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PURDUE UNIVERSITY
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PORTUGAL UNIVERSITY INSTITUTES DEVELOPMENT PROJECT

(Contract AID/NE-C-1701)

REPORT ON
SHORT-TERM STAFF ASSIGNMENT

Submitted by
DR. JOHN J. PORTER
School of Textiles
Clemson University
Clemson, South Carolina

September 29 through November 28, 1985

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REPORT ON SHORT-TERM STAFF ASSIGNMENT AT THE INSTITUTO UNIVERSITARIO DA BEIRA INTERIOR (IUBI) COVILHA, PORTUGAL

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REPORT OF ACTIVITIES AT THE INSTITUTO UNIVERSITARIO DA BEIRA INTERIOR COVILHA, PORTUGAL

INTRODUCTION

This report describes the activities performed by John J. Porter during the months of October and November 1985, when serving as a short-term advisor at the Instituto Universitario da Beira Interior (IUBI) at Covilha, Portugal. The activities were carried out under the auspices of the Purdue/AID Portugal University Institutes Project (contract AID/NE-C-1701).

During this period, a five-week course in wastewater treatment and energy and chemical recovery was presented at IUBI. The course offered two nights a week at 6:00 p.m. at the suggestion of Dr. Ferra to facilitate participation of industrial personnel and satisfy the seminar requirements in the scope of work. Three papers, in Portuguese, were given to all participants.

Several textile plants in the area were visited so that a knowledge of textile industry could be obtained. A research project was started by Dr. Isabel Ferra to evaluate a new technique of anaerobic treatment recently evaluated in Sao Paulo, Brasil. The project will hopefully aid Portugal in developing an economical method of treating wastewater.

AREA OF CONSULTANCY

Assist in the design and implementation of a course and seminars on wastewater treatment and provide assistance to faculty conducting research in the area of effluent treatment of textile.

OBJECTIVE OF THE CONSULTANCY

The specific objectives of the consultancy were as follows:

A. Courses and Seminars

A course was initiated on wastewater treatment and pollution control which described the effect of pollution on the environment and also discussed the analyses of wastewater and methods of treating domestic and industrial wastewaters. The course also covered methods of recovery of chemicals and energy from wastewater so that savings could be obtained.

B. Research

A research project was initiated to assist Dr. Ferra in an area of research that could be valuable to the textile industry and Portugal. The project involved the use of anaerobic treatment as described by Lettinga[1] and coworkers and underevaluation in Sao Paulo, Brasil.[2] The system utilizes an "Upflow Anaerobic Sludge Blanket" for treatment and requires very little energy for operation. A simple vertical column using a pump and a collector system for the methane gas generated is all that is required. These factors are the principal reasons Brasil is evaluating the use of this system for the city of Sao Paulo.

A column was designed at IUBI and fabricated in Lisboa and set in operation in Dr. Ferra's laboratory. Domestic and textile wastewaters were collected near IUBI and fed-monitored by COD and BOD analyses. The column will be operated for several months to establish treatment efficiency and optimize operating conditions.

PORTUGUESE COUNTERPARTS

Essentially, all of the work was coordinated with Dr. Isabel Ferra and she made arrangements for scheduling of the course and assisted in presentations where translations were needed. Dr. Ferra was also actively involved in the design of the research project and will continue the work after the advisor completes his contract.

DURATION OF THE ASSIGNMENT

The activities outlined above were performed between September 30 through November 29, 1985.

ACCOMPLISHMENTS WITH RESPECT TO OBJECTIVES

Effluent Evaluation

Objective 1 -- Assist Professor Ferra with knowledge of effluents in region and relative cost of treatment methods.

This objective was accomplished by visitations to several textile plants near Covilha and reviewing analyses of effluents from some of these mills. This afforded the opportunity to review and criticize analytical methods and techniques used for wastewater analyses. Constructive suggestions were made and beneficial exchange of information was realized.

A review of several treatment methods useful for textile wastewaters was presented directly to Professor Ferra and also presented in the course given at IUBI. This exchange resulted in the start of a research project believed to be very useful in the future to Portugal for textile wastewater treatment and is discussed in a following section.

Seminars

Objective 2 -- Conduct one or more seminars in effluent treatment at IUBI.

This objective was accomplished by offering a course in wastewater treatment during the evening at 6:00 p.m., two nights a week for five weeks. Several industry personnel attended the course and participated in discussions with Professor Ferra and the short-term advisor. This method enabled Professor Ferra to become familiar with both specific contacts in textile mills near IUBI and their problems relative to wastewater treatment. Also discussed were methods of recovering hot water and chemicals from wastestreams. This approach is valuable in that it offers the cost benefit of conserving valuable chemicals and energy when it can be applied.

Short Course

Objective 3 -- Assist in the design and implementation of a course in effluent treatment at Covilha.

This was accomplished in a five-week course offered to students at IUBI and personnel from industry accessible to IUBI. The course covered the following topics:

Course on Wastewater Treatment and Pollution Control

1. Introduction
   a. Development of Regulations
   b. Methods of Treatment
   c. Effect of Pollution on Environment

2. Wastewater--Characterization
   a. Analyses of Wastewater
   b. Effect of Pollutants on Receiving Streams
   c. Treatability of Wastewater

3. Methods of Treatment of Wastewater
   a. Biological Treatment
   b. Chemical Treatment
   c. Physical Treatment
   d. Carbon Absorption
   e. Reverse Osmosis
   f. Other Techniques

4. Degrees of States of Wastewater Treatment
   a. Primary Treatment
   b. Secondary Treatment
   c. Tertiary Treatment
   d. Sludge Treatment

5. Design of a Wastewater Treatment Plant
   a. Laboratory Study
   b. Pilot Plant Study
   c. Design of Treatment System

Material was taken from the following textbooks and papers. The papers were given to all participants in the course and the textbooks were placed in the IUBI library.

"Introduction to Wastewater Treatment," R. S. Ramalho, Academic Press, Inc., New York, New York 1977. (Contained in IUBI Library)

"Wastewater Treatment Plants--Planning, Design, and Operation," Syed R. Qasin, Holt, Rinehart and Winston, New York, No. 4, 1985. Donated to IUBI by Dr. R. C. Peterson

"Environment Engineering," Howard S. Peavy, Donald R. Rowe, George Tchobanoglous, McGraw-Hill Book Company, New York, No. 4, 1985. Donated to IUBI by Dr. R. C. Peterson.

Publications submitted for the course included:

"Reproducao de Agua, Energia e Produtos Quimicos Atraves de Modificacoes no Processo e no Equipamento," John J. Porter, Senia-Symposia, 677 Etiqt, 1983, Rio de Janeiro, Brasil.

"Tratament de Elementos Texteis nos Estados Unidos," John J. Porter, Seminario Sobre Control de Efluentes, Texteis Cetex Americana - Sp, Abril de 1985.

"Tratamento de Esgotos por Digestoses Anaerobios de Fluxo Ascendente," Sonia Maria Manso Vieira, Revista DAE, 44, 139, p 322, 1984

Research Project

Objective 4 -- Research project initiated during consultancy.

After discussing the situation regarding pollution control used by the textile industry near Covilha it was evident that little had been done up to the present time and limited money would be available for construction in the immediate future. Because of these factors, it seemed that a low capital and operating cost system would be needed to offer the greatest impact for pollution control over the next ten year period. A system which has the potential for meeting these requirements was the "Upflow Anaerobic Sludge Blanket" process developed in the Netherlands[1] and recently evaluated in Sao Paulo, Brasil.[2]

Some of the most attractive features of anaerobic treatment as compared with aerobic treatment are listed by Dr. Manuel Jose Teixeira Carrondo[3] as follows:

Advantages of Anaerobic Treatment[4, 5, 6]

1) Low production of stabilized sludge (0,04 - 0,14 Kg sludge/ /Kg COD removed, as compared to 0,3 - 0,5 Kg sludge/Kg (COD removed in anaerobic process);
2) Possibility of recovering 80 - 90% of the energy present in the metabolized waste as methane gas (which may be used as a fuel);
3) Low consumption of nutrients;
4) Lower energy requirements than aerobic treatment (no need for aeration and smaller amounts of sludge for dewatering and disposal);
5) High degree of waste stabilization (about 90%) compatible with very high organic loadings;
6) Well acclimated anaerobic reactors can be preserved unfed for periods up to one year without any appreciable deterioration in sludge properties;
7) Anaerobiosis sharply enhances public health quality of the waste by inactivating pathogenic bacteria, as well as some viruses and parasites; when properly conducted no nuisant odour is produced.

Limitations of Anaerobic Treatment[4,5]

1) Great sensibility to some specific compounds such as $SHCl_3$, CCl_4 and CN which have been found to be toxic;
2) Due to the slow growth rate of the anaerobic bacteria, the first start-up may take several months, although a period of

8-12 weeks is possible when innoculation with digested sewage is carried out;

3) A rather high temperature (30° - $40^{o}C$) is desirable to reach high conversion rates;

4) Anaerobic digestion is essentially a pretreatment method. It has been estimated that anaerobic digestion offers a potential net energy saving of about $2,3 \times 10^{4}$ K/Kg COD removed and that its operating costs are about USA $90/ton COD removed smaller than for aerobic treatment[7].

In addition, studies conducted with an expanded bed reactor showed that the use of this anaerobic treatment may reduce capital costs from 40 to 80%, with installed energy requirements of only 10 - 20% of an equivalent aerobic system[8].

The factors listed above encouraged our interest in the work at IUBI.

Laboratory reactors were assembled in Professor Ferra's laboratory and a pilot scale column, 2 meters tall, was designed and submitted to a manufacturer in Lisboa for fabrication. The column was put in operation in November and a routine established for operation and monitoring of the treatment system. It was also agreed that the short-term advisor would keep in close contact with IUBI by mail after the period of consultancy was completed. It was also desired to obtain additional support so the short-term advisor could return to IUBI and participate in the research directly. The results of the treatment system to date look very promising and hopefully will be of

significant value to the textile industry and Portugal. Contacts were made with other institutions working in Portugal or related projects.

REFERENCES

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6. Forday, W., P. F. Greenfield. Anaerobic Digestion, Effl. Water Treat. J., October, 405 (1983)

7. Parkin, G. F., R. E. Speece, C. H. J. Yang, W. M. Kocher. Response of Methane Fermentation Systems to Industrial Toxicants, J. Water Pollut. Control Fed., 55 (1), 44 (1983)

8. Callender, I. J., J. P. Bardford, Recent Advances in Anaerobic Digestion Technology, Process Biochem., 8, 24 (1983)

IDENTIFICATION OF PROBLEMS ENCOUNTERED

In general the facilities and secretarial help for courses, seminars and travel were very good. The staff at IUBI was most cooperative in assisting with telephone calls and making arrangements for trips during the term of consultancy. Professor Ferra was always available and very cooperative with all phases of the consultancy.

The area that caused some problem was in acquisition of material for the research project initiated during the term of consultancy. The time requirements for purchasing supplies from local vendors in Covilha was long in view of the limited time available for assistance. This problem is not uncommon to universities in the U.S. and is part of bureaucratic limitation of many academic and government organizations. It points to the need for IUBI staff to be involved in research and for the administration at IUBI to try to facilitate that effort by providing suitable support help. It is felt by the short-term advisor that the problem can be corrected by identification to the administration and their natural desire to support activities such as research which bring favorable publicity to IUBI.

RECOMMENDATION FOR SOLVING PROBLEMS

The problem of acquiring materials and supplies for research can be easily corrected by the acknowledgement of the administration at IUBI that they will support research efforts by the faculty. This support does not have to include significant financial support but

only administrative assistance and the accessibility of laboratory work space at night and on weekends when necessary.

CONTACTS MADE DURING CONSULTANCY

1. Several textile plants were visited during the first two weeks at Covilha. These were visited by most short-term advisors and were used to familiarize the short-term advisor with the textile industry. These contacts are not included in this section unless new or special work was initiated with the plant.

2. Eng^{o} Nobre Santos, Direccao Geral dos Recursos e Aproveitamentos Hidraulicos, Lisbon, Portugal. Information was obtained on regulation proposed for Portugal and the laboratory facility in Lisbon visited.

3. Ing^{o} Jose G. Batanero Bernabeu, Centro de Estudio Hidrograficos, Madrid, Spain. Information was obtained for the development of regulations for Spain and the appropriate contact for the division responsible for textile regulation.

4. Dr. Carrondo, Universidade Nova de Lisboa, Faculdade de Ciencias e Tecnologia, 2825 Monte da Caparica. Visited laboratory in Almada and discussed anaerobic treatment process. Established an agreement for future interaction.

ACKNOWLEDGEMENTS

It is necessary to acknowledge the valuable assistance provided by the staff at IUBI. Especially helpful were Isabel Aibeo and Ana Maria da Costa Braz in the laboratory with the assembly of pilot equipment and the performance of laboratory work. Their conscientious help along with Dr. Isabel Ferra and Maria Manuela Estevao in performing analyses was necessary to the success of the short-term assignment. Also most helpful was the cooperation of Alberto Pereira to willingly assist the advisor with personnel needs for travel and communication. The secretarial help provided by Linia Saraiva and Ana Bela Freire was very cooperative and most useful during the term of the project.

APPENDIX A

Itinerary of Activities During the Assignment

ITINERARY OF ACTIVITIES DURING ASSIGNMENT

First Week

Sunday, September 29	Departed from Sao Paulo, Brazil
Monday, September 30	Arrived in Lisboa, met driver and traveled to Covilha. Then met Alberto F. Pereira in Covilha to discuss program at IUBI.
Tuesday, October 1	Met with Isabel Ferra and made plans for next two months, which included a course on wastewater treatment and a program for interaction with textile industries. Met with available faculty members at IUBI.
Wednesday, October 2	Placed personal books and material in new office and examined available information in library on wastewater treatment. Continued discussions with Isabel Ferra and discussed development of research project using anaerobic treatment.
Thursday, October 3	Discussed secretarial needs with Linia Saraiva who was assigned to work with me. Reviewed research work on anaerobic treatment and wrote letters to researchers active in this field. Developed information for wastewater treatment course.
Friday, October 4	Interacted with Dr. Chris Peterson and discussed problems relative to wastewater treatment for the pulp and paper industry. Contacted Professor Novais at Instituto Superior Tecnico in Lisboa and located equipment suppliers for laboratory needs.
Saturday, October 5	Weekend.
Sunday, October 6	Weekend.

Second Week

Monday, October 7	Visited textile mills in Covilha, Paulo de Oliveira, Textile Testing Laboratory and two wool scouring mills. Exchanged information with Dr. Chris Peterson on wastewater treatment programs in pulp and paper and textiles. Discussed anaerobic pilot project with Isabel Aibeo.

Tuesday, October 8	Contacted Professor Novais, Lisboa Biochemical Engineering Department, to obtain information on pilot equipment needs. Discussed anaerobic project with Isabel Aibeo and visited a textile dye house near IUBI to locate available dye wastewater for pilot study.
Wednesday, October 9	Studied additional information available at IUBI library to develop wastewater treatment course. Prepared outline for wastewater treatment course and discussed proposed seminar with Isabel Ferra. It was agreed that the first part of November would be the best time to allow Dr. Peterson and me to participate together.
Thursday, October 10	Designed laboratory apparatus for anaerobic research project. Visited city municipal sanitation department to obtain their assistance in selecting sewer manhole closest to IUBI which would provide wastewater for study.
Friday, October 11	Visited wastewater treatment plant in Dominguiso and discussed operation with Isabel Aibeo. Discussed design of laboratory apparatus with fabricator in Lisboa. Contacted paper mill in Salamanca, Spain, and Water Pollution Control Agency in Madrid, Spain, to plan visit to both locations.
Saturday, October 12	Weekend
Sunday, October 13	Weekend

Third Week

Monday, October 14	Made arrangements for visit to pulp and paper mill in Salamanca, Spain, and the government agency in Madrid, Spain, responsible for pollution control. Conferred with Isabel Ferra on laboratory analyses of BOD and COD. Went to wastewater treatment plant in Dominguiso to make arrangements to take sludge sample.
Tuesday, October 15	Returned to Dominguiso and obtained sludge sample and made simple analyses of sludge. Developed program of analyses and operation for laboratory anaerobic waste treatment study.

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Wednesday, October 16	Set up a small anaerobic reactor in laboratory to determine if sludge sample will develop anaerobic activity.
Thursday, October 17	Left Covilha to go to Salamanca and met Alfredo Solano and visited Gureola Scott pulp and paper company.
Friday, October 18	Completed activities in Salamanca and traveled to Madrid, Spain.
Saturday, October 19	Weekend
Sunday, October 20	Weekend

Fourth Week

Monday, October 21	Visited Jose G. Batanero Bernabeu of the Centro de Estudios Hidrograficos in Madrid, Spain, to discuss regulations and wastewater systems in Spain.
Tuesday, October 22	Returned from Madrid to Covilha
Wednesday, October 23	Reviewed progress of laboratory anaerobic study with Isabel Aibeo and checked on delivery of pilot plant equipment. Answered questions for Isabel Ferra about BOD analyses.
Thursday, October 24	Prepared first lecture for wastewater treatment course which was presented at 6 p.m. to both students of IUBI and industrial representatives.
Friday, October 25	Sick
Saturday, October 26	Weekend
Sunday, October 27	Weekend

Fifth Week

Monday, October 28	Started up a second small laboratory on anaerobic reactions with sludge from Dominguiso. Prepared material for course.
Tuesday, October 29	Worked in laboratory with Isabel Aibeo and Ana Maria da Costa Braz on anaerobic reactors and worked on set-up for pilot scale reactor in laboratory. Prepared information on course.

Wednesday, October 30	Worked in laboratory with Isabel Ferra on anaerobic projects and made plans to go to symposium in Lisbon with Isabel Ferra. Left for Lisbon.
Thursday, October 31	Attended Polution Control Symposium for Portugal, Spain and France presented in Lisbon.
Friday, November 1	Holiday.
Saturday, November 2	Weekend
Sunday, November 3	Weekend

Sixth Week

Monday, November 4	Worked with Isabel Aibeo on anaerobic treatment system and analyses procedures for wastewater.
Tuesday, November 5	Prepared material for course and worked in laboratory on anaerobic treatment system.
Wednesday, November 6	Discussed laboratory wastewater analyses with Isabel Ferra and needs for pilot anaerobic reactor.
Thursday, November 7	Prepared material for course and worked in laboratory on anaerobic treatment system with Isabel Aibeo and Ana Maria da Costa Braz.
Friday, November 8	Reviewed analytical procedure for total and suspended solids analyses and made recommendations for changes. Worked with anaerobic reactors in laboratory.
Saturday, November 9	Weekend
Sunday, November 10	Weekend

Seventh Week

Monday, November 11	Worked in laboratory to prepare sample of sludge for use with pilot scale anaerobic reactor. Interacted with Isabel Ferra to plan visit to Dr. Manuel Carrondo's laboratory and Direccao Geral de Recursos e Aproveitamentos Hidraulicos (Federal Pollution Control Agency) in Lisbon.

Tuesday, November 12	Prepared material for course on wastewater treatment and worked in laboratory with reactors. Designed support assembly for pump for pilot reactor.
Wednesday, November 13	Assembled column and piping and arranged feed tanks for pilot reactor. Monitor progress of laboratory reactors.
Thursday, November 14	Left with Isabel Ferra for Lisbon to visit Federal Pollution Control Agency in the afternoon. Visited with Nobre Santos and discussed work on pollution control in Portugal and research at IUBI.
Friday, November 15	Visited laboratory of Dr. Carrondo in Lisbon with Dr. Isabel Ferra to discuss anaerobic systems being studied at University of Lisbon.
Saturday, November 16	Weekend
Sunday, November 17	Weekend

Eighth Week

Monday, November 18	Discussed methods of analyses with Dr. Isabel Ferra and helped technicians with specific laboratory procedures. Assembled column in Dr. Ferra's laboratory and checked operation.
Tuesday, November 19	Worked with Isabel Aibeo on column operation and prepared material for course on wastewater treatment.
Wednesday, November 20	Prepared material for report for USAID and worked in laboratory.
Thursday, November 21	Prepared material for wastewater treatment course and corresponded with contacts made the preceeding week in Lisbon. Worked in laboratory. Met with Reitor Morgado to discuss work at IUBI.
Friday, November 22	Prepared material for final course session and worked in laboratory.
Saturday, November 23	Weekend
Sunday, November 24	Weekend

Ninth Week

Monday, November 25	Made final adjustments in pilot equipment and prepared column and sludge for start-up. Reviewed analyses schedule with Dr. Isabel Ferra. Start-up anaerobic reactor.
Tuesday, November 26	Monitored operation of anaerobic column and prepared report for Purdue/AID Portugal Project.
Wednesday, November 27	Reviewed assignment with Dr. Isabel Ferra and monitored operation of anaerobic column. Prepared report for Purdue/AID.
Thursday, November 28	Completed preparation of report and made final arrangements for analyses of samples taken from anaerobic column. Left Covilha for Lisbon to return to Brasil.
Friday, November 29	Returned to Brasil.