IDRC RESEARCH PROJECT ON PIGGERY
WASTEWATER TREATMENT USING ALGAE

FINAL REPORT ON WORK ACCOMPLISHED
DURING EIGHT MONTH CONSULTANCY IN SINGAPORE

by

Joseph C. Dodd, PhD.
30 June 1973

Director, Health Sciences Division
International Development Research Centre
Box 8500
Ottawa, Canada K1G 3H9

Dear Sir,

Re: FINAL REPORT ON WORK ACCOMPLISHED DURING EIGHT MONTH CONSULTANCY IN SINGAPORE

I am pleased to submit this report on the work accomplished during my eight month consultancy authorised by the Centre on September 27, 1977, Centre File 3-P-76-0141. In addition to a description of the work accomplished, the report includes a series of photographs of the major project facilities as constructed and in operation.

My arrival and departure dates in Singapore were October 31, 1977 and June 30, 1978, respectively. The objectives of the consultancy were achieved during this period, with the exception of supervision of the construction work on the demonstration ponds, which had not started by the end of the consultancy. The collection and primary treatment system and pilot ponds were operating satisfactorily, with Microactinium predominating in all of the ponds. This is a closely related alga to Scenedesmus, with similar favourable harvesting characteristics. The centrifuge was in operation, and accumulation of algal concentrate for feeding trials was in progress.

Again, I would like to express my thanks to the Centre for this second consultancy, and for the cooperation and help received from the staff in Singapore.

Yours faithfully,

[Signature]

Joseph C. Dodd, PhD.
Consulting Engineer
37 Belmont Avenue
Upwey, Victoria 3158
Australia
Background
This report describes the work accomplished during my eight month consultancy on the research project, "Pig Wastewater Purification, Reclamation and Nutrient Recovery by High Rate Algae Pond System". Background information on this project is contained in my "Report on Work Accomplished During Ten Week Consultancy in Singapore", submitted to IDRC on October 4, 1977. Further information is also contained in the Monthly Reports submitted previously under the eight month consultancy.

Objectives
The objectives of the eight month consultancy, as contained in the letter of engagement dated September 27, 1977, are listed below:

a. Specific Technical Objectives.

1. Implementation of studies on algae growth in the miniponds;

2. construction of the wastewater collection and primary treatment system and ensuring design standards are adhered to;
3. testing the digesters and designing digestion facilities;

4. construction and testing of pilot ponds, with specific reference to waste treatment, effluent quality and algae growth;

5. final plans for the larger demonstration ponds and supervising their construction;

6. designing a mechanical harvester for recovering of algae from the large ponds.

b. Undertake such other assignments as are agreed upon between myself and IDRC.

c. Submit monthly progress reports and a detailed final report of the work accomplished.

Work Accomplished

The work called for in the letter of engagement was accomplished during the consultancy, with the exception of supervision of the construction work on the demonstration ponds, which had not started by the end of the consultancy. Work accomplished is described below by specific objective, together with a brief description of the work.

1. Minipond Studies. Operation of the four 10 m² miniponds continued from the previous consultancy through 6 May, when they were shut down in order to concentrate staff and laboratory resources on the pilot pond and centrifuge operations. Much useful information and experience was gained from the operation of the miniponds, some of which was briefly reported in the monthly progress reports and which will be further amplified in the project report. Operating procedures and techniques were
developed which had application in the pilot pond operation. Process control factors such as feed strength and areal BOD loading, depth, mixing regime and excess solids removal were investigated.

2. **Collection and Primary Treatment System.** Construction of the collection and primary treatment system was carried out in accordance with the design prepared during the ten week consultancy. Testing of components of the system began in mid-April and regular operation for feeding the pilot ponds commenced on 28 April. Some difficulties with the high lift pumps and macerator were experienced initially, but these were satisfactorily overcome.

3. **Sludge Digesters.** The 10 m³ bag digester associated with the miniponds continued to be operated until early June, when it was shut down. Although the small bag digester performed reasonably well during the early period of operation and produced burnable biogas, solids handling would be a major problem with a larger unit. Consequently, it was decided not to operate the 50 m³ bag digesters with sludge, but to use them for storage of biogas from the high rate digester, or for dilution water storage for the primary treatment system. Design of the 15 m³ high rate digester was carried out, and calling of tenders was in progress at the end of the consultancy. The digester design provides for mechanical mixing, and heating of feed or recirculated sludge using either solar or electrically heated hot water in an external concentric pipe heat exchanger.

4. **Pilot Ponds.** The pilot ponds were constructed in accordance with the design prepared during the ten week consultancy. Pond filling was started on 25 April, and regular feeding was commenced on 28 April. The initial Chlorella predominance shifted to *Micractinium*, a larger alga with spines closely related to *Scenedesmus* and with similar harvesting characteristics, during the first month of operation in pond A and shortly thereafter is the remaining ponds. *Micractinium* continued to predominate through to the end of the consultancy. After the start-up and stabilisation period, healthy cultures having a suspended solids of 500 - 700 mg/l were maintained with low bacterial content.
Pond loading appears to be the most important controllable process variable, with too high a loading causing dark colour and increase in bacterial fraction, and too low a loading leading to the possibility of rotifer infestation. Assessment of pond condition by visual appearance, microscopic examination of biomass, and measurement of D.O. and pH, appears feasible as a loading control technique. These early warning indicators would be used to adjust pond loading in response to changes in weather and wastewater characteristics prior to deterioration of pond conditions. The pond mixing and excess solids removal equipment performed effectively and efficiently.

5. **Demonstration Ponds**. Due to the relatively short period of pilot pond operation and the need to evaluate pilot pond performance, demonstration pond construction was not started during this consultancy. However, the demonstration pond design was carried out taking into account the limited experience with the pilot ponds. As a result of the later construction start than planned, and the difficulty of carrying out the work under wet weather conditions prevailing around the end of the year, it was decided to split the construction into an earthwork contract and a later general construction contract. Tenders for the demonstration pond earthwork contract were about to be called by the Public Works Department at the end of the consultancy. The number and size of the demonstration ponds were changed from four 500 m² ponds shown in the work plan to two 1240 m² ponds. This allows for more efficient and cost-effective use of the site, and reduces the scale-up factor to field scale production ponds. Since the demonstration ponds will now be operational rather late in the pond optimisation testing programme, the reduction in number of ponds is not considered serious. The proposed demonstration pond civil construction features and paddle wheel mixers will be similar to the pilot ponds. Modifications in pond construction to achieve greater economy will be considered in consultation with the contractor, such as possible alternative wall construction in selected non-critical areas. This could include corrugated asbestos-cement sheeting driven into place rather than concreted, for example. The pond depressed sections will be too large and inaccessible for hand desludging, so a hand-powered travelling carriage is proposed for moving the suction
device and associated pump. This will also provide useful information for the design of travelling equipment proposed for field scale ponds.

6. Mechanical Harvester Design. The design of the mechanical harvester was carried through the arrangement and preliminary detailing stages to allow a budget cost estimate to be prepared for comparison with alternative harvesting methods and for Phase 2 planning. The sizing of the mechanical harvester was set at an effective belt width of 500 mm and a filtration drum diameter of 2000 mm. This size is considered appropriate for reliable scale-up to larger commercial sizes, and suitable for possible continued use at the Sembawang Field Experimental Station after the research phase is completed. Materials of construction were chosen to be suitable for relatively long term use but not sacrificing economy on non-critical items. The preliminary drawings and specifications were submitted to a local fabricator who had worked on other mechanical features of the project. On consultation with the fabricator, an estimated cost for budget purposes for the basic harvesting machine without auxiliary equipment, external piping or wiring, is expected to be in the order of S$25,000. The auxiliary equipment and connecting up are expected to cost a further S$25,000, and allowing a 20 percent contingency factor, the total budget estimate for the mechanical harvester would be S$60,000.

7. Small Scale Harvesting and Feeding. Though not a stated objective of the eight month consultancy, a brief comment on the small scale harvesting and feeding work is included for completeness. The Alpha-Laval centrifuge was installed in a temporary shed due to delays in construction of the new harvesting building, and was initially operated on 19 May. An algal concentrate of suitable solids content for feeding experiments was obtained by using relatively long detention time, or by recycling the product for a second thickening step. A stock of frozen concentrate was being accumulated
for later feeding trials. Purchase of the drum dryer by IDRC from Richard Simon and Sons in May allowed finalisation of boiler specifications and calling of quotations. Boiler purchase arrangements were nearly complete by the end of the consultancy.

8. Photographs. Although the foregoing brief discussion summarises the work accomplished during the consultancy, this phase of the project was largely concerned with the construction of the test facilities, which can perhaps be conveyed better by photographs. Consequently, the remainder of this report consists of a series of photographs with accompanying captions to show the major elements of the test facilities as constructed and in operation.

Photo 1.
Minipond C and D, pond conditions on 9 December 1977
Photo 2.
High lift pumping station, drain and macerator.

Photo 3.
Primary system holding tanks and sedimentation tanks.

Photo 4.
Holding tank raw wastewater, mixer operating.
Photo 5.
10m³ bag digester producing burnable biogas.

Photo 6.
Pilot ponds and tanks under construction.

Photo 7.
Pilot ponds from outlet end.
Photo 8.
Pilot ponds, desludging depressed section.

Photo 9.
Centrifuge during discharge of algal slurry.

Photo 10.
Pilot pond effluent, centrate, and algal slurry (left to right) 1st run of 20 May 1978.