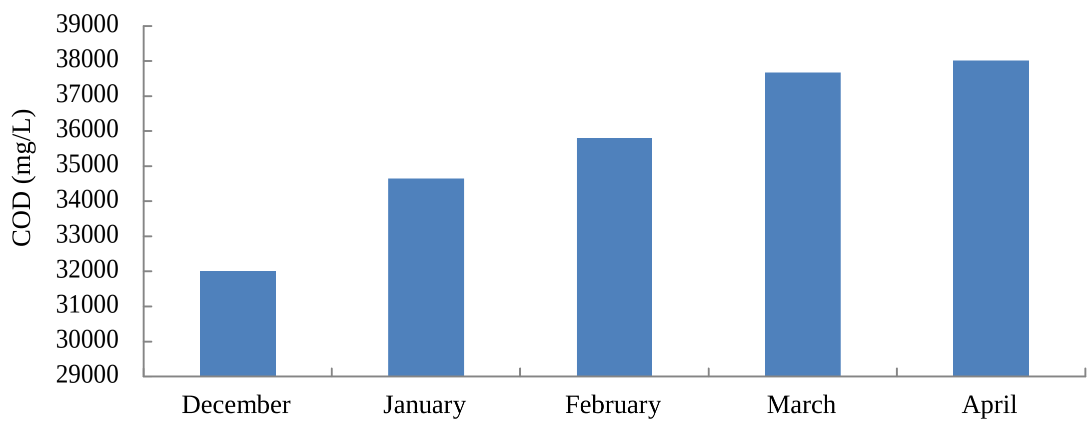

Figure 4. Seasonal Variations of COD Concentration of Leachate

The experimental result shows the variations in efficiency of COD removal due to change in temperature. The average COD concentration for leachate sample was in range of 32000 to 38000 mg/L.

Alkalinity

The leachate sample collected from MSW landfill leachate was tested for alkalinity. The results for alkalinity test of leachate have been observed by performing the experiment is shown in Figure 5 given below.

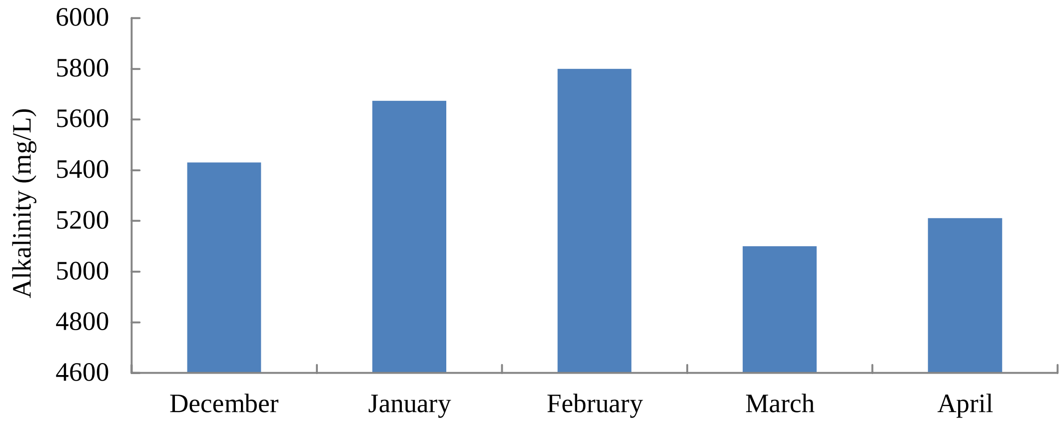

Figure 5. Seasonal Variations of Alkalinity Values for Leachate

The average alkalinity of leachate was observed to be in rage of 5000 to 6000 mg/L. Results concluded that alkalinity present in leachate can resists changes in the value of pH.

Solids

Solids are further classified as SS, DS and VS. The solid removal efficiency was found to be different monthly. The results provided for different removal efficiencies are as follow:

During the experiment of solids it was observed that solids removal efficiency in months of winter was satisfactory. The average of results was in range of 1500 to 2200 mg/L and removal efficiency was observed to be 80 % which corresponds to minimum efficiency of suspended solids was 9 % of total efficiency (Figure 6).

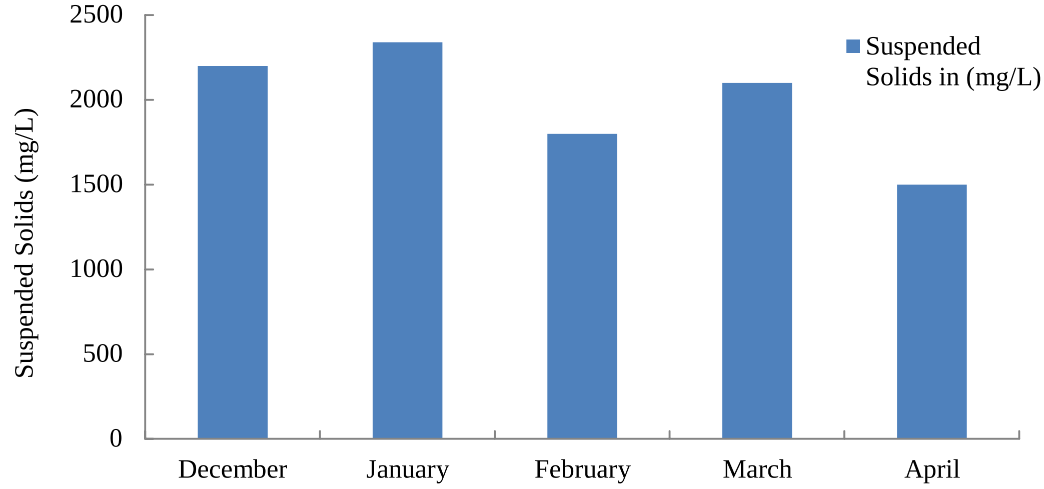

Figure 6. Graph Showing the Concentrations of Suspended Solids

4.1.6 Dissolved Solids

Dissolved solids concentrations during different months has been observed and the results are shown in Figure 7 given below. Experimental result shows that the value has been increased for dissolved solids concentration in month of April.

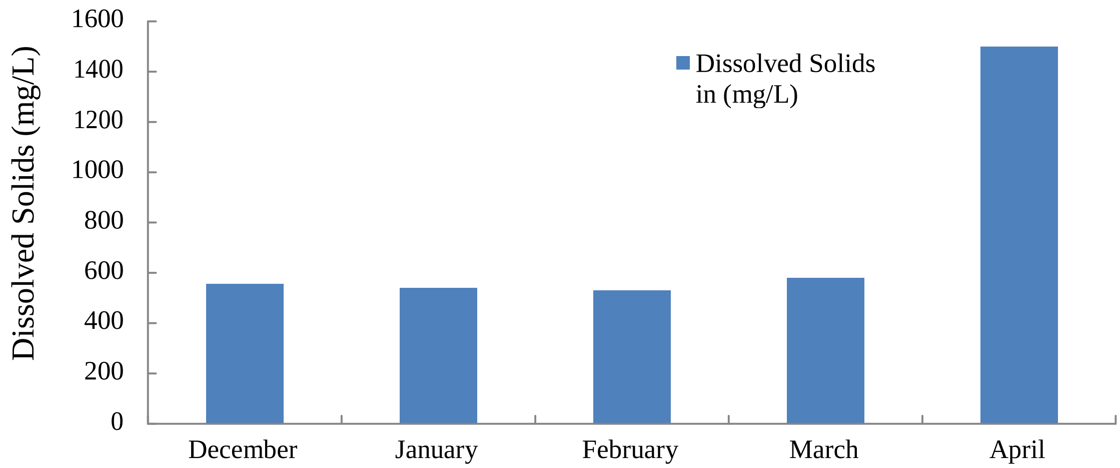

Figure 7. Graph Representing the Values for Dissolved Solids

4.1.6 Volatile Suspended Solids

The amount of volatile solids in wastewater indicates the presence of organic matter in leachate sample. Reduction in volatile solids was indicating biomass growth in leachate. That further indicates the production of biogas.

BATCH STUDIES

Batch studies were conducted at low temperatures in serum bottles of 100 ml capacity with rubber caps. Methodology adopted for the batch process depends on the inoculum and sludge content. The main factors that influences the generation of methane gas are food to micro-organisms ratio. Two sets of experiment was as follows

- Biochemical methane potential of MSW leachate at low temperature conditions(19 °C)
  F/M 1:1, 0.5:1, 0.75:1, 2:1.
- Biochemical methane potential of MSW leachate at room temperature
  F/M 1:1, 0.5:1, 0.75:1, 2:1.

Cumulative gas production for first set

Cumulative production of gas for first set has been performed for short interval of time. Gas production in initial phase was observed to be low, with time gas production has been observed to be increased.

It has been observed that 0.75 and 0.5 F/M ratio generates maximum biogas as it consist more ratio of food that is sludge, so the generation of biogas for the substrate consist of more sludge produces more biogas than the substrate consists less ratio of sludge.

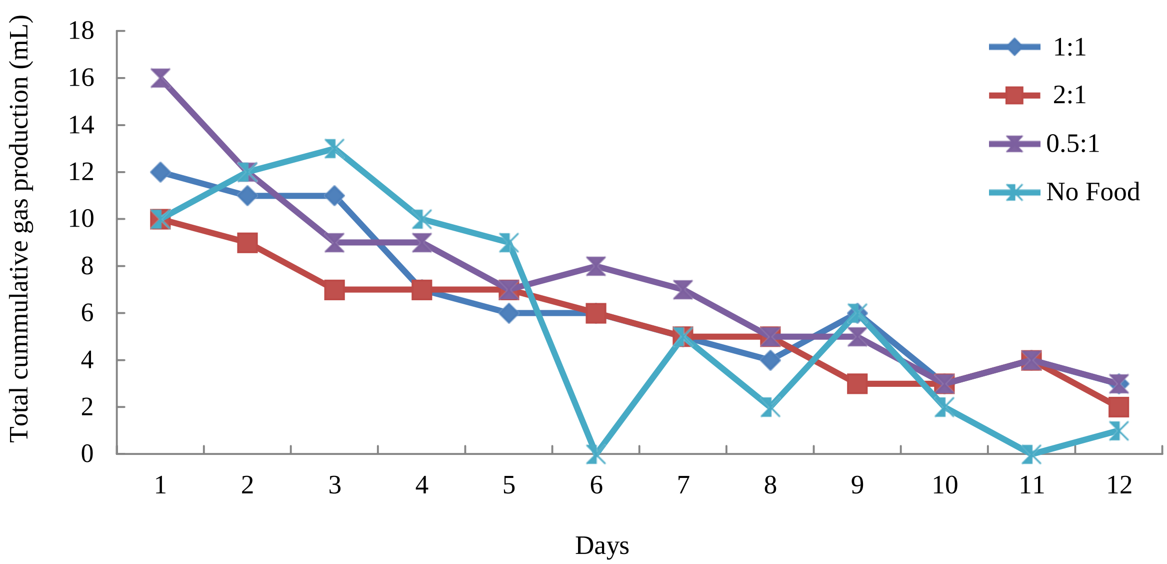

Figure 8. Total cumulative production of gas for Set-I

Total cumulative gas production for second set

Cumulative production of gas for second set has been observed for different F/M ratios for 30 days. It has been seen that gas production was maximum for 0.75:1 ratio. Following values represents the variations in production of methane gas for different substrates.

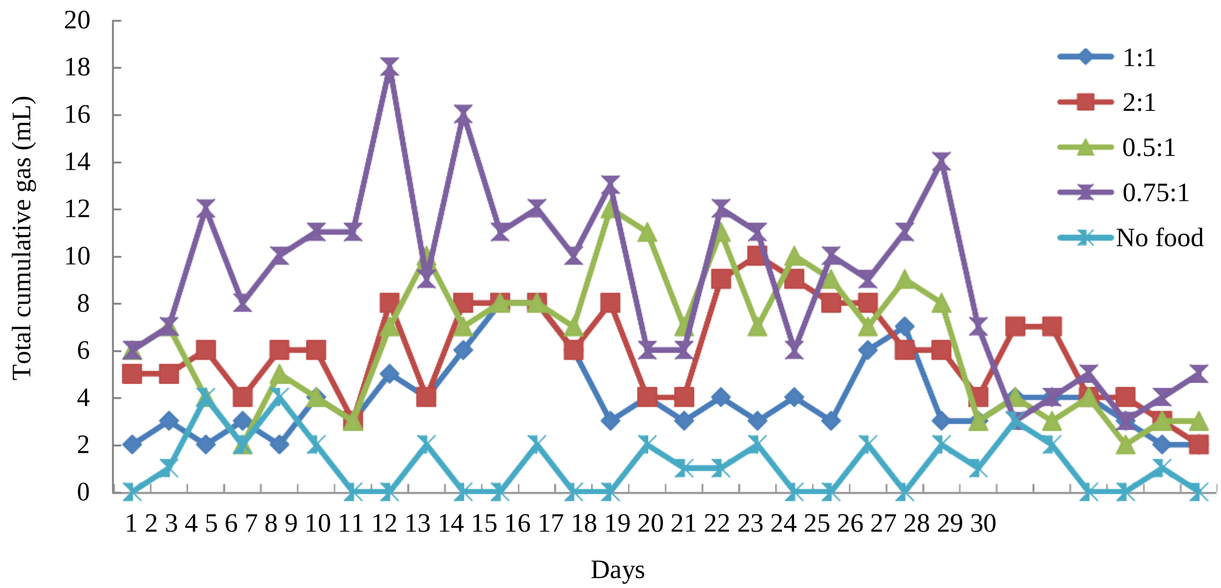

Figure 9. Total cumulative Gas Production (mL) for Set-II

For set-II experiment production of biogas was observed to be more than the set-I, experiment conduct for set-II was for 30 days and it was conduct under room temperature. F/M ratio 0.75 produces the maximum biogas, and variation for 0.75 F/M ratio biogas productions from 3rd to 4th day was very less and it was due to leakage of gas from the bottle, and variation has been noticed for each ratio.

Total cumulative COD

BMP determination has been made for different F/M ratio 1:1, 0.5:1, 0.75:1, 2:1 leachate has been used as substrate.BMP test for the leachate were made under different temperature. Biogas was observed for 12 days at 19 ℃ for first step of experiment. Second round was performed for 30 days at room temperature. For first set of experiment biogas production was low. Reason for low gas production can be psychrophilic conditions. Gas deducted is shown in Figure 9.

Total cumulative COD for leachate samples for different F/M ratios has been observed are shown in Figure 10 given below.

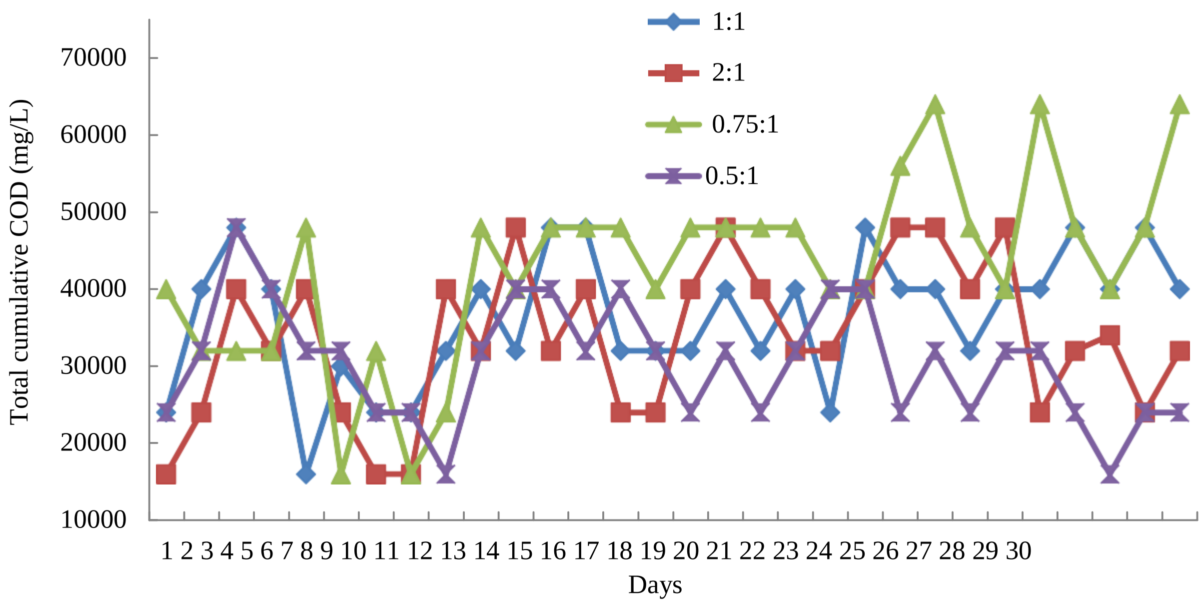

Figure 10. Values for total cumulative COD for set II

Concentration of COD for the different F/M ratios was observed to be varying for each substrate it was due to the varying sludge to leachate ratio for each substrate. COD was observed to be maximum for 0.75 ratio.

Total cumulative BOD

Total cumulative BOD for leachate samples for different F/M ratio after interval of every 3 days for maximum of 30 days' time period has been observed shown in Figure 11 given below.

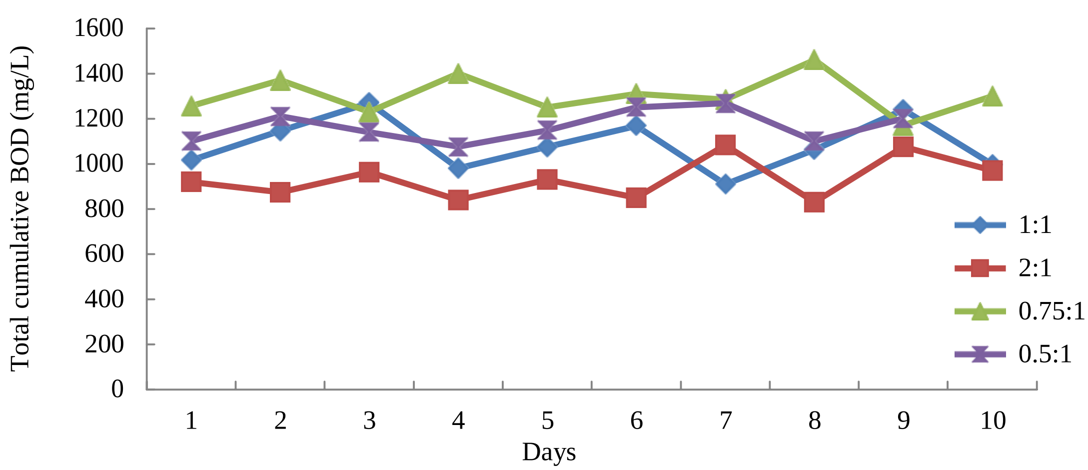

Figure 11. Values for Total Cumulative BOD for set-II

For second set of experiment, was conducted at room temperature. BOD observed during the period was more for the ratio of 0.75:1.Variations observed in the values was due to the experimental error.

BMP

BMP indicates production of biogas and anaerobic potential for maximum quantity of methane production. F/M 0.75:1 has more gas production while other ratios have poor production of biogas. It has been shown in figure given below that with decrease in F/M ratio BMP value will also decrease.

4.3.1 Specific Methanogenic Activity of sludge

SMA is capability of sludge to produce methane. Specific methanogenic activity was determined with two sets of experiments; methane generation was estimated through serum bottle technique to assess degradability. SET I - Specific methanogenic activity at 19 ℃ for 12 days. SET II - Specific methanogenic activity at room temperature for 30 days.

Specific methanogenic activity at room temperature for Set-II

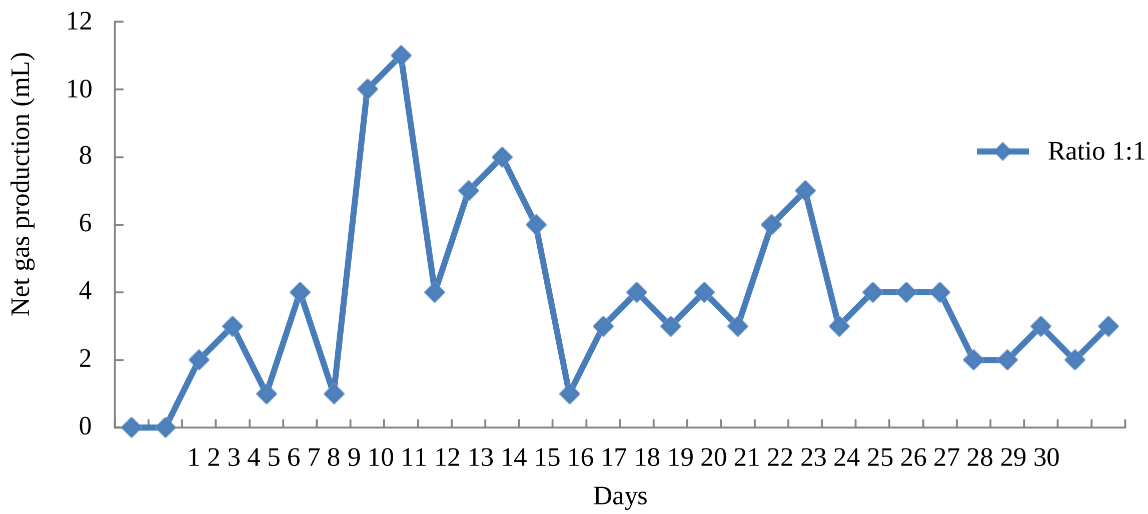

Figure 12. Net Gas Production for F/M ratio 1:1

It was observed that gas production from 1:1 ratio was satisfactory, for first three days there were no production of biogas, it was due to the leakage of gas or experimental error. Increase in the production of biogas was observed from 7th to 10th day, it can be due to increase in the temperature. After 15th day production becomes almost constant.

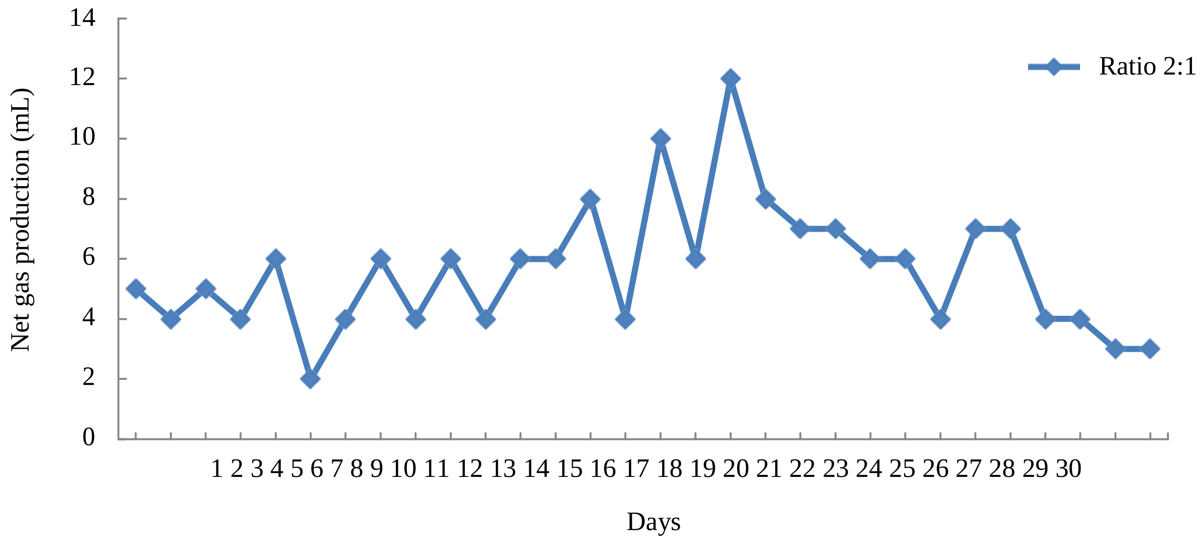

Figure 13. Net gas production for F/M ratio 2:1

Production of gas for F/M ratio 2:1 was observed to me more than 1:1 ratio and it was due to the presence of more concentration of sludge in respective substrate. Increasing production of biogas from 15th to 19th day was due to increase in temperature. Change in the concentration of production from day 19th to 30th day of production was observed due to formation of methanogenic process.

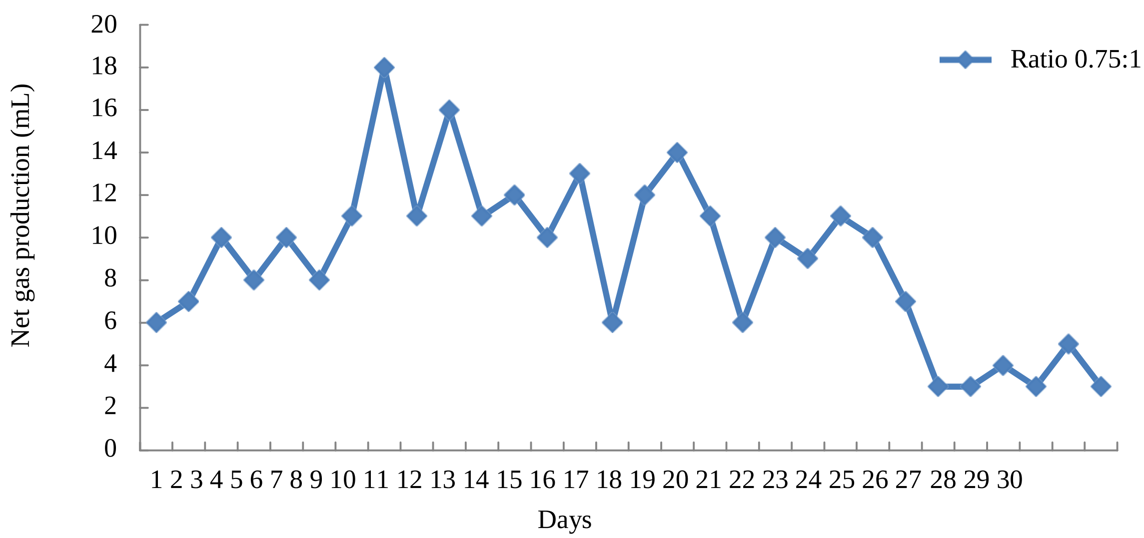

Figure 14. Net Gas Production for F/M ratio 0.75:1

Gas production was observed is maximum for 0.75:1 F/M ratio; it was due to the presence of more sludge in the inoculum than other ratios.

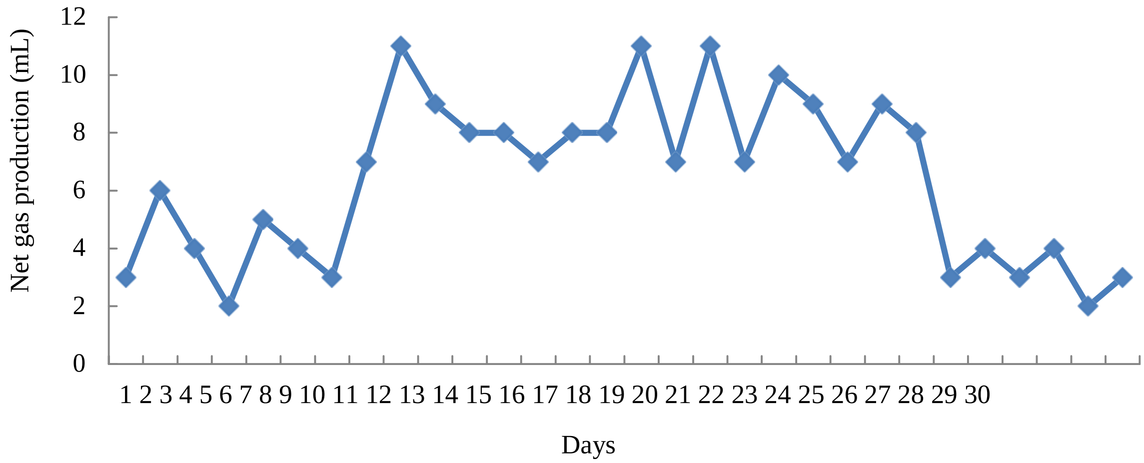

Figure 15. Net Gas Production for F/M ratio 0.5:1

Gas production for ratio 0.5:1 was observed to satisfactory, increase in the production of biogas was observed from 7th to 9th day due to increase in temperature and from 25th to 30th day it was found to less than initial stages.

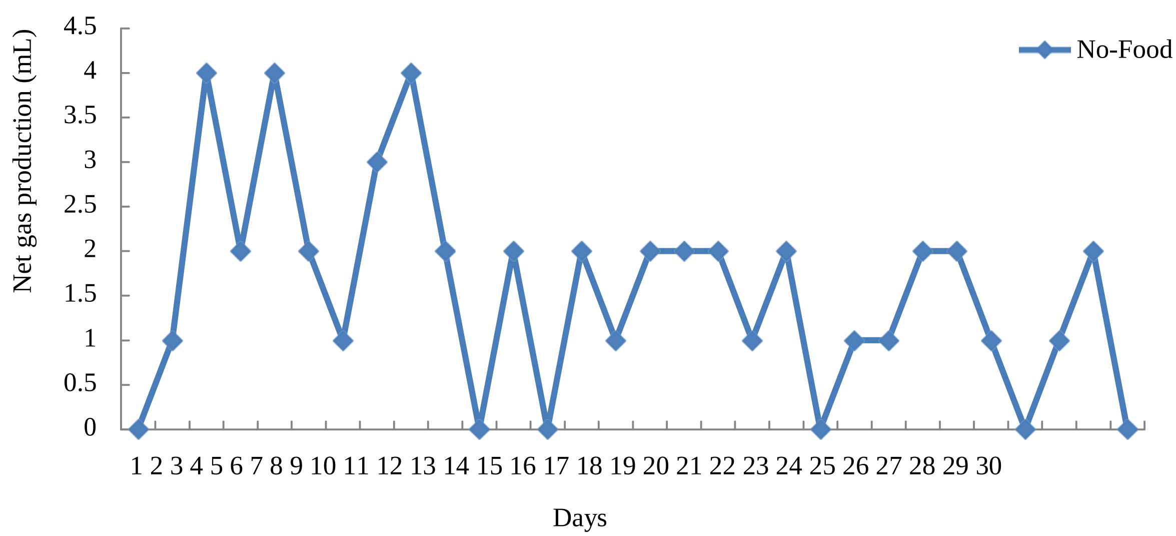

Figure 16. Net gas production for No-Food

Net gas production for no-food was observed to be very less from other F/M ratio for set-II and it was due to absence of leachate.

CHAPTER-5

CONCLUSION

BMP test was conduct for two sets of experiment. To conduct test serum bottles were used to generate biogas from different F/M ratios. To provide anaerobic condition for inoculum nitrogen gas was used, that was being injected by needle from top of the cap of inoculum bottle. Experiment was performed under different temperature for maximum gas production. During the experiment, it was observed for temperature 19 ℃ gas production was less than gas production for room temperature. Total biogas production under 19 ℃ temperature for different F/M ratios was very less from experiment performance for second set under room temperature for 30 days. Fluctuation in temperature has affects bacteria producing methane gas. Substrates has influenced by F/M ratio, Maximum production has observed for ratio 0.75:1.Increase temperature for the BMP test has decreased bio-meters production. Results indicate that 2:1 has observed more production than 0.5:1, 1:1.

5.1 RECOMMENDATION FOR FURTHER RESEARCH

Studies should be carried to enhance the production of biogas at different temperature to get maximum production of biogas from leachate. Production of biogas has been observed to be more in summer, so temperature provided for optimum gas production should be maximum. Biogas production can be estimated for different food to micro-organism ratios.

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APENDIX – A

A.1 CHARACTERISTICS OF LEACHATE

Table A. 1. pH Values of Leachate

Month	pH
December	6.4
January	7.8
February	9.2
March	8.1
April	9.0

Table A. 2. BOD Values of Leachate

Month	BOD (mg/L)
December	2060
January	2290
February	2490
March	2680
April	2900

Table A. 3. COD Concentration for Leachate

Month	COD (mg/L)
December	32000
January	34640
February	35800
March	37670
April	38000

Table A. 4. Alkalinity Value for Leachate

Month	**Alkalinity (mg/L)**
December	5430
January	5673
February	5800
March	5100
April	5210

Table A. 5. Concentration Values for Suspended Solids

Month	**Suspended Solids (mg/L)**
December	2200
January	2340
February	1800
March	2100
April	1500

Table A. 6. Concentration Values for Dissolved Solids

Month	**Dissolved Solids (mg/L)**
December	577
January	540
February	530
March	580
April	486

Table A. 7. Percent Moisture Content, Volatile Solids Content

Parameter	Moisture	Volatile Solids	VS/TS
Sludge	7.69□	81.7□	95.66□

Table A. 8. Cumulative Gas Production for First Set of Experiment

F/M ratio	**Temperature (ºC)**	**Total biogas production (mL)**
1:1	19	78
2:1	19	69.2
0.75:1	19	99
0.5:1	19	100
No Food	19	84

Table A. 9. Cumulative Gas Production for Second Set of Experiment

F/M ratio	**Temperature (ºC)**	**Total biogas production (mL)**
1:1	Room Temperature	144
2:1	Room Temperature	150
0.75:1	Room Temperature	262
0.5:1	Room Temperature	169
No Food	Room Temperature	45

APENDIX-B

PHOTOGRAPHS

Figure B. 1. Location of Landfill Leachate Site

[Source: sato et al, 2006]

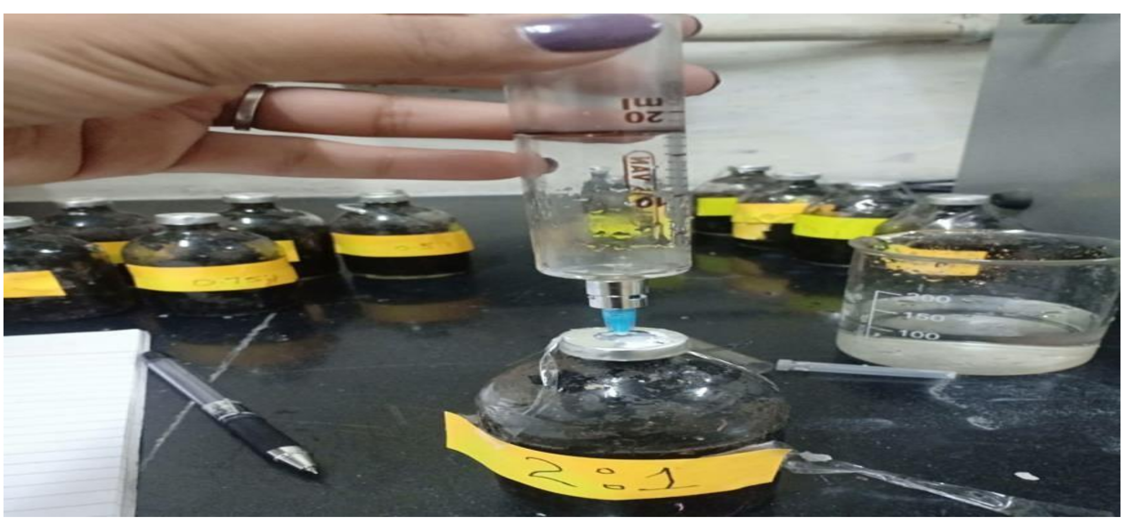

Figure B. 2. Gas measurement from bottle

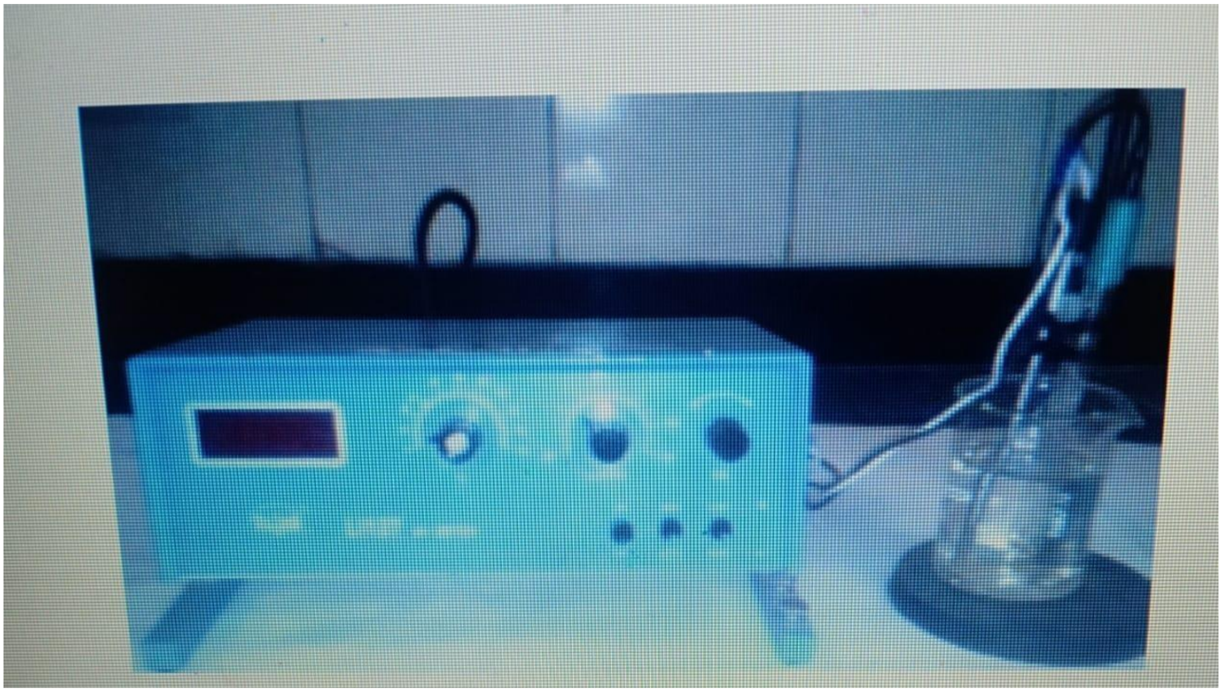

Figure B. 3. Digital pH Meter

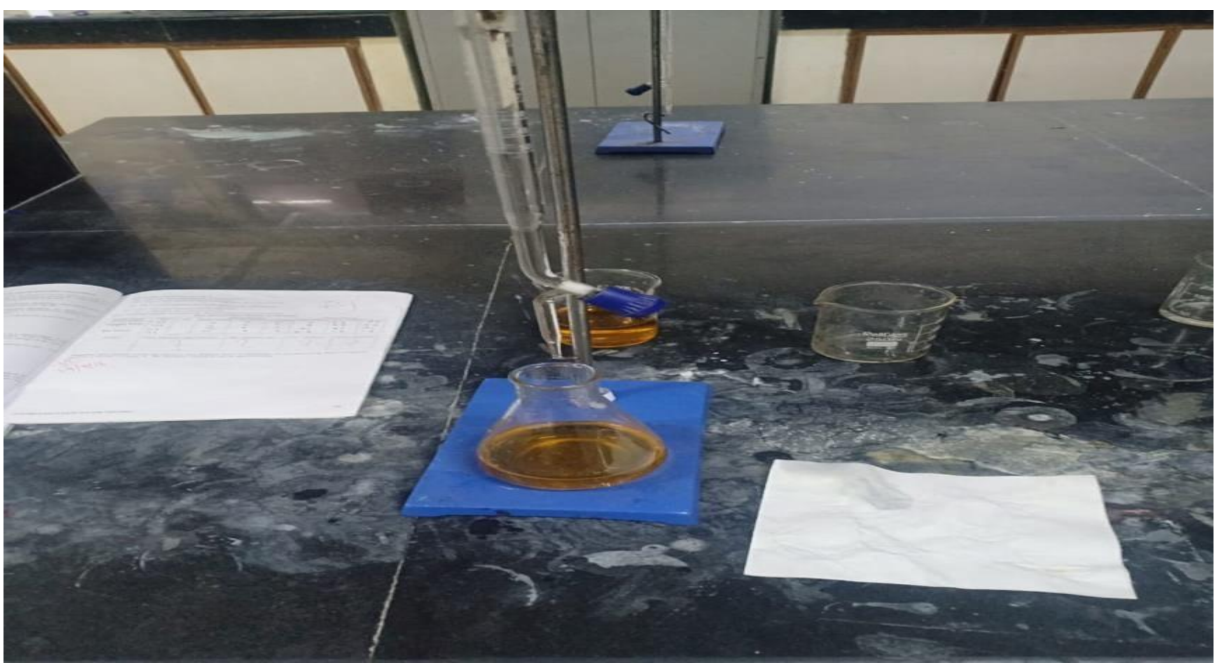

Figure B. 4. Alkalinity Test Setup

Figure B. 5. Digital DO Meter

Figure B. 6. COD Digester

Figure B. 7. Experimental Setup of BMP

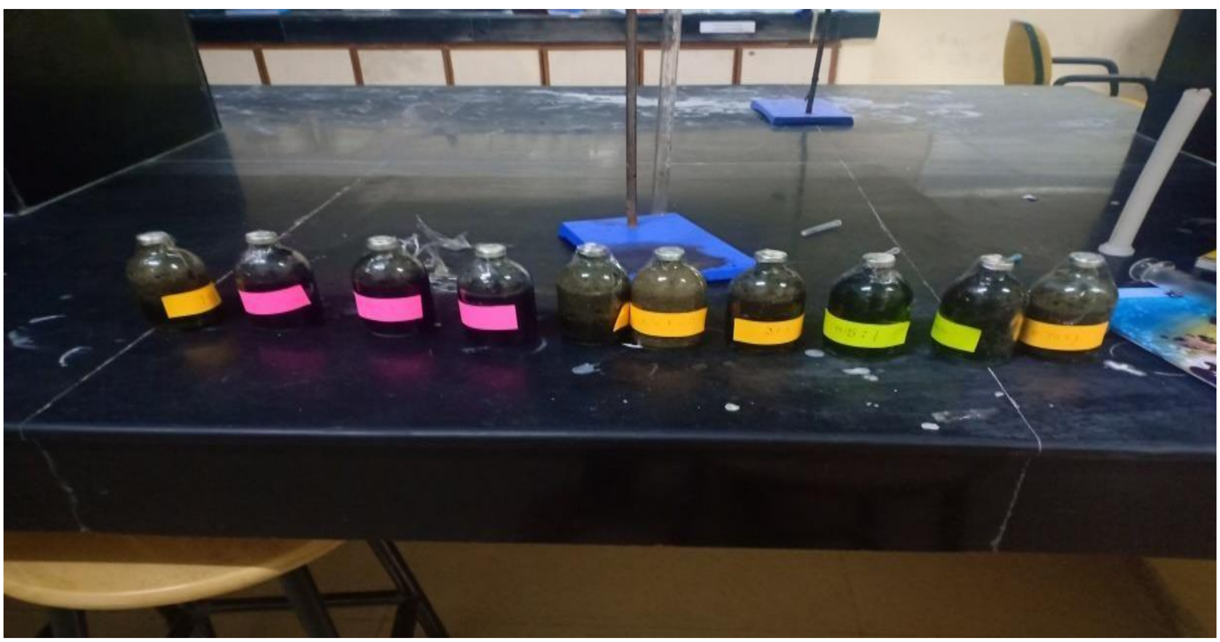

Figure B. 8. BMP Bottles

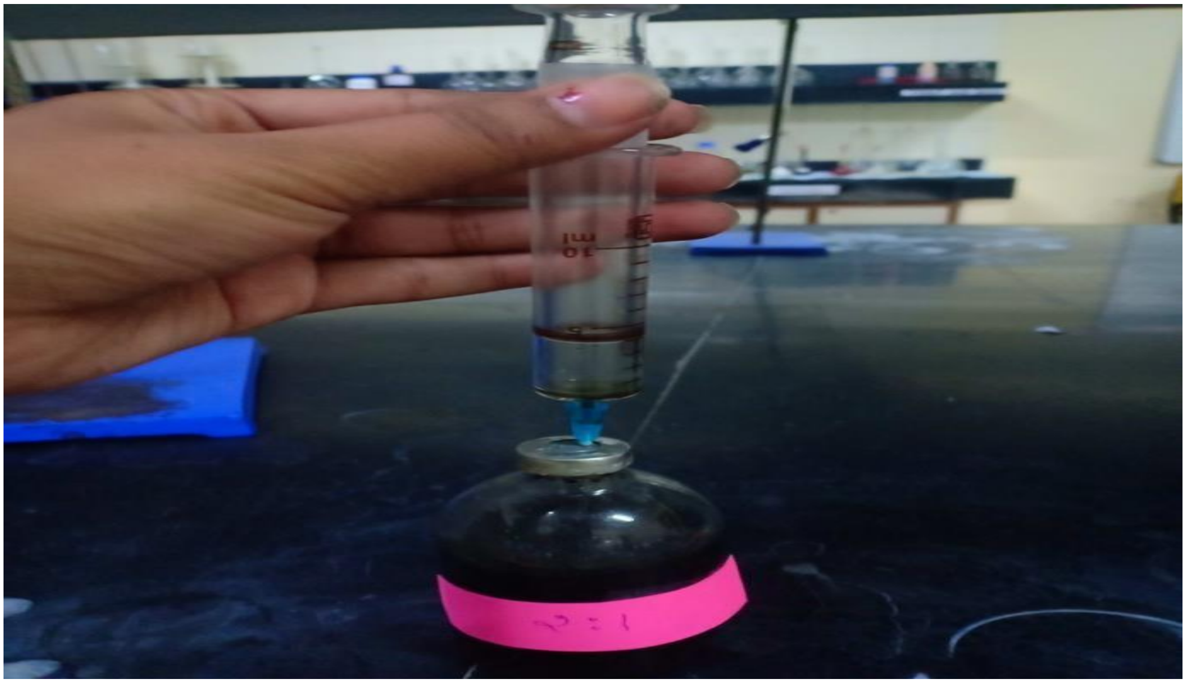

Figure B. 9. Gas Volume Measurement from Serum Bottles Using Glass Syringe

Figure B. 10. Nitrogen Cylinder Used for BMP Test

Figure B. 11. Muffle Furnace