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BIOGAS TECHNOLOGY

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PREFACE

The National Seminar on Biogas Technology was held in the Department of Civil Engineering, Punjab Agricultural University, Ludhiana from July 9 to July 11, 1981. The Seminar was organized with the support of ICAR/UNESCO Centre of Advanced Studies in the College of Agricultural Engineering and the Department of Science and Technology, Government of India. With the publication of these proceedings the organizing committee has fulfilled its commitment made with the participants.

The papers presented in this seminar deal with various aspects of biogas technology like contemporary development of biogas technology in India and China and their present status, chemistry and microbiology of anaerobic processes, economic aspects of biogas technology, integrated energy from renewable sources, biogas plant operation, mathematical modelling of biogas designs, etc. A special invitee Dr. E.L. Halwagi of National Research Centre, Cairo, Egypt, presented an excellent account of status of biogas technology in Egypt.

I shall like to place on record my appreciation towards Dr. B. S. Pathak, Dr. S. R. Verma, Dr. S. S Johl and the faculty and staff of Department of Civil Engineering who helped in organizing the seminar. Without their help it would not have been possible to hold the seminar successfully.

Special thanks are due to Dr. N. S. Randhawa, Deputy Director General, ICAR and Dr. M. S. Randhawa, Former Vice Chancellor for their encouragement in the biogas research programme at the Punjab Agricultural University.

It is hoped that the information contained in the proceedings will be useful to the scientists working in biogas technology.

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PILOT DEMONSTRATION OF BIOGAS TECHNOLOGY IN RURAL AREAS OF EGYPT

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1- INTRODUCTION

Within the context of the National Research Centre (NRC) R&D plan, 'Energy' constitutes one of the five priority programmes concomitant with national priorities. Biogas technology (BGT) is one major project in the NRC 'Energy' programme. Emphasis was placed on this project for several reasons. Foremost among these, are factors relating to rural development, energy, land productivity, sanitation, pollution abatement and waste recycling.

Since the latter part of 1978, a 5- year R&D and demonstration project was officially undertaken by the NRC under the auspices of the Academy of Scientific Research and Technology with financial support from USAID. The project is entitled "Development and Application of BGT in Rural Areas of Egypt". Its ultimate objective is to demonstrate that the application of BGT is technically, socially and economically feasible in rural areas of Egypt.

The project strategy fom the outset was based on the following premises:

1- Multidisciplinary team work to cover the various interrelated facets of the project.

2- Transfer and adaptation of appropriate technologies as much as possible.

3- Research confined to areas pertaining to local factors as well as increased efficiency of the Biogas system and its component sub-systems.

4- Pilot and field demonstrations to assess the technical as well as the socio-economic feasibility should not be started before adequate preparations are made in order to maximise the probabilities of a successful outcome.

2 PREPARATORY ACTIVITIES

Village demonstrations are not as simple as they may deceivingly appear to be. They are rather complex endeavours that require lengthy and careful preparations. Such preparations entail: development of scientific and technical capabilities, profound understanding of village socio-economic setting, development of interest and awareness among the village masses and proper cognizance of the villagers points of view, needs and expectations.

In order to shorten the time span needed to start the demonstration phase, several preparatory activities were concurrently undertaken. These encompassed assessment of appropriate technologies, sociological surveys, research and development activities; as well as an in-house pilot demonstrations.

Fact Finding Stage

The project started with a short fact -finding phase in which the BGT state-of-art was assessed; an Asian study tour was conducted by a multidisciplinary group in China, India and Thailand; techno-socio-economic surveys of a number of typical Egyptian villages representing traditional as well as new-planned types have been undertaken. Selection was based on preset criteria taking into account replicability, adequate representation of the characteristics of Egyptian villages, prospects of demonstration success and location accessibility.

Research, Development and In-house Pilot Demonstration

The second phase, which is almost complete, encompassed extensive oriented R& D work as well as in-house pilot demonstrations. A great deal of digestibility research work was carried out to bracket optimum conditions conducive to greater efficiency, highest pathogens destruction rates and diminishing the effect of toxic and inhibitory materials. Various substrates including cow and water buffalo dung, sewage and agricultural wastes (weeds, water hyacinth, maize and cotton stalks) were investigated at different mixing ratios, organic loading and temperature. Certain pretreatments including pre-composting were also examined.

Work was further conducted on the fate and effect of pesticides and herbicides possibly contaminating the agricultural feed-stocks. Two relevant problems were also studied on laboratory scale; the selective inhibition of hydrogen sulphide, and destruction of ova and embryos of Ascaris. Furthermore, a sizeable portion of work was done on the evaluation of digested products as fertilizer and soil conditioner; as well as on their handling, storage and application.

The highlights of research results may be summarised in the following:

1. The optimum initial solids concentration, which produces the highest volume of methane is around 8%.
2. Temperature strongly affects the rate of gas production.
3. Addition of crushed maize stalks increases the gas yield up to about 70% maize stalks in the mixture, after which a drop occurs.
4. Mixing of cotton stalks with cow dung appears to have an adverse effect on gas yield. However, pretreatment of cotton stalks by soaking into hot water for one hour leads to a considerable improvement.
5. Anaerobic digestion over a long enough period can virtually affect 100% reducton in faecal coliform. Streptococci seem to persist longer.
6. Incorpration of wrought iron seems to have notable beneficial effects on rate of gas production, hydrogen sulphide content and sulphate reducing bacteria count during anaerobic digestion.
7. The surest way to handle the Ascaris problem is through precomposting of the digestor feed materials whereby the generated heat would completely affect the required Ascaris destruction.
8. Digested materials have higher fertilizing value than an equivalent amount of farm yard manure.

9. The air dried slurry has high content of organic matter and minerals, but a considerable loss of nitrogen through volatilization took place.
10. Adsorption of slurry on silt decreased the nitrogen loss to 2% only, but the product has low conetent of organic matter and nutrients.
11. The post-composting of digested slurry resulted in increasing the total nitrogen content as well as the quantity of manure, but the product has a lower content of minerals than dried slurry.

The engineering and development work was directed towards design, construction, operation and testing of three family-size prototype units at the demonstration site of the National Research Centre; as well as development of local appropriate gas-use devices. The first prototype unit is a fixed roof 10 m^3 rectangular digester of Chinese design. The second is 6 m^3 cylindrical wide, shallow type dome- roofed Chinese digester. It is anticipated, after the experience gained with construction of the second prototype and its successful operation for almost one year, that this type has good prospects as a family-size unit in rural areas of Egypt. It presently costs around U.S.$. 300 using locally available materials and skills. The third prototype unit is a new adapted design combining the features of both plug flow and the Indian movable cap types. Its effective size is about 7 m^3 and costed around U.S.$ 500. Provisions for solar heating of feed water, composting of the digestor effluent on the top of the plug flow part, and attachment to both a latrine and an animal shed were incorprated in the unit. This type seems readily expandable to the community size. The National Research Centre demonstration site, with all the biogas systems present, is also utilized for training as well as for publicising the BGT.

Performance characteristics, particularly those pertaining to the Chinese cylindrical wide dome-roofed type were assessed using cow dung. New data were obtained on the effect of operating pressure and internal mixing patterns. Major findings are briefly outlined in the following:

(a) The digestor, on account of its design and insulation effect of the ground, has inherently good thermal stability characteristics. Temperature varies very slowly with time (about 2 degrees C per month). Axial temperature profiles inside the digester indicated negligible differences (0.2- 0.4° C).

(b) Gas production rate decreases with pressure. At constant temperature of 24° C, it varied from 0.304 m^3/m^3 digestor/day at a pressure of 7 cm. water to 0.18 at a pressure of 70. This is attributed to the losses accompanying the increased dead volume of digested slurry in the outlet port.

(c) Methane content of the gas increased with increasing pressure (upto 75%). This appears to be a consequence of higher carbon dioxide solubility.

(d) Residence time distribution of digestor contents was determined using a novel and simple tracer technique. A pulse of plastic beads having approximately same density as that of slurry was employed at zero time and their concentration in the effluent was determined over a two month period. Results indicated an appreciable degree of internal mixing.

3- VILLAGE DEMONSTRATION

To start BGT promotion in the right direction, field demonstrations are essential. The village demonstration phase is thus the central focus of the whole project. The purpose is to introduce the technology to the farmer on a concrete level through full-scale demonstration so as to convince him with its adoption and identify his point of view regarding its applicability and scale. According to the project plan, demonstrations are to take place in two selected villages, a traditional and a new planned type. Family-size as well as community -scale units are to be demonstrated. These demonstrations will then be followed up and evaluated to assess

their viability, social and environmental impacts and identify the optimum course of action for possible implementation on the national scale.

It was decided to start demonstrations in a nearby traditional village for which a preliminary socio-economic survey was made. Consequently, extensive visits were made to the village for orientation and preparation purposes as well as for selecting appropriate sites where initial demonstrations will taken place. Personal discussions at various levels were intensified, and limited group meetings were held. Posters and films were employed for spreading awareness. Selected village representatives were invited to visit the NRC demonstration site where they could see the operating prototype units and understand the basic ideas related to their construction, operation and maintenance.

The implementation of the village demonstration program started since late February 1981. Two family-size digestors, 10 cu. m. each were built, one of a modified Indian type attached to a farmer house, and the other of the Chinese type erected in the village collective unit. Certain modifications were introduced in the design and construction techniques to cope with the local village conditions (particularly that pertaining to the adverse effect of the high water table) and to increase the gas yield, as well as to simplify the handling of the digestor effluent. Both units were successfully started -up since May 1981.