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NATIONAL RESEARCH CENTRE

APPLIED SCIENCE AND TECHNOLOGY PROJECT
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Demonstration subproject
(Academy of Scientific Research and Technology)

THE DEVELOPMENT AND APPLICATION OF BIOGAS TECHNOLOGY IN RURAL AREAS OF EGYPT

Tenth progress report (PR/10)

Submitted to the JCC

by

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1- INTRODUCTION

This summary progress report covers the period from actober 1983 to March 1984. It undertakes to outline the recent project achievements and propose the future course of action.

2- ACHIEVEMENTS OVER THE PAST SIX MONTHS

The highlights of the major achievements are presented in the following subsections. Emphasis has been on monitoring of field demonstration units; and introducing whenever necessary beneficial engineering modifications Various project disciplinary groups continued with relevant R & D work as well as needed support services and studies. In addition, complementary endeavors encompassed preparation work for the November 1984 biogas conferenence to be held in Cairo, training of project personnel and miscellaneous activities that have not been included in the project plans for the report period.

2.1- Follow-up and Modification of Demonstration Units

Follow-up of operating field digestors continued on a regular basis. This encompassed basically technical performance and environmental factors effects. Modifications were made either to alleviate operating problem or to improve the efficacy of the field unit in question. Most of these efforts were devoted to the shubra Kass large-scale unit.

2.1.1- The Shubra Kass Plant

As outlined in the previous reports, a 50 cubic meter capacity unit was installed at Shubra Kass village near Tanta. The unit is operated in conjunction with a typical poultry rearing farm in that area.

Over the past six months, the unit was successfully operated. Howlver, frequent problems and operation difficulties were encountered. These are mostly related to the poultry manure characteristics; particularly those emanating from the high nitrogen content of the

substrate, and the large amount of wheat straw mixed with the poultry droppings (resulting from its use as bedding material).

The follwing major modifications have been introduced to evade operating problems and to increase the net gas production rate and its utilization.

1- Mixing of slurry and scum breaking: Because of the presence of a high percentage of wheat straw in the feestock, the manual mixers installed for scum breaking were not operating satisfactorily. In order to circumvent this labor-intensive and irrepairable mechanical mixing system, a new gas mixing system was installed. The mixing gas is delivered at 5 points distributed over the whole digestor length by means of a compressor capable of circulating about 10 m^3/hr of biogas. This mixing system was found to be highly efficient, easy to operate, and only consumes about half KW per day of electric energy.

2- Recycling of the slurry: The unit was equipped with a slurry recycling system. This consists of a submerged slurry pump and a distribution piping network. The effluent is recycled from the outlet opening to the feed mixing chamber of the digestor. In addition, the slurry can be recycled at two points above the scum layer in order to assisst in its breaking and digestion.

Slurry recycling has several advantages. These include increasing the effective solid retention time and the number of active bacteria held within the system, as well as decreasing the overall heating requirements through the partial recycling of the warm effluent and using it as diluent for fresh feed.

3- Electrical power generation with waste heat utilization: A 3.5KW gasoline engine-generator was converted to operate on biogas. A damper and a filter for the purification of biogas were installed in the gas line connected to the engine. The damper was designed to act both as a damper and water trap.

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A specially designed heat exchanger was used to capture the waste heat from the engine flue gases to produce hot water. The hot water thus produced is connected to the hot water line of the biogas unit. This in effect can replace the gas heater in either heating the slurry in the digestor or producing hot water for feeding.

A relatively elaborate measurement and control system is under installation. This will allow complete evaluation of the electric generation setup.

4- Hydrogen sulfide removal system. A specially designed scrubber was installed to remove the H_2S present in the biogas in order to alleviate corrosion problems in the metallic components of the system. The scrubber is 300 liter volume packed with iron turnings. The upper part of the scrubber is filled with porous plastic material which acts as a gas filter.

7.1.2- Status of the other Demonstration units

Except for the unit shared by the two families at Omar Makram village, all other field units continued to operate on a satisfactory basis. As a matter of fact, much improvement has been noted in the performance of the single-household units as a result of the modifications introduced last year. The following account outlines the status of each of the field units in both the villages of Manawat and Omar Makram.

A- The Manawat Units

A.1- The Modified Indian Unit Attached to the Khamis Family House.

This very first field demonstration unit continued toward the end of its third year to manifest its technical as well as socio-economic success. The high decrease in the labor costs associated with the manure handling operations after installing the biogas unit, encouraged the owner to start a small cattle fattening operation. The number of animals have been recently doubled. All the dung is fed

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to the unit and thus it operates at full capacity. The gas produced now exceeds the family requirements. Presently, we are trying to convince the owner to share this excess gas with a nearby family. If this attempt succeeds, a green-house will be installed around the unit to further increase the gas production rate. The additional gas will more than pay-off for the additional expenses.

A.2- The Modified Chinese Biogas Plant at the Village Collective Unit

Though this plant is not fed on a regular basis, it continues to operate reasonably well. In fact, it serves its purpose of being an 'exhibition-type' of unit visible in a centrally located place in the village.

Recently, the polyethylene gas line has been replaced by galvanized iron pipes. This will make the system easier to operate and safer to use.

B- The Omar Makram Units

B.1- The Chinese-type Unit attached to the Sharkawy Family House

This unit continued to show unequivocally its worth and viability. It actually provides a case in point for illustrating the feasibility of biogas technology when favorable conditions prevail.

The green-house installed around the unit last september proved to be quite advantageous. Preliminary results indicate an increase in the gas production rate by around 70% during the winter season.

B.2- The Diab Family Indian-Type Unit

This unit has also been running very well. The gas production rate increased by more than 50% after the installation of the green-house. The gas produced now is sufficient for the family needs, and is expected to exceed their requirements during the summer season.

The modification introduced last year in the effluent over-flow system enhanced the operability of the unit. The handling process of the effluent is now much cleaner and more convenient.

It is worthy of mention that the unit in its present state, after installing the greenhouse and modifying the effluent handling system, becomes a unique model. In effect, it illustrates that a small biogas digestor of just 5 m^3 size fed on manure of only 3 large animals can supply a relatively large family with the amount of gas required for their cooking needs.

5.3- The Indian-Type Unit shared By The Two Families

This unit is still shut-down on account of social differences that could not be as yet resolved. Attempts are still pursued along several lines that will hopefully solve the existing explicit and implicit problems between the two families.

6.- Research and Support Activities

In addition to the follow up of operating digestors, research work continued along the same lines described in the previous year reports. The highlights of these endeavors are outlined in the following.

The Fertilizer Evaluation Group

During the last six months the group continued studing the accumulative residual effect of biogas slurry in fresh form or after its treatments for a long storage period, in comparison with other manures supplemented to the same sand and clay soils in a controlled green-house experiment. The organic manures were added at the rate of 2% (20 tons/feddan) on dry basis at the beginning of every cultivation period. An ordinary crop rotation was carried. The first crop in this rotation was wheat as a winter crop (from November 1982 till May 1983). The second crop was turnips. It was cultivated from the half of August 1983 to the end of January 1984. The third crop will be onion.

The yield response of each crop was measured and analysed statistically. The root and shoot of each plant were analysed for total nitrogen, phosphorus and potassium as well as some microelements. The uptake of these elements was also determined. Soil samples at the beginning of cultivation and at the harvesting of each crop were taken for complete analysis for macro and

microelements, and major soil microbial groups related to soil fertility to follow the changes due to fertilization and cultivation. Also some important physical properties such as the soil water holding capacity and the total soluble salts were followed.

The results of the three cultivation periods will be reported in the next report.

The Parasitology Group

Work encompassed basically:

a. Conducting Laboratory-controlled experiments on the effect of anaerobic digestion of sludge upon the viability of parasitic helminth, protozoa and microorganisms; and
b. Performance of some ovicidal fungi.

Results indicated that:

1- Anaerobic digestion of sludge influenced the viability and development of T. vitulorum eggs and Eimeria oocysts .
- There is a decrease in the number of eggs and cysts due to their gravity settlement in the Laboratory-scale units.
3- The anaerobic digestion of sludge did not affect the viability of clostridial organisms but it enhanced its growth, while it did influence the growth of atypical Mycobacterium organisms and salmonella spp.
4- The performance of the ovicidal and oocysticidal fungi was adversely affected by the anaerobic digestion conditions.

The Fundamental Microbiology Group

The studies on combating scum formation by using anti-foaming agents were extended towards assessing the effects of these agents on the two main pracesses of anaerobic digestion, namely the cellulose utilisation and methanogenesis. This necessitated the further development of techniques used towards this aim. The textile coupon technique has been modified by using the aluminium cap sealed tubes. In addition to the determination of cellulytic activities, by the loss in weight, samples from gas phase

can be withdrawn for analyses. A wet combustion method is being developed for the manometric assay of methane. By measuring the fluorescent coenzgme F_{420} and CoM after their separation by thin layer chromrtography and thin layer electrophoresis. Epifluorescence microscopy is being used also for semi tquantification of methanogens.

The Central Services Laboratory

This group extended its support services to cover all the analyses, chemical and instrumental, needed for the follow up of operating digestors. In addition, the group takes care of a substantial portion of the analyses required by the fertilizer evaluation group, particularly in determining, the digested effluent content of metallic trace elements. The two group supervisors also undertake most of the coordination and follow-up work in conjunction with phase two equipment orders.

.J- Preparation For The 1984 Cairo Biogas Conference

Active arrangements continued in preparation for the International Biogas conference to be held in Cairo during the period 17-24 November 1984. The first conference announcement was widely distributed. Favorable responses came from a number of important international agencies. These included: USAID washington, IDRC canada, GTZ Germany, and a number of UN agencies. Over 50 individuals have sent abstracts before the deadline of March 1st.

Representatives of AID/TVA visited the principal investigator and the NRC twice. Intensive discussions and exchange of opinions took place during these visits. As a result, AID/TVA have agreed to sponsor 30 attendees from developing countries, in addition to around 5 staff members. A contribution of U.S. $ 15000 is committed as a share in the administrative costs. NAS has been following up all these developments.

Mr. James Chauvin from the Canadian IDRC Health Sciences Division met with the principal investigator on March 11 to discuss matters concerning the conference and relevant research interests. He indicated

that the IDRC will definitely be represented in the conference on account of the importance of its themes in the context of IDRC interests.

Coordination is also taking place for the participation of local institutions. These include: the agricultural Research Centre, supreme energy councils, and various universities.

.4- Other Activities

The following two events are worthy of mention:

1- Professor Robert A. Mah (Professor of Environmental Microbiology and Public health, UCLA), an internationally reputable authority in the field of methanogenesis, while being on a private visit to Egypt, spent two days at the NRC (December 6 and 7, 1983). He met with some key members of project team for a whole day. The next day, he presented an excellent review on "The Biogenesis of Methane in anaerobic systems" in a special seminar to which a number of epecialists from inside and outside the NRC were invited. These activities were arranged for last year while the principal investigator was visiting with Dr. Mah at UCLA.

2- Dr. T. Prakasam, one of the project U.S. Panel members, spent the period from December 24, 1983 till January 4, 1984 with the project team. His mission was carefully coordinated by NAS, and covered two major tasks. The first is to review the overall technical progress with the various project groups in preparation for a final joint document compiling the major experiences and findings accumulated throughout the project life span. The second is to conduct an intensive short course on " Application of principles of Microbiology and Biochemistry in the design and operation of waste treatment systems". This proved to be very useful and successful. Twenty participants from the Pilot Plant Laboratory, Water Pollution Control Laboratory and the Fundamental Microbiology group attended the course. Notes were prepared in advance and were distributed to all attendees prior to the course.

3- FUTURE PLANS

Future work will generally continue along the same lines presented in this report. These embody follow-up of field digestors, the R&D

support activities, and the conference preparations.

In addition, intensive efforts will be directed toward:

1- Completion of the new biogas project demonstration site at the NRC extension area. This has been lagging behind schedule because of delays in the site clearance and preparation.

2- Building additional field demonstration digestors.

3- Finalizing the techno-socio-economic assessment of the prospective biogas technologies within the prevailing conditions in the Egyptian rural areas.

4- CONCLUDING REMARKS

Much progress has been accomplished, though the overall achievements are less than our aspirations. We believe that the project has had, even as small as it may be, a favorable impact inside and outside Egypt. Some of the papers that came out of this project are being frequently referred to and even quoted in the literature. In fact, there has been much demand on the reprints, that we are out of most of them; and have to resort to making additional photocopies to meet the new requests. The upcoming conference, we hope, will further magnify and extend the project utility, and produce long-lasting conclusive assessments relating to the biogas technology, the bounds of its feasibility and the practical ways and means for its sound diffusion and healthy growth.

By March 1985, the present project will come to an end. But the spirit, the capabilities, the resources, the systems and the experiences that have been generated, should continue to fluorish. One way to ensure that, is to start a follow-on project under the auspices of the Applied Science and Technology Project. We shall be glad to prepare a full-fledged, justifiable proposal in this regard if the JCC will approve this concept in principle. The most opportune time for submitting such a project proposal would be after the end of the Cairo biogas conference in order to make full use of its outcome.