Kafrelsheikh University
Faculty of Agriculture
Agricultural Engineering Department

"UTILIZATION OF AGRICULTURAL WASTE"

EXPLOITATION OF SOME CROP RESIDUES AND WATER HYACINTH MIXED WITH CATTLE DUNG FOR GENERATING BIOGAS

BY

ABDELWAHAB ABDELALEM ABDELWAHAB HAMED
B.Sc., in Agric. Science (Animal Production), Fac. of Agric., Kafrelsheikh, Tanta University, 1983

THESIS

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(AGRICULTURAL MECHANIZATION)

SUPERVISION COMMITTEE

Dr.
FATHEY IBRAHIM HINDY
(God to have mercy upon him)
Associate professor of Agric. Eng.,
Agric. Eng., Department,
Kafrelsheikh University.

Dr.
SAID ELSAYED ABOUZAHER
Assistant professor of Agric. Eng,
Agric.Eng., Department,
Kafrelsheikh University

Dr.
REZK MOHAMED KHOLIEF
Senior Researcher, Agric. Eng. Res. Inst
Agric. Res. Center., EL-Dokki, EL-Giza, Egypt.

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APPROVAL SHEET

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ABDELWHAB ABDELALEM ABDELWHAB HAMED

This thesis for M.Sc. Degree in Agricultural science
(Agricultural Mechanization)

Has been approved by:

Prof. Dr. MOUBARAK MOHAMED MOUSTAFA..
Professor Emeritus of Agricultural Engineering
Faculty of Agriculture, Ain-shams University Cairo, Egypt.

Prof. Dr. ISMAIL A. ABDELMOTALEB..
Professor of Agricultural Engineering and
head of Agricultural Engineering Department
Faculty of Agriculture, Kafrelsheikh University.

Dr. REZK MOHAMED KHOLIEF..
Senior Researcher
Agricultural Engineering Research Institute.
Agricultural Research Center., El-Dokki, El-Giza, Egypt.

Date: 18 / 9 /2007

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Dedication

To

The Spirit of My Father,

My Mother,

My Brothers,

My Dear Wife,

My lovely Sons and daughter.

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Exploitation of Some Crop Residues and Water Hyacinth Mixed With Cattle Dung for Generating Biogas

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Abstract

The riddance from crops residues is a great environmental problem in Egypt because of great quantities from agricultural residues such as rice straw, maize stalks, cotton stalks and water hyacinth. Farmers do burn that residues especially rice straw. Burn has bad effects on health for population and is plays a great role in agricultural residues value wasting. On the other hand, the water hyacinth has other effects of the fast growth losses of water in irrigation systems due to higher evaporation. Attempts to control the weed have caused high costs and labor requirements, leading to nothing but temporary removal of the water hyacinths . It is one of the suggested option to change and improve the present pattern of using crop residues in rural areas in Egypt. It is an economical, safer and cleaner substitute for the direct combustion of these residues. The objective of this study was to evaluate of biogas production from agricultural residues available in rural Egypt. The experiments carried out to examine biogas productivity from previous agricultural residues during the period of 30/8/2005 - 30/12/2006.

Experiments carried out in ten cylindrical shape stainless steel reactors have 10.77 L gross value. Each reactor was equipped with a mechanical stirrer. Was attached to the electric motor to control the mixing duration intervals at 15 min /4 hours. The reactors were placed in the water bath to keep the slurry temperature at level of 311± 2 K (38 ± 2 °C). Agricultural residues collected as agricultural byproducts after harvesting the corresponding crops from rural areas of Kafrelshiekh Governorate as well. Water hyacinth was collected from a drain located in AlHamoul city at Kafrlsheikh Governorate. The raw materials were dried in the sun and chopped in traditional stationary thresher; the raw materials were mixed with fresh cattle dung at different levels and feed into reactors. Biogas yield was significantly affected by kind of agricultural residues and level of cattle dung, cumulative biogas yield (L kg TS added) differ according to kind of residue fermented. The cumulative biogas yield of rice straw at cattle dung ratio 1: 2 (303.1 L /kg TS), maize stalks at cattle dung ratio 1: 2 (249.87 L /kg TS), water hyacinth at cattle dung ratio 1: 3 (170.76 L /kg TS) and cotton stalks at cattle dung ratio is 1: 1 (156.59 L /kg TS).

1. INTRODUCTION

Agricultural activities all over the world results in a huge quantity of residues. In the past, these residues had been considered as waste causing problems and should be eliminated. Nowadays, the agricultural residues should be treated as a source of wealth from the view point of agricultural production. One of the important utilization of this residues is to be used as a source of energy or in other words as an attractive renewable and non-traditional energy source. This reflects an indication to the contribution in solving the expected energy problem and saving the environment.

In Egypt there are about 86.79 M ton / year (86.79 Tg / year) of agricultural residues annually (**Helmy et al 2003**). From which there are 31.42 M ton / year (31.42 Tg / year) of plant residues and 55.37 M ton / year (55.37 Tg / year) of animal residues. On the other hand, water hyacinth is considered as one of the undesirable biological species that grow accompanied with the agricultural activities. It causes a high percentage of water loss in addition to the working as an obstruction within irrigation and drainage channels. Main crops such as rice, maize and cotton refuse about 11.04 M ton / year (11.04 Tg / year) of residues. These three crop residues in addition to water hyacinth have the main attention of the present work. Its exploitation in generating energy on one side and in parallel contributes in saving the environment on the other one is the main goal.

Anaerobic digestion is a one of the well known methods that can be used for generating energy in the form of biogas. The main component of the biogas is methane which represents about 50% to 70% of the biogas **(Mital 1996)**. Therefore, the anaerobic digestion had been used widely for generating biogas from various materials. An attention should be given to the agricultural residues as raw materials for biogas generation. A considerable research effort had been given and concentrated on generating biogas from animals manure such an effort leads to an establishment of applied and integrated systems that can be used by the farmer to produce his requirements of energy. The improvement and development of the existed systems is still need to enhance the biogas generation process itself. On the other hand, if this enhancement makes the agricultural residues involved in, the on additional benefit will be added and this was the corner stone of the present study. Therefore, searching for a sound technique for generating biogas from the agricultural wastes should be given a paramount importance.

Rice straw, maize stalks and cotton stalks as the residues of the main crops in Egypt in addition to water hyacinth were given the priority in the present study. This leads to enhance the energy sources in terms of biogas and contribute in eliminating the residues corresponding problems. Consequently, the main aim of the present study was to exploit rice straw, maize stalks, cotton stalks, and water hyacinth mixed with cattle dung for generating biogas. Specific objectives can be summarized as follow:

1- Develop an experimental system to represent the biogas reactor units.
2- Study the effect of the type of agricultural residue on the biogas generation process.
3- Study the effect of mixing ratios between the agricultural residue and cattle dung on the biogas generation process.

2- REVIEW OF LITERATURE

2.1 Anaerobic fermentation of agricultural wastes:

2.1.1 Definition of anaerobic fermentation process

Carr (1968) illustrated that if carbohydrates are burnt completely they produce three end-products, namely, carbon dioxide, water and energy. The same end-products result if carbohydrates are respired. In biological system the energy is not dissipated, but is used for various essential activities, such as chemical syntheses, temperature maintenance, locomotion, etc. Organisms employing this form of respiration require oxygen and are said to be aerobic. There is another but smaller group of organisms classed as anaerobes that require no oxygen for respiration. These are found among the micro-organisms, some of which are so strictly anaerobic that they are unable to function in the presence of oxygen. Others, such as yeasts, can live with or without this gas and are termed facultative anaerobes.

Alcoholic fermentation

$$\underset{\text{Glucose}}{C_6H_{12}O_6} \longrightarrow \underset{\text{Ethyl alcohol}}{2C_2H_5OH} + 2CO_2 + \text{Energy}$$

This is the overall picture of alcoholic fermentation that can be achieved with the crude extracted juices of yeast cells.

Mital (1996) anaerobic fermentation is a biological process which takes place in the absence of air. A number of stages are involved in this process: initially organic material is hydrolysed by enzymes into simple sugars, alcohol peptides and amino acids. These are then converted to volatile fatty forming bacteria then convert the fatty acids into methane, carbon dioxide, and water

Ostrem et al. (2004) defined Anaerobic digestion (AD) as the conversion of organic matter into carbon dioxide , methane , and sludge by employing bacteria in an oxygen-depleted environment. The process of AD is one of the oldest forms of digestion and occurs naturally in the absence of oxygen such as in bogs, rice field, improperly aerated compost.

2.1.2 An overview of biogas process technology:

Mital (1996) stated that biogas can be produced by fermenting organic materials in the absence of air(or oxygen) with the help of bacteria (micro-organisms) to break down materials to intermediates such as alcohols and fatty acids and finally to methane, carbon dioxide and water . This process is called anaerobic fermentation and was known to exist from quite long time back. Biogas has also been known as the swamp gas. Sewer gas, fuel gas, marsh gas, wet gas, and in India more commonly as gobar gas. Natural gas is produced by the action of anaerobic bacteria on plants that grew thousands of years age . Biogas and natural gas are therefore very much akin to one another. The main fuel component of both is methane gas. However, over the years, pressure and temperature of underground rocks have converted part of the methane in natural gas to other gases such as ethane, propane, butane and the condensate. In contrast, biogas is produced in a digester by anaerobic fermentation. A period of 15 days or so enables anaerobic bacteria to convert organic matter to biogas which however is too short for the conversion of methane to other gases like ethane, propane, butane . The enormous potential of the smallest living organisms such as bacteria, yeasts and fungi to transform organic wastes into valuable source of fuel and enriched fertilizer through a simple process of anaerobic fermentation has been widely recognised .Anaerobic fermentation is a anaerobic fermentation has been widely recognised .Anaerobic fermentation is a simple and low cost process which can be economically carried out in rural areas where organic wastes are generated aplenty which otherwise pollute environment and pose health hazards .Animal and human wastes are excellent feedstock for biomethanation which are available plentifully all over. Wastes in large quantities on renewable basis are also available from agricultural crops and residues , fruit and vegetable plants and municipal refuse. The potential for generating gaseous fuel and enriched fertilizer through biomethanation is enormous which can bring economic and environmental gain to a vast population .

Plochl and Heiermann (2006) stated that the biogas plants in developing countries have a low efficiency – approx. 0.5 m^3 biogas per m^3 digester volume – especially compared to biogas plants in Europe – approx. 1.0 m^3 biogas per m^3 digester volume. Biogas plants also demand a certain effort of maintenance and control which often doesn't meet the literacy skills of rural population. During recent years of biogas production three major types of digesters have emerged in developing countries namely the Chinese fixed dome digester (Figure2.1) and the Indian floating drum digester (Figure 2.2) and very recently tube digesters (Figure 2.3). These digesters are usually in the size to convert the human and animal waste of one household and to deliver the energy demand of this household for cooking and lightning. The average of the digester ranged from 5-10 m^3 and delivers around 0.5m^3 biogas per m^3 digester volume **(Akinbami et al., 2001; Omer and Fadalla, 2003)**

They explained that the floating cover digester is constructed with concrete and steel; whereas the fixed dome digester is usually build with the locally available materials, which even can be bricks. Tube digesters are constructed with folded polyethylene foils and porcelain pipe as inlet and outlet. Although there are substantial differences between these types of digester their working principle is very much the same. The feedstock enters through the inlet pipe either directly or after a mixing pit the digester tank. This is either a one-compartment tank or a two-compartment one where the substrate has an average retention time of 10 to 30 days. The gas is collected above the slurry and leaves the tank through a gas pipe in the top of the cover. In the case of the fixed dome type, the top is made of concrete or bricks and as the rest of the digester below ground. The floating cover type has steel cover floating on the slurry, which is above ground, whereas the rest of the digester is also below ground. The digested slurry leaves the digester through an outlet pipe and is collected in an outlet pit or a displacement tank.

Each type of digester does not have facilities for agitating the slurry or for maintaining a certain temperature in the digester and controlling it. There are also no facilities to remove sand, stones or other inert materials, which will, over some years, decrease considerably the volume of the digester and hence will reduce its efficiency. It is also expected that the concentration of non-degradable organics increase and that these will build either a sludge sinking to ground or a crust at the top of the slurry both reducing the effective volume of the digester and the latter even blocking the gas flow to the gas storage. The expansion of inert and non-degradable material makes it necessary to stop the process from time to time and to remove these materials. The very low cost of the tube digesters makes it rather easy to exchange this in the case of increasing inefficiency.

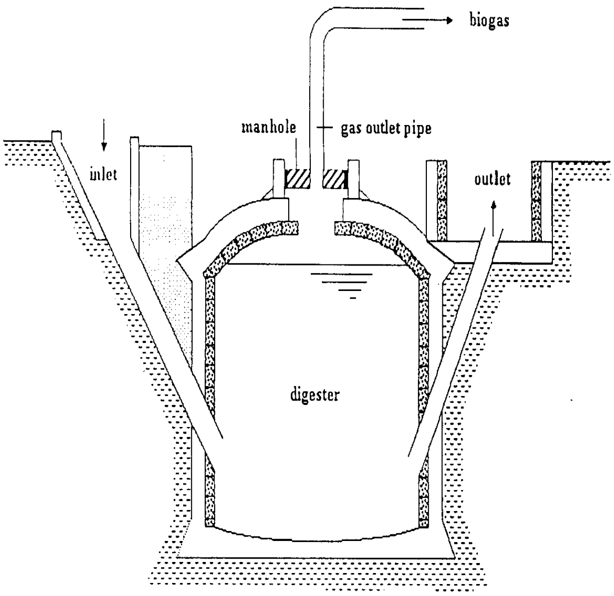


Figure 2.1: Fixed dome digester, Chinese type, **(Plochl and Heierman, 2006)**

Slurry, dung and night soil are added through the inlet pipe (left), the digested slurry can be intermediately stored in the outlet pit from where it can be taken for fertilization. The gas is stored above the digesting slurry, because of the limited space the opening and the gas outlet pipe have to be sealed carefully. The digester can be build of different material e.g. clay for the outer wall and brick stones for the inner wall

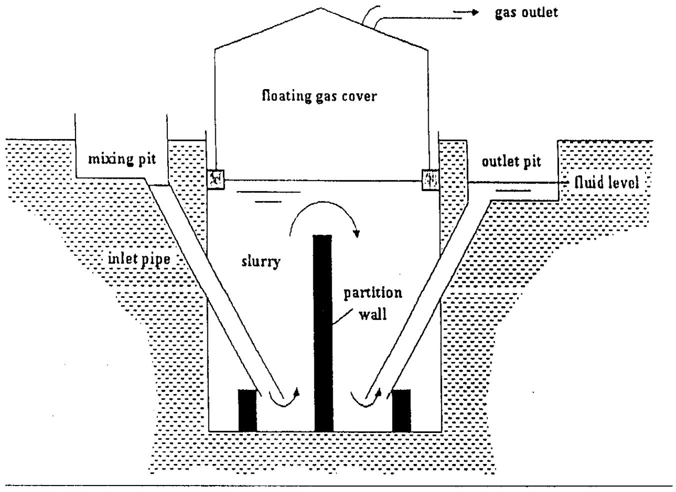


Figure 2.2: Floating cover digester, Indian type (Plochl **and Heiermann, 2006)**

Slurry, dung and night soil are collected in a mixing pit from where the slurry enters the digester through the inlet pipe. In the example shown here there is a partitioning wall between inlet and outlet. The digested slurry is collected in a outlet pit. In difference to the Chinese type the gas storage is a floating gas cover, which allows to enlarge or to diminish the space of gas storage depending on the amount of gas produced. As this gas cover is made of steel there is less risk of uncontrolled gas outflow

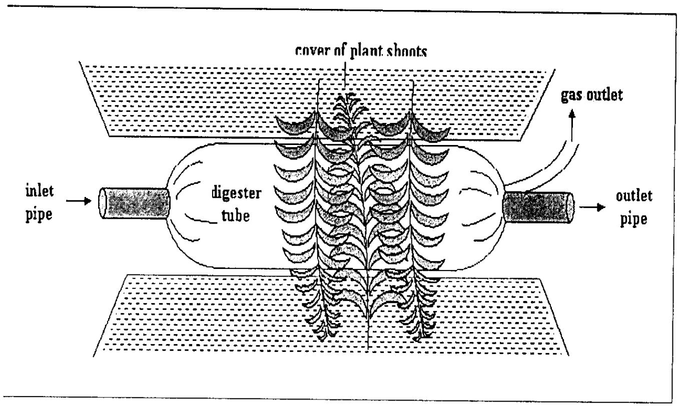


Figure 2. 3: Tube digester, **(Plochl and Heiermann, 2006)**

Slurry, dung and night soil enter the digester through the pipe on the one side. The substrate flows slowly through the tube while the biogas is formed and transferred through a separate pipe to its storage. Liquid digested slurry quits the digester through the pipe on the other side, whereas non-digested solids stay in the tube. The tube is usually covered with plant shoots like palm leaves or banana leaves to prevent a destruction of the foil.

They added that the digesters described have also considerable advantages such as they are inexpensive compared to sophisticated systems, can be built with locally available material, are easy to handle and do not have moving parts prone to failure

As well, they explained that In Europe digesters are mainly made of concrete with a steel skeleton or of steel. Their sizes vary between 500 and 3,000 m³, although there are still smaller units for small farms. The digesters have usually a cylindrical form standing upright in most cases. Not only because of the climatic conditions in Europe but also in order to control temperature conditions inside the digester tanks are equipped with an insulation and a heating system. Digesters are also equipped with a system to agitate or to stir the digesting slurry. There are many systems available to stir the system such as slow moving propellers stirring for longer periods, fast turning propellers switched on only for short periods using the biogas pressed through the slurry for agitation (Figure2.4). The biogas is collected either in an external plastic bag or in the space above the slurry covered with a folio.

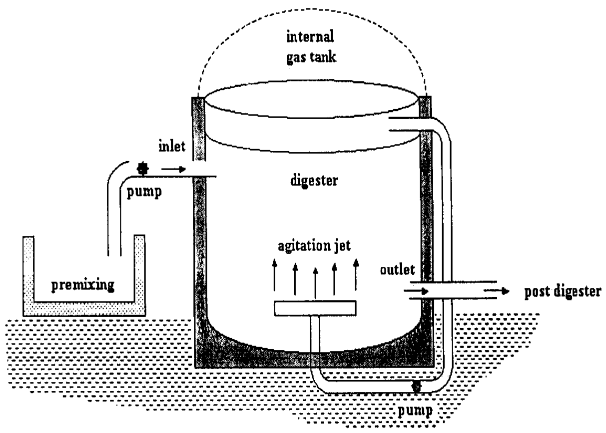


Figure 2.4: Digester for wet anaerobic digestion European example, **(Plochl and Heiermann, 2006)**

Slurry, organic waste, crop residues and energy crops are added to the mixing pit from where the feedstock is pumped into the digester tank. The slurry in the digester tank is stirred (not shown here) or agitated by pressurised biogas (shown here). Digested slurry is pumped from digester to post digesting or storage. The digester is usually made of reinforced concrete, the pipes are made of steel, inlet and outlet are controlled with pumps. Gas storage is often made of impermeable folios covering the digesters and storage tanks.

These digesters are flow through systems, which are fed several times per day. In the case of agricultural biogas plants the slurry comes directly from the stables or is collected in small storages before entering the digester. There is often a premixing pit where other feedstock can be added to the slurry. Sometimes the bulk feedstock can be added directly to the digester through an extra input system. The outlet works in parallel to the inlet. The digested slurry is often pumped to a post digester and/or to a storage tank. These storage tanks must have, by national legislation, the capacity to store the slurry for several, often six to nine, months. The average retention time in the main digester is usually around 28 days. But it can be easily demonstrated that, especially if crops and crop residues were added, biogas evaluation can be detected still after 90 days. Therefore, at many biogas plants it is worked with a post digester and/or the slurry storage tank is also covered with a foil, which works as gas storage. During post-digesting process and storage approximately 30% of the total biogas evaluation is captured. One of the trace gases in biogas is hydrogen sulphide, which converts during combustion to sulphurous acid. This acid leads to enhanced corrosion of the engines therefore hydrogen sulphide is removed from the biogas. This can be done either through controlled inflow of air to the digester where hydrogen sulphide or it is removed by external filters. In addition to the described technology of wet anaerobic digestion there is a growing interest in dry anaerobic digestion. The wet technology works with slurries of less than 12% dry matter content whereas the dry process can handle dry matter contents of 30% and more which would enable the user to use mainly crops and crop residues as feedstock. In the past dry anaerobic digestion was limited to waste processing biogas plants. Dry continuous-flow systems are very expensive and the income from waste disposal fees was necessary for an economic business. In recent times a number of batch technologies have been developed for dry anaerobic digestion which is less expensive in investment costs. But these are still lacking proof that they working with sufficient efficiency and acceptable operation costs.

2.1.3 Effect of temperature on fermentation

Mital (1996) mentioned that temperature of digester contents has a major effect on biogas yield. There are different temperature ranges during which mesophilic and thremophilic bacteria's are most active causing maximum gas yield. It is generally found that former are most active between the range 35 to 40° C and the latter between 50 to 60° C. When digester operates at a temperature of 15° C it takes nearly a year for the digestion cycle to complete whereas if the temperature is around 35° C ,cycle can be easily completed in less than a month's time or so. When digester temperature is say 25° C, it takes about 50 days for digestion of cattle wastes to complete whereas, if the temperature, ranges between 32 to 38°C, digestion is generally complete within 28 days

Zupancic and Ros (2003) investigated the heat and energy requirements thermophilic anaerobic sludge digestion .They concluded that the thermophilic sludge digestion is much faster than mesophilic . This means that thermophilic digesters would be only up to 30% of the size of mesophilic digesters. The major part the heat requirement in thermophilic sludge digestion is inflow sludge heating .They used a well insulated digester to minimize the heat loss. These heat losses of the sludge digester make up only 2 to 8% of the heat requirements. This means the digester size influences the heat requirements very little. If there are several stages of thermophilic sludge digestion, every stage brings only 2 to 8% more heat demand, but generally much better sludge digestion .They added also that if thermophilic anaerobic sludge digestion is compared to the mesophilic process, it is obvious that the thermophilic one is much faster. In less than 10 days hydraulic retention time (HRT) the same levels of volatile suspended solids (VSS) removal can be achieved, while in the mesophilic process it takes 30-40 days.

2.1.4 Effect of mixing on fermentation process:

Mixing greatly helps to ensure intimate contact between micro-organisms which leads to improve fermentation efficiency **(Mital 1996).**

EL-Hadidi (1999) found that the suitable mechanical mixing operations may be obtained by using the stirring shaft equipped with upper-most and lower-most impellers, 15 min./4 h mixing duration and interval at 60 r.p.m. mixing speed of stirring shaft. He explained that the fermenting materials during fermentation process settles into three layers; the top layer formed of scum with a high content of fresh material , the middle layer composed of a clear fermented material containing little solids, while the bottom layer containing sediment and low in fresh material. The digesting materials in this lower layer are under a high hydrostatic pressure and therefore, the produced gas is dissolved in the fermenting liquid and is not easily uptaking so, mixing process will help to achieve an almost uniform distribution of fresh material and microbes.

Karim et al. (2005) indicated that the mixing did not improve the performance of the digesters with more dilute 5% manure. As both unmixed and mixed digesters energy input of 8W per m^3 volume performed the same under the studied conditions. Thus, there was no difference in the performance of digesters fed with 5% manure slurry and mixed by different modes of mixing, including biogas recirculation, impeller mixing, and slurry recirculation. However, the effect of mixing and the mode of mixing at constant energy input of 8W per m^3 volume became prominent when digesters were fed with thicker manure slurry 10%. With this feed the unmixed digester produced the least biogas .The digesters fed with 10% manure slurry and mixed by slurry recirculation, impeller mixing and biogas recirculation produced approximately 29%, 22% and 15% more biogas than the unmixed digester.

2.1.5 Effect of pre-treatment on fermentation process

Sharma et al. (1988) investigated the effect of particle size of seven agricultural and forest residues used as feedstock for biogas generation through anaerobic digestion were investigated in batch digesters at 37° C. Out of five particle sizes (0.088, 0.40, 1.0, 6.0 and 30.0 mm), maximum quantity of biogas was produced from raw materials of 0.088 and 0.40 mm particles. For succulent materials such as leaves, large particles could be used. However, for other materials such as straws, large particles could decrease the gas production more effectively compared to those of leaves. Methane content of biogas was ranged from 67 to 73% for all materials except for straws which were around 60%. The results support the concept that a physical pretreatment such as grinding could significantly reduce the volume of digester required, without decreasing biogas production.

Day et al. (1990) reported that laboratory results of anaerobic digestion of fresh and dry dairy manure showed that the methane yields, based on m^3 CH_4 / kg volatile solids fed, from fresh and dry manure were the same statistically (a = 0.05). However, fresh manure produced a greater total volume of methane

thane dry manure when the loss organic materials during drying were taken into account.

Mital (1996) indicated that for plant owners who own cattle shed, it is advisable that they should construct a drain for collecting urine and allowing it to soak waste materials to be used as feed for biogas plants after sun-drying. In the same way, urine available from human-beings can also be gainfully utilized by making it to drain into pits that can hold soakable waste materials. Use of urine-soaked waste materials is particularly advantageous during winter months when gas production otherwise is low.

Al Aghbari (1998) indicated that the gas production from non-treated crop residues was poor. Whereas the gas yield can be improved by either pretreating crops residues by anaerobic fermentation or by combining the crop residues with the dairy manure prior to loading in the digester.

Shyam (2000) reported that the pretreatment of dry leaves of agricultural residues, i.e. soaking the leaves with the effluent slurry and 2% and 5% sodium hydroxide solution for a period of one week increased the gas yield by about 15% and also hastened the process as major part of the gas was collected within 7-8 weeks as compared to 10-11 weeks for untreated leaves.

Mshandete et al. (2005) showed that decreasing the particle size of fibrous plant material enhances anaerobic digestion process .Total fibre degradation increased from 31% to 70% for the 2 mm fibres , compared to untreated sisal fibres .Furthermore, the results confirmed that methane yield was inversely proportional to particle size. Methane yield increased by 23% when the fibres were cut to 2 mm size and reached 0.22 m^3 CH4/Kg volatile solids, compared to 0.18 m^3 CH4/kg volatile solids for untreated fibres.

Ganesh et al (2005) suggested a procedure for extracting volatile fatty acids (VFAs) from water hyacinth (WH) using simple and inexpensive equipment of the type commonly available in the rural households of the third world countries. The VFAs that extracted were used as feed supplement in caw dung-fed floating-dome biogas digesters. The VFA extraction was based on aerobic/facultative degradation of water hyacinth and significant quantities were extracted from each WH charge daily for up to 6 days. When caw-dung slurry was fortified with the VFAs and fed to a conventional biogas digester, it yielded about 22% higher quantity of biogas per unit feed than was obtained from equivalent mass (dry weight basis) of the unfortified cow-dung slurry.

Siegert and Banks (2005) stated that the presence of increasing concentrations of VFA in a batch anaerobic reactor system were shown to have a differential effect on the metabolically distinct phases of hydrolysis, acidogenesis and biogas production associated with the anaerobic digestion process. Independently of the system PH, VFA caused the inhibition of the cellulolytic activity at concentrations ≥2 g $L^{-1,}$ and therefore of the rate of cellulose hydrolysis. The fermentation of glucose was slightly inhibited at VFA concentrations above 4 g L^{-1}. The inhibitory effect on the production of biogas and also the methane to carbon dioxide ratio was evident about 6 g^{-1} VFA in the initial mixture when used as the sole substrate. In combination with paper as primary substrate, biogas production due to the paper was more than halved above 1 gL^{-1} initial VFA, indicating inhibition of the hydrolysis process. Where glucose was the primary substrate biogas production was more than halved above 8 g L^{-1} which indicated that the fermentation was less sensitive to inhibition caused by VFA.

Neczaj and lach (2006) observed that the ultrasonic pretreatment enhances the subsequent anaerobic digestion resulting in a better degradation of volatile solid and increased production of biogas. Volatile solids concentration in the effluent of the digester fed with disintegrated sludge were 31% less than in the conventional process. Total biogas production was almost two time higher for disintegrated waste activated sludge.

2.1.6 Effect of hydraulic retention time (HRT) on fermentation process:

Hall et al. (1985) illustrated for cattle dung material over a 70 days batch digestion the TS reduction was found to be 26.5% and the VS reduction 31.2%. During this time whereas the cellulose content of the material was reduced by 57.2%. In batch digestions lasting 40 days, reduction percentage of 22.7%, 25.7% and 31.5% were found for TS, VS and the corresponding cellulose respectively.

Lo and Liao (1985) indicated that the fixed-film reactors fed with screened slurry performed better than the conventional reactors receiving the same feed material. The fixed-film reactor could be operated at HRT as short as 1 h with high gas production whereas the conventional design could only maintain low gas output at hydraulic retention times of less than eight, six or two days at temperatures of 22° C, 35° C, or 55° C, respectively.

Sayed-Ahmed and Huzayyin (1986) stated that the gas production during the first five days did not contain any methane and was mainly carbon dioxide, produced from the activity of the aerobic micro-organisms. After the oxygen in the container was consumed, anaerobic reaction started on the eighth day and combustible gas generation started.

El-Awady et al. (1988) reported that biogas from chicken manure for 30 days of batch fermentation under dilution ratio of 1/1 (water/manure) showed that a detention time of approximately 15 days is sufficient to obtain 65%of the available biogas. The production rate of biogas was 0.026 m^3/m^3 per day. They added that for 110 days batches fermentation and variable water dilutions, a detention time of 80 days was found sufficient to obtain 87% of available biogas. The production rate of biogas from 50 batch feeding was 0.02 m^3/m^3 per day.

Molnar (1988) indicated that for a batch fermenter with more efficient insulation and fed with an agricultural waste mixture of 25% beef cattle manure and 75% corn post-harvest residues, gas production rates varied between 2.53 and 0.7 m^3 m^{-3}(from fermentr volume) day^{-1} during the 30 days retention time. The volatile solids (VS) conversion rate was approximately 42%.

Mallik et al. (1990) illustrated that with water hyacinth (WH) mixing with cattle dong and poultry excreta and hard wood sawdust maximum gas production was achieved with 15 days, thereafter it gradually declined and he cited from (**Deshpande et al. 1979)** use of WH as an additive to cattle dung (CD) in biogas plant enhances volatile fatty acids in fermentation slurry because of its quick hydrolysis and fermentation .

EL-Hadidi (1994) reported that the optimum retention time for poultry wastes was found to be 30 days in the mesophilic range 20° C to 40° C, where as the PH (hydrogen ion concentration) of the medium was maintained at 6 to 8. and he cited from **(GTZ 1985)** which stated that for the hygienic consideration a retention period of 30 day is sufficient to obtain a kill rate over 95% for the commonly pathogens and ova during anaerobic digestion.

Ahmed et al. (1999) indicated that the gas production in the continues reactors began almost immediately after the initiation of the experimental run throughout one day and escalated rapidly thereafter reaching a maximum at some time ranging between 15 and 30 days. They added that the rate of biogas production was affected by changing HRT , where the rate of biogas production decreases with the increasing of HRT, while that the biogas yield increased with the increase in HRT.

Chanakya et al. (1999) found that 40-60% of volatile solids (VS) destruction occurs with most biomass feedstocks at residence time of 20-30 days.

Shoeb and Singh (2000) reported that gas production rate from water hyacinth is higher as compared to pure caw dung slurry. However, the time period for attaining the maximum production rate is longer about 40 to 50 days for water hyacinth as compared to caw dung 20 – 30 days at 40^{0} C . This is due to the fact that bacteria needed for biogas production in the case of water hyacinth takes a longer time period to grow whereas in ruminants waste such as caw dung pathogens are already present and bacterial growth takes a little time for biogas production.

El Ashry (2001) illustrated that the daily biogas production throughout the fermentation of 4 treatments (rice straw, maize stalks, cotton stalks and bagasse in digesters) biogas generation that the different residues differed in the detention period (the initial period needed to generate flammable gas).The detention period were 43, 40, 36 and 50 days for rice straw, maize stalk, cotton stalks and bagasse respectively. Production of flammable gas started earlier in case of fibrous residues e.g. cotton stalks and maize stalks respectively. Bagasse became acid at the beginning of digestion, the generation of biogas started therefore much later thane other crop residues. The high content of sugars in bagasse and the slow growth of methane bacteria are responsible for the quick production of acids which accumulate when slow conversions to methane occur.

Ostrem et al. (2004) reported that the retention time is determined by the average time in takes for organic material to digest completely as measured by the chemical and biological oxygen demand (COD and BOD) of exiting effluent. Speeding up the process will make the process more efficient. Microorganisms that consume organic material control the rate of digestion that determines the time for which the substrate must remain in the digestion chamber, and therefore the size and cost of the digester.

Ostrem et al. (2004) cited from (Davis **and Cornwell 1998)** reported that in the anaerobic digestion (AD) process technology, two types of reactors are used the batch process and the continues process. In the batch process, the substrate is put in the reactor at the beginning of the degradation period and sealed for the duration of digestion. All of the reaction stage occur more or less consecutively and therefore the production of biogas follows a bell curve. Retention time ranges from 30-60 days and only about 1/3 of the tank volume is used for active digestion. The disadvantage of this type of system is the large tank volume required due to the long retention time. The low organic loading rate and the formation of a scum layer. In the continuous process, fresh substrate is added and an equal amount of effluent is removed continuously.

De la Rubia et al (2006) stated that the retention time has a considerable effect on the population levels of methanogens and on the composition of fermentative products volatile fatty acids (VFA). The chemical oxygen demand (COD) mass balance indicates that COD used for methane generation increased when solid retention time (SRT) decreased or when the influent organic loading rate increased. This implies that the amount of COD used in the anabolism route decreased with SRT due the microbial population being adapted under new operational conditions and more COD being used to generate methane.

2.1.7 Effect of C/N ratio on fermentation:

Mital (1996) reported that the carbon necessary energy to micro-organisms for their sustenance whereas nitrogen helps in building their cell structures. Depending upon relative richnesses in carbon or nitrogen content, feed materials can be classified as nitrogen-rich or carbon-rich materials. It is generally found that during digestion micro-organisms utilize carbon 25 to 30 times faster than nitrogen which in other words means that carbon content in feedstock should be 25 to 30 times more than nitrogen. To meet this requirement constituents of feedstock are kept in a manner so as to ensure a C:N ratio of 25 to 30 :1, and concentration of dry matter as 7 to 10 %. High C/N ratio means that nitrogen will be exhausted earlier than carbon. Conversely a low C/N ratio or too much nitrogen in relation to carbon results in high ammonium concentrations which may become toxic to anaerobic bacteria.

Parawira et al. (2004) reported that the potato waste and sugar beet leaves were co-digested successfully resulting in improved methane yield and accumulated methane production compared with separate digestion of the substrates . They cited from (**Kayhanian and Hardy 1994)** and (**Nyns 1986)** reported that the C:N ratio of the co-digested potato waste and sugar beet leaves, which ranged between 16 and 28, are within the values required for stable anaerobic digestion of organic waste.

2.1.8 Effect of total solids concentration (TS) on fermentation Process:

Hall et al. (1985) illustrated that the total solids reduction of 26.5% over 70 days is similar to that of **(Hills 1980)** who obtained a 34.6% reduction over a 100 day batch digestion of dairy manure. The VS reduction was found to be 31.1% compared with a 36.3% reduction obtained in a 140 day batch digestion conducted by **(Wong-Chong 1975).**

Hatem (1988) showed the comparative quantities of biogas obtainable from digestion of various wastes and crops at a typical loading concentration of 5% total solids. For a given material at a particular temperature , the quantity of biogas produced per Kilogram of dry matter decreased as the loading concentration increased.

Mital (1996) indicated that the for optimum gas yield through anaerobic fermentation, normally 8 to 10 per cent TS in feedstock is desired. This is achieved by making slurry of fresh cattle dung in water at the ratio of 1:1.

EL-Bakhshwan (1998) indicated that the digestion of 5% and 10% TS the rate of biogas production (V/V day) was increased at 10% than that at 5% TS. While the productivity of biogas (L/Kg TS added /day) decreased.

Shyam (2000) cited from (**Pathak et al. 1985)** studied the effect of initial total solid concentration (TSC) in anaerobic fermentation of cattle dung and cattle dung-rice straw mixture in batch-type laboratory digesters at room temperature that varied between 26 and 32° C. It was seen that a larger percentage of the solids was converted when the initial TSC was high. Consequently, the gas yield was found to increase with the TSC of the slurry. A mixture of cattle dung and chopped rice straw in the ratio of 1:2 (on dry mass basis) and containing 15.2% initial TSC performed better than cattle-dung slurry in total solids (TS) conversion and gas production. This might be attributed mainly to a higher percentage of degradable solids in the dung and rice-straw mixture (cellulose + hemicellulose 53.1% of TS as against 47% in the dung). He also indicated that the gas production was highest (0.228 m^3/ Kg TS charged) for 2:1 mixture of cattle dung and dry leaves (W/W) at initial total solids concentration(TSC) of 20%. The gas production was reduced significantly for high initial TSC of around 40% and was negligible for TSC above 40%. At 20% TSC, the rate of conversion of cellulose and hemicellulose was reported to be higher 34% to 40% and faster as major part was degraded during the first four to five weeks

Parawira et al. (2006) indicated that the methane yield increased with increasing organic loading rate up to 0.231 CH_4/g COD degraded in the USAB (upflow anaerobic sludge blanket) reactor and 0.161 CH_4/g COD degraded in the APB(anaerobic packed-bed) reactor. The UASB could be run at a higher organic loading rate than the APB reactor and achieved higher methane yield.

2.1.9 Effect of inhibitory Factors on fermentation process:

Mital (1996) indicated that the when volatile acid concentration reaches a value of 200 p p m, or ammoniacal nitrogen concentration exceeds a value of 1500 p p m, microbial activity is greatly retarded. Variety of materials act as inhibitory factors to the fermentation process for instance, presence of certain metals such as copper in waste material act toxic during anaerobic digestion. Some of the commonly recognized toxic materials include common alkali and alkaline-earth cations such as sodium, potassium, calcium, and magnesium. Traces of pesticides such as DDT and chlorinated hydrocarbons which usually accompany crop residues as feed tend to produce toxic effect during anaerobic fermentation. For minimizing toxicity, dilution with water or addition of certain non-toxic materials to substrate is recommended.

2.1.10 ffect of enriched seeding bacteria on fermentation Process:

Mital (1996) indicated that for starting anaerobic fermentation, it is often necessary to introduce enriched seeding into the digester for starting the process. As it is known, anaerobic fermentation proceeds with the help of acid-forming and methane-forming bacteria. Among these two groups of bacteria, the first category of acid formers is more abundant whereas the second category of methane formers is less abundant, more fastidious, and more susceptible to adverse environmental changes. In starting –up a biogas plant, it is a common practice to seed it with adequate population of both acid-forming and methane-forming bacteria. Generally digested sludge from a biogas plant, actively digesting sludge from a municipal digester, material from a well-rotted manure pit, or caw-dung slurry are used as seed.

2.1.11 Biogas storage:

AL-Aghbari (1998) added that the relative amount of CO_2 has a dramatic influence on the lower heating value of biogas. The critical point of CH_4 is negative 82.1° C; above this temperature it cannot be liquefied.

Kapdi et al. (2005) reported that biogas is mainly used for cooking purposes. To get full potential of biogas, need emerges for its commercialization by making it transportable. Therefore biogas scrubbing and compression at high pressure for storage in cylinders are essential. On of the easiest and cheapest method involves the use of pressurized water as an absorbent. The raw biogas is compressed and fed into a packed bed column from bottom; pressurized water is sprayed from the top. The absorption process is, thus a counter-current one. This dissolves CO_2 as well as H_2 S in water, which are collected at bottom of the tower. The water could be recycled to the first scrubbing tower.

2.1.12 Stages of anaerobic digestion:

EL-Hadidi (1994) illustrates that the gas produced at different time intervals which indicates to the gas production was started at the fourteenth day and continued till the 28th day, after this time the gas production was started to decrease, which may be due to the consumption of the substrate available for biodegradation. This result obviates that when it is recommended to operate in a continuous fashion the food / microorganism ratio must be maintained at the value obtained at this time which controls the quantities to be fed to fermentor , the portion of the recycled sludge and the quantity of wasted sludge.

Ateya et al. (1997) indicated that three gas production stages were observed and could be explained according to the dynamic nature of the anaerobic process itself. The first stage which started on the 12th day and continued through the 20th day may be considered as the bacteria-reproduction state where the methanogenic bacteria started to reproduce, and conversion of the substrate into gas was very low. The second stage which started on the 21st day and continued to about the 29th day may be explained by the fact that the numbers of bacteria involved in the digestion process became greater while the nutrients available to them were quite enough and in excess. Such a condition is conducive for gas production, and fact, the gas production started to increase during this period. The third and last stage from about the 30th to the 38th day was characterized by maximum gas production at almost constant rate, it was clear that this stage constitutes the steady-state of operation of this digester. It is reasonable to assume that during this stage the amount of available nutrients was in enough to satisfy the needs of the larger numbers of bacteria within the digester. This was not the case in the last days during which the digester experienced deficiency of nutrients which led to the decline and eventually stopping gas production.

Al-Masri (2001) mentioned that four stages were observed during the gas generation and could be correlated with the four anaerobic fermentation stages of the organic matter hydrolysis, acetogenesis, premethanogenesis (outset of methanogenesis) and methanogenesis. The results indicated that the highest amount of gas production was achieved within 29-40 days.

Ostrem at el. (2004) cited from (**Themelis and Verma 2004)** indicated that the typical reactions of anaerobic digestion can be described as follows :

(1) $$C_6H_{12}O_6 \longrightarrow 2C_2H_5OH + 2CO_2$$

(Organic compound) (Ethanol) (Carbon dioxide)

(2) $$2CH_5OH + CO_2 \longrightarrow CH_4 + 2CH_3COOH$$

(Ethanol) (Carbon dioxide) (Methane) (Acetic acid)

(3) $$CH_3COOH \longrightarrow CH_4 + CO_2$$

(Acetic acid) (Methane) (Carbon dioxide)

(4) $$CO_2 + 4H_2 \longrightarrow CH_4 + 2H_2O$$

(Carbon dioxide) (Hydrogen) (Methane) (Water)

Demirer and Chen (2005) used a two-phase reactor at a SRT/HRT (solids retention time / hydraulic retention time) of 10 days (2 days acidogenic and 8 days methanogenic) for anaerobic digestion of dairy manure. Their results indicated that there are 50 and 67% higher biogas production or volume reduction at OLR (organic loading rates) of 5 and 6 g VS/L day respectively, compared to a conventional one-phase configuration with SRT/HRT of 20 days. The two-phase reactor made an elevated OLR of 12.6 g VS/L day possible which was not achievable for the conventional one-phase configuration. Consequently signification cost savings due to both superior performance and reduced volume requirements.

2.1.13 Biogas production and analysis:

Hatem (1988) indicated that the lowest yield of biogas was obtained from the digestion of cattle manures, as might be expected because the bacteria in the ruminant's stomach consume a substantial portion of the digestible matter in the original plant material. Poultry manure at the same loading concentration gave considerably more biogas per Kilogram of total solids, than cattle manure. This possibly reflect the less effective digestive capability of the hen, and also the difference in diet, of the various crops tested ,maize was capable of producing the highest quantity of biogas eventually reaching 646 L/kg total solids (dry matter) after 40 days. All the crops produced at least twice as much biogas as did cattle manure, showing that the net energy production from digestion of crops would be much higher than from digestion of manure.

Shoeb and Singh (2000) reported that the total amount of gas production from water hyacinth is about one and a-half time higher than the cow dung per gm volatile solid. A blend of water hyacinth and caw dung in the ratio of 2:3 by weight is most suitable for biogas production. The rate of production of biogas from water hyacinth is higher as compared to cow dung slurry. However the fermentation process takes a longer time period in the case of water hyacinth. The kinetic studies performed with water hyacinth + inooculum show that gas production rate increases twelve times in a very short period of five days in comparison to cow dung +water hyacinth from 20 to 40 days systems.

El Ashry (2001) showed that the productivity of biogas differ according to the type of residue fermented. Maize stalks gave the highest biogas productivity followed by cotton straw, while bagasse and rice straw gave low productivity. The average of CH_4 content was about 60%. Generation of methane started after few days of fermentation and began to increase gradually to reach its average percentage. The highest value of CH_4 recorded for cotton stalks 64.0% followed by bagasse 62.7%, rice straw 59.2% and maize stalks 58.9%.

Helmy et al. (2003) mentioned that the cattle dung was gave higher production of biogas. While, cotton stalks was lowest, the rice straw gave higher biogas production at fermentation process time ranged between 30 to 40 days. While, at fermentation time from 10 to 30 days and more than 40 days fermentation time, the biogas production will be low. The proper temperature ranged between 30 to 40^{o} C at this range the biogas production was higher than less than 10^{o} C and more than 40^{o} C. The proper percentages between total solid and water was 1:1, at this percentage gave high biogas production. While, by increasing percentage of water, the biogas production decreased. They showed that the expectant of production residual quantity will be 1152 m3 biogas per year. So, the expectant production of biogas will be 217 010 429 m3, this production need to about 188372 units with volumetric capacity of 10 m3 or 37675 units with volumetric capacity of 50 m3

2.1.14 Biogas energy benefit:

El-Awady et al. (1988) cited for **(FAO, 1978)** that any internal combustion engine can be adapted to use biogas. A diesel engine was fueled by connecting the gas to the air intake and closing the diesel oil feed. It was reported that one cubic meter of gas was enough to run an internal combustion engine one h.p or 0.75kw for 2 hours, a three ton truck for 2 Km distance, to light a lamp 60 to 100 watts for 6 hours and to generate one kw of electricity .

EL-Shimi and Badawi. (1993) stated that the calorific value of biogas 23.08 MJ/m3 at efficiency of 60% and the kerosene is 38.19 MJ/l at efficiency 60%. So, one cub. Meter of biogas is equivalent to 0.6 litter of kerosene. The biogas production as a new and renewable energy source could cover the domestic energy need for rural family consists of 5 to 8 persons. They added the sludge obtained from bio fermentation process contains high concentration of plant nutrients and organic matter. Its application at the rate equivalent to traditional chemical fertilizer increased the yield of maize 35.7%, wheat 12.5%, rice 5.9%, broad beans 6.6%, cotton 27.5%, carrots 14.4% and spinach 20.6%

EL-Hadidi (1994) illustrated that the energy obtained from the produced gas is sufficient to sustain the needs of the farm for heating, lighting and other mechanical operations. The digested sludge can be used as a free pathogenic fertilizer with high fertilizing value or as animal fodder additive.

Goodrich et al. (2005) stated that 800 cows at the farm produce enough methane to generate about 2900 kwh per day of electricity, 1500 kwh of which is used on the farm. The remainder is sold as "Green Energy" and marketed to consumers who wish to use electricity generated from renewable sources

Hadi and Akiyama. (2006) studied the possibility of hydrogen production from biogas using hot slag. They conducted a study in which decomposition rate of CO2-CH4 in a packed bed of granulated slag was measured at constant flow-rate and pressure. The molten slag discharged at high temperature over 1700 K from smelting industries such as steelmaking or municipal waste incineration . It has enough potential for replacing energy required for hydrogen production due to the catalytic steam reforming or carbon decomposition of hydrocarbon.

2.1.15Effect of atmospheric pressure on fermentation process:

Alvarez et al. (2006) illustrated that somewhat surprisingly, the pressure effect in the range studied 495 to 760 mm Hg was not significant. Although, the effect could possibly be found significant in an extended study, the effect is nevertheless small, and low pressure will not negatively affect the biogasification of the manures in a small scale distributed process on the Altiplano.

2.1.16 Characteristics of digestion of plant matter:

Hatem (1988) illustrated that during anaerobic digestion of manures, the solids settle to the bottom unless regularly mixed. Lighter materials such as bedding straw float to the surface and form a scum. However, during digestion of plant matter, the fresh material is floated and will only sink to the bottom as it is digested. As a result, the most active area of digestion in a digester using plant matter is the top third, whilst in digesters using manures it is the bottom third. For a digester fed on plant matter the mixer need to be placed near the top and it appears likely that mixing will be more difficult than in manure digesters.

2.1.17 Effect of loading rate on fermentation process:

EL-Shimi et al. (1992) cited from **(Alaa El Din et al. 1984)** that the production rate of biogas increased by increasing the loading rate of digesting materials; the maximum production rate was at 2.6 Kg VS / m^3 / day of cattle manure

Parawira et al. (2006) indicated that the methane yield increased with increasing organic loading rate up to 0.231 CH_4/g COD degraded in the upflow anaerobic sludge blanket (USAB) reactor and 0.161 CH_4/g COD degraded in the anaerobic packed-bed (APB) reactor. The UASB could be run at a higher organic loading rate than the APB reactor and achieved higher methane yield.

2.1.18 Effect cattle manure on fermentation:

Gunnarsson and Petersen (2005) cited by **(El-Shinnawi et al. 1989)** produced biogas from water hyacinth mixed with caw dung , and found the caw dung to provide enough microorganisms to serve as inoculums. The conclusion from these reports is that in developing countries it is probably better to not use costly pre-treatment and instead use a longer residence time

2.1.19 Biogas yield from crop residues:

Mital (1996) cited from experimental studies that conducted by(**Kalra and panwar 1986)** to investigate biodegradability of rice straw which caused biogas yield of 200 Litre / kg under batch digestion from experimental digesters of 190 litres capacity. Rice-husk did not undergo complete digestion following its high lignin content and unfavourable non-lignin carbon-to-nitrogen (C/N) ratio. A mixture of rice-straw and cattle dung in equal proportion on dry weight basis yielded 9.1 % more gas than rice-straw alone. He cited from **(Rahman et al. 1986)** the biogas yield in batch loaded laboratory digesters from rice-straw , sawdust and water-hyacinth with caw dung. Under identical conditions, rice-straw produced 310 liter biogas with 77.8% methane content, sawdust 144.8 liter and 62.28 % in ether content and water hyacinth 368 liter with 77.13 % (methane content).

Mahnert et al. (2005) cited by **(El Bassam, 1998)** reported that the value of a substrate in the biogas process depends on its potential as a high yield plant species and on the quality of the biogas produced, such as the achievable methane content. The most suitable plant species for the production of biogas are those which are rich in degradable carbohydrates, such as sugars, lipids and proteins, and poor hemicelluloses and lignin, which have a low biodegradability .Hence, to find the optimal crop species for anaerobic digestion is of particular interest. The conservation and storage of biomass is also a necessary factor for the quality, using the substrate continuously as feedstock for biogas production.

Mahnert et al. (2005) reported that at low organic loading rates (OLR), the biogas yield of a grass-slurry mixture is equivalent to the total sum of biogas from the proportionate single substrates. Therefore, the biogas yield from a mixture of grass and slurry can be calculated by the VS-biogas yield of grass and of slurry and the VS-portion of the grass in the mixture. The impact of OLR on the methane content is not distinctive, but seems to be substrate-specific. Also, the methane content decreased with increasing proportion of grass from 59-63% to 53-59%.

2.1.20 Effect of chemical properties of wastes on biogas yield:

Abdewahab, et al. (1994) shows heavy metals content (ug/l) in water body of El-hamol region as following:

Table (2.1) Annual average for heavy metal content (ug / L) in water. Samples from main Kharbiea drain as following:

copper	cadmium	zinc	lead	nickel	manganese	iron	cobalt
112.08	10.76	119.5	224.08	6.13	358.25	1445	54.25

Gunnarsson and Petersen (2005) cited by (**El-Shinnawi et al. 1989**) conducted trials with anaerobic digestion of agricultural waste. Rice straw, maize stalks, cotton stalks and water hyacinths mixed with cow dung were digested in different containers. The mixture of water hyacinth and cow dung was found to produce more biogas per kilogram VS added than maize and cotton stalks, but the total biogas production per kilogram DM added was lower for the water hyacinth .The low values for total gas production was probably mostly due to the high lignin content and low percentage of volatile solids in the water hyacinths

Gunnarsso and Petersen (2005) cited by **(Patel et al 1993)** found that the addition of metal ions: Fe^{3+} , Zn^{3+} , Ni^{2+} , Co^{2+} , and Cu^{2+} , will enhance gas production and increase the methane content in the produced gas and also result in better process stability. Water hyacinth from polluted water might already contain sufficient amount of heavy metals. **(Geeta et al. 1990)** reported increased biogas production when nickel was added to water hyacinth or a mixture of water hyacinth and cow dung.

Gunnarsso and Petersen (2005) cited by **(Chanakya et al. 1993)** found that water hyacinth has a high content of fermentable matter and therefore a high potential for biogas production, but the high lignin content can reduce the actual production. The low bulk density could result in large voids with poor compaction and low feed rates.

Wulf (2005) stated that biogas production strongly depends on the used substrates as proteins, fat, starch sugars and crude fibre (cf. ruminant nutrition). Difficult to degrade: cellulose, hemicellulose. Not degradable: lignin theoretical gas composition can be calculated from input substances

$C_a H_b O_c + (a - b/4 - c/2)\ H_2O \longrightarrow (a/2 + b/8 - c/4)\ CH4 + (A/2 - b/8 + c/4)\ CO_2$

Plochl and Heiermann. (2006) stated that the usefulness of a crop as feedstock for anaerobic digestion depends on its yield capacity compared to the effort for cultivation and on the quantity and the quality of the biogas produced, such as the methane content achievable. From this point of view, the most suitable plant species are those rich in easily degradable carbohydrates, such as sugar and protein matter and poor in hemicelluloses and lignin which have a low biodegradability. Furthermore, crops shall be easy to store to make them available for digestion all year round. Hence, the optimum harvest time as well as preservation and storage methods are of particular interest. Another aspect for suitability is determined by the means of cultivation and availability on the particular farm.

Amon et al. (2006) indicated that the methane production from organic substrates mainly depends on their content of substances that can be degraded to CH_4 and CO_2. Composition and biodegradability are key factors for the methane yield from energy crops and animal manures. Crude protein, crude fat, crude fiber, cellulose, hemi-cellulose, starch and sugar markedly influence methane formation.

2.2: Utilization of agricultural waste:

Uses of crop residues (including household fuel, building materials, feed and bedding, mushroom cultivation, pulp and chemicals). The recycling of crop residues (by leaving them to decay on the soil surface, incorporating them into soil, or using as mulches and compost), and crop residue burning .

Demirer and Chen (2005) stated that the anaerobic digestion (AD) of manure can offer substantial benefits, both economic and intangible, to animal feeding operators and surrounding communities, such as on-site energy generation , production of stable, liquid fertilizer and high quality solid soil amendment, reduction in odors, and reduction in ground and surface water contamination.

2.3 Types and quantities of agricultural waste :

There are numerous types and great quantities of agricultural wastes that belong to both plant and animal production .Major field crops represent about 40-50% of the agricultural waste. Another 25% of organic wastes can also be expected during the processors of producing food for human and animals **(Ministry of agriculture 2000).** On the other hand, the agricultural wastes reach about 23 million ton (23 Gg) per year. This quantity consists of straw, stalks, hay, tops and resultant of tress stripe. About 7 million ton (7 Gg) is used as an animal feed and about four million ton (4 Gg) are used as an organic fertilizer directly or after using it as a beddling under cattle's. The rest which is the 12 million ton (12 Gg) are of our concern since they always burned causing air pollution or stored on the houses roofs which is another problem can lead to fires and can make as a good medium for insects growth . Animal wastes reach about 12 million ton (12 Gg) per year .About 3 million ton (3 Gg) per year always are used to produce an organic fertilizer. The rest 9 million ton (9 Gg) are considered without benefit for the agricultural activity and causes pollution to the environment and sickness outbreaks between people and plants **(Ministry of Agriculture 2000).**

Shoeb and Singh (2000) reported that the water hyacinth under favorable conditions a growth rate as high as 17.5 metric tons of wet water hyacinth per hectare per day has been reported. Due to vegetative reproduction it spreads rapidly clogging drainage, ditches.

Helmy et al. (2003) reported the total quantity of different residues in Egypt the following table:

Table 2.2: Total quantity of different residues in Egypt including plants, animal residues.

Plant residues	Quantity, Tg/year	Animal residues	Quantity, Tg/year
Rice residual	3.80	Buffalo	32.3
Wheat straw	7.20	Caws	15.70
Corn residual	5.87	Sheep	3.15
Barley straw	0.14	Camel	0.15
Beans straw	0.52	Pigs	0.77
Fenug reek straw	0.02	Hors	2.08
Clover straw	0.15	Hen	0.21
Pea straw	0.03	Pigeon	0.03
Lupine straw	0.01	Duck	0.13
Cotton straw	1.37	Turky	0.01
Soybean straw	0.30	Rabbit	0.49
Sesame straw	0.86		
Sugar cane residual	4.60		
Peanut straw	0.04		
Sunflower	0.01		
Vegetables residual	4.93		
Fruit residual	1.57		
Total	31.42	Total	55.37

Source statistics of Agriculture, Ministry of Agriculture, (2002).

2.3.1 Transformation of agricultural wast into animal feed:

Hamad et al. (1994) reported that the ruminate animals, need a great quantity of the diets daily using agriculture roughages to feed them. They showed that there was a great interest aiming to decrease the animals need for grain in order to satisfy the demand for direct human consumption . Therefore, the researches tried to process the roughages to increase its availability of energy and other materials from lignocellulosic wastes such as chopping; grinding and compressing .The main purpose of this process is to increase the acceptability of the material to the animal feeding consequently increasing feed intake and to enhance the rate and extent of digestion. Chopping roughages increased the feed intake of dry matter (DM) (gram/day. head) for sheep the palatability of the sheep on chopped maize stalks was increased by 255% and 394% for screen of hole 50mm and 20mm respectively (diameter of hole outlet machine) as compared with unchopped ones . Feed intake (DM)gram /day/head was increased by 110% and 141% using screen of 50 and 20mm holes respectively from the chopped rice straw as compared with the unchopped. The sheep refused unchopped sugar cane bagasse and cotton stalks. The palatability of chopped roughages were increased by 382% ,480%for sugar cane bagasse and 379%,460% for cotton stalks using screen holes of 50,20mm respectively as compared with unchopped roughage . The greatest amount of DM intake gram/head day was gained from chopped maize stalks through screen holes of 20 mm, while the lowest amount gained from cotton stalks through 50mm screen holes .

Kholief (1996) reported that the animal production in the Egypt need more active work, in order to find new sources of food or to modify the usual ones country .Animal feed shortage in dry seasons is a common problem in the developing countries . This has been in the incentive for the serious efforts made in many countries in the third world to improve the animal feeding value through process from crop residues. Sugar beet become an important crop in Egypt , not only for sugar production ,but also for producing fodder. By mass, beet tops consists of about one third crown and two thirds leaves. The green mass of tops ranges for 75 to 80 percent of the mass of topped beets. Beet tops are fed mostly to cattle and sheep either ensiled, fresh or pellets from as cured in small piles in the field. Beet tops are palatable and nutritious for animals. Ruminants are able to utilize large quantities without injury .Beet tops contain about two-thirds of the digestible nutrients found in corn silage . The advantages of pelleting better keeping quality, homogeneity from the time of production up to offering to animal, more palatability for animals, pelleting for ruminants decreases the ratio of the acetate to propionate in the rumen and reducing shortage space.

2.3.2 Pyrolesis of agricultural waste :

Sdaka (1998) reported that biomass can be pyrolyzed in the absence of oxygen to produce combustible char, tar and gas. When saw dust is pyrolyzed , it produces more tar and gas than rice hull. By increasing the final temperature, the char weight fraction decreased sharply, while tar and gas weight fractions increased clearly. Heating tar, also, affected the weight fractions of char, tar and gas . The same effects were observed with the heating value. The residence time has a small effect on the weight fractions and heating value . The maximum weight fraction values of the tar and gas of 57% and 19% respectively were recorded at pyrolysis temperature of 600° C and heating rate of 60° C/min during pyrolysis of saw dust . The tar heating value reached its maximum of 9.5 and 7.5 MJ /Kg at the temperature of 600°C and heating rate of 60°C/ min for saw dust and rice hull, respectively.

3. MATERIALS AND METHODS

The main objective of the present study was to evaluate of biogas production from agricultural residues and water hyacinth mixed with cattle dung available in Rural Areas of Egypt. The contribution to know ledge pointed out from the present study plays a good role in spreading biogas production technology in rural areas of Egypt. On the other hand, it enhances the environment protection and introduces a significant source of nontraditional energy. The experimental system was manufactured and some preliminary experiments were done during the period of February to July 2005 to stand on the Suitable quantity of residues to work on. The main experimental work was carried out during the period of 30/8/2005 30/12/2006.

3.1: Materials:

3.1.1. Experimental biogas generation system:

The whole experimental system consists of four main units. The first is the biogas reactors which represent the main unit of the fermentation process. The second is the stirring unit required to enhance the fermentation process and increase efficiency of biogas generation for all treatments. The third is the heating system to save the required temperature level for mesophilic bacteria. Temperature control device was added for controlling it at the fixed required temperature for all treatments. The fourth is the gas collection system to collect and calibrate the generate biogas for all treatments.

a: Biogas reactors:

An experimental biogas generation system was fabricated at the workshops of Belqas and Met kamer city. It consists of ten cylindrical shape stainless steel Figure 3.1. Each one has gross dimensions of 19 cm diameter and 38 cm height that correspond 10.77 L gross value. The operating volume of the reactor was 8.5 L. The remainder volume after eliminating the volume of the submerged parts of the stirring system was left for generated gas to be gathered. The cover of the reactor was made of a circuitous stainless steel sheet plate of 24 cm diameter and 1 mm thickness it equipped with a hole as the outlet of the generated gas. The cover was secured to the reactor by means of seven steel brads Figure 3. 2. A rubber gasket was fitted between the cover and the vessel to provide a gas-tight seal. Each reactor was equipped with a mechanical stirrer. Figure 3 .3 Shows a schematic diagram of the experimental biogas generation system.

b: Stirring system:

Figure3.3 shows a mechanical stirring system consists of ten shafts each one serves a one reactor was used for stirring process to enhance the fermentation performance . Each stirring shaft has 37cm length and 5 mm diameter. The stirrer provided with two impellers at distance of 1cm and 15 cm from the bottom of the reactor. Top impeller has dimensions of 6 cm long , 3 cm wide , and 1 mm thickness. The reactors were arranged in two parallel rows as shown in Figure 3. 3. so that, two horizontal shaft equipped with five worm gears Figure 3.4. to transfer the power to the five vertical stirrers at each row. This offers a reduction in rotational speed of about 1: 28. A 0.25 kw electrical motor has 1400 rpm rotational speed was used as the power source for the stirring system through identical pulleys and belts as shown in Figure 3.5. Therefore, the stirring shafts rotate at 50 rpm. An electrical timer (DTD- 1440-2) was attached to the electric motor to control the mixing duration intervals at 15 min / 4 hours. (Recommended by **(El-hadidi, 1999),** Figure 3.6.

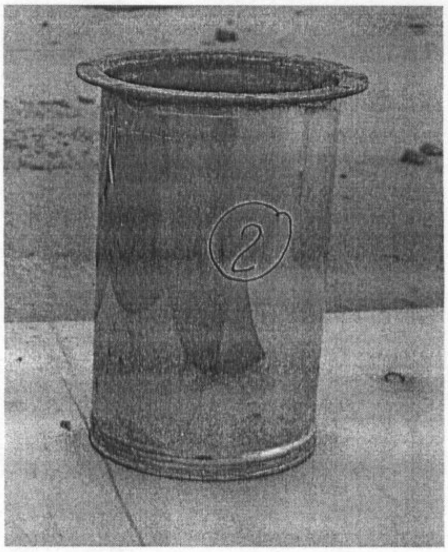


Figure 3. 1: A photo graph of an reactor.

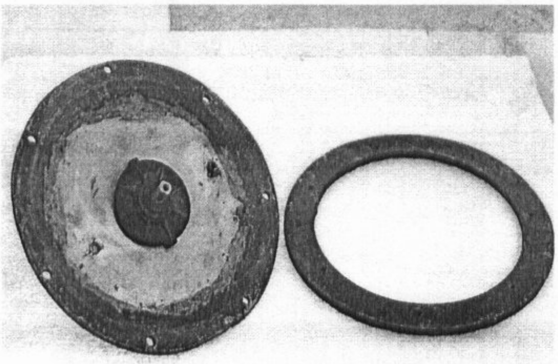
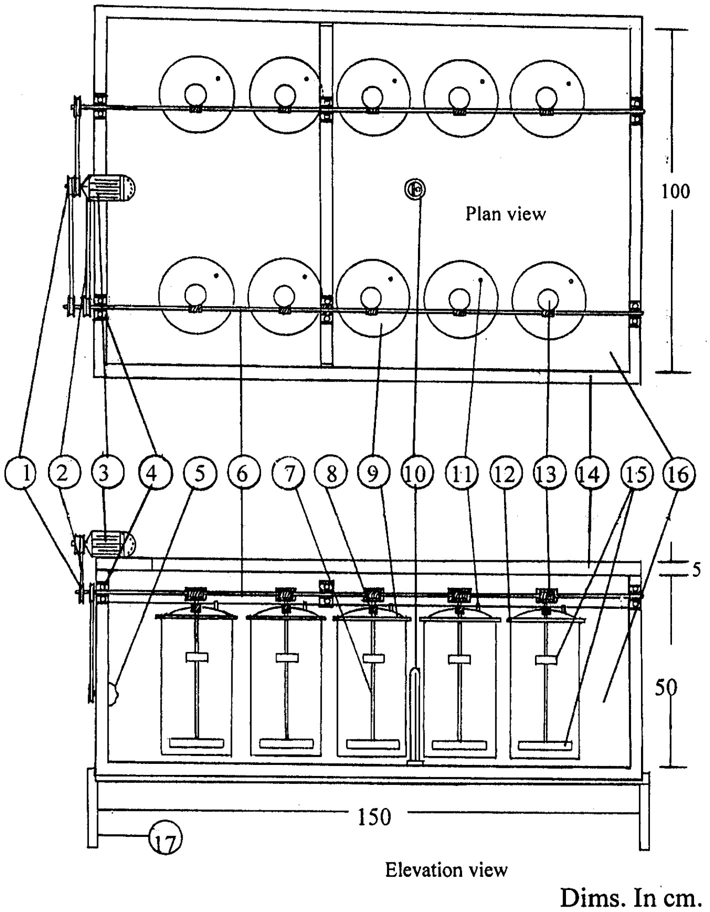


Figure 3. 2: A photograph of the reactor covers rubber scale



1- Pully. 2- V-belt. 3- Motor 4- Ball rollman 5- Fan.
6- Worm gear shift 7- Stirrer shaft 8- Gasket 9- Cover reactor
10- Electric hater 11- Outlet valve 12- Rubber gasket 13- Worm gear.
14- Insulation 15- Impellers 16- Water bath 17 -Stand

Figure 3.3: A schematic diagram of the experimental biogas generation

c: Heating system:

An insulated metal sheet water bath equipped with an electrical heater and temperature control device (thermostat) was used as the heating system. The reactors were placed in the water bath to keep the slurry temperature at level of 311± 2 K (38 ± 2 °C) **Mitol (1996)**. Water bath has gross dimensions of 1.5m length, 1m width and 0.5 m height with a water depth of 0.50 m .A fan fixed inside the water at height of 15 cm from the water bath bottom to agitate the water in order to maintain a homogeneous temperature distribution inside the water bath. Fan powered by the electrical motor through ploys and belts having a rotational speed reduction ratio of about 550 rpm Figure 3.7. Temperature data are recorded daily using 3 thermometer observations.

d: Gas collecting system:

The daily gas production was measured by the way of water displacement at the atmospheric pressure and room temperature. Ten Plastic jars Figure 3.8 each has 30 L capacity attached to reactors gas outlets by a flexible plastic tube were calibrated and used for biogas collection. Figure 3.8 indicates a photograph of a biogas collecting unit.

3.1.2: Collection of Raw materials and inoculums:

Three crop residues namely rice straw (*Oryza sativa)* Skah 4178 variety (RS) , maize stalks *(Zea mays*) national variety (M S) and cotton stalks (*Gossypvum barodense*) Geza 86 variety (C S) , in addition to water hyacinth (*Eichhornia crassipes)* (W H) were used as the principal raw material for generating biogas . The fresh cattle dung (C D) was used as a control treatment and as a mixing material with the studied residues. The source of cattle dung was cattle's from rural areas of Kafrelshiekh Governorate. Rice straw (RS), maize stalks (M S) and cotton stalks (CS) were collected as agricultural byproducts after harvesting the corresponding crops from rural areas of Kaferelshiekh Governorate as well. Water hyacinth was collected from a drain located in Al-Hamoul city at kaferelsheikh Governorate.

The raw materials were dried in the sun and chopped in traditional stationary thresher Figure 3.9 shows samples of the chopped raw materials.

Raw materials except cattle dung to be digested were kept in sealed plastic bags at the atmospheric temperature. Cattle dung were collected fresh for each experimental run. Anaerobically digested sewage sludge from a wastewater treatment plant of sugar beet company (Al-Hamoul) screened by I mm sieve. The liquid screened was used as an inoculum in the batches. Additional water for the batches was provided from water course.

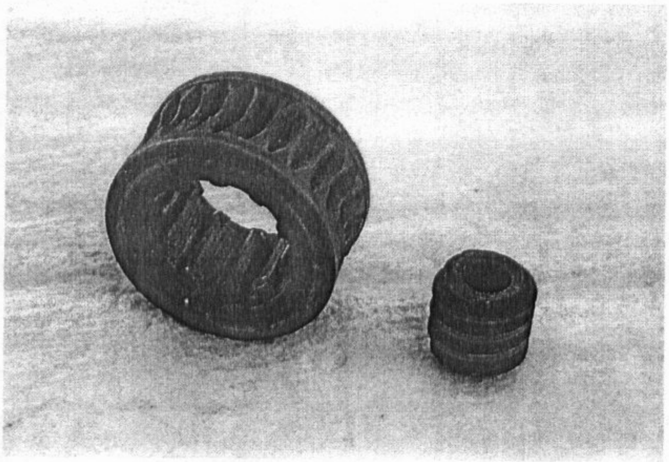


Figure 3. 4: A photograph of the worm gears assembly.

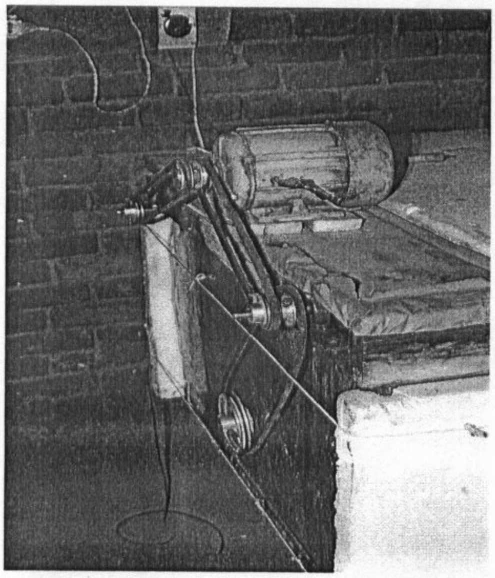


Figure 3.5: A photograph of motor and power transmission system.

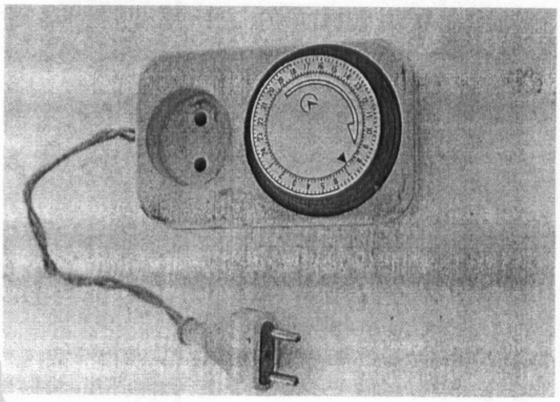


Figure 3.6: A photograph of timer (Model , DTD-1440-2.)

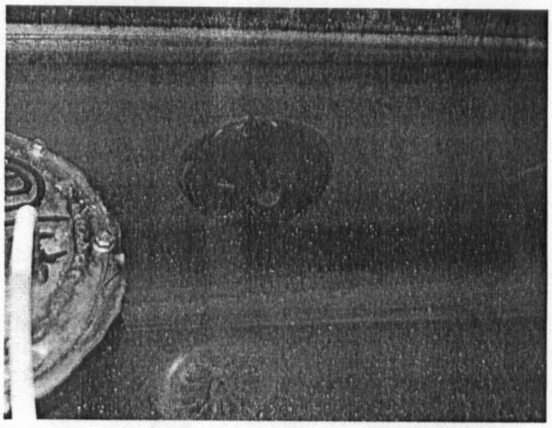


Figure 3.7: A photograph of the fan used to agitate the water .

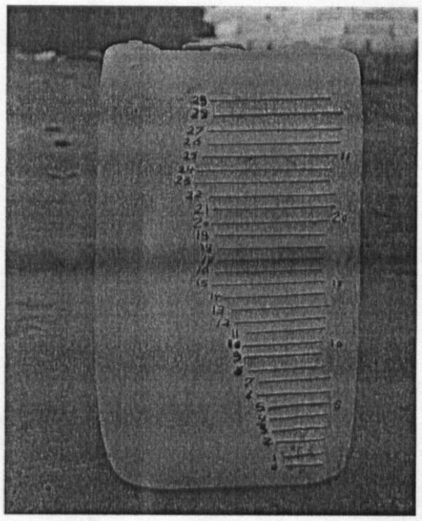
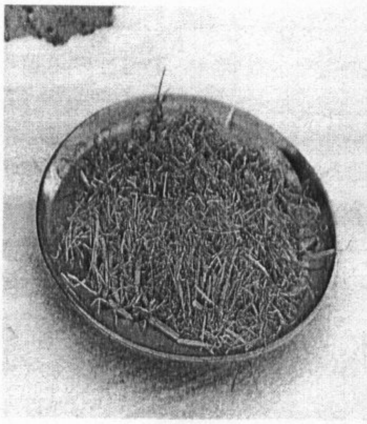
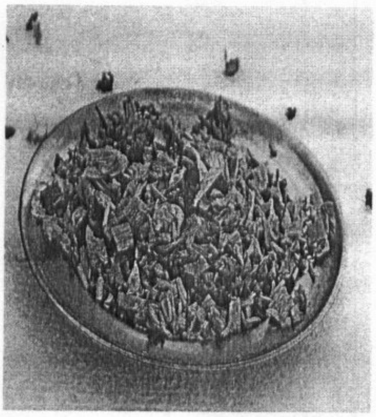


Figure 3.8: A photograph of a biogas collecting unit.

Cotton stalks



Rice straw



Water hyacinth

Maize stalks

Figure 3.9: A photograph of the four raw materials after shopping process.

3.1.3: Laboratory equipment:

a- Balance E.METTLER, Swiss made, max. mass 2000 gram, IDN=1 g

b- Electric oven, temperature Range from 30 to 300 °C.

c- Furnace maximum temperature measuring 1000° C.

d- Thermometers.

e- Timer, model, DTD-1440-2

f- Thermostat, (range from 10°C to 40oC.)

3.2: Methods:

3.2.1: Chemical analysis of raw materials:

Before starting the anaerobic digestion experiments, samples of the assigned substrates were analyzed according to standard methods as follows :

a: Total solids (TS):

A sample of the used raw material oven-dried at 105 °C for 24 hours and weighed, **(APHA, 1989)**.

b: Volatile solids (VS) :

The total solids obtained from the last step were placed in a muffle furnace at 550 ° C for 2 hours. The difference between the weights of the total solids and of the ash gave the volatile solids, **(APHA, 1989)**

c: Organic carbon (C):

Organic carbon was determined by Walkley and Black rapid titration method as out lined **Cottenie (1982).**

d: Total nitrogen (N):

Total nitrogen: the determination of plant nitrogen was carried out by the modified Kieldahl procedure according to **Cottenie (1982).**

Table 3.1: Chemical analyzed of raw material used for fed biogas digesters.

parameter	Total solids TS%	Volatile solids (VS) %from TS	Ash %from TS	Nitrogen (N) %from TS	Carbon (C) %from TS	C/N ratio
Cattle dung	18	83	17.00	1.70	42.50	25
Rice straw	95.14	71.14	28.86	0.714	38.30	53.64
Maize stalks	94.87	84.54	15.46	0.588	32.12	54.63
Cotton stalks	93.54	79.99	20.01	0.96	38.77	40.39
Water hyacinth	92.79	44.73	55.27	0.63	14.01	22.24

3.3 Experimental procedure:

The experiments were carried out in anaerobic batch digesters using ten digesters each with a working volume of 8.5 liter. Mixtures of chopped agricultural residues and fresh caw dung were prepared according to the next schedule that explains all treatments of the study.

3.3.1 Experimental treatments:

Thirteen treatments were conducted as follows:

1- 100gm rice straw + 100gm caw dung + 200ml inoculum (RS 1:1)
2 - 100gm rice straw + 200gm caw dung + 200ml inoculum (RS 1:2)
3 - 100gm rice straw + 300gm caw dung + 200ml inoculum (RS 1:3)

4 - 100gm maize stalks + 100gm caw dung + 200ml inoculum (MS 1:1)
5 - 100gm maize stalks + 200gm caw dung +200ml inoculum (MS 1:2)
6 - 100gm maize stalks + 300gm caw dung +200ml inoculum (MS 1:3)

7 - 100gm cotton stalks + 100gm caw dung + 200ml inoculum (CS 1:1)
8 - 100gm cotton stalks + 200gm caw dung + 200ml inoculum (CS 1:2)
9 - 100gm cotton stalks + 300gm caw dung + 200ml inoculum (CS 1:3)

10 - 100gm water hyacinth + 100gm caw dung + 200ml inoculum (WH 1:1)
11- 100gm water hyacinth + 200gm caw dung + 200ml inoculum (WH 1:2)
12- 100gm water hyacinth + 300gm caw dung + 200ml inoculum (WH 1:3)

13- 300gm caw dung +200ml inoculum used as a control treatment (Control)

Each treatment was replicated 3 times results 39 treatments and replications. Ten treatments were conducted each experimental system run by using the ten reactors. After each run, the ten reactors were cleaned and prepared to conduct another run. This procedure cues repeated until the 39th treatment and replication had been accomplished.

3.3.2: Operational conditions:

The total solid (TS) content for all treatments except the control one ranged from 1.35% to 1.78%. Control treatment has a total solid (TS) content of about 0.65%. The components were mixed and water was added to bring the total volume of the digested mixture to 8.5 liter. After loading the organic wastes, the anaerobic reactors were sealed to maintain anaerobic conditions and placed within the water bath at a constant mesophilic temperature range 311±2k of (38±2°C). The mechanical stirrer were operated automatically by the electrical timer at 15 min every 4 hr daily. The stirrer rotational speed was adjusted at 50 r.p.m. The retention time period for all treatments was 90 days.

The biogas produced, at standard condition (0° C, 1013 mbar) from raw material was determined daily during the digestion period t and plotted as a cumulative curve $y(t)$ related to volatile solids. According to **(Mahnert et al 2002)** an exponential function of the *chapman function with three parameters-type* $Y(t) = Y_{max}\,(1-e^{-a*t})^{b}$ has been used for calculating the possible maximum gas production Y_{max}. **(Mahnert et al .2005)**

3.3.3: Net biogas production from the agricultural residues:

To evaluate the net amount of biogas production from the types of agricultural residues, the cattle dung contribution in the produced biogas was eliminated. This was done by subtracting the recorded biogas for the control treatment from the recorded one of the each other treatment.

3.3.4: Statistical analysis:

To distinguish among the effect significant of the different treatments, the experiments were analyzed statistically as split plot design. Mixing ratios was considered as the main plot, the agricultural residue as the sub plot and the experiments were terminated in three replications.

The present study aimed to investigate how to utilize the agricultural residues, specifically, rice straw, maize stalks and cotton stalks in addition to water hyacinth to acquire a non-traditional energy in the form of biogas. Mixing the residue with the animal manure, specifically, cattle dung to enhance the biogas generation process was also investigated. Biogas generation from agricultural residues, by anaerobic digesters was monitored throughout 90 days of batch operation. Each treatment was replicated three times. Biogas production rate and the amount of accumulated biogas yield were investigated. Biogas generation process as affected by the substrate material and its mixing ratio was illustrated.

4. RESULTS AND DISCUSSION

Biogas yield can be expressed in several ways. The term biogas production rate is used here to indicate the daily yield of biogas per a digester. It can be expressed related to a unit weight of the substrate, i.e in daily yield per one kilogram feed. This eliminates the effect of the variation in the substrate weight within the digester. Biogas productivity can also be related to volatile solids (VS) added and total solids (TS) added. Measuring biogas yield related to (VS) added involves the biodegradability of the waste **(Hill, 1982 and Ahmed et al ., 1999).** Corresponding accumulated biogas yield was also determined and indicated in the same manner. A mathematical model to describe the accumulated biogas yield behavior was presented. The contribution of the crop residue and water hyacinth in the accumulated biogas yield was calculated as well. The effected of crop residue percentage on biogas yield and weekly percentage of accumulated yield were also illustrated.

4.1. Daily biogas production rate:

4.1.1 Daily biogas production rate per a digester, L/day.

Regarding rice straw, the rate of biogas production rate L / day per a digester at various mixing ratios of cattle dung with rice straw throughout steady the 90 days state were illustrated in Figure 4.1. The production oscillated sharply thereafter reaching a maximum at sixth to seven day for all three mixing ratios . Whereas the maximum for cattle dung only, i.e. 0:3 mixing ratio, was found at the twelfth day. The maximum values reached about 1.73, 2.15 and 1.83 L / day for mixing ratios 1:1, 1:2 and 1:3 respectively. While cattle dung reached a maximum value of about 1 L / day. The production continued to drop slowly until 41th, 78th, 64th and 30th day of operation for 1:1, 1:2, 1:3 and 0:3 mixing ratios respectively since it reached about 0.17 L / day. Whereas the

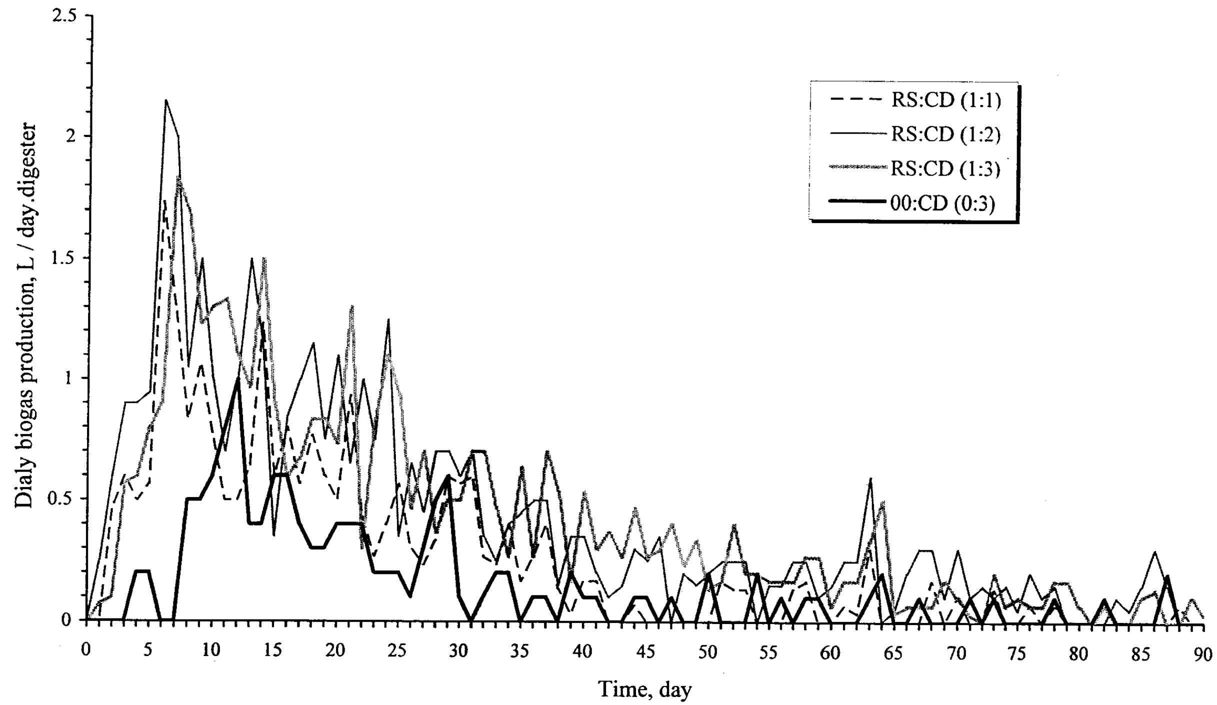


Figure 4.1: Daily biogas production per digester when using a different ratios of cattle dung with rice straw as the fermenting substrate.

remnant period of the 90 days, the production rate ranged between 0.0 and 0.2 L / day with zero values as the majority of the range for all mixing ratios of rice straw and cattle dung. Generally, it can be notice that the biogas production rate increases with the increase of cattle dung ratio in the mixture from 1:1 to 1:2 but it decreased at the ratio of 1:3. However by comparing with cattle dung, it can be concluded that the production rate increases by increasing the rice straw with cattle dung

Concerning maize stalks, the rate of biogas production rate L / day per a digester at various mixing ratios of cattle dung with maize stalks throughout steady the 90 days state were illustrated in Figure 4.2. The production oscillated sharply thereafter reaching a maximum at 11 to 34 day for all three mixing ratios . Whereas the maximum of cattle dung only, i.e. 0:3 mixing ratio, was found at the twelfth day. The maximum values reached about 0.8, 1.23 and 1.35 L / day for mixing ratios 1:1 , 1:2 and 1:3 respectively. Whereas cattle dung it reached a maximum value of about 1 L / day. The production continued to drop slowly until 63^{th}, 87^{th}, 82^{th} and 30^{th} day of operation for 1:1, 1:2, 1:3 and 0:3 mixing ratios respectively since it reached about 0.17 L / day because consumption of organic matter by bacteria . While the remnant period of the 90 days, the production rate ranged between 0.0 and 0.2 L / day with zero values as the majority of the range for all mixing ratios of maize stalks and cattle dung. However by comparing with cattle dung, it can be concluded that the production rate increases by adding or mixing the maize stalks with cattle dung. Using cotton stalks, the rate of biogas production rate L / day per a digester at various mixing ratios of cattle dung with cotton stalks throughout steady the 90 days state were illustrated in Figure 4.3. The production oscillated sharply thereafter reaching a maximum at five to nine day for all three mixing ratios . Whereas the maximum of cattle dung only, i.e. 0:3 mixing ratio, was found at the twelfth day. The maximum values reached about 1.13, 1.07 and 1.7 L / day

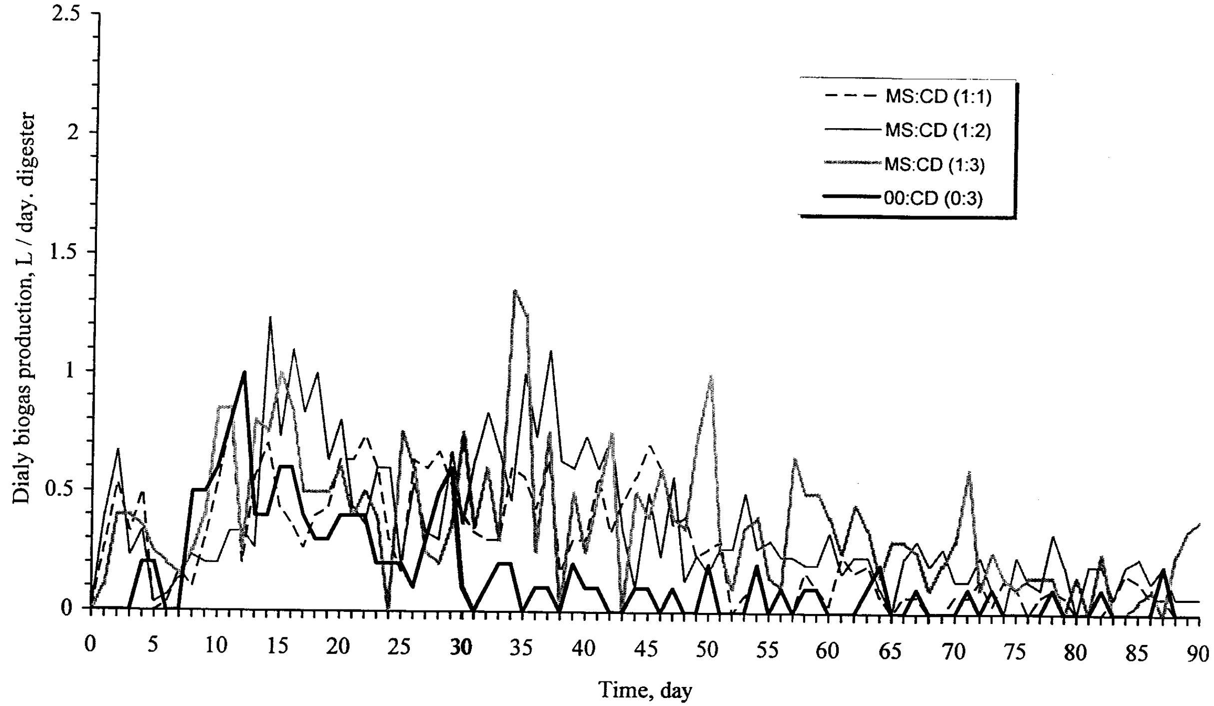


Figure 4.2: Daily biogas production per digester when using different ratios of cattle dung with maize stalks as the fermenting substrate.

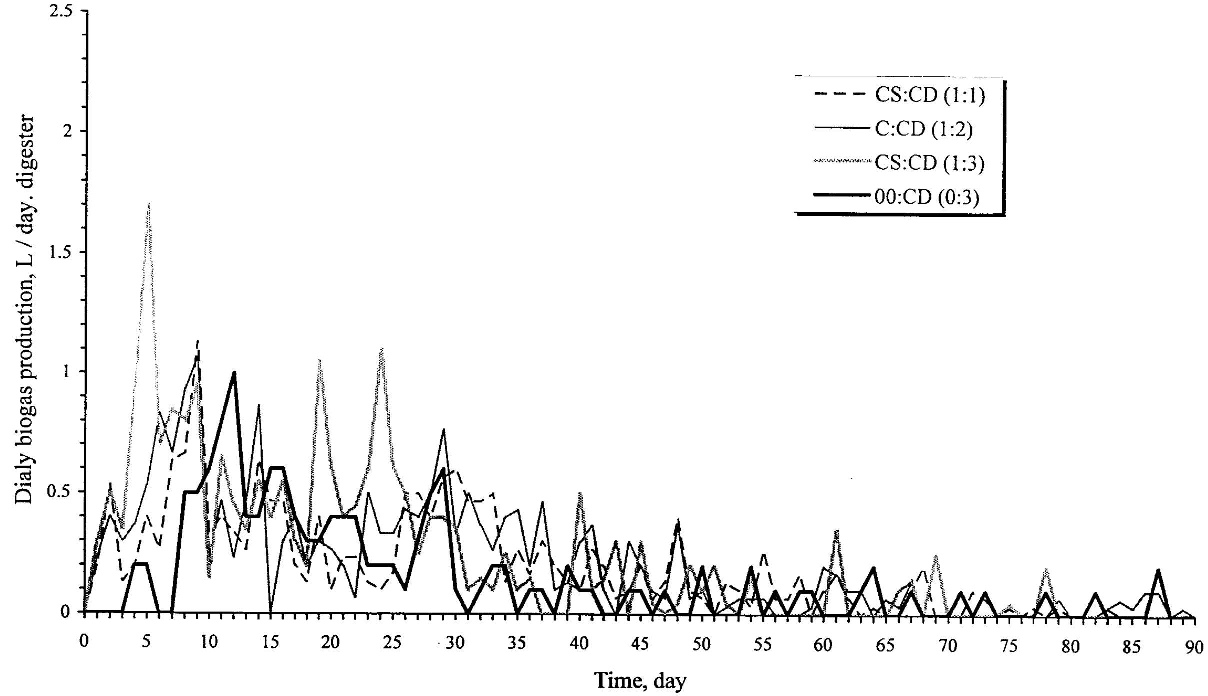


Figure 4.3: Daily biogas production per digester when using different ratios of cattle dung with cotton stalks as the fermenting substrate.

for mixing ratios 1:1 , 1:2 and 1:3 respectively. While cattle dung reached a maximum value of about 1 L / day. The production continued to drop slowly until 48th, 48^{h}, 43th and 30th day of operation for 1:1, 1:2, 1:3 and 0:3 mixing ratios respectively since it reached about 0.17 L / day because consumption of organic matter by bacteria. Wheres the remnant period of the 90 days, the production rate ranged between 0.0 and 0.2 L / day with zero values as the majority of the range for all mixing ratios of cotton stalks and cattle dung. However by comparing with cattle dung, it can be concluded that the production rate increases by increasing the rice straw with cattle dung.

Regarding water hyacinth, the rate of biogas production rate L / day per a digester at various mixing ratios of cattle dung with water hyacinth throughout steady the 90 days state were illustrated in Figure 4.4. The production oscillated sharply thereafter reaching a maximum at 18th day for all three mixing ratios. Whereas the maximum of cattle dung only, i.e. 0:3 mixing ratio, was found at the twelfth day. The maximum values reached about 1.17, 1.40 and 1.53 L / day for mixing ratios 1:1, 1:2 and 1:3 respectively. While cattle dung reached a maximum value of about 1 L / day. The production continued to drop slowly until 30th, 30th, 37th and 30th day. of operation for 1:1, 1:2, 1:3 and 0:3 mixing ratios respectively since it reached about 0.17 L / day because consumption of organic matter by bacteria. Wheres the remnant period of the 90 days, the production rate ranged between 0.0 and 0.2 L / day with zero values as the majority of the range for all mixing ratios of water hyacinth and cattle dung. However by comparing with cattle dung, it can be concluded that the production rate increases by increasing the rice traw with cattle dung.

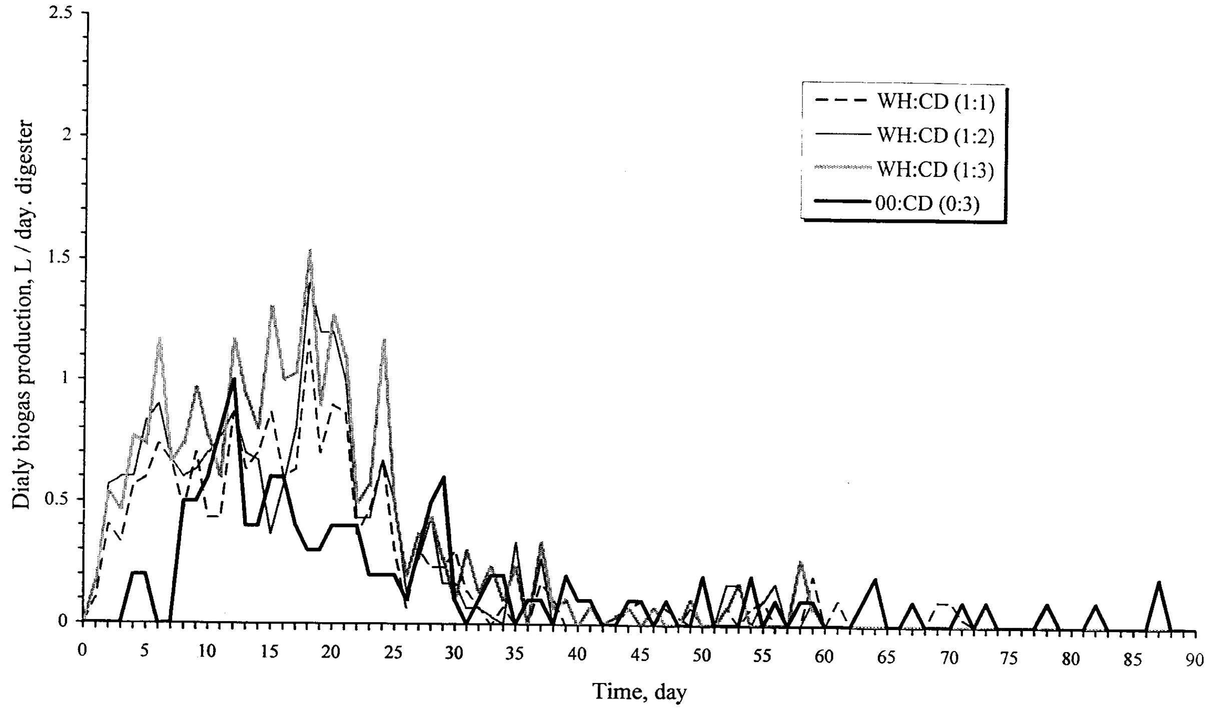


Figure 4.4: Daily biogas production per digester when using different ratios of cattle dung with water hyacinth as the fermenting substrate.

4.1.2 Daily biogas production rate, L/ day. kg substrata

Dealing with the results by using rice straw, the rate of biogas production rate L / day kg substrata at various mixing ratios of cattle dung with rice straw throughout steady the 90 days state were illustrated in Figure 4.5. The production oscillated sharply thereafter reaching a maximum at sixth to seven day for all three mixing ratios. Whereas the maximum for cattle dung only, i.e. 0:3 mixing ratio, was found at the twelfth day. The maximum values reached about 8.68, 7.17 and 4.58 L / day kg substrata for mixing ratios 1:1 , 1:2 and 1:3 respectively. While cattle dung reached a maximum value of about 3.33 L / day kg substrata. The production continued to drop slowly until 41th, 78th, 65th and 30th day of operation for 1:1, 1:2, 1:3 and 0:3 mixing ratios respectively since it reached about 0 .5 L / day kg substrata. Whereas the remnant period of the 90 days, the production rate ranged between 0.0 and 0.5 L / day kg substrata with zero values as the majority of the range for all mixing ratios of rice straw and cattle dung. Generally, it can be notice that the biogas production rate increases with the increase of cattle dung ratio in the mixture from 1:1 to 1:2 but it decreased at the ratio of 1:3. However by comparing with cattle dung, it can be concluded that the production rate increases by increasing the rice straw with cattle dung.

In the same manner by using maize stalks, the rate of biogas production rate L / day kg substrata at various mixing ratios of cattle dung with maize stalks throughout steady the 90 days state were illustrated in Figure 4.6. The production oscillated sharply thereafter reaching a maximum at 11th to 34th day for all three mixing ratios. Whereas the maximum for cattle dung only, i.e. 0:3 mixing ratio, was found at the twelfth day. The maximum values reached about 4.0, 4.11 and 3.38 L / day kg substrata for mixing ratios 1:1 , 1:2 and 1:3 respectively. While cattle dung reached a maximum value of about 3.33 L / day kg substrata. The production continued to drop slowly

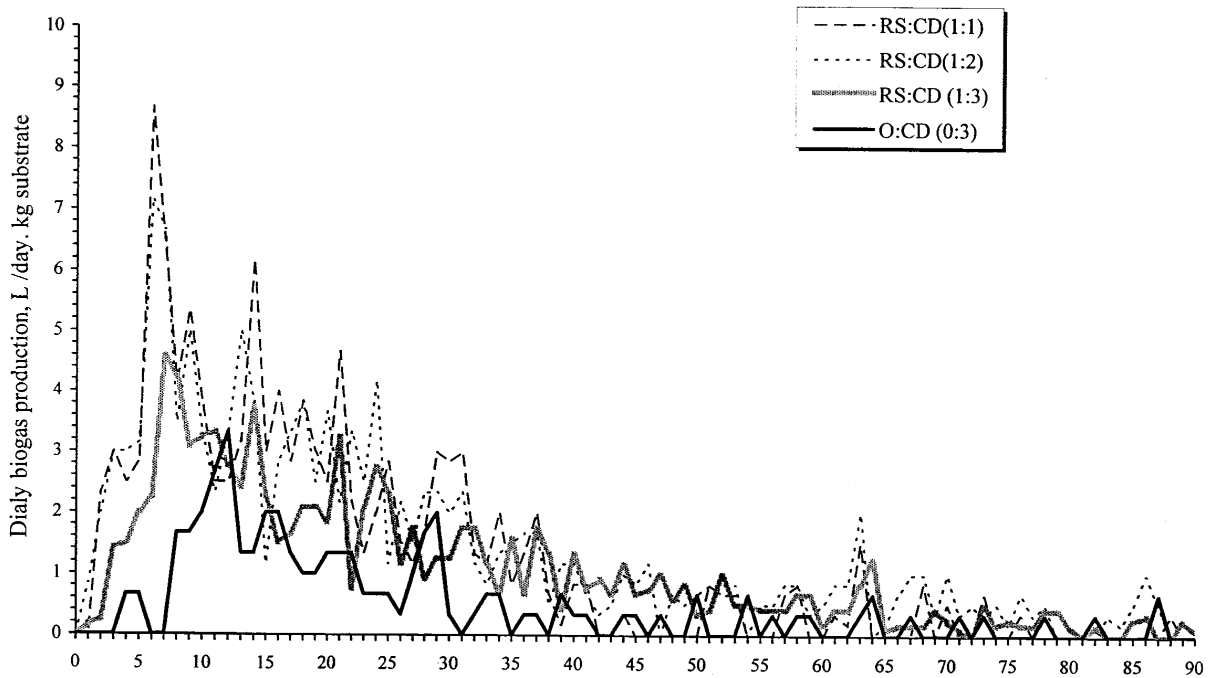


Figure 4.5: Daily biogas production per a unit mass of substrate added when using a mixture of rice straw-cattle dung at different ratios as the fermenting substrate.

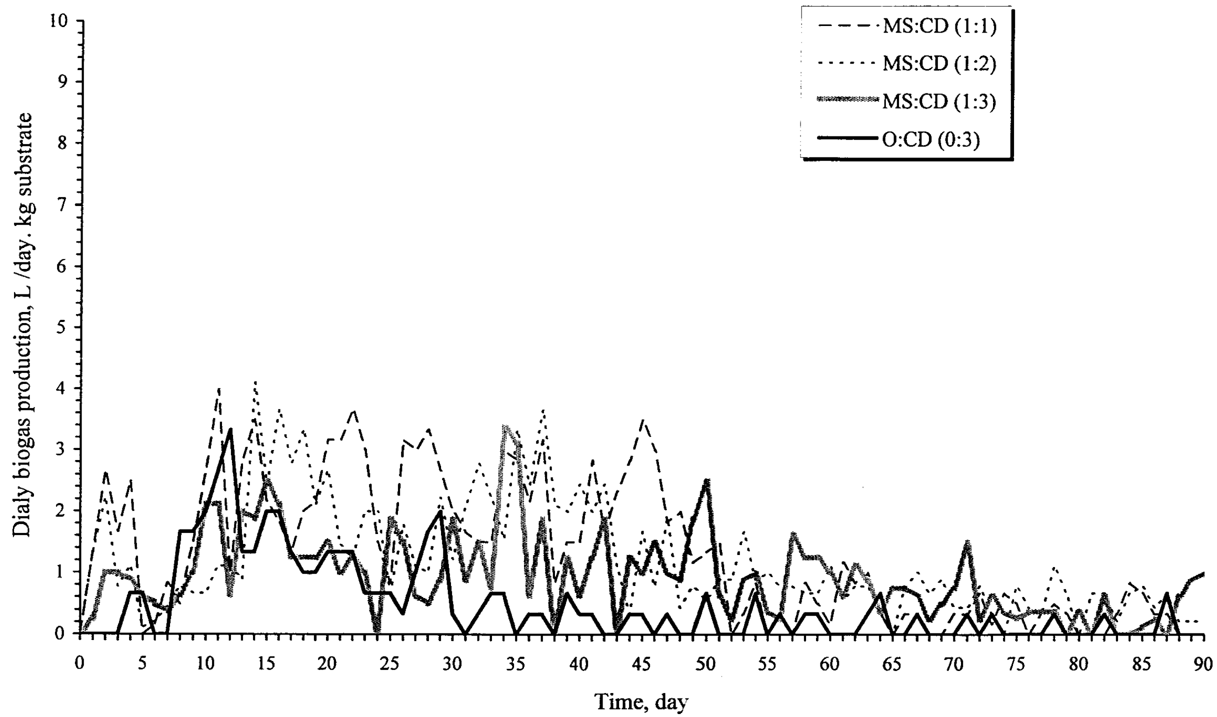


Figure 4.6: Daily biogas production per a unit mass of substrate added when using a mixture of maize stalks-cattle dung at different ratios as the fermenting substrate.

until 64^{th}, 87^{th}, 82^{th} and 30^{th} day of operation for 1:1, 1:2, 1:3 and 0:3 mixing ratios respectively since it reached about lees than 0.5 L / day kg substrata. However the remnant period of the 90 days, the production rate ranged between 0.0 and 0.5 L / day kg substrata with zero values as the majority of the range for all mixing ratios of maize stalks and cattle dung. Moreover by comparing with cattle dung, it can be concluded that the production rate increases by increasing the maize stalks with cattle dung.

The same tendency was obtained by using cotton stalks, the rate of biogas production rate L / day kg substrata at various mixing ratios of cattle dung with cotton stalks throughout steady the 90 days state were illustrated in Figure 4.7. The production oscillated sharply thereafter reaching a maximum at 9^{th} day for both 1:1 and 1:2 mixing ratios and at 5^{th} day for 1:3 mixing ratio . Whereas the maximum for cattle dung only, i.e. 0:3 mixing ratio, was found at the twelfth day. The maximum values reached about 5.67, 3.56 and 4.25 L / day kg substrata for mixing ratios 1:1, 1:2 and 1:3 respectively. Whilst cattle dung reached a maximum value of about 3.33 L / day kg substrata. The production continued to drop slowly until 61^{th}, 50^{th}, 51^{th} and 30^{th} day of operation for 1:1, 1:2, 1:3 and 0:3 mixing ratios respectively since it reached about lees than 0.5 L / day kg substrata. However the remnant period of the 90 days, the production rate ranged between 0.0 and 0.5 L / day kg substrata with zero values as the majority of the range for all mixing ratios of cotton stalks and cattle dung. it can be concluded that the production rate increases by increasing the cotton stalks with cattle dung.

Concerning water hyacinth, the rate of biogas production rate L / day kg substrata at various mixing ratios of cattle dung with water hyacinth throughout steady the 90 days state were illustrated in Figure 4.8. The production oscillated sharply thereafter reaching a maximum at 18^{th} day for all three mixing ratios . Whereas the maximum for cattle dung only, i.e. 0:3

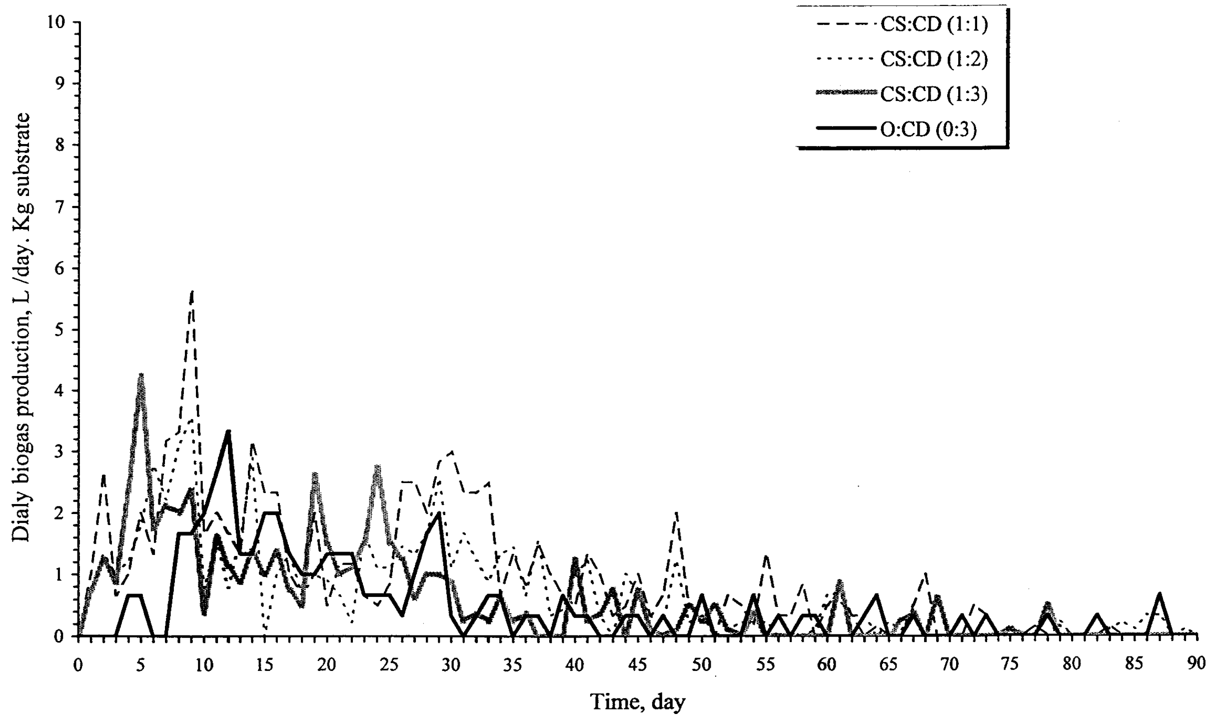


Figure 4.7: Daily biogas production per a unit mass of substrate added when using a mixture of cotton stalks-cattle dung at different ratios as the fermenting substrate.

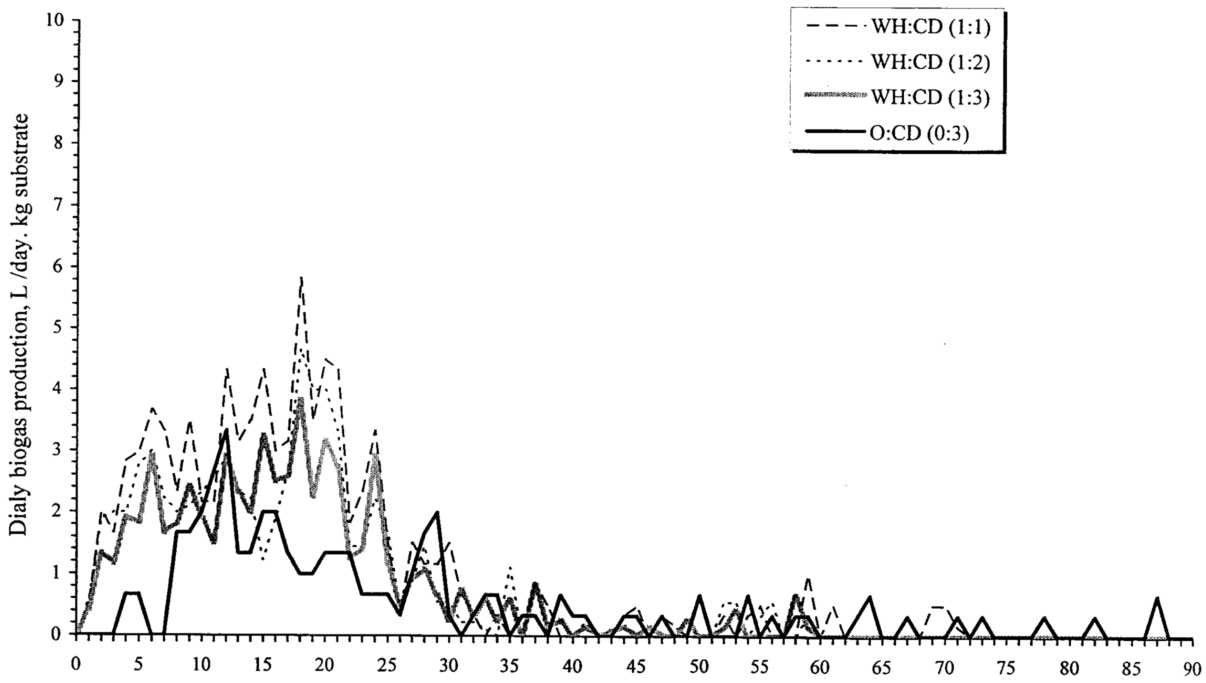


Figure 4.8: Daily biogas production per a unit mass of substrate added when using a mixture of water hyacinth-cattle dung at different ratios as the fermenting substrate.

mixing ratio, was found at the twelfth day. The maximum values reached about 5.83, 4.67 and 3.83 L / day kg substrata for mixing ratios 1:1 , 1:2 and 1:3 respectively. While cattle dung reached a maximum value of about 3.33 L / day kg substrata. The production continued to drop slowly until 34th, 32th, 39th and 30th day. of operation for 1:1, 1:2, 1:3 and 0:3 mixing ratios respectively since it reached about lees than 0.5 L / day kg substrata. However the remnant period of the 90 days, the production rate ranged between 0.0 and 0.5 L / day kg substrata with zero values as the majority of the range for all mixing ratios of water hyacinth and cattle dung. it can be concluded that the production rate increases by increasing the cotton stalks with cattle dung

4.1.3 Daily biogas production rate , L/ day. kg VS

Using rice straw, the rate of biogas production rate L / day kg VS at various mixing ratios of cattle dung with rice straw throughout steady the 90 days state were illustrated in Figure 4.9. The production oscillated sharply thereafter reaching a maximum at sixth to seven day for all three mixing ratios . Whereas the maximum for cattle dung only, i.e. 0:3 mixing ratio, was found at the twelfth day. The maximum values reached about 20.98, 22.04 and 16.30 L / day kg VS for mixing ratios 1:1 , 1:2 and 1:3 respectively. Meanwhile cattle dung it reached a maximum value of about 22.31 L / day. Kg VS. The production continued to drop slowly until 41th, 78th, 63th and 30th day. of operation for 1:1, 1:2, 1:3 and 0:3 nixing ratios respectively since it reached about less than 2.0 L / day. kg VS. On the other hand the remnant period of the 90 days, the production rate ranged between 0.0 and 0.2 L / day kg VS with zero values as the majority of the range for all mixing ratios of rice straw and cattle dung. Generally, it can be notice that the biogas production rate increases with the increase of cattle dung ratio in the mixture from 1:1 to 1:2 but it decreased at the ratio of 1:3. However by comparing

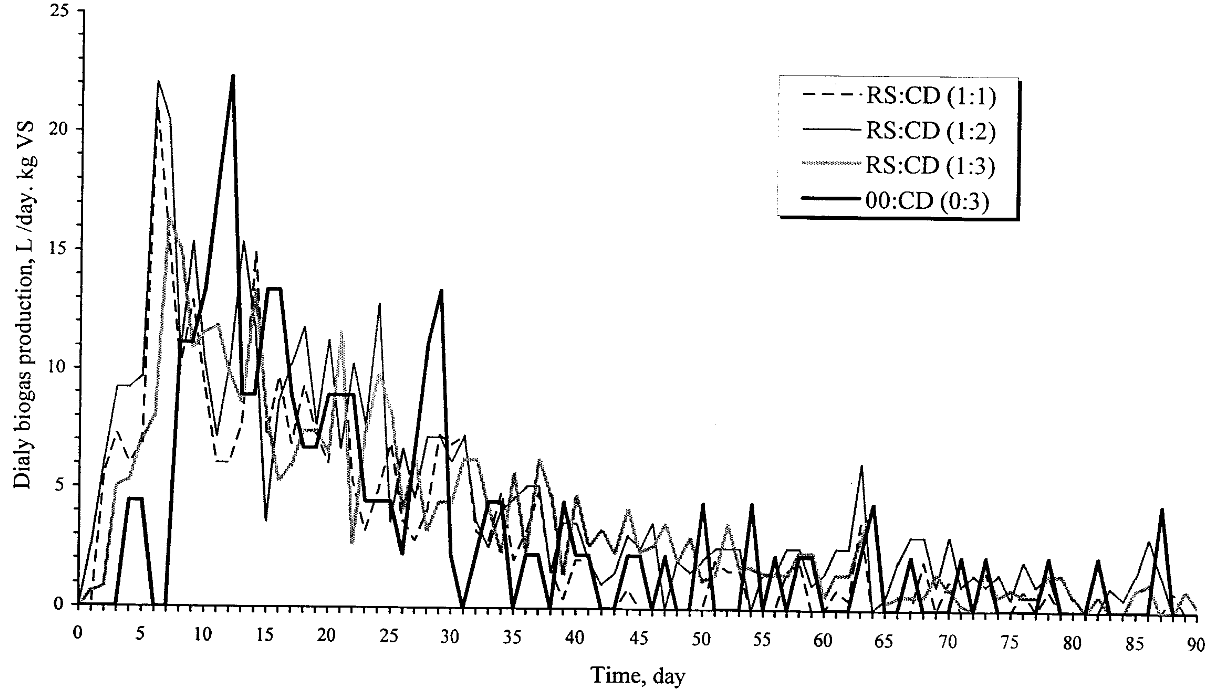


Figure 4.9: Daily biogas production per a unit mass of volatile solids added when using a mixture of rice straw-cattle dung at different ratios as the fermenting substrate.

with cattle dung, it can be concluded that the production rate increases by increasing the rice straw with cattle dung.

Concerning maize stalks, the rate of biogas production rate L / day kg VS at various mixing ratios of cattle dung with maize stalks throughout steady the 90 days state were illustrated in Figure 4.10. The production oscillated sharply thereafter reaching a maximum at 11 to 34 day for all three mixing ratios . Whereas the maximum for cattle dung only, i.e. 0:3 mixing ratio, was found at the twelfth day. The maximum values reached about 8.41, 11.2 and 10.80 L / day Kg VS for mixing ratios 1:1 , 1:2 and 1:3 respectively. Whilst cattle dung it reached a maximum value of about 22.31 L / day kg VS . The production continued to drop slowly until 63th, 87th, 82th and 30th day. of operation for 1:1, 1:2, 1:3 and 0:3 mixing ratios respectively since it reached about 2.0 L / day kg VS. However, the remnant period of the 90 days, the production rate ranged between 0.0 and 0.2 L / day kg VS. With zero values as the majority of the range for all mixing ratios of maize stalks and cattle dung. Also by comparing with cattle dung, it can be concluded that the production rate increases by increasing the maize stalks with cattle dung

Regarding cotton stalks, the rate of biogas production rate L / day kg VS at various mixing ratios of cattle dung with cotton stalks throughout steady the 90 days state were illustrated in Figure 4.11. The production oscillated sharply thereafter reaching a maximum at five to nine day for all three mixing ratios. Whereas the maximum for cattle dung only, i.e. 0:3 mixing ratio, was found at the twelfth day. The maximum values reached about 12.63, 10.19 and 14.21 L / day kg VS for mixing ratios 1:1, 1:2 and 1:3 respectively. For cattle dung it reached a maximum value of about 22.31 L / day kg VS. The production continued to drop slowly until 48th, 48^{h}, 43th and 30th day of operation for 1:1, 1:2, 1:3 and 0:3 mixing ratios respectively since it reached about less than 2.0 L / day. The date showed that the remnant period of the 90 days, the production rate

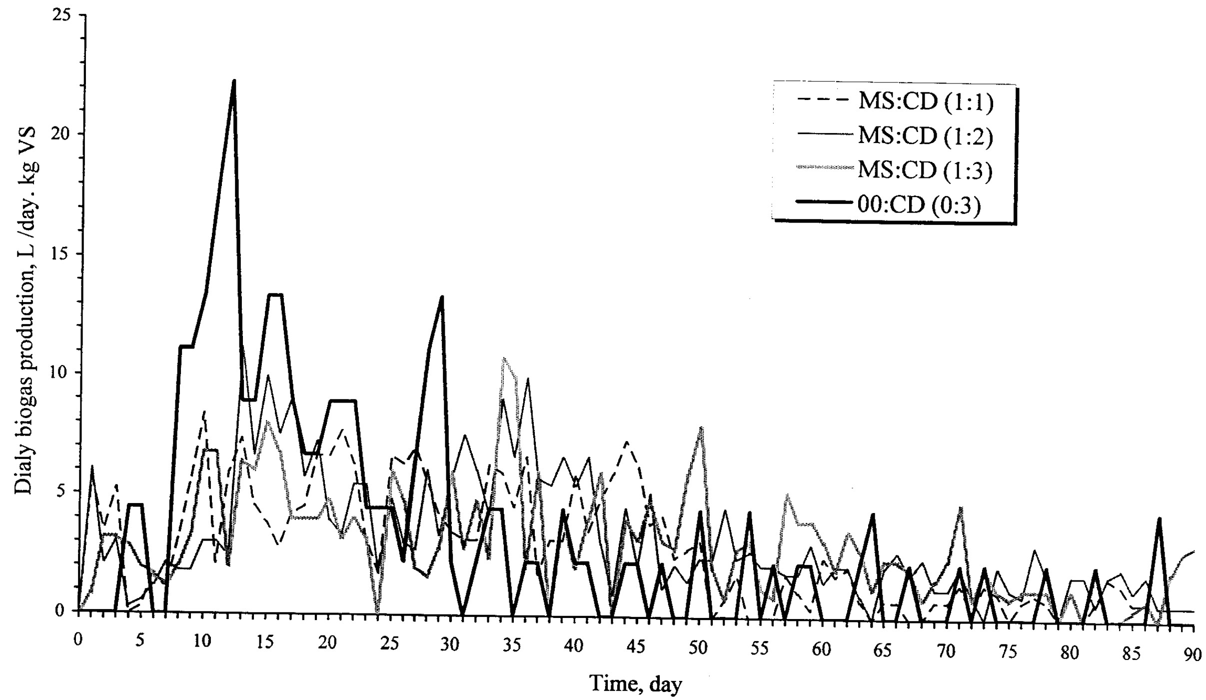


Figure 4.10: Daily biogas production per a unit mass of volatile solids added when using a mixture of maize stalks-cattle dung at different ratios as the fermenting substrate.

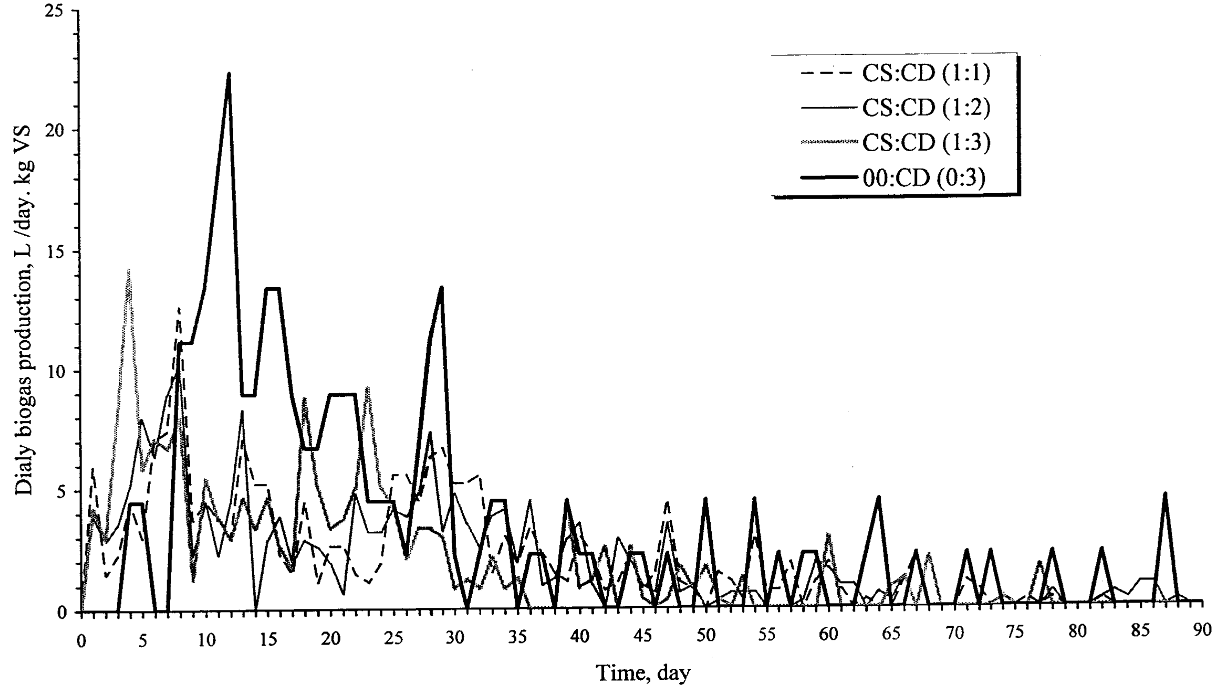


Figure 4.11: Daily biogas production per a unit mass of volatile solids added when using a mixture of cotton stalks-cattle dung at different ratios as the fermenting substrate.

ranged between 0.0 and 2.0 L / day kg VS with zero values as the majority of this range for all mixing ratios of cotton stalks and cattle dung. However by comparing with cattle dung, it can be concluded that the production rate increases by increasing the cotton stalks with cattle dung.

Dealing water hyacinth, the rate of biogas production rate L / day kg VS at various mixing ratios of cattle dung with water hyacinth throughout steady the 90 days state were illustrated in Figure 4.12 The production oscillated sharply thereafter reaching a maximum at 18th day for all three mixing ratios . Whereas the maximum for cattle dung only, i.e. 0:3 mixing ratio, was found at the twelfth day. The maximum values reached about 20.67, 19.61 and 17.76 L / day kg VS for mixing ratios 1:1 , 1:2 and 1:3 respectively. While cattle dung it reached a maximum value of about 22.31 L / day kg VS. The production continued to drop slowly until 32th, 32^{h}, 37th and 30th day of operation for 1:1, 1:2, 1:3 and 0:3 mixing ratios respectively since it reached about less than 2.0 L / day kg VS . The date indicated that the remnant period of the 90 days, the production rate ranged between 0.0 and 2.0 L / day kg VS with zero values as the majority of the range for all mixing ratios of water hyacinth and cattle dung. However by comparing with cattle dung, it can be concluded that the production rate increases by increasing the water hyacinth with cattle dung. Using water hyacinth as an additive to cattle dung in biogas plants enhances volatile fatty acids in fermenting slurry because of its quick hydrolysis and fermentation **(Deshpande et al., 1979)**

4.1.4 Daily biogas production rate, L/ day. kg TS

Regarding rice straw, the rate of biogas production rate L / day kg TS at various mixing ratios of cattle dung with rice straw throughout steady the 90 days state were illustrated in Figure 4.13. The production oscillated sharply thereafter reaching a maximum at sixth to seven day for all three mixing ratios . Whereas the maximum for cattle dung only, i.e. 0:3 mixing ratio, was found at the twelfth day.

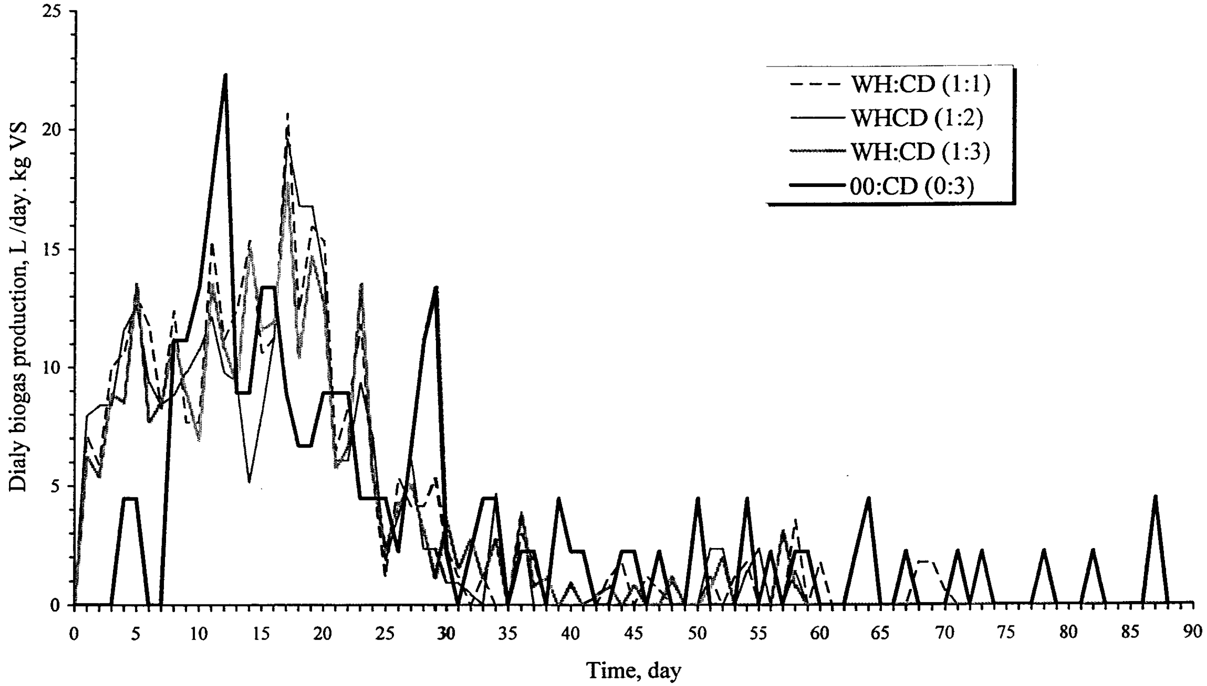


Figure 4.12: Daily biogas production per a unit mass of volatile solide added when using a mixture of water hyacinth-cattle dung at different ratios as the fermenting substrate.

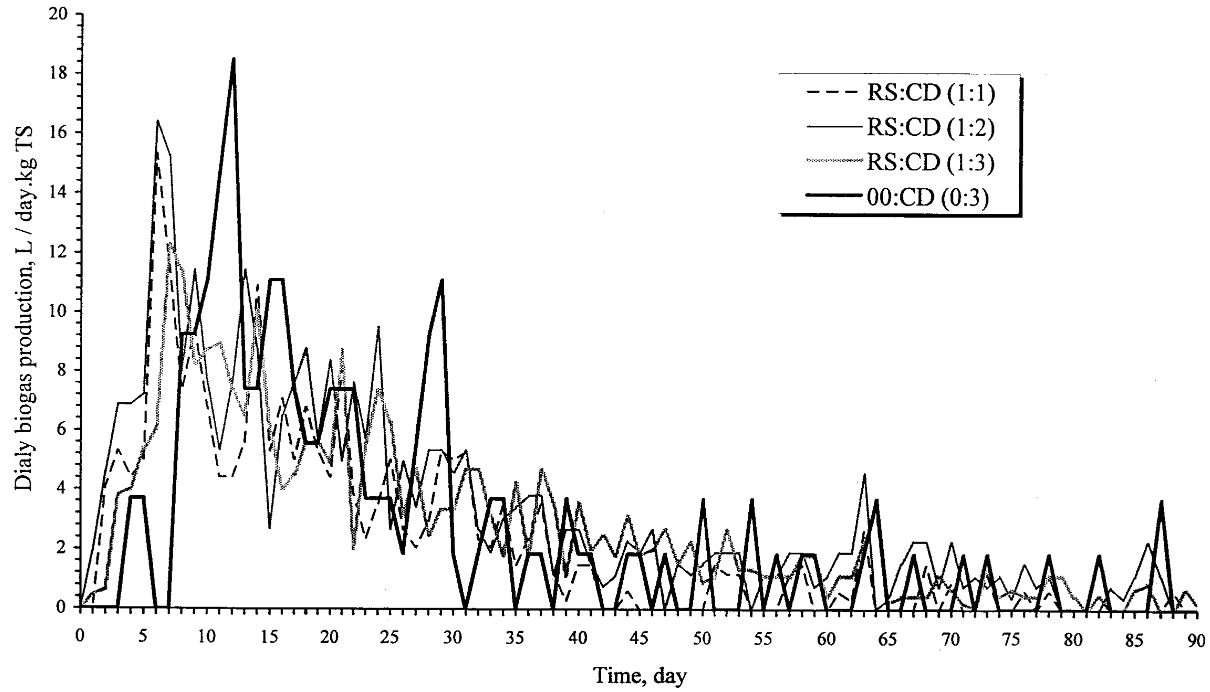


Figure 4.13: Daily biogas production per a unit mass of total solid added when using a mixture of rice straw-cattle dung at differen ratios as the fermenting substrate.

The maximum values reached about 15.32, 16.39 and 12.29 L / day kg TS for mixing ratios 1:1 , 1:2 and 1:3 respectively. However cattle dung it reached a maximum value of about 18.52 L / day kg TS. The production continued to drop slowly until 41th, 78th, 65th and 30th day of operation for 1:1, 1:2, 1:3 and 0:3 mixing ratios respectively since it reached about less than 1.0 L / day kg TS. Also the remnant period of the 90 days, the production rate ranged between 0.0 and 1.0 L / day TS with zero values as the majority of the range for all mixing ratios of rice straw and cattle dung. Generally, it can be notice that the biogas production rate increases with the increase of cattle dung ratio in the mixture from 1:1 to 1:2 but it decreased at the ratio of 1:3. However by comparing with cattle dung, a mixture of cattle dung and chopped rice straw in the ratio of 1:2 (on dry mass basis) and containing 15.2% initial TS performed better than cattle dung slurry in total solids (TS) conversion and gas production. This might be attributed mainly to a higher percentage of degradable solids (cellulose + hemicellulose) in the dung and rice straw mixture. (**Shyam 2000** cited from **Pathak et al 1985).**

Concerning maize stalks, the rate of biogas production rate L / day kg TS at various mixing ratios of cattle dung with maize stalks throughout steady the 90 days state were illustrated in Figure 4.14. The production oscillated sharply thereafter reaching a maximum at 11 to 34 day for all three mixing ratios . Whereas the maximum for cattle dung only, i.e. 0:3 mixing ratio, was found at the twelfth day. The maximum values reached about 7.08, 9.42 and 9.07 L / day kg TS for mixing ratios 1:1 , 1:2 and 1:3 respectively. Meanwhile cattle dung it reached a maximum value of about 18.52 L / day kg TS . The production continued to drop slowly until 63th, 87th, 82th and 30th day. of operation for 1:1, 1:2, 1:3 and 0:3 mixing ratios respectively since it reached about 2.0 L / day kg TS. For the remnant period of the 90 days, the production rate ranged between 0.0 and 2.0 L / day kg TS with zero values as the majority of the range for all mixing ratios of maize stalks and cattle dung. However by comparing with cattle dung, it can be

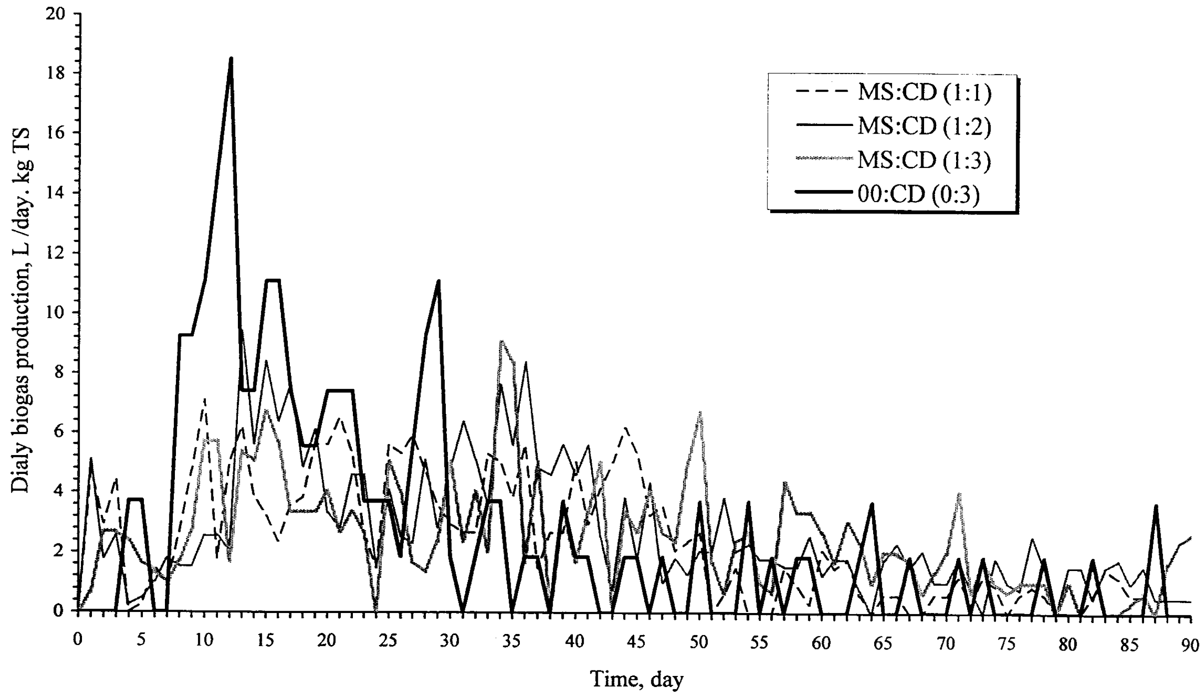


Figure 4.14: Daily biogas production per a unit mass of total solids added when using a mixture of maize stalks-cattle dung at different ratios as the fermenting substrate.

concluded that the production rate increases by increasing the maize stalks with cattle dung

Regarding cotton stalks, the rate of biogas production rate L / day kg TS at various mixing ratios of cattle dung with cotton stalks throughout steady the 90 days state were illustrated in Figure 4.15. The production oscillated sharply thereafter reaching a maximum at five to nine day for all three mixing ratios. Whereas the maximum for cattle dung only, i.e. 0:3 mixing ratio, was found at the twelfth day. The maximum values reached about 10.16, 8.24 and 11.52 L / day kg TS for mixing ratios 1:1, 1:2 and 1:3 respectively. Whilst cattle dung it reached a maximum value of about 18.52 L / day kg TS. The production continued to drop slowly until 48^{th}, 48^{h}, 43^{th} and 30^{th} day. of operation for 1:1, 1:2, 1:3 and 0:3 mixing ratios respectively since it reached about less than 2.0 L / day kg TS . On the other hand the remnant period of the 90 days, the production rate ranged between 0.0 and 2.0 L / day kg TS with zero values as the majority of this range for all mixing ratios of cotton stalks and cattle dung. However by comparing with cattle dung, it can be concluded that the production rate decreases by adding or mixing the cotton stalks with cattle dung.

Dealing water hyacinth, the rate of biogas production rate L / day kg TS at various mixing ratios of cattle dung with water hyacinth throughout steady the 90 days state were illustrated in Figure 4.16. The production oscillated sharply thereafter reaching a maximum at $18^{th\ day}$ for all three mixing ratios . Whereas the maximum for cattle dung only, i.e. 0:3 mixing ratio, was found at the twelfth day. The maximum values reached about 10.53, 10.87 and 10.44 L / day kg TS for mixing ratios 1:1 , 1:2 and 1:3 respectively. Also cattle dung it reached a maximum value of about 18.52 L / day kg TS. The production continued to drop slowly until 32^{th}, 32^{h}, 37^{th} and 30^{th} day. of operation for 1:1, 1:2, 1:3 and 0:3 mixing ratios respectively since it reached about less than 2.0 L / day kg TS . The data showed that the remnant period of the 90 days, the production rate ranged between 0.0 and

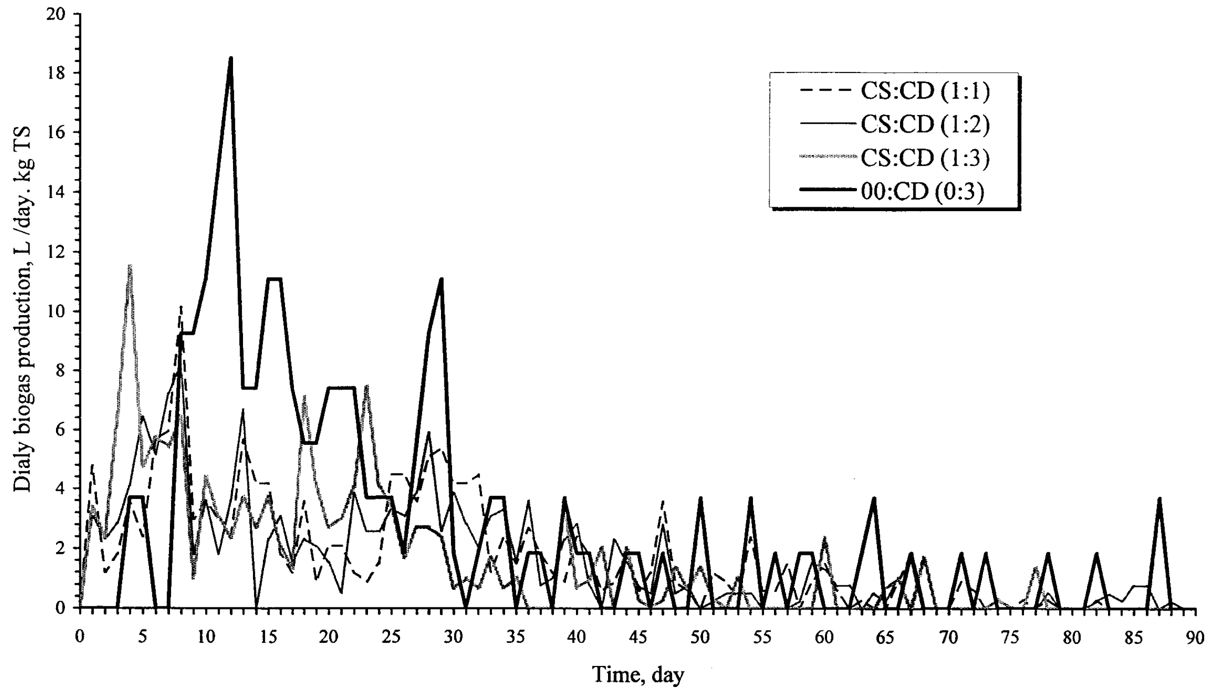


Figure 4.15: Daily biogas production per a unit mass of total solids added when using a mixture of cotton stalks-cattle dung at different ratios as the fermenting substrate.

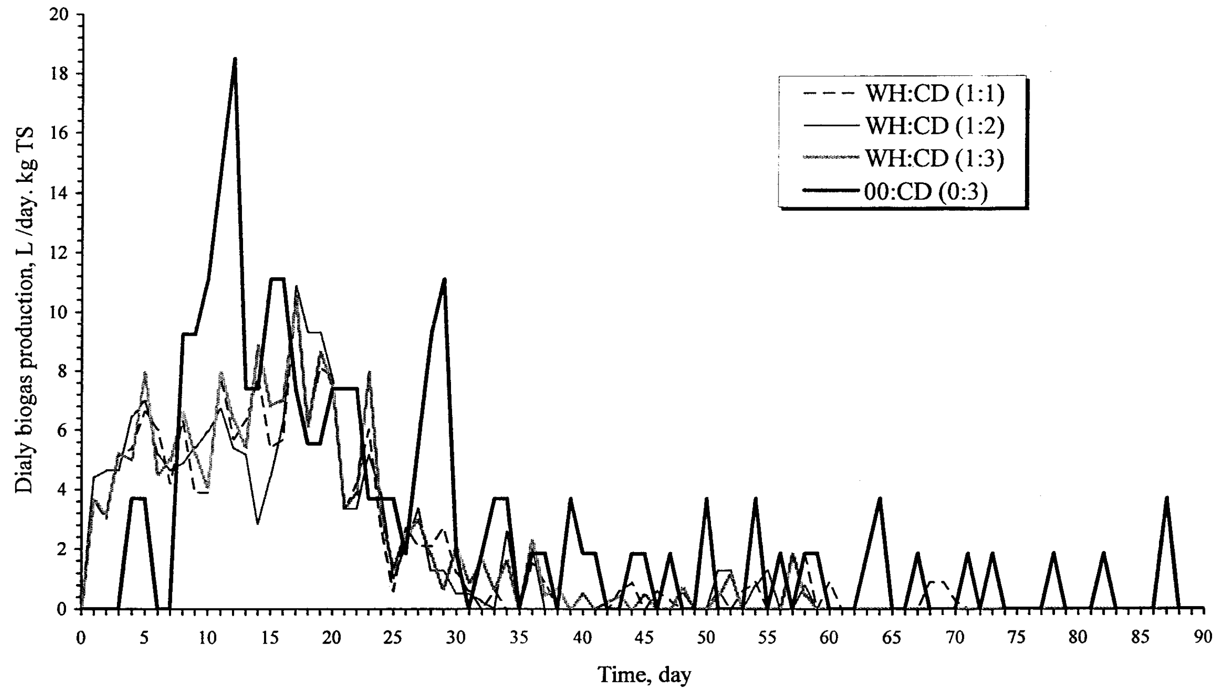


Figure 4.16: Daily biogas production per a unit mass of total solids added when using a mixture of water hyacinth-cattle dung at different ratios as the fermenting substrate.

2.0 L / day kg TS with zero values as the majority of the range for all mixing ratios of water hyacinth and cattle dung. however and comparing with cattle dung, it can be concluded that the production rate decreases by increasing the water hyacinth with cattle dung.

From Figures 4.1 to 4.16 show pronouncedly that biogas production rate from rice straw, maize stalks, cotton stalks and water hyacinth, through 90 days attaining to the minimum biogas production rate at longer time (about 40 - 80 days)for agricultural residues and water hyacinth as compared to cattle dung about 30 days. This is due to the fact that bacteria needed for biogas production in the case of agricultural residues takes a long time period to grow whereas in ruminants waste such as cattle dung pathogens are already present and bacterial growth takes a little time for biogas production.

4.1.5 Percentage of weekly production to the expected maximum accumulated one:

From Table 4.1: Then the increasing percentage of biogas yield takes a increase until 1^{th} to 6^{th} week and clearly decline rate for all treatments until the end of the experiments.

A maximum of the biogas production rate could be gained during the 2 week of fermentation for rice straw mixture at the three mixing ratios.

A maximum of the biogas production rate could be gained during the 3 to 6 week of fermentation for maize stalks mixture at the three mixing ratios.

A maximum of the biogas production rate could be gained during the 1 to 2 week of fermentation for cotton stalks mixture at the three mixing ratios.

A maximum of the biogas production rate could be gained during the 3 week of fermentation for water hyacinth mixture at the three mixing ratios.

A maximum of the biogas production rate could be gained during the 2 week of fermentation for cattle dung alone.

Table 4.1: Weekly biogas yield ratio from total biogas yield

week	(1) RS:CD			(2) MS:CD			(3) CS:CD			(4) WH:CD			(5) --:CD
	RS:CD (1:1)	RS:CD (1:2)	RS:CD (1:3)	MS:CD (1:1)	MS:CD (1:2)	MS:CD (1:3)	CS:CD (1:1)	CS:CD (1:2)	CS:CD (1:3)	WH:CD (1:1)	WH:CD (1:2)	WH:CD (1:3)	0:CD (0:3)
0	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
1	21.72	19.50	12.58	7.59	5.70	5.40	13.55	17.30	24.88	19.03	21.04	17.95	3.17
2	23.24	19.87	23.59	13.24	8.55	12.12	21.56	22.14	18.14	23.69	23.95	23.80	31.65
3	20.04	14.72	15.17	13.10	16.91	12.70	11.45	8.65	16.28	32.08	31.72	32.44	22.68
4	10.63	12.96	12.14	15.31	8.96	7.88	11.64	13.32	18.14	13.43	13.92	14.76	14.24
5	11.89	8.68	9.74	12.55	14.16	14.45	17.17	15.91	6.74	4.48	4.05	5.45	8.97
6	4.92	5.41	7.42	11.31	15.68	8.76	7.82	8.65	4.19	1.49	1.62	2.26	4.75
7	0.29	3.52	5.87	13.79	6.42	8.76	6.11	5.71	4.19	1.49	0.32	1.06	2.11
8	1.81	3.14	3.70	3.31	6.11	6.86	3.82	1.73	2.33	1.31	2.91	0.93	3.69
9	2.94	4.65	3.70	3.72	4.89	9.05	3.24	3.11	1.63	1.68	0.49	1.33	2.11
10	1.13	3.14	2.58	1.10	3.77	4.67	1.91	1.21	2.33	1.12	0.00	0.00	2.11
11	0.84	2.14	1.37	2.21	2.85	4.38	1.34	0.00	0.23	0.19	0.00	0.00	1.58
12	0.28	0.75	1.21	1.65	3.67	1.61	0.38	0.86	0.93	0.00	0.00	0.00	1.58
13	0.28	1.51	0.96	1.10	2.34	3.36	0.00	1.38	0.00	0.00	0.00	0.00	1.36
	100.00	100.00	100.00	100	100	100	100	100	100	100	100	100	100

1 - Rice straw: cattle dung. 2- Maize stalks: cattle dung 3- Cotton stalks: cattle dung
4- Water hyacinth: cattle dung 5- Cattle dung only

4.2 Accumulated biogas production:

Accumulated biogas production in terms of L / digester, L / kg feed, L / kg VS and L / kg TS were shown in the following Figures from 4.17 to 4.32. All investigated crop residue and water hyacinth as well as cattle dung showed monophasic curves of accumulated biogas production. After a steep increase, biogas production decreased resulting in a plateau of the cumulative curve. This general trend had been found in the accumulated biogas production related to digester, feed add, volatile solids added (VS) and total solids added (TS). This is in greement with all references in this area

4.2.1 Modeling accumulated biogas production:

The biogas produced from crop residues and water hyacinth mixed with cattle dung was determined daily during the digestion period. Cumulative value was then calculated weekly, so that we have 13 values each of them represents the cumulative production during a one week. However the 13[th] value was calculated from only the last six days production to complete the whole period of 90 days. The weekly cumulative values during the digestion period (t) of 13 weeks were plotted as cumulative curve $Y_{(t)}$ related to volatile solids (VS) and total solids (TS). Meanwhile the purpose of investigating the biogas yield behavior throughout the fermentation time, the accumulated yield in terms of L / digester, L / kg feed , L / kg VS and L /kg TS was presented graphically. According to **(Mahnert et al. 2002)** the Cumulative biogas yield could be described by an exponential equation in the following form:

$$Y_{(t)} = Y_{max} \ (1-e^{-at})^b \quad .... \quad ....(4.1)$$

Were :

$Y_{(t)}$ = accumulated biogas yield at time t, (week).

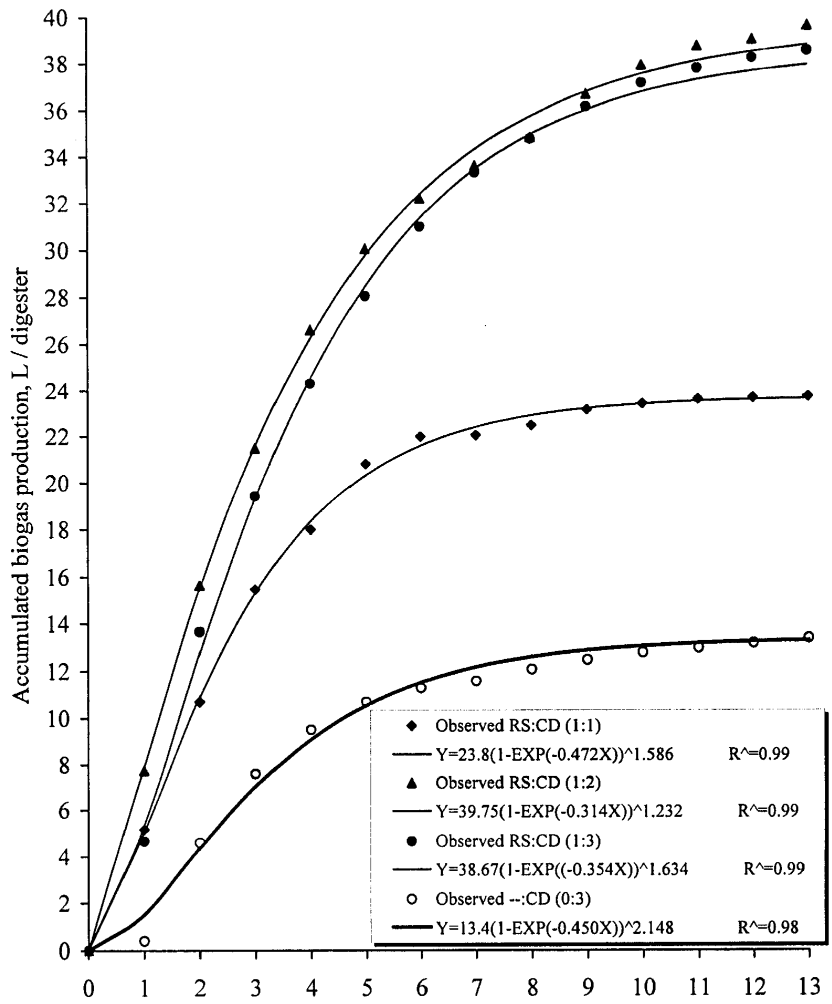
Y_{max} = maximum accumulated biogas yield at the end of the fermentation time (L/digester, L/kg feed, L/Kg VS and L/ kg TS).

a and b = the equation parameters, in which a and b are positive values.

The above mentioned equation (4.1) was found to offer a very good description of the accumulated biogas production for all treatments. The parameters a and b and R^2 values corresponding each treatment are indicated in the following sections. However, high significancy of a and b parameters (probability of t = 0.00001) and the regression between $Y_{(t)}$ and t (probability of F = 0.00001) were found for all treatments. As well as, R^2 values ranged between 0.98 to 0.99 for all treatments.

4.2.2 Accumulated biogas production, L/ digester:

Regarding rice straw, Figure 4.17 showed that the sharp increase in biogas yield until 7^{th} week of anaerobic digestion for all mixing ratios. Exception was found for the control treatment, i.e. cattle dung, since the biogas yield sharply increased until the 5^{th} week. After that, biogas production decreased resulting in a plateau of the cumulative curve. It can be noticed that the rice straw gives the higher yield of biogas production at mixing ratio rice straw: cattle dung 1:2 followed by mixing ratio 1:3 and



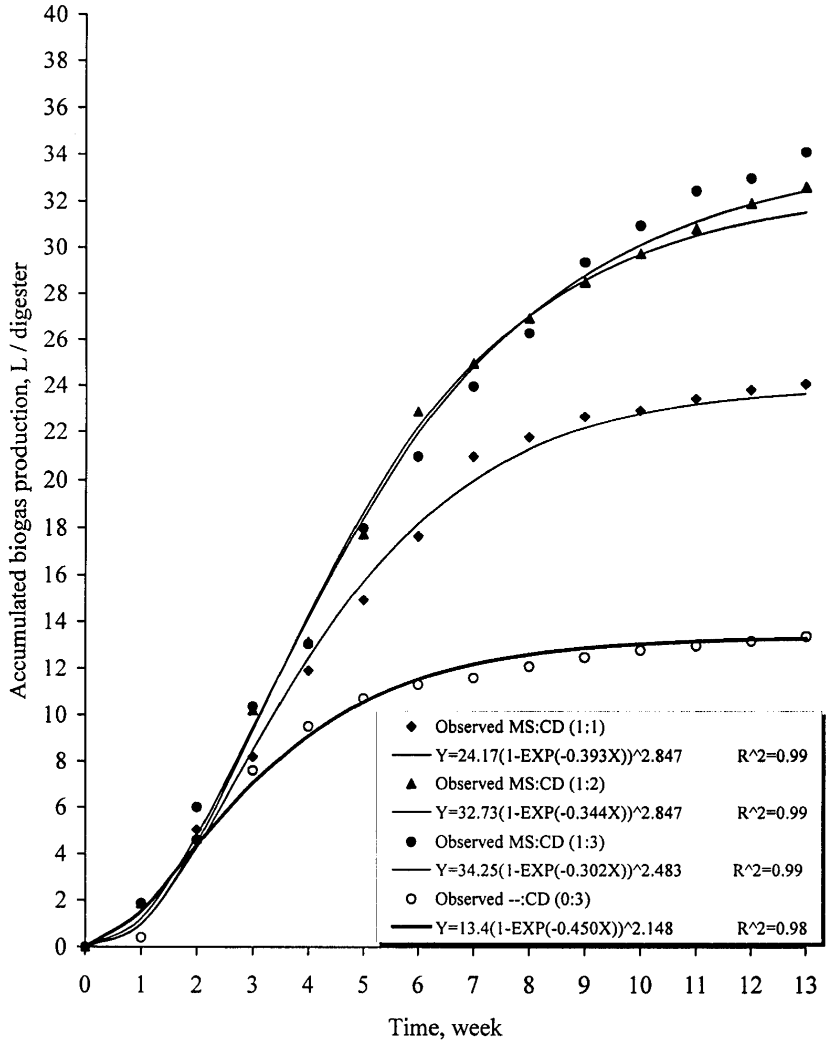
Figur 4.17 : Accumulated biogas production through ninety days when using different ratios of rice straw : cattle dung as the fermenting substrate.

finally 1:1. The amount of biogas production throughout 90 days fermentation for all mixing ratios were 23.8, 39.75, 38.67 and 13.40 L / digester for mixing ratios 1:1, 1:2, 1:3 and control treatment respectively.

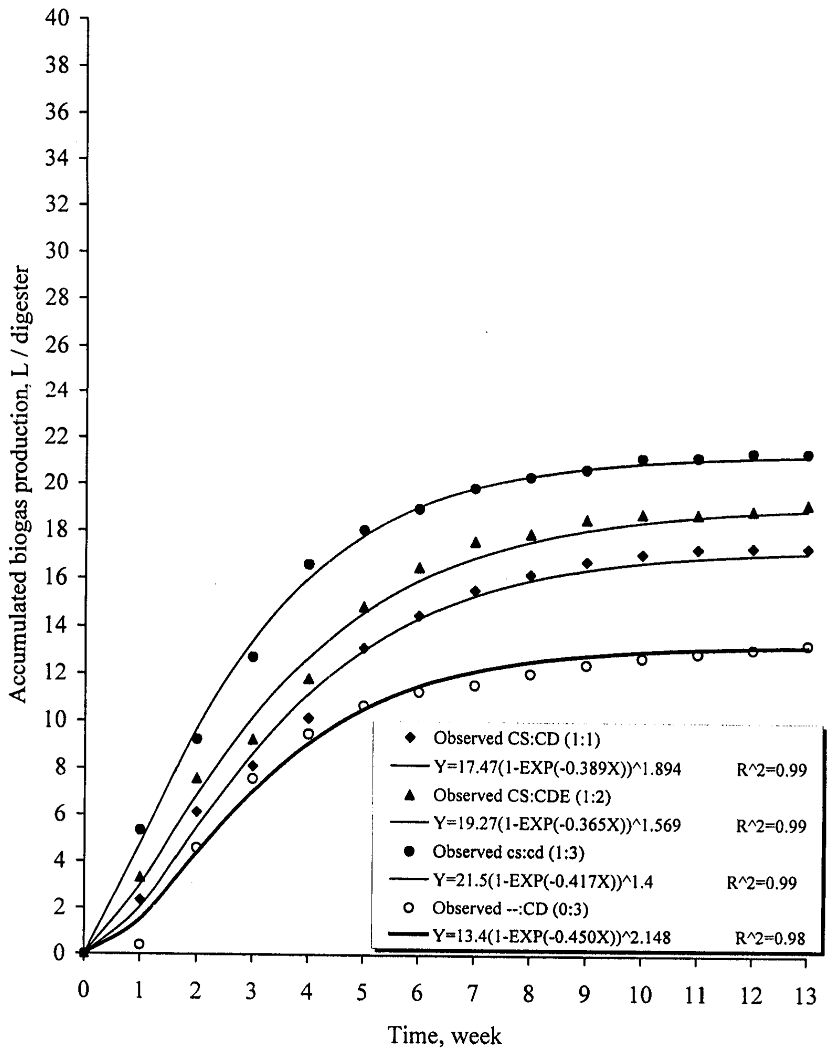
Concerning maize stalks, Figure 4.18 showed that the sharp increases in biogas yield until 9th week of anaerobic digestion for all mixing ratios. Exception was found for the control treatment, i.e. cattle dung, since the biogas yield sharply increased until the 5th week. After that, biogas production decreased resulting in a plateau of the cumulative curve. It can be noticed that the maize stalks gives the higher yield of biogas production at mixing ratio maize stalks: cattle dung 1:3 followed by mixing ratio 1:2 and finally 1:1. The amount of biogas production throughout 90 days fermentation for all mixing ratios were 24.17, 32.73, 34.25 and 13.40 L / digester for mixing ratios 1:1, 1:2, 1:3 and control treatment respectively.

Using cotton stalks, Figure 4.19 showed that the sharp increase in biogas yield until 6th week of anaerobic digestion for all mixing ratios. Exception was found for the control treatment, i.e. cattle dung, since the biogas yield sharply increased until the 5th week. After that, biogas production decreased resulting in a plateau of the cumulative curve. It can be noticed that the cotton stalks gives the higher yield of biogas production at mixing ratio cotton stalks: cattle dung 1:3 followed by mixing ratio 1:2 and finally 1:1. The amount of biogas production throughout 90 days fermentation for all mixing ratios were 17.47, 19.27, 21.5 and 13.40 L / digester for mixing ratios 1:1, 1:2, 1:3 and control treatment respectively.

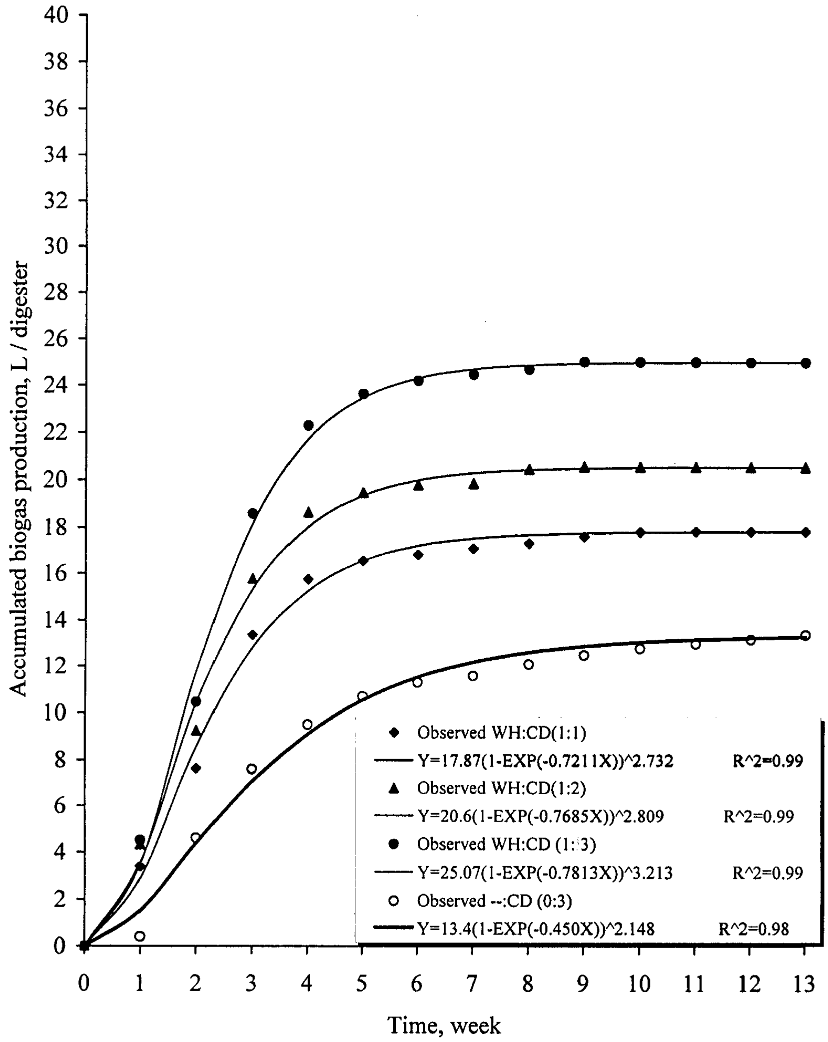
Dealing water hyacinth, Figure 4.20 showed that the sharp increase in biogas yield until 4th week of anaerobic digestion for all mixing ratios. Exception was found for the control treatment, i.e. cattle dung, since the biogas yield sharply increased until the 5th week. After that, biogas



Figur 4.18 : Accumulated biogas production through ninety days when using different ratios of maize stalks: cattle dung as the fermenting substrate.



Figur 4.19 : Accumulated biogas production through ninety days when using different ratios of cotton stalks : cattle dung as the fermenting substrate.



Figur 4.20 : Accumulated biogas production through ninety days when using different ratios of water hyacinth : cattle dung as the fermenting substrate.

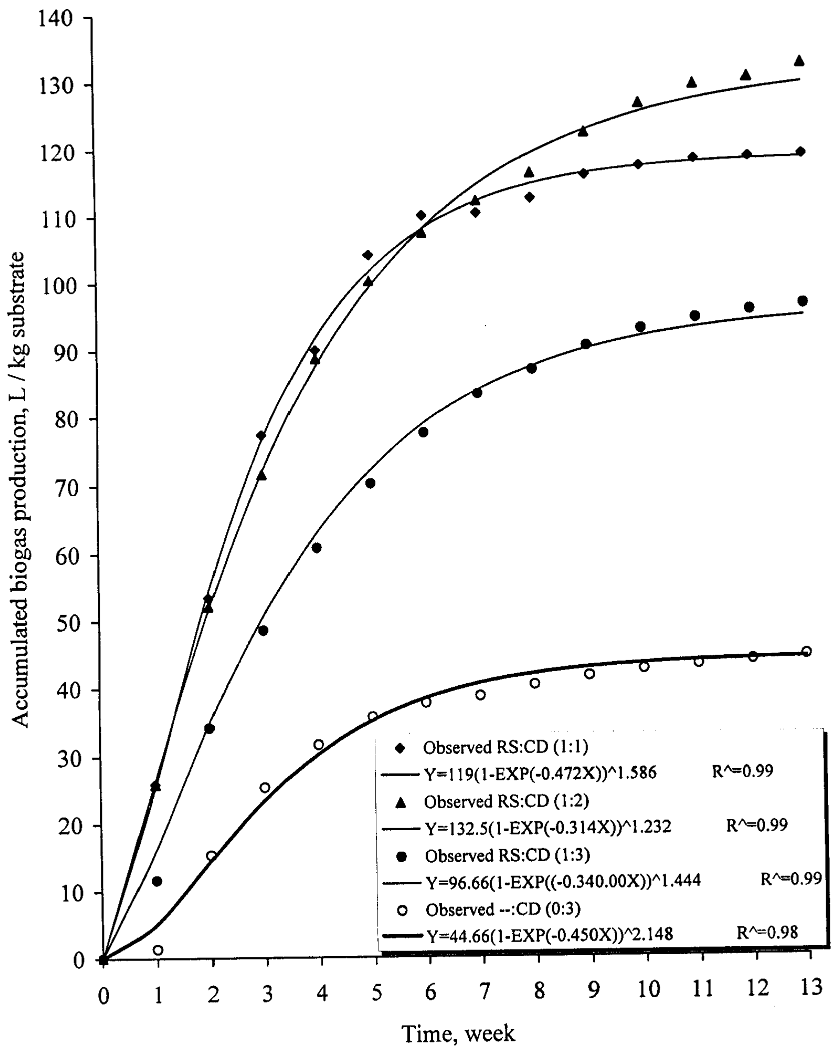
production decreased resulting in a plateau of the cumulative curve. It can be noticed that the water hyacinth gives the higher yield of biogas production at mixing ratio water hyacinth: cattle dung 1:3 followed by mixing ratio 1:2 and finally 1:1. The amount of biogas production throughout 90 days fermentation for all mixing ratios were 17.87, 20.6, 25.07 and 13.40 L / digester for mixing ratios 1:1, 1:2, 1:3 and control treatment respectively.

Analysis of variance in Tables A-1 and A-2 had been done to indicate the significancy effect of treatment on the accumulated biogas production in l / digester. It was found a highly significant difference between treatments. Highly significant effect was found for the agricultural waste. Highly Significant effect was found for the mixing ratio. Significant effect was found for the interaction between the agricultural waste and mixing ratio

From the previously mentioned results one can conclude that the highest biogas yield when using rice straw was 39.75 L /digester at a mixing ratio 1:2. When using maize stalks the highest yield reached 34.73 L / digester at a mixing ratio 1:3. For cotton stalks, it reached 21.5 L /digester at a mixing ratio 1:1. When using water hyacinth, it reached 25.07 L digester at a mixing ratio 1:3.

4.2.3 Accumulated biogas production, L/ kg substrata:

Regarding rice straw, Figure 4.21 showed that the sharp increase in biogas yield until 7th week of anaerobic digestion for all mixing ratios. Exception was found for the control treatment, i.e. cattle dung, since the biogas yield sharply increased until the 5th week. After that, biogas production decreased resulting in a plateau of the cumulative curve. It can be noticed that the rice straw gives the higher yield of biogas production at



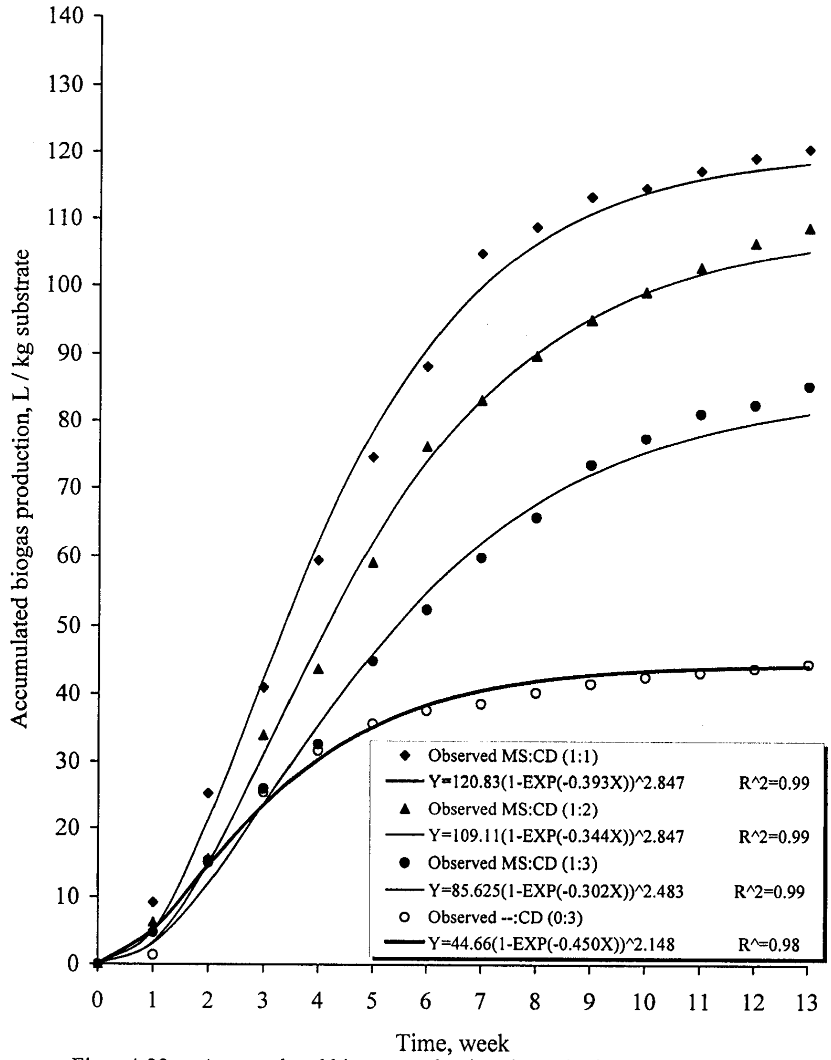
Figur 4.21 : Accumulated biogas production through ninety days when using different ratios of rice straw : cattle dung as the fermenting substrate.

mixing ratio rice straw: cattle dung 1:2 followed by mixing ratio 1:3 and finally 1:1. The amount of biogas production throughout 90 days fermentation for all mixing ratios were 119.0, 132.5, 96.67 and 44.67 L / kg substrata for mixing ratios 1:1, 1:2, 1:3 and control treatment respectively.

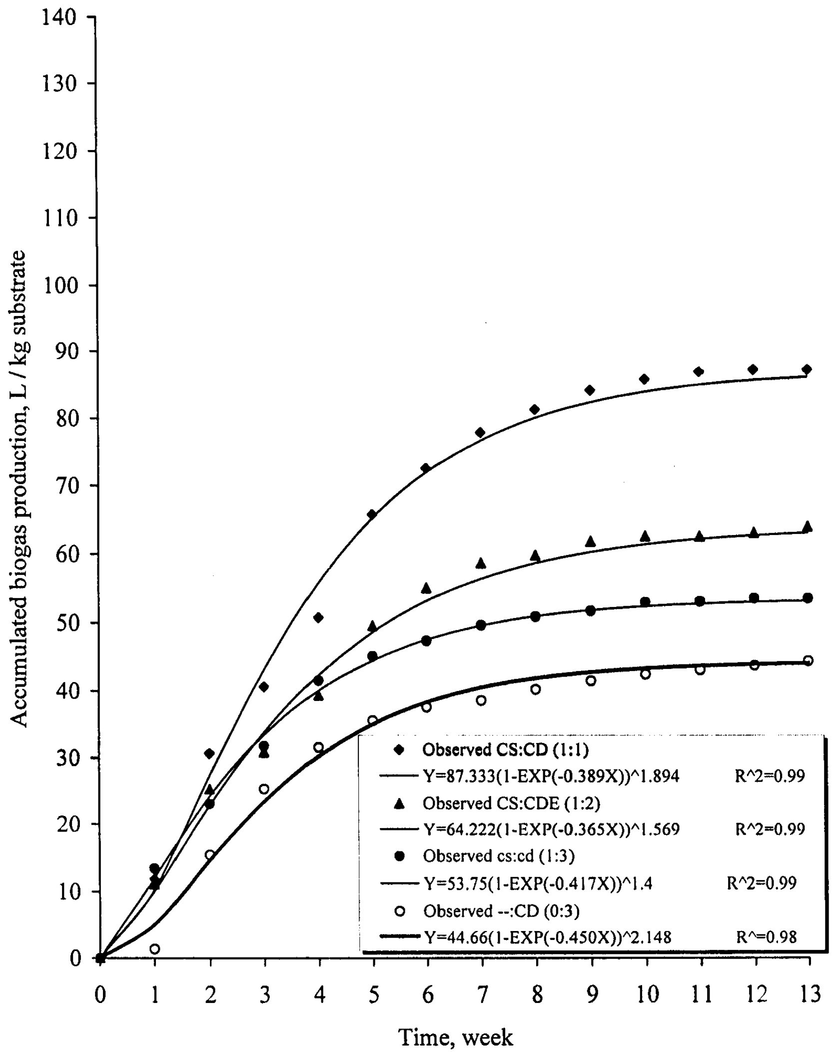
According to maize stalks, Figure 4.22 showed that the sharp increase in biogas yield until 9th week of anaerobic digestion for all mixing ratios. Exception was found for the control treatment, i.e. cattle dung, since the biogas yield sharply increased until the 5th week. After that, biogas production decreased resulting in a plateau of the cumulative curve. It can be noticed that the maize stalks gives the higher yield of biogas production at mixing ratio maize stalks: cattle dung 1:1 followed by mixing ratio 1:2 and finally 1:3. The amount of biogas production throughout 90 days fermentation for all mixing ratios were 120.83, 109.11, 85.63 and 44.67 L /kg substrata for mixing ratios 1:1, 1:2, 1:3 and control treatment respectively.

In the same manner by using cotton stalks, Figure 4.23 showed that the sharp increase in biogas yield until 6th week of anaerobic digestion for all mixing ratios. Exception was found for the control treatment, i.e. cattle dung, since the biogas yield sharply increased until the 5th week. After that, biogas production decreased resulting in a plateau of the cumulative curve. It can be noticed that the cotton stalks gives the higher yield of biogas production at mixing ratio cotton stalks: cattle dung 1:1 followed by mixing ratio 1:2 and finally 1:3. The amount of biogas production throughout 90 days fermentation for all mixing ratios were 87.33, 64.22, 53.75 and 44.67 L / kg substrata for mixing ratios 1:1, 1:2, 1:3 and control treatment respectively.

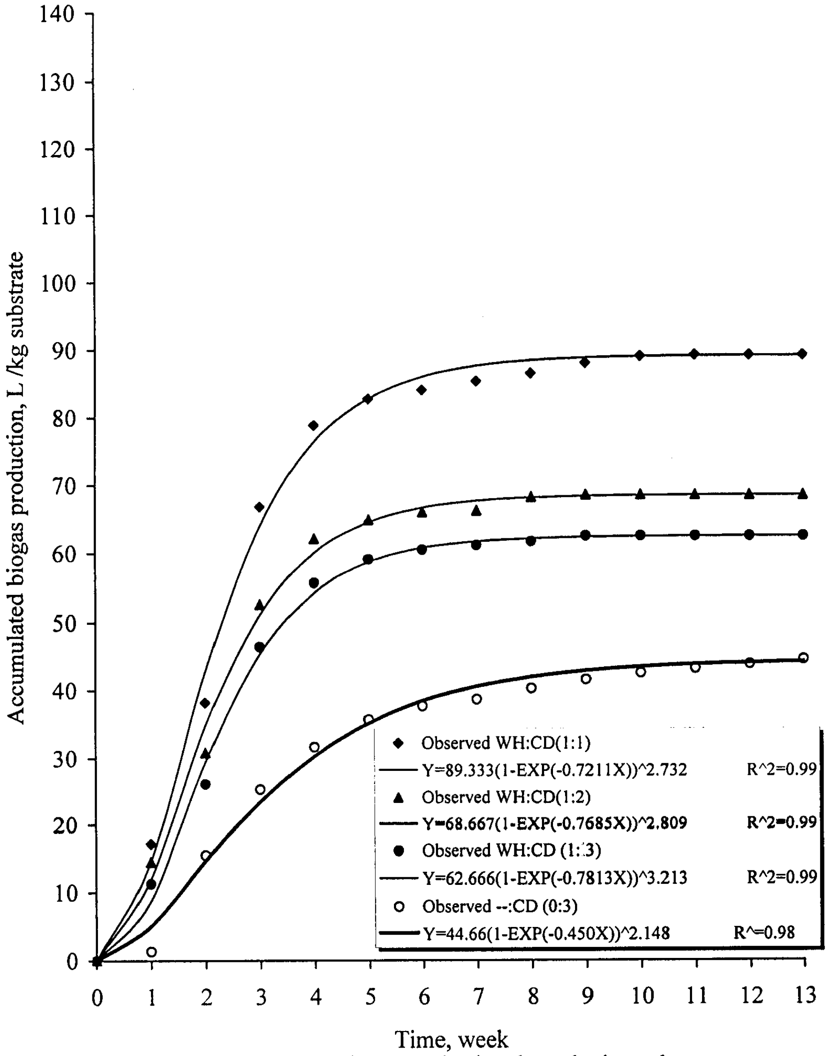
The same tendency was obtained in case of water hyacinth, Figure 4.24 showed that the sharp increase in biogas yield until 4th week of anaerobic digestion for all mixing ratios. Exception was found for the control treatment, i.e. cattle dung, since the biogas yield sharply increased until the 5th week. After



Figur 4.22 : Accumulated biogas production through ninety days when using different ratios of maize stalks : cattle dung as the fermenting substrate.



Figur 4.23 : Accumulated biogas production through ninety days when using different ratios of cotton stalks : cattle dung as the fermenting substrate.



Figur 4.24 : Accumulated biogas production through ninety days when using different ratios of water hyacinth : cattle dung as the fermenting substrate.

that, biogas production decreased resulting in a plateau of the cumulative curve. It can be noticed that the water hyacinth gives the higher yield of biogas production at mixing ratio water hyacinth: cattle dung 1:1 followed by mixing ratio 1:2 and finally 1:3. The amount of biogas production throughout 90 days fermentation for all mixing ratios were 89.33, 68.67, 62.67 and 44.67 L / kg substrata for mixing ratios 1:1, 1:2, 1:3 and control treatment respectively.

Analysis of variance in Tables A-3 and A-4 had been done to indicate the significancy effect of treatment on the accumulated biogas production in L / kg substrata. It was found a highly significant difference between treatments. Highly significant effect was found for the agricultural waste. Highly Significant effect was found for the mixing ratio. On the other hand no significant effect was found for the interaction between the agricultural waste and mixing ratio

From the previously mentioned results one can conclude that the highest biogas yield when using rice straw was 132.5 L /kg substrata at a mixing ratio 1:2. When using maize stalks the highest yield reached 120.83 L / kg substrata at a mixing ratio 1:1. Also for cotton stalks, it reached 87.33 L /kg substrata at a mixing ratio 1:1. By using water hyacinth, it reached 89.33 L / kg substrata at a mixing ratio 1:1.

4.2.4 Accumulated biogas production, L / kg VS:

Regarding rice straw, Figure 4.25 showed that the sharp increase in biogas yield until 7th week of anaerobic digestion for all mixing ratios. Exception was found for the control treatment, i.e. cattle dung, since the biogas yield sharply increased until the 5th week. After that, biogas production decreased resulting in a plateau of the cumulative curve. It can be noticed that the rice straw gives the higher yield of biogas production at mixing ratio rice

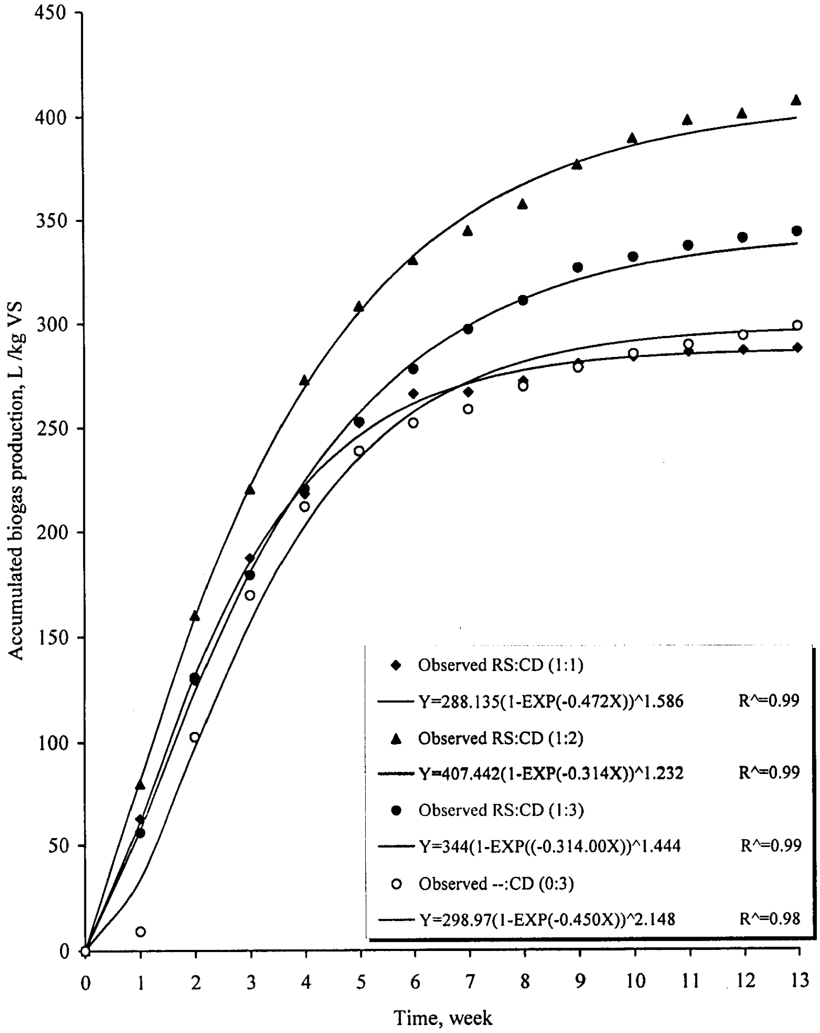


Figure 4.25 : Accumulated biogas production through ninety days when using rice straw : cattle dung at different ratios as the fermentation substrate.

straw: cattle dung 1:2 followed by mixing ratio 1:3 and finally 1:1. The amount of biogas production throughout 90 days fermentation for all mixing ratios were 288.13, 407.44, 344.0 and 298.97 L / kg VS for mixing ratios 1:1, 1:2, 1:3 and control treatment respectively.

Concerning maize stalks, Figure 4.26 showed that the sharp increase in biogas yields until 9th week of anaerobic digestion for all mixing ratios. Exception was found for the control treatment, i.e. cattle dung, since the biogas yield sharply increased until the 5th week. After that, biogas production decreased resulting in a plateau of the cumulative curve. It can be noticed that the maize stalks gives the higher yield of biogas production at mixing ratio maize stalks: cattle dung 1:2 followed by mixing ratio 1:3 and finally 1:1. The amount of biogas production throughout 90 days fermentation for all mixing ratios were 254.0, 297.35, 273.95 and 298.97 L /kg VS for mixing ratios 1:1, 1:2, 1:3 and control treatment respectively.

By using cotton stalks, Figure 4.27 showed that the sharp increases in biogas yield until 6th week of anaerobic digestion for all mixing ratios. Exception was found for the control treatment, i.e. cattle dung, since the biogas yield sharply increased until the 5th week. After that, biogas production decreased resulting in a plateau of the cumulative curve. It can be noticed that the cotton stalks gives the higher yield of biogas production at mixing ratio cotton stalks: cattle dung 1:1 followed by mixing ratio 1:2 and finally 1:3. The amount of biogas production throughout 90 days fermentation for all mixing ratios were 194.59, 184.01, 179.7 and 298.97 L / kg VS for mixing ratios 1:1, 1:2, 1:3 and control treatment respectively.

Dealing water hyacinth, Figure 4.28 showed that the sharp increase in biogas yield until 4th week of anaerobic digestion for all mixing ratios. Exception was found for the control treatment, i.e. cattle dung, since the biogas yield sharply increased until the 5th week. After that, biogas production

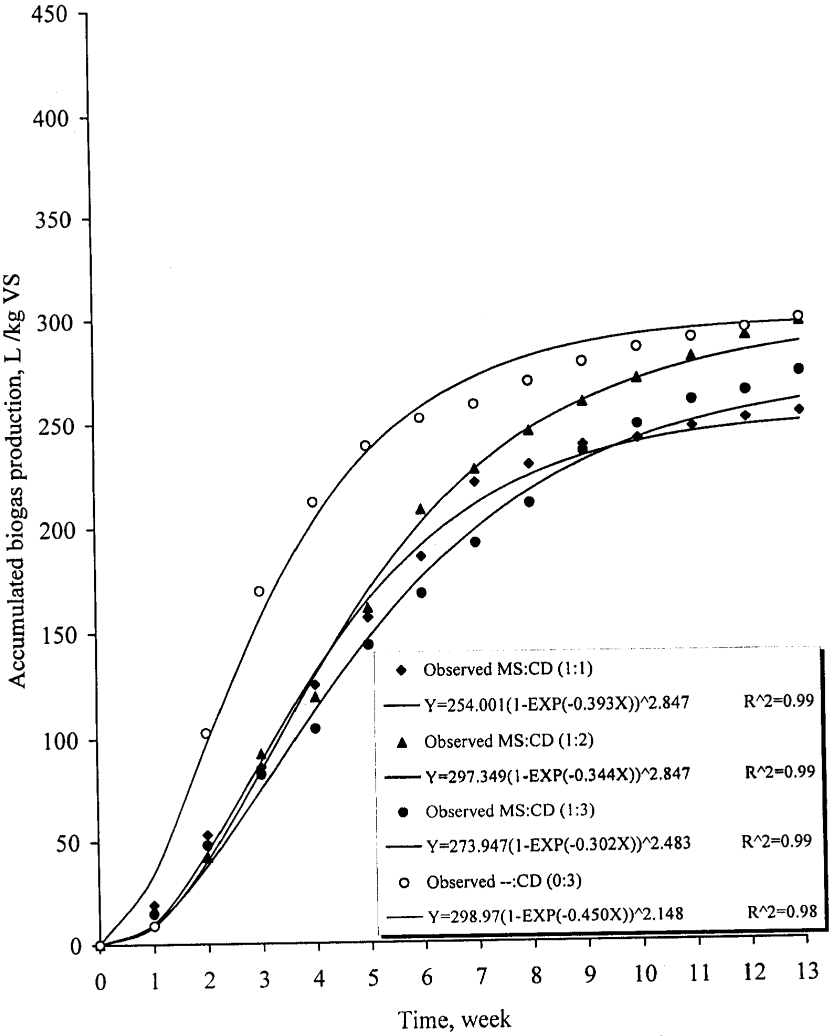


Figure 4.26 : Accumulated biogas production through ninety days when using maize stalks : cattle dung at different ratios as the fermentation substrate.

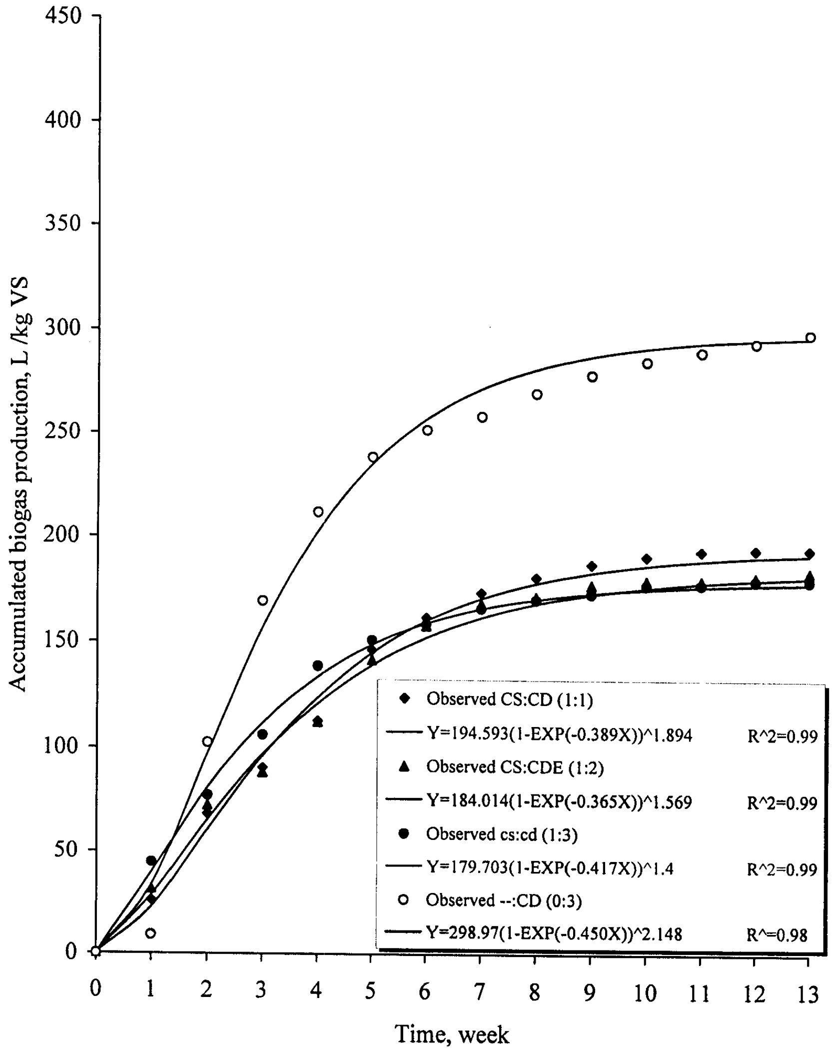


Figure 4.27 : Accumulated biogas production through ninety days when using cotton stalks : cattle dung at different ratios as the fermentation substrate.

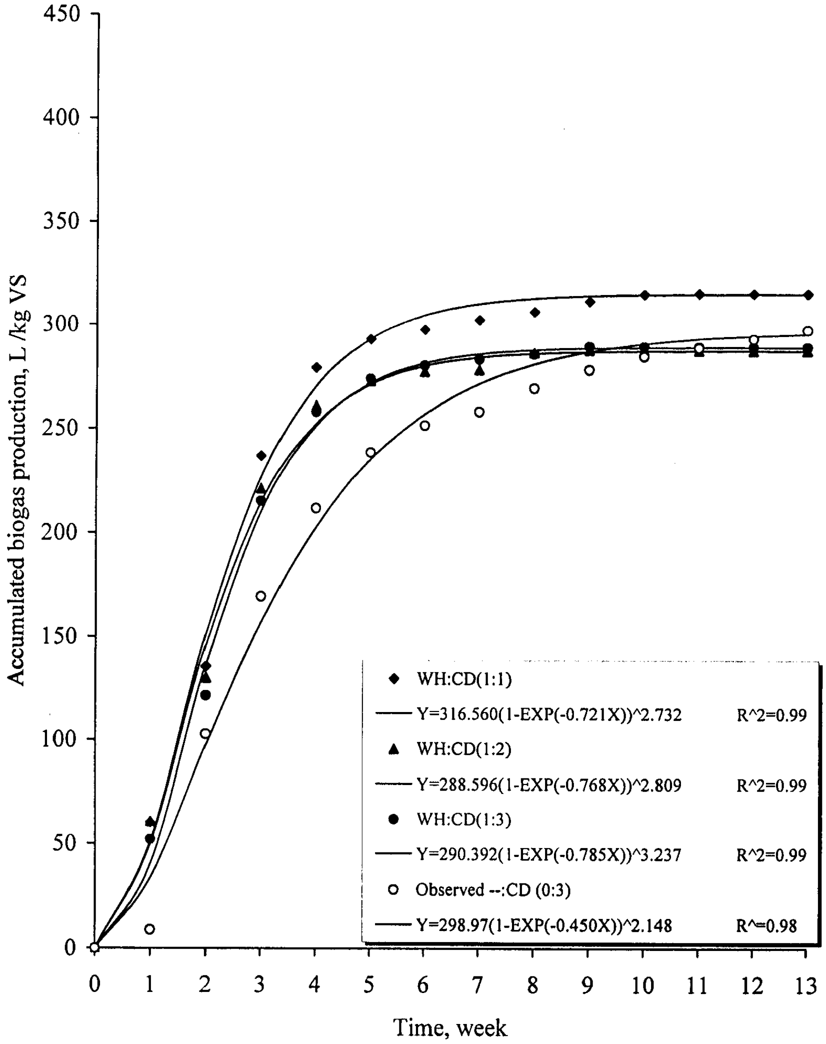


Figure 4.28 : Accumulated biogas production through ninety days when using water hyacinth : cattle dung at different ratios as the fermentation substrate.

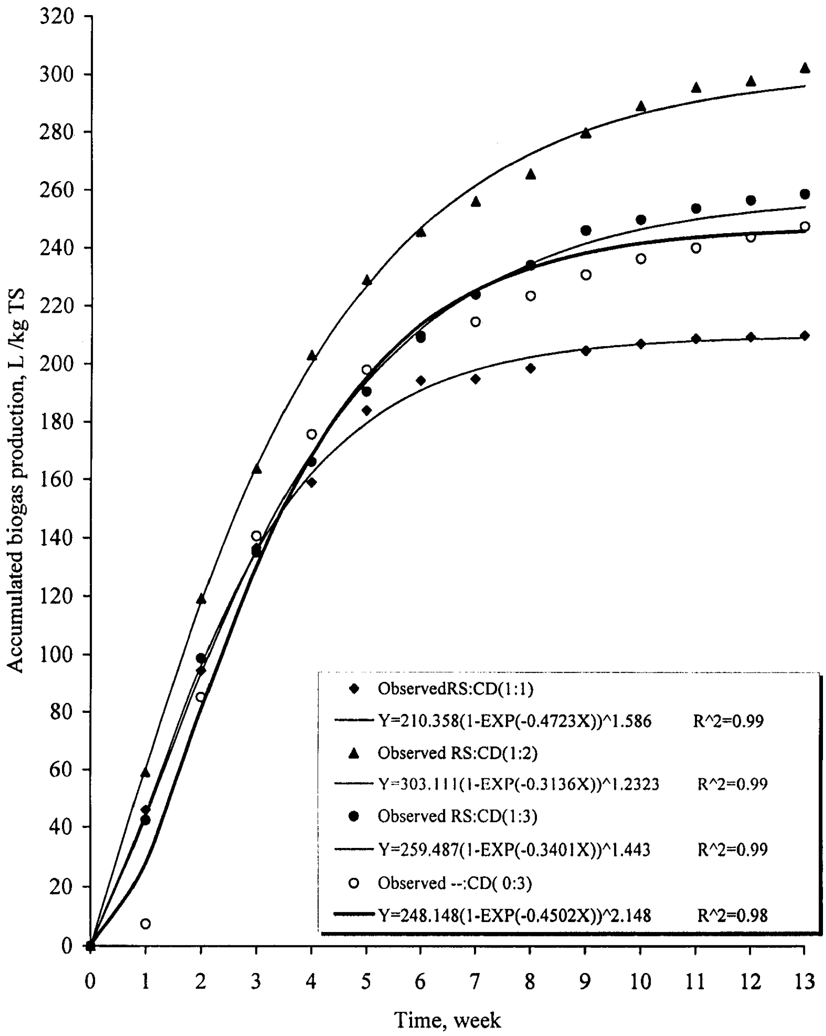
decreased resulting in a plateau of the cumulative curve. It can be noticed that the water hyacinth gives the higher yield of biogas production at mixing ratio water hyacinth: cattle dung 1:1 followed by mixing ratio 1:3 and finally 1:2. The amount of biogas production throughout 90 days fermentation for all mixing ratios were 316.56, 288.59, 290.39 and 298.97 L / kg VS for mixing ratios 1:1, 1:2, 1:3 and control treatment respectively.

Analysis of variance in Tables A-5 and A-6 had been done to indicate the significancy effect of treatment on the accumulated biogas production in L / kg VS. It was found a highly significant difference between treatments. Highly significant effect was found for the agricultural waste. no Significant effect was found for the mixing ratio. On the other hand significant effect was found for the interaction between the agricultural waste and mixing ratio.

From the previously mentioned results one can conclude that the highest biogas yield when using rice straw was 407.44 L /kg VS at a mixing ratio 1:2. When using maize stalks the highest yield reached 297.35 L / kg VS at a mixing ratio 1:2. For cotton stalks, it reached 194.59 L /kg VS at a mixing ratio 1:1. When using water hyacinth, it reached 316.56 L / kg VS at a mixing ratio 1:1.

4.2.5 Accumulated biogas production, L / kg TS:

Regarding rice straw, Figure 4.29 showed that the sharp increase in biogas yield until 7^{th} week of anaerobic digestion for all mixing ratios. Exception was found for the control treatment, i.e. cattle dung, since the biogas yield sharply increased until the 5^{th} week. After that, biogas production decreased resulting in a plateau of the cumulative curve. It can be noticed that the rice straw gives the higher yield of biogas production at mixing ratio rice straw: cattle dung 1:2 followed by mixing ratio 1:3 and finally 1:1. The amount of biogas production throughout 90 days fermentation for all mixing ratios were



Figur 4.29 : Accumulated biogas production through ninety days when using different ratios of rice straw : cattle dung as the fermenting substrate.

210.36, 303.1, 259.49 and 248.15 L / kg TS for mixing ratios 1:1, 1:2, 1:3 and control treatment respectively.

According to maize stalks, Figure 4.30 showed that the sharp increase in biogas yield until 9th week of anaerobic digestion for all mixing ratios. Exception was found for the control treatment, i.e. cattle dung, since the biogas yield sharply increased until the 5th week. After that, biogas production decreased resulting in a plateau of the cumulative curve. It can be noticed that the maize stalks gives the higher yield of biogas production at mixing ratio maize stalks: cattle dung 1:2 followed by mixing ratio 1:3 and finally 1:1. The amount of biogas production throughout 90 days fermentation for all mixing ratios were 214.05, 249.87, 230.06 and 248.15 L /kg TS for mixing ratios 1:1, 1:2, 1:3 and control treatment respectively.

Meanwhile, by using cotton stalks, Figure 4.31 showed that the sharp increase in biogas yield until 6th week of anaerobic digestion for all mixing ratios. Exception was found for the control treatment, i.e. cattle dung, since the biogas yield sharply increased until the 5th week. After that, biogas production decreased resulting in a plateau of the cumulative curve. It can be noticed that the cotton stalks gives the higher yield of biogas production at mixing ratio cotton stalks: cattle dung 1:1 followed by mixing ratio 1:2 and finally 1:3. The amount of biogas production throughout 90 days fermentation for all mixing ratios were 156.59, 148.72, 145.72 and 248.15 L / kg TS for mixing ratios 1:1, 1:2, 1:3 and control treatment respectively.

Also, when using water hyacinth, Figure 4.32 showed that the sharp increases in biogas yield until 4th week of anaerobic digestion for all mixing ratios. Exception was found for the control treatment, i.e. cattle dung, since the biogas yield sharply increased until the 5th week. After that, biogas production decreased resulting in a plateau of the cumulative curve. It can be noticed that the water hyacinth gives the higher yield of biogas production at mixing ratio

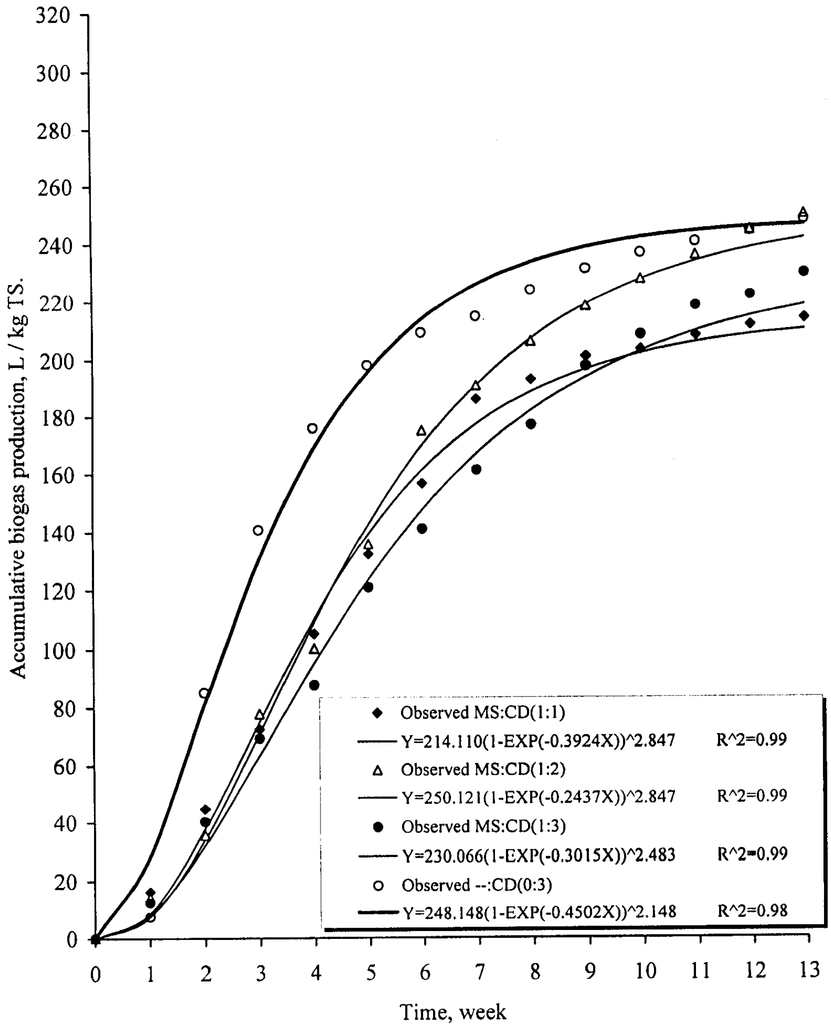
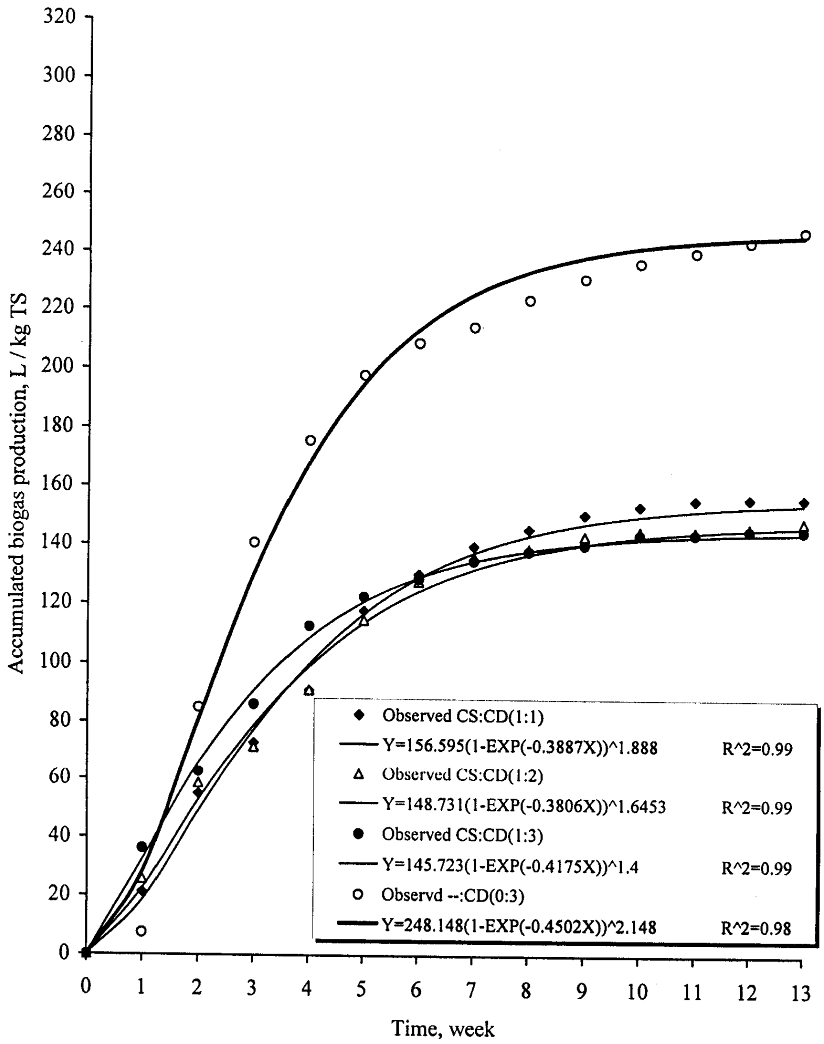
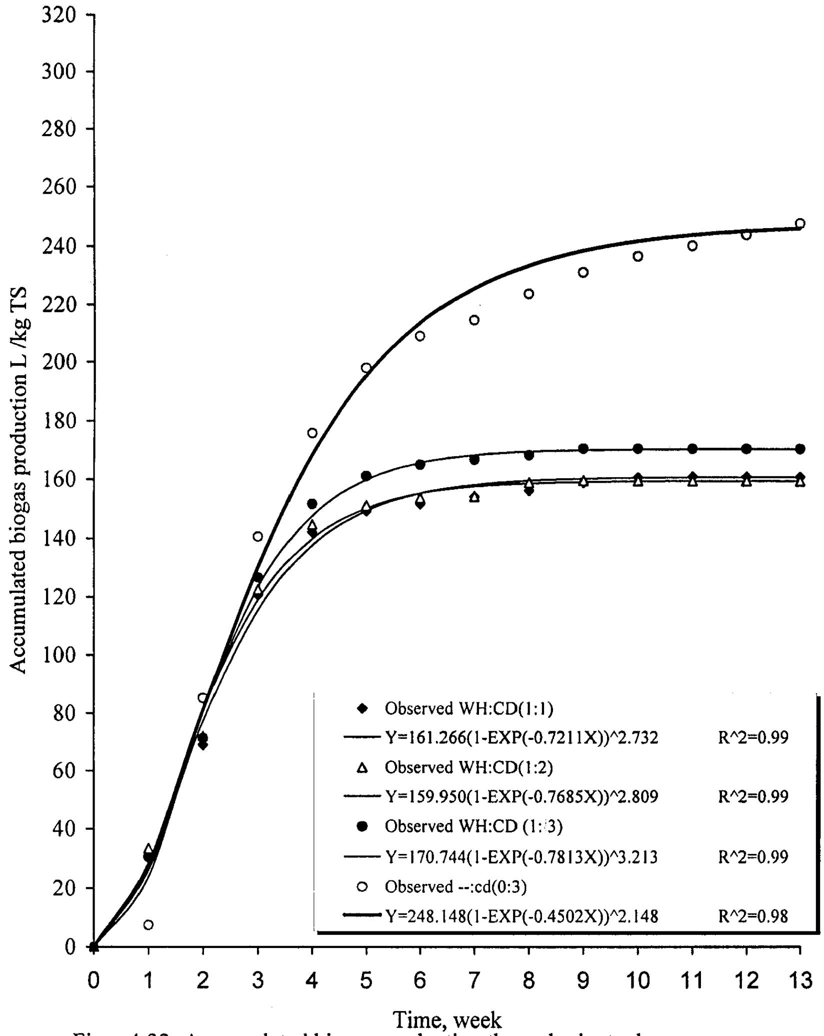


Figure 4.30 : Accumulated biogas production through ninety days when using different ratios of maize stalks: cattle dung ratios as the fermentation substrate.



Figur 4.31:Accumulated biogas production through ninety days when using different ratios of cotton stalks : cattle dung as the fermenting substrate



Figur 4.32 :Accumulated biogas production through ninety days when using different ratios of water hyacinth : cattle dung as the fermenting substrate.

water hyacinth: cattle dung 1:3 followed by mixing ratio 1:1 and finally 1:2. The amount of biogas production throughout 90 days fermentation for all mixing ratios were 161.26, 159.95, 170.76 and 248.15 L / kg TS for mixing ratios 1:1, 1:2, 1:3 and control treatment respectively.

Analysis of variance in Tables A-7 and A-8 had been done to indicate the significancy effect of treatment on the accumulated biogas production in L / kg TS. It was found a highly significant difference between treatments. Highly significant effect was found for the agricultural waste. Highly Significant effect was found for the mixing ratio. On the other hand highly significant effect was found for the interaction between the agricultural waste and mixing ratio.

From the previously mentioned results one can conclude that the highest biogas yield when using rice straw was 303.1 /kg TS at a mixing ratio 1:2. When using maize stalks the highest yield reached 249.87 L / kg TS at a mixing ratio 1:2. For cotton stalks, it reached 156.59 L /kg TS at a mixing ratio 1:1. When using water hyacinth, it reached 170.76 L / kg TS at a mixing ratio 1:3.

4.2.6 Net accumulated biogas production L /kg residue.

Figure 4.33 showed the theoretical net accumulated biogas production from three agricultural residues and water hyacinth as a single substrate in L/ kg residue. This was done by eliminating biogas produced from cattle dung share. The theoretical net accumulated biogas production from rice straw mixture were 193.3, 308.2 and 253.0 L/kg residue at mixing ratios 1:1, 1:2 and 1:3 respectively. Whereas maize stalks it reached 197.0, 238.0 and 208.5 L/kg residue at mixing ratios 1:1, 1:2 and 1:3 respectively. Meanwhile cotton stalks the corresponding values were 130, 103.3 and 81.0 L/kg residue at mixing ratios 1:1, 1:2 and 1:3 respectively. Finally water hyacinth gives 134.0, 116.7 and 116.7 L/kg residue at mixing ratios 1:1, 1:2 and 1:3 respectively. It was revealed that

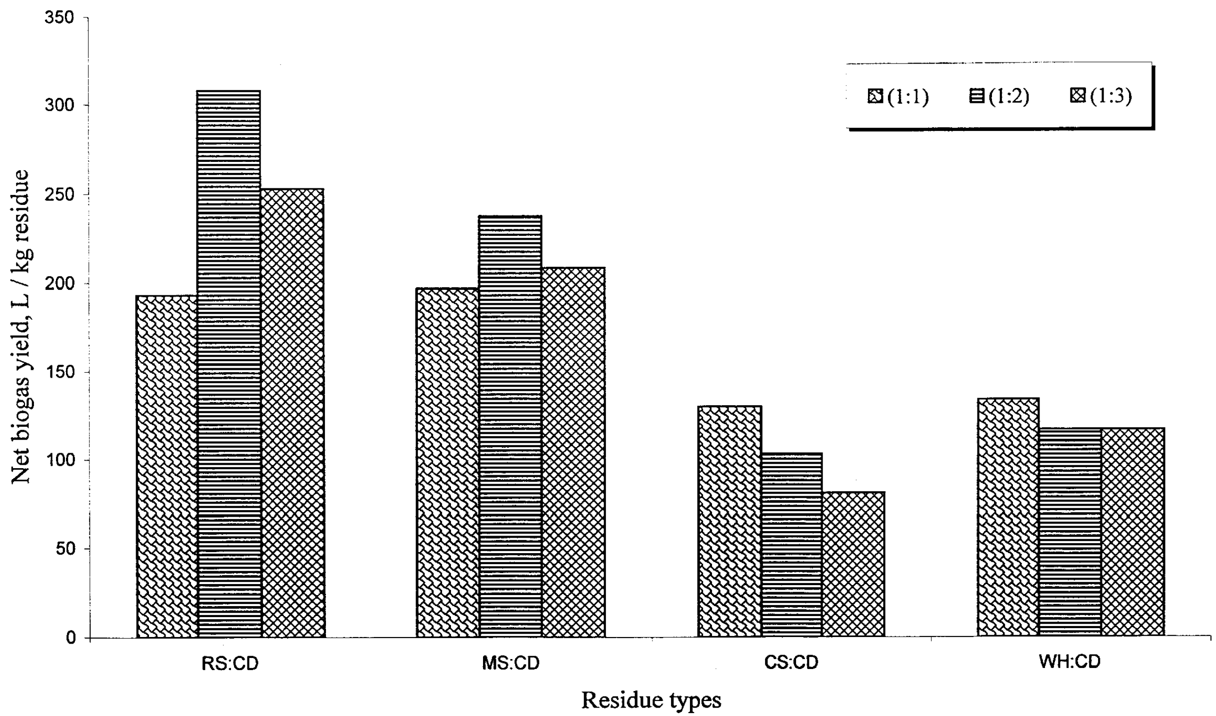


Figure 4.33: Net accumulated biogas yield at the end of 90 days

there was a variation in net accumulated biogas production per a unit mass of the residue because of the different mixing ratio for all agricultural residues and water hyacinth with cattle dung. This variation was appeared virtually when using rice straw or maize stalks than that when using cotton stalks or water hyacinth. This may refer to the high content of lignin that has no digestibility in water hyacinth and cotton stalks than that in rice straw and maize stalks.

4.2.7 Contribution of crop residue as a percentage in the substrate in the accumulated biogas yield:

To indicate the contribution of crop residue percentage in terms and their effect on the biogas yield expressed in terms L /digester, L / kg feed, L / kg VS, L / kg TS were shown in the following sections. as well as, the variation in the substrate mass and moisture content with the different crop residue percentage are indicated.

a. Effect of crop residue percentage in the substrate on the accumulated biogas yield, L/digester

The accumulated biogas yield under three levels of crop residues and water hyacinth-cattle dung mixtures in L/ digester is shown in Figure 4.34. It is clear that increasing crop residue percentage in the mixture decreases the biogas yield in terms of L / digester. Actually this result was expected because of the corresponding decrease in the substrate mass within each digester by increasing the crop residue percentage. For the digester with 25 % rice straw (75 % cattle dung), the biogas yield was 38.7 L / digester. Whereas, for the digester with 33.33 % rice straw (66.66 % cattle dung), the biogas yield was 39.75 L /digester. Finally for the reactor with 50 % rice straw (50 % cattle dung), the biogas yield was 23.8 L / digester.

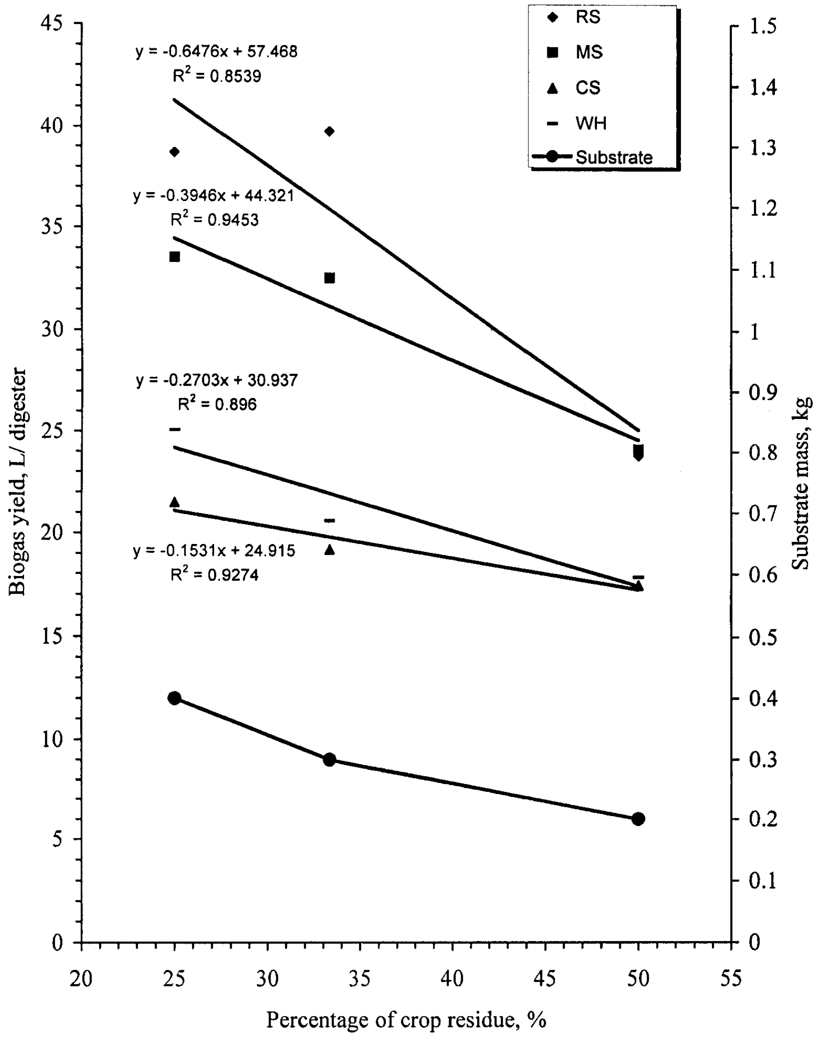


Figure 4.34 : Effect of crop residue or water hyacinth percentage mixed with cattle dung on the accumulated biogas yield per digester throught ninty days.

However, maize stalks mixture, the corresponding values were 34.25, 32.73 and 24.17 L /digester at 25 %, 33.33 % and 50 % crop residue in the substrate respectively.

In the meanwhile cotton stalks mixture, the corresponding values were 21.5, 19.27 and 17.47 L /digester at 25 %, 33.33 % and 50 % crop residue in the substrate respectively.

In the same manner water hyacinth mixture, the corresponding values were 25.07, 20.6 and 17.87 L /digester at 25 %, 33.33 % and 50 % crop residue in the substrate respectively.

b. Effect of crop residue percentage in substrate on accumulated biogas yield in, L/kg substrata:

The accumulated biogas yield under three levels of crop residues and water hyacinth-cattle dung mixture in L/ kg substrata is given in Figure 4.35 it is revealed that increasing crop residue percentage in the mixture increases biogas yield in L / kg substrata this is because of the corresponding decrease in the moisture content of the substrate or in other words increasing the concentration of the active material in the substrate.

Whereas rice straw mixture, the corresponding values were 96.67, 132.5 and 119 L /kg substrata at 25 %, 33.33 % and 50 % crop residue in the substrate respectively.

Also, maze stalks mixture, the corresponding values were 85.63, 109.11 and 120.83 L / kg substrata at 25 %, 33.33 % and 50 % crop residue in the substrate respectively.

Meanwhile cotton stalks mixture, the corresponding values were 53.75, 64.22 and 87.33 L / kg substrata at 25 %, 33.33 % and 50 % crop residue in the substrate respectively.

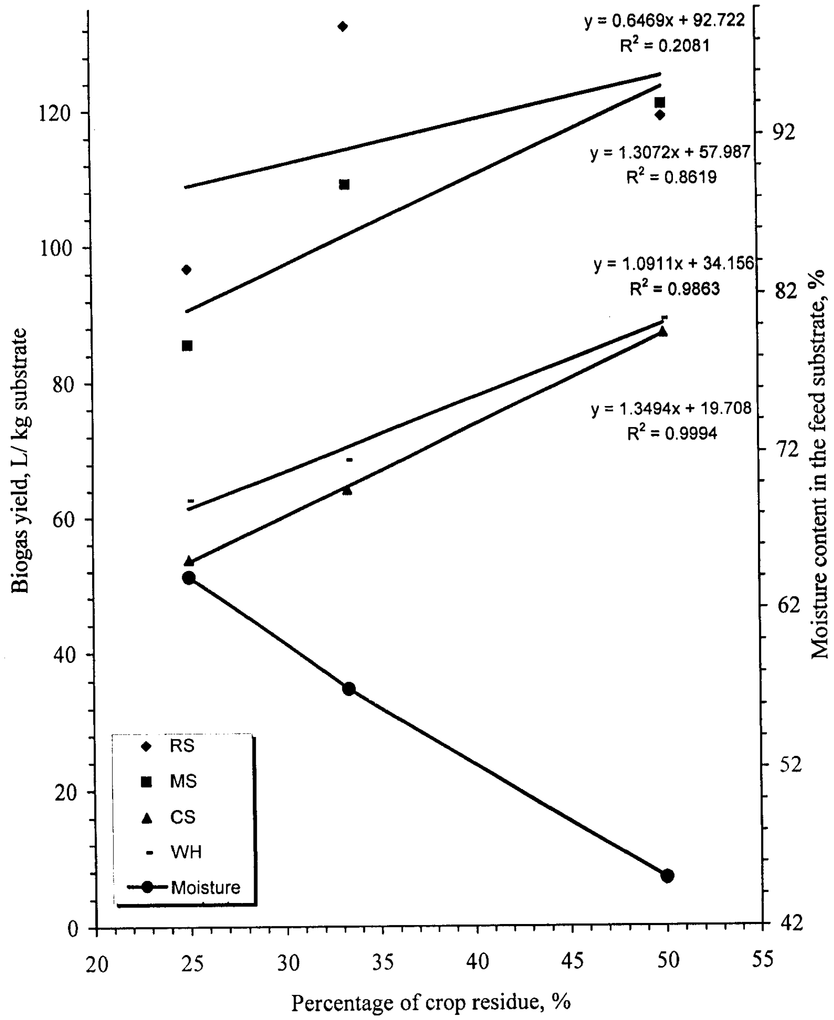


Figure 4.35 : Effect of crop residue or water hyacinth percentage mixed with cattle dung on the accumulated biogas yield per kg substrate throught ninty days.

On the other hand water hyacinth mixture, the corresponding values were 62.67, 68.67 and 89.33 L / kg feed at 25 %, 33.33 % and 50 % crop residue in the substrate respectively.

c. Effect of crop residue percentage in the substrate on the accumulated biogas yield, L / kg VS:

Figure 4.36 shows a decrease in biogas yield in L / kg VS for rice straw and maize stalks by increasing crop residue percentage in the mixture. On the other hand there was on increase in biogas yield by increase crop residue percentage for cotton stalks and water hyacinth. These both inverse general trend may refer to the fairly variation in volatile solids content. The results indicated that, the increase in lignin content specifically in water hyacinth since it has a high content of hemicellulose and cellulose, but the existing hemicellulose has a rather strong association with the lignin in the plant, which makes it unavailable for the microorganisms **(Patel et al., 1993a)**.

The obtained data of biogas yield from rice straw mixture indicated that, the corresponding values were 344.0, 407.44 and 288.14 L /kg VS at 25 %, 33.33 % and 50 % crop residue in the substrate respectively.

Mean while maze stalks mixture, the corresponding values were 273.95, 297.05 and 253.93 L / kg VS at 25 %, 33.33 % and 50 % crop residue in the substrate respectively.

Also, cotton stalks mixture, the corresponding values were 179.7, 184.0 and 197.59 L / kg VS at 25 %, 33.33 % and 50 % crop residue in the substrate respectively.

On the other hand water hyacinth mixture, the corresponding values were 290.38, 288.6 and 316.55 L / kg VS at 25 %, 33.33 % and 50 % crop residue in the substrate respectively.

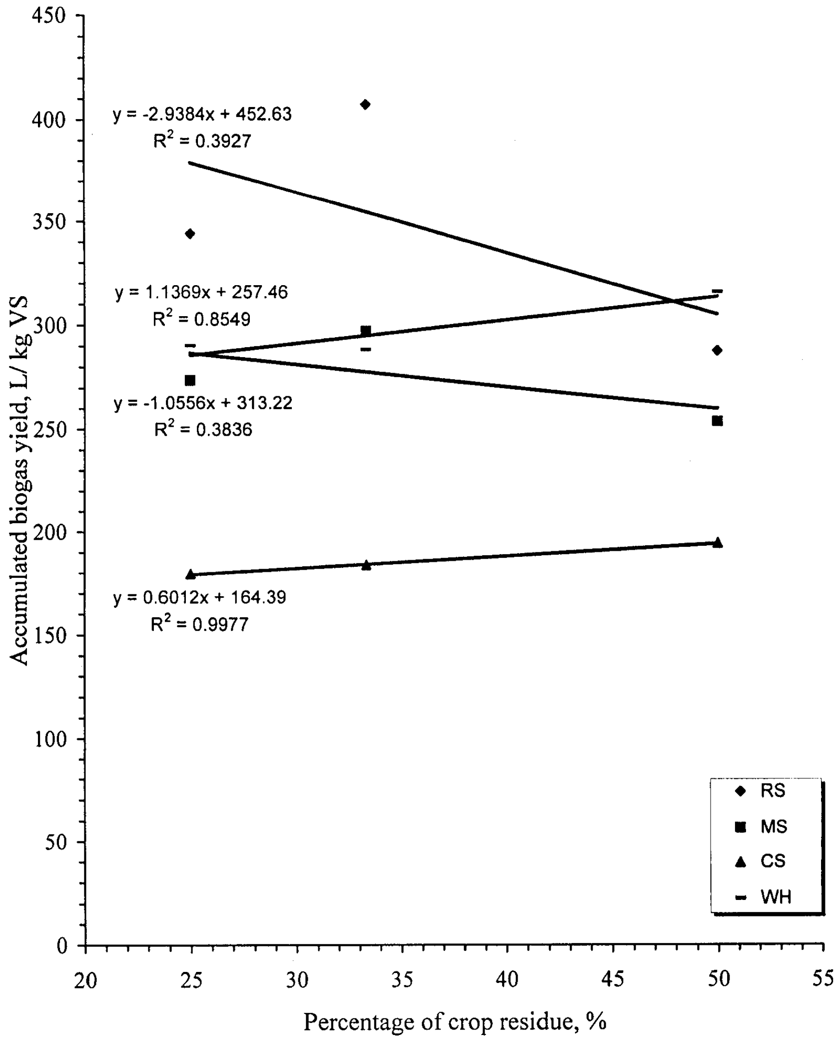


Figure 4.36 : Effect of crop residue or water hyacinth percentage mixed with cattle dung on the accumulated biogas yield per kg VS throught ninty days.

d. Effect of crop residue percentage in the substrate on the accumulated biogas yield, L/kg TS.

As a general trends the biogas yield decreased by increasing crop residue percentage in the substrate mixture for the crop residue Figure 4.37. One exception was found for cotton stalks mixture since it appear to increase by increasing crop residue percentage.

The results indicated that by using rice straw mixture, the corresponding values were 210.36, 303.1 and 259.49 L /kg TS at 25 %, 33.33 % and 50 % crop residue in the substrate respectively.

Also maze stalks mixture, the corresponding values were 214.05, 249.87 and 230.25 L / kg TS at 25 %, 33.33 % and 50 % crop residue in the substrate respectively.

However cotton stalks mixture, the corresponding values were 156.59, 148.72 and 145.72 L / kg TS at 25 %, 33.33 % and 50 % crop residue in the substrate respectively.

Whilst water hyacinth mixture, the corresponding values were 161.26, 159.95 and 170.76 L / kg TS at 25 %, 33.33 % and 50 % crop residue in the substrate respectively.

4.3. Weekly biogas yield gain:

From Figures 4.38 to 4.41 indicates the weekly biogas yield gain expressed in a percentage of the weekly accumulated biogas production from the total accumulated biogas yield at the end of the 90 days for all treatments.

Half the biogas yield could be gained during the third, five, (4, 4 and 3) and third week of fermentation for rice straw, maize stalks, cotton stalks and water hyacinth mixture at the three mixing ratios respectively. Half the biogas

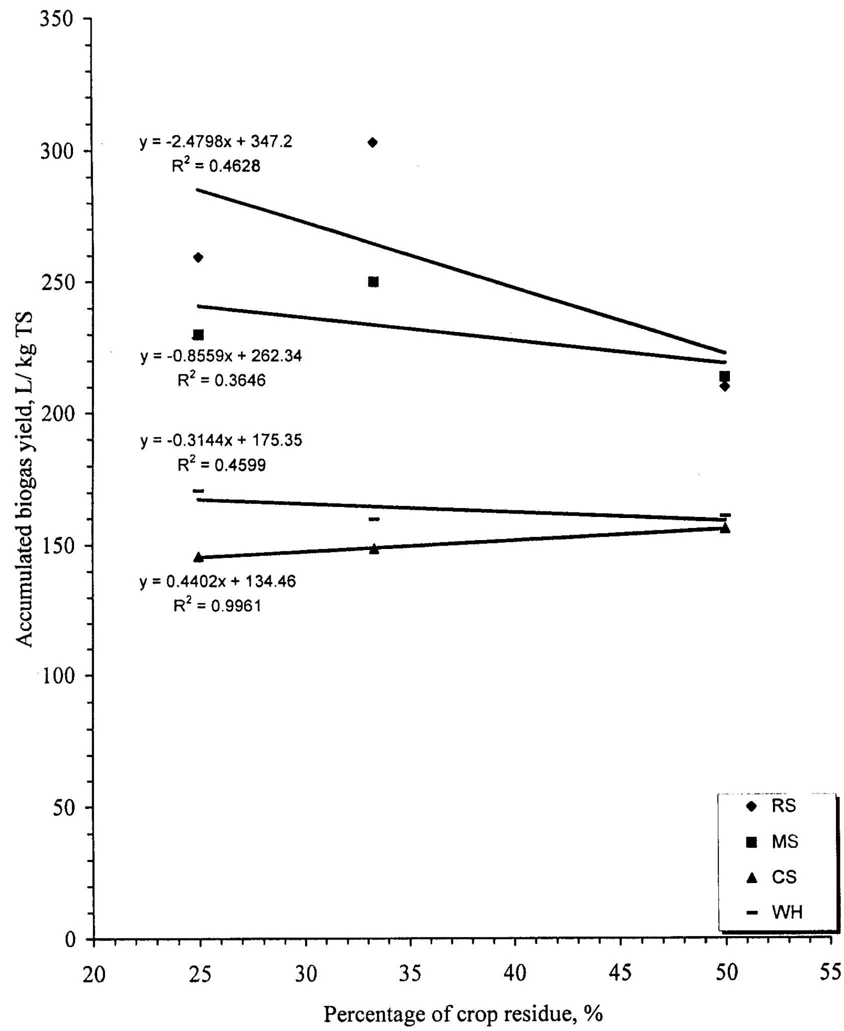


Figure 4.37 : Effect of crop residue or water hyacinth percentage mixed with cattle dung on the accumulated biogas yield per kg TS throught ninty days.

yield could be gained during the forth week of fermentation for cattle dung alone.

From Figures 4.38 to 4.41 and a general trend it is clear that there is a sharp increase in biogas yield gain until 90 % of the total yield was gained. Then the increasing percentage of biogas yield takes a clearly decline rate until reaching the 100 % of the total yield. This could be found for all treatments.

Figure 4.38 a 90 % of the biogas yield could be gained during the 6, 9 and 8 week of fermentation for rice straw mixture at the three mixing ratios .

Figure 4.39 a 90% of the biogas yield could be gained during the 8, 10 and 10 week of fermentation for maize stalks mixture at the three mixing ratios

Figure 4.40 a 90% of the biogas yield could be gained during the 8, 7 and 7 week of fermentation for cotton stalks mixture at the three mixing ratios.

Figure 4.41 a 90 % of the biogas yield could be gained during the 5, 4 and 5 week of fermentation for water hyacinth mixture at the three mixing ratios.

Figure 4.42 a 90 % of the biogas yield could be gained during the eight week of fermentation for cattle dung alone.

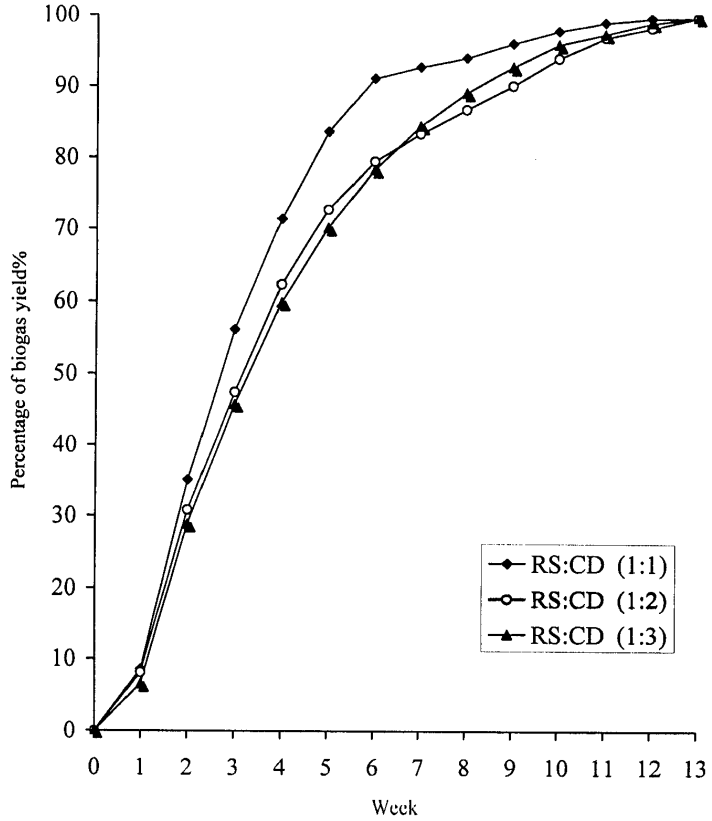


Figure 4.38: Accumulated biogas yield as percentage of total accumulated value when using different ratios of rice straw: cattle dung as the fermenting substrate.

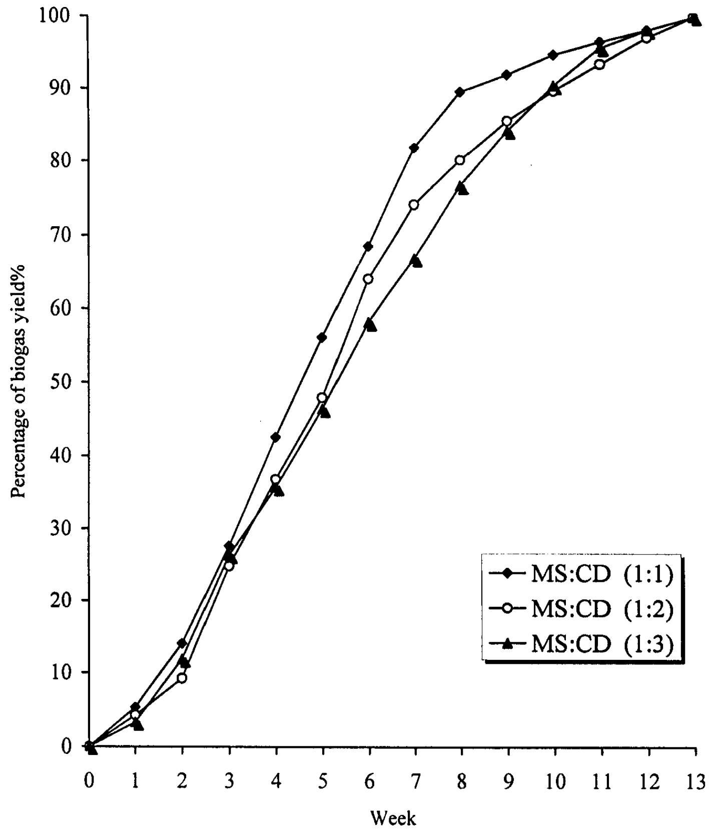


Figure 4.39: Accumulated biogas yield as percentage of total accumulated value when using different ratios of maizestalks:cattle dung as the fermenting substrate.

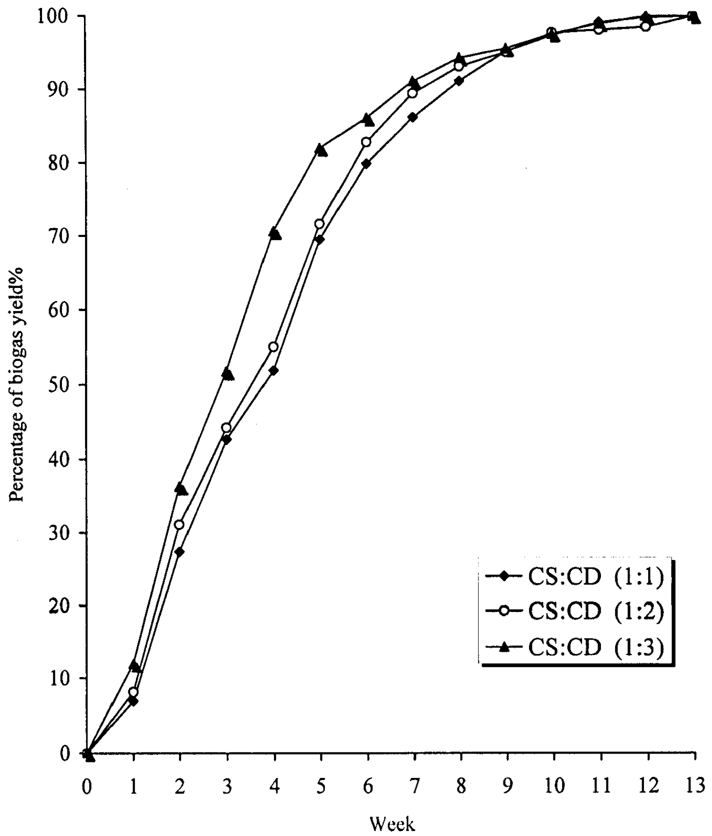


Figure 4.40: Accumulated biogas yield as percentage of total accumulated value when using different ratios of cotton stalks:cattle dung as the fermenting substrate.

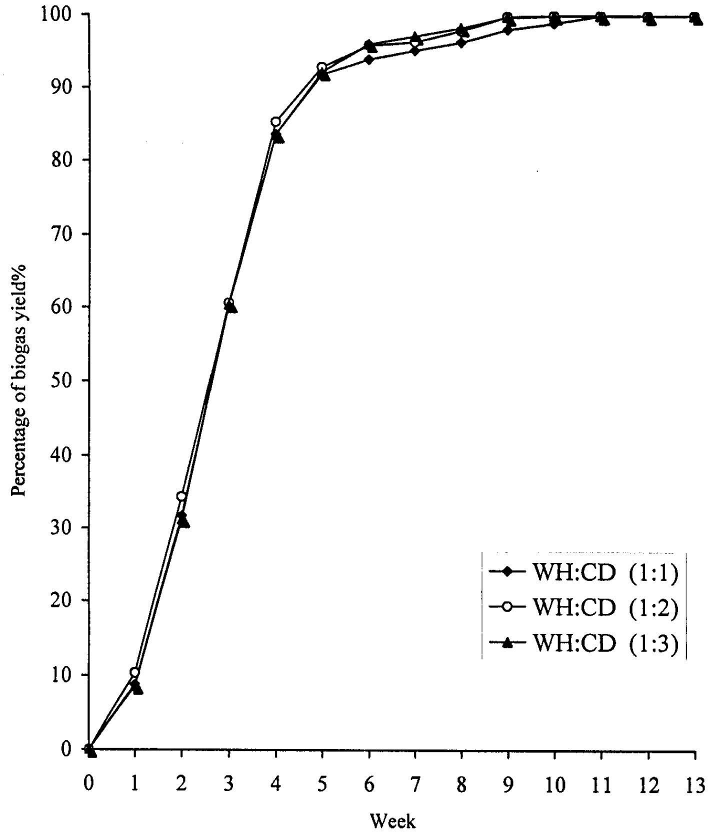


Figure 4.41: Accumulated biogas yield as percentage of total accumulated value when using different ratios of water hyacinth: cattle dung as the fermentation substrate.

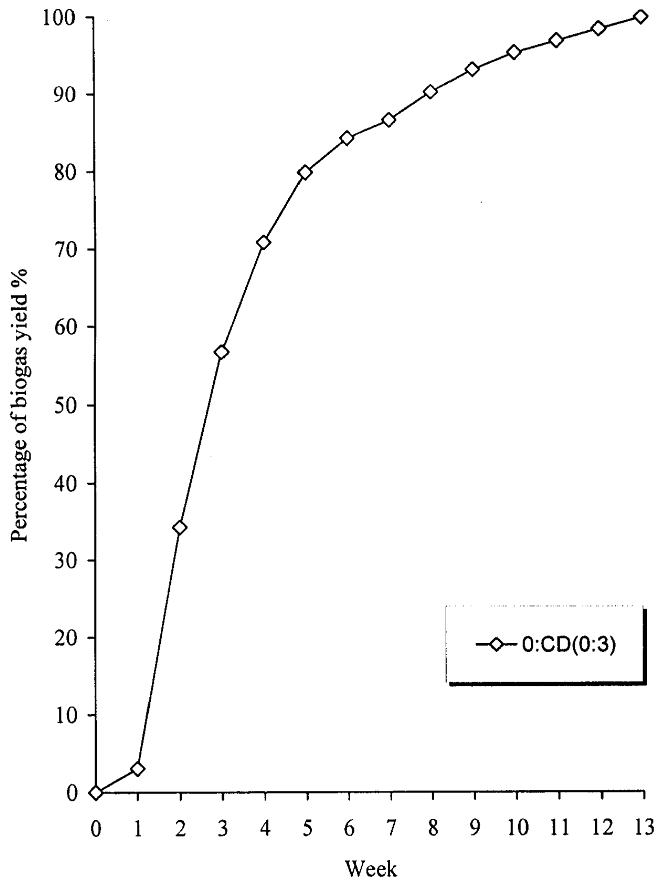


Figure 4.42 : Accumulated biogas yield as percentage of total accumulated value for cattle dung

Table 4.2 : Recommended conditions for the studied agricultural waste anaerobic digestion for generating biogas values depend on 90 % gain of the expected maximum yield at 90 days.

Agricultural waste	mixing ratio	Fermentation time, day	Biogas yield		
			L/kg feed	L/kg TS	L/kg VS
RS	01:01	42	110	194.45	266.34
	01:02	63	122.5	280.23	376.69
	01:03	56	87.08	234.68	311.11
MS	01:01	56	109	193.14	229.126
	01:02	70	99.44	227.96	271
	01:03	70	77.63	208.57	248.35
CS	01:01	56	81.33	145.84	181.22
	01:02	49	58.89	136.38	168.73
	01:03	49	49.75	134.88	166.33
WH	01:01	35	82.83	149.53	293.53
	01:02	28	62.22	144.94	261.51
	01:03	35	59.17	161.23	274.17
CD	00:03	56	40.33	224.07	289.97

5. SUMMARY AND CONCLUSIONS

One of the biggest environmental problems in Egypt is how to get rid of agricultural wastes. Amount of wastes of some crops like rice straw, maize stalks and cotton stalks reached 11.04 M ton / year (11.04 Tg /year) **(Helmy et al. 2003)**. Getting rid of these wastes is a big problem for the farmer. He burns these wastes, but , this is environmentally harmful, causes health problems in addition to loosing these wastes as an organic matter. Using the organic fertilizer that contains grass seeds, causes spreading for grasses, and loses a good deal of organic matter as a result of bad treatment. As well, water hyacinth as an another biological species accompanies the agricultural activities represents an additional problem. It grows fast, closes water canals, and causes a high percentage of water loss. High costs for cleaning these canals from large amount of water hyacinth without an economical benefit are not just ivied. Therefore one of the most suitable ways to cope with these problems and to treat these wastes is the anaerobic fermentation technology. It does not cost much, produces biogas which is one of the permanent energy sources, produces organic fertilizer which is rich in feeding elements especially nitrogen. In addition, it plays an important role in reducing the effect of diseases causes and the harmful grasses.

5.1 Scope of the work

The scope of the present study was to investigate how to utilize the agricultural residues and animal manure to acquire a non-traditional energy source. Specifically, rice straw, maize stalks, cotton stalks and water hyacinth mixed with cattle dung were given the main interest in the present work.

5.2 Treatments

Three mixing ratios namely, 1:1, 1:2 and 1:3 to illustrate the ratio of crop residue or water hyacinth to cattle dung were investigated. A ratio of 0:3 which means neither crop residue nor water hyacinth was added to cattle dung, i.e. the substrate is 100% cattle dung, was investigated as a control treatment. All experimental runs were conducted at constant temperature, agitation schedule and fermentation time. Each treatment was replicated three times. The whole experiments were done during the period form 30/8/2005 to 30/12/2006.

5. 3 Materials and methodology

The experiments were carried out by using 10 laboratory experimental reactors 10.7 liters each that were made from stainless steel. The reactors were placed in an insulated water container works as a water bath at a constant temperature 311± 2 K (38 ± 2 ° C) by the way of an electrical heater and a thermostat. The container equipped with a fan for stirring the water to keep the uniformity of water temperature. Each reactor equipped with a stainless steel shaft has 2 impellers and takes its movement from an 0.25 k W motor having 1400 r. p. m speed. This rotational speed is lowered to nearly 50 r .p. m for the stirrer. The stirring schedule was kept constant at a quarter of an hour every 4 hours. The reactor was provided by sun dried crop residue that was cuted into pieces by a traditional stationary thresher. 100 gm of the cutted residue are added to each reactor in addition to 100, 200 and 300 gm of fresh cattle dung for getting the mixing ratio of 1:1, 1:2 and 1:3 respectively among the crop residue or water hyacinth and cattle dung.

All experiments were run for 90 days. During which the daily biogas yield was collected and recorded. The average of the three replicates was calculated. The accumulated biogas yield was calculated as well . Absolute values in L and specific values in L /kg TS were presented.

5.4 Modeling the accumulated biogas yield:

For the purpose of investigating the biogas yield behavior throughout the fermentation time, the accumulated yield in terms of L /kg TS was presented graphically. A general trend of the cumulative curve in which after a steep increase in biogas yield, it goes to decrease resulting in a plateau of the cumulative curve was modeled according to **(Mahnert et al. 2002)** and **(Mehanert et al 2005).** This cumulative biogas yield could be described by an exponential equation in the following form:

$$Y_{(t)} = Y_{max}\ (1-e^{-at})^{b}$$

Where:

$Y_{(t)}$ = accumulated biogas yield at time t.

Y_{max} = maximum accumulated biogas yield at the end of the fermentation time

a and b = the equation parameters, in which a and b are positive values.

5. 5 Statistical analysis;

Experimental data were analyzed according to split plot design in three replications. This indicates the significancy of the studied factors and the interaction between them.

5. 6 Important results:

1- The statistical analysis showed significant differences in the accumulated biogas yield due to the type of the agricultural wastes in addition to water hyacinth at all three mixing ratios. On the other hand, no significant differences were found in the accumulated biogas yield caused by the variation in mixing ratios for all four substrate materials. Exceptions during the fermentation period after the ninth week since significant differences were found during this remainder period.

2- The highest values of accumulated absolute biogas production were found to be 39.75, 34.25, 25.07 and 21.5 L for rice straw mixed with cattle dung at a ratio of 1:2, maize stalks mixed with cattle dung at a ratio of 1:3, water hyacinth mixed with cattle dung at a ratio of 1:3, and cotton stalks mixing with cattle dung at a ratio of 1:3, respectively.

3- For specific accumulated biogas production in terms of L / kg TS, the highest values were 303.1, 249.87, 170.76 and 156.59 for rice straw mixed with cattle dung at a ratio of 1:2, maize stalks mixed with cattle dung at a ratio of 1:2, water hyacinth mixed with cattle dung at a ratio of 1:3 and cotton stalks mixed with cattle dung at a ratio of 1:1, respectively.

4- For specific accumulated biogas production in terms of L / kg VS, the highest values were 407.44, 316.55, 397.05 and 194.59 for rice straw mixed with cattle dung at a ratio of 1:2, water hyacinth mixed with cattle dung at a ratio of 1:1, maize stalks mixed with cattle dung at a ratio of 1:2 cotton stalks mixed with cattle dung at a ratio of 1:1, respectively.

5- Regarding daily average of specific production in terms of L /kg TS the highest values rate were 3.37, 2.78, 1.9 and 1.74 for rice straw mixed with cattle dung at a ratio of 1:2, maize stalks mixed with cattle dung at a ratio of 1:2, water hyacinth mixed with cattle dung at a ratio of 1:3, cotton stalks mixed with cattle dung at a ratio of 1:1, respectively.

6- Half of the accumulated absolute biogas yield was obtained after a fermentation period ranged from the mid of the third week and the end of the fifth week.

7- As a general trend, it was found that increasing the ratio of crop residues in the mixture decreases the accumulated absolute biogas production.

8- A good agreement was found between the observed and predicted value was found when using the developed exponential model. The model's parameters (a and b) was highly significant (probability of t = 0.00001).
The whole model was highly significant as well (probability of F = 0.00001).
This had been approved for each model of each treatment.

However it can be stated that the best plant residue was the rice straw that has been given the highest accumulated production. The highest daily production was reached with rice straw mixed with cattle dung at a ratio of 1:2. The lowest value in production was recorded for cotton stalks mixed with cattle dung at a ratio of 1:2 .

Results indicated that the fermentation process takes a minimum period to get 90 % of the maximum production when using water hyacinth mixed with cattle dung at ratio of 1:2 . This was reached at the fifth week.

5.7 Recommendations:

According to the results of the present research , it can be recommended that:

1- If rice straw is used for producing biogas , it should be mixed with cattle dung at the ratio of 1:2 for only six weeks in batch fermentation.

2- If maize stalks is used for producing biogas , it should be mixed with cattle dung at a ratio of 1:1 for only nine weeks in batch fermentation .

3- If cotton stalks is used for producing biogas , it should be mixed with cattle dung at a ratio of 1:1 for only seven weeks in batch fermentation .

4- If water hyacinth is used for producing biogas , it should be mixed with cattle dung at a ratio of 1:1 for only five weeks in batch fermentation.

5.8 Conclusion

Table 4.2 indicates the recommended conditions for the studied agricultural waste anaerobic digestion for generating biogas. The recommended condition depend on the suggestion that gaining of 90 % of the expected maximum yield at 90 days is satisfactory. Generally, for all treatments, it was revealed that a fermentation time ranged from 4-10 weeks is enough to get the suggested biogas yield gain.

However, from the view point of the future work, the following points should be taken into consideration:

1- Investigate the effect of fermentation temperature on the recommended condition terms of fermentation time biogas yield gain.

2- Investigate the effect of agitation scheduelliy on the generating biogas process behavior.

3- Consequently, designing on integral system for generating biogas by using the agricultural waste seeking its economical feasibility.

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Table A.1: Analysis of variance for biogas yield (L/digester)

SV	DF	SS	MS	F
REPLICATE (R)	2	30.169479	15.084740	<1
CD (C)	3	1879.423906	626.474635	36.66**
ERROR (a)	6	102.530937	17.088490	
WASTE (W)	3	951.158073	317.052691	45.62**
W X C	9	543.900052	60.433339	8.69**
ERROR (b)	24	166.811250	6.950469	
TOTAL	47	3673099369		

cv(a) = 18.1%., cv(b) = 11.6%

**= significant at 1% level;

Table A. 2 : The interaction between waste types (W) and cattle dung level (C) of means for biogas yield (L/digester) (AVA. OVER 3 REPS)

WASTE	CD				W-MEAN
	1: 1	1: 2	1: 3	0: 3	
RS	23.800 a	39.750 a	38.700 a	13.400 a	28.913
MS	24.167 a	32.733 b	30.067 b	13.400 a	25.092
CS	17.467 b	19.267 c	21.500 c	13.400 a	17.908
WH	17.867 b	20.600 c	25.067 c	13.400 a	19.233
C-MEAN	20.825	28.088	28.833	13.00	22.786

In a column, means followed by a common letter are not significantly different at the 5% level by DMRT

Comparison	S.E.D.	LSD(5%)	LSD(1%
2-C means at each W	2.515	5.624	8.064
2-W means at each C	2.153	4.443	6.021

Table A.3: Analysis of variance for biogas yield (L/kg substrate)

SV	DF	SS	MS	F
REPLICATE (R)	2	174.63361	87.31681	<1
CD (C)	3	24854.54167	8284.84722	56.71**
ERROR (a)	6	876.49292	146.08215	
WASTE (W)	3	10481.50052	3493.83351	40.70**
W X C	9	5366.44988	596.27221	6.95**
ERROR (b)	24	2060.04200	85.83508	
TOTAL	47	43813.66060		

cv(a) = 15.4%., cv(b) = 11.8%

**= significant at 1% level;

Table A. 4 : The interaction between waste types (W) and cattle dung level (C) of means for biogas yield (L/kg substrate) (AVA. OVER 3 REPS)

WASTE	CD				W-MEAN
	1: 1	1: 2	1: 3	0: 3	
RS	119.000 a	132.500 a	96.750 a	44.667 a	98.229
MS	120.833 a	109.113 b	75.167 b	44.667 a	87.445
CS	87.333 b	64.220 c	53.750 c	44.667 a	62.493
WH	89.333 b	68.667 c	62.667 c	44.667 a	66.333
C-MEAN	104.125	93.625	72.083	44.667	78.625

In a column, means followed by a common letter are not significantly different at the 5% level by DMRT

Comparison	S.E.D.	LSD(5%)	LSD(1%
2-C means at each W	8.201	18.064	25.642
2-W means at each C	7.565	15.613	21.159

Table A.5: Analysis of variance for variance for biogas yield (L / kg VS)

SV	DF	SS	MS	F
REPLICATE (R)	2	4547.8415	2273.9208	1.21 ns
CD (C)	3	13339.1637	4446.3879	2.37 ns
ERROR (a)	6	11269.9439	1878.3240	
WASTE (W)	3	92390.4371	30796.8124	43.93**
W X C	9	51670.4408	5741.1601	8.19**
ERROR (b)	24	16826.6276	701.1095	
TOTAL	47	190044.4548		

cv(a) = 15.5%; cv(b) = 9.5%

**= significant at 1% level; ns = not significant

Table A. 6 : The interaction between waste types (W) and cattle dung level (C) of means for biogas yield (L/kg VS) (AVA. OVER 3 REPS)

WASTE	CD				W-MEAN
	1: 1	1: 2	1: 3	0: 3	
RS	288.133 ab	407.44 a	343.997 a	298.973 a	334.636
MS	254.000 b	297.35 b	240.490 c	298.973 a	272.703
CS	194.593 c	184.01 c	179.700 d	298.973 a	214.320
WH	316.557 a	288.59 b	290.390 b	298.973 a	298.629
C-MEAN	263.321	294.350	263.644	298.973	280.072

In a column, means followed by a common letter are not significantly different at the 5% level by DMRT

Comparison	S.E.D.	LSD(5%)	LSD(1%)
2-C means at each W	25.761	57.822	83.114-2
2-W means at each C	21.620	44.621	60.472-2

Table A.7. Analysis of variance for variance for biogas yield (L / kg TS)

SV	DF	SS	MS	F
REPLICATE (R)	2	1267.7012	633.8506	<1
CD (C)	3	25489.3558	8496.4519	9.77 *
ERROR (a)	6	5218.3483	869.7247	
WASTE (W)	3	54481.4175	18160.4725	56.61**
W X C	9	28057.5725	3117.5081	9.72**
ERROR (b)	24	7698.8950	320.7873	
TOTAL	47	122213.2904		

cv(a) = 13.9%; cv(b) = 8.4%

**= significant at 1% level; * = significant at 5%level

Table A. 8 : The interaction between waste types (W) and cattle dung level (C) of means for biogas yield (L/kg TS) (AVA. OVER 3 REPS)

WASTE	CD				W-MEAN
	1: 1	1: 2	1: 3	0: 3	
RS	210.367 a	303.133 a	259.467 a	248.133 a	255.275
MS	214.133 a	250.133 b	230.067 a	248.133 a	235.617
CS	156.600 b	148.767 c	145.700 b	248.133 a	174.800
WH	161.233 b	159.967 c	170.767 b	248.133 a	185.026
C-MEAN	185.583	215.500	201.500	248.133	212.679

In a column, means followed by a common letter are not significantly different at the 5% level by DMRT

Comparison	S.E.D.	LSD(5%)	LSD(1%
2-C means at each W	17.474	39.242	56.426
2-W means at each C	14.624	30.183	40.905

عبد الوهاب عبد العليم عبد الوهاب

المستخلص العربي

يعتبر التخلص من المخلفات الزراعية في مصر من أكبر المشاكل البيئية من حيث الكميات الضخمة من مخلفات المحاصيل الزراعية مثل قش الارز وحطب الذرة وحطب القطن بالاضافه الي ياسنت الماء فالمزارع يلجا الي حرق تلك المخلفات بخاصة قش الارز مما يسبب اضرار صحية بالغة للسكان، كما يهدر بالحرق قيمة تلك الفضلات الزراعية ، اما ياسنت الماء فلة مشاكل إضافية، فتكاثره السريع يسبب سد للمجاري المائية من مراوي ومصارف.

لذلك تعتبر تكنولوجيا التخمر اللاهوائى هي من انسب طرق معالجة تلك المخلفات والتخلص من بذور الحشائش ومسببات الامراض ، ونظرا لاهمية الوقوف علي كميات غاز البيوجاز الناتجة من كل نوع من الفضلات الزراعية المذكوره بالاضافة لياسنت الماء فقد تم اجراء التجارب الاتية في الفترة من ٢٠٠٥/٨/٣٠ وحتى ٢٠٠٦/١٢/٣٠ وقد تم اجراء التجارب في ١٠ مخمرات معملية سعة الواحد منها ١٠,٧ لترتقريبا ومصنوعة من الاستانلس استيل المقاوم للصدأ وموضوعة في حمام مائى معزول حراريا وعلي درجة حرارة ثابتة ثرموستاتيا علي ٣٨ ± ٢ ° م والمخمر مزود بمحرك ميكانيكى لتقليب المحتويات لمدة ١٥ دقيقة كل ٤ ساعات عن طريق موتور يعمل بسرعة ١٤٠٠ لفة في الدقيقة و متصل بتايمر ويتم تخفيض السرعة عن طريق ترس دودى الى ٥٠ لفة في الدقيقة

وتم تجفيف المخلفات في الشمس وتقطيعها في الة دراس الى قطع صغيره وتغذيه الهاضم بها مخلوطة مع روث الماشية بنسب مختلفة هى ١:١ ، ٢:١ ، ٣:١ فضلات : روث .

وكانت اهم النتائج :- هي اختلاف انتاج الغاز اختلافا معنويا باختلاف نوع الفضلات الزراعية المستعملة وذلك باستعمال درجة الحراره المناسبة للبكتريا الميزوفيلك حيث كانت النتائج كما يلي مرتبة من اعلي انتاج الى اقل انتاج (٣١٣,١ ، ٢٤٩,٨٧ ، ١٥٦,٥٩ ، ١٧٠,٧٦ لتر/ كجم مادة صلبه TS) لكل من قش الارز مع نسبة خلط مع روث الماشيه ٢:١ ، يلية حطب الذرة عند مستوي خلط مع روث الماشية ٣:١ ، متبوعا بياسنت الماء عند مستوى خلط مع روث الماشية ٣:١ ، واخيرا حطب القطن عند مستوى خلط مع روث الماشية ١:١ علي الترتيب .كما يمكن الحصول علي نسبه تفوق ٩٠% من انتاج الغاز فى اخر المدة عند الاسابيع الاتية (التاسع ، السابع ، السادس، الخامس) لكل من حطب الذرة مع نسبة خلط مع روث الماشية ١:١، حطب القطن مع نسبة خلط مع روث الماشية ١:١ ، قش الارز مع نسبة خلط مع روث الماشية ٢:١، ياسنت الماء مع نسته خلط مع روث الماشية ١:١ على الترتيب.

الملخص العربى

استغلال مخلفات بعض المحاصيل وياسنت الماء المخلوطة مع روث الماشية لتوليد الغاز الحيوى

يعتبر التخلص من المخلفات الزراعية فى مصر من اكبر المشاكل البيئية حيث بلغت كميات مخلفات محاصيل مثل قش الارز وحطب الذرة وحطب القطن ١١,٠٤ تيرا جرام في العام (حلمى واخرون٢٠٠٣) بالاضافة الي ياسنت الماء مما يمثل عبء علي المزارع في التخلص من هذة المخلفات فهو يلجأ الي حرق المخلفات الزراعية للتخلص منها الامر الذى يسبب اضرار بيئية بالغة للسكان تتمثل في المشاكل الصحية كما ان ذلك يهدر قيمة هذة الفضلات الزراعية، ويسبب انتشار الحشائش الضارة بالاراضى الزراعية نتيجة استخدام السماد البلدى المحتوي علي بذور الحشائش وضياع نسبة كبيرة من المادة العضوية نتيجة المعالجة الخاطئة. وعلي الجانب الاخر تظهر مشكلة ياسنت الماء الذى يتسبب في فقد كميات هائلة من المياة بالاضافة الي سرعة تكاثرة وانتشارة مسببا اعاقة للسريان في المجاري المائية سواء للرى او الصرف علاوة على زيادة تكاليف تنظيف الترع و المصارف من الكميات الضخمة من ياسنت الماء دون اى عائد اقتصادي.

ولعل بساطة تكنولوجيا الغاز الحيوى وملائمتها لظروف الريف في البلدان العربية هما من بين أهم العوامل المشجعة علي نشر استخدامها. فهذة التكنولوجيا لاتساهم في حل مشكلة الطاقة فحسب وانما تساعد ايضا فى حل مشكلتى نقص الغذاء وازدياد تلوث البيئة. ان توفير كميات من السماد العضوي بدلا من فقدة عند حرق المخلفات يؤدى الي زيادة انتاجية الاراضى الزراعية و خصوبتها. كما ان معالجة هذة المخلفات عن طريق الهضم اللاهوائي تؤدى أيضا الى القضاء علي معظم الكائنات و الطفيليات المسببة للامراض و الاوبئة. ويتم ذلك بشكل متوازن ومتوافق مع البيئة ودورة الطبيعة.

لذلك تعتبر تكنولوجيا التخمر اللاهوائي غير مكلفة وهي من انسب طرق معالجة تلك المخلفات منتجا الغاز الحيوي احد مصادر الطاقة المتجددة و كذلك انتاج السماد العضوي الغنى بالعناصر الغذائية و خصوصا ارتفاع نسبة النتروجين وايضا التخلص من مسببات الامراض وبذور الحشائش.

وقد اهتم البحث بكيفية الاستفاذة من المخلفات الزراعية وروث الحيوانات كمصدر للطاقة غير التقليدية و بخاصة قش الارز وحطب الذرة وحطب القطن و ياسنت الماء المخلوطين مع روث الماشية.

معاملات التجربة:-

ولقد اشتملت الدراسة تاثير المتغيرات التالية علي انتاجية الغاز الحيوى كما يلى:-

أ- تم استخدام اربعة مخلفات زراعية وهم قش الارز، حطب الذرة، حطب القطن, وياسنت الماء

ب- تم استخدام ثلاثة نسب خلط للمخلفات الزراعية الي روث الماشية وهم ١:١، ٢:١، ٣:١ بالاضافة الى المعاملة كنترول (٣:٠) كنسب وزنية.

ولقد أجريت التجارب فى درجة حرارة ثابتة و ايضا معدل تقليب ثابت ، وكررت كل معاملة ثلاث مرات وذلك لاستخدام تصميم القطع المنشقة فى التحليل الاحصائى وتم دراسة العلاقة بين المعاملات المختلفة من خلال نتائج التحليل الاحصائى.

المواد المستخدمة في التجربة:

تم اجراء التجارب علي ١٠ مخمرات معملية سعة الواحد منها ١٠,٧ لتر تقريبا مصنوعة من الاستانلس استيل وموضوعة في حمام مائي معزول بمادة عازلة علي درجة حرارة ثابتة عن طريق سخان كهربائي و مضبوطة ثرموستاتيا عند درجة حرارة هي ٣٨° ± ٢° م و الحمام مزود بمروحة لتقليب الماء للحفاظ علي تجانس درجة الحرارة بداخلة و المروحة تاخذ حركتها من الماتور عن طريق سيور وبكرات تعمل علي تخفيض سرعة الماتور الي٥٥ لفة/ دقيقة، كما ان المخمرات مزودة بمقلب عبارة عن عمود من الاستانلس استيل مزود بعدد ٢ رفاص ياخذ حركتة عن طريق تروس دودية مركبة علي عامود متصل بماتور كهربائي قدرتة ٢٥٠ وات ويعمل بسرعة ١٤٠٠ لفة / دقيقة وتعمل التروس الدودية علي تخفيض السرعة الى ٥٥ لفة / دقيقة تقريبا وتنقل الحركة من الماتور الي العامود بواسطة سيور وبكرات، ويتم تقليب المحتويات بمعدل ١/٤ ساعة كل ٤ ساعات علي مدار اليوم وتم تزويد المخمر بمخلفات المحاصيل المجففة في الشمس و المقطعة بواسطة الة دراس بلدية الى جذاذات صغيرة.

وقد تم دراسة ثلاثة انواع من المخلفات الزراعية هي قش الارز و حطب الذرة و حطب القطن بالاضافة الي ياسنت الماء، مضافا اليهم ثلاث مستويات مختلفة من روث الماشية الطازج وكانت النسب المضافة من روث الماشية هي ١٠٠, ٢٠٠, ٣٠٠ جم روث ماشية الي ١٠٠ جم من المخلفات الزراعية، وتم تجميع الغاز الناتج من عملية التخمر في عبوات بلاستيكية بازاحة الماء ومتابعة انتاج الغاز اليومي ومحصول الغاز التراكمى خلال ٩٠ يوم هي مدة التجربة لكل معاملة وكذلك قياس درجة الحرارة المثبتة.

معادلة حساب محصول البيوجاز التراكمي:

لتجميع محصول البيوجاز خلال مدة التخمر. حسب المحصول بوحدات لتر / كج TS عن طريق رسم منحنى. كان الاتجاة العام للمنحنى التراكمى بعد الزيادة الحادة في محصول البيوجاز. يتجة الي الانخفاض

المستمر في المنحنى التراكمي ويقدم بشكل تخطيطي طبقا لمعادلة (Mahanert, et al. ٢٠٠٥) ويوصف محصول البيوجاز التراكمي بواسطة المعادلة الاتية:

$$Y_{(t)} = Y_{max} (١-e^{-at})^{b}$$

عندما:

$Y_{(t)}$ = محصول البيوجاز التراكمي

Y_{max} = اقصي محصول بيوجاز عند نهاية مدة التخمر

a and b = ثوابت المعادلة، a,b تكون قيم موجبة.

يمكن تلخيص النتائج المتحصل عليها كما يلي:-

١- أظهرت النتائج ان اعلي انتاج للغاز هو ٣٩,٧٥, ٣٤,٢٥, ٢٥,٠٧, ٢١,٥ مع قش الارز عند مستوي خلط مع روث الماشية ١:٢ يلية حطب الذرة عند مستوى خلط مع روث الماشية ١:٣ متبوعا بياسنت الماء عند مستوي خلط مع روث الماشية ١:٣واخيرا حطب القطن عند مستوي خلط مع روث الماشية ١:٣علي الترتيب.

٢- بمقارنة النتائج عند احتساب الناتج من البيوجاز باللتر لكل كج مادة صلبة مضافة (TS) كان اعلي انتاج هو ٣٠٣,١, ٢٤٩,٨٧, ١٧٠,٧٦, ١٥٦,٥٩ مع قش الارز عند مستوي خلط قش الارز : روث الماشية ١:٢ يلية حطب الذرة عند مستوي خلط حطب الذرة : روث الماشية ١:٢ متبوعا بياسنت الماء عند مستوي خلط ياسنت الماء: روث الماشية١:٣ واخيرا حطب القطن عند **مستوي خلط حطب قطن : روث الماشية ١:١ علي الترتيب.**

٣- بمقارنة النتائج عند احتساب الناتج من البيوجاز باللتر لكل كج مادة صلبة متطايرة (VS) كان اعلي انتاج هو ٤٠٧,٤٤, ٣١٦,٥٥, ٢٩٧,٠٥, ١٩٤,٥٩ مع قش الارز عند مستوى خلط قش الارز : روث الماشية ١:٢ متبوعا بياسنت الماء عند مستوى خلط ياسنت الماء : روث الماشية ١:١ يلية حطب الذرة عند مستوي خلط حطب ذرة : روث الماشية ١:٢ واخيرا حطب القطن عند مستوي خلط حطب قطن : روث الماشية ١:١ علي الترتيب.

٤- بمقارنة متوسطات الانتاج اليومى باللتر لكل كج مادة جافة (TS) تبين ان اعلي متوسط انتاج هو ٣,٣٧, ٢,٧٨, ١,٩, ١,٧٤ لكل من قش الارز عند مستوى خلط قش ارز : روث الماشية ١:٢, يلية حطب الذرة عند مستوى خلط حطب ذرة : روث الماشية ١:٢ بعد ذلك ياسنت الماء

عند مستوى خلط ياسنت : روث الماشية ١:٣ واخيرا حطب القطن عند مستوي خلط حطب القطن : روث الماشية ١:١ علي الترتيب.

٥- مما سبق يمكن استنتاج ان افضل مادة مخلفات نباتية هي قش الارز الذى اعطى اعلى انتاج تراكمي وكذلك اعلي معدل انتاج يومي مع مستوي خلط قش الارز : روث الماشية ١:٢, كما ان اقل مادة مخلفات نباتية انتاجا للغاز هى حطب القطن خاصة عند مستوي خلط حطب قطن : روث الماشية ١:٣.

٦- كما تم عمل مقارنة لاسرع انتاج خلال ٩٠ يوم مدة التجربة حيث اشارت النتائج الى ان عملية التخمر تاخذ اقل مدة للحصول على ٩٠% من اقصى انتاج عند استخدام ياسنت الماء المخلوط مع روث الماشية بنسبة ١:٢ وذلك عند الاسبوع الخامس.

٧- نصف كمية الانتاج التراكمي المطلق للبيوجاز تم الحصول علية خلال مدة التخمر في المدى من منتصف الاسبوع الثالث حتى نهاية الاسبوع الخامس.

٨- وجد انة عموما بزيادة نسبة المخلفات الزراعية في المخلوط ينخفض انتاج الغاز التراكمى.

٩- وجد ان احسن اتفاق مابين القيم المشاهدة و المتوقعة كان عند استخدام المعادلة الاسية المتطورة حيث كانت معنوية العوامل (a,b) مرتفعة (احتمال t = ٠,٠٠٠٠١)

١٠- اظهر التحليل الاحصائى ان انتاج الغاز اختلف اختلافا معنويا باختلاف نوع المخلفات الزراعية بالاضافة لياسنت الماء عند ثبات درجة الحرارة عند الدرجة المثلي لنشاط البكتريا الميثانية الميزوفيلك وهي ٣٨ ±٢° م وعند معدل التقليب الثابت وهو ٤/١ ساعة لكل ٤ ساعات.

التوصيات:

في ضوء النتائج المتحصل عليها من هذا البحث أمكن التوصل الى المقترحات و التوصيات الاتية:

١- اذا أريد استعمال قش الارز لانتاج البيوجاز يجب ان يستعمل بنسبة خلط مع روث الماشية ١:٢ ولمدة ستة اسابيع فقط في تخمر دفعى.

٢- اذا أريد استعمال حطب الذرة لانتاج البيوجاز يجب ان يستعمل بنسبة خلط مع روث الماشية ١:١ ولمدة تسعة اسابيع فقط في تخمر دفعى.

٣- اذا أريد استعمال حطب القطن لانتاج البيوجاز يجب ان يستعمل بنسبة خلط مع روث الماشية ١:١ ولمدة سبعة اسابيع فقط في تخمر دفعى.

٤- اذا أريد استعمال ورد الماء لانتاج البيوجاز يجب ان يستعمل بنسبة خلط مع روث الماشية ١:١ ولمدة خمسة اسابيع فقط في تخمر دفعى.

" الاستفادة من المخلفات الزراعية "

استغلال مخلفات بعض المحاصيل وياسنت الماء المخلوطة مع روث الماشية لتوليد الغاز الحيوي

رسالة مقدمة من

عبد الوهاب عبد العليم عبد الوهاب حامد

للحصول على درجة الماجستير في العلوم الزراعية (الميكنة الزراعية)

لجنة المناقشة والحكم على الرسالة:

الأستاذ الدكتـــور / مبـــارك محــمد مصـطفى...

أستاذ الهندســـة الزراعيـــة المتفرغ – كلية الزراعة – جامعة عين شمس.

الأستاذ الدكتـــور / اسماعيل أحمد عبد المطلب...

أستاذ الهندسة الزراعية ورئيس قسم الهندسة الزراعية- كلية الزراعة- جامعة كفرالشيخ.

الدكتـــــــــــور / رزق محــمد خلــيف ....

باحث أول – معهد بحوث الهندسة الزراعية- مركز البحوث الزراعية- الدقي- الجيزة- مصر.

التاريخ: ٢٠٠٧/٩/١٨

جامعة كفر الشيخ
كلية الزراعة
قسم الهندسة الزراعيه

" الاستفادة من المخلفات الزراعية "

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رسالة مقدمة من

عبد الوهاب عبد العليم عبد الوهاب حامد
بكالوريوس علوم زراعية (انتاج حيوانى)- جامعة طنطا ١٩٨٣

كجزء من المتطلبات للحصول على درجة الماجستير في العلوم الزراعية
(الميكنة الزراعية)

لجنة الاشراف:

الدكتور
فتحى ابراهيم هندى
أستاذ الهندسة الزراعيه المساعد
قسم الهندسة الزراعية- كلية الزراعة
جامعة كفر الشيخ (رحمه الله)

الدكتور
سعيد السيد أبوزاهر
مدرس الهندسة الزراعية
قسم الهندسة الزراعية- كلية الزراعة
جامعة كفر الشيخ

الدكتـور
رزق محمد خليف
باحث أول
معهد بحوث الهندسة الزراعية
مركز البحوث الزراعية- الدقي- الجيزة- مصر.

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