The Feasibility of Family Biogas Production from Mixed Organic Wastes in Palestinian Rural Areas

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This Thesis was defended successfully on 8/9/2004, and approved by:-

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Dedication:-

I dedicate the study to my parents, brothers, sisters and to all my teachers and instructors at: schools, Bir-Zeit and An-Najah National Universities.

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The Feasibility of Family Biogas Production from Mixed Organic Wastes in Palestinian Rural Areas

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Abstract

Biogas technology is a technology that applied to produce biogas (energy source) and organic fertilizer by anaerobic digestion for organic materials, especially organic wastes that should be disposed off to give more socio-economic and environmental positive impacts.

The success of biogas plants (projects) at an area depends on: - availability of organic materials, cost of constructing, founded energy sources and its costs, experience, knowledge, ambient climate conditions especially temperature, and acceptability for people constructing these plants.

The research concerned with studying the feasibility of family biogas production from mixed organic wastes in Palestinian rural areas by field survey and experiment.

The field survey data support the opinion about the importance of constructing family biogas plants in Palestinian rural areas where the average of rural family members' number is (6.85) with high average monthly energy cost (45.97 JD) per family or (6.711JD) per capita.

The field survey data also indicate the availability of organic wastes for rural families, since most of these families raise animals (72.47%), and of cultivation activities (87.45%), besides their generated domestic wastes.

Moreover; these families follow useless or negative methods for disposing off their: - animals' dung {collected to be disposed off later, 71.20%}, domestic solid wastes {disposed off in general containers, 75.80%} and waste water {drained off to the cess pits, 89.00%}, in contrast; these families fed their plants and crops residues to animals (70.80%) which is a positive disposing method.

Field survey data reveal Palestinian rural people suffer from negative impacts of organic wastes {reply average percentage, 60.30%}. They have also a positive awareness toward wastes impacts and issues {average percentage, 65.2%}. Attitudes could enhance their acceptance {average percentage, 65.8%} for constructing biogas plants, especially if they provided with financial assistance and necessary knowledge about biogas technology and its benefits.

Twenty samples (18 in barrel digesters each of 240 litter, and 2 in large digesters each of 1500 litter) of mixed organic wastes were tested at ambient conditions. The effects of organic waste type, stirring, enlargement and dilution factors on samples biogas production were studied.

The pH- values for all samples (initially ranged between 6.52 and 8.12) drop slowly in the first days of the digestion process to below 6, then raise gradually to reach more than 7 at last days for all samples. The experiment data show all samples produce biogas at ambient temperature with an average biogas weight (51.9g) per kilogram of mixed organic wastes, and reach their maximum biogas production within a time interval of (24 to 36) days from the beginning of the experiment which continue for 60 days.

Food residues produce the highest biogas quantity (67.3g/Kg waste), then mixed animals dung (59.5g/Kg dung) while wheat straw produce the lowest weight (37.2g/Kg straw). For animals dung types: - the chicken dung has the best biogas productivity (57.9g/Kg dung), the sheep and goat dung (53.8g/Kg dung) and finally the cow dung (48.7g/Kg dung). The biogas production enhanced by increasing sample water content (B11>B7>B10), and with stirring for the digester content where productivity of (D1) with stirrer is {58.93g} biogas /Kg waste while for (D2) without stirrer is {48.46g }biogas / Kg waste.

Results indicate the Palestinian rural family will save monthly (23.07 JD) as a result of using biogas (instead natural gas) and using digested organic material as an organic fertilizer, if this family construct a $9m^3$ biogas plant with daily loading for (30.83 Kg) of organic wastes into the digester.

It is recommended that: -

1- More studies be done for providing more information to rural people about biogas technology.

2- More efforts must be done for enhancing their acceptability to this technology.

3- Enhance means for provide public with sufficient assistant for constructing biogas plants.

Chapter One

Introduction

The rapid increasing in world population and the great development in industrial, commercial, agricultural…etc sectors require large quantities of energy, and create large quantities of wastes that should be disposed off with minimum environmental negative impacts and costs. In addition to that; the limited sources and quantities of un renewable energy (oil, natural gas, and fossil coal) with their negative impacts on our health and environment, obliges us to search about new and renewable sources for energy with least negative impacts. Anyhow; this study deals with a technology that produces fuel and organic fertilizer from organic wastes which is biogas technology.

1.1- Study Problem

The continuous traveling between my home (in Jenin –north of West Bank) and my work (in El-Aezeria, east of Jerusalem), and my passing through different roads each time (as result of closing the main road: Jenin – Nablus – Jerusalem by the occupation army), and so passing through many Palestinian rural villages and communities, show me many bad environmental situations and sights, especially the accumulation of wastes near homes, accumulation of animals dung near animals farm, and distribution of insects and rodents. This in addition to the previous knowledge about disposing rural families for their wastewater into cess pits, and the intensive using for manufactured fertilizers, herbicides and insecticides let me to think about introducing a study for treating generated organic wastes by a method that give benefits to our rural society and environment. Biogas technology is considered a renewable source of energy and a good method for reducing the volume of generated wastes that should be disposed off with more positive impacts on our health, economy and our environment in general. Biogas technology is not applied in Palestine while its application started from some decades in many countries over the world as India, China, and other countries [Mattocks, 1984]. So what are the possibilities and feasibility of applying this technology in Palestine especially in rural areas, and at family level where animals and agricultural wastes are available in addition to the domestic water wastes? It was found that the best solution may be achieved by applying biogas technology which provides rural community with energy (biogas) and good organic fertilizer from organic wastes.

1.2- Over view of Biogas Technology

After reading many studies and reports about available technologies for treating wastes mainly technologies treat organic wastes which usually available for rural families especially animals' dung, crops residues and domestic wastes with centering on technologies that could be constructed, operated and repaired by rural family itself. It was found that many methods and technologies could be applied to treat organic wastes such as direct combustion, fermentation, gasification, pyrolysis and anaerobic digestion [Mattocks, 1984].

Direct combustion means burning organic wastes to get energy. It is a simple, easy and of low cost process, but it generates smoke and ash which means that this process associated with many pollutant gases, poly-aromatic hydrocarbons and total suspended particles that cause chronic diseases as asthma and lung cancer [Jo Lawbuary, no date].

Fermentation or composting of organic wastes to get organic fertilizers is a simple and easy method and could be operated by the farmer himself, but this process has two main disadvantages:- The first one is that " some of the nutrients in the raw waste –particularly nitrogen, phosphorus and potassium- convert to a gas, evaporate, and are lost to the atmosphere, or they leach out through the soil" and the second disadvantage that this process " is limited to producing only fertilizer" [Mattocks, 1984].

Anaerobic digestion (biogas technology) for organic wastes produces both fertilizer and biogas (energy source). The benefits of this technology could be understood from what Mattocks [1984] wrote: "unlike composting the digestion process retains and even improves the nutrient value of the original feed stock. With biogasification raw wastes can be digested and return to the environment in the form of fertilizer and fuel without degrading the environment". But the main disadvantage of biogas technology with respect to composting is that the cost for its construction is higher [Mattocks, 1984]. More points about this technology benefits and constrains for its dissemination and application are listed in the following two sections, while detail information about it are found in chapter three (literature review).

For the previous reasons biogas technology is considered the most important and suitable technology for rural families, and so it was selected to be the subject of this study.

1.3- Environmental and Socio-Economical Impacts of Biogas Technology

Constructing biogas plants gives many positive environmental and socio-economical impacts not only to the owner but also to the local society and national level. The following environmental and socio-economic impacts are abstracted from these references: - [Bo Holm-Nielsen and Al- Seady, (no date); Mattocks, 1999; Al-Masri, 2000; Loimor, 2000; Oregon Office of Energy, 2002; At-Information and British Biogen websites].

1.3.1- Environmental impacts

Using organic wastes (animals dung, plants waste, domestic organic waste, waste water) as a substrate for the biogas plants considered one of the most important ways for wastes management. The following main impacts could be achieved if this technology successfully applied: -

1- Reducing the volume of wastes that to be disposed off by other disposal ways as incineration, landfill, direct burning or bad accumulation which eliminate negative impacts associated with these ways as: smoke, dust, leachate forming and gases emissions. Biogas technology decreases air, soil, ground and surface water pollution.

2- Reducing uses of fossil fuels, charcoal, firewood and direct burning of animals dung for getting energy which decrease air pollutants, save frosts, decreasing soil erosion and saving time and efforts for gathering firewood.

3- Reducing pathogens and the following statement emphasize that "Anaerobic digester systems can reduce fecal coli form bacteria in manure by more than 99 percent, virtually eliminating a major source of water pollution" [Oregon Office of Energy, 2002].

4- Using of digested organics as crops fertilizer reduces using of chemical and manufactured fertilizers return positively on consumer health.

5- The odor of digested wastes is much less than that of undigested. Figure (1) shows digested manure odor to that of undigested for Swine USA anaerobic Digester plant [Loimor, 2000].

6- Eliminating or reducing accumulated wastes decreases the distribution of rodents, insects, flies and other disease victors in addition to enhancing area aesthetic sight.

Surely all of above positive impacts will enhance and improve human body and physical health.

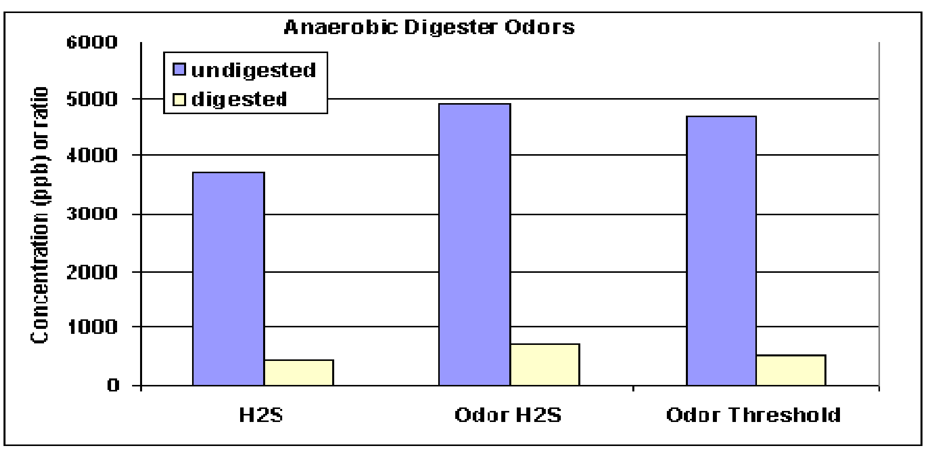


Figure1 Hydrogen sulfide and odor threshold in gases from digested and undigested manure [Loimor, 2000].

1.3.2- Socio- Economical impacts

The following are some of the socio- economic impacts that resulted from constructing biogas plants: -

1-Provide new job opportunities.

2- Using renewable energy source from materials that should be disposed off, decreasing paid money for getting energy from other sources like natural gas and so saving family income.

3- Using produced biogas reduces the quantity of imported natural gas and other energy sources which save money for government.

4- Using digested organics for fertilizing crops reduces the used amount of manufactured fertilizers, which save money for both farmer and government. Also this using enhances crops production, which will increase the farmer income.

1.4- Constrains for Biogas Technology Dissemination

The main constrains that faces dissemination of biogas technology in most societies are:-

1- Cost for constructing biogas plants [British Biogen, website], and long the time period (relatively) required for get back the capital.

2- Instability of biogas production and fall of biogas production in cool months.

3- Experience required for constructing biogas digesters.

4- Found of some toxic components (usually in trace quantities) in biogas, especially hydrogen sulphide and ammonia [British Biogen, website].

1.5- Applicability of Biogas Technology in Palestinian Rural Areas

This study is concerned with the feasibility and possibilities of applying family biogas plants (small-scale) in Palestinian rural areas by using animals, crops and domestic wastes. Since most of Palestinian farmers raise animals or/ and plant agricultural crops and get their energy requirements from firewood, coal, natural gas, electricity nets and some of them burn animal dung as additional energy source. Also, most of farmers follow wrong ways for disposing off their animals dung and other waste types, for example; most of them accumulate their animals dung beside the farm which is mostly found near their residence home, then through it in their crops fields without any treatment (as fermentation)or by direct burning. Therefore, applying biogas plants in rural areas may considered a good way for wastes disposal with obtaining a renewable energy source, a good organic crops fertilizer and other environmental and socio-economical positive impacts.

Construction biogas plants in any area mainly depends on: - availability of organic materials, suitable temperature, availability of constructing materials and technology experience in installing and operating such plants, required capital and economical benefits that could be obtained from constructing these plants, in addition to acceptability of farmers (investors in our study) to install such plants [At- information, British Biogen –websites-; Mattocks, 1984]. So what basic evidences that support the idea about constructing biogas plants in Palestinian rural area?

1.5.1- Availability of organic wastes

The organic wastes are mostly available in our rural areas, since Palestine is considered basically an agricultural country and the following population [Palestinian Central Bureau of Statistics (PCBS), 2002.] and agricultural statistics (appendix I) for 1998-1999 [PCBS, 2001.] show that:-

1- The total population in Palestinian territories till December, 1997 was (2,895,683), and (914,866) of them live in rural areas. But in Jenin Governorate (one of the most important of agricultural areas in Palestine), the percentage of rural population was 56.1% (the total population of this governorate was 203,026).

2- The total number of cattle was (23,858), sheep (504,078), goats (295,033), and poultry were (50,477,000: layers + broilers). There are other raised animals as: donkeys, horses which found in small numbers (mostly one animal or two).

3- The total cultivated area was (1,612,013) dunum.

These figures point to the big agricultural activation in Palestine and so to the large quantities of generated wastes.

1.5.2- Ambient temperatures

The tables in appendix Ц represent the monthly average maximum and minimum temperatures [Saleh, 2003] that measured at the main agricultural stations in north Palestinian governorates (West-Bank) and show that:-

1- The monthly average maximum temperatures in all stations are more than 20C° for seven months (from April to October).

2- In the most agricultural activation areas (Al-fara', Jericho, and Jenin), the monthly maximum averages are more than 20C° for:-

a) - nine months at Jenin station (from March to November).

b) - all months of the year (except January where the maximum temperature average is about 19C°) in Al-Fara' and Jericho.

c) - nearly, the monthly averages for minimum temperature are about half or less by about 10C° than that of the corresponding maximum temperatures.

Comparing these observations with results of the studies about the digestion process which emphasize that the digestion process could be occur even at low temperatures (as low as 40F° {4.44C°} [British Biogen, website], we can conclude that the temperatures at Palestinian areas are acceptable for methanogenes act at low temperature range (below 35C°) for most months of the year, especially in the large agricultural activation areas. It is right that the digestion process affected negatively by temperature falling or fluctuation but this effect could be avoided or decreased by installing the digester under-ground, or by using plastic house or any temperature isolating materials around the digester[FAO/CMS, 1996; Mattocks, 1984; EREC; 2002].

1.5.3- Other parameters

From the evidences that support the opinion about the possibility for succession of biogas plants in Palestinian rural areas are:

- The availability of different constructing materials as cement, bricks, plastic {sheets, pipes, and tanks} and steel {especially tanks that were used for transporting water which could be repaired and reused as a digesters} with costs usually acceptable to farmers.

- The experience in digging and preparing water reserving wells of a shape like to that of fixed-dome digesters.

- Availability of water for organic waste dilution with suitable prices at most agricultural areas as: Al-Fara' (springs + artesian wells), El-Jeftelk (water and wastewater stream + artesian), Barqeen, Kufer-Dan, Qaliqelia (artesian wells), Al-O'ja (spring). In addition to possibility of using home wastewater, since most of rural families dispose their wastewater into especial absorption cess.

As a result, the availability of organic wastes, water, wastewater, constructing materials and reasonable ambient temperatures lead to conclusion that the biogas plants may succeeded in our rural areas, but what needed is the complete knowledge and experience in constructing these plants with increasing farmers knowledge and acceptability to biogas technology and its benefits.

Chapter Two

Aims, Objectives, Hypothesis and Methodology

The main aims of this study is to study the feasibility of applying biogas technology, and to share in disseminating this important technology in our rural areas at family scale which may provide our families and society with many benefits such as:- biogas, organic fertilizer, decreasing the volume of organic wastes that must be disposed off, job opportunities and improving environment.

2.1- Hypothesis and Objectives

2.1.1- Hypothesis

The general hypothesis of the study is: - ***Constructing family biogas plant in Palestinian rural area will give positive socio-economic impacts and improve the environment. ***

To simplify the evaluation of this compound hypothesis, we should evaluate the following issues:

1- Availability of organic wastes for the rural families by studying types and numbers of raised animals, and planting types and its areas.

2- Fate of organic wastes in rural areas (animals dung, crops residues, domestic waste and wastewater).

3- Energy sources for rural family and its energy consumption.

4- Suffering of rural families from negative impacts of organic wastes.
5- Opinion of rural people toward wastes issues.
6- Knowledge of farmers about biogas technology and anaerobic fermentation process, and their acceptance to apply biogas technology.
7- Biogas production from mixed organic wastes at Palestine ambient conditions.

2.1.2- Objectives

The main objectives of this study are:-

1- Producing biogas and organic fertilizer from available organic wastes.
2- Test that installing family biogas plant in our area at ambient conditions is socially accepted technology that will give economic and environmental benefits.
3- Applying worldly available technology in Palestine to reduce dependence on natural gas and other traditional energy sources to save money for both farmer and government.
4- Improving local environment.

2.2- Methodology

To fulfill the objectives of this study and to evaluate its hypothesis, a field survey (questionnaire) was distributed on a sample of the study society (Palestinian rural families) and different samples of organic wastes were mixed in different ratios and tested experimentally to test economical and technical feasibility of biogas production in Palestine.

The detail information about the experimental works and field survey are found in chapters four and five, respectively.

Chapter Three

Literature Review: - Biogas Production Technology

3.1- History

The digestion of organic matter by anaerobic microorganisms occurs naturally in the wet environments where there is no oxygen found as: swamp, bottom of lakes, inside wastewater net pipes and landfill sites [British Biogen, website]. The evolved gas from anaerobic digestion of organic matter was noticed and used very early, Richard Mattocks [1984] pointed in his report that “ancient Chinese experimented with burning the gas given off when vegetables and manures were left to rot in a closed vessel"[Mattocks, 1984]. Also, other report point to the using of biogas during 10^{th} BC century in Assyria and 16^{th} century in Persia for heating bath water [British Biogen, website].

In the last centuries appear many scientists who interested in anaerobic digestion process by studying the evolved gases, anaerobic microorganisms, substrate and other affecting conditions and factors. From these scientists: Helmont, Volta, Beachans, Pastuer and especially Sir Humphry Davy who indicated that methane was one of the gases that generated from anaerobic digestion in 1808[Mattocks, 1984 ;British Biogen, website]. These efforts lead to appearing and constructing what known now by biogas plants. In 1859, the first biogas plant was constructed in India at a leper Colony in Bombay, while the first plant appears in England in1895 [British Biogen, website], and "the biogas production and use began in 1970s" in America [Oregon Office of Energy, 2002]. Other biogas plants were constructed in Middle East, Africa and Oceania [Mattocks, 1984].

In Arab countries; the applying of biogas plants started in 1970s" in Egypt, Morocco, Sudan and Algeria while it began in 1980s" in other Asian Arab countries as Iraq, Jordan and Yemen [Haddad, 1993]. In Egypt; there were (18) family biogas plants and (2) farm plants built tell 1998 [El-Shimi & Arafa, 1998], also two family biogas plants were built in Keraeda and Um-Jar villages of Sudan in the period between 19 / 1 and 16 / 2 / 2001 [ACSAD, website]. Dr. Haddad [1993] mention two constructed plants for producing biogas from liquid wastes in Jordan, one in Aen-Ghazal and the other is the central station of Irbid. In our country (Palestine) there is one farm plant for producing biogas from cow dung which constructed by Dr. Jamal Abu-Omer (Dr. in faculty of agriculture, An-Najah University, Nablus).

The number of biogas plants in Arab countries is very small if it is compared with their numbers in other countries. For example; there were (209) millions of family biogas plants constructed in India tell 1999 [Annual Report, 1999-2000] and several millions plants in China [Mattocks, 1984] and about (2000) agricultural biogas plants in Germany built tell 2004 [Köttner, 2004].

The studies, reports and researches about biogas subject are so much and available, especially at internet websites where if you write (biogas) in the space prepared for subject searching at any famous website (as yahoo) and click on the bottom (search), it will appear a long list that include hundreds of reports, studies and many electronic sites specialized in biogas such as: - At Information, Biorealis, British Biogen and Environmics.

From the important studies about biogas a study for Mattocks [1984] which include information about factors affecting the anaerobic digestion process, productivity of many organic materials for biogas, some of biogas plants designs and constructing materials with its quantities, and the expected socio-economical and environmental impacts may resulted from applying biogas plants. Moser and other scientist [1998] wrote a report in which they explain costs, benefits and operation experience for seven agricultural anaerobic digesters constructed between 1996 and 1998. Schomaker and other scientist [2000] describe the physical, chemical and biological methods that could be used for improving biogas quality by separation undesired components in biogas.

There are many batch studies did experimentally in laboratories as that which was done by Al-Masri [2000] which its results show a "significant decrease in the biogas production with an increase in the proportion of olive cake in place of animal waste" [Al-Masri, 2000]. Another experiment was done by TRI [website] scientist for testing the effect of adding Nickel element on anaerobic digestion for rice straw where they found an increase in biogas production when Nickel added to some extent. A study for Callaghan and other scientist [1999] show that "the use of fish offal and brewery solids as co-digestates with cattle slurry produced an increase in the methane yield, compared with that of a control digestion using cattle slurry a lone, while the fruit, vegetable wastes and chicken manure at concentration of 15% total solids depressed the methane yield" [Callaghan and others, 1999].

From the studies about biogas in Palestine there was a study for Dr. El-Jaber [1993] in which he estimated theoretically the quantities of biogas could be produced yearly from animal dung, kitchen wastes and wastewater. Moreover; he introduces a primary economic evaluation for different sizes of biogas plants with some information (number of families, main raised animals, agricultural areas, electricity and water sources) about (8) visited villages, but with no visit to any rural community in south governorates of West Bank or Gaza. His study also did not include any experiment working for the possibility of applying the biogas technology. Dr. Haddad [1993] estimates in his study the quantities of biogas that may produced from liquid wastes in West Bank, while Dr. Moneer Abedo and Fouad Abod (no date) estimate in their study the quantities of biogas may produced from cow, sheep, and chicken wastes in Palestinian territories.

3.2- General

The following pages include some information about biogas, biogas technology and factors that affecting the digestion process

3.2.1- Biogas: - composition, properties, energy and technology

Biogas is a mixture of gases evolved from digestion process of organic matter by anaerobic bacteria at anaerobic conditions (i.e. without oxygen)[Mattocks, 1984]. Most studies about biogas indicate that methane (CH_4) {which is the recommended component because of its high energetic value} and carbon dioxide (CO_2) are the main components, where the ratio of methane ranged between 50 - 80% and the ratio of carbon dioxide range is 20 - 50% [EREC, 2002]. Other components of biogas that may be found in small amounts (traces) are: Hydrogen (H_2), Nitrogen (N_2), Hydrogen Sulfide (H_2S), Carbon monoxide (CO), Ammonia (NH_3), Oxygen (O_2) and water vapor (H_2O)[Schomaker and others, 2000]. As an example; table (1) shows most gases in biogas with their ratios [FAO/CMS, 1996].

Table 1 Components of Biogas (FAO/CMS, 1996)

Substance	**Symbol**	**Percentage**
Methane	CH_4	50 - 70
Carbon Dioxide	CO_2	30 - 40
Hydrogen	H_2	5.0 - 10
Nitrogen	N_2	1.0 – 2.0
Water Vapour	H_2O	0.3
Hydrogen Sulphide	H_2S	Traces

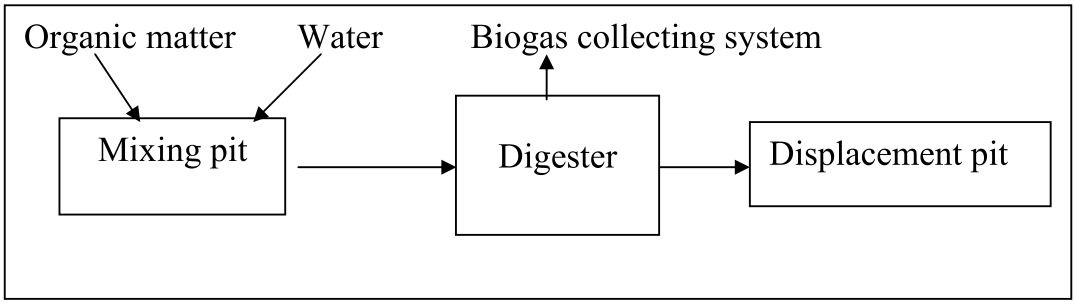
Methane and carbon dioxide are odorless and colorless gases. Hydrogen sulfide is colorless but it has an odor of rotten eggs in addition to its toxicity [FAO/CMS, 1996]. Carbon dioxide, hydrogen sulfide, ammonia and water vapor (in presents of the mentioned gases) are considered corrosive substances [Schomaker and others, 2000]. In general; biogas with all its components is colorless, odorless and lighter than air [FAO/CMS, 1996].

Biogas burned with blue flame at ignition temperature (temperature at which a certain substance ignited) 650 – 750C° [FAO/CMS, 1996] and has an energetic value of (400 – 600) British thermal unit (BTU) per cubic foot (ft^3) [Hansen, 2002] or (5.5) kilocalories (Kcal) per cubic meter (m^3) [At Information, website].While pure methane (the fuel component of the biogas) has energetic value of (995) BTU per ft^3, and natural gas more than (1000) BTU per ft^3 [Mattocks, 1984]. Anyway the following statement gives a sense about the energy that could be obtained from one (m^3) of biogas which: -"will light a 60 – 100 watt bulb for 6 hours, cook 3 meals for a family of 6, generate 1.25KW of electricity and run a 1 HP motor for 2 hours" [A Chinese Biogas Manual, from internet]. This statement also shows the possibilities uses of the biogas which are: - lighting gas bulbs, generating electricity and power, heating water, cooking and more.

The process of biogas production with all its sets, materials (as pipes, digester, valves, gas holder, organic…) and other affecting factors (as temperature, pH, moisture…) and system design is known by **biogas technology** [FAO/CMS, 1996]. The basic components of this technology (Figure 2) are the same what ever the plant type and size (discussed later in this chapter) could be. These basic components are: - wet organic substrate, mixing and displacement pits, digester and gas collecting system. But the differences could be in the moisture of the substrate and its type, volume of the digester and the material from which it is made (cement, plastic, steel, fiberglass…etc), if it is over or under ground and if it is temperature isolated or not [FAO/CMS, 1996; At-Information, website]. Also, the difference could be in the way of mixing organic matter with water in mixing pit and stirring slurry inside digester: - manually or mechanically.

The technology development depends on many factors as: - investor budget, ambient conditions especially temperature, type and availability of organic substrate, aims of the installed plant and its scale [Mattocks, 1984] and required uses of produced biogas (i.e. “direct heating require removing some of water vapor which can be easily done by simple condensation while produced gas need more purification to be used as fuel in electricity generator engines in large scale plants” [Schomaker and others, 2000]). The technology of small plants should be simple as possible so that its costs will be acceptable and suitable to be operated and repaired by the farmer [At-Information, website].

Figure 2 Schematic of the basic components for the biogas plant.



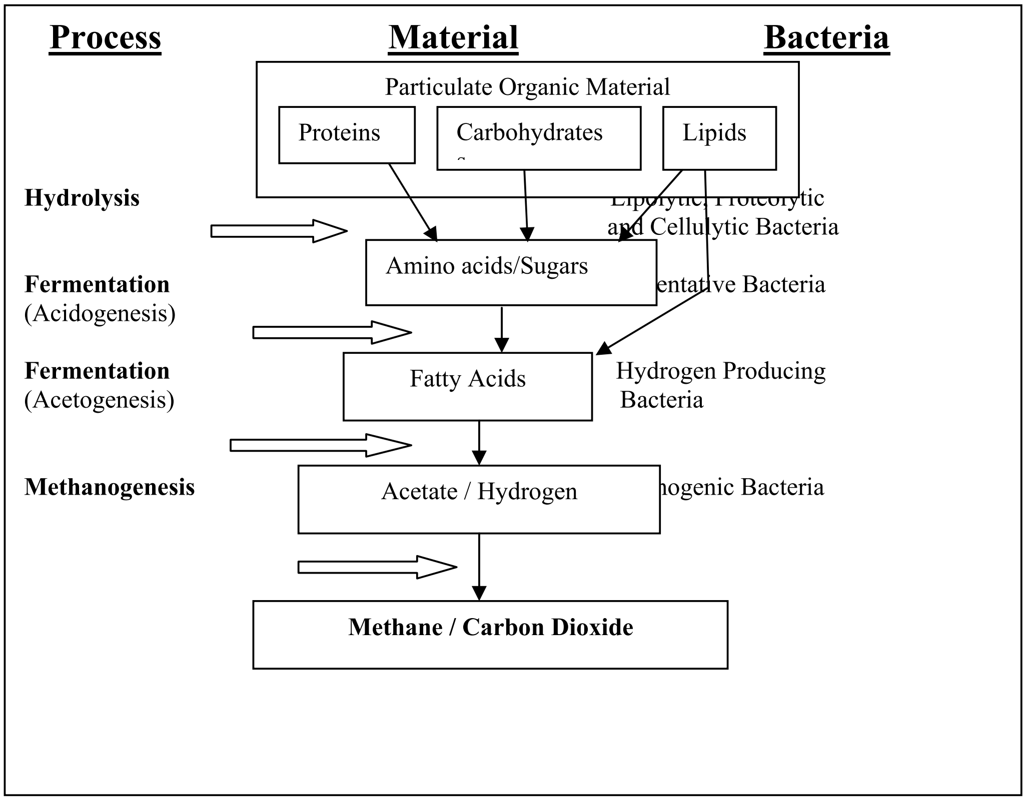
3.2.2- Anaerobic digestion (Methanization) process and affecting factors

A) **-** Anaerobic Digestion Process: -

The digestion process means the degradation – decomposition – of organic materials by anaerobic microorganisms at anaerobic conditions (absence of free oxygen) [FAO/CMS, 1996; Mattocks, 1984]. The products of this process are: gases in which methane and carbon dioxide are the main components and sludge which is the remaining material that should be getting out from the digester after the digestion process complete [British Biogen, website].

Before discussing the factors that affecting the anaerobic digestion in some brief, we should know how the organics converted by anaerobic bacteria into methane and carbon dioxide in a process known by methanization. According to Schomaker and others [2000], the digestion process consists of three main stages as shown in figure (3).

Figure 3 Anaerobic conversion of organic material into biogas [Schomaker and others, 2000, from AD-NETT].



In the first stage, the complex organic materials (as proteins, carbohydrates, and lipids) are hydrolyzed by the effects of some enzymes that produced by some species of bacteria (as Cellulytic bacteria) into smaller molecules as amino acids and sugars. Then, these produced molecules converted by fermentative bacteria to fatty acids. In the second stage, the resulted fatty acids converted by acetogenic and hydrogen producing bacteria into acetates and hydrogen gas. Finally; the acetates and hydrogen molecules are converted by methanogenic bacteria into methane and carbon dioxide as the following chemical equations show [FAO/CMS, 1996]: -

1- CH_3COOH (acetic acid) $\longrightarrow$ CH_4 (methane) + CO2 (carbon dioxide).

2- $2CH_3CH_2OH$ (ethanol) + CO_2 $\longrightarrow$ $CH_4 + 2CH_3COOH$

3- $CO_2 + 4H_2$ (hydrogen) $\longrightarrow$ CH_4 + H2O (water).

The physical container at which the digestion process occurs is called digester or bio-digester as some reports call it [FAO/CMS, 1996]. This digester must be made so that air can't enter inside it. It could be made of concrete, plastic, bricks, metal…etc, and of different volumes according to the volume of slurry (the mixture of organic materials and water that to be fed into the digester) in addition to its loading rate and the time required for the organics to remains inside the digester (Retention – or Hydraulic Retention –Time) [Mattocks, 1984; FAO/CMS, 1996].

B) **-** Factors Affecting The Digestion Process: -

There are many factors affecting the digestion process inside the digester and the quantity of produced biogas: - microbes balance, temperature, substrate type, stirring, grinding of organic materials before its introducing into the digester, total solids or moisture, carbon / nitrogen ratio (C/N), time remaining of organics inside the digester, acidity (pH), and the presence of activators or inhibitors [Mattocks, 1984; FAO/CMS, 1996]. Each factor effect in and affected by the other factors, but each one will be discussed alone in some brief.

1- Microbes balance: -

Methanogenes convert simple acids and hydrogen that produced by fermentative bacteria species into methane gas and carbon dioxide; this means there should be stable ratios between the different types of anaerobic bacteria population. For example; if the acidogenic bacteria population increases more than the appropriate ratio then there will be an excess accumulation of acids inside the digester which will increase acidity (pH fall down) causing deactivation or stop acting of methanogenes and so the digestion process. In contrast; if the population of acidogenic bacteria decreases significantly, there will be no enough acids for methanogenic bacteria which will decrease biogas production [Mattocks, 1984; FAO/CMS, 1996; Schomaker and others, 2000].

2- Substrate type: -

Anaerobic bacteria can digest all organic materials but they differ in the time interval required for complete digestion. That is; some are easily digested and in short time (from few to many days) while others hardly digested and in long time (months or years) and this according to the compounds from which the organic matter is composed [Mattocks, 1984; FAO/CMS, 1996]. For example; organic matter with highest amount of lignin ("its amount increases with plant age, in plant stem more than in plant leaves… and in horses dung more than in other cattle dung" [Mattocks, 1984].) is the hardest to be digested. Also; as organic matter contents of cellulose fibers increases, as its digestion become more difficult [Mattocks, 1984]. The increasing of volatile solids ("the weight of organic solids burned off when heated to about 538 C°" [FAO/CMS, 1996]) in organic matter will increase the amount of produced biogas in the digestion process. C/N ratio is another character of organic matter that effects on its digestion which will be discussed below. As a result; there is a relationship between the chemical composition of the organic substrate and the digestion process.

3- C / N ratio: -

C/N ratio means the ratio of carbon element amount in organic matter to its content of nitrogen element amount [FAO/CMS, 1996]. The best C/N ratio is 20-30 atoms of carbon for each atom of nitrogen (20-30 carbon atoms: 1 nitrogen atom) [Mattocks, 1984; FAO/CMS, 1996; EREC, 2002]. High or low C/N ratio will effect negatively on the digestion of the substrate. Organic wastes differ in their C/N ratio, for example; C/N ratio for cow dung is 24, wheat straw is 90, chicken dung is 10 and for sheep dung is 19 [FAO/CMS, 1996]. For good biogas production the adjusting of C/N ratio is desirable and this can be achieved by mixing wastes of high ratio with those of low ratio [FAO/CMS, 1996].

4- Temperature: -

Methanogenes can act on the substrate in wide range of the temperature "from below freezing to above 57.2 C°" [EREC, 2002.]. There are three ranges of temperature at which digestion process can be occurred and these ranges are [Mattocks, 1984]: -

"A- Low temperature range (Psycrophilic bacteria range): - less than 35C°

B- Medium temperature range (Mesophilic bacteria range): - ranged between 29C° and 40C°

C- High temperature range (Thermophilic bacteria range): - from 50C° to 55C°". According to another source [FAO/CMS, 1996], the optimum temperature for the digestion process is 35C°. In general; the higher temperature inside the digester the less time required for completing digestion of organic materials (more production of biogas) since more methanogenic bacteria are working upon substrate and also more destruction for diseases causing microbes.

The temperature inside the digester should be stable, since the methanogenic bacteria are highly sensitive toward changes and variations of temperature inside the digester especially at high temperature ranges (51.7-39.4C°) where the productivity of the biogas dropped significantly, while it drops gradually at low temperature range (35-0C°)[EREC, 2002]. That is, a sudden or fast temperature changes reduces the production of biogas or may be stop its production, so temperature monitoring is essential especially for biogas plants work at high temperature range and may additional heating system or advanced digester isolation is required.

5- pH- value:

Methanogenes are so sensitive toward acidity inside the digester. The best pH value that preferred by methanogenes is around 7, therefore high or low pH values decrease or stop the activity of methanogenes which will effect adversely the biogas production [FAO/CMS, 1996].

Naturally, in the first few days the pH falls as a result of producing acids by acidogenes. After that; pH rises gradually as a result of nitrogen digestion (forming NH_4+). Then the pH stabilized between 7.2 and 8.2 where production process of biogas stabilized also [FAO/CMS, 1996].

For adjusting pH value, acidic materials as sodium bicarbonate should be added to the digester contents (or with loaded organics) in the case of significant pH rising while lime or any other basic material can be added in the case of pH falling [Mattocks, 1984].

6- Grinding: -

Grinding or breaking down of organics to small pieces before introducing them into the digester will enhance the digestion process by decreasing the retention time and enhancing biogas production. Since materials grinding increases their area that exposed to the action of anaerobic bacteria and so simplifying the digestion process [Mattocks, 1984; FAO/CMS, 1996].

7- Stirring: -

Repeated digester contents agitation or stirring is very important for completing digestion process and enhancing biogas production. Since stirring break down the scum formed on the surface of digester contents and "prevent the bacteria from stagnating in their own waste products" [Mattocks, 1984].

Stirring is more important for large-scale biogas plants, or plants with a floating-drum digester model than that of small scale. Stirring for digester contents of small plants could be done manually by steel rods from substrate introducing pipe, or by paddles while large scale plants require more sophisticated stirring system as gas recirculation and mechanical stirrer [Mattocks, 1984; FAO/CMS, 1996; At-Information, website].

Good mixing of organic wastes with water before introducing the slurry into the digester enhances the digestion process [FAO/CMS, 1996].

8- Total solids: -

Total solids mean the amount of solid particles in the unit volume of the slurry and they usually expressed in the percentage form [FAO/CMS, 1996]. Mattocks [1984] pointed that the percentage of total solid should be between 5% and 12% while other source reported that the best biogas production occur when total solid is ranged from 7% to 10% because of avoiding solids settling down or "impeding the flow of gas formed at the lower part of digester" [FAO/CMS, 1996]. Therefore; dilution of organic substrate or wastes with water to achieve the desirable total solids percentage is required.

9- Retention time: -

The required time for complete digestion of the substrate inside the digester depends on the type of the substrate, substrate particles size, stirring… and mainly on the temperature of the digester [Mattocks, 1984; FAO/CMS, 1996]. In general the highest digester temperature and the finest substrate particles size the shorter retention time. According to the most reports about anaerobic digestion process the retention time of 40 to 60 days is satisfied for digesters work at temperature range between 20 and 35C° [EREC, 2002; Mattocks, 1984; FAO/CMS, 1996].

10- Inhibitors and Activators: -

Presence of some substances in the contents of the digester below certain concentrations may activate the digestion process and so increasing the biogas production, but at higher concentrations it may become inhibitors. As an example; "presence of NH_4 from 50 to 200 mg/l stimulates the growth of microbes, whereas its concentration above 1500 mg/l produces toxicity" [FAO/CMS, 1996.]. Results of other study pointed that adding small amount of nickel metal (as nickel chloride) to rice straw substrate stimulate its biogas production while nickel larger amount gives opposite results [TRI, website]. The presence of some substances can kill anaerobic bacteria as antibiotics, drugs and other medical wastes [Mattocks, 1984].

3.2.3- Biogas plants types

The biogas plant could be constructed over earth surface or underground with or without heat insulation or heating system. Underground installation is preferred because of saving area, decreasing temperature changes effects on digestion process, protecting system materials from physical damage and avoiding explosion hazard [Mattocks, 1984; FAO/CMS, 1996; At-Information, website]. The biogas plant could be constructed from cement, fiberglass, plastics, steel or any other materials with taking in account air tightness and the effects of ambient conditions on these materials [At-Information, website].

The gasholder could be a part of the digester or a separate vessel. The digester shape could be rectangular, cylindrical, hemi-spherical, egg-shaped …

As said previously, the basic elements of the biogas technology are the same (mixing and displacement pits, digester and biogas collecting system), but biogas plants generally differ in their volumes (size), design and continuity of substrates loading [At-Information, website]. Selecting a biogas plant type depends on the availability and type of substrate (organic material or waste), ambient conditions (especially temperature), capital and available constructing materials, experience and available technology, rate of substrate loading and retention time [Mattocks, 1984; FAO/CMS, 1996; EREC, 2002; At-Information, website].

A) - Size types: -

Biogas plants are divided to three types according to their size: - small, medium and large scale types.

Small and medium scale biogas plants are usually constructed to satisfy all or some of the family needs from energy so they called family types. Their digester volume ranged from $1m^3$ up to $15m^3$ or to slightly larger volume. For economic reasons, the least recommended size is $5m^3$ [AT Information, website].

Large-scale plants usually constructed for commercial aspects or for dealing with large amounts of wastes as municipal solid waste and big farms plants. The sizes of these plants ranged from $20m^3$ to hundreds of cubic meters. The plant of Carven Dairy farm which sized to accommodate the daily manure produced from 1000 cows [Moser and others, et, al, no date] is an example.

B) - Continuity types: -

Biogas plants can be classified according to the rate of substrate loading into three types which are: - continuous, semi-continuous and batch [FAO/CMS, 1996].

In the continuous plants, there is a daily (or regular) introducing of the substrates into the digester with getting out the same quantity of digested materials. While in the case of batch plants, all of the require amount of substrates to fill the digester are added once at the beginning of the digestion process and removed all at once time from the digester after completing substrate digestion. In semi-continuous plants, fast or reasonable digested substrates are added into and removed from the digester in a regular manner, while slowly or hard digested substrates (as straw) are introduced in about twice a year as a batch load[AT Information, website].

Continuous plants provide the farmer or the investor with stable and high biogas production, in addition to daily disposal of wastes, which avoid him, the bad odor that resulted from accumulation of wastes. These plants require fluid and homogeneous substrate and they are so sensitive toward substrate characteristics (especially pH and total solids) and ambient conditions, there fore it requires continuous monitoring. Batch plants are less sensitive, but their biogas production is not constant in addition to wastes accumulation negative impacts [Mattocks, 1984; FAO/CMS, 1996; At-Information, website].

C) - Design types: -

There are many biogas plant designs that could be installed, but the simplest with the lower construction cost designs are selected because this study is concentrated on family biogas plants (small plants) that should be operated and maintained by farmer himself (owner).

There are two main designs that are well known and installed in millions plants at many developed countries as India, China, Nepal and Vietnam [Mattocks, 1984; At-Information, website]. This large distribution of these designs return to their simplicity, relative low cost of construction and refers to their successes at ambient conditions in these countries. These designs which usually installed underground are: - fixed-dome and floating-drum digesters.

1- Fixed-dome plants: -

This design consist basically from mixing pit with substrate inlet pipe, digester, gas holder which is usually a part of the digester with gas outlet pipe and the displacement pit with outlet pipe from the digester. The following figures 4, 5, 6, and 7) show the basic element and some models of this design [At Information, website].

2- Floating-drum plants: -

The main components of this design are nearly the same as that of fixed-dome design, but the difference is in the system of biogas collection. In this design, the biogas collected inside mild steel drum that adjusted over the top of the digester. This drum moves up and down according to the biogas pressure rise up under gas pressure, that is; when the quantity of biogas increases, the drum moves up and as the biogas consumed it is moved down [FAO/CMS, 1996]. Figure (8) shows a schematic diagram for a water- jacket floating-drum design and photo (1) shows one of the applied floating-drum plant [AT Information, website] while figure (9) is a schematic diagram for KVIC model [Jo Lawbuary, no date].

Fixed-dome design costs less than floating-drum design and it is of less repair requirements and no problems with scum formation. Floating-drum design provides biogas with stable rate or pressure while the biogas rate in fixed-dome design is variable [Mattocks, 1984; FAO/CMS, 1996; At-Information, website].

More developed designs were installed and experimented, but mostly it requires high construction costs and high knowledge to be operated and maintained, therefore it will be not included with details in this study because the concern is with the simplest and least cost digesters that could be constructed, repaired and operated by the rural family itself. Bag digester, plug-flow digester, anaerobic filter, covered lagoon, slurry based digester [FAO/CMS, 1996; Lusk, 1999] and multi-stage Biorealis digester [Biorealis, website] are some of these designs.

3.3- Specificity of This Study

Because ambient conditions (as temperature, agricultural activities, economical and social situations) differ from country to another, and because of possibilities for using different organic materials as a substrate in biogas plants, in addition to the presence of many factors (discussed in the following section of this chapter) that affect on the digestion process, make the biogas technology a subject for continuous research and development.

This study has two main new points by which it differ from previous studies, and these points are:-

1- The experiment which did at ambient conditions (not in laboratory and not a study for already constructed plant), and applied over ground in the most agricultural governorate (Jenin) of Palestine. Moreover; the biogas production for (20) samples of mixed organic wastes (animals dung, food residues and wheat straw) were tested at the same time and in two different digester volumes (18 barrels each of 240 litter capacity, and 2 large steel digesters each of 1500 litter capacity).

2- The Field survey that distributed on rural communities over the rural areas in West Bank (all governorates). This survey is distinguished by its aims and subjects, especially studying the availability of organic wastes for rural families, ways followed by rural families for disposing their wastes, families agricultural activities and energy sources and consumption for rural families.

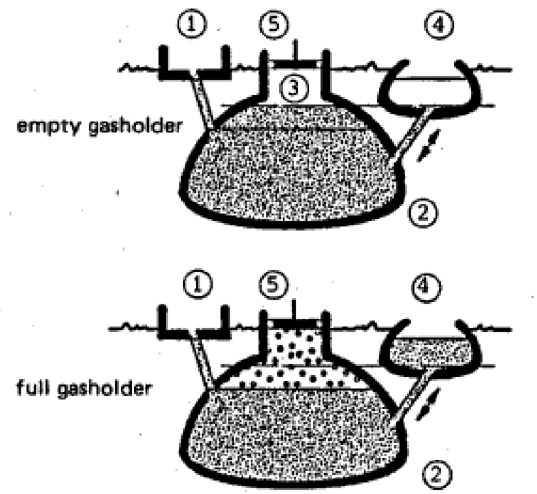


Figure 4 Basic function of a fixed-dome biogas plant, 1- Mixing pit, 2- Digester, 3- Gasholder, 4- Displacement pit, 5- Gas pipe

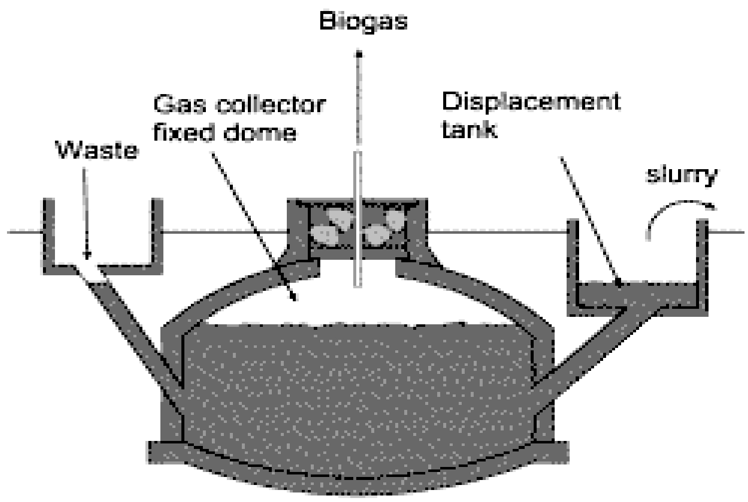


Figure 5 Chinese fixed dome plant

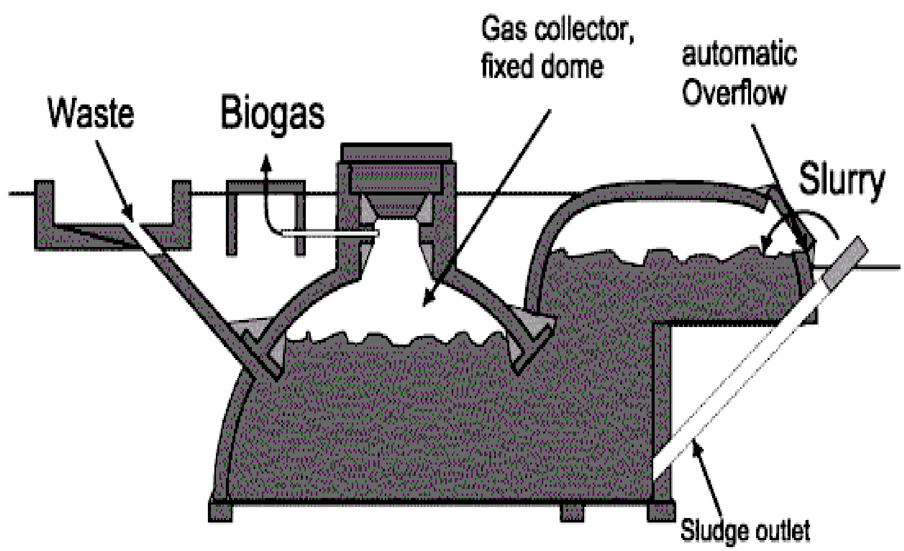


Figure 6 Fixed dome plant CAMARTEC design

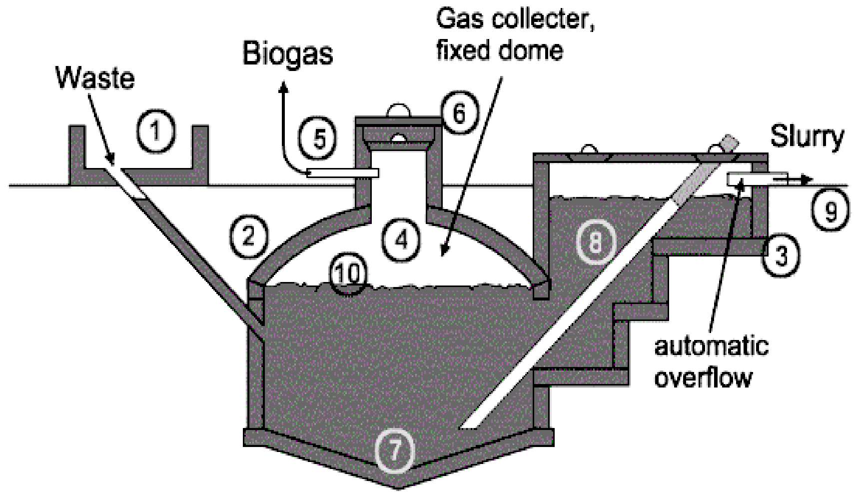


Figure 7 Fixed dome plant Nicarao design: 1. Mixing tank with inlet pipe and sand trap. 2-Digester. 3. Compensation and removal tank. 4. Gasholder. 5. Gas pipe, 6-Entry hatch, with gastight seal. 7. Accumulation of thick sludge. 8. Outlet pipe. 9. Reference level. 10. Supernatant scum, broken up by varying level

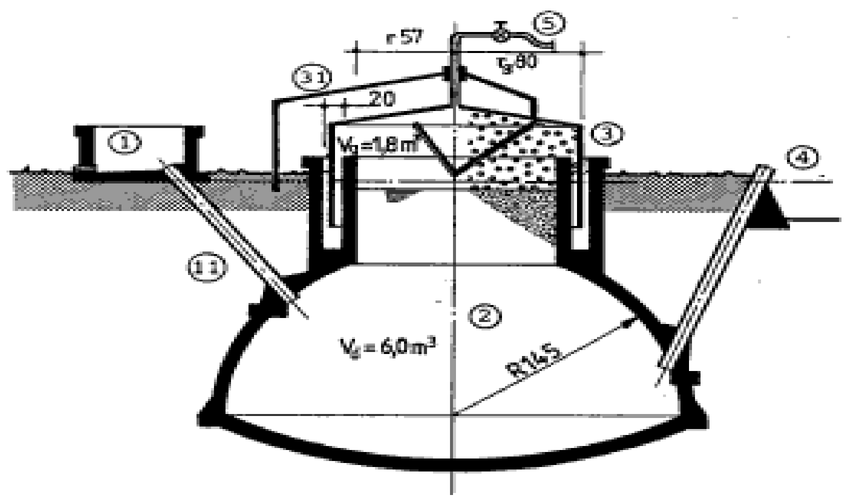


Figure 8 Water-jacket plant with external guide frame. 1- Mixing pit, 11-Fill pipe, 2- Digester, 3-Gasholder, 31- Guide frame, 4- Slurry store, 5- Gas pipe.

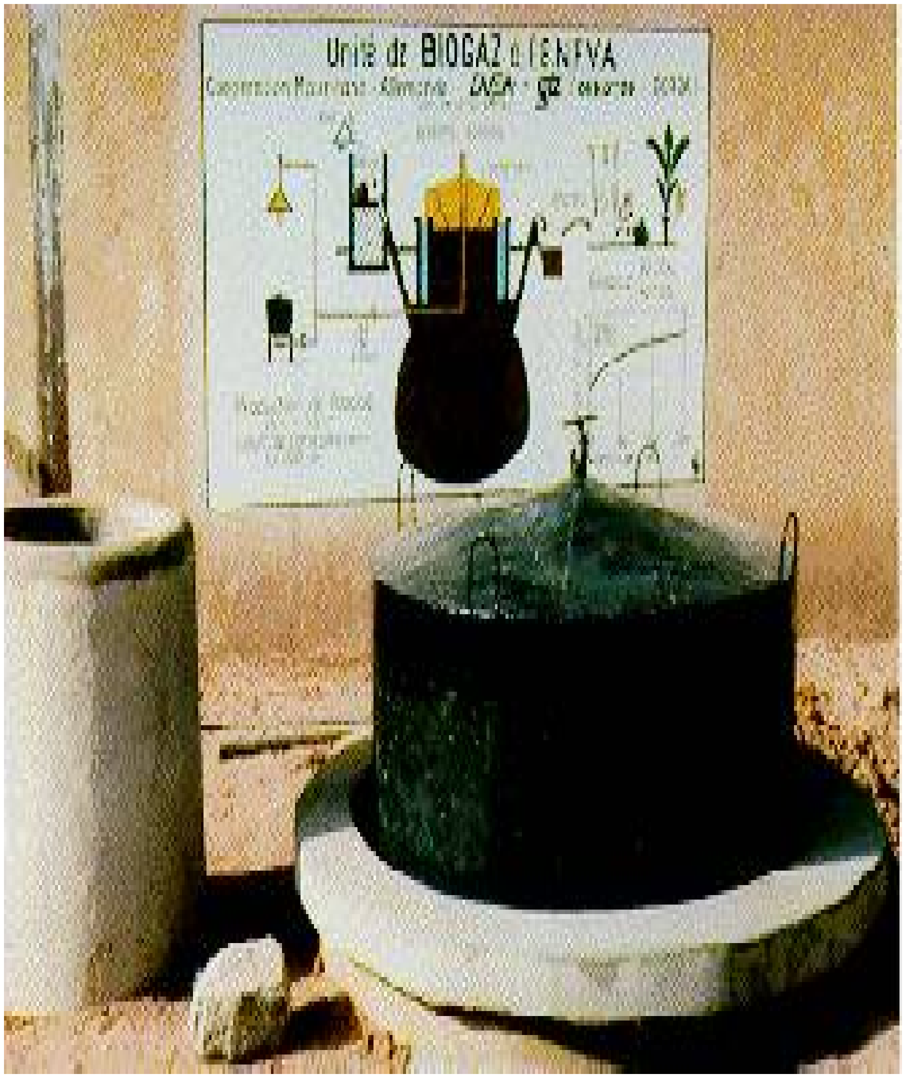


Photo 1 Floating-drum plant in Mauritania

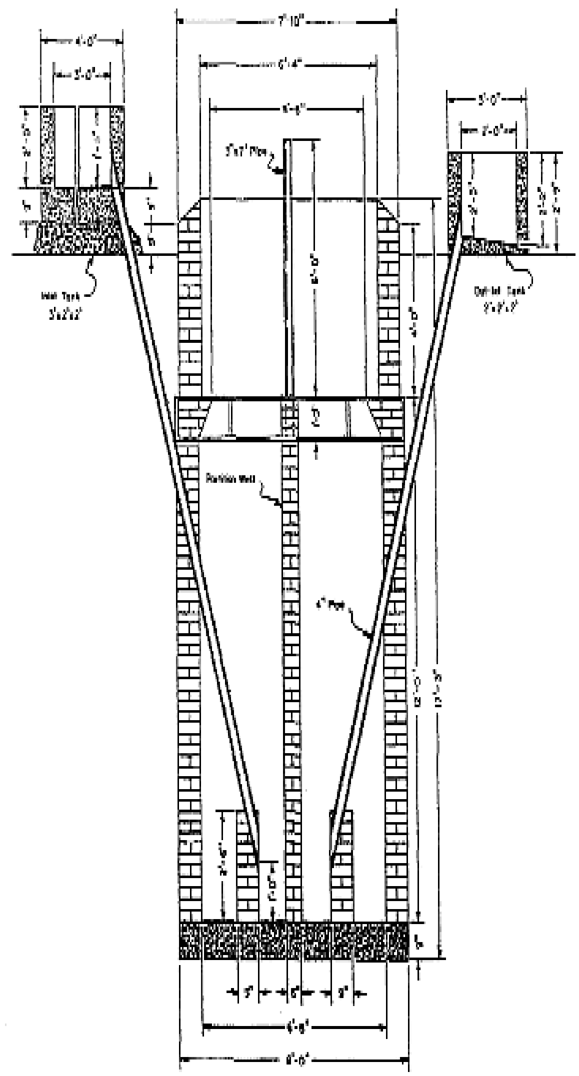


Figure 9 The KVIC floating drum model (Lichtman, 1983)

Chapter Four

Experimental Program

4.1- Materials and Equipments

The used materials and equipments are:-

1- Digesters: - steel vessels that are used for anaerobic digesting of introduced organic waste samples, and it metallically operated so that no air could be interred inside it. There are two types of these digesters (made for running the experiment to study the effect of enlargement on organic wastes productivity for biogas) according to their volume:-

a) 18 Barrels, each of about (240) litter capacity. Figure (10) shows the schematic diagram of a barrel digester.

b) 2 steel digesters, each of (1.5m^3) volume, one is with stirrer while the other is without stirrer. Figure (11) is the schematic diagram of 1.5m^3 with stirrer digester.

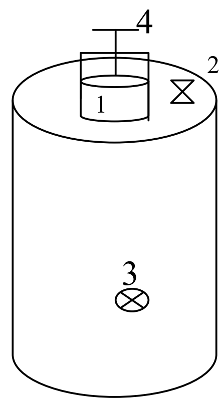


Figure 10 Schematic diagram of a barrel digester:- 1- inlet opening (8 inch diameter), 2- gas valve (0.5 inch), 3- valve to get out slurry samples (0.5 inch), 4- screw to close tightly inlet cover.

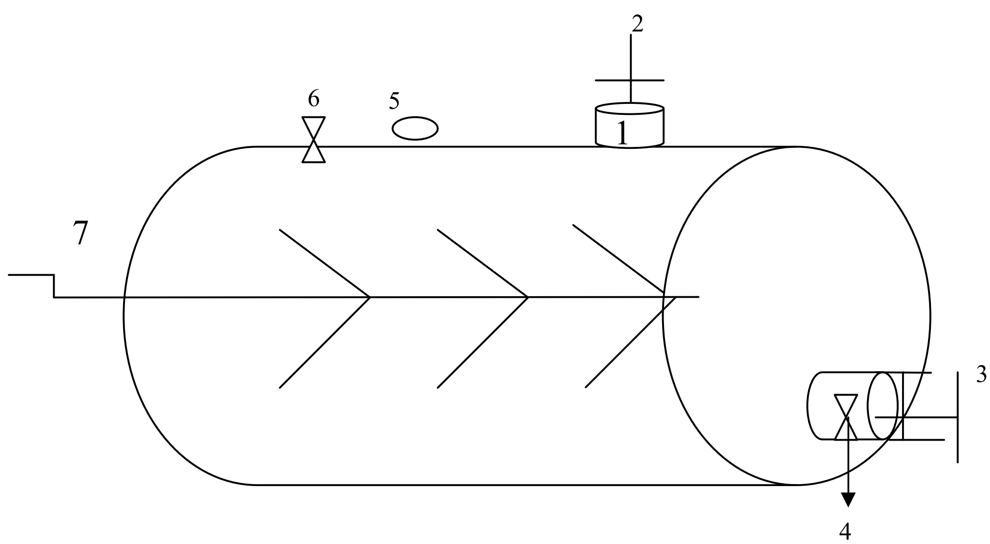


Figure 11 Schematic diagram of 1.5m³ digester with stirrer:- 1- Inlet open, 2- screw closer, 3- outlet open with screw closer, 4- sample getting out valve (0.75inch), 5- pressure gauge, 6- gas valve (0.5 inch), 7- manual stirrer. Each inlet or outlet opening is of 8 inch diameter.

2- Valves:-

a) Gas valves: to each digester and barrel, 0.5 inch ball chromate valve was installed to withdraw biogas.

b) Slurry valves: to each barrel, 0.5 inch liquid valve was installed, while 0.75 inch valves were installed for large digesters.

3- Pressure gauges: - a pressure gauge was installed for each of the two large digesters, while a third pressure gauge with suitable connector to the gas valve was used for monitoring pressure inside barrels.

4- 100Kg kale (of deviation± 100 gram) was used for weighting organic waste samples.

5- 1Kg electronic balance (of deviation ± 0.5gram) was used to weight produced biogas that withdrawn from the digesters.

6- Internal car tubes (3) for collecting biogas from the digesters.

7- Air compressor (Poma type of 25 litter tank storage capacity) to withdraw biogas from car tube and pressurizing it into gas holder. A gas valve was installed instead of its filter to simplify biogas withdrawing.

8- Gas holder: a barrel of 240 litter capacity was prepared to store biogas.

9- Maxima-Minima thermometer to record maximum day and minimum night temperatures.

10- pH- checker (pocket-sized pH meter) for measuring slurry acidity.

11- Plastic vessel (12 litters) for measuring wastes and water volumes.

12- Steel funnel for simplifying substrate introducing into the digesters.

13- Steel vessel (100 litter) for wastes mixing.

14- Teflon roles and silicon bottles for greasing and prefect tighten of conjunction points.

15- PVC pipes of different lengths and connectors for connection purposes.

The following photos (2, 3, and 4) show these materials.

Photo 2 Barrel Digesters

Photo 3 Some of the Used Instruments

Photo 4 Large (1.5m³) Digesters

4.2- Wastes Collection and Preparation

The used organic wastes in this experiment are:- cow dung, sheep and goat dung, chicken waste, wheat straw, and food residues. All wastes were airy dried for 6 weeks before its using, except food residues which were used freshly.

a- Cow dung which was collected from neighbour farm in which four adult cows are raised.

b- Sheep and goat dung which was collected from my family farm, in which thirty seven sheep and eight goats are raised with twelve sheep and five goats of less than one year age.

c- Chicken waste which was collected from broilers chicken farm located in Jalkamous village.

d- Wheat straw which was bought as bales from local farmer. It is used as a planting waste because of its hardness to be digested, since it has high C/N ratio (90), and also most farmers feed it to their animals, so it is usually found with animals' dung.

e- Food residues (as a domestic solid waste) were separated from local community domestic solid waste disposal containers.

f- Water from local artesian well was used for wastes dilution.

4.3- Samples Compositions

Twenty samples of organic wastes were introduced in twenty digesters (18 barrels and 2 large digesters), and the composition of each digester sample with ratio of each organic waste type and water dilution factor are found in table (2). This table show:-

-In the first nine (from B1 to B9) samples, the animals wastes ratio {cow: sheep and goat: chicken} to each other are fixed (each 33.3% of the total animal waste), while the ratios of {animal: food residues: wheat straw} are differ from sample to sample, since the main aim for preparing these samples is studying the effect of each waste type on the samples productivity for biogas and on the retention time of the anaerobic digestion for mixed organic wastes (the best sample will be that produce the highest biogas weight in shorter retention time).

- Samples 10 and 11 compositions are the same as that of sample 7, but with difference in the water dilution factor (amount of added water) to study the effect of organic wastes moisture on its productivity for biogas.

- Samples (12) to (18):- The ratios of food residues, wheat straw and total animals waste were fixed (33.3% for each from the total sample waste weight) with varying the ratios of the animals dung types for studying the effect of each animal dung type on the mixed organic waste productivity for biogas, and on the retention time for the samples anaerobic digestion.

- The composition ratios of (D1) and (D2) samples are the same as that of sample (B1), but with multiplying their weight six times for studying the effect of enlargement and stirring on the samples biogas production and digesting retention time.

Table 2 Samples Compositions.

Digester	Animal Dung ratio (to each other)			Sample Composition (waste types ratio)			Water Dilution Factor
	Cow	Sheep and Goat	Chicken	Total animal dung Ratio	Food Residues	Wheat Straw	
B1	0.666	0.666	0.666	2	1	1	2.5
B2	0.666	0.666	0.666	2	2	0	2.5
B3	0.666	0.666	0.666	2	0	2	2.5
B4	0	0	0	0	2	2	2.5
B5	0.333	0.333	0.333	1	2	1	2.5
B6	0.333	0.333	0.333	1	1	2	2.5
B7	1.333	1.333	1.333	4	0	0	2.5
B8	0	0	0	0	4	0	2.5
B9	0	0	0	0	0	4	2.5
B10	1.333	1.333	1.333	4	0	0	2.0
B11	1.333	1.333	1.333	4	0	0	3.0
B12	1.333	0	0	1.333	1.333	1.333	2.5
B13	0	1.333	0	1.333	1.333	1.333	2.5
B14	0	0	1.333	1.333	1.333	1.333	2.5
B15	0.666	0.666	0	1.333	1.333	1.333	2.5
B16	0.666	0	0.666	1.333	1.333	1.333	2.5
B17	0	0.666	0.666	1.333	1.333	1.333	2.5
B18	0.444	0.444	0.444	1.333	1.333	1.333	2.5
D1	4	4	4	12	6	6	2.5
D2	4	4	4	12	6	6	2.5

Where :-
*** B= Barrel,
*** D1= 1.5m³ digester with stirrer, D2= 1.5m³ digester without stirrer.
*** To get weight of any waste in the sample, multiply by 3, for example; weight of cow dung in B1= 0.666*3= 2Kg, while its weight in D1= 4*3= 12Kg.
***Water dilution factor means: water volume units added to each mixed waste volume unit.
*** Total weight of organic wastes in each barrel = 12 Kg.
*** Total weight of organic wastes in each of D1 and D2 = 72 Kg.

4.4- Experimental Site: - Location and Conditions

The experiment did in Saba'en area which located in Jenin governorate that considered from the most agricultural areas in Palestine. This area is also close to my home so that I could take measurements at the suitable time and monitor the experiment continuously (to avoid any unusual conditions, especially closing roads by occupation) especially for stirring (6 times every day) the contents of digester (D1).

The digesters were placed on the earth surface inside a plastic room but there were some holes in the plastic cover sheet, so that the temperature inside the room is as the atmospheric temperature.

4.5- Experimental Procedure

4.5.1- Sample preparing and introducing

For each sample, the required waste weight was weighted by kale and drained in the mixing steel vessel were mixed with required amount of water. After that, the pH of the sample was measured and recorded, and then the slurry was introduced into the digester. Finally the opening inlet of the digester was closed with ensuring all valves are tightly closed so that no air could be interred into the digester.

4.5.2- pH- recording

For each digester, about (20 ml) sample of the digester slurry was taken from the liquid valve, and its pH was measured by pH-checker and recorded. The pH was measured daily in the first (15) days, then it was measured once every (3) days because pH changes are usually large in the first days of the anaerobic digestion process for organic wastes [FAO/CMS, 1996].

4.5.3- Temperature

The maximum day and minimum night temperatures at the experiment location were recorded every day by using maxima-minima thermometer.

4.5.4- Stirring

The contents of (1.5m^3) with stirrer digester {D1} were stirred manually and gently 6 times every day, and for about five minutes each time where some studies indicate that the most effective stirring could be achieved by gentle and frequent stirring for digester contents [FAO/CMS, 1996; At-Information, website].

4.5.5- The pressure inside the digesters was monitored from time to time but without recording its values {monitoring only}.

4.5.6- Biogas withdrawing and weighting

The car internal tube is weighted by the electronic balance, and then it is connected to the gas valve of the digester, and when gas valve opened the biogas flow into tube as a result of pressure difference between pressure inside the digester and pressure inside the tube. When the gas flow stops, the tube disconnected and weighed with its content. The difference between tube weights before and after biogas withdrawing is the weight of biogas which recorded. After that; the content of the tube are withdrawn by connecting it to the compressor. The process is repeated till there is no change in the weight of biogas inter into the tube. All these steps were done for each digester.

The first biogas withdrawn was done after three days from the time of introducing samples into the digesters because all studies indicate that the biogas production began after 2 to 3 days from introducing organic wastes into the digester. Other withdraws were did once every three days (the expected time to get a biogas amount that could be weighted significantly and to avoid high pressure may caused by produced biogas in the case of giving longer time between biogas withdraws).

The following photos (5-12) explain some of the experiment procedure steps.

Photo 5 Mixing samples

Photo 6 Introducing sample into the digester

Photo 7 Withdrawing slurry sample for measuring its pH

Photo 8 Measuring slurry pH.

Photo 9 Withdrawing biogas from barrel digester into tube**.**

Photo 10 Withdrawing biogas from large digester into tube

Photo 11 Weighting biogas by digital balance.

Photo 12 Withdrawing biogas from tube by the compressor.

Chapter Five

Field Survey

The field survey aims basically for obtaining data about availability and types of organic wastes generated from rural family activities, and the ways followed by farmers for treating or disposing off the wastes with their effects on farmers' life. The survey aims also obtaining data about sources and costs of energy for the family. Moreover, questions about biogas technology were included in this survey to see farmers' knowledge about the technology and their acceptance to apply it. Appendix Щ represent the complete copy of the field survey (Appendix IV represent the Arabic copy that distributed on rural families).

5.1- Study Society

The society of the study is the Palestinian rural families in West Bank.

5.2- Sample

The researcher chose the purpose sample method (in which a sufficient sample selected by a way that the researcher think it covers the purpose and aims of his study [Alquds Open University, 1998]) for collecting questionnaire data because of difficulties of political situation (closure on Palestinian cities and villages) and unavailability of financial sources to cover money outcome for the study.

260 copies of the questionnaire (in Arabic language which is the language of our society, Appendix IV) were distributed on 260 rural families who live at different Palestinian rural areas (Jenin, Nablus,

Tulkurem, Jericho, Rammalah and Hebron). And the questionnaire contents were explained to each family for removing any misunderstanding or any mysterious in questions. Each family was given two weeks for filling the questionnaire. Then, the copies were collected and the obtained data organized and statistically analyzed with noting that 13 copies were canceled because their data were incomplete, so; the net number of copies that was used for analysis is **247**.

5.3- Questionnaire

The questionnaire is divided into three main parts: - family and family agricultural activities, general indications and different questions (Appendix Ш).

5.3.1-Part One: - family and family activities data

In this part, the family was asked to fill its: - members number, raised animals number from each type, irrigated and un irrigated agricultural areas and monthly average costs for each energy source with its uses.

For animals feed types, the farmer asked to choose the suitable option from (always, almost, sometimes, rarely, never) that agrees with his using for each feed type of the reported types (grains, straw, and manufactured feed). To calculate average frequency of using (chapter six) for each feed type, the options were scored as follow:-

option	always	almost	sometimes	rarely	never
score	4	3	2	1	0

Seven statements were structured about the seven ways that may be used by farmers for disposing their animals' dung with leaving a space for additional statement to be added by the family if there is another disposal way. For each statement there was five possible options (all, most, some, little, nothing) and the farmer asked to check with (√) under the option agrees with his using the disposal method. The options were scored as in the following table to get out averages for each statement and comparing results. The same thing was done for planting residues and domestic waste disposal ways, but with eight statements for planting residues and eleven statements for domestic disposal methods.

Option	all	most	some	little	nothing
Score	4	3	2	1	0

5.3.2- Part Two: - General indications and farmers opinion

This part is divided into two main subparts which are: - general indications and farmers opinion towards wastes issues.

General indications subpart consist of (16) statements with five options for each statement (always, mostly, sometimes, rarely, and never) and the farmer was asked to chick with (√) under the option agrees with his believe. The statements were structured to get indications about rural family suffering from negative impacts of organic wastes (statements numbers: - 1, 2, 3, 4, 5, 11, 14, and 16) and to get data about some behaviors of farmers (statements: - 6, 7, 8, 9, 10, 12, 13 and 15). For statistical analysis; the options were scored as the options of animal feed types.

Farmer's opinion toward wastes issues subpart consists of (21) statements with four (4) options for each statement (surely, maybe, doubted, no). 17 (of the 21) statements were structured for estimating farmers environmental awareness toward wastes issues, and most of these statements are positive (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 14, 16 and 21) while others are negative (11, 13, and 15). The remaining statements (17, 18, 19 and 20) were structured for estimating rural people acceptability for applying biogas technology. For statistical analysis, dipole standard scale {which usually used for calculating average reply of each statement when there are two directions (positive and negative) for the structured statements [Mattarba, 1998]} used here and the options were scored as follows:-

Direction of statement	**Option**	surely	may be	doubted	no
+	**Score**	4	3	2	1
-	**Score**	1	2	3	4

5.3.3-Part Three: - Different questions

There are nine questions in this part:-

* Questions one and two were structured to measure the farmers knowledge about biogas technology and anaerobic digestion process with four options (much, something, little, nothing) for answering each. The farmer was asked to circle the choice that express about his knowledge. To evaluate the results of these questions data, the options were scored as follows:-

Option	much	something	little	nothing
Score	3	2	1	0

* Questions number three, four, five and six were structured about cess pits that usually used for disposing family wastewater with giving two options (yes, no) for each of questions three and four, and three options for question five (yes, maybe, no) and four options for the sixth question (six months, one year, two year, three years and more). The percentage of each option (from total replies on all of each question options) for each question was calculated for evaluation.

* In question number seven, the farmer was asked to answer about the distance (in meter) between his home and the nearest waste disposal place.

* In question number eight, the farmer was asked to answer the average time interval (in days) before removing dung from his animal farm each time.

* Question number nine was structured to obtain data about problems that face rural families in disposing their animals, crops and domestic wastes.

The obtained data for each element of the questionnaire were organized and the required calculations were done (chapter 6), then the results were tabulated in chapter (7).

Chapter Six

Statistical Treatment and Institutional Analysis

6.1- Statistical and Calculations Treatment

The Statistical Package for Social Sciences (SPSS) program {available in markets on computer compact disk}, which is the most famous statistical program used for evaluation and calculations of data in social sciences studies, was used in the study for the field survey and experimental data evaluation and calculations.

The percentage (60%) is considered a critical percent [Mattarba, 1998] for evaluating the positively or negativity of the survey results. Results of percentage above (60%) are considered positive while those of percentage less than (60%) are considered negative.

The statements (in the field survey) about waste disposal ways (animals dung, domestic solid wastes, wastewater and crops residues) were ranked according to their calculated percentages. The statements were ranked to see which is the most disposal way that is followed by the rural families for disposing off each type of wastes.

The following mathematical formulas [Waker and Josephlev, 1969] were used for field survey and experiment calculations:-

Average ($\bar{x}$) = $(X_1 + X_2 + \dots + X_n) / n$

Standard deviation (Sd.) = SQ$\{[(X_1-\bar{X})^2 + (X_2-\bar{X})^2 + \dots + (X_n-\bar{X})^2]/n\}$

Where SQ :- square root

For calculating the average reply and its percentage for statements of options in the field survey:

$$\text{Average Reply} = \frac{\text{Sum.(Number of replies on option X option score)}}{\text{Total number of replies on statement options}}$$

Average reply is calculated for each statement, and sum means summation.

$$\text{Percentage of Reply} = \frac{\text{Average of Reply}}{\text{Maximum Score}} \text{ X } 100\%$$

As an example; the average reply for the frequency of using grains by farmer for feeding cows was calculated after arranging the obtained data as follows:-

Animal:- cow	Feed type :- grains					
option	always	almost	sometimes	rarely	never	**Total**
score	4	3	2	1	0	
No. of replies	83	49	11	26	10	**179**
No. of replies X score	332	147	22	26	0	**527**

Average Reply = 527 / 179 = 2.94

Percentage of Reply = (2.94 / 4) X100% = 73.5% (see table -5- in the following chapter -7-)

The same calculation method was followed for all statements and questions of options in the field survey and the results are tabulated in the main finding and discussion chapter (7).

6.2- Chemical and Biological Analysis

Hope was doing the following chemical tests:- determining the methane (CH_4) ratio in the produced biogas, determining the concentrations of hazard gases (mainly hydrogen sulphide and nitrogen gases) in biogas, determining the concentrations of basic elements (nitrogen, phosphorus and potassium) for plants growing and crops production before and after the digestion of organic wastes. Moreover; the hope was determining the presence of diseases causing microbes and victors (as parasites, warms and its eggs and bacteria) before and after the anaerobic digestion of tested organic wastes (biological test).

The tests are necessary for more confidence in evaluating the objectives of the study, but unfortunately I did not do these chemical and biological tests because of many reasons mainly:-

1- Ambient political and security conditions in the country (repeated closure by occupation army on cities and villages) which inhabit transporting of samples from the location of experiment (Saba'en – Jenin) to University laboratories (in Nablus) or to laboratories out of Palestinian territories.

2- The gas chromatography device (which I promised from officials in laboratory to use it before doing my experiment) in An-Najah National University laboratory (where I was a student) was not ready for analyzing gases. In addition to un founding technical persons that are experienced with gases analysis in other universities (Al-Quds and Bir –Ziet).

Chapter Seven

Main Finding and Discussion

The obtained data from the field survey (questionnaire) and experiment were organized and statistically analyzed, and the following are the results with discussion.

7.1- Field Survey Results and Discussion

To simplify results analysis and getting out conclusions for the field survey, the obtained data is arranged according to the field survey parts.

7.1.1:- Part One Results: - family and family activities data

I) – Family Members:-

The following table (3) represents the total surveyed families with their total members number, average and standard deviation.

Table 3 Rural families and family size.

Total Surveyed Families	Family Members		
	Total Members of Surveyed Families	Average Members Per Family	Standard Deviation
247	1692	6.85	2.25

The average of Palestinian rural family members is (6.85) and the computed average is not so far from that computed by Palestinian Central Bureau of Statistics (PCBS) in its statistical survey of 1997 which was (6.30) [Palestinian Central Bureau of Statistics, 2002].The small difference (0.55) may be due to the political conditions that started in September, 2000 where the job opportunities decreases and the number of un employed people increases which reflected in the decreasing of marriage cases and so decreasing the total number of small size families with continuous increasing for members of the founded families.

Ц) – Family Raised Animals and Animals Feed Types:-

The quantity of organic waste (dung or manure) that is produced by an animal differ not only according to animal species, but also according to the animal age, feed type, health and if an animal is confined or not [Mattocks, 1984]. Moreover, the quantity and quality of biogas production per kilogram of animals waste is differ from animal to animal till if these wastes digested at the same conditions [FAO/CMS, 1996; Mattocks, 1984]. After deep studying for many reports and studies about this subject, the following points were concluded:-

- Each (1Kg) of organic waste (including animals dung) could produce from 20 litter to about 116 litter of biogas [Junaidi, 2000; Mattocks, 1984; Shacklady; 1983].
- Animals are divided into animals units as follows:- each one (1) adult cow considered as a one unit, each ten (10) sheep are one unit and each one hundred (100) of chickens are considered as a one animal unit [Abedo and Abod; no date].
- The daily cattle waste (or each one animals' unit) could produce about 600 litter of biogas [Junaidi, 2000].
- The daily capita energy requirements could be covered by biogas produced from one to two daily cattle dung (600 – 1200 litter) [Junaidi, 2000; At-Information, website].

But the results of one paper {that talk about real biogas plant which deal with dung of (15) cows (200 Kg daily dung)} emphasize that the daily produced biogas cover the energy need of 35 persons [Islam, Mazharul; 2002] which means the daily capita consumption from energy could be covered by biogas produced from 5.71 Kg (by dividing 200Kg daily dung on 35 persons)of cow dung or daily cow dung (200 Kg dung / 15 cows = 13.33Kg dung from each cow) could cover the energy needs of more than two persons (13.33Kg dung from one cow / 5.71Kg dung for covering each person requirements from energy = 2.33 persons).Similar results seen in other studies and sources as Chinese biogas handbook (some pages on internet, no date).

Because of the differences between studies about estimating numbers of animals units that could cover the capita consumption from energy (some studies indicate that the capita daily requirements of energy could be covered by biogas produced from one animal daily unit or less [Islam, Mazharul; 2002], while others indicate that it could be covered from about two animal units as Junaidi, 2000), a middle solution is taken by assuming that the quantity of biogas produced from the waste of each animals' unit could cover the capita needs from energy. Depending on this assumption, the Palestinian rural family (with average members 6.85) requirements from energy could be covered by biogas produced from the waste of about seven (7) animal units. Because Palestinian rural family (almost) raise different types of animals, the results of surveyed families about their raised animals will represented in the form of animal units (table -4-).

Table 4 Families and its animals units.

Animal Units	*Average of Units	Standard Deviation	No. of families	Percentage of families from total families raise animals	Percentage of families from total surveyed families
0	-	-	**68**	-	**27.53%**
0< unit<1	0.54	0.16	38	21.23%	15.39%
1– 1.99	1.34	0.22	35	19.55%	14.17%
2- 2.99	2.31	0.32	9	5.03%	3.64%
3-3.99	3.43	0.28	13	7.26%	5.26%
4-4.99	4.61	0.184	7	3.91%	2.83%
5-5.99	5.49	0.193	6	3.35%	2.43%
6-6.99	6.49	.211	14	7.82%	5.67%
7 and more	19.72	11.35	57	31.84%	23.10%
Total number of families which raise animals			**179**		**72.47%**
Total			**247**	**100%**	**100%**

*Average of animal units = (summation of units in the interval) / no. of families in the interval

From this table and figures (12 and 13), it is clear more than (⅔) of Palestinian rural families (72.47%) raise animals and (31.84%) of families that raise animals have animal units (7 units and more) which means they could cover their energy requirements from their animals dung only (if these families construct biogas plants). It appears that (22.34%) of families, whom raise animals, own animal units (3 – 6.99) that could cover about one half or more of their energy needs.

Figure12 Percentages of families according to their animal units

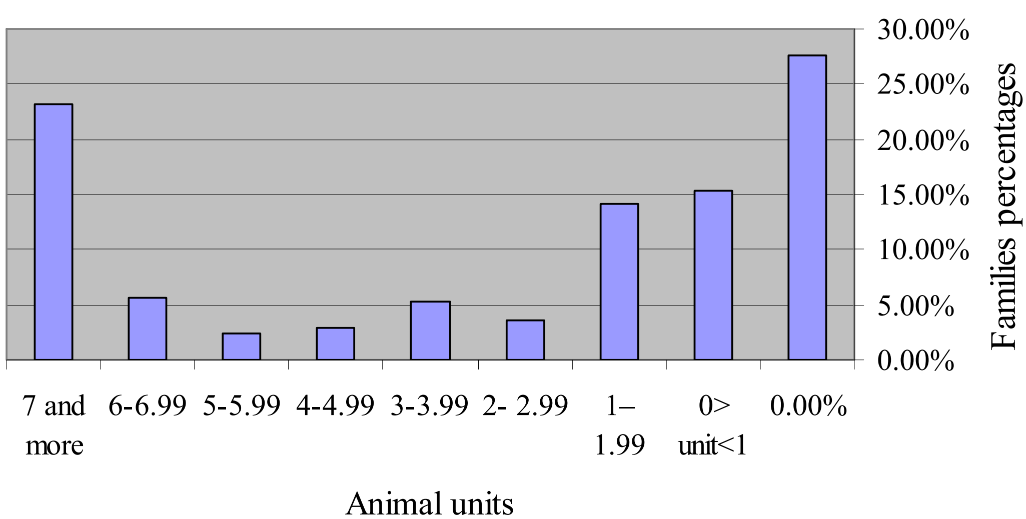
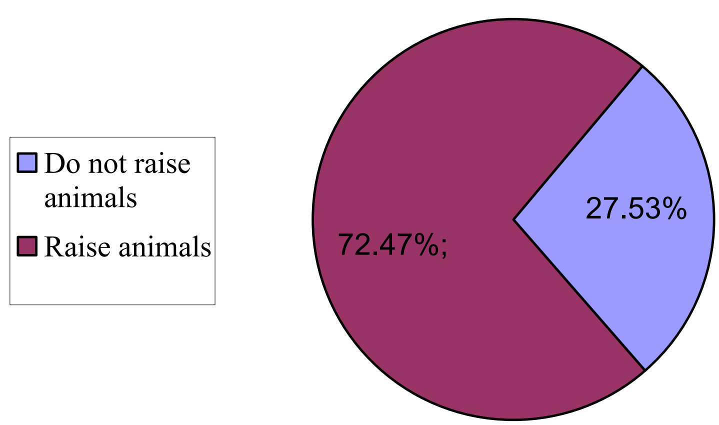


Figure 13 Percentages of families according to raising animals



The computed averages and percentages of the answers for families raise animals about their frequency of using each feed types for feeding their animals are found in the table (5).

Most studies use the percentage 60% [Mattarba, 1998] as standard point for evaluating results, where percentages more than 60% are considered positive results while percentages below 60% are considered negative. The results in table (5) show all feed types are fed to animals in frequent way which is expected because grains and straw are usually fed to adult animals while manufactured feed are used to fed growing animals and to animals that farmer like to increase their weight or productivity of milk. The table shows that straw (with total average 3.40, average percent 84.9%) is used more frequently than grains (total average 3.00, average percent 75.1%), and grains more than manufactured feed (total average 2.79, and average percent 69.7%). This may back to the fact straw cost is less than that of grains and grains cost is less than manufactured feeds cost.

Table 5 Frequency of using animals feed types.

Feed	Grains		Straw		Manufactured Feed	
Animal	Average of reply	Percentage (%)	Average of reply	Percentage (%)	Average of reply	Percentage (%)
Cow	2.94	73.5	3.65	91.2	2.58	64.5
Sheep + Goat	3.56	89.0	3.14	78.5	2.72	68.0
Chicken	2.51	62.7	-	-	3.06	76.5
Total Average	3.00	75.1	3.40*	84.9*	2.79	69.7

[Maximum range and score is 4]
*Total averages for cows, sheep and goat with out including chickens.(calculations in chapter 6)

Ш) – Family Planted Areas:-

The large agricultural activation of Palestinian rural families could be seen through table -1- of appendix (I) which represent the results of PCBS survey for cultivated area in Palestinian territories for 1998/1999, but most of the cultivated area is cultivated with trees (1124015 of 1612013 dunum) especially olives. PCBS results also show most of the cultivated area is rain fed (total area of rain fed crops is 1381158 dunum with percentage of 85.68% from the total cultivated area) which implies government should introduce assistances (financial, information, technical…) to farmers in order to enhance their incomes and so encourage them to cultivate their lands more efficiently, and one of these possible ways is encouraging them to construct biogas plants that could provide farmers with organic fertilizer.

The amount of generated residues and organic wastes from plants depends on many factors as type of crop [Mattocks, 1984], type of cultivation (rain fed, irrigated), fertilizing, climate, cultivated area, type of soil and availability of essential elements for plant growth in the soil. For example; irrigation and fertilizing enhance crops growth and productivity which resulted in more generated crops wastes or residues as straw or leaves, fruit and vegetables skins.

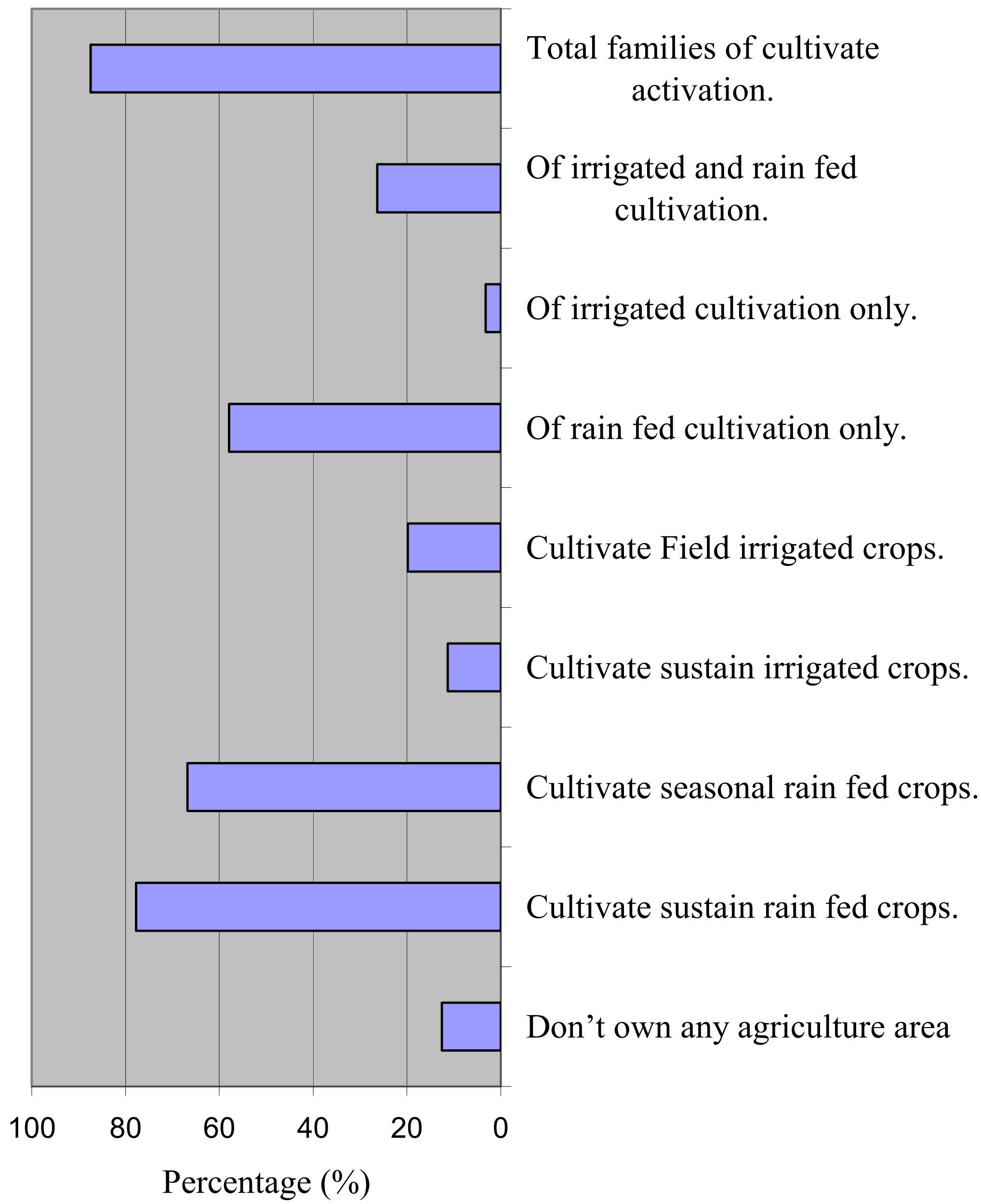
There is no specific relation between the owned area by the family and the amount of generated organic wastes, in addition to the fact most of Palestinian rural families who own sustain crops (especially olive trees) also cultivate other seasonal or irrigated crops (from survey data), so the obtained results from questionnaire were evaluated as in the following table (6).

It appears from table (6) and figure (14) that Palestinian rural society is an agricultural society where most of families (87.45%) have cultivate activities, but with noting more than half of families (57.90% of total surveyed families, 66.20% from families of cultivate activation) depend on rain fed (un irrigating) cultivation only. It is clear sustain (trees) rain fed type comes first then seasonal (especially grains as wheat) rain fed crops, after that field irrigated (mainly vegetables) crops and finally sustain irrigated (as orange) crops. These results could be supported by information in table (3) of appendix Ш.

Table 6 Cultivate activation of Palestinian rural families

Families	Number of Families	Percentage(%) from total families of cultivate activation	Percentage (%) from Total Surveyed Families(247)
Don't own any agriculture area	**31.00**	**-**	**12.55**
Cultivate sustain rain fed crops.	192.0	88.89	77.73
Cultivate seasonal rain fed crops.	165.0	76.39	66.80
Cultivate sustain irrigated crops.	28.00	12.96	11.34
Cultivate Field irrigated crops.	49.00	22.69	19.84
Of rain fed cultivation only.	143.0	66.20	57.90
Of irrigated cultivation only.	8.000	3.704	3.240
Of irrigated and rain fed cultivation.	65.00	30.09	26.32
Total families of cultivate activation.	**216.0**	**100.0**	**87.45**

Figure 14 Cultivate activation of Palestinian rural families



IV) – Energy Sources and Consumption:-

The main energy sources {table (7) below- results of survey data} for Palestinian rural families are natural gas and electricity. 98.78% of rural families use natural gas with a monthly cost average (11.07) Jordan Diner – JD- {which is a price of about two gas cylinders of 12Kg capacity} per family and (1.62 JD) per capita. 97.98% of rural families are connected to electricity with an average monthly cost of (25.06 JD) per family.

More than one third (36.03%) of rural families use liquid fuel (gasoline, diesel and kerosene).Other sources are used by small number of families as coal, fire wood and animal dung which are mainly obtained without cost.

Table (7) data shows the average monthly energy cost (total) for Palestinian rural family is (45.97 JD) which an important money amount with respect to the rural family income especially at ambient political conditions where job opportunities decreased and the unemployment distributed. This reflect the need for finding cheep sources of energy and a new job opportunities which shows the importance of encouraging rural families for constructing biogas plants.

According to the surveyed people, the electricity is mainly used for lighting and operating electrical devices as televisions, washing machines, water pumps and coolers. Natural gas is used for cooking, house and water warming in winter months while some people point to gas using for bread making. For liquid fuel, it is used mainly for tractors, cars, water pumps and little point to its using for heating. Families use fire wood mainly for cooking, boiling water, heating in winter and some families use it for bread making. While coal used mainly for heating and animals dung for bread making by taboon.

Table 7 Energy sources and monthly consumption of rural families.

Energy Source	No. of families with their percentage from total surveyed families (247)			Total monthly consumption for all families (JD)	Monthly Average Consumption (JD)			
					Per Family		Per Capita	
	Did not use	Use without cost	Use with cost		*average	Sd.	**average	Sd.
Electricity	5.000 2.02%	-	242.0 97.9%	6190	25.06	9.57	3.660	1.41
Natural Gas	3.000 1.22%	-	244.0 98.7%	2735	11.07	4.86	1.620	0.71
Liquid Fuel	158.0 63.9%	-	89.00 36.0%	2182	8.830	4.82	1.290	0.70
Coal	203.0 82.1%	23.00 9.31%	21.00 8.50%	88.39	0.358	0.51	0.052	0.04
Fire Wood	197.0 79.7%	38.00 15.4 %	12.00 4.860%	160.5	0.650	0.47	0.095	0.02
Animal Dung	228.0 92.3%	19.00 7.69%	-	-	-	-	-	-
Total				**11355.49**	**45.97**	**20.2 total**	**6.711**	**2.880 total**

Where: - JD: Jordan diner and Sd.: Standard deviation.
*Average = total consumption / 247 where 247 is the total number of surveyed families.
** Average = total consumption / 1690 where 1690 is the total number of surveyed families members.

V) – Organic Wastes Disposal Methods:-

A:- Animals Dung:- The calculated averages and percentages of families replies (calculations are found in chapter 6) about the ways they follow to dispose off or treat their animals dung are found in the following table (table 8) with their rank or order. The averages and percentages are calculated in order to rank the disposal ways from the most followed disposal way by rural families (rank 1) to the least followed way.

Collecting animals dung in especial place for later disposing (from table 8 below) is the most followed way (71.2%, Rank 1) by rural families which emphasized by the second statement (collected to be through in the field, percentage 66.4%, and rank 2). These ways lead to the accumulation of animal's dung resulted in increasing of wastes negative impacts such as bad odors, distribution of disease causing and victors which was observed from the founded situation in rural areas during the visits to rural communities and through doing the experiment where it was observed the odor of organic wastes before loading it into the digesters (before digestion) was greater than its odor after removing it from the digesters (after finishing the experiment – after complete digestion).

Distributing dung without fermentation is not the best way since using fermented dung gives better results for crops production in shorter time [British Biogen and At-Information websites].

The other ways are used or followed rarely by farmers since all these ways with percentages less than 34%.

Table 8 Animals dung treatment and disposal ways**.**

No.	Statements	*Average of reply	Percentage (%)	**Rank**
1-	Collected in especial place to be disposed off later.	2.85	71.2	**1**
2-	Collected to be through in the field (without fermentation).	2.66	66.4	**2**
3-	Fermented for using as an organic crops fertilizer.	1.28	32.0	**4**
4-	Burned to get energy (taboon for example)	1.34	33.4	**3**
5-	Burned as a disposal method.	1.24	31.0	**5**
6-	Collected for sale.	1.01	25.3	**6**
7-	Fermented for biogas production.	0.02	0.56	**7**
8-	Other ways------------------------- (No answers mentioned)	-	-	-

*** Maximum range and score is 4.
* calculation method found in chapter 6

B- Planting Wastes Fate:-

Most rural families (see table 9) feed the generated plants waste and crops residues to their animals (average reply 2.83 of 70.8%, rank 1; for calculations see chapter 6). This followed way emphasized by statement number 6 (straw made bales, with 56% percentage, rank 3).

For wood (trees wastes); it is mainly burned by families (rank 2) to get energy for heating, boiling water and bread making. The other methods for crops residues disposal are of little or rare use (all of percentage less than 39%, their percentages and rank are found in table 9).

The result most of crops waste is used in a good way. Remain amounts of the waste that disposed off wrongly could be collected and fed once or twice a year into biogas digester, if the family construct a biogas plant.

Table 9 Planting wastes and residues fate

No	Statement	Average	Percentage	Rank
1-	Fed to animals (straw and leaves).	2.83	70.8	1
2-	Burned in the field.	1.54	38.4	4
3-	Remains in the field ground.	1.09	27.3	7
4-	Removed to the field bounders.	1.43	35.7	5
5-	Wood burned to get energy.	2.61	65.3	2
6-	Straw made bales.	2.24	56.0	3
7-	Fermented to produce biogas and/ or organic fertilizers.	0.00	0.00	9
8-	Disposed off with animals wastes.	1.26	31.5	6
9-	Other ways-----------(straw grinded for animals feed)	0.37	9.30	8
*** Maximum range and score is 4; Calculations found in chapter 6				

C- Domestic Wastes Fate:-

Tables (10 and 11) show the ways followed by rural families for disposing their domestic wastes (table 10) and wastewater (table 11) with its averages, percentages and rank.

From table (10); it appears the main followed way for disposing solid domestic wastes is by disposing it into general disposal containers (percentage 75.8%), then the disposing of wastes in especial place near house (percentage 36.0%). Other methods are followed by small number of families or rarely followed.

Table 10 Family domestic waste fate.

No. in survey	Statement	Average	Percentage (%)	Rank
1-	Disposing solid domestic wastes in general containers.	3.03	75.8	1
2-	Disposing solid domestic wastes on animals wastes disposal place	0.985	24.6	3
3-	Feeding organic domestic waste to animals.	0.864	21.6	5
4-	Fermenting organic wastes to get biogas and/ or fertilizers.	0.170	4.17	6
5-	Disposed off in especial place near home.	1.44	36.0	2
6-	Distributed in the planting areas.	0.879	22.0	4
Max. Range and score is 4; Calculations in chapter 6				

Table 11 Family wastewater fate

No. in survey	Statement	Average	Percentag e (%)	Rank
7-	Wastewater drained off to the cess pits.	3.56	89.0	1
8-	Wastewater drained off on the earth surface.	0.364	9.10	3
9-	Wastewater drained off into near home valley or water stream.	0.273	6.82	5
10-	Using wastewater for irrigating home plants.	0.576	14.4	2
11-	Draining wastewater into general disposing net.	0.348	8.71	4
Max. Range and score is 4; Calculations in chapter 6				

It appears from table (11) above that most of rural families dispose their home wastewater into cess pits (percentage 89%) with much less following for other ways. Disposing wastewater into cess pits contaminate soil and ground water which impact negatively on human, animals and plants life.

7.1.2:- Part Two Results: - General indications and farmers opinion

As seen in the field survey (Appendix Ш), this part consist of two subparts: - general indications and farmers opinion toward wastes issues and applying biogas technology. The following tables summarize the results for each subpart.

I) – General Indications.

The concentration is on evaluating two main subjects: - suffering of rural families from negative impacts of organic wastes and studying some of farmers' behaviors.

A) - Suffering of rural families from negative impacts of organic wastes:-

The replies averages of asked rural people on each statement of this subject (statements are: 1, 2, 3, 4, 5, 11, 14, 16 of table -8- of the survey) with their percentages are calculated (chapter 6) and the results summarized in the following table (12).

The computed results show rural families mainly suffer from the bad smell of accumulated solid wastes (average 3.69, percentage 92.3%), then from distribution of rodents, flies and insects (average 3.16, percentage 79.0%). And suffer from smell of wastewater (average 3.07, percentage 76.7%), unavailability and bad governmental services (average 2.93, percentage 73.3%).While rural families suffering from taboon smoke, neighbour animal farms and repeated diseases in family members is low where the percentages of replies are less than 50%.

For suffering from governmental services, they could be ranged as follows (from the highest suffering to less):- roads (this mainly return to ambient political conditions), water and financial help, agricultural advertising, solid waste disposal, wastewater disposal, health services, electricity and finally education services.

The net result point the rural families suffer from the negative impacts of organic wastes (average 2.41, percentage 60.3%).

Table 12 Suffering of rural families from negative impacts of wastes and governmental services.

No. in survey	No.	statement		Average	Percentage (%)	Result*
1-	1	Suffering from rodents, flies, snakes, insects…ect		3.16	79.0	+
2-	2	Suffering from bad smell of accumulated solid wastes.		3.69	92.3	+
3-	3	Suffering from smell of wastewater.		3.07	76.7	+
4-	4	Suffering from taboon smoke.		1.42	35.5	-
5-	5	Suffering from neighbors farms		1.89	47.3	-
11-	6	Suffering from repeated diseases in my family members.		1.75	43.8	-
14-	7	Neighbour complain to you from your animals farm impacts		1.39	34.8	-
16-	8	Suffering from unavailability or bad governmental services	a- electricity	1.86	46.5	-
			b- water	3.31	82.8	+
			c- agricultural advertising	3.25	81.3	+
			d- roads	3.63	90.8	+
			e-finance help	3.30	82.8	+
			f-wastewater disposal	3.11	77.8	+
			g-solid waste disposal	3.21	80.3	+
			h-health services	2.97	74.3	+
			i-education	1.74	43.4	-
		Average for statement 16		*2.93*	*73.3*	+
Average for all statements				**2.41**	**60.3**	**+**

Max. Range and score is 4, Calculations as in previous tables.
*(+) result means family suffers from negative impact while (-) result means family did not suffer from the subject of statement.

B) – Some of farmers practices:-

The studied practices are: - grazing animals on plants grow on organic wastes, using of manufactured fertilizers, using of chemical drugs and treatments, frequency of cleaning animals farm and wearing of farmer for safety clothes when using toxic materials. These issues are expressed by the statements (6, 7, 8, 9, 10, 12, 13, and 15) found in table -11- of the questionnaire.

The calculated averages and percentages in table (13) show that farmers usually use manufactured fertilizers, insecticides, herbicides and animal and plants drug (all with percentages more than 62% - for statements 3,4,5 and 6). This emphasizes the farmers suffering from negative impacts of wastes.

The results in table (13) show most of farmers did not grazing their animals on plants that grown on wastes. The same table shows most of farmers did not wear safety clothes when they are using animals and plants drugs which reflect the need for more efforts to raise farmer awareness to such issues.

Table 13 Some of farmers practices.

No in survey	No	statement	Average*	Percentage	Result***
6-	1	Grazing my animals on plants grow on solid disposal place.	1.38	34.5	-
7-	2	Grazing my animals on plants grow on wastewater stream sides.	1.41	35.3	-
8-	3	Using manufactured fertilizers to enhance my crops production	2.96	74.0	+
9-	4	Using insecticides, herbicides,… for enhancing crops production	2.53	63.3	+
10-	5	Using animals' drugs for animals' treatment.	2.71	67.7	+
12-	6	Using drugs to reduce or kill insects, rodents, flies….	2.48	62.0	+
15-	7	Wearing protecting clothes when using animals and plants drugs and treatments.	1.67	41.8	-

*** (+) means the practice usually done while (-) refers to rare practice.
* Max. Range and score is 4. Calculations as in chapter 6

Ц) – Farmer opinion toward wastes issues and his acceptability for applying biogas technology.

A- Farmer Opinion:-

The calculated averages percentages for the statements about the opinion of farmers toward wastes issues for evaluating their environmental awareness with its indications are summarized in the below table (14). The results show a farmer positive opinion toward most of the issues that concerned with impacts of wastes in constructed statements where the results are positive (more than 60%) for 12 statements {which are of numbers :- 1,2,3,4,6,7,10,12,13,14,16 and 17} of 17. The net result is positive with average score (2.61) and average percentage (65.2%).

The positive direction of farmer opinion could be developed and used for raising farmers' acceptability to construct biogas plant.

B- Farmer acceptability for biogas technology.

For evaluating the acceptability of rural families to construct biogas plants, the averages and percentages of farmers' replies on the subject statements (17, 18, 19 and 20 of table-9- of the survey) are calculated and the results summarized in table (15).

The result for acceptability of farmers to constructing biogas plants and using biogas instead of natural gas is positive with average score (2.63) and average percent (65.8) with noting the raise of this acceptability in the case of getting a financial help {table (15)}.

Table 14 Farmer environmental awareness toward wastes impacts.

No. in the survey	No	Statement	Direction of statement	Average*	Percentage (%)	Result**
1-	1-	Accumulating wastes pollutes soil and water environments.	+	3.07	76.8	+
2-	2-	Burning wastes and crops residues pollute air environment.	+	2.69	67.2	+
3-	3-	Accumulating and wrong disposal and treatment of wastes increase distribution of flies, rodents…	+	3.34	83.6	+
4-	4-	Flies, rodents… are considered diseases causing or / and disease victors.	+	2.98	74.6	+
5-	5-	Un isolated cess pits causes pollution to the ground water in additional to soil.	+	2.25	56.2	-
6-	6-	Polluting soil, water and air impacts negatively human health.	+	2.46	61.6	+
7-	7-	Wastes accumulation and wrong disposal cause negative impacts on human body and physical health.	+	2.58	64.6	+
8-	8-	Irrigating crops with wastewater causes diseases for consumer health.	+	2.23	55.8	-
9-	9-	Feel disturbed when I see accumulated waste.	+	1.97	49.2	-
10-	10	Cleaning animal farm within short periods impacts positively human life and animal health.	+	2.82	70.4	+
11-	11	Using manufactured fertilizers (for crops and animals) impacts positively consumer health.	-	2.14	53.6	-
12-	12	Grazing animal's plants growing on wastes will negatively impacts human and animal health.	+	2.51	62.8	+
13-	13	Un fermented organic waste as a fertilizer is better than the	-	2.41	60.2	+

		fermented waste.				

Table 14 Continues …

14-	14	Using animals and plant drugs enhance their production.	+	3.42	85.4	+
15-	15	Using animals and plants drugs improve human health.	-	1.84	46.0	-
16-	16	Applying biogas technology reduces the volume of the wastes to be disposed off.	+	2.55	63.8	+
21-	17	Feel disturbed from smelling wastes odors.	+	3.06	76.4	+
Average				**2.61**	**65.2**	**+**

* Max. Range and score is 4.
** (+) means positive result, while (-) means negative result toward waste issue.

Table 15 Farmers acceptability for applying biogas technology.

No. in the survey	No.	Statement	Direction of statement	Average*	Percentage (%)	Result***
17-	1-	I will apply biogas technology, if its economic is feasible.	+	2.38	59.4	-
18-	2-	I will construct a biogas plant, if I get a financial help.	+	2.94	73.6	+
19-	3-	I will use biogas instead of natural gas, if it is of less cost.	+	2.73	68.2	+
20-	4-	If you don't raise animals, are you ready to raise animals if biogas plants applied and give good economic results?	+	2.48	62.0	+
Average				**2.63**	**65.8**	**+**

* Max. Range and score is 4. *** (+) means the statement is acceptable and (-) refers to farmer un acceptability.

7.1.3:- Part Three Results: - Different questions

I)-Farmer knowledge about biogas technology and anaerobic fermentation process:-

The following table (16) shows the results and evaluation for the farmers knowledge about biogas technology and anaerobic fermentation process before the visit and explaining these issues to them. The results in the table indicate most of farmers (80.2%) know nothing about biogas technology, while their knowledge about anaerobic fermentation for organic materials was better but with a low average percent (50.7%). The net result for both (knowledge about biogas technology and anaerobic fermentation) is negative which implies more efforts should be done to raise farmers knowledge toward such projects and its benefits.

Table16 Farmer knowledge about biogas technology and anaerobic digestion process.

Question number	Subject	Reply Choices								Average Of Reply	Percentage (%)	Result**
		much		something		little		nothing				
		No. of answers	percentage	No. of answers	percentage	No. of answers	percentage	No. of answers	percentage			
1	Biogas Technology	5.0	2.0	18	7.3	26	10.5	198	80.2	0.1	3.50	-
2	Anaerobic Fermentation	42	17	79	32	92	37.3	34	13.8	1.5	50.7	-

Max. range for average and score is 3.
** (-) means negative result.

Ц) – Cess pits:-

A-The results of rural people answers on questions (3 and 4) of the field survey are found in the following table (17). The results indicate most of rural families (96.76%) dispose their wastewater into cess pits. This result supported by the families answers on statement 7 (average answers percentage 89.0%) of table (11) which refers to the stability of the survey. Most of cess pits (69.46%) are not internally isolated from their surroundings which indicate to the large contamination of soil and ground water through sealing of cess pits contents.

Constructing biogas plants will be a good solution not only for disposing wastewater but also for obtaining biogas, organic fertilizer and decreasing the soil and ground water contamination.

Table 17 foundation of cess pits for family waste water disposal.

cess pits	Found	Not Found	Isolated	Un isolated
No. of Families	239.0	8.00	73.00	166.0
Percentage	96.76%	3.24%	30.54%	69.46%

B- The results of rural people answers on question (5) of the field survey are summarized in table (18) below.

Table 18 Thought of rural people about sealing of cess pit contents into its surrounding soil.

Choice	Yes	May be	No	Total
No. of answers	99.00	136.0	12.00	247.0
Percentage	40.08%	55.06%	4.860%	100.0%

Table (18) shows 55.06% of rural people thought cess pits contents seal into surrounding soil, 40.08% are sure and 4.86% of them do not think so. These results support the positive results obtained for farmers opinion toward impacts of organic wastes (table 14).

C- Table (19) contains the results of rural people answers on question (6) of the field survey which is about withdrawing of the absorption pit contents with time.

Table 19 Cess pits content withdrawing with time.

Choice (With in)	6 months	One year	Two years	Three years or more	Total
No. of answers	17.00	77.00	48.00	97.00	239.0
Percentage	7.113 %	32.22%	20.08%	40.59%	100.0%

The calculated percentages in table (19) emphasize most of cess pits are not isolated. Most of cess pits in rural areas filled after two years or more of using (20.08% after two years and 40.59% after three years or more). This also indicates most of cess pit contents seal to its surrounding soil and so to a wrong disposal method.

Ш) - Distance between families homes and wastes disposal places.

The negative effects of wastes on family life increase with decreasing of the distance between home and wastes disposal place. The results in table (20) show the distance between family home and wastes disposal place is less than 50 meters (with average 22.73 meter) for 44.13% of rural families while 36.44% of rural families are far from disposal place by 151 meter or more. The results point to the suffering of rural families from negative impacts of wastes accumulation.

Table 20 Distance between family home and the nearest wastes disposal place.

Distance Intervals (meter)	Average Distance (meter)	No. of Families	Percentage of families
1 - 50	22.73	109.0	44.13%
51 - 100	81.55	27.00	10.93%
101 - 150	136.8	21.00	8.502%
151 and more	1483	90.00	36.44%
Total		247.0	100.0%

IV) - Frequency of cleaning animals farms

Table (21) summarizes the results for question (8) of the field survey:-

Table 21 Frequency of family cleaning for its animal's farm.

Cleaning once within (days)	No. of Families do that	Percent of families from families that raise animals
1 - 7	127	70.9%
8 - 14	18.0	10.1%
15 - 21	10.0	5.59%
22 - 28	5.00	2.79%
29 and more	19.0	10.6%
Total	179	100%

This table shows most families (70.9%) remove or clean their animals farms once or more with in a week which is a positive behavior, but most of the dung accumulated near the animal farm (see the result of statement -1- in table 8). The result means biogas plants should be constructed. Continuous farm cleaning mean the ability of providing biogas digester with dung in short times and prevent waste accumulation.

Families that clean their farms after long time are usually families whom raise large number of animals especially poultry, where these animals (poultry) are usually raised periodically and so cleaning is done after finishing each animals period.

V) - Problems faces rural families in disposing wastes:-

The problems face rural families in disposing their animals waste, plants residues, wastewater and domestic wastes are summarized in the following points:-

1- Transporting wastes after cleaning animals farm and long distance between family home and wastes containers or disposing place.

2- Difficulty of farms wastes removing in winter season.

3- Late of wastes collecting truck which cause over filling of wastes containers (accumulation of wastes) and so distribution of bad odors and insects.

4- Unavailability of enough number from wastes containers.

5- Unavailability of wastewater disposing net.

6- Some families complain from unavailability of vacuum tank when cess pit filled and from bad odors distributed when the cess pit contents emptying.

7- Some rural families complain from neighbour animal farms (odors, distribution of rats and flies).

Above problems indicates to the suffering of rural families in disposing off wastes and this emphasize the opinion about negative impacts of wastes on rural families life.

Many surveyed families (especially those whom raise animals on commercial scale) were asked for more information about biogas producing process and its costs, and about the uses and benefits of the biogas. Some educated persons were asked for increasing farmers awareness about biogas technology and its benefits.

7.2- Experiment Results and Discussion

The experiment was started at 25/10/2003 and finished at 25/12/2003, that is, the retention time was 60 days. The daily maximum and minimum temperatures were recorded and the pH values for each sample were measured. The weights of produced biogas from each sample were measured. Below tables and discussion describe the results.

7.2.1- Temperature

The night minimum and the day maximum temperatures were recorded every day during the digestion process by a maximum – minimum thermometer. The recorded temperatures are found in table (22) below. The night minimum temperatures were ranged between 9 and 19C° with an average temperature 12.03C°, while maximum temperatures were ranged between 16 and 35C° with an average maximum temperature 25.4C°.

The anaerobic digestion affected negatively with temperature changes and so the quantity of the produced biogas because methanogenes bacteria activation decreases with temperature variations [FAO/CMS, 1996]. The biogas productivity of the tested samples will be better if the experiment done at stable temperature.

Table 22 Daily maximum and night minimum temperatures during the experiment days.

Day	Min. Temp.	Max. Temp.	Day	Min. Temp.	Max. Temp.
1.00	18.5	36.0	31.0	11.5	28.0
2.00	19.0	34.0	32.0	13.0	26.5
3.00	19.0	33.5	33.0	12.0	29.0
4.00	18.0	30.5	34.0	13.5	27.5
5.00	17.5	27.0	35.0	11.0	25.0
6.00	16.0	24.0	36.0	10.0	23.5
7.00	14.5	21.0	37.0	10.5	22.0
8.00	17.5	30.0	38.0	9.00	23.0
9.00	13.5	32.0	39.0	11.0	19.5
10.0	13.0	32.0	40.0	10.5	18.0
11.0	11.0	31.0	41.0	10.5	20.5
12.0	11.0	34.0	42.0	12.0	18.0
13.0	11.0	33.0	43.0	10.0	16.5
14.0	11.5	35.0	44.0	10.5	16.0
15.0	11.5	34.0	45.0	9.00	18.0
16.0	12.0	32.0	46.0	9.50	18.5
17.0	11.5	33.0	47.0	9.00	17.0
18.0	14.0	33.5	48.0	10.0	18.5
19.0	12.0	30.0	49.0	10.0	20.5
20.0	11.0	29.0	50.0	12.5	23.0
21.0	12.0	28.0	51.0	14.0	21.0
22.0	13.5	28.5	52.0	11.0	22.5
23.0	10.0	28.0	53.0	12.5	20.5
24.0	11.0	30.0	54.0	10.5	22.0
25.0	12.0	29.0	55.0	13.0	19.5
26.0	10.5	25.5	56.0	11.5	19.0
27.0	10.0	26.0	57.0	10.0	17.0
28.0	10.5	26.0	58.0	9.00	18.0
29.0	11.0	26.5	59.0	10.0	20.5
30.0	12.0	27.0	60.0	9.50	19.0
			Average	**12.03**	**25.4**

Standard deviation	**2.53**	**5.72**

7.2.2- pH – Values

The initial pH values (at samples loading time) were ranged between 6.52 and 8.12. the lowest value was for sample in barrel 8 –B8- (table 23) which consists from food residues only and the highest value for sample in barrel 10 that consists of wheat straw only. Increasing the ratio of food residues in the sample (first row of table 23) lowers its pH value, since food residues contain large amount of vegetables and fruits wastes which contain organic acids.

The pH values {table (23) and figures (15+16)} were dropped (acidity increases) gradually in the first days of the digestion process and reach below 6 for all samples except samples in B5 and B17 which its pH values fall below 5. Then pH values were rise gradually to reach more than 7 at the last days (where pH values stabilized) of the digestion process for all samples.

The fallen in pH values at the beginning of the experiment return to the fact that the first step in the anaerobic digestion is the converting of organic materials by acidogenes into acids which converted after that by methanogenes into biogas and so raising the pH values [Schomaker and others, 2000; FAO/CMS, 1996].

Table 23 pH Values For Each Sample with Time

Day	pH – Value for Samples									
	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
1	6.89	6.76	7.38	6.63	6.60	7.40	7.61	6.52	7.82	8.12
3	6.51	6.15	6.94	6.11	6.01	6.99	7.11	6.21	7.02	7.71
6	6.28	5.63	6.78	5.86	5.72	6.55	6.67	6.18	6.46	7.23
9	5.82	5.21	6.49	5.53	5.58	6.00	6.51	6.23	6.24	6.59
12	5.35	5.13	6.37	5.58	5.31	5.83	6.56	6.31	6.20	6.17
15	5.14	5.02	6.23	5.40	4.95	5.76	6.53	6.42	6.17	5.92
18	5.12	5.18	6.09	5.26	4.86	5.47	6.60	6.51	6.19	5.87
21	5.28	5.24	5.93	5.00	4.74	5.37	6.73	6.82	6.45	5.81
24	5.53	5.66	5.85	5.13	4.71	5.30	6.81	7.09	6.53	5.70
27	5.88	6.03	5.97	5.39	4.71	5.37	6.95	7.13	6.78	5.83
30	6.37	6.58	6.27	5.62	4.65	5.43	7.18	7.10	6.95	5.96
33	6.71	6.63	6.51	5.57	4.79	5.52	7.19	7.17	7.06	6.35
36	7.01	6.82	6.73	5.60	5.03	5.85	7.24	7.21	7.19	6.68
39	7.25	7.17	6.99	5.73	5.36	6.07	7.33	7.21	7.25	6.96
42	7.30	7.22	7.27	5.96	5.50	6.48	7.31	7.23	7.36	7.27
45	7.28	7.25	7.33	6.29	5.61	6.70	7.46	7.21	7.41	7.53
48	7.36	7.39	7.46	6.51	5.94	6.92	7.52	7.25	7.48	7.68
51	7.32	7.41	7.56	6.70	6.21	7.11	7.50	7.22	7.54	7.75
54	7.27	7.43	7.51	6.96	6.58	7.19	7.61	7.23	7.59	7.81
57	7.23	7.41	7.54	7.07	6.88	7.25	7.58	7.21	7.61	7.82
60	7.25	7.41	7.58	7.04	7.00	7.39	7.59	7.23	7.68	7.85

Table 23 … continues

Day	pH – Value for Samples									
	B11	B12	B13	B14	B15	B16	B17	B18	D1	D2
1	7.96	7.29	7.13	6.73	7.16	6.95	7.03	6.85	6.92	7.04
3	7.38	6.72	6.68	6.35	6.50	6.41	6.56	6.50	5.94	6.17
6	6.85	6.50	6.01	5.91	5.97	6.12	6.23	6.31	5.37	6.04
9	6.47	6.31	5.97	5.78	5.91	5.88	6.12	5.81	5.39	5.83
12	6.01	6.25	5.73	5.74	5.96	5.90	5.15	5.37	5.46	5.79
15	5.83	6.14	5.86	5.69	6.05	5.91	5.05	5.18	5.37	5.82
18	5.74	6.03	5.83	5.58	6.27	5.78	4.92	5.10	5.44	5.85
21	5.69	5.92	5.90	5.51	6.45	5.98	5.09	5.23	5.70	5.93
24	5.62	5.89	6.15	5.49	6.81	5.83	5.26	5.46	5.92	5.87
27	5.60	6.05	6.37	5.62	6.78	5.71	5.18	5.78	6.27	5.96
30	5.58	6.27	6.54	5.89	6.93	5.92	5.25	6.31	6.14	6.01
33	5.61	6.41	6.55	6.04	7.00	6.18	5.39	6.57	6.29	6.06
36	5.76	6.76	6.69	6.15	7.20	6.15	5.57	6.89	6.57	6.00
39	5.93	6.91	6.80	6.20	7.29	6.34	5.86	7.03	6.61	6.13
42	6.13	7.08	7.02	6.41	7.36	6.57	5.95	7.15	6.79	6.34
45	6.48	7.26	7.11	6.63	7.40	6.84	6.32	7.19	7.13	6.65
48	6.89	7.31	7.16	6.70	7.46	7.01	6.79	7.20	7.28	6.70
51	7.23	7.30	7.28	6.99	7.43	7.15	6.72	7.26	7.35	6.89
54	7.52	7.35	7.27	7.05	7.51	7.13	6.86	7.25	7.42	6.94
57	7.60	7.32	7.48	7.16	7.49	7.22	6.97	7.28	7.39	7.03
60	7.65	7.34	7.42	7.19	7.55	7.23	7.00	7.27	7.45	7.29

Because the temperature changes were nearly stable through the experiment time, there was no significant sudden pH drop observed (except some pH - fluctuations for some samples {B4, B6, B17, D1} in the period between ~16- 30 day of the digestion process), since methanogenic bacteria are sensitive for temperature changes where its activation increases (converting of acids to methane increases and so the pH value of digester content decreased) with increasing the temperature of digester while its activation decreases (converting acids into methane decreases which lead to accumulation of acids and so the pH value rises) if the temperature decreased [FAO/CMS, 1996]. This refers to the approximate stability of microorganisms inside the digesters which could be concluded from figures 15 and 16.

Figure 15 pH changes with time for samples from B1 to B10

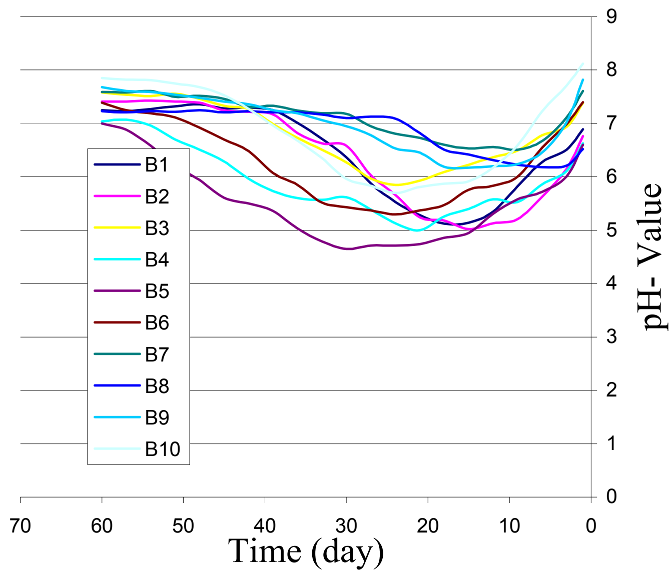
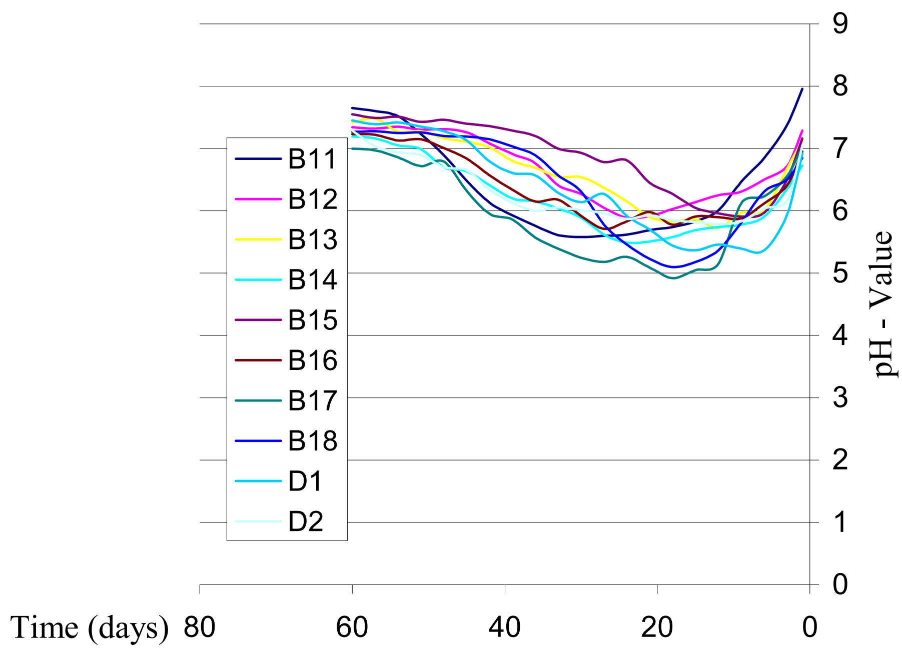


Figure 16 pH changes with time for samples from B11 to B18 and D1, D2



7.2.3- Samples biogas productivity

All samples produce biogas of weight in between (37.2 g) and (67.3g) per each kilogram waste (table 24). All samples reach their maximum productivity within a time interval 24 – 36 days from the beginning of the experiment (table 24, and figures 17, 18, 19, 20 and 21).

Depending on the results of table (24), the following issues will be evaluated and discussed: - effect of waste types on biogas production from mixed samples (B1 to B9), effect of animal dung type, effect of dilution, effect of enlargement and finally effect of stirring.

Table 24 Weights of produced biogas from each sample with time.

Day	Weight of withdrawn biogas for Samples (gram).									
	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
3	2.50	1.00	2.00	0.50	2.50	4.50	3.50	6.00	-	1.50
6	5.00	4.00	2.50	3.50	2.50	5.50	5.00	8.50	1.50	4.00
9	6.50	9.50	5.00	4.50	4.00	8.50	10.5	13.0	2.00	4.50
12	11.5	14.0	8.50	6.00	10.0	9.00	16.5	25.0	3.50	7.50
15	18.0	15.5	11.0	7.00	17.5	21.0	29.0	46.5	5.50	10.0
18	24.5	26.5	20.0	9.50	22.0	18.5	50.5	63.0	13.0	16.5
21	34.5	37.5	32.5	16.0	35.5	26.0	67.0	82.5	24.5	28.5
24	43.0	50.5	49.0	35.5	46.5	32.5	88.0	90.5	46.0	51.5
27	69.5	74.0	66.5	50.5	68.0	41.0	92.5	86.0	52.0	72.0
30	92.0	74.0	84.5	62.5	73.5	59.0	83.5	80.0	55.5	68.5
33	81.0	68.5	70.5	73.0	71.0	84.5	75.5	68.0	57.5	67.0
36	63.5	69.0	62.0	80.5	72.0	80.5	62.0	53.0	54.0	56.0

39	38.0	61.5	41.5	65.0	64.5	78.5	45.0	50.5	42.5	39.5
42	30.0	49.5	28.5	44.0	33.0	60.0	36.5	42.0	35.0	25.0
45	19.0	30.0	25.5	28.0	20.0	37.5	25.0	31.5	22.0	27.5
48	6.50	12.5	18.5	13.0	10.5	15.0	14.5	20.0	16.0	21.5
51	3.50	1.50	9.00	4.50	6.00	7.50	6.50	13.0	10.5	17.0
54	2.00	0.00	6.50	1.50	3.50	1.50	2.00	14.0	4.00	11.5
57	1.50	1.00	2.50	1.00	3.00	2.00	0.50	9.50	1.00	6.00
60	0.50	0.00	1.00	1.50	4.50	1.50	0.50	5.00	0.00	2.50
Total	**550**	**600**	**547**	**507.5**	**570**	**594**	**714**	**807.5**	**446**	**538**
Av./Kg	**45.83**	**50.0**	**45.58**	**42.3**	**47.5**	**49.5**	**59.5**	**67.3**	**37.2**	**44.83**

Table 24 Continues….

Day	**Weight of withdrawn biogas for Samples**									
	B11	B12	B13	B14	B15	B16	B17	B18	D1	D2
3	3.50	2.00	2.50	3.00	1.00	1.00	1.50	5.50	23.5	16.5
6	5.50	3.00	5.00	4.50	2.50	3.50	5.00	9.00	45.5	25.5
9	11.0	9.50	11.5	6.00	5.50	8.00	9.50	14.5	98.0	47.5
12	17.5	11.5	18.0	13.5	8.00	12.0	13.0	27.0	153	73.5
15	28.0	18.5	29.0	27.5	15.5	20.5	25.0	42.5	226.5	109
18	49.5	27.0	51.5	44.0	24.0	32.0	41.5	65.5	290	162.5
21	70.5	43.5	75.0	56.5	32.0	48.0	65.0	72.0	374	197.5
24	90.0	54.0	83.0	68.0	45.5	60.5	79.5	89.0	483	235
27	95.0	66.0	97.5	84.0	63.5	73.5	91.0	87.5	597.5	276.5
30	87.5	93.0	79.5	88.5	85.0	86.5	98.5	81.0	574	310
33	78.0	85.0	64.0	89.0	80.5	74.5	86.0	64.0	481.5	337
36	60.5	69.5	39.5	76.0	71.0	63.0	72.0	51.0	376.5	355.5
39	46.5	41.5	28.0	54.0	59.0	40.5	55.0	43.5	258.5	324

42	38.0	19.5	22.0	36.5	43.0	28.5	34.0	39.0	137.5	305.5
45	22.0	13.0	16.0	23.5	20.0	18.0	12.5	25.5	71.0	269.5
48	18.5	9.50	10.5	12.0	6.50	13.0	9.50	15.0	26.5	218.5
51	9.50	8.00	7.00	5.50	4.50	7.50	6.00	10.5	10.5	131
54	2.50	5.00	3.50	1.50	3.00	1.50	4.50	6.50	6.50	62.0
57	1.50	3.50	1.00	0.00	2.50	2.00	2.50	5.00	5.00	19.5
60	2.00	1.50	1.00	1.00	2.50	0.00	2.00	3.50	4.50	13.0
Total	**737**	**584**	**645**	**694.5**	**575**	**594**	**713.5**	**757**	**4243**	**3489**
Av./Kg	**61.4**	**48.7**	**53.8**	**57.9**	**47.9**	**49.5**	**59.5**	**63.1**	**58.93**	**48.46**

Av. :- average.
The deviation for the used digital balance is 0.5 gram.

Figure 17 Biogas production with time for barrels from B1 to B10

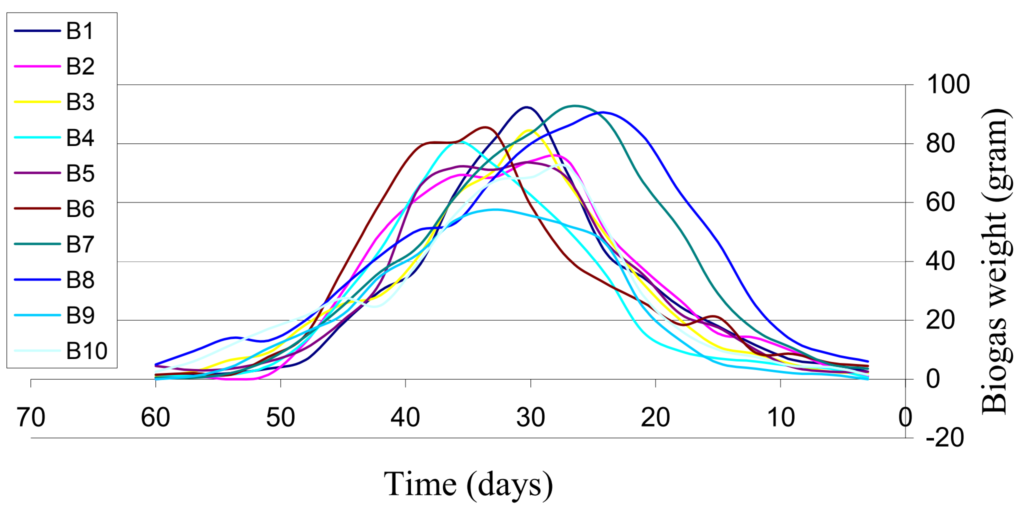


Figure 18 Biogas production with time for barrels from B11 to B18

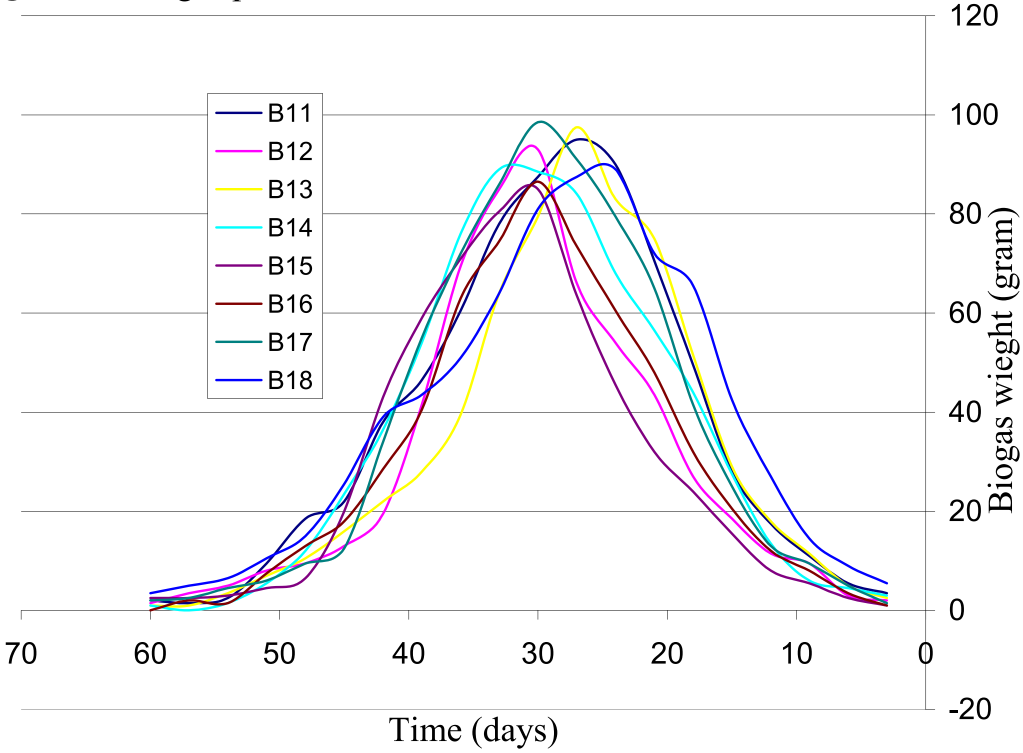


Figure 19 Biogas production with time for D1 and D2

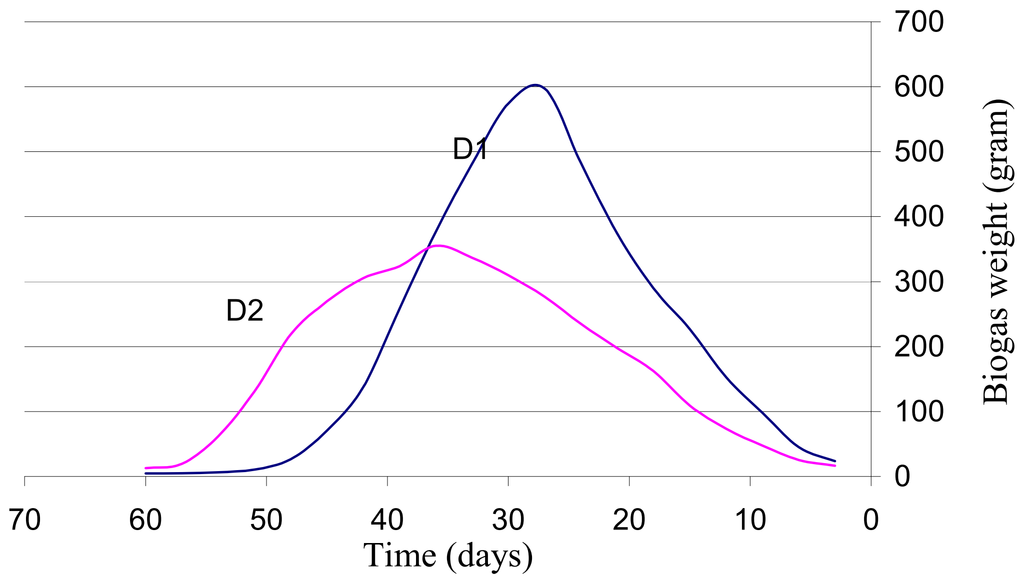


Figure 20 Total biogas weight produced by samples for B1 to B18

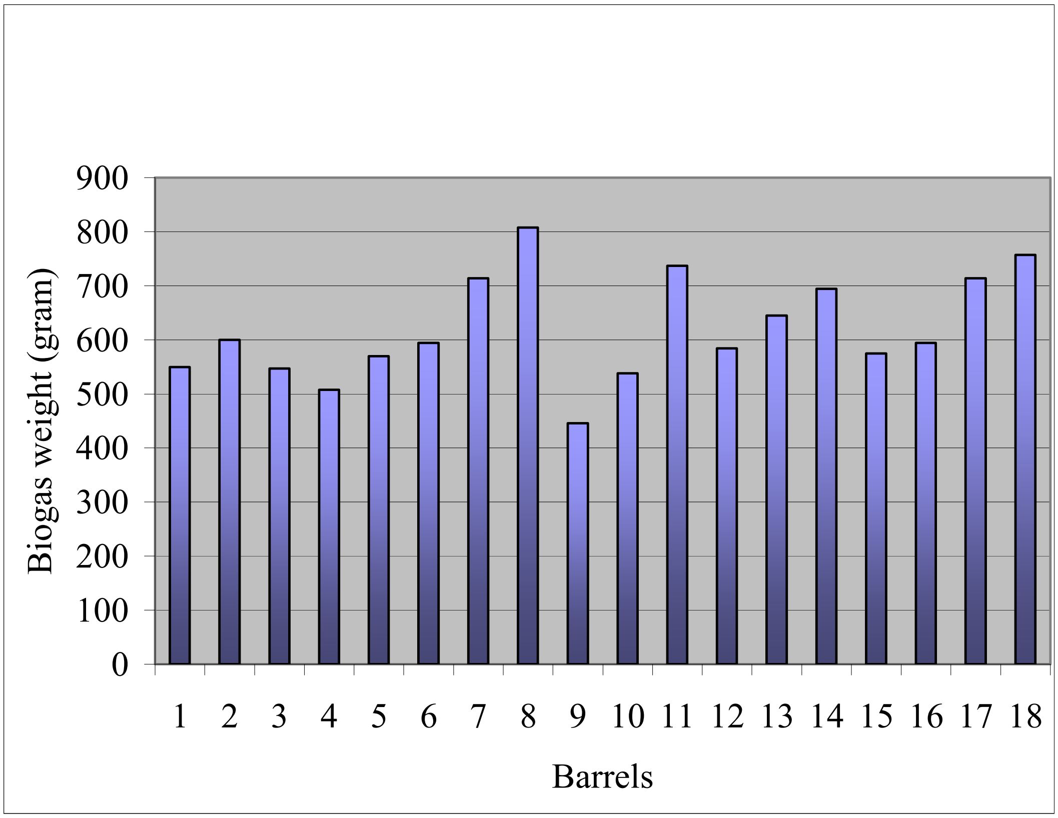
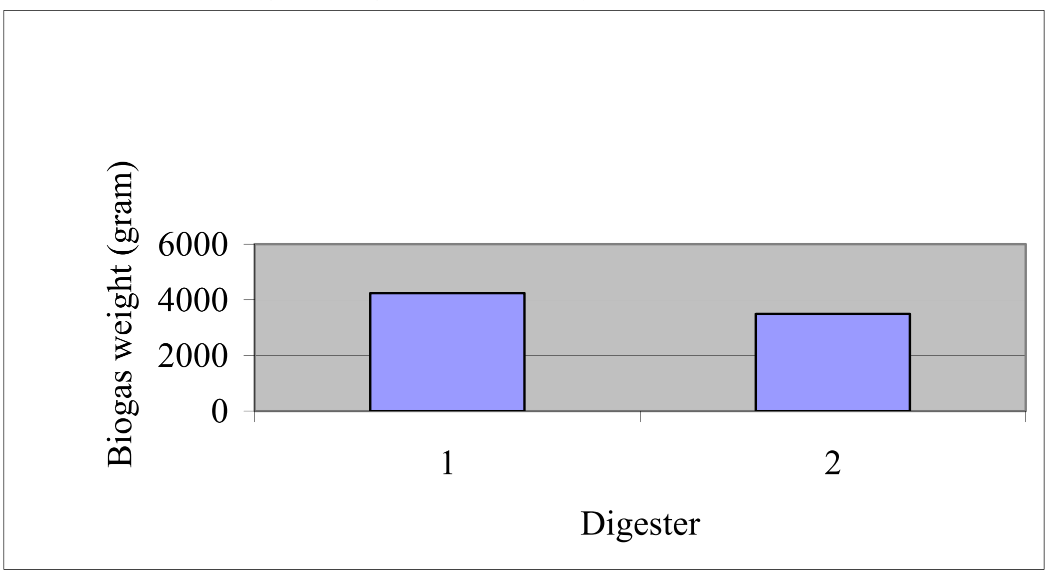


Figure 21 Total biogas weight produced by samples in D1 and D2

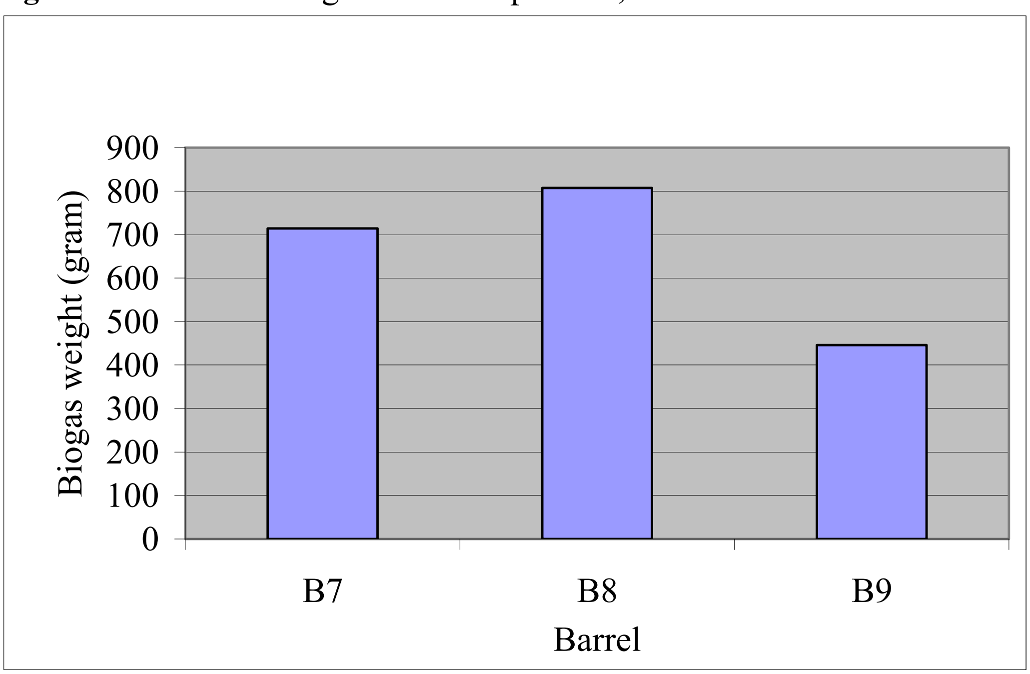


A} - Waste type effect:-

The food residues (alone) produce the biggest quantity of biogas (67.3 g/ kg waste –B8-) with maximum production at shorter time (day24). This may return to the large content of food residues from volatile solids. Animals waste (alone –B7-) comes in the second rank where its average production per kilogram waste is 59.5g. Straw (B9) is the lowest waste type in producing biogas (37.2g /kg waste) because of its high C/N ratio and of its high fibrous content which digested hardly [Mattocks, 1984]. The following figure (22) explains these results.

No significant differences observed for biogas productivity from samples (B2, B3, B4, B5, and B6) which may due to using small quantities of different waste types for each sample.

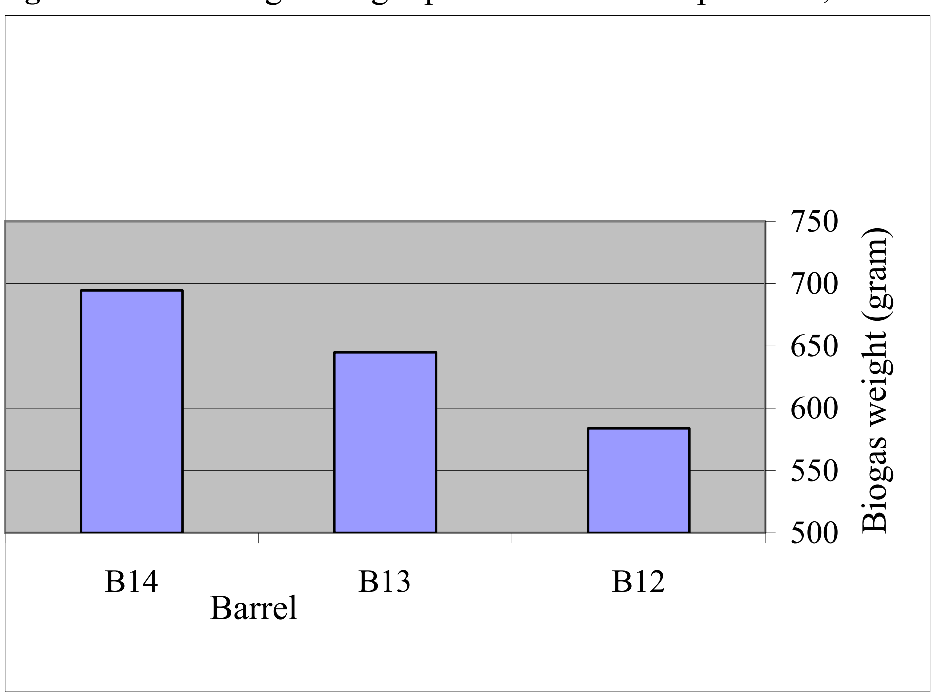
Figure 22 Produced biogas from samples B7, B8 and B9



B} - Animal dung type effect:-

By comparing the results in table (24) and figure (23 below) for samples in B12 (cow dung), B13 (sheep and goat dung) and B14 (chicken waste); the sample of chicken waste produces the highest biogas weight (57.9g/Kg dung) but with maximum production rate at longer time. Then the sample of sheep and goat dung (53.8g biogas/Kg dung). The sample of cow dung produces the lowest weight (48.7 g/Kg dung). These results are reasonable because chicken waste is of the highest volatile solids (the waste productivity for biogas increases with increasing of its volatile solids contents; [Mattocks; 1984]) and of the lowest C/N ratio (24 for cow dung, 19 for sheep, 12 for goat and 10 for chicken dung, [FAO/CMS; 1996]) and of the highest retention time where the best digestion occurs when C/N ratio ranged between 20 and 30.

Figure 23 Total biogas weight produced from samples B12, B13 and B14



Results of samples (B12, B13, B14, B15, B16, B17, and B18) – figure 19 - indicate that sample of equal ratios (B18) from the three animal dung types (cow, sheep and goat, chicken) produces the largest quantity of biogas (63.1 g/kg waste) with reaching its maximum production at shorter time. The reason is not so clear, it may be returned to the reaching best total solids ratio or best C/N ratio among different waste types.

Mixing a quantity of cow dung with an equal quantity of sheep and goat dung or chicken waste has no significant difference with respect to using cow dung only or in the case of mixing it with one of the other animals waste (B12, B15 and B16) on both its biogas productivity and retention time of the digestion process. This may return to the fact cow dung is of the best C/N ratio but of the lowest volatile solids content, sheep and goat is of the middle C/N ratio and volatile solid contents and chicken dung of the lowest C/N ratio but with the highest volatile solids content, and these differences create the equalization.

For sheep and goat samples it is clear that mixing their dung with cow dung reduce their productivity (B16: 49.5 g of biogas/Kg dung) comparing with the case of using it alone (B13:- 53.8 g/kg dung), while mixing them with an equal amount of chicken waste enhance their production (B17:- 59.5g / kg dung).

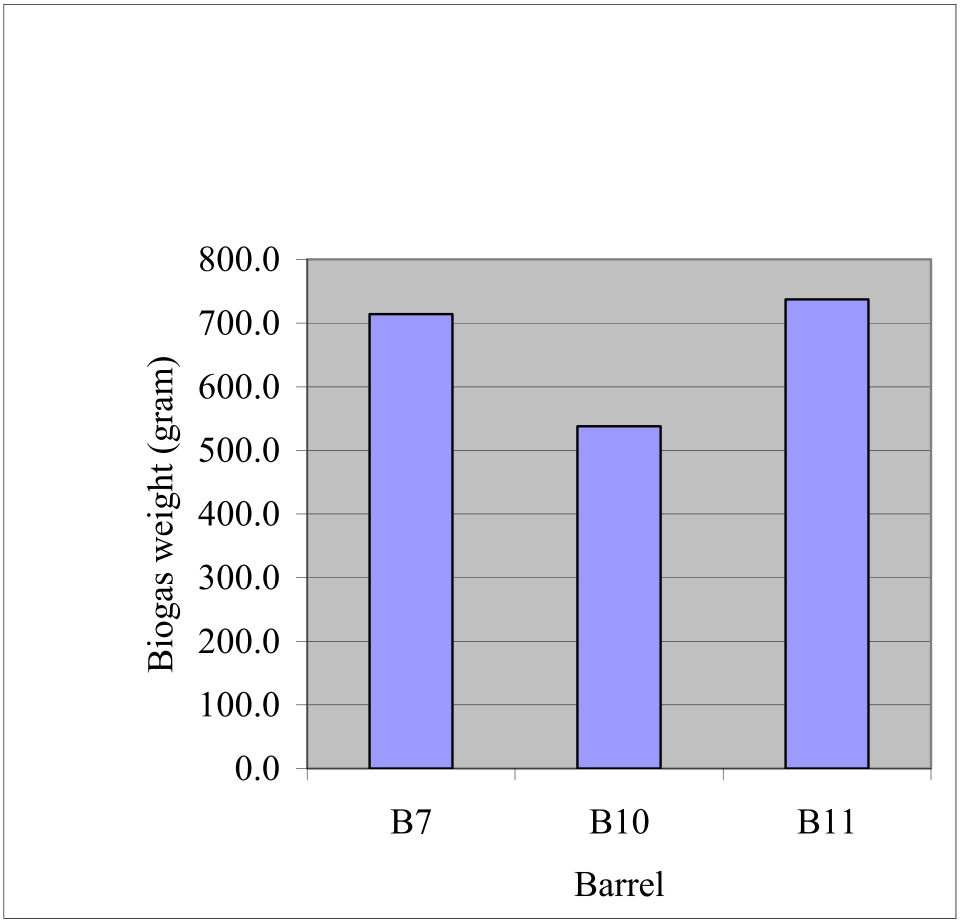
Mixing chicken waste (alone in B14 with biogas production 57.9 g /kg dung) with cow dung lower its productivity (B16: 49.5g / kg dung), while mixing it with an equal amount of sheep and goat dung enhance their biogas productivity (B17: 59.5g/ kg dung).

The two statements above could be explained by the fact that sheep and goat dung enhance C/N ratio for chicken dung, and chicken dung increase the volatile solids content of the mixed waste. While cow dung decrease significantly the volatile solids content of the mixed waste despite of its enhancing for C/N ratio.

C} - Dilution effect:-

Comparing results for samples (B7, B10, and B11and figure 24), it seen that sample biogas productivity increases with increasing water amount (dilution).Sample B11 of dilution factor 3 produces 61.4g of biogas per kg waste, B7 of dilution factor 2.5 produces 59.5 g /kg waste and sample B10 of dilution factor 2 produces 44.83g per kilogram waste. This may be returned to the fact that increasing water amount decreases the changes of sample pH and temperature in addition to decreasing total solid ratio.

Figure 24 Produced biogas from samples B7, B10 and B11



D)-Enlargement Effect:-

Increasing the amount of the slurry inside the digester decreases the effect of temperature and pH flocculation on the digestion process which enhances the organic wastes productivity for biogas. This could be observed form the results of samples B1, D1 and D2 (of the same waste types ratios), where the averages for biogas weight per each 1Kg of wastes in D1 (58.93g) and D2 (48.46g) are bigger than its average (45.83g) in B1 (small digester).

The curves of biogas productivity with time for large samples (D1, D2 – Figure 19) are smother than small samples (B1 to B18- Figures 17 and 18).The same thing could be observed from the pH-curves of these samples (figures 15 and 16).

E} - Stirring effect:-

The results of samples in D1 (with stirrer) and D2 (without stirrer) show that the stirring for digester contents is an important factor to improve organic wastes productivity for biogas and to decrease the retention time of the digestion process.

From table (24) and figures (19 and 21); it is clear D1 organic contents produce biogas (total weight 4243g) more than that of D2 (3489g), and it is appear the maximum biogas productivity in D1 was reaching on day 27 with 54 days for complete digestion (retention time), while maximum biogas productivity in D2 was reaching on day 36 with more than 60 days (retention time) for complete digestion of its contents. Moreover the curve of biogas productivity with time for D1 is smother and more symmetrical than that of D2 (figure 16) which means the digestion process in D1 went on by a better way than in D2.

The above results could be explained on the base that stirring make the substrate more available for acting microorganism, equalize the pH and temperature of the digester contents and “ prevent the bacteria from stagnating in their own waste products” [Mattocks, 1984].

Increasing the weights of samples with longer retention time may give more differences among tested samples, and so the indications become more observable and the results more simple for explanations. Also; doing the experiment in warm months will enhance samples production for biogas with decreasing the retention time.

The results show that the average of produced biogas per kilogram for all samples is equal **(51.9 gram)** with standard deviation (7.63).

Chapter Eight

Application of Biogas Technology in Palestine

In this chapter, a family biogas producing system will be proposed depending on the field survey and the experiment results of the study, the evidences for biogas technology succession in Palestinian rural areas that mentioned in chapter one and some information about biogas technology from other studies. Also; the construction materials with its costs and the time period required to get back the capital of constructing the proposed plant will be estimated.

8.1- Sizing the Digester

The following points reported to calculate the volume of the required biogas production digester for Palestinian rural family:-

1- The average weight of biogas that could be produced from (1Kg) of mixed organic wastes is (51.9gram) [experimental result].

2- The monthly average for Palestinian rural family consumption from natural gas is (24Kg) [table -7- of the field survey results].

3- Suitable retention time for anaerobic digestion process in Palestine ambient conditions is (60) days.

4- The biogas energy value is nearly one half of natural gas [Hansen, 2001].

5- Each animal unit generate daily from (10 Kg) to more than (15Kg) of organic wastes [Mattocks, 1984] (after converting units from pound to kilogram).

6- The daily generated dry organic matter form each rural capita in Palestine is (0.175 Kg) [El-Jaber, 1993], therefore; the daily weight of the generated organic waste by rural family (6.85 capita / family, field survey result) is (1.2) Kg.

7- The best ratio for the slurry components (to be introduced into the digester) is 1 volume unit of organic waste to 3 volume units of water [experiment result].

8- Assume that the volume of each 1Kg of slurry is 1 litter.

9- The volume of the digester = (Volume for slurry X retention time) + volume of gas holder [At Information, website].

10-The volume of the gas holder should be one fifth of the total digester volume [GTZ, 1993].

Depending on above points; the monthly weight of biogas required for Palestinian rural family to cover its monthly requirement from natural gas is (48) Kg, which could be produced from (924.9) Kg {from 48 / 51.9 g biogas per Kg of mixed organic waste} of organic waste.

This means the daily required quantity of mixed organic waste is (30.83) Kg {from dividing 924.9 by 30}.This quantity of organic waste could be obtained from (2 to 3) animal units {available for 42.93% of the rural families, table 4 of the field survey results, but by summation of percentages for 2-3 to more 7 units intervals}, or from (1 to 2) animal units {available for 57.1% of rural families, table 4} with domestic waste generated by the family.

The daily required quantity of water for dilution = 30.83X3 = 92.49 Kg; so the daily volume of waste and water = 30.83 + 92.49 = 123.3 litter.

The total volume of digester for slurry = 123.3X retention time

= 123.3X 60 days = 7398 litter = 7.4 m^3

The volume of gas holder = 1/5 X 7.4 ≈ 1.5 m^3.

So; the **total volume of the required digeste**r = 7.4 + 1.5 ≈ **9 m^3**.

8.2- The Proposed Design for Family Biogas Plant

Because the concern is the rural family; so the simplest design of long operation time, low construction cost and that could be operated and repaired by the family itself should be selected. The best choice is a Chinese fixed – dome design which shown in figure (4) of chapter (3) [FAO/CMS, 1996; Mattocks, 1984 and At-Information website]. Other evidences that support this choice are:-

1- The founded experience for the society in digging rain-water wells which shape is similar to that of fixed – dome design, in addition to the founding of experienced workers for wells walls cement coating.

2- Most of Palestinian villages and rural families locate on mountains and their sides where the rock layers are found at small depth under the soil surface which eliminate the need for building bricks or cement walls when the digester constructed under ground.

3- Constructing the digester under ground reduces the negative impacts resulted from atmospheric temperature changes, earth area required for constructing biogas plant and reduces the hazard of biogas explosion inside the digester.

4- Availability of constructing materials such as:- cement, sand, small stones and plastic pipes with a reasonable prices.

As a result a 9 m^3 Chinese fixed – dome design is the proposed one with continuous loading (daily or weekly) for wastes into the digester which decrease the negative impacts associated with wastes accumulation and provide the family with nearly a daily stable amount of biogas.

The following figure (25); explain the design and its measurements which calculated by the following equations:-

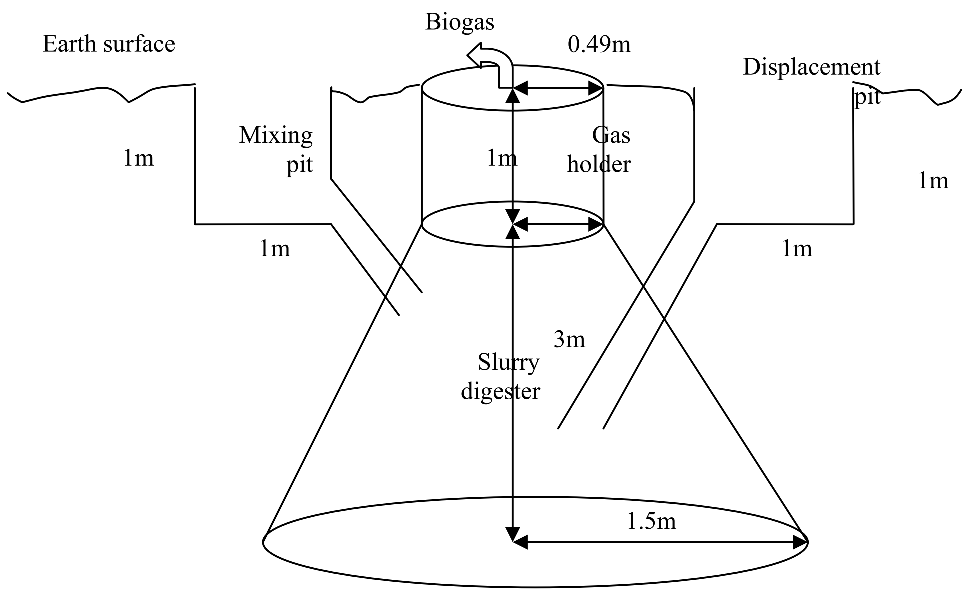
Cylinder volume = $2\pi r^2 h$

Cone volume = $\frac{1}{3} \pi r^2 h$

Cubic volume = $w\, l\, h$

Where: - $\pi = 3.14$, r : radius, h: height, w: width, l: length.

Figure 25 A $9m^3$ Family biogas plant.



8.3- Construction Materials and Costs

After asking many experienced people in digging rain-water collecting wells, cement coating, and about bricks, sand, small stones, cement bags (50Kg), rigid plastic pipes and other materials (required for constructing the biogas plant) prices. The costs for constructing the proposed design of the family biogas plant may be estimated as follows:-

Table 25 Requirements and costs for constructing the proposed design.

Requirements	**Cost (JD)**
Digging operations with workers (4 days working time)	250
2 m^3 of small stones-	15
2 m^3 of sand	20
15 cement bags (each 50Kg)	50
2 rigid plastic pipes (3 meter length, and 8" diameter)	10
Gas valve and connectors.	10
50 litter of Plastic or asphalt paints	55
80 bricks (10X10X40 centimeter, may required for pits)	15
Miscellaneous	75
Total	**500**
Where:- JD: Jordan diner; m: meter;	

8.4- Investment for Applying the Proposed Family Biogas Plant

The biogas plants produce both biogas and organic fertilizer. The biogas could be used mainly instead of natural gas, while organic fertilizer used to improve crops yield, and so could be used instead of manufactured fertilizers. Therefore; the monthly direct economic benefits for biogas plants could be estimated as follows:-

Monthly economic benefits (investment)

= investment of (biogas + organic fertilizer) – monthly costs.

A) - Biogas using investment:-

The proposed biogas system designed to produce biogas quantity could cover the monthly consumption of rural family from natural gas, so the monthly sum saving expected from using biogas is (**11.07 JD**) {table 7 of survey results, chapter 7}.

B) - Organic fertilizer investment:-

The organic matter contains from 65-90% volatile solids and 30-60% of the volatile solids (depending on the type of the organic matter) converted by anaerobic digestion into biogas [El-Jaber, 1993]. If the averages for the previous percentages (77.5% volatile solids and 45% for the percentage of amount of volatile solids that converted into biogas) are taken for calculations, then:-

The amount of organic waste (introduced into the digester) that lost monthly (converted into biogas)

= monthly loaded organic waste weight X 77.5% X 45%

= 924.9 Kg X 77.5% X 45%% = 322.6 Kg

Then; the amount of organic matter gets out from the digester into the displacement pit is:

= loaded amount – converted amount into biogas

= 924.9 - 322.6 = 602.3 Kg. (the quantity that will be used to fertilize crops).

The manufactured fertilizer of the lowest price available in the local markets is (Ammoniac) fertilizer which sale to farmer by about (135 JD / ton). Assuming that each ton of the digested organic waste (organic matter get out of the digester) will be sale by 20% of Ammoniac price, then the price of 1 ton of the digested organic waste = 20% X 135 = 27JD.

Therefore; the monthly investment for organic fertilizer from biogas plant = 602.3 X (27 JD/1000Kg) = **16.3 JD**.

C) - Monthly cost

The monthly cost for operating the biogas plant may come from replacing some of the used equipments (mainly gas valve, gas transporting pipe) and purchasing for water in the case of using clean water for diluting organic wastes to be introduced into the digester (the use of water could be reduced or eliminated by using waste water).

In the case of purchasing for water and with knowing that the price for $1m^3$ of water (provided by truck tank) is about 1.2 JD, then:

The monthly cost for water is

= volume of used water (per month) X 1.2 JD/ m^3

Volume of water = daily added volume X 30 day/month

= 92.49 litter X 30 = 2774.7 litter/month ≈ 2.77 m^3

The monthly cost of water = 2.77 X 1.2 = 3.3 JD.

If 1 JD added monthly for miscellaneous cost, then:

The monthly total cost = 1 + 3.3 = **4.3 JD**

As a result; **the monthly investment** is

= 11.07 (biogas) + 16.3 (organic fertilizer) – 4.3 (monthly costs)

= **23.07 JD**

8.5- Time Required for Getting Back the Capital of Biogas Plant Construction

The time period required for getting back the money paid for the construction of the proposed biogas plant = capital / monthly investment

= 500 JD / (23.07 JD/ month)

= **21.7 months = 1.8 years**

This means the rural family will get back the capital of constructing its biogas plant with in a time period of less than two years which is a reasonable period

Chapter Nine

Results Summary, Conclusions and Recommendations

The main results and the findings of the study will be summarized to simplify the evaluation for the study objectives, to get out conclusions and the recommendations.

9.1- Results summary and conclusions

The field survey results show most of the Palestinian rural families raise animals (72.47%) and have cultivation activities (87.45%). Also; most rural families use or follow wrong ways for disposing off their animals dung (collected to be disposed off later, rank 1 in table 8 of chapter 7), solid domestic wastes (disposed into general containers, rank 1 in table 10), and waste water (disposed into cess pits, rank 1 of table 11, and 96.76% of rural families have cess pits –table 17-). The results indicate to the availability of organic wastes for rural families which could be used as a substrate for biogas plants to produce biogas (energy source) and organic fertilizer for improving crops production. Not only waste water could be used as a substrate for producing biogas but it could be also used for diluting organic wastes before its loading into the digester.

The field survey results revealed rural families suffer from negative impacts of organic wastes (average percentage of reply 60.3%, table 12). This could be reduced by applying biogas technology which sanitize [Mattocks, 1984} the organic wastes.

Moreover; the field survey results revealed rural people have a good environmental awareness (positive result, table 14 of chapter 7) toward organic wastes issues and impacts, and they have a good acceptability (positive result, table 15) for constructing biogas plants especially if they get a financial assistant. The good awareness and acceptability could be invested for disseminating biogas technology in the country, especially in rural areas.

Experimentally; all tested organic samples produce biogas (average 51.9 gram biogas per each kilogram of organic waste) at ambient conditions with in a retention time of 60 days. The experiment results revealed increasing substrate moisture, sample enlargement and good stirring for digester contents improve samples productivity for biogas and lower the retention time of the digestion process (table 24 and figures from 14 to 23 of chapter 7).

The success of the experiment indicates to the technical application feasibility for biogas technology in the country, where all materials (especially digesters) used were prepared and operated locally.

Economically; the results of calculations in chapter (8) revealed constructing (construction cost 500 JD) a $9m^3$ fixed –dome biogas family plant {of continuous (daily) loading for organic wastes (30.83 kg waste / day)} could cover the monthly energy requirements of Palestinian rural family obtained from natural gas (saving 11.07 JD monthly) by using the produced biogas, and saving or investing (16.3 JD) by using (or selling) the effluent organics instead of manufactured crops fertilizers. This means constructing a family biogas plant is economically feasible, and so reduces the dependence on the imported natural gas.

The objectives of the study will evaluated depending on the mentioned results (experiment and survey results) with taking in consideration the following observations:-

1- The experimentally produced biogas burned with a flame like of natural gas which indicates to a good biogas quality.

2- The odor of the organic wastes after the completing the digestion process was less than its odor before loading into the digesters.

3- The color of the digested wastes (after emptying the digesters) was nearly black as the color of the digested organics that described by FAO/CMS [1996] report.

The observations emphasize that what happened in the experiment was an aerobic digestion process which produces biogas and organic fertilizer. Therefore, the first objective (producing biogas and organic fertilizer from available organic wastes) of the study is achieved.

For the second objective; the experiment results show constructing biogas digesters at ambient conditions is feasible technically. And field survey results indicate biogas technology is socially accepted. Moreover, calculations in chapter (8) emphasize that constructing a 9 m^3 biogas plant will give economical benefits for rural family and reduce or eliminate accumulation of organic wastes which will decrease its the negative impacts. The results indicate to achieving of the second objective of the study.

The using of biogas (socially accepted, positive result for statement three in table -15- of chapter 7) instead of natural gas means reducing dependence of the rural family on the imported natural gas which will save money for rural families and government. This implies the objective three will achieved if biogas technology disseminate in the country.

The fourth objective (improving local environment) expected to be achieved in the case of dissemination of biogas plants in the rural areas, where this technology provide rural family with biogas and organic fertilizer by anaerobic digestion for organic wastes which means reducing the volume of wastes to be disposed off, decreasing the accumulated wastes (enhancing aesthetic situation, and decreasing soil, air and water contamination), more job opportunities and sanitizing wastes (better human, animals and plants health) as most studies emphasize (as Mattocks, 1984 and EREC, 2000).

Chemical and biological analysis for the produced biogas and organic effluent from digesting organic wastes used in the experiment are necessary to give more confidence in evaluating the objectives of the study, but (unfortunately) the analysis did not done (reasons mentioned in chapter 6).

9.2- Recommendations

Depending on the results and observations for the experiment and the field survey of the study the following recommendations are reported:-

1- Biogas plants should be constructed to decrease the volume of organic wastes that should be disposed off.

2- Constructing a 9 m^3 fixed-dome biogas plants with continuous loading for organic wastes (operated and repaired by rural family) will cover the daily energy requirements (instead natural gas) for rural family and provide it with organic fertilizer for improving crops production.

3- Cess pits could be repaired or constructed so that it could be used as a digester for anaerobic digestion of organic wastes.

4- Straw should be grinded before introducing it into the digester to enhance its biogas production and to facilitate stirring process.

5- Training persons (by energy authority, environment authority, Ministry of agriculture, agricultural communities and local universities) on biogas technology to provide advertising for rural families.

6-Financial help (from government or non governmental organizations -NGO´s-) should be provided to rural families to help them in constructing biogas plants.

7- More studies about applying biogas technology in Palestine should be done to disseminate successfully this important technology in the country.

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جدول 1: المساحة المزروعة بأشجار الفاكهة والخضراوات والمحاصيل الحقلية لعام 1999/1998

Table 1: Cultivated Area of Fruit Trees, Vegetables and Field Crops, 1998/1999

Area: dunum المساحة: دونم

Governorate / Region	المجموع العام Grand Total	Field Crops المحاصيل الحقلية			Vegetables الخضراوات			Fruit Trees أشجار الفاكهة					المحافظة / المنطقة
		المجموع Total	مروي Irrigated	بعلي Rainfed	المجموع Total	مروي Irrigated	بعلي Rainfed	المجموع Total	Unbearing غير مثمر Irrig. مروي	Unbearing غير مثمر Rainfed بعلي	Bearing مثمر Irrig. مروي	Bearing مثمر Rainfed بعلي	
Jenin	**339373**	93667		93667	43062	18266	24796	202644	–	–	469	202175	جنين
Tubas	**45622**	20045	3359	16686	13508	13084	424	12069	295	1735	1258	8781	طوباس
Tulkarm	**160513**	12151	1107	11044	13072	11709	1363	135290	–	3055	4886	127349	طولكرم
Nablus	**253000**	37732	3111	34621	5476	3899	1577	209792	11	2933	3105	203743	نابلس
Qalqiliya	**67634**	5358	–	5358	5625	4886	739	56651	–	1149	5721	49781	قلقيلية
Salfit	**86380**	6343	–	6343	969	140	829	79068	–	3630	73	75365	سلفيت
Ramallah and Al-Bireh	**185295**	30217	12	30205	2677	336	2341	152401	–	444	150	151807	رام الله والبيرة
Jericho	**34179**	2466	2466	–	23305	23305	–	8408	304	–	8104	–	أريحا
Jerusalem*	**16155**	1749	–	1749	335	–	335	14071	1	429	–	13641	القدس•
Bethlehem	**40652**	5782	17	5765	2277	1056	1221	32593	–	825	–	31768	بيت لحم
Hebron	**230392**	88160	8	88152	3215	829	2386	139017	11	9638	5	129363	الخليل
Remaining West Bank	**1459195**	**303670**	**10080**	**293590**	**113521**	**77510**	**36011**	**1042004**	**622**	**23838**	**23771**	**993773**	**باقي الضفة الغربية**
North Gaza	**36998**	4482	3537	945	12586	12401	185	19930	502	5	18723	700	شمال غزة
Gaza	**30620**	2900	600	2300	6697	6697	–	21023	–	1500	10009	9514	غزة
Deir Al-Balah	**31309**	5472	1004	4468	9119	9119	–	16718	1236	137	11703	3642	دير البلح
Khan Yunis	**30633**	8748	8748	–	6456	6456	–	15429	2525	–	9051	3853	خانيونس
Rafah	**23258**	3610	2980	630	10737	10737	–	8911	315	575	2529	5492	رفح
Gaza Strip	**152818**	**25212**	**16869**	**8343**	**45595**	**45410**	**185**	**82011**	**4578**	**2217**	**52015**	**23201**	**قطاع غزة**
Palestinian Territory	**1612013**	**328882**	**26949**	**301933**	**159116**	**122920**	**36196**	**1124015**	**5200**	**26055**	**75786**	**1016974**	**الأراضي الفلسطينية**

* Jerusalem: Does not include those parts of Jerusalem which were annexed by Israel in 1967.

• القدس: لاتشمل ذلك الجزء من محافظة القدس الذي ضمته اسرائيل عنوة بعيد احتلالها للضفة الغربية عام 1967.

Appendix (I)...

جدول 2: عدد الأبقار حسب السلالة والجنس والعمر لعام 1999/1998

Table 2: Number of Cattle by Strain, Sex and Age, 1998/1999

Governorate / Region	المجموع العام Grand Total	Total المجموع				Friesian Cattle الأبقار الهولندية				Local Cattle الأبقار البلدية				المحافظة / المنطقة
		ثيران Bulls	عجلات Heifer Calves	عجول Bull Calves	أبقار Cows	ثيران Bulls	عجلات Heifer Calves	عجول Bull Calves	أبقار Cows	ثيران Bulls	عجلات Heifer Calves	عجول Bull Calves	أبقار Cows	
Jenin	**1718**	22	300	301	1095	13	237	245	891	9	63	56	204	جنين
Tubas	**1785**	39	263	228	1255	4	57	24	129	35	206	204	1126	طوباس
Tulkarm	**1482**	632	94	240	516	631	79	230	476	1	15	10	40	طولكرم
Nablus	**4762**	67	477	864	3354	62	437	822	3113	5	40	42	241	نابلس
Qalqiliya	**1744**	48	341	551	804	26	224	407	466	22	117	144	338	قلقيلية
Salfit	**378**	5	46	75	252	3	10	33	136	2	36	42	116	سلفيت
Ramallah and Al-Bireh	**540**	9	64	126	341	8	63	124	314	1	1	2	27	رام الله والبيرة
Jericho	**709**	12	204	107	386	9	179	84	331	3	25	23	55	أريحا
Jerusalem*	**228**	-	-	3	225	-	-	3	225	-	-	-	-	القدس*
Bethlehem	**70**	8	9	6	47	8	9	6	47	-	-	-	-	بيت لحم
Hebron	**5433**	35	1194	2308	1896	33	1168	2268	1866	2	26	40	30	الخليل
Remaining West Bank	**18849**	**877**	**2992**	**4809**	**10171**	**797**	**2463**	**4246**	**7994**	**80**	**529**	**563**	**2177**	**باقي الضفة الغربية**
North Gaza	**2005**	-	495	390	1120	-	495	390	1120	-	-	-	-	شمال غزة
Gaza	**609**	-	116	116	377	-	116	116	377	-	-	-	-	غزة
Deir Al-Balah	**866**	19	163	164	520	9	163	164	520	10	-	-	-	دير البلح
Khan Yunis	**785**	-	150	149	486	-	150	149	486	-	-	-	-	خانيونس
Rafah	**744**	26	97	292	329	26	97	292	329	-	-	-	-	رفح
Gaza Strip	**5009**	**45**	**1021**	**1111**	**2832**	**35**	**1021**	**1111**	**2832**	**10**	**-**	**-**	**-**	**قطاع غزة**
Palestinian Territory	**23858**	**922**	**4013**	**5920**	**13003**	**832**	**3484**	**5357**	**10826**	**90**	**529**	**563**	**2177**	**الأراضي الفلسطينية**

* Jerusalem: Does not include those parts of Jerusalem which were annexed by Israel in 1967.

* القدس: لاتشمل ذلك الجزء من محافظة القدس الذي ضمته اسرائيل عنوة بعيد احتلالها للضفة الغربية عام 1967.

Appendix (I)...

جدول 3: اعداد الأغنام والماعز وخلايا النحل والدجاج اللاحم والبياض لعام 1999/1998

Table 3: Number of Sheep, Goats, Beehives, Broilers and Layers, 1998/1999

Governorate / Region	Poultry (1000) الدجاج (بالألف)		Beehives خلايا نحل			Goats الماعز			Sheep الأغنام			المحافظة / المنطقة
	البياض Layers	اللاحم Broilers	المجموع Total	قديمة Traditional	حديثة Modern	المجموع Total	أخرى Other	بلدي Local	المجموع Total	أخرى Other	بلدي Local	
Jenin	73	6724	3611	2006	1605	10570	-	10570	28345	22535	5810	جنين
Tubas	21	1391	1071	13	1058	10023	140	9883	33119	761	32358	طوباس
Tulkarm	266	3953	2523	-	2523	3877	-	3877	16644	15430	1214	طولكرم
Nablus	55	2095	2692	164	2528	27106	-	27106	65085	6600	58485	نابلس
Qalqiliya	115	2197	2588	35	2553	9410	1499	7911	19819	7740	12079	قلقيلية
Salfit	40	490	869	100	769	3395	1140	2255	4287	1837	2450	سلفيت
Ramallah and Al-Bireh	336	4454	3295	278	3017	40154	-	40154	44399	280	44119	رام الله والبيرة
Jericho	8	563	6070	1000	5070	33719	-	33719	29222	-	29222	أريحا
Jerusalem*	22	405	175	-	175	20247	-	20247	29646	67	29579	القدس*
Bethlehem	63	672	1404	105	1299	51617	-	51617	48655	-	48655	بيت لحم
Hebron	315	10654	2247	5	2242	71600	830	70770	150187	4142	146045	الخليل
Remaining West Bank	**1314**	**33598**	**26545**	**3706**	**22839**	**281718**	**3609**	**278109**	**469408**	**59392**	**410016**	**باقي الضفة الغربية**
North Gaza	123	1167	9000	-	9000	1120	-	1120	8800	-	8800	شمال غزة
Gaza	460	3808	5410	-	5410	4523	-	4523	8923	-	8923	غزة
Deir Al-Balah	52	1808	2600	-	2600	2816	-	2816	5655	960	4695	دير البلح
Khan Yunis	68	6461	960	-	960	2880	-	2880	5682	-	5682	خانيونس
Rafah	42	1576	1680	-	1680	1976	976	1000	5610	3610	2000	رفح
Gaza Strip	**745**	**14820**	**19650**	-	**19650**	**13315**	**976**	**12339**	**34670**	**4570**	**30100**	**قطاع غزة**
Palestinian Territory	**2059**	**48418**	**46195**	**3706**	**42489**	**295033**	**4585**	**290448**	**504078**	**63962**	**440116**	**الأراضي الفلسطينية**

* Jerusalem: Does not include those parts of Jerusalem which were annexed by Israel in 1967.

* القدس: لاتشمل ذلك الجزء من محافظة القدس الذي ضمته اسرائيل عنوة بعيد احتلالها للضفة الغربية عام 1967.

Appendix (II) The monthly averages of maximum and minimum temperatures for Palestinian agricultural stations [Saleh, Waleed Irsan, 2003].

Country : Palestine (West Bank)   Station : AL ARROUB
.Altitude: 960 meter(s) above M.S.L
(Latitude: 31.36 Deg. (North)   Longitude: 35.07 Deg. (East

Month	MaxTemp	MiniTemp	Humidity	Wind Spd.	SunShine	Solar Rad.	ETo
	(deg.C)	(deg.C)	(%)	(Km/d)	(Hours)	(MJ/m2/d)	(mm/d)
January	12.3	4.4	77.0	207.0	6.2	11.3	1.54
February	13.0	4.8	78.0	242.0	6.2	13.3	1.92
March	16.5	6.3	71.0	259.0	7.5	17.6	2.97
April	20.9	8.1	65.0	233.0	8.5	21.3	4.14
May	25.7	12.3	57.0	156.0	10.1	24.9	5.10
June	28.5	14.7	54.0	121.0	11.8	27.7	5.67
July	29.6	15.9	59.0	121.0	11.6	27.2	5.65
August	30.0	16.2	64.0	130.0	11.0	25.3	5.29
September	28.4	14.4	70.0	121.0	9.9	21.6	4.25
October	25.7	12.1	64.0	138.0	8.6	17.0	3.33
November	20.4	9.6	72.0	138.0	7.6	13.2	2.12
December	14.7	6.4	75.0	190.0	6.3	10.7	1.58
Average	22.1	10.4	67.2	171.3	8.8	19.3	3.63

Pen-Mon equation was used in ETo calculations with the following values
:for Angstrom's Coefficients
a = 0.25   b = 0.5

D:\WALEED2\ARROUB.TXT

CropWat 4 Windows Ver 4.2   2003/12/4

Climate and ETo (grass) Data

Data Source: D:\WALEED2\BEITQAD.PEM

'Country : Palestine (West BanK)   Station : BEIT QAD 'JENIN
.Altitude:-190 meter(s) above M.S.L
(Latitude: 32.28 Deg. (North)   Longitude: 35.21 Deg. (East

Month	MaxTemp	MiniTemp	Humidity	Wind Spd.	SunShine	Solar Rad.	ETo
	(deg.C)	(deg.C)	(%)	(Km/d)	(Hours)	(MJ/m2/d)	(mm/d)
January	17.4	6.8	80.0	181.0	5.4	10.2	1.68
February	18.2	7.1	84.0	190.0	5.6	12.4	2.00
March	21.6	8.6	76.0	190.0	6.8	16.5	3.08

Appendix (II) Continue

April	28.3	11.2	67.0	190.0	7.8	20.2	4.75
May	31.0	14.0	39.0	216.0	9.7	24.2	6.74
June	32.9	17.3	63.0	225.0	11.3	26.9	6.74
July	33.6	19.6	63.0	233.0	11.1	26.4	6.81
August	34.2	21.1	65.0	207.0	10.0	23.7	6.16
September	33.2	19.8	64.0	173.0	9.1	20.4	5.12
October	30.6	16.1	65.0	130.0	8.1	16.2	3.63
November	25.0	11.8	66.0	147.0	6.8	12.1	2.56
December	18.8	8.7	74.0	181.0	5.4	9.6	1.80
Average	27.1	13.5	67.2	188.6	8.1	18.2	4.26

Pen-Mon equation was used in ETo calculations with the following values
:for Angstrom's Coefficients
a = 0.25   b = 0.5

D:\WALEED2\BEITQAD.TXT

CropWat 4 Windows Ver 4.2   2003/12/4

Climate and ETo (grass) Data

Data Source: D:\WALEED2\FARAA.PEM

Country : Palestine (West Bank)   Station . Al-Far'a
.Altitude -198 meter(s) above M.S.L
(Latitude. 32.08 Deg. (North)   Longitude: 35.30 Deg. (East

Month	MaxTemp (deg.C)	MiniTemp (deg.C)	Humidity (%)	Wind Spd. (Km/d)	SunShine (Hours)	Solar Rad. (MJ/m2/d)	ETo (mm/d)
January	19.5	9.3	73.0	110.4	5.7	10.6	1.69
February	20.2	9.2	73.0	156.0	6.0	12.9	2.34
March	24.3	12.1	63.0	146.4	7.5	17.4	3.53
April	29.1	14.4	63.0	86.4	8.7	21.5	4.28
May	34.6	19.0	52.0	79.2	10.3	25.1	5.53
June	37.1	21.1	51.0	86.4	11.6	27.4	6.30
July	39.4	22.7	51.0	163.2	11.7	27.3	7.55
August	38.5	24.2	52.0	156.0	11.0	25.2	6.89
September	36.6	22.9	43.0	120.0	9.9	21.5	5.50
October	33.5	20.2	54.0	60.0	8.5	16.7	3.32
November	27.9	16.8	55.0	60.0	7.3	12.7	2.16
December	21.5	11.9	67.0	50.4	6.2	10.4	1.37
Average	30.2	17.0	58.1	106.2	8.7	19.1	4.20

Pen-Mon equation was used in ETo calculations with the following values
:for Angstrom's Coefficients
a = 0.25   b = 0.5

D:\WALEED2\FARAA.TXT

Climate and ETo (grass) Data

Appendix (II) Continue

Data Country : Palestine (West Bank)   Station : Hebron
.Altitude: 1005 meter(s) above M.S.L
(Latitude: 31.53 Deg. (North)   Longitude: 35.10 Deg. (East

Month	MaxTemp (deg.C)	MiniTemp (deg.C)	Humidity (%)	Wind Spd. (Km/d)	SunShine (Hours)	Solar Rad. (MJ/m2/d)	ETo (mm/d)
January	10.2	4.0	74.0	223.2	4.7	9.7	1.45
February	11.5	4.7	72.0	230.4	4.8	11.7	1.86
March	14.6	6.5	66.0	228.0	6.4	16.1	2.75
April	19.6	9.9	55.0	206.4	8.1	20.7	4.10
May	23.6	13.2	48.0	168.0	9.0	23.3	4.97
June	.25.9	15.8	51.0	168.0	8.3	22.5	5.17
July	27.2	17.0	57.0	165.6	9.6	24.2	5.36
August	27.2	17.0	60.0	156.0	10.9	25.1	5.21
September	26.0	15.9	62.0	146.4	10.3	22.1	4.36
October	23.2	14.0	59.0	144.0	9.8	18.4	3.36
November	17.5	9.9	64.0	158.4	7.0	12.5	2.12
December	12.1	5.6	73.0	182.4	4.7	9.1	1.41
Average	19.9	11.1	61.8	181.4	7.8	18.0	3.51

Pen-Mon equation was used in ETo calculations with the following values
:for Angstrom's Coefficients
a = 0.25   b = 0.5

CropWat 4 Windows Ver 4.2   2003/12/

****

Climate and ETo (grass) Data

Data Source D WALEED2'JAIRPORT.PEM

Country : Palestine (West BanK)   Station : JERICHO AIRPORT
.Altitude:-276 meter(s) above M.S.L
(Latitude: 31.52 Deg. (North)   Longitude: 35.30 Deg. (East

Month	MaxTemp (deg.C)	MiniTemp (deg.C)	Humidity (%)	Wind Spd. (Km/d)	SunShine (Hours)	Solar Rad. (MJ/m2/d)	ETo (mm/d)
January	19.0	9.3	71.0	121.0	6.3	11.3	1.80
February	20.6	10.0	64.0	138.0	7.1	14.3	2.57
March	24.4	12.0	59.0	164.0	7.3	17.3	3.75
April	29.5	15.9	53.0	164.0	9.0	22.0	5.24
May	34.4	20.0	43.0	181.0	11.1	26.4	7.06
June	37.0	22.4	39.0	173.0	12.5	28.7	7.83
July	38.6	24.0	41.0	156.0	12.6	28.6	7.76
August	37.9	24.8	46.0	138.0	12.1	26.8	6.95
September	35.8	23.6	49.0	130.0	10.1	21.9	5.57
October	32.7	20.2	51.0	121.0	8.7	17.1	4.11
November	28.1	15.0	55.0	130.0	8.2	13.7	3.00
December	21.4	11.2	66.0	121.0	6.3	10.6	1.90
Average	29.9	17.4	53.1	144.8	9.3	19.9	4.80

Pen-Mon equation was used in ETo calculations with the following values
:for Angstrom's Coefficients
a = 0.25   b = 0.5

****

Appendix (II) Continue

Climate and ETo (grass) Data

Data Source: D:\WALEED2\JERICHO.PEM

Country : West Bank Station : Jericho
.Altitude:-250 meter(s) above M.S.L
(Latitude: 31.85 Deg. (North) Longitude: 35.45 Deg. (East

Month	MaxTemp (deg.C)	MiniTemp (deg.C)	Humidity (%)	Wind Spd. (Km/d)	SunShine (Hours)	Solar Rad. (MJ/m2/d)	ETo (mm/d)
January	19.1	7.4	70.0	160.8	5.5	10.5	2.00
February	20.9	8.3	65.0	187.2	5.9	12.9	2.77
March	24.3	10.5	57.0	235.2	7.7	17.7	4.29
April	29.3	14.2	45.0	292.8	9.3	22.4	6.63
May	33.7	17.6	38.0	285.6	9.4	23.8	8.01
June	36.7	20.4	38.0	276.0	11.8	27.7	8.98
July	37.8	22.1	40.0	288.0	11.7	27.3	9.20
August	37.6	22.4	44.0	266.4	11.6	26.1	8.42
September	36.1	21.2	47.0	225.6	10.5	22.3	6.83
October	32.3	17.9	51.0	170.4	10.5	19.1	4.78
November	26.4	12.9	60.0	141.6	6.5	11.9	2.77
December	20.5	9.0	70.0	136.8	5.6	9.9	1.84
Average	29.6	15.3	52.1	222.2	8.8	19.3	5.54

Pen-Mon equation was used in ETo calculations with the following values
:for Angstrom's Coefficients
a = 0.25 b = 0.5

CropWat 4 Windows Ver 4.2 2003/12/4

Climate and ETo (grass) Data
Country : West Bank Station : Jericho
.Altitude:-250 meter(s) above M.S.L
(Latitude: 31.85 Deg. (North) Longitude: 35.45 Deg. (East

Month	MaxTemp (deg.C)	MiniTemp (deg.C)	Humidity (%)	Wind Spd. (Km/d)	SunShine (Hours)	Solar Rad. (MJ/m2/d)	ETo (mm/d)
January	19.1	7.4	70.0	160.8	5.5	10.5	2.00
February	20.9	8.3	65.0	187.2	5.9	12.9	2.77
March	24.3	10.5	57.0	235.2	7.7	17.7	4.29
April	29.3	14.2	45.0	292.8	9.3	22.4	6.63
May	33.7	17.6	38.0	285.6	9.4	23.8	8.01
June	36.7	20.4	38.0	276.0	11.8	27.7	8.98
July	37.8	22.1	40.0	288.0	11.7	27.3	9.20
August	37.6	22.4	44.0	266.4	11.6	26.1	8.42
September	36.1	21.2	47.0	225.6	10.5	22.3	6.83
October	32.3	17.9	51.0	170.4	10.5	19.1	4.78
November	26.4	12.9	60.0	141.6	6.5	11.9	2.77
December	20.5	9.0	70.0	136.8	5.6	9.9	1.84
Average	29.6	15.3	52.1	222.2	8.8	19.3	5.54

Appendix (II) Continue

Climate and ETo (grass) Data

Country : Palestine (West Bank) Station : Jerusalem
.Altitude: 800 meter(s) above M.S.L
(Latitude: 31.78 Deg. (North) Longitude: 35.22 Deg. (East

Month	MaxTemp (deg.C)	MiniTemp (deg.C)	Humidity (%)	Wind Spd. (Km/d)	SunShine (Hours)	Solar Rad. (MJ/m2/d)	ETo (mm/d)
January	11.4	6.1	67.0	292.8	5.4	10.4	1.89
February	12.9	6.9	66.0	324.0	7.1	14.3	2.45
March	16.0	8.7	59.0	331.2	7.4	17.3	3.48
April	20.9	10.3	50.0	333.6	9.4	22.6	5.14
May	24.8	15.3	45.0	324.0	11.4	26.8	6.56
June	27.3	17.7	48.0	350.4	12.4	28.6	7.30
July	28.4	18.9	53.0	367.2	12.1	27.9	7.25
August	28.6	19.0	57.0	336.0	11.8	26.4	6.62
September	27.5	18.1	58.0	307.2	10.1	21.8	5.52
October	24.5	16.4	56.0	235.2	7.3	15.4	3.90
November	18.7	12.3	59.0	254.4	6.5	11.9	2.77
December	13.3	8.0	66.0	288.0	5.9	10.2	1.98
Average	21.2	13.1	57.0	312.0	8.9	19.5	4.57

Pen-Mon equation was used in ETo calculations with the following values
:for Angstrom's Coefficients
* a = 0.25 b = 0.5

CropWat 4 Windows Ver 4.2 2003/12/4

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Climate and ETo (grass) Data

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Data Source: D:\WALEED2\NABLUS.PEM

Country : Palestine (West Bank) Station : Nablus
.Altitude: 680 meter(s) above M.S.L
(Latitude: 32.22 Deg. (North) Longitude: 35.25 Deg. (East

Month	MaxTemp (deg.C)	MiniTemp (deg.C)	Humidity (%)	Wind Spd. (Km/d)	SunShine (Hours)	Solar Rad. (MJ/m2/d)	ETo (mm/d)
January	13.1	6.2	67.0	156.0	4.7	9.6	1.58
February	14.4	6.7	67.0	170.4	4.8	11.5	2.02
March	17.2	8.8	62.0	180.0	6.4	16.0	2.93
April	22.2	12.1	53.0	184.8	8.2	20.8	4.36
May	25.7	14.9	51.0	192.0	8.9	23.1	5.30
June	27.9	17.4	55.0	216.0	8.4	22.7	5.65
July	29.1	19.3	61.0	223.2	9.6	24.2	5.83
August	29.4	19.5	65.0	211.2	10.9	25.0	5.65
September	28.4	18.5	64.0	184.8	10.2	21.8	4.77
October	25.8	16.2	57.0	139.2	9.8	18.2	3.57
November	20.2	12.1	57.0	141.6	7.0	12.3	2.32
December	14.6	7.8	67.0	139.2	4.5	8.8	1.49

Appendix (II) Continue

Average 22.3 13.3 60.5 178.2 7.8 17.8 3.79

Pen-Mon equation was used in ETo calculations with the following values
:for Angstrom's Coefficients
a = 0.25 b = 0.5
****

Climate and Eto (grass) Data

Data Source : D:\WALEED2\ Tulkarm.PEM

Country: Palestine (WestBank) Station: TULKARM.
Altitude: 65 meter(s) above M.S.L
(Latitude: 32.31 Deg. (North) Longitude: 35.03 Deg. (East

Month	MaxTemp (deg. C)	MiniTemp (deg.C)	Humidity %	WindSpd. (Km/d)	Sunshine (Hours)	Solar Rad (Mj/m2.d)	Eto (mm/d)
January	13.3	8.6	72.0	103.2	5.2	10.0	1.34
February	13.8	8.7	76.0	98.4	5.5	12.3	1.64
March	16.7	10.8	75.0	91.2	6.5	16.1	2.37
April	21.5	13.8	65.0	81.6	7.7	20.1	3.47
May	24.6	15.9	62.0	79.2	9.0	23.2	4.30
June	27.2	19.4	69.0	69.6	10.3	25.5	4.87
July	29.0	22.1	68.0	69.6	9.7	24.3	4.93
August	29.6	22.7	74.0	64.8	8.9	22.2	4.48
September	28.2	21.2	70.0	62.4	8.3	19.3	3.70
October	26.8	19.2	67.0	69.6	7.6	15.6	2.83
November	20.8	14.3	64.0	91.2	6.7	12.0	1.93
Desember	15.9	10.6	71.0	96.0	5.3	9.5	1.33
Average	22.3	15.6	69.4	81.4	7.6	17.5	3.10

Pen-Mon equation was used in ETo calculations with the following values for Angstrom's Coefficients:

a = 0.25 b = 0.5

Appendix (Ш): The field survey {questionnaire) of this study.

An-Najah National University
Faculty of Graduated Studies
Environmental Science Program

SURVEY

Dear Farmer:-

Biogas technology is a technology applied for producing biogas (mainly methane gas) by anaerobic digestion for organic materials. Produced biogas could be used as energy source for many purposes like: - cooking, boiling water, lighting and operating engines. In additional to the biogas, this process produces a good organic fertilizer that could be used to enhance crops production and soil conditions. Also, there are many environmental positive impacts resulted from applying this technology.

This survey is a scientific one that mainly aims to see the ways used by farmers for treating and disposing their domestic, animals, and crops wastes; in additional to their sources of energy. And how these ways impact on their body and physical health, economic, and social life. The obtained data will be compared with the situation if the biogas technology applied in our rural areas.

All data will be used for scientifically purposes, and it will be deal with complete secret. So; we hope you will fill the correct required data on which our results and conclusions will be build up, which may help you in improving your life conditions.

Supervisor:-Prof. Marwan Haddad

Student: - Medyan Adel Hassan. Date: -01 / 11 /2003.

PART ONE

Family, and Family Raised Animals, Planted Areas, Energy Sources, and Generated Organic Wastes Fate Data.

A) - Please fill in the following space the required data:-

1- Total number of your family members -------------

2- Residence -------------.

B) - Raised Animals and Animals Dung Disposal Ways Data:-

Please; fill in the following table the required data about animals raised by your family. For animals feed types, write the suitable word that express about your animals feeds from (always, almost, sometimes, rarely, never).

Family Raised Animals Data

No.	Animals	Numbers	Animals Feed			
			grains	straw	fertilizers	Others (specify)
1-	Cows					
2-	Sheep					
3-	Goats					
4-	chickens					
5-	Others: a- b- c-					

Please; chick with (√) under the word that suitable to the statement about ways that may followed by your family for disposing or treating animals dung

Animals dung Treatment and Disposal Ways

No	Statements	All	Most	Some	Little	Nothing
1-	Collected in especial place to be disposed off later.					
2-	Collected to be through in the field (without fermentation).					
3-	Fermented for using as an organic crops fertilizer.					
4-	Burned to get energy (taboon for example)					
5-	Burned as a disposal method.					
6-	Collected for sale.					
7-	Fermented for biogas production.					
8-	Other ways------------------ ---------------------					

C) - Family Planting Areas and Crops Residues Disposal and Treatment Ways Data:-

Please; fill in the following tables the required information about your family planting activities.

Family Irrigated Crops

No.	Type of Planting	Most Planted Crops	Area (m^2)
1-	Plastic (covered)		
2-	Sustain(as lemons)		
3-	Un covered		

Family un irrigated Crops

No.	Type of Planting	Most Planted Crops	Area (m^2)
1-	Seasonally Crops		
2-	Sustain (as olives)		

Please; in the following table chick with (√) under the word that is suitable to the statement about ways that may followed by your family for treating and disposing its planting wastes and residues:

Planting Wastes and Residues Fate

No	Statement	All	Most	Some	Little	Nothing
1-	Fed to animals (straw and leaves).					
2-	Burned in the field.					
3-	Remains in the field ground.					
4-	Removed to the field bounders.					
5-	Wood burned to get energy.					
6-	Straw made bales.					
7-	Fermented to produce biogas and/ or organic fertilizers.					
8-	Disposed off with animals wastes.					
9-	Other ways-----------------					

D) - Family Energy Sources Data:-

Please; fill in the following table your family energy sources with their monthly average costs and uses.

Family Energy Data

No.	Energy Source		Monthly Average Cost	Uses
1-	Electricity			
2-	Natural gas			
3-	Coal			
4-	Fire wood			
5-	Liquid fuel	gasoline		
		diesel		
		kerosene		
6-	Animal dung			
7-	Others			

E) - Family Domestic Wastes Fate:-

Please in the following table chick with (√) under the word that is suitable to the statement which talk about the way that may followed by your family for disposing off and treating organic domestic wastes.

Family Domestic Waste Fate

No.	Statement	always	almost	Sometimes	rarely	never
1-	Disposing solid domestic wastes in general containers.					
2-	Disposing solid domestic wastes on animals wastes disposal place					
3-	Feeding organic domestic waste to animals.					
4-	Fermenting organic wastes to get biogas and/ or fertilizers.					
5-	Disposed off in especial place near home.					
6-	Distributed in the planting areas.					
7-	Wastewater drained off to the absorption pit.					
8-	Wastewater drained off on the earth surface.					
9-	Wastewater drained off into near home valley or water stream.					
10-	Using wastewater for irrigating home plants.					
11-	Draining wastewater into general disposing net.					

PART TWO

General Indications

A) - Wastes and other issues impacts on rural people life.

Please; chick with (√) under the word that express about the situation expressed by the statements in the table below.

Wastes and Other Issues Impacts On Rural People Life.

No	statement	always	almost	Some times	rarely	never
1-	Suffering from rodents, flies, snakes, insects…ect					
2-	Suffering from bad smell of accumulated solid wastes.					
3-	Suffering from smell of wastewater.					
4-	Suffering from taboon smoke.					
5-	Suffering from neighbors farms					
6-	Grazing my animals on plants grow on solid disposal place.					
7-	Grazing my animals on plants grow on wastewater stream sides.					
8-	Using manufactured fertilizers to enhance my crops production					
9-	Using insecticides, herbicides,… for enhancing crops production.					
10-	Using animals' drugs for animals' treatment.					
11-	Suffering from repeated diseases in my family members.					
12-	Using drugs to reduce or kill insects, rodents, flies….					
13-	Cleaning my animals farm.					

Last table continues..

14-	Neighbors complain to you from your animals farm impacts							
15-	Wearing safety clothes when using animals and plants drugs and treatments.							
16-	Suffering from unavailability or bad governmental services	a- electricity						
		b- water						
		c- agricultural advertising						
		d- roads						
		e-finance help						
		f-wastewater disposal						
		g-solid waste disposal						
		h-health services						
		i-education						

B)-Farmer opinion toward wastes issues.

Please; in table -9- below chick with (√) under the word that agrees with your opinion toward the issues in the following statements.

Farmer Opinion toward Wastes Issues

No	Statement	Surely	May	Doubte	No
1	Accumulating wastes pollutes soil and water environments.				
2	Burning wastes and crops residues pollute air environment.				
3	Accumulating and wrong disposal and treatment of wastes increase distribution of flies, rodents…				
4	Flies, rodents… are considered diseases causing or / and disease victors.				
5	Un isolated cess pits cause pollution to the ground water in additional to soil.				
6	Polluting soil, water and air impacts negatively human health.				
7	Wastes accumulation and wrong disposal cause negative impacts on human body and physical health.				
8	Irrigating crops with wastewater causes diseases for consumer health.				
9	Feel disturbed when I see accumulated waste.				
10	Cleaning animal farm within short periods impacts positively human life and animal health.				
11	Using manufactured fertilizers (for crops and animals) impacts positively consumer health.				
12	Grazing animals plants growing on wastes will negatively impacts human and animal health.				
13	Un fermented organic waste as a fertilizer is better than the fermented waste.				
14	Using animals and plant drugs enhance their production.				
15	Using animals and plants drugs improve human health.				
16	Applying biogas technology reduces the volume of the wastes to be disposed off.				
17	I will apply biogas technology, if its economic is feasible.				
18	I will construct a biogas plant, if I get a financial help.				
19	I will use biogas instead of natural gas, if it of less cost.				
20	If you don’t raise animals, are you ready to raise if biogas plants applied and give good economic results?.				
21	Feel disturbed from smelling wastes odors.				

PART THREE

Different Questions

Please; circle the symbol of your choice that agrees with your reply to the questions of choices. While write your answers in the prepared spaces for the questions require that:-

Q1:- Before this visit, your knowledge about biogas technology:-

a- much   b- something   c- little   d- nothing

Q2:- Your knowledge about anaerobic fermentation process for organic wastes:-

a- much   b- something   c- little   d- nothing

Q3:- Is there a cess pit for disposing your family waste water?

a- yes   b- no

Q4:- If there is a cess pit, is it internally isolated by cement or any other material?

a- yes   b- no

Q5:- Do you think that the contents of the cess pit seals into surrounding soil?

a- yes   b- may be   c- no

Q6:- Your family cess pit contents emptied once within a period of:-

a- 6 months   b- one year   c- two year   d- three years and more

Q7:- The distance between your home and the nearest waste disposal place is: - (-------) meter.

Q8:- Your animals' farm cleaned once every ---------- days.

Q9:- Problems facing your family in disposing off or treating :-

1- Home solid wastes are ---

2- Animals dung are ---

3- Wastewater are ---

4- Crops residues and planting wastes ---

Please; if you have any notes or suggestions about this questionnaire subjects write it below.

=== Thank You ===

Appendix (IV) Arabic copy of the survey

بســــــــم الله الرحمن الرحيم

جامعة النجاح الوطنية

كلية الدراسات العليا

قسم العلوم البيئيـــة

استبيان

السلام عليكم و رحمة الله؛

عزيزي المزارع:-

تكنولوجيا الغاز الحيوي هي تكنولوجيا مطبقة لإنتاج الغاز الحيوي (أساسا غاز الميثان) من عملية الهضم اللاهوائي للمواد العضوية. يمكن استخدام الغاز الناتج كمصدر للطاقة لعدة أغراض مثل:- الطبخ، تسخين الماء، الإضاءة، وتشغيل المحركات. بالإضافة للغاز الحيوي ينتج عن هذه العملية سماد عضوي يمكن استخدامه لتحسين إنتاج المحاصيل الزراعية. أيضا هنالك عدة تأثيرات بيئية إيجابية تنتج من تطبيق هذه التكنولوجيا.

هذا الاستبيان هو استبيان علمي يهدف أساسا إلى استيضاح الطرق المتبعة من قبل المزارعين لمعالجة و التخلص من نفاياتهم:- المنزلية، الحيوانية، و الزراعية بالإضافة لمصادر حصولهم على الطاقة؛ وكيف تؤثر هذه الطرق على صحتهم البدنية و النفسية و على وضعهم الاقتصادي و حياتهم الاجتماعية. البيانات التي سيتم الحصول عليها سوف تقارن مع الوضع فيما لو طبقت مشاريع الغاز الحيوي في منطقتنا.

جميع البيانات التي ستعبأ من قبل المزارع في هذا الاستبيان سوف تستخدم لإغراض علمية فقط، و سوف تعامل بسرية تامة. لذلك نرجو منكم تعبئة المعلومات المطلوبة و الصحيحة، حيث ستبنى عليها النتائج و الاستنتاجات التي قد تساعدكم في تحسين ظروف حياتكم.

شاكرين حسن تعاونكم.

المشرف:- البروفسور مروان حداد

الطالــــب:- مدين عادل حسن

التاريـــخ:- 2003/11/1م

القسم الأول

بيانات:- العائلة؛ الحيوانات المرباة لديها؛ مصير النفايات العضوية الناتجة عن نشاطاتها

أ)- الرجاء تعبئة البيانات المطلوبة في الفراغات التالية:-

1- مجموع عدد أفراد أسرتك ------.

2- مكان السكن -----------.

ب)- بيانات الحيوانات المرباة و طرق التخلص من روثها:-

الرجاء تعبئة الجدول التالي بالبيانات المطلوبة حول الحيوانات المرباة لدى عائلتك. فيما يتعلق بنوع طعام الحيوانات، الرجاء وضع الكلمة المناسبة من القائمة (دائما/ غالبا/ أحيانا/ نادرا/ أبدا) في العامود المناسب أمام نوع الحيوان.

بيانات الحيوانات المرباة لدى العائلة.

الرقم	الحيوانات	العدد	طعام الحيوانات			
			حبوب	قش	أعلاف مصنعة	غير ذلك (حدد)
1	أبقار					
2	أغنام					
3	ماعز					
4	دجاج					
5	أخرى:- ا- ب- ج-					

في الجدول التالي، الرجاء وضع إشارة (√) تحت الكلمة المناسبة للعبارة التي تقابلها حول الطرق التي تتبعها عائلتك لمعالجة أو التخلص من روث حيواناتها.

طرق معالجة و التخلص من روث الحيوانات

الرقم	العبارة	جميعه	معظمه	بعضه	قليل منه	لاشيء
1	يتم جمعه في مكب خاص للتخلص منه فيما بعد					
2	يتم جمعه لينثر في الحقل (بدون تخمير)					
3	يخمر ليستعمل كسماد عضوي للمحاصيل					
4	يحرق للحصول على الطاقة (كما في الطابون مثلا)					
5	يحرق كوسيلة للتخلص منه					
6	يجمع كي يباع للمزارعين					
7	يتم تخميره لإنتاج الغاز الحيوي					
8	طرق أخرى (حدد ---------)					

ج)- بيانات العائلة الزراعية:-

الرجاء تعبئة الجداول التالية بالبيانات المطلوبة حول نشاطات عائلتك الفلاحية.

المحاصيل المروية.

الرقم	نوع الزراعة	المحاصيل الأكثر تكرارا في الزراعة	المساحة (م²)
1-	بلاستيكية		
2-	دائمة (كالحمضيات)		
3-	غير مغطاة		

المحاصيل الغير مروية لدى العائلة.

الرقم	نوع الزراعة	أكثر المحاصيل تكرارا في الزراعة	المساحة (م²)
1	الفصلية		
2	دائمة (كالزيتون)		

رجاء في الجدول التالي؛ وضع إشارة (√) تحت الكلمة المناسبة للعبارة المقابلة و التي تعبر عن الطرق المتبعة من قبل العائلة لمعالجة أو التخلص من بقايا و نفايات المحاصيل الزراعية.

مصير بقايا و نفايات المحاصيل.

الرقم	العبارة	جميعه	معظمه	بعضه	قليل	لا شئ
1	يطعم للحيوانات (القش و الأوراق)					
2	يحرق في الحقل					
3	تترك في أرض الحقل					
4	يلقى على حدود الحقل					
5	يحرق الخشب (سيقان و أغصان) للحصول على الطاقة					
6	يجمع القش على شكل قوالب (بالات)					
7	تخمر البقايا النباتية للحصول على الغاز الحيوي أو السماد العضوي					
8	تلقى في مكب روث الحيوانات					
9	أخرى (حدد ----------------)					

د)- بيانات مصادر الطاقة للعائلة الريفية:-

بالرجاء تعبئة الجدول التالي بالبيانات المطلوبة حول معدلات التكاليف الشهرية لكل من مصادر الطاقة المذكورة مع ذكر أهم الاستخدامات لكل منها.

بيانات الطاقة للعائلة

الرقم	مصدر الطاقة		معدل الاستهلاك الشهري (دينار أردني)	الاستخدامات
1	الكهرباء			
2	الغاز الطبيعي			
3	الفحم النباتي			
4	الحطب			
5	الوقود السائل	البنزين		
		السولار		
		الكاز		
6	روث الحيوانات			
7	أخرى			

هـ)- مصير النفايات المنزلية للعائلة:-

رجاء؛ في الجدول التالي وضع إشارة (√) تحت الكلمة المناسبة للعبارة المقابلة المتعلقة بالطرق التي تتبعها عائلتك للتخلص من نفاياتها المنزلية.

مصير النفايات المنزلية للعائلة.

الرقم	العبارة	دائما	غالبا	أحيانا	نادرا	أبدا
1-	إلقاء النفايات المنزلية الصلبة بالحاويات العامة					
2-	إلقاء النفايات المنزلية الصلبة في مكب روث الحيوانات					
3-	إطعام النفايات المنزلية العضوية للحيوانات					
4-	تخمر النفايات المنزلية العضوية للحصول على الغاز الحيوي و/ أو السماد العضوي					
5-	يتم إلقائها في مكب خاص قرب البيت					
6-	تنثر في الأرض الزراعية					
7-	يتم التخلص من المياه العادمة بتصريفها لحفرة امتصاصية					
8-	تصرف المياه العادمة على سطح الأرض					
9-	يتم تصريف المياه العادمة لأحد الأودية أو الجداول المائية القريبة من البيت					
10-	أستخدم المياه العادمة لري النباتات المنزلية					
11-	يتم تصريف المياه العادمة في شبكة التصريف العامة					

القسم الثاني

مؤشرات عامة

يتكون هذا القسم من جزأين هما :- تأثيرات النفايات و أمور أخرى على حياة الريفيين و رأي المزارع تجاه قضايا النفايات.

أ)- تأثيرات النفايات و أمور أخرى على حياة الريفيين

بالرجاء؛ في الجدول التالي وضع إشارة ($\surd$) تحت الكلمة المناسبة التي تعبر عن الحالة الواردة في العبارة المقابلة لها.

تأثيرات النفايات و أمور أخرى على حياة الريفيين

الرقم	العبارة	دائما	غالبا	أحيانا	نادرا	أبدا
1-	أعاني من انتشار الحشرات، الفئران، الزواحف					
2-	أعاني من الروائح الكريهة للنفايات المتراكمة					
3-	المعاناة من الرائحة الكريهة للمياه العادمة					
4-	أعاني من دخان الطابون (للعائلة أو الجيران)					
5-	منزعج من وجود حظائر الحيوانات عند الجيران					
6-	أرعى حيواناتي على النبات النامي على مكب النفايات الصلبة					
7-	أرعى حيواناتي على النبات النامي على جوانب جداول المياه العادمة					
8-	أستخدم الأسمدة المصنعة لتحسين إنتاج المحاصيل					
9-	استخدم مبيدات الأعشاب، مبيدات الحشرات و الأدوية لتحسين إنتاجية المحاصيل					
10-	أستخدم الأدوية لمعالجة حيواناتي					
11-	هناك أمراض تكرر إصابة أفراد العائلة بها					
12-	أستخدم الأدوية لقتل أو التقليل من الحشرات والفئران و الذباب					
13-	يتم تنظيف حظيرة الحيوانات المرباة لدي					

14-	يشكو لك جيرانك من تأثيرات حظيرة حيواناتك						
يتبع الجدول السابق							
15-	أرتدي الألبسة الواقية (الكفوف، القناع...) عند استخدام الأدوية و العلاجات الزراعية						
16-	أعاني من عدم توفر أو سوء الخدمات الحكومية	أ- الكهرباء					
		ب- الماء					
		ج- الإرشاد الزراعي					
		د- الطرق					
		ه- المساعدات المالية					
		و- المياه العادمة					
		ي- التخلص من النفايات					
		ز- الخدمات الصحية					
		ر- التعليم					

ب)- رأي المزارع تجاه قضايا النفايات

الرجاء؛ في الجدول التالي وضع إشارة (√) تحت الكلمة التي تتوافق حسب رأيك مع العبارة المقابلة لها.

رأي المزارع تجاه قضايا النفايات.

الرقم	العبارة	متأكد	ممكن	متشكك	لا
1-	تراكم النفايات يلوث التربة و البيئة المائية				
2-	حرق النفايات و بقايا المحاصيل يلوث البيئة الهوائية				
3-	تراكم والتعامل و التخلص الخاطئ من النفايات يزيد من انتشار الحشرات و الفئران				
4-	تعتبر الحشرات و القوارض... من مسببات الأمراض				
5-	الحفر الامتصاصية الغير معزولة عن محيطها تسبب تلوثا للتربة و المياه الجوفية				
6-	تلوث الماء الهواء والتربة يؤثر سلبا على صحة الإنسان				
7-	تراكم النفايات و التخلص الخاطئ منها يؤثر سلبا صحة				

	الإنسان البدنية و النفسية				
يتبع الجدول السابق					
8-	ري المحاصيل بالمياه العادمة يسبب أمراضا للمستهلك				
9-	أشعر بالضيق عند رؤية النفايات المتراكمة				
10-	تنظيف حظيرة الحيوانات على فترات قصيرة ينعكس ايجابيا على صحة الإنسان و الحيوان				
11-	استخدام المخصبات المصنعة (للنبات و الحيوان) يؤثر ايجابيا على صحة المستهلك				
12-	رعي الحيوانات على مكب النفايات و جداول المياه العادمة يؤثر سلبا على صحة الإنسان				
13-	النفايات العضوية الغير مخمرة أفضل من تلك المخمرة				
14-	استخدام الأدوية للحيوان و النبات يحسن من إنتاجها				
15-	استخدام الأدوية للحيوان و النبات يحسن صحة الإنسان				
16-	تطبيق تقنية الغاز الحيوي يقلل من حجم النفايات المراد التخلص منها				
17-	سوف أطبق تقنية الغاز الحيوي إذا كانت مجدية اقتصاديا				
18-	مستعد لبناء مشروع للغاز الحيوي إذا حصلت على مساعدة تمكنني من ذلك				
19-	سوف استخدم الغاز الحيوي بدلا من الغاز الطبيعي إذا كان أقل تكلفة				
20-	مستعد لاقتناء حيوانات (إن لم يكن لديك)، إذا طبقت مشاريع الغاز الحيوي و أعطت نتائج اقتصادية جيدة				
21-	أشعر بالضيق عندما أشتم رائحة النفايات				

القسم الثالث

أسئـــــلة مختــلفة

السؤال الأول:- قبل هذه الزيارة، معرفتك عن تقنية الغاز الحيوي:-

أ- كبيرة ب- بعض الشيء ج- قليلة د- لا شيء

السؤال الثاني:- معرفتك حول عملية التخمر اللاهوائي للنفايات العضوية:-

أ- كبيرة ب- بعض الشيء ج- قليلة د- لا شيء

السؤال الثالث:-توجد حفرة امتصاصية لتصريف المياه العادمة المنزلية :-

أ- نعم ب- لا

السؤال الرابع :- الحفرة الامتصاصية (إن كانت موجودة) معزولة أسمنتيا أو بمادة أخرى:-

أ- نعم ب- لا

السؤال الخامس :-محتويات الحفرة الامتصاصية تتسرب للحفرة المحيطة بها :-

أ- نعم ب- ممكن ج-لا

السؤال السادس :- يتم نضح محتويات الحفرة الامتصاصية مرة واحدة كل :-

أ-6 شهور ب- سنة ج- سنتين د- 3 سنوات أو أكثر

السؤال السابع :- المسافة بين بيتك و أقرب مكب نفايات هي ---------- متر.

السؤال الثامن :- يتم تنظيف حظيرة حيواناتي مرة واحدة كل ---------- يوما .

السؤال التاسع:- المشاكل أو الصعوبات التي تواجها عائلتك في التخلص من :-

1- النفايات المنزلية الصلبة هي --------------------------------

Appendix (I):- Agricultural Statistics (1998/1999) for Palestinian Territories. [PCBS, 2001]

جدول 1: المساحة المزروعة بأشجار الفاكهة والخضراوات والمحاصيل الحقلية لعام 1999/1998

Table 1: Cultivated Area of Fruit Trees, Vegetables and Field Crops, 1998/1999

Area: dunum

Governorate / Region	المجموع العام Grand Total	Field Crops المحاصيل الحقلية			Vegetables الخضراوات			Fruit Trees			
		المجموع Total	مروي Irrigated	بعلي Rainfed	المجموع Total	مروي Irrigated	بعلي Rainfed	المجموع Total	Unbearing غير مثمر		Bearing
									Irrig. مروي	Rainfed بعلي	Irrig. روي
Jenin	**339373**	93667		93667	43062	18266	24796	202644	–	–	469
Tubas	**45622**	20045	3359	16686	13508	13084	424	12069	295	1735	1258
Tulkarm	**160513**	12151	1107	11044	13072	11709	1363	135290	–	3055	4886
Nablus	**253000**	37732	3111	34621	5476	3899	1577	209792	11	2933	3105
Qalqiliya	**67634**	5358	–	5358	5625	4886	739	56651	–	1149	5721
Salfit	**86380**	6343	–	6343	969	140	829	79068	–	3630	73
Ramallah and Al-Bireh	**185295**	30217	12	30205	2677	336	2341	152401	–	444	150
Jericho	**34179**	2466	2466	–	23305	23305	–	8408	304	–	8104
Jerusalem*	**16155**	1749	–	1749	335	–	335	14071	1	429	–
Bethlehem	**40652**	5782	17	5765	2277	1056	1221	32593	–	825	–
Hebron	**230392**	88160	8	88152	3215	829	2386	139017	11	9638	5
Remaining West Bank	**1459195**	**303670**	**10080**	**293590**	**113521**	**77510**	**36011**	**1042004**	**622**	**23838**	**23771**
North Gaza	**36998**	4482	3537	945	12586	12401	185	19930	502	5	18723
Gaza	**30620**	2900	600	2300	6697	6697	–	21023	–	1500	10009
Deir Al-Balah	**31309**	5472	1004	4468	9119	9119	–	16718	1236	137	11703
Khan Yunis	**30633**	8748	8748	–	6456	6456	–	15429	2525	–	9051
Rafah	**23258**	3610	2980	630	10737	10737	–	8911	315	575	2529
Gaza Strip	**152818**	**25212**	**16869**	**8343**	**45595**	**45410**	**185**	**82011**	**4578**	**2217**	**52015**
Palestinian Territory	**1612013**	**328882**	**26949**	**301933**	**159116**	**122920**	**36196**	**1124015**	**5200**	**26055**	**75786**

* Jerusalem: Does not include those parts of Jerusalem which were annexed by Israel in 1967.

ن الذي ضمته اسرائيل عنوة بعيد احتلالها للضفة العربية عام 1967.

جدوى إنتاج الغاز الحيوي العائلي من النفايات
العضوية الممزوجة في المناطق الريفية الفلسطينية

إعداد
مدين عادل مصطفى حسن
إشراف
البروفسور مروان حداد

الملخص

تكنولوجيا الغاز الحيوي هي تكنولوجيا مطبقة لإنتاج الغاز الحيوي (مصدر طاقة) والسماد العضوي بالتخمر اللاهوائي للمواد العضوية، و خصوصا النفايات العضوية التي يجب التخلص منها مما يعطي المزيد من الأثار الإجتماعية- الإقتصادية و البيئية الإيجابية.

النجاح لمشاريع الغاز الحيوي في اي منطقة يعتمد على:- توفر المواد العضوية، تكاليف البناء، مصادر الطاقة الموجودة و تكاليفها، الخبرة و المعرفة، الظروف الماخية السائدة و خصوصا درجة الحرارة، و قابلية الناس لإقامة هذه المشاريع.

عني هذا البحث بدراسة الجدوى لإنتاج الغاز الحيوي العائلي من النفايات العضوية الممزوجة في مناطق الريف الفلسطيني بوساطة الإستبانة و فحص (20) عينة من النفايات العضوية الممزوجة تجريبيا.

بيانات الاستبيان تدعم رأينا حول أهمية إقامة مشاريع الغاز الحيوي العائلية في مناطقنا الريفية حيث أن معدل عدد أفراد الأسرة الريفية الفلسطينية هو (6.85) مع معدل شهري مرتفع لتكاليف الطاقة (45.97 دينار أردني للعائلة, أو 6.711 دينار أردني للفرد)، بالإضافة لتكاليف الاستخدام المعتاد للإسمدة المصنعه، الأدوية و العلاجات لحيواناتهم و محاصيلهم.

إن بيانات الإستبيان تشير أيضا لتوفر النفايات العضوية عند عائلاتنا الريفية، حيث أن معظم هذه العائلات يربي الحيوانات (72.47%) و ذو نشاطات فلاحة (87.45%)، بالإضافة لنفاياتهم المنزلية. علاوة على ذلك؛ تتبع هذه العائلات طرق غير مفيدة أو سلبية للتخلص من:- روث حيواناتها (تجمع للتخلص منها فيما بعد – 71.20%-)، نفاياتها المنزلية الصلبة (تلقى في

الحاويات العامة – 75.80%–) و مياهها العادمة (تسحب للحفر الإمتصاصية – 89.00%–). في المقابل؛ تطعم هذه العائلات بقايا محاصيلها و نباتاتها للحيوانات (70.80%) و هذه طريقة تخلص إيجابية.

أيضا؛ كشفت بيانات الإستبيان أن مواطني الريف الفلسطيني يعانون من الأثار السلبية للنفايات العضوية (نسبة معدل الإجابة ،60.3%) و أن لديهم وعيا أيجابيا حيال تأثيرات النفايات و قضاياها (متوسط النسبة، 65.2%). يمكن إستغلال هذه الامور لتحسين قابليتهم (متوسط النسبة الحالية،65.8%) لإقامة مشاريع الغاز الحيوي، و خصوصا إذا تم تزويدهم بالمساعدة المالية و المعرفة الضرورية حول تكنولوجيا الغاز الحيوي و فوائدها.

تم فحص عشرون عينة (18 عينة في هوا ضم صغيرة حجم كل منها 240 ليتر، و عينتان في هاضمين كبيرين حجم كل منهما 1500 ليتر) من المواد العضوية الممزوجة في الظروف الطبيعية. و قد تم دراسة تأثير العوامل التالية على إنتاجية العينات للغاز الحيوي و هي:– نوع النفايات العضوية، الخلط، حجم العينة و عامل زيادة كمية الماء.

هبطت درجات الحموضة لجميع العينات (تراوحت في البداية بين 6.52 و 8.12) ببطء في الأيام الأولى من عملية الهضم إلى ما دون (6)، ثم ارتفعت تدريجيا حتى وصلت أعلى من (7) في الأيام الأخيرة لها جميعا. أيضا؛ دلت بيانات التجربة على أن جميع العينات أنتجت الغاز الحيوي في درجات الحرارة السائدة و بمعدل (51.9غرام غاز حيوي) لكل كيلوغرام من النفايات العضوية المختلطة و وصلت لإعلى إنتاج لها من الغاز الحيوي خلال الفترة الزمنية ما بين (24 إلى 36) يوما من بداية التجربة و التي إستمرت لمدة (60) يوما.

حسب نتائج التجربة؛ فإن بقايا الطعام أنتجت أكبر كمية من الغاز الحيوي (67.3غ / كغ نفايات) ثم روث الحيوانات (59.5غ / كغ روث) بينما قش القمح أنتج أقل وزن (37.2غ / كغ قش). بالنسبة لإنواع روث الحيوانات؛ فإن روث الدجاج هو الأفضل انتاجية للغاز الحيوي (57.9غ / كغ روث) و بعد ذلك روث الأغنام و الماعز (53.8غ / كغ روث) و أخيرا روث الأبقار (48.7غ / كغ روث). لقد اتضح أن انتاج الغاز الحيوي يتحسن بزيادة المحتوى المائي للعينة (B11>B7>B10) و مع تحريك محتويات الهاضم حيث بلغت انتاجية الهاضم (D1)

ذو المحرك (58.93غ غاز حيوي / كغ نفايات) بينما بلغت انتاجية الهاضم (D2) بدون المحرك (48.46 غ / كغ نفايات).

من المتوقع أن العائلة الريفية الفلسطينية سوف توفر شهريا (23.07) دينارا أردنيا نتيجة استخدام الغاز الحيوي (بدلا من الغاز الطبيعي) و استخدام المادة العضوية المهضومة كسماد عضوي فيما لو أقامت مشروع غاز حيوي حجم 9م^3 و بإضافة يومية (30.83كغم) من النفايات العضوية.

بناء على نتائج الدراسة يوصى بما يلي :-

- إجراء المزيد من الدراسات لتزويد مواطني الريف بمعلومات أكثر حول تكنولوجيا الغاز الحيوي.
- بذل المزيد من الجهود لتحسين قابليتهم لهذه التكنولوجيا.
- تحسين الوسائل لتزويد العامة بالمساعدة الكافية لإقامة مشاريع الغاز الحيوي.

بسم الله الرحمن الرحيم

جامعة النجاح الوطنية
كلية الدراسات العليا

جدوى إنتاج الغاز الحيوي العائلي من النفايات العضوية الممزوجة في المناطق الريفية الفلسطينية

إعداد

مدين عادل مصطفى حسن

إشراف

البروفسور مروان حداد

قدمت هذه الأطروحة استكمالا لمتطلبات درجة الماجستير في العلوم البيئية بكلية الدراسات العليا في جامعة النجاح الوطنية في نابلس ، فلسطين.

2004م