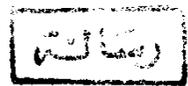


UTILIZATION OF RENEWABLE
ENERGY SOURCES IN AGRICULTURE

By

MOHAMED ABD EL-MAGID IBRAHIM OMAR GENAIDY

B.Sc. (Agricultural Mechanization)
Ain-Shams University, 1982



26093

Thesis

Submitted in Partial Fulfilment of
The Requirements for the Degree of

MASTER OF SCIENCE

in

Agricultural Sciences
(Agricultural Mechanization)



Soil Science Department
(Agricultural Mechanization Division)
Faculty of Agriculture
Ain-Shams University

631.371
M.A

1988

631.371

M.A

APPROVAL SHEET

Name : MOHAMED ABD EL-MAGID IBRAHIM OMAR GENAIDY

Title : Utilization of Renewable Energy Sources in
Agriculture.

Approved by:

Prof. Dr. A.M. Abdel Hafez

Prof. Dr. M. M. El-Hadi

Prof. Dr. A. E. Sultan

(Committee in charge)

Date 8 / 2 / 1988



ACKNOWLEDGEMENT

The author wishes to express his deep thanks and sincere appreciation to Prof. Dr. Mohamed N. El-Awady, Prof. and Head of Agric.Mech. Division, Ain Shams Univ. for suggesting this research, his interest, guidance, and supervision throughout this work.

Special thanks are extended also to Prof. Dr. Mobarak M. Mostufa, Prof. of Agric.Mech. Ain Shams Univ. and Dr. Abd El-Ghani M. El-Gindy, Ass. Prof. of Agric. Mech. Ain-Shams Univ. for supervision.

I would like to express my deep thanks and appreciations to all who assisted in any way in this research.

CONTENTS

	<u>Page</u>
I- INTRODUCTION	1
II- REVIEW OF LITERATURE.....	4
i. Bio-gas	4
i.1-Historical Background	4
2-Factors affecting the biogas process.....	6
2-1- Effect of temperature	6
2-2- Effect of hydrogen ion concentration(pH).....	7
2-3- Carbon: Nitrogen ratio	8
2-4- Dilution and stirring of digesting materials..	9
2-5- Loading rate and retention time	10
2-6- Volatile solids (V.S.)and type of wastes used.	11
3- Design and construction of biogas plants.....	12
4- Biogas utilizaiton	18
ii- Solar Energy	21
1.Applications of solar energy.....	21
2.Advantages of solar crop-drying	23
3.Solar-drying systems	25
4.Moisture content and temperature of drying	27
5.Air movement	28
6.Drying time	29
7.Efficiency of drying	30
III- MATERIALS AND METHODS	31
i- Biogas	31

	<u>Page</u>
i.1- Prototype digester and operation.....	31
i.2- Materials	31
i.2-a- Cattle dung	31
i.2-b- Chicken manure	34
i.3- Experimental procedures	34
i.3-a-Evaluation of biogas generation from cattle dung fermented in 50 l. biogas digester ...	34
i.3-b-Evaluation of biogas generation from chicken manure fermented in 50 l. biogas digester	37
i.4- Methods	38
i.4-a- Measurement of gas yield	38
i.4-b- Methane content	39
i.4-c- Carbon dioxide	39
i.4-d- Hydrogen-ion concentration	42
i.4-e- Moisture content	42
i.4-f- Total solids	42
i.4-g- Volatile solids	42
i.4-h- Organic carbon	42
i.4-i- Total nitrogen	42
i.4-j- Heat transfer through biogas digester walls	43
ii- Solar Energy	43
ii-1. Solar dryer.....	43
ii-1.a- Solar tent dryer design.....	46
ii-1.b- Solar tray-dryer design	46

	<u>Page</u>
ii-2-Materials	46
ii-3-Experimental procedure	46
ii-3-a- Evaluation of potato and onion drying by solar dryer as compared with direct sun drying	49
ii-3-b- Evaluation of mint drying by solar tent- dryer as compared with direct sun drying.	49
ii-3-c- Evaluation of grape drying by solar tent dryer as compared with direct sun drying.	49
ii-4- Methods	50
ii-4-a- Temperature measurement	50
ii-4-b- Moisture content measurement.....	50
ii-4-c- Relative humidity measurement	51
IV- RESULTS AND DISCUSSION	54
i- Biogas	54
i-1- Evaluation of biogas generation from cattle dung fermented in 50 l. biogas digester.....	54
i-1-a- Batch-fed digester of 50 l.....	54
i-1-b- 20 l.batch-feeding	60
i-1-c- Feeding under variable water dilutions....	62
i-2- Evaluation of biogas generation from chicken manure fermented in 50 l. biogas digester...	68
i-2-a- Feeding under variable water dilutions (ratio 2/1)	68
i-2-b- Feeding under variable water dilutions (ratio 3/1)	71

	<u>Page</u>
i-2- a- Batch-fed digester of 50 l	75
i-2-d- Batch-fed digester for 30 days-digester...	82
ii- Solar Energy (Solar dryer)	85
ii-1- Effect of drying air temperature on the agricultural crops.....	85
ii-2- Effect of moisture contents on the agricultural crops	89
ii-3- Evaluation of drying coefficient	89
V- CONCLUSION	95
VI- SUMMARY	99
VII- REFERENCES	104
VIII- APPENDICES	112
IX- ARABIC SUMMARY	

* * *

I- INTRODUCTION

Fossil energy is used in agriculture whenever it is economical and practical. Investment of energy in agriculture is of first importance. However, the efficiency of energy use in agriculture at present is not as great as it might be.

In the early 1970s, costs of petroleum increased rapidly. The depletion of nonrenewable petroleum energy resources has caused increased interest in renewable energy. Since 1973, the work on energy has been continuous.

Renewable energy can be obtained from many known resources such as:

- (1) Plant residues and animal wastes (biomass),
- (2) Sun (solar energy), and
- (3) Wind.

I.1. Biogas.

Biomass is a term applied to plant and animal materials collectively. Its supply will continue as long as solar energy supports life on earth. The technological procedures for converting biomass to energy are already available. Biomass produces "biogas" which is mostly methane (CH_4). In order to design a biogas plant to operate optimally, a knowledge

of the fermentation characteristics of the organic raw materials used is essential. Under the fermentation characteristics we include gas release in relation to time and the total gas yield until gas production ceases. Since it is not possible to forecast the fermentation behaviour of a substrate from its material composition, it must be determined by experiment.

The anaerobic technique of methanogenic fermentation is mainly used in agriculture for:

- The production of energy-rich gas as a substitute for conventional fuels.
- The reduction of environmental pollution which can be caused by untreated organic material.
- The improvement of the fertilizer value of the solid and liquid materials treated by the fermentation process.

I.2. Solar energy.

Energy from the sun can be used directly and indirectly. Solar energy has traditionally been used on farms to dry mature crops in the field or in a ventilated shed.

Drying crops, heating farm buildings, greenhouses and residences, and heating water for farm and domestic uses are applications compatible with direct sun collection and use of solar energy.

1.3. Wind energy.

Wind energy systems are possible alternatives in the north coast and other areas of the A.R.E. where high wind velocities prevail.

The present study was conducted to evaluate possibilities of energy production from biogas, and solar energy, for Agricultural applications.

II- REVIEW OF LITERATURE

i- BIO-GAS

1- Historical Background.

Natural gas, is probably the most important resource of methane in nature (contains about 95% methane). Natural gas was formed together with petroleum and coal from decomposing vegetation of the carboniferous swamps. Four thousand years ago in southwest China, this gas was already known as an energy supply and used for heating purposes in salt production. It was conducted through bamboo canes from deposits more than 1000 meters below the ground (Zehnder, 1978).

Energy requirement per head of cattle are estimated at the equivalent of 240 kg of fuel oil per year, of which 58% is expended on heating, sterilising and hot water, 8% on forage drying, 6% on electricity and the remainder on transport and tractors. The effluent produced per head of cattle is calculated to produce calories equal to 226 kg fuel oil per year (almost the amount required per head).

Solar energy is considered useful especially when backed up by a reliable source of power. Cultivation for energy is seen as a source a fairly distant future but an experiment has shown that 1 kg of fodder beet tops can produce 0.41 m³ methane (Meucelin, 1978).

The first scientific experiment was carried out by Davy (1808) in which anaerobic digestion of agricultural wastes was done. The researcher was able to collect 0.3 l of methane, and double that amount of carbon dioxide, from straw mixed with cattle dung and kept in a retort vacuum..

During the past 50 years many cities in Europe and North America have built anaerobic digesters to produce biogas and used it as a source of fuel for operating the sewage treatment plants. Recently, the biogas is converted to electricity which covers 60-80% of the plant energy demand. For example, in 1951, 48 sewage treatment plants in the Federal Republic of Germany provided more than 16 million m³ of sewage gas, 3-4% of which was utilized for power production, 16.7% for the digester heating, 28.5% was delivered into the municipal gas supply system, and 51.4% was converted to vehicle-motor fuel (Muenchner Beitrage Zur Abwasser, 1956).

In Egypt, the first biogas digester was to treat sewage sludge at Al-Gabal Al Asfer Farm since 1939. The digester had a volume of 750 m³ and was connected with a 1500 m³ biogas holder (Alaa El-Din et al.,1983).

2- Factors affecting the biogas process:

2.1- Effect of temperature.

Early investigation of the effect of temperature on anaerobic digestion of waste presented conflicting results. FAO (1978) reported that the micro-organisms which take part in methane production have optimum activity at 20-30°C. At lower temperatures, gas production is reduced. However, Hills (1982) reported that biogas is a product of biological activity, so the rate of production is greatly affected by temperature. Methane production can occur at any temperature up to ~70°C, but the optimum for maximum gas production in a practical plant appears to be 35°C. Greater gas production is possible at higher temperatures but the thermal sensitivity of methanobacters is critical, and the technology is insufficiently advanced at this time to recommend elevated temperature operation for farm digesters.

Digester processes have been classified into three types, depending on the operating temperature:

- 1- Psychophilic under 68°F (20°C).
- 2- Mesophilic from 68°F to 113°F (20-45°C).
- 3- Thermophilic from 113°F to 150°F (45-65°C).

The cost, complexity, and energy use of the rate of gas production increase with the temperature, as does

the rate of gas production. The amount of gas produced per kg of feedstock, however, can either increase or decrease with temperature (OTA, 1981).

2.2- Effect of hydrogen ion concentration (pH).

Methane forming bacteria are sensitive to pH. They work best in a range of pH 6.8 to 7.2 although they will tolerate a range of 6.5 to 8.0. If the pH grows too high the acidic carbon dioxide formed by the digestion process brings it down, but if it should be too low, the gas producing bacteria are unable to use up the acids quickly enough and the digestion stops. It will be a matter of some time before the balance is restored and digestion can resume. Introducing fresh raw material for digestion at a too high rate can cause the fermenting material to become acidic (FAO, 1978).

Hills et al. (1982) reported that the pH of a properly functioning digester should be between 7.0-8.0. Also, Hills (1980) observed ammonia-nitrogen and volatile acids concentration as high as 2,240 mg/l and 1,440 mg/l, resp., within a pH range of 7.4-7.8.

Nasr (1980) studied the effect of different pH values (from 6 to 10.7) on the gas production using constant initial solids of 4% maize stalks and found that the maximum volume of methane production took place at pH value of 8 where 183 and 153 l methane/kg VS.