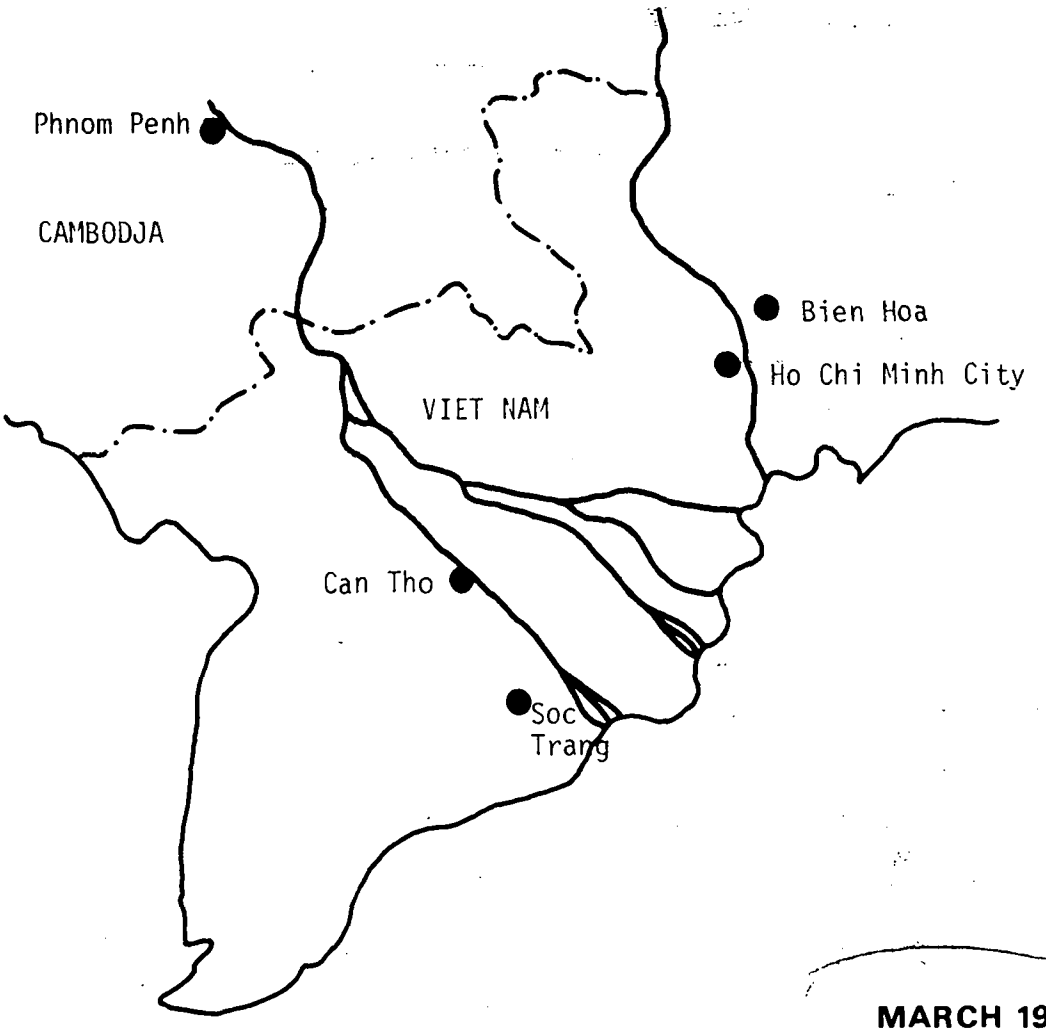
BIOGAS GENERATION AND ANAEROBIC TREATMENT OF WASTEWATER IN VIETNAM



MARCH 1983

DEPARTMENT OF WATER POLLUTION CONTROL

BIOGAS GENERATION AND ANAEROBIC TREATMENT OF WASTEWATER IN VIETNAM (VH 17)

- Report of a mission to Vietnam for the preparation of the interuniversitary cooperation between the Polytechnic University of Ho Chi Minh City and the Department of Water Pollution Control of the Agricultural University, Wageningen.

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1. AIM OF THE MISSION

The aim of my journey was to prepare a proposal for the future cooperation in the field of anaerobic treatment of wastes between the Polytechnic University of Ho Chi Minh City and the Department of Water-Pollution Control of the Agricultural University of Wageningen.
The project proposed in this report figures as Appendix 7. A bar-chart of the project activities is included in appendix 7 (pag. 43).
It is the intention that this project will be financed by NUFFIC in the framework of its PUO-fund.

During the correspondence that preceded the mission the two participants had agreed that their cooperation should have as its principal issue the anaerobic treatment of night soil, wastewater and agricultural wastes. As for the schedule of this mission, I had asked my colleagues in Vietnam to give me a broad outlook on the whole of the sanitary situation in the countryside. It appeared that they had prepared an interesting programme, for which I want to express my gratitude (see appendix 5).
This schedule focussed on three topics:
* the energy supply, and the possible use of biogas as an energy source,
* the problem of wastewater disposal in densely populated areas,
* the drinking-water supply, especially in the Mekong Delta.

A report on these topics will be found in the chapters 2, 3 and 4.
These chapters want to present an outline of the problems and the way the people in Vietnam are already working at their solution within their - unfortunately very limited - possibilities.

In chapter 5 there is a brief description of the Polytechnic University of Ho Chi Minh City.

Finally, I wish to express my hope that on the basis of the data in this report and the project proposal, the financing of the project will be agreed on soon.

2. BIOGAS GENERATION

The feasibility of a programme aiming at biogas generation from wastes in the countryside and of research serving as a basis, will mainly depend on the contribution the programme can make to the energy and fertilizer supply.

In sections 2.1 and 2.2 I shall shortly describe the energy and fertilizer problems as met with in Vietnam. Section 2.3 summarizes some criteria for the evaluation of a biogas programme. Section 2.4 reviews some examples of biogas research in the surroundings of Ho Chi Minh City.

2.1 Energy supply in the Mekong Delta

The supply of energy, especially to small communities and individual farming families, is felt as an important and difficult problem.

At the moment energy consumption in the Delta is low. The towns and some villages are supplied with electricity in a limited way. This electricity is generated by oil-fired engines. In the near future a big hydro-electric plant will also contribute to the electricity supply.

In most parts of the countryside there is no electric grid and oil is used for lighting. For cooking purposes mostly wood, or charcoal derived from wood, are used. There is an extensive trade and bartering in fire-wood. In the densely populated Delta a shortage of wood is felt. The gathering of wood is very time-consuming and prices are high.

In agriculture the use of fuels is still low as well. For activities like ploughing and the pumping of irrigation water animal traction and human labour are used in many places.

Something has been done about the mechanisation of agriculture during the last twenty-five years, especially among the wealthier farmers. This development was made possible by foreign financial aid. Recently contracts have been made for the supply of Austrian tractors. These are mainly used on the state-owned farms. In a village working collectively which we visited there were five tractors for an area of 500 ha. The village counts 1500 inhabitants.

It is hoped that Vietnam will have its own oil-sources in the future. Off-shore exploring activities have been going on for some years and have been resumed recently. Until now, however, nothing seems to be certain about the capacities of these fields.

Until now oil must be purchased from abroad at high costs in foreign currency.

The exploration of the use of the renewable energy sources, sun and wind, is at the very beginning.

At the Ho Chi Minh City Polytechnic University a windmill was being built for experimental purposes. In the Mekong Delta the use of windmills does not seem very feasible for the lack of a constant (strong) wind.

In view of the lack of energy sources, which expresses itself in high costs and hard labour for fuel supply, and the wish to explore new possibilities in this field experiments are started in various places in order to generate biogas from wastes.

2.2 Fertilizers

The vaste rice fields of the Mekong Delta mainly derive their fertility from the yearly flooding of the rivers.

Chemical fertilizer is used to a limited extent only. The large imports of before 1975 have diminished strongly.

Organic wastes like animal dung, night-soil and vegetable wastes (e.g. rice straw) are reused as fertilizers. Rice-straw is burned on the fields; dung and night-soil are spread in the vegetable gardens around the houses. This may cause hygienic problems. Night-soil is also used to fertilize the fish ponds. A large-scale application of the reuse of organic waste can be observed at the Ho Chi Minh City Refuse Plant.

The city's garbage is composted here. Farmers from the surroundings collect the compost which is partly enriched with pig dung.

The charges are 150 dong per ton for ordinary compost and 250 dong in the open market for enriched compost. (1 dong = 5 Dutch cts).

We may present these possible uses of waste materials as follows:

1.	Dung	→	Land (vegetable gardens)
	Night-soil	→	fish ponds or gardens
	Plant waste	→	burning on the land,
			building material

2. Dung
   Night-soil → composting → land, fish ponds
   Plant waste

3. Dung
   Night-soil → anaerobic → land, fish ponds
   Plant waste digestion → biogas.

We see as a third possibility the use of anaerobic digestion. In contrast to the other reuse-methods biogas can be produced. An additional benefit of anaerobic digestion (and composting) is a certain disinfection of the animal and human waste. This is of importance in view of the reuse as a garden fertilizer.

2.3 The feasibility of a biogas programme

Whether a programme for the construction of anaerobic digesters on a large scale in the Mekong Delta is feasible cannot be assessed at the moment.

On the one hand the necessary data on the design of a digester suited to local circumstances are not yet available, on the other hand a precise impression of all the relevant agricultural, economic, social and environmental parameters needed for a thorough evaluation is lacking.

It will be one of the tasks of the present project to contribute the material for this assessment.

In Appendix 2 a number of regional characteristics to assess in advance the chances of a biogas generation programme[1)] is summarized.

As a region does more satisfy all the characteristics simultaneously the chance will be greater that a biogas program in such a region will be successful.

An overall tentative assessment indicates that the Mekong Delta surely has good opportunities for a biogas program. But it can not yet be determined on which scale (the number and the size of the installations) biogas production from wastes can be applied in a socially and economically favorable way.

1) These characteristics were borrowed from A. Barnett, L. Pyle and K. Subromanian, Biogas Technology in the Third World. IDRC, 1978.

A possible restriction could be the availibility of enough animal waste (pig dung) and of investment capital.

Almost all families in the countryside own one ore more pigs and a number of chickens, but the dung of these few animals, if it can be collected at all, will probably not be enough to feed a small digester to produce the daily cooking gas for the family.

From data about comparable installations in other Third World countries it can be concluded that the quantity of daily dung of 5-10 pigs is needed for such a digester. Other organic waste will have to be added to the pig dung: human waste, kitchen wastes, banana leaves, water hyacinth, etc.

The experiences in other Asian countries show both successes and drawbacks.

There are large scale biogas applications in the People's Republic of China, in the Republic of Korea and in India. Many other countries are gaining experiences too, but on a smaller scale: Thailand, the Philippines, Nepal.

The family-size digester appears to meet many problems, all resulting in a too low gas production. Bigger digesters with a skilled operation on a continuous basis may offer better results.

The proposed research will have to demonstrate the possibilities of a remunerative production of biogas in the countryside by a combined feed of various types of waste and/or the use of bigger installations operated collectively.

2.4 Present research and development activities in the field of biogas

2.4.1 Research at the Ho Chi Minh City Polytechnic University (pig-manure)

2.4.2 Research at Electricity Company II in Ho Chi Minh City (pig-manure and domestic wastes)

2.4.3 Research at an experimental pig farm in Ho Chi Minh City (pig-manure)

2.4.4 Research at the Ho Chi Minh City Refuse Treatment Plant (municipal solid waste)

2.4.1 Research at the Ho Chi Minh City Polytechnic University

The research is carried out in cooperation by two Departments: the Department of Food Technology (Mr. Nguyen Duc Luong and Mr. Luu Tien Hiep) and the Department of Environmental Engineering (Mr. Lam Minh Triet).

The research comprises both laboratory experiments and pilot plant investigations.

The objective of the research is the production of biogas from wastes in the first place, but also an efficient treatment of waste noxious to the environment.

Laboratory research

In the past year research has been carried out in the field of the digestion of pig dung, cattle dung and mixtures of these. They were batch-wise experiments. As contrasted to batch-wise experiments at Wageningen there is no possibility to keep the temperature constant during the experiments. But the variation is not very great and the average temperature is 28°C.
The investigated parameters were: content of solid matter in the substrate, pH, time, gas production, seeding material, temperature, ratio of volume of substrate to volume of air in the flasks at the start of the experiment. The methane production started well after a short lag-phase, and the total amount produced after some weeks is equal to the amount found in Dutch experiments: ca 200 liter CH_4/kg dry pig-dung.

It was found favourable for the final gas production to start the experiment with a certain volume of air above the dung. It must be remarked, however, that the air and the developing methane may form an explosive mixture.

Pilot plant experiments

In the university's mechanical workshop two reactor types have been constructed. One is a horizontal-displacement reactor through which the substrate passes plug-flow wise. The volume of this reactor is about 300 litres.

The second type is a vertical drum digester of the same volume.

Experiments had already been done with the first reactor type. The substrate was pig dung in various mixtures with water. In a first design the reactor was built from concrete sewer-segments. These are cheaply available in the market. The reactor, however, proved to be not gastight, so that measurements of the gas production failed. A second design was made of steel.

It struck me, that the pilot plants were provided with only a few possibilities for manipulation. There were no welded pipes to tap substrate samples at different places, no facility to eliminate the scum layer, no openings for measuring instruments or for cleaning the reactor.

Whereas some useful facilities cannot eventually be applied in full-scale reactors in the countryside because of their high costs, they may be of great importance to the research in order to get more information about the microbiological processes.

2.4.2 The research at Electricity Company II

On June 4th we met Mr. Nguyen Te and Mr. Nguyen Tran The of Electricity Company II of Ho Chi Minh City. These gentlemen are carrying out experiments with the digestion of pig dung on a small plot behind a private house.

They were aiming at the supplementary energy supply on a family scale. They want to design a cheap anaerobic reactor for various types of domestic waste: ping-dung, chicken-dung, kitchen waste, night-soil, urine, water plants, etc., the digested slurry of which may be used as a fertilizer in gardens or in fish ponds. They are also working at bigger reactors. One of the main problems is to find really cheap building materials.

1. The investigations were started with a small 240 liter reactor consisting of two joined earthenware jars as used in Vietnam to store drinking water. The feed of the reactor was a mixture of pig and cow dung. The reactor had been producing biogas, but it proved unsuitable because of the formation of a scum layer which could not be eliminated.

2. Subsequently a reactor was built of the Indian type. It has a volume of 2,4 m^3. It is constructed from three concrete segments (sewer pipes) with a diameter of ca 1 meter and a length of 1 meter. The biggest part of the reactor finds itself underground. The floating gasholder is made of steel. Its inner side is provided with steel pins pointing downwards to break the scum layer.
   It was claimed that the scum layer could be destroyed by moving the gasholder by hand.
   The pig dung came from pig sties in the same place. It did not contain any straw. Also water spinach was added as a feed to the digester.

In front of the reactor a concrete basin was built to mix the dung with water. Behind it there was a basin to collect the slurry.
The digester had been working for four months. The gas was used for cooking. There were no means to measure the amount of gas produced. Gas production from the slurry was observed after being drawn off from the digester.

3. Further, some digesters of the Chinese type were being contructed.
A design had been made consisting of two cylindrical tanks joined in their middle by a short wide pipe. These tanks are reaching only 1,5 meter deep into the ground. Their diameter is 1 meter. As construction material concrete reinforced with bamboo is used.
My spokesmen were optimistic about obtaining gastight tanks. The volume of the digester is 2,4 m^3. A gas production of 1 m^3/day is striven for. This is about 650 litres of CH_4 per day. This corresponds to the digestion of ca 3 kg of dry pig-dung per day or the dung of 8 pigs of an average size. The daily volume of this dung at 10% dry solids is 30 litres. So, the nominal detention time is about 60 days.

2.4.3 The research at an experimental pig farm in Ho Chi Minh City

Yet another example of the Vietnamese experiments in the field of dung digestion is the 2 m^3 digester at an experimental pig farm in Ho Chi Minh City. We visited this farm on June 8, 1982.

The reactor is based on the principle of the Chinese digester. It is made of concrete (see figure 1). The feed consists of the dung of 5 pigs with an average weight of 80 kg. and of rice-bran. Dung and bran are mixed with water in a 1:1 dilution. This digester has a very good gas production. The gas is used for cooking the meals of the farm's personnel.

Problems are the formation of a scum layer and a layer of bottom sludge.

Further, the actual mixing of the feed with water and the drawing off with buckets of the slurry is experienced as too time consuming.

There were plans to equip the digester with a pump for the effluent slurry.

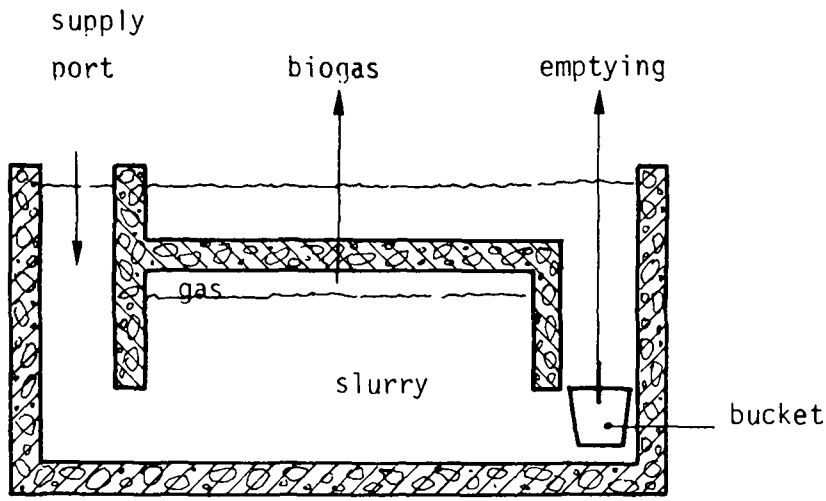


Figure 1.A 2 m^3 experimental pig dung digester in Ho Chi Minh City (chinese type).

2.4.4 The research at the Ho Chi Minh City Refuse Treatment Plant

Experiments have been carried out to digest municipal garbage from Ho Chi Minh City in closed tanks fed batch-wise. These experiments were successful as may be expected of a highly biogradable substrate. In the future this process will be applied on a large scale. The gas produced will be dehydrated, and malodorous substances will be eliminated by activated carbon treatment. Subsequently it will be compressed and stored in cylinders. The gas will be sold in the market. It is expected that the process will be cheaper than the aerobic composting applied at the moment.

2.5 Conclusions concerning research aimed at biogas generation on the village level

1. At this moment it is as yet impossible to appraise the possibilities and limitations of the application of methane generation in the Mekong-Delta-villages.

2. In two main respects a biogas programme may improve the situation for the population. First, energy could be supplied for cooking, lighting and small engines. Secondly the digestion of night-soil and animal waste may improve the properties as to hygiene of these materials, towards their use as fertilizers for fish-ponds or vegetable gardens.

3. A research propramme aiming at obtaining laboratory and field experience with biogas generation and adapting the existing designs to local circumstances may provide the indispensable information for the later decision whether biogas generation might be applied on a wide scale in Vietnam.

3 WASTEWATER PROBLEMS

3.1 General information

Summarizing the wastewater problems in Ho Chi Minh City and the Mekong Delta it is important to distinguish between the situation in the countryside and that in the city.

In hamlets and villages with populations varying from some families to several thousands of inhabitants there are three main systems of night-soil disposal. First, people may defecate freely in the surroundings of their houses, secondly there maybe pit-latrines and thirdly there may be direct disposal into fish-ponds. These ponds have, as we observed in the Village of Xa Long Hoa (Long An Province), a surface of some 10 x 10 m or 20 x 20 m and a depth of 1-2 m. They mostly serve one family.

Fish can be bred when a proper ratio between pond-volume (difference between dry and wet season!) and organic load exists. The fish is consumed cooked or fried.

The village-sanitation is not without health-problems. If the fish is cleaned properly by transferring into clean water no problems may arise but in practice parasitic diseases may be difficult to overcome because of the way of night-soil disposal.

Also it is important to prevent the use of the pond as a source of drinking water.

In chapter 4 on the drinking-water supply I will go into some details about the characteristic methods of sanitation in the Vietnamese countryside.

The wastewater problems of the cities have a different character.

Because the cities were built in the colonial era in a French style and lack space, one does not find many ponds here.

Via septic tanks and sewers the sewage water is transferred to the often stafnant surface water. There is no question of purification of domestic and industrial wastewater.

In Soc Trang (80.000 inhabitants), Prov. of Hau Giang, I was informed about the very bad shape of the local drainage system and the harmful consequences on the drinking-water supply of the unpurified discharge of the city's wastewater. Here, as in many other parts of the Mekong Delta, surface water is an important source for the production of drinking water (see chapter 4).

In Ho Chi Minh City the sewage water is discharged into the Saigon River. This causes a direct hygienic danger to the population which lives along, and partially over, the river.

In a village on the outskirts of Ho Chi Minh City, called Tan Binh Village or District 15, I was introduced to an industrial wastewater problem. Some details are given in 3.2.

Further advice was asked about the disposal of wastewater at the central Cho Ray Hospital in Ho Chi Minh City (see 3.3).

3.2 The wastewater problem in Tan Binh Village near Ho Chi Minh City

(See figure 2 below)

During the mission special attention was given to this village, because the Department of Environmental Engineering had made an investigation of the problems in this area. This investigation mainly consisted of obtaining a general picture of the wastewater situation and the water management in this district. Measurements of the flow and quality of the sewage and surface water had been undertaken. Subsequently, proposals had been made to solve the problem.

Figure 2 shows the situation.

Along the road one finds a number of factories. There are two textile mills, a food factory and a chemical industry which produces sodium glutamate. These factories pump their processing water from deep wells. The flow amounts to 10,000 - 15,000 m^3/day. After use it is discharged into a ditch flowing into a small river. The BOD of this water is about 300 mg/l.
The river was said to have a flow of about 15,000 m^3/day (0.174 m^3/sec) as well, but this flow varies with the seasons. In the dry season the direction of its flow seemed to be reversed, mainly by extensive irrigation practice, the industrial site being surrounded by an agricultural area of about 120 hectares.

In the dry season the villagers grow vegetables like cabbages and aubergines on their fields while in the rainy season they also grow rice. In the dry season the fields need the irrigation water from the river which causes problems, because of the heavy water-pollution.

During the last dry season the cabbages did not grow and two thirds of the fields were actually unusable. For the local people this was a severe

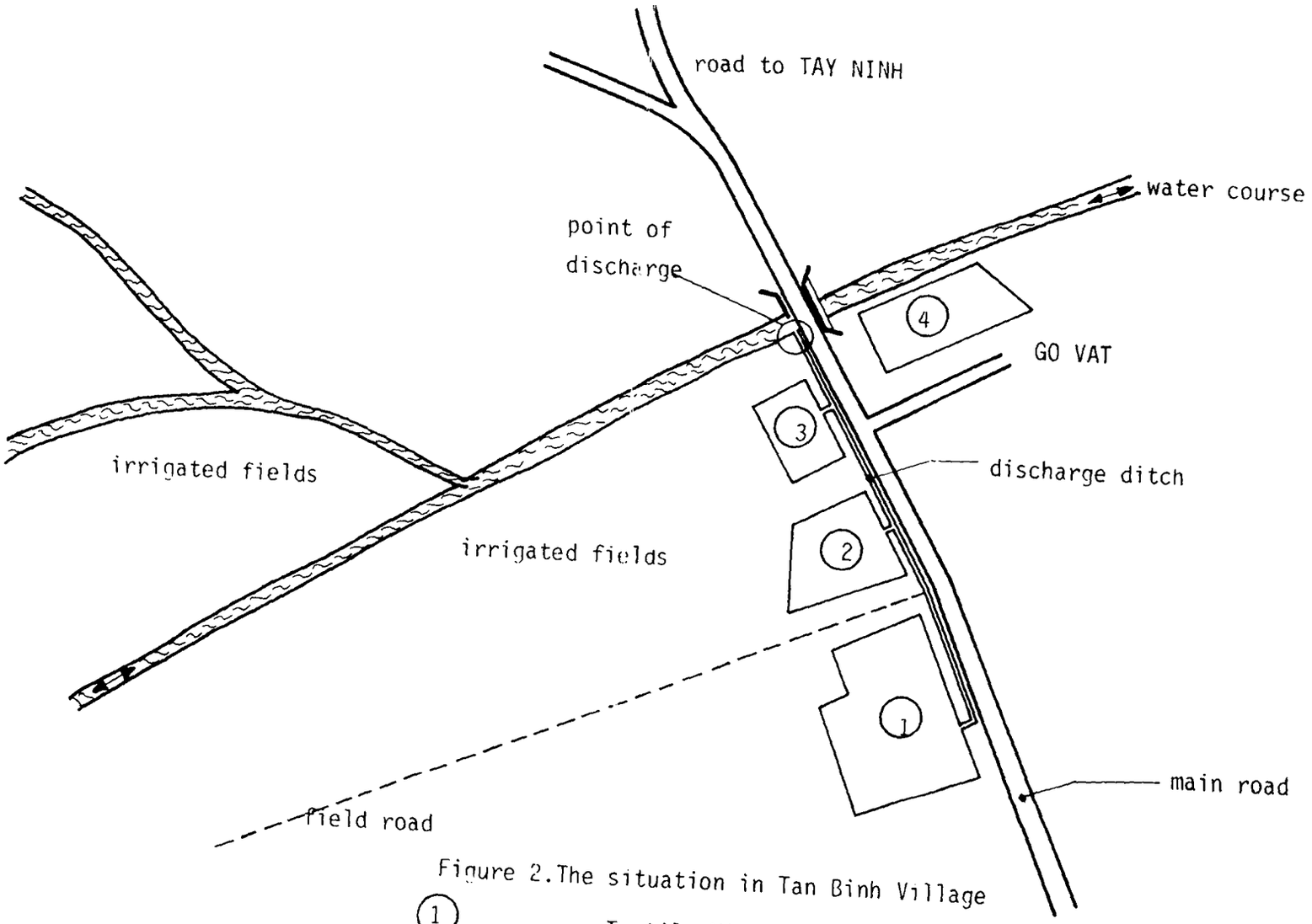


Figure 2. The situation in Tan Binh Village

1. Textile Mill
2. Textile Mill
3. Cannery and vegetable oil
4. Chemical industry

problem and the Administration of the District, therefore, was very interested in possible solutions.

In recent years the Department of Environmental Engineering has worked on suggestions on how to take up this problem. The factories, wastewater had been sampled twice and a plan for treatment of the wastewater had been proposed. It appeared that the factory management were willing to collaborate towards a solution.

A redevelopment of the production processes, to make the wastewater less polluting, was discussed but as yet funds were not available.

Apparently it was expected that a relatively cheap purification of the total flow of wastewater could be realized.

The solutions the Polytechnic University had sought were primarily based on the question of how to get enough irrigation water for these 120 hectares. The first thought was to drill more deep wells, but this did not promise enough water and would be very expensive. Secondly, it was investigated whether other sources of surface water could be found in the neighbourhood. It appeared that these sources could not supply sufficiently. Further, a simple treatment of the wastewater flow was considered: anaerobic preliminary treatment and aerobic after-treatment in ponds with water plants (e.g. water hyacinth). After this treatment the water might be discharged into the river in order to dilute it. Much interest apparently existed in a contribution to this subject by the Wageningen Department of Water Pollution Control.

3.3 The wastewater problem of the Cho Ray Hospital, Ho Chi Minh City

Through the intermediary of the Polytechnic University my advice was asked by the Cho Ray hospital on the discharge of their wastewater. The Cho Ray hospital is HCM City's biggest hospital counting 1000 beds, caring for 1300 personnel and additionally treating about 1000 out-patients a day. It is a modern hospital built around 1970 by a Japanese contractor. Equipment is largely Japanese. This causes an important spare part supply problem.

The wastewaters are treated in septic tanks before the discharge into the city's sewerage. These tanks are cleaned before the rainy season and the sludge is dumped outside the town.

A question had arisen about the handling of radioactive wastes both from diagnosis and from therapy. Those wastes are stored in a special reservoir.

Can this reservoir be emptied into the sewerage? In Dutch hospitals working with radioactive isotopes, mainly in the treatment of cancer, the isotopes used are Iodine, Technetium, Gallium, Indium. In therapy especially the quantities used are considerable, but the isotopes are short-lived so that a storage of three months is normally sufficient to decrease the residual activity to near-background radiation levels.

It was agreed that the nature and quantity of the isotopes used would be listed and afterwards judgement would be passed on their possible treatment.

3.4 Conclusions about the wastewater problem

Since the South of Vietnam has to contend with many problems of waste and wastewater disposal a research programme contributing to simple, cheap and locally adapted technology will be very useful.

In this respect the anaerobic treatment called the upflow anaerobic sludge, blanket method (UASB), as developed in the Department of Water Pollution Control, is one of the promising approaches. This is especially so for waste (e.g. market-place wastes) and wastewater with a high content of degradable matter.

Anaerobic treatment in an UASB reactor has the advantage over anaerobic ponds and aerobic methods in that a considerable degradation of organic matter can take place in a small space while at the same time the developing gas is regained.

However, the possibilities of pond systems and land treatment in Vietnam must not be overlooked. A research programme will also have to pay attention to the determination of priorities in the measures against water pollution. The interuniversitary project VH 17 (app. 7) supports the Department of Environmental Engineering, so that it will have the know-how and means for starting both tasks: a development of treatment methods and a determination of priority measures.

4 DRINKING-WATER SUPPLY

4.1 The problem of the drinking-water supply

The water situation in the Southern part of Vietnam has the following characteristics:

- the presence of big rivers, especially the Mekong River. This river in the wet season has a flow of 6,000 m^3/sec. In the dry season the flow diminishes to 1,500 m^3/sec. Also there are many big and small canals;
- the succession of the wet and dry seasons;
- the intrusion of salt water from the sea into a large part of the delta;
- small amounts of fresh groundwater at normal depths.

Especially the last characteristic causes a very problematic supply of fresh water in the provinces south of Ho Chi Minh City, e.g. in Long An and Hau Giang.

4.2 The water-supply of Ho Chi Minh City

Ho Chi Minh City, as contrasted with other towns, has a good drinking-water supply.

The main flow of water comes from the Ho Chi Minh City Water-Supply Plant, situated on the outskirts of the town. It is a modern surface-water treatment plant built in 1966.

It takes 500,000 m^3 per day (5.8 m^3/sec) from the Dong Nai River. This water is subsequently purified by microstraining, coagulation, flocculation, sedimentation and rapid sand-filtration.

If necessary pH can be adjusted by lime dosing. The purification process is finished by a light chlorination in order to combat algal and bacterial growth in the pipelines. In total the plant supplies water to 3.5 million people.

HCMC has an extensive distribution network consisting of seven parts.

House connections are common. Communal facilities still exist, but are gradually abolished. A waterprice of 0.5 dong/m^3 is charged to the public.

4.3 The water supply of the city of Soc Trang, Hau Giang Province

In chapter 3 (on water pollution problems) the situation in Soc Trang has already been mentioned.

The whole drinking-water supply system dates back to the French colonial time before 1954.

The raw water is pumped from a very silty canal and is treated by means of coagulation, filtration and chlorination.

During my visit it appeared that the installation was out of order except for the pumps. However, these pumps were not working either through a defect in the electricity supply. The coagulation and filtration-tanks were leaking and there was a lack of chlorine. The responsible people were greatly distressed about the situation, they told that a new transporting canal had been dug (30 km long), but this apparently was not yet in use. The only remedy would be a thorough overhaul of the installations, but the funds for this were lacking.

4.4 The water supply in the village of Xa Long Hoa (5.000 inhabitants) District of Huyen Can Duoc

The village has to make use of various water sources because none of the sources in itself has a sufficient capacity to supply the inhabitants and their cattle continually.

In the rainy season (June-November) people catch the water flowing down from their roofs. It is stored in earthenware jars with a volume of about 120 litres. Also the rainwater is caught in special ponds exclusively used for this purpose, each family having such a pond. The water from this pond is used for washing and also for cleaning the fish bred in fish-ponds fertilized with night-soil. The ponds contain water until some months of the dry season are past. Keeping these ponds clean from pollution caused by animals is felt as a problem.

Apart from these rainwater-ponds people have their fish-ponds over which one finds the toilets*.

The village also has a groundwater source. The water is pumped up by means of a Diesel pump from 140 m deep to a small water-tower centrally placed in the village. From there the women fetch the water in tins. The chloride content was said to be 335 mg/l.

* In many other places the fish ponds are connected with the canals but separated from them by a wire-screen.

By means of geohydrological maps it was shown that the situation in the village is relatively favourable. In the surrounding region the water is found at still greater depths: in Tan An city at 200 meter, in Ben Luc at 260 m (the flow, here, is 6 litres/s) and near the coast at 500 m.

Shallow wells (up to 20 meters deep) are not very popular in the area. They often have a low flow; the water is said to be rather acid (pH: 4-5) and containing too much iron, so that people do not like its taste.

The Polytechnic University was very much interested in simple and cheap methods to deferrize the water.

In the dry season drinking-water moreover, has to be supplied by tank-lorries. They bring the water from Ho Chi Minh City. This is a heavy burden for the population, especially the women. As the lorries cannot reach the village the women have to carry the tins of water over long distances. It costs a great deal of time and the water is expensive as well: 5 dong per 40 litres.

The surface-water from canals in the neighbourhood of the village is unfit for human consumption; it would have to be purified and disinfected, and often, in the dry season, it is too salty to serve for drinking.

Those responsible in the District and the Province displayed great concern about the water-situation and were eager to hear suggestions for improvements.

4.5 Conclusions about the drinking water supply

The drinking-water supply in the Mekong Delta is a very problematic one.

Shallow wells yield insufficient quantities of water. Often, this water is of a poor quality.

The extraction of ground water is possible in some regions, in others it is too costly because of the great depth of the water.

The production from surface-water always requires a relatively costly pre-treatment.

Because of the intrusion of salty water from the sea, long canals are necessary in the coastal areas to bring down fresh water, thus keeping the chloride content of the drinking-water at an acceptable level in the dry season.

An improvement of the Mekong Delta water-supply will require large investments, especially in the field of civil construction and installations.

A more precise definition of priorities is beyond the scope of this report.

It must be stated that in the Mekong Delta, just as in many other regions in Third-World countries, an improvement of the accessibility of drinking-water of good quality is of great importance to the population and ought to be treated as a priority in the development of the countryside.

5 SOME GENERAL INFORMATION ABOUT THE POLYTECHNIC UNIVERSITY OF HO CHI MINH CITY.

Cooperation in the future will be between the Department of Water Pollution Control of the Agricultural University Wageningen Holland and two Departments of the Polytechnic University of Ho Chi Minh City, viz the departments of Food Technology and Environmental Engineering. In this chapter some general information will be supplied about the Vietnamese University.

At this moment the University comprises nine Faculties. In Appendix 3 a summary of the Faculties and the composing Departments is given. The total University Staff amounts to 920 persons, of whom 80 are scientists with a PhD or MSc degree, 370 teaching staff, 270 administrative staff and 200 supporting laboratory and technical staff. There are 4,000 students; 3,000 are full-time students, 1,000 are corresponding students. Beside these students the University also comprises a small number of students who follow short practical evening courses. Approximately 25% of the students are women.

Having originally a four-year-programme, the University recently adopted a five-year-programme. Within these five years the students have regular practical training periods outside the University. As the student advances to the final year this training is more oriented towards his or her own discipline.

Special tasks of the University

In accordance with the science policy of the central Government and the Five-Year Plan the Polytechnic University has been assigned the task of giving scientific support to the development of the southern part of the country, especially the Mekong Delta countryside. The University hopes to contribute in the following fields (not all fields are mentioned): problems of irrigation and drainage in the Mekong Delta, reduction of acidity and salinity of water, digging of canals, materials for building, equipment for agriculture, potable water supply, wastewater treatment, food preservation, energy-supply in the villages, etc.

These supporting tasks are given shape by research in the above-mentioned fields and by teaching students in the same line.

By teaching its students the University tries to meet the man-power needs in the Southern part of the country. This region comprises 20 million inhabitants.

It may be added that where engineers are concerned social demand is larger than supply. Especially the Provinces need many engineers to support their technical staffs.

Entrance into the University

In Vietnam a good education, and especially a universitary one, is highly esteemed for its social as well as for its cultural value. Every year about 3,500 persons present themselves for the entrance examinations the Polytechnic University. Out of these 3,500, 600 matriculate. The maximum mark at this entrance is 30. Applicants from the countryside are given a better chance to enter the University by giving them 5 extra points added to their mark. This is done to increase the number of students from the countryside, and it recognizes the relatively poor educational conditions in countryside secondary schools. At this moment, however, the number of countryside students is still considered too small. In order to improve this situation special one-year courses are provided for students from the Provinces before they go in for the entrance exams. This year 150 students followed this course. More than 90% of the students who start at the university will eventually graduate.

Student life and job prospects

Students do not pay for their university education; there is a scholarship system. 60% of the students board with relations in Ho Chi Minh City, 40% lives in student homes. All students get jobs after graduation, although not always at the level of their knowledge and skill; often an engineer has to do non-engineering tasks. Students in Civil Engineering may often obtain work with the Provinces with building firms, research institutes, or engineering offices; mostly they get jobs paid by the Government. Students in Chemical Engineering go e.g. to food-processing industries and research institutes.

APPENDIX 1

SOME PRELIMINARY QUESTIONS TO ASSESS THE FEASIBILITY OF A BIOGAS PROGRAMME.

1. Animal husbandry

It seems to us that the possible usefulness of biogas systems in the countryside of Vietnam will be related to several aspects of animal husbandry.

How many animals of different kinds are kept, and how many animals per farmer? How much dung may be collected for fermentation purposes?

Is there a considerable quantity of larger-scale farming units, e.g. State-owned or collective farms? How the dung is put to use at the moment?

Is there a manure traffic?

What is the prevailing type of animal bedding material?

And how are human wastes treated in the villages?

2. Agricultural waste

Which are the different types of agricultural organic waste materials other than cattle, pig or poultry dung?

Could they be used for biogas generation? In what quantities are they available?

3. Rural energy

What type (or types) of energy are used and in what quantities?

To what extent could biogas alleviate energy problems?

As far as possible these questions are dealt with in Chapter 2 and Appendix 2.

The amount of pig dung to be collected per family may appear to be one of the limiting factors in a biogas generation programme aiming at the family-size digester. The pigs are rather small in number and run freely around the farmer's house.

On the other hand the availability of vegetable wastes like e.g. banana leaves, fruit wastes, water hyacinth seems ample.

The research programme will have to emphasize the use of mixtures of different wastes as a substrate for anaerobic digestion.

APPENDIX 2

LIST OF CHARACTERISTICS FOR THE ASSESSMENT OF A BIOGAS GENERATION-PROGRAMME AND APPRAISAL OF THE MEKONG DELTA SITUATION.

As a region does satisfy all the characteristics simultaneously the chance will be the greater that a biogas programme in such a region will be socially successful.

Legend to the table:

+ : the Mekong Delta has positive features with regard to this characteristic in our present view

- : the Mekong Delta has negative features with regard to this characteristic in our present view

? : it is yet unknown whether the Mekong Delta has positive or negative features in this respect.

Necessary inputs have a low opportunity cost

1	Agriculture is such that sufficient amounts of animal waste from which methane gas can be produced are available with an opportunity cost that is at least no higher than when it is used directly as a fertilizer (or fuel)	?
2	Agriculture is such that sufficient amounts of agricultural vegetable wastes are available with an opportunity cost that is at least no higher than when it is used directly as a fertilizer or fuel.	?
3	Industries exist that produce as by-products large amounts of material from which methane can be produced	+
4	No social restriction on the use of human waste	+
5	Human waste and/or animal dung are traditionally collected	+
6	Water is available to dilute the digester feed	+

7	Capital or credit facilities are available for a biogas program	?
8	Labour is available and willing to undertake the work of operating the digester on a continuous basis	?

Efficiency of the operation of the plant is adequate

9	A sufficient, regular and uniform input of gas-producing material into the digester. The input must have a low content of sand, straw and floating materials	?
10	Technical advice and skills are available for the construction of the plant and for trouble-shooting	- not yet
11	Smaller-size plants of which the operation is not very reliable can be avoided	?
12	Lowest temperature about 15°C	+
13	Adequate plant design (e.g. no blockages, no condensation, no scum-layer, easy to clean)	?

Alternatives to the outputs from the biogas plant have a high opportunity cost

14	Other fuel and fertilizer sources are not readily available, have a poorer quality, or are expensive	+
15	Wood is scarce	+
16	Dung is being burned as fuel	-
17	There is insufficient water to make use of chemical fertilizers	-
18	Insufficient cash to buy other fuels	?

19	Insufficient cash to buy other fertilizers	+
20	The gas can be used near the digester	+
21	The handling of the slurry from the digester is not too expensive	+

APPENDIX 3

SUMMARY OF THE FACULTIES AND DEPARTMENTS OF THE POLYTECHNIC UNIVERSITY OF HO CHI MINH CITY

1 Faculty of Mechanical Engineering
Machine Construction, Metallurgy, Textile Technology, Precision Mechanical Engineering.

2 Faculty of Electrical Engineering
Electric Engineering, Electrical Systems, Computer Science, Electric Equipment, Automatic Control and Electrification.

3 Faculty of Chemical Technology
Inorganic Chemical Technology, Organic Chemical Technology, Chemical Machinery, Food Technology.

4 Faculty of Power Engineering
Thermal Engineering, Automobile and Tractor Engineering, Construction Hoisting and Conveying Equipment.

5 Faculty of Water Engineering
Hydraulic Engineering, Hydroelectrical Engineering, Surveying, Irrigation and Drainage, Harbour and Water-way Engineering.

6 Faculty of Civil Engineering
Housing Construction, Structural Engineering, Foundation Engineering, Road and Bridge Engineering, Building Materials. Environmental Engineering.

7 Faculty of Applied Geology
Structural and Hydrological Geology, Mineralogy and Exploration.

8 Faculty of In-Service Training
Housing Construction, Road and Bridge Engineering, Electrical Systems, Electric Equipment, Electronic Engineering, Food Technology, Hydraulic Engineering, Automobile and Tractor Engineering, Machine Construction.

9 Board of Basic Sciences
Mathematics, Physics, Chemistry, Theoretical Mechanics, Languages, Industrial Drawing.

APPENDIX 4

BIODATA OF THE VIETNAMESE INVOLVED IN THE PROGRAMME

NGUYEN XICH LIEN
Ph. D. Food Technology
Dean, Faculty of Chemical Technology
Head, Department of Food Technology

1 Research interest: Biochemistry in food preservation and processing

2 Present responsibilities: In charge of research and training activities in biogas generation in the Department.

3 Tasks in the programme:

- Coordination of research activities in biogas generation of the programme
- Study-tour in India for three months to observe research work and development work in biogas generation.

LAM MINH TRIET
Ph. D. Environmental Engineering
Head, Department of Environmental Engineering
Faculty of Civil Engineering

1 Research interest:

- Wastewater treatment
- Potable water treatment

2 Present responsibilities: In charge of research activities and teaching in the areas of wastewater treatment and potable water treatment in the Department.

3 Tasks in the programme

- Coordination of research activities in wastewater treatment and applications of treated wastewater.
- Fellowship in Wageningen for six months, during which time the following activities are envisaged:

* Acquaintance with the student training programmes in environmental science in general and water pollution control in particular

* Curriculum development with Dutch counterparts in the subjects that are taught in Vietnam such as wastewater treatment, pollution control by biological, chemical, aquatic plant methods
* Participation in research activities, training activities (especially laboratory work for students)
* Use of research apparatus and equipment.

LUU TIEN HIEP
Ph. D. Chemical Engineering
Staff member, Department of Chemical Engineering
Faculty of Chemical Technology

1 Research interest:
- Biogas technology
- Biochemical Engineering
- Computer-aided design

2 Responsibilities in the Department:
Teaching and research in Unit Operations and Chemical Reaction Engineering

3 Tasks:
- Design of process and equipment as involved in the programme

NGUYEN DUC LUONG
Engineer in Microbiology
Staff-member, Department Food Technology
Faculty of Chemical Engineering

1 Research interest:
Small-scale biogas generation

2 Responsibilities in the Department:
Teaching and research in Applied Microbiology

3 Tasks in the programme:
- Study of biochemical and microbiological process in biogas generation
- Training in Wageningen in biological and microbiological processes in biogas production. Familiarization with research equipment.

(Miss) LE THI HANH
Chemical Engineer
Staff-member, Department Food Technology Faculty of Chemical Engineering

1 Research interest: Small - scale biogas generation

2 Responsibilities in the Department:
- Analytical work
- Design of biogas digesters

3 Tasks in the programme:
- Analysis of biogas, feeding materials
- Design of biogas digesters

NGUYEN TRUNG VIET
Engineer in wastewater treatment
Staff-member, Department of Environmental Engineering
Faculty of Civil Engineering

1 Research interest: wastewater treatment

2 Present responsibilities:
Research and teaching in the area of wastewater treatment

3 Tasks in the programme:
- Research in anaerobic treatment of municipal and industrial wastewater
- Further training in the areas of wastewater treatment
- Experimentation methods and experimental modelling in Holland.

TRAN VAN THINH
Engineer in wastewater treatment
Staff, Department of Environmental Engineering
Faculty of Civil Engineering

1 Research interest: aerobic wastewater treatment

2 Present responsibilities:
Research and teaching in the area of wastewater and potable water treatment

3 Tasks in the programme:
Study of wastewater treatment, particularly by aerobic treatment in the biological pond.

DANG DUY TINH
Engineer in water-supply and removal
Staff-member, Department Environmental Engineering
Faculty of Civil Engineering

1 Research interest: water-supply and removal

2 Present responsibilities:
Research and teaching in water supply and removal

3 Tasks in the programme:
Study in the application of treated wastewater for irrigation and fish-farming.

APPENDIX 5

WORKING SCHEDULE 3 JUNE - 17 JUNE 1982

Date	Morning	Afternoon
3/6	Arrival at the airport Tan Sonh Nhut. Ho Chi Minh City (HCMC)	Reception at the Polytechnic University, HCMC.
4/6	Trip to Long An Province: visit to village: Xa Long Hoa. Problems of drinking water supply. Reception by Village Committee and Provincial Responsible persons at Can Duoc and Tan An.	HCMC: visit to experimental family-farm digester see p. 2.4.2.
5/6,6/6	Two days trip to Vung Tau	
7/6	Discussions on biogas research at the Faculty of Chemical Technology, Dept. Food Technology	Discussions on wastewater treatment at the Faculty of Civil Engineering, Dept. Environmental Engineering
8/6	Inspection tour of the Ho Chi Minh City Drinking-Water Purification Plant Visit to pig farm with 2 m^3 experimental digester	Visit to exhibition of Vietnamese handicrafts. Visit to some open markets
9/6	Travel to Hau Giang Province: Cities of Soc Trang and Can Tho. Reception by Soc Trang Municipal Committee. Discussion on drinking-water supply and sewage disposal. Visit to Soc Trang Drinking-Water Purification Plant. Visit to village with collective farming near Soc Trang. Reception by Agricultural Science Office in Can Tho. Discussions on agriculture, rural energy, village economy, etc.	

10/6	Visit to Agricultural Research Centre under construction. Visit to Experimental Rice-Farm. Visit to State Pig Breeding-Farm. Reception Provincial Committee.	
11/6	Lecture: History of wastewater technology in Western Europe	Visit to Cho Ray hospital Discussion on hospital waste waters. see 3.3.
12/6	Inspection tour to HCMC refuse treatment plant. Visit to snake farm	Inspection tour to Village 15 in Tân Binh District. Problems of Industrial Wastewaters. Discussion on use of treated wastewater for irrigation. see 3.2.
13/6	Trip to village Lai Thiêu	
14/6	Working session on future cooperation	Lecture on some aspects of education and research at Dutch universities
15/6	Lecture on land treatment and agricultural reuse of wastewater Lecture on anaerobic treatment of wastewater and animal waste	Working session on project proposal Reception by Municipality of Ho Chi Minh City
16/6	Free	Working session on project proposal. Final discussion with Rectorial Board Farewell Dinner with Polytechnic University
17/6	Final discussion on PUO questionnaire with Fac. of Chemical Technology and Civil Engineering.	Departure for Holland.

APPENDIX 6

Addresses of the participating universities.

1 The Ho Chi Minh City Polytechnic University
Faculty of Chemical Engineering
268 Ly Thuong Kiet
Q 10, Ho Chi Minh City
Vietnam.

2 The Agricultural University Wageningen
Department of Water Pollution Control
Biotechnion
De Dreijen 12
6703 BC Wageningen
The Netherlands.

APPENDIX 7

6 PROJECT OF DEVELOPMENT COOPERATION BETWEEN WAGENINGEN AGRICULTURAL UNIVERSITY AND HO CHI MINH CITY POLYTECHNIC UNIVERSITY (VH. 17)

I GENERAL

I.1. Title:

Anaerobic treatment of waste water, organic wastes and biogas generation.

I.2. Objectives of the project

- Advanced training and education of research and teaching personnel in wastewater treatment and biogas generation.
- Development of simple, cheap and reliable methods for wastewater treatment. Treated water can be used for irrigation and fish-farming.
- Development of simple, cheap and reliable digesters for biogas generation. Biogas will be used for cooking, lighting and running small engines in the countryside.

Rationale

The anaerobic treatment of organic wastes in principle offers good opportunities for the utilization of waste materials by producing biogas and for combating noxious environmental influences of these wastes. In many western countries anaerobic treatment technology has developed rapidly during the last twenty years, and is finding a wide application. In Asian countries too, a significant development is going on, particularly in the field of biogas generation.

Whether the final results of such a development may be considered favourable depends on social, economic, cultural and technical factors. The South of Vietnam seems to have appropriate characteristics in many respects. One of the results of this project is expected to be a better assessment of the feasibility of particular anaerobic treatment applications.

In Vietnam recently experiments in anaerobic treatment have been initiated by the University and various State organizations.

The project joins these initiatives, and aims at enhancing the scientific know-how in this field. The wastewater treatment especially will be important for the cities and their surroundings, particularly for Ho Chi Minh City. Here, problems of water pollution caused by discharge of domestic and industrial wastewaters and dumping of garbage urgently ask for a solution.

At the treatment plants for these types of waste methane gas can be a useful by-product.

It is felt that the energy supply to the countryside is an important problem. Biogas generation from waste could contribute to its solution. First, the anaerobic treatment of organic wastes is of importance to the energy supply in the countryside. But, secondly, by means of digestion a better quality of dung, night-soil and other waste materials can be obtained, which will be favourable for their use as fertilizing substances.

I.3. Institutions involved

- Polytechnic University of Ho Chi Minh City
  Department of Environmental Engineering, and
  Department of Food Technology.
- Agricultural University of Wageningen
  Department of Water Pollution Control.

Rationale

Both departments of the Polytechnical University have a great interest in the application of anaerobic digestion. Environmental Engineering wants to put an emphasis on the wastewater treatment. The Department of Food Technology has already gained some experience in the field of the digestion of dung. This department especially wants to work on the generation of biogas in the countryside.

At the start of the project the laboratory and pilot plant facilities of this department will be improved first.

Both applications of anaerobic treatment (wastewater treatment and biogas generation) are founded on the same scientific basis. The project will first strengthen this basis within both departments.

The Wageningen department will cooperate closely in the whole of the project. This will especially be the case in the beginning within the framework of joint fellowships to the Agricultural University, the installation of equipment and a study-tour to India. Pilot plants installed on the university campus will be operated by collaborators of both departments. In the final stage the Department of Food Technology will take care of the pilot plant installations at a pig-farm and in a village, whereas the Department of Environmental Engineering will operate the pilot plant for industrial wastewater in the Tan Binh District.

The Department of Water Pollution Control of the Agricultural University of Wageningen began working on anaerobic treatment methods in 1970. Initially emphasis was laid upon the treatment of high and medium strength wastewaters from industrial origin.

Because the Department is vividly interested in the possibilities of anaerobic treatment technology in developing countries, it started research in this field some years ago. In this interuniversity project (VH 17) the Department hopes to gain experience in the application of anaerobic treatment in the countryside of developing countries.

I.4. Duration of the project

Starting date: January 1983
Completion date: December 1985
At the end of the project evaluation may prove the necessity of a follow-up.

II SITUATION OF THE COUNTERPART INSTITUTION

1 The department of Environmental Engineering is in charge of training environmental engineers with specialization in pollution control, waste treatment and water-supply. Its main research interests include treatment of municipal and industrial wastewater, and applications of treated wastewater. The Department has done some research work in aerobic and anaerobic treatments of wastewater.

2. The Department of Food Technology trains food technologists in various fields such as industrial microbiology, food preservation and processing. It has done preliminary research in biogas generation from animal waste, household waste and industrial solid waste.

3. Both departments have limited access to training and research facilities (instruments, apparatus, machinery, auxiliary equipment, spare parts, publications) in wastewater treatment and biogas generation.

III DESCRIPTION OF THE PROJECT

III.1. The objectives

1.1 Short-term objectives

- Training of teaching and technical staff in the areas of wastewater treatment and biogas generation

- Strengthening of the existing laboratories of wastewater treatment and biogas generation
- Provision of books and periodicals in the related areas
- Gathering of data in related areas for equipment development and design
- Test run on model equipment developed during the programme.
- Gathering of agricultural, economic, social and environmental data in order to facilitate the assessment of the feasibility of biogas programmes in the countryside. Particularly it will be necessary to find out the amounts of waste materials amenable to anaerobic digestion.

1.2 Long-term objectives

- From the pilot plant investigations, it is expected that the knowledge may be applied to other locations where similar pollution problems are encountered, viz.
  * Biogas generation for lighting and cooking in families and communities of about 20 - 50 families.
  * Treatment of wastewater for irrigation in areas of about 100 - 200 ha.
- Training students and members of staff in biogas technology and wastewater treatment in Holland and Vietnam.

III.2 Description of the proposed activities

2.1 Teaching and training

- Two staff-members are to be sent to Wageningen Agricultural University for further training in environmental science and engineering, particularly in wastewater treatment and biogas generation. During their stay attention will be paid to the development/or improvement of curricula in the following fields:
  * Treatment of municipal and industrial wastewater
  * Wastewater chemistry
  * Laboratory work in wastewater treatment
  * Industrial microbiology
  * Biochemical and microbiological processes in wastewater treatment and in anaerobic treatment of organic waste
  * Hydrobiology (use of water plants)
  * Epidemiology
- One member of staff from the Agricultural University is to be sent to Vietnam for a short period to assist in the design of pilot-plants and the

experimental work in the field of anaerobic digestion as well as to evaluate the training of Vietnamese staff-members in Wageningen.

- Development and strenghtening of laboratory facilities in:
  * Microbiology
  * Biogas and water analysis
  * Pilot plants for wastewater treatment and biogas generation
  * Instruments for field-work in water pollution control, auxiliary equipment
- Publications to be purchased on:
  * Environmental science and engineering
  * Gas and water analysis
  * Water treatment
  * Renewable energy and energy from biogas

2.2 Research

- Two staff-members are to be sent to the Agricultural University for further training in research work in the related field.
- Laboratory facilities are to serve both training and research purposes, so there is no need for research-oriented equipment
- Provision of some major equipment
- Research programme in related areas can be divided into the following phases:
  * Continuation of laboratory studies of the factors affecting biogas generation such as pH, solids concentration, retention time, seeding, raw materials, batchwise and continuous feeding, etc.
  * Microbiological study of methanogenesis
  * Pilot plant study of biogas generation from animal waste and vegetable wastes; at the university special emphasis will be laid on digestion of mixtures of different types of waste
  * Feasibility study of some digesters under different conditions (animal waste)
  * Pilot plant study of the digesters set up at a pig farm and in a village
  * Measurement of properties of wastewater at the Tan-Binh area where polluted water can be amenable to anaerobic treatment
  * Laboratory study of anaerobic digestion of wastewater from the above mentioned area

* Approaches to the design of anaerobic reactors that are cheap and effective
* Pilot plant study of one suitable reactor that hase been developed in the programme at Tan-Binh
* Study of treated wastewater for fish farming and irrigation

2.3 Other activities

- Vietnamese personnel will be given the opportunity to visit India, where research in biogas technology and wastewater treatment is being carried out.

III.3. Means

3.1 Personnel

3.1.1 Dutch University staff

The personnel of the Agricultural University of Wageningen, to some extent involved in the project, will be as follows:

Ir. J.C.L. van Buuren	(project organization)
H.J. Donker	(coordinator of pilot plants)
Ir. P.C. Grin	(research on domestic wastewater)
S.W. Hobma	(research on anaerobic digestion)
J.B.R. van der Laan	(analytical methods)
Dr. G. Lettinga	(coordinator of anaerobic digestion research)
Prof.Dr. L. Lyklema	(head of the department)
Dr. A.F.M. van Velsen	(consultant on pig dung digestion)
Ir. G. Zeeman	(research on cattle dung digestion)

3.1.2 Staff to be involved with project activities, and to receive project related training at Wageningen Agricultural University.

1. LAM MINH TRIET
2. NGUYEN XICH LIEN
3. LUU TIEN HIEP
4. NGUYEN DUC LUONG
5. NGUYEN TRUNG VIET
6. TRAN VAN THINH
7. LE THI HANH
8. DANG DUY TINH

Rationale

In the barchart (page 43) it can be seen how the exchange of personnel is going to take place. In general it has been necessary to keep the contribution of the Department of Water Pollution Control relatively small.

Further points of departure were the gaining of research experience by two Vietnamese staff-members during eighteen months in Holland and the technical and scientific assistance in the anaerobic digestion research by a Dutch staff-member visiting Vietnam (two weeks).

3.2 Supply of materials of equipment

- Materials and equipment for pilot plant construction
- Apparatus for microbiological investigation
- Fermentor (10 l) with auxiliary equipment
- Spectrophotometer with UV lamps and spare parts
- Measuring instruments (pH, pressure, recorder, etc.)
- Photocamera, slide projector, screen
- Pocket calculators
- Small engines (stirring, pumps)
- Gas engine and generator (5 KW)
- Centrifuge
- Compressors
- Vacuum pump
- Metering pump
- Glassware
- Tool kit
- Chemicals
- Field kit for water analysis
- Spare parts
- Operation manuals

3.3 Other means

- Dutch staff will be housed in a hotel, a car and driver will be provided by the University, a secretary and office will also be provided at the campus.
- Floor space is available for laboratories and pilot plants. Air conditioning facilities are also available.
- Supporting staff are also available

3.4 Execution: planning of activities

See page 43 for bar-chart

3.5 Organization of the project

Dutch working committee: J.C.L. van BUUREN

Vietnamese working committee: NGUYEN XICH LIEN

3.6 Financial contributions to be obtained from:

a. Dutch University: Nil

b. Ho Chi Minh City Technical University:

Up to 1.500.000 dong for materials and equipment purchased in Vietnam, especially for the construction of pilot plants, and for expenses incurred by Dutch staff in Vietnam.

c. PUO funds:

	Guilders
Pilot plants (including gas-engine)	45.000
Laboratory equipment and chemicals	100.000
Freight charge (20% of 145.000)	29.000
Fellowships (18 months)	52.000
Study-tours	20.000
Books and journals	25.000
Travelling costs	15.000
DSA for Dutch experts in Vietnam	1.000
Accomodation for Vietnamese in Holland	6.000
Sundries	7.000
Total:	300.000

The total costs of the pilot plants are estimated at 90.000 guilders. Ho Chi Minh City Polytechnical University and PUO-funds both will contribute 50% of the costs.

3.7 Miscellaneous

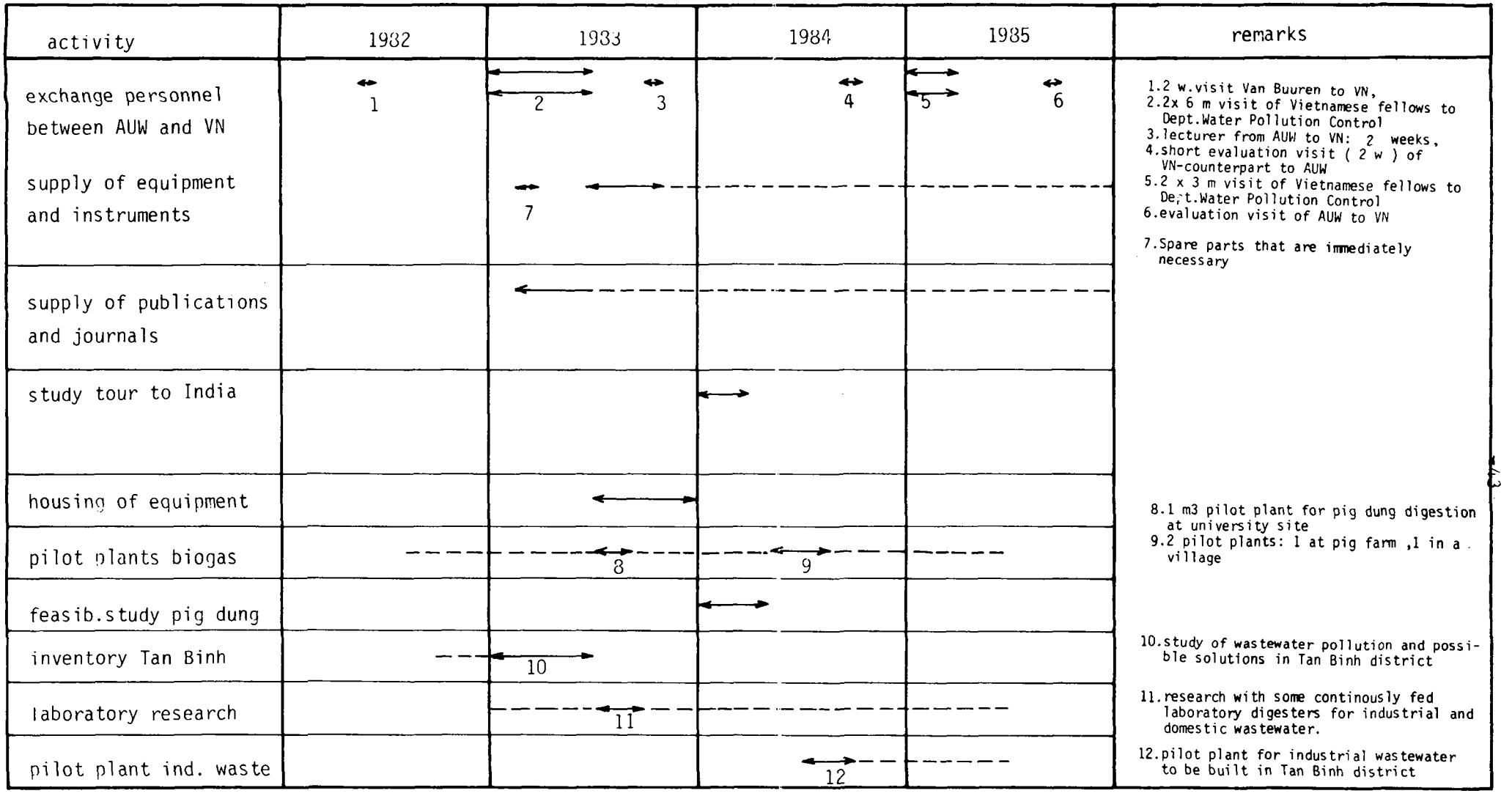
- Free use of research results coming out of the cooperation by both Universities. Publications of the results are carried out upon mutual agreement. The project proposal written in English will be published by the Agricultural University. The Vietnamese counterpart will publish its translation.
- Follow up activities will be discussed by the Working Committees.
- Upon agreement, material will be transferred to appropriate partners at the end of the project.

3.8 Review and evaluation

Progress reports in English will be made every six months by the appropriate staff and sent to partners at the earliest possible. The reports will evaluate work done during the period and mention the plan for the next semester so that at any time both partners will know what is going on and the objectives reached so far.

After three years a final evaluation report will be done by the heads of the working committees.

SCHEDULE OF ACTVITIES OF PROJECT VH 17



AUW = Agricultural University Wageningen

VN = Polytechnic University Ho Chi Minh City