PRELIMINARY PROPOSAL TO:

U.S. ENVIRONMENTAL PROTECTION AGENCY

HIGH FIELD GRADIENT MAGNETIC SEPARATION FOR WASTE WATER PURIFICATION APPLICATIONS IN PUERTO RICO

prepared by

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CENTER FOR ENERGY AND ENVIRONMENT RESEARCH
UNIVERSITY OF PUERTO RICO — U.S. DEPARTMENT OF ENERGY

Preliminary Proposal to:

U. S. Environmental Protection Agency

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Submitted by:

CENTER FOR ENERGY AND ENVIRONMENT RESEARCH
UNIVERSITY OF PUERTO RICO

Prepared by:

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Center for Energy and Environment Research
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INTRODUCTION

This proposal is the outcome of intense discussion among CEER personnel reflecting very great concern about the effects of water pollution and potable water shortages on the health and welfare of the people of Puerto Rico. The present level of contamination of Puerto Rico's fresh surface water and groundwater as well as of its aquatic recreational areas and beaches is already alarming and increased population pressures are anticipated to aggravate the problem of pollution control. The population density of Puerto Rico, an island 30 x 150 mi. in size is rated the 6th highest worldwide and with most of the population (ca. 90%) resident on a very narrow coastal plain the effective population density may be the highest in the world. The large volume of waste generated by Puerto Rico's advanced industrialization programs population density pressures and a fragile coastal zone environment have all combined to produce a grave challenge to the health, welfare and lifestyle of Puerto Ricos 3.2 million inhabitants.

At several locations on the island hazardous water pollutants from industry, municipalities and communities are discharged to the environment with little or no treatment. In the past, a great number of community activities and projects aimed to minimize adverse health conditions and social and esthetic effects associated with water contamination. In the light of the existing conditions on the island however, it appears obvious that conventional treatment management methods have failed to significantly reduce water pollution, much of this attributable to non-point sources (eq. storm overflow). New methods and technology development appear to be urgent priorities for reclamation of polluted water to meet Puerto Rico's requirements by 1990.

BACKGROUND

In a new program, CEER proposes the application of a novel and powerful technology, called High Gradient Magnetic Separations (HGMS) as an efficient and flexible means to remove pollutants from waste waters at very high rates of throughput. HGMS utilizes "state of art" technology and its applications worldwide, now include.

Mineral Processing
Effluent and Waste Water Treatment
Chemical Processing
Biochemical Processing
Pharmaceutical Processing

In the case of wastewater treatment from sewage plants it has been shown that HGMS is clearly superior to conventional processes used in the purification of water. The advantages of the methodology include overall cost savings, considerably smaller space and land area requirements, very high throughputs,

continuous operation, improved sludge properties and very broad range of applicability.

PROJECT OBJECTIVE

The primary objective of this project is the testing and establishment of high gradient magnetic separation of industrial and domestic waste water. The secondary objective is utilization of the technique for water reclamation and reuse.

The tasks necessary to achieve this goal are:

1. Acquire Sala Magnetic Mobile Laboratory demonstration trailor.
2. Training and familiarization with the equipment.
3. Select sites for waste water testing.
4. Test magnetic separation on each effluent.
5. Assign "effectiveness" of separation parameters to each type of waste.
6. Prepare cost estimates for "problem" industries and for total upgrading (water upgrading to potable quality).

PROJECT METHODOLOGY

The objective of this project can be achieved by the utilization of the following methods briefly outlined in correspondence to the specific tasks:

1. Rent, overhaul and ship the already operational mobile lab from Sala Magnetics, Boston, MA.

2. The course offered by Sala Magnetics and Boliden Kemi will be given by 2 specialists to a team of 6 persons: 1 scientist, 1 scientific associate, 1 technician and 3 graduate students.

3. Contact industries and arrange (on a discrete basis) a demonstration for problem wastes. Contact municipalities and government agencies. Choose 10 widely different waste problems.

4. Station the laboratory for 1 week in a convenient place for the magnetic separation treatment demonstration. Try treatment varying: seed and poly electrolyte concentrations, matrix loading, residence times, magnetic field and flow rate.

5. Analyze influent and effluent with respect to suspended solids, pH, apparent color, turbidity, settleable solids, BOD, COD, Coliform bacteria and heavy metals.

6. Classify wastes using a matrix of influent characteristics with respect to ability (% removal or change) of magnetic separation to treat the waste. Calculate costs of separation based on estimated effluents - per diem. Using appropriate EPA data, calculate cost of total upgrading and also compare costs with conventional treatments.

The proposed methods will be divided into three separate operational phases with the exception of the last task, which will be the final report and recommendations.

The planned operational phases are:

I

Task 1

Task 2

Task 3

II

Task 4

Task 5

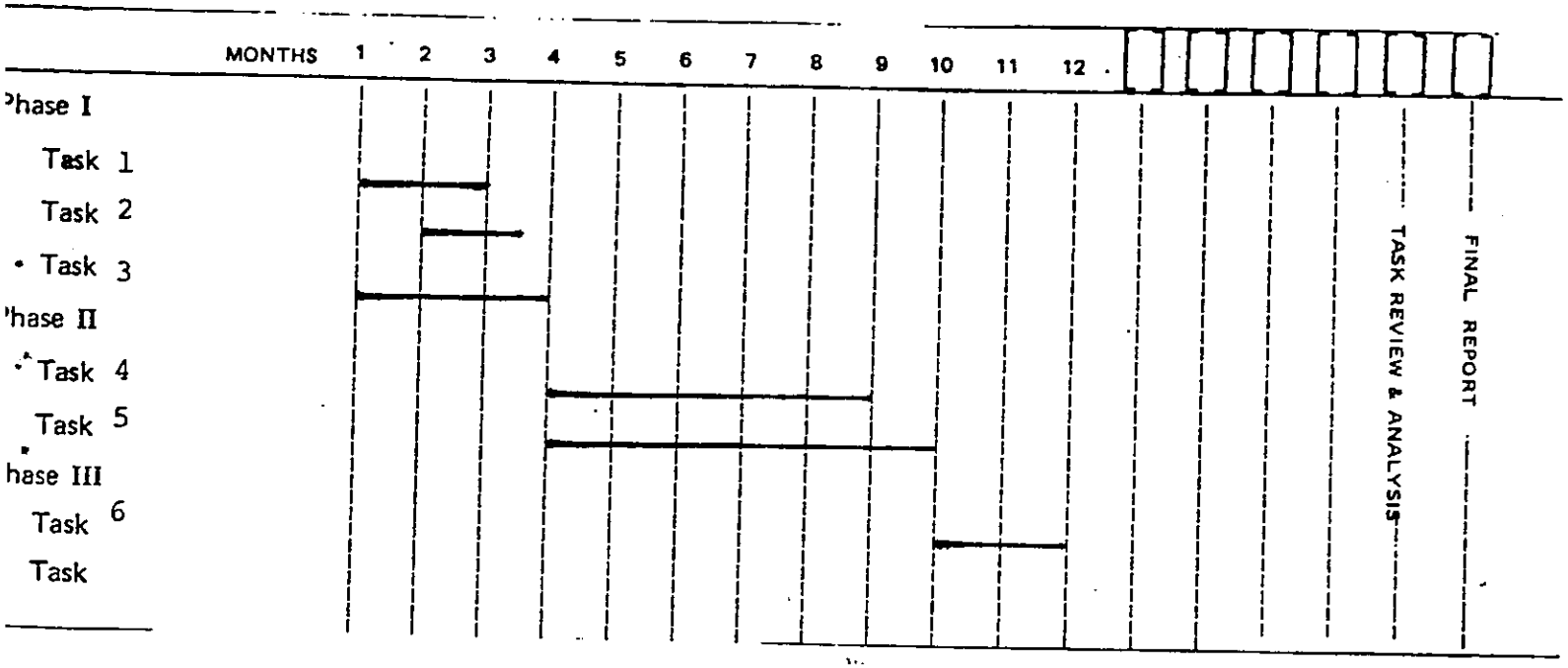
III

Task 6

Task

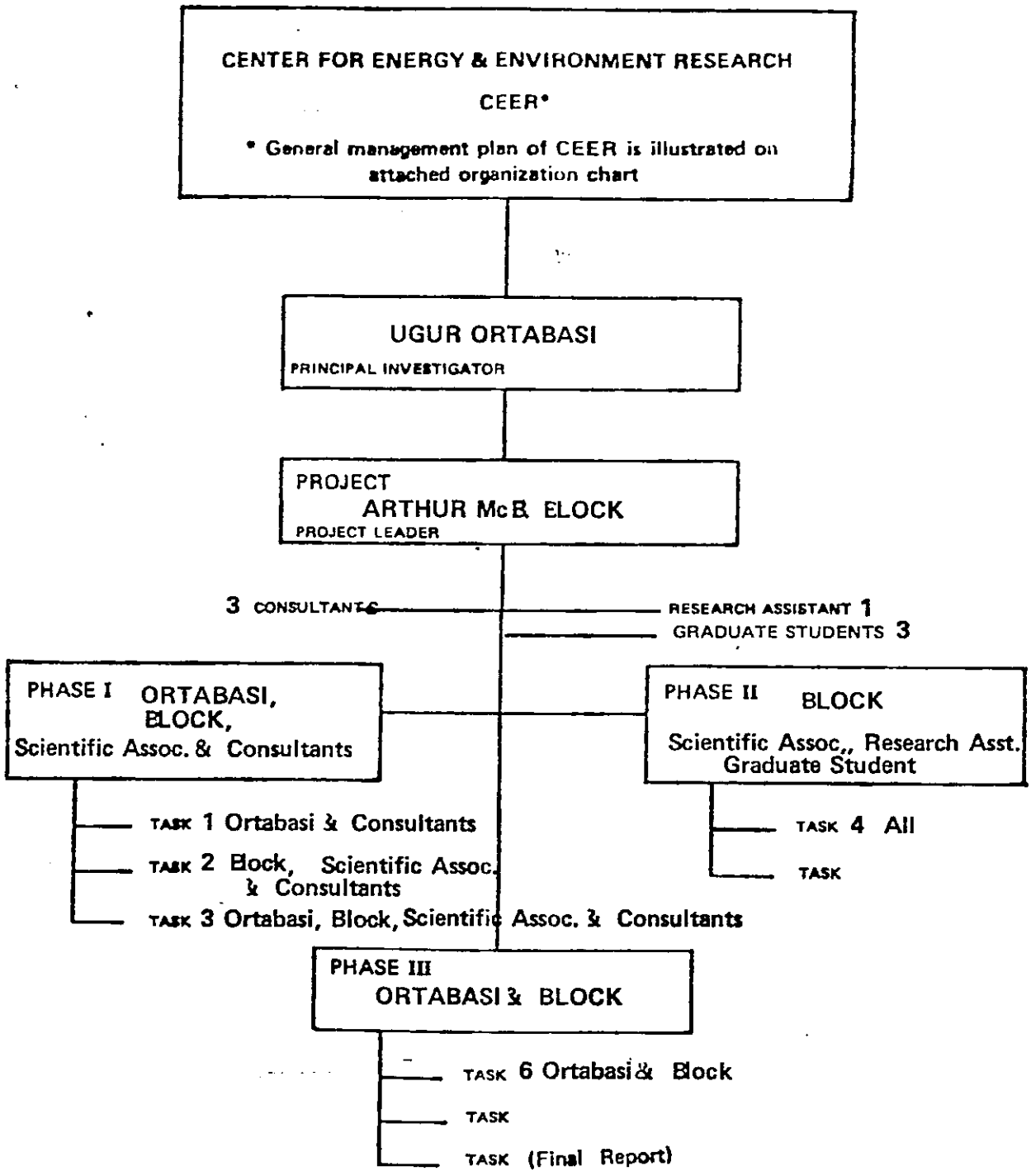
PROJECT TIME SCHEDULE

Approximately 12 months is estimated for the completion of this program section.


MONTHS 1 2 3 4 5 6 7 8 9 10 11 12
Phase I
Task 1
Task 2
Task 3
Phase II
Task 4
Task 5
Phase III
Task 6
Task
TASK REVIEW & ANALYSIS
FINAL REPORT

PROJECT MANAGEMENT PLAN

The proposed management plan for this project is shown on the organization chart below. As part of the CEER research program, accounting and administrative procedures will be handled by the appropriate CEER facilities. Personnel to be used on this project will be drawn from CEER staff, University faculties, and other sources as required for specific tasks of predetermined duration. CEER facilities and equipment will be used and supplemented where necessary with project supplies.



PROJECT BUDGET (12 months period)

It is proposed to develop this project utilizing the matrix technique of project management and staffing. During the 12 months period, personnel will be used for varying periods of time for discrete task assignments. Where possible they will be drawn from other CEER or University programs on an available time basis. Utilization of part time personnel appears to be one way of reducing overall project costs and eliminating the sometimes costly "dead spots" in which personnel have finished a specific element of their task and must wait for additional information or material. The matrix approach allows for efficient team operation at minimum personnel costs. Items marked with an * are costs to supplement equipment, supplies, and services supplied by CEER. This latter includes laboratory space, highly sophisticated laboratory equipment, vehicles and boats, and all administrative and accounting services.

ESTIMATED BUDGET for 12 months period

Personnel (task determined time)

Principal Investigator) Project Leader)	F.T.E. Scientist	10%	4,000.00
		50%	10,000.00
Scien. Assoc.		50%	7,000.00
Res. Asst.		100%	6,200.00
3 x Grad. Students		100%	5,400.00
3 x Consultants			15,000.00
		---	47,600.00
		Total Salaries	47,600.00
		15% Fringe	7,140.00

Operating expenses and services

Materials & Supplies (estimated)	4,500.00
---	4,500.00

Equipment and supplies*

Rental & Shipping (Round trip), Overhaul of Sala-Lab. and insurance	45 20,000.00

Sub Total	79,240.00
Overhead 41%	32,488.00
Total Project	3 111,728.00
~~EPA Share: 95%~~	~~106,142.00~~ ~~125,142.~~

LITERATURE REFERENCES

1. Weber, Walter J. Physiocochemical Processes for Water Quality Control. Wiley-Interscience, New York, 1972, 640 pp.

2. Oberteuffer, J.A. High Gradient Magnetic Separation. IEEE Transactions on Magnetics, Vol. MAG-9 (3): 303-306, 1973.

3. Bitton, G. and R. Mitchell. Removal of E. coli Bacteriophage by Magnetic Filtration. Water Research, 8: 107, 1974.

4. Mitchell, R., Bitton, G. and C. DeLatour. Magnetic Separation: A New Approach to Water and Waste Treatment. In: Proceedings of the Seventh International Conference on Pollution Research, Paris, 1974.

5. Oberteuffer, J. A. Magnetic Separation: A Review of Principles Devices and Applications. IEEE Transactions on Magnetics, Vol. MAG-10 (2): 23-238, 194.

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7. Oberteuffer, J.A., Wechsler, I., Marston, P.G. and M. J. Mc Nallan. High Gradient Magnetic Filtration of Steel Mill Process and Waste Waters. IEEE Transactions on Magnetics, Vol. MAG-11 (5): 1591-1593, 1975.

8. Okuda, T., Sugano, I. and T. Tsuji. Removal of Heavy Metals from Wastewater by Ferrite Co-Precipitation. Filtration and Separation, 12(5): 472-278, 1975.

9. Allen, D., Arvidson, B., Oberteuffer, J. and R. Sargent. SALA-HGMS-TM Filters for the Treatment of Combined Sewer Overflow. In: Proceedings of the Third National Conference on Complete WATERUSE, Cincinnati, Ohio, June, 1976.

10. Allen, D. Addendum to SALA-HGMS-TM Filters for the Treatment of Combined Sewer Overflow. Presented at the Third National Conference on Complete WATERUSE, Cincinnati, Ohio, June, 1976, pp. 26.

11. Mitchell, R., Bitton, G. and J. Oberteuffer. High Gradient Magnetic Filtration of Magnetic and Non-Magnetic Contaminants from Water. Separation and Purification Methods, 4 (2): 267-304, 1976.

12. Allen D., M. and J.A. Oberteuffer. Combined Storm Overflow Treatment with SALA-HGMS-(R) High Gradient Magnetic Filters. In: Proceedings of the Joint US/USSR Symposium on Physical-Mechanical Treatment of Waste Waters, Cincinnati, Ohio, April, 1977. pp. 32.

APPENDICES

Appendix A : Overview of High Gradient Magnetic Filtration.

Appendix B : SALA- High Gradient Magnetic Filtration Pilot Plant Trailer.

APPENDIX A
OVERVIEW OF HIGH GRADIENT MAGNETIC FILTRATION

The use of magnets to separate substances of varying character is not new. Magnetic separation techniques have been used since the nineteenth century to remove tramp iron and to concentrate iron ores. A variety of conventional magnetic separation devices is in wide use today. These devices generally separate relatively coarse particles of highly magnetic material containing large amounts of iron from nonmagnetic media (direct filtration).

In recent years magnetic devices have been developed which are capable of separating even weakly magnetic materials of micron size at inherently high flow rates. These so-called "high gradient magnetic separators" have been designed to maximize the magnetic forces on fine, paramagnetic materials. They are capable of efficient separation of even weakly magnetic suspended solids or precipitates for which conventional magnetic separation techniques are ineffective. This capability is the result of the development of a filamentary ferromagnetic matrix and a large volume, high-field magnet. The combination of an efficient magnet and high gradient matrix permits the economical production of strong magnetic forces over a large surface area in the active volume of the separator. The separations may be carried out economically, and at process rates of up to several hundred gpm/ft^2.

For normally nonmagnetic colloidal material in polluted water, the addition of magnetic iron oxide (magnetite) along with a flocculating agent can render these colloids sufficiently magnetic to be removed by high gradient magnetic separators (indirect filtration). The machines provide the rapid filtration of many pollutants from water with a small expenditure of energy. Removal is much more efficient than with sedimentation because the magnetic forces on fine particles may be many times greater than gravitational forces. This technology has a high potential for use in water pollution control.

High gradient magnetic separation is used in the kaolin clay industry to remove weakly magnetic impurities of less than 2 micron size from clay. Industrial-size high gradient magnetic separators treat up to 60 tons per hour of dry clay, as a 30 percent slurry.

Other proven applications for HGMS magnetic separators include iron ore, feldspar, and many other types of mineral beneficiation. Waste reclamation and recycling, ultra purification of chemical refractories and powders,

removal of smoke stack particulates, cleaning of refueling pool waters at nuclear power plants, steam purification and other thermal power applications, and steel mill waste water purification are some of the recent problems that HGMS magnetic separators are or will soon be handling. All are direct applications and do not require the addition of a seed or flocculant to be effective.

Besides CSO and raw sewage, high gradient magnetic separation is applicable to numerous nonmagnetic waste waters such as paper mill wastes, electroplating waters, secondary effluent polishing, potable water processing, on board ship treatment of gray and black water, and almost any polluted stream in which the goal is to remove all solids from the water portion.

PRINCIPLES OF HIGH GRADIENT MAGNETIC FILTRATION

Magnetic and Competing Forces

High gradient magnetic separators, like all magnetic separators, utilize the interaction of magnetic and competing forces on a mixture of magnetic and nonmagnetic particles to provide separation based on the magnetic susceptibilities of the particles. The magnetic forces of attraction in a high gradient magnetic separator hold the magnetic particles to the edges of the matrix fibers while the competing hydrodynamic forces carry the fluid and nonmagnetic particles through the separator. For small particles the forces of hydrodynamic drag are larger than gravitational forces, and increase with slurry velocity in the separator. The magnetic forces necessary to trap these particles must therefore be large.

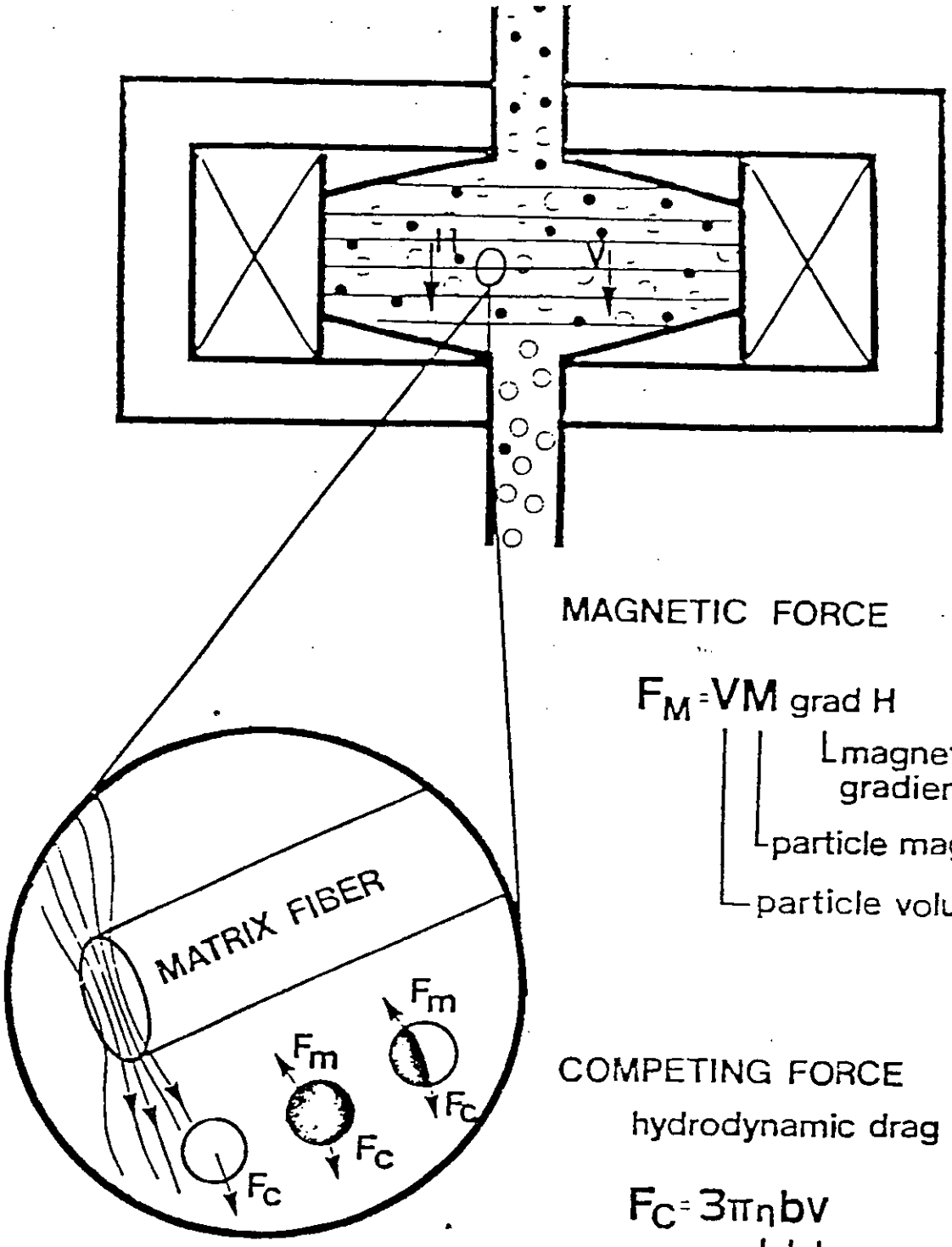
Maximizing the Magnetic Forces

High gradient magnetic separators effectively maximize the magnetic force on even weakly magnetic particles. The magnetic force (F_m) on a particle is given by the following expression:

$$F_m = vM \text{ grad } H$$

where v is the volume of the particle, M is its magnetization, and grad H is the magnetic field gradient that acts on the particle. The magnetic field gradient appears in the expression for magnetic force for the following reason. Placed in a magnetic field, all particles develop north and south poles at either end as shown in Figure III-1. In a uniform field the net force on a particle will be zero, since the field exerts an equal and opposite force on either end of the particle. In a gradient magnetic field, however, the force exerted by the stronger field at one end of the particle will produce a net force on the particle. Therefore, the larger the change in field across the particle (magnetic field gradient), the greater the force on the particle.

The magnetization of ferromagnetic fibers, like those in the high gradient magnetic separator matrix, produces extremely high magnetic field gradients. It turns out that the greatest force is produced on the particles when



MAGNETIC FORCE

$F_M = VM \text{ grad } H$

- M: magnetic field gradient
- grad H: particle magnetization
- V: particle volume

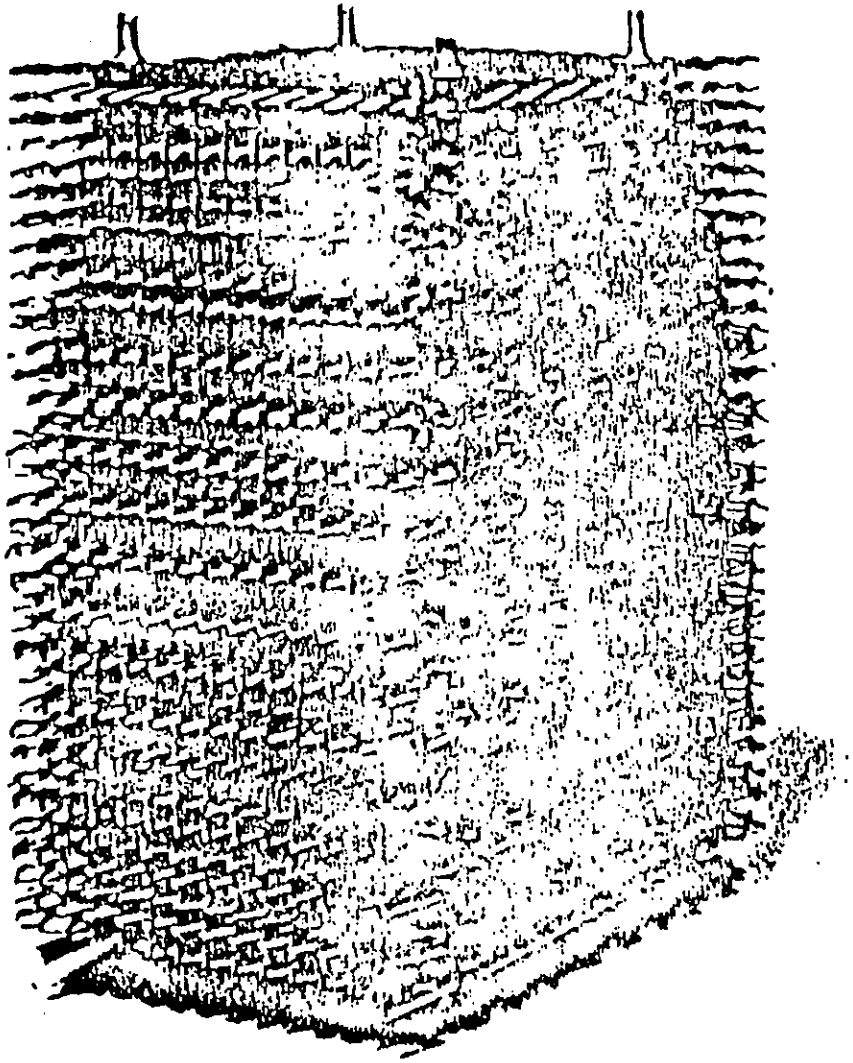
COMPETING FORCE

hydrodynamic drag

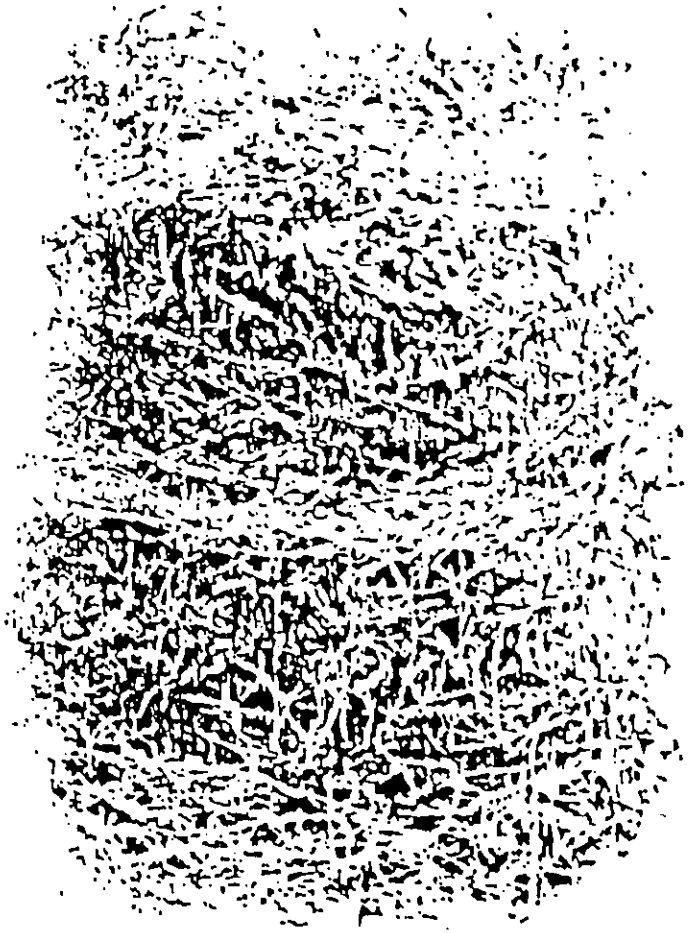
$F_C = 3\pi\eta bv$

- v: slurry velocity
- b: particle diameter
- η: slurry viscosity

FIGURE III-1 CUT-AWAY VIEW OF HIGH GRADIENT MAGNETIC SEPARATOR



Expanded Metal



Stainless Steel Wool

FIGURE III-2 MATRIX MATERIALS USED IN HIGH GRADIENT MAGNETIC SEPARATORS

separated are important operational variables in addition to those cited above. Thus, seeded water treatment is dependent upon the maintenance of a delicate chemical balance in order to achieve an effective union of suspended solids and seed particles before their magnetic removal.

MAGNETIC SEEDED WATER TREATMENT AS APPLIED TO CSO AND RAW SEWAGE

The seeded water treatment (mag-seed) process is a unique application of high gradient magnetic separation to the removal of nonmagnetic suspended and colloidal-sized particles suspended in a liquid medium (usually water). It has considerable potential in a large number of effluent waste water cases where certain standards must be met before disposal, as well as in some closed loop operations where corrosion products or contamination may result in degradation of liquid quality within the system. The system is of particular interest for its possible application to CSO and raw sewage and a number of other areas. Calculations for effectiveness of separation, economics of capital investment and operating costs, land requirements, dependability, process flow rates, and detention times, etc., have so far been favorable in comparison with presently available technology.

PREVIOUS WORK

This report is a continuation of Report #600/2-77-015 (March 1977) entitled, "Treatment of Combined Storm Overflows by High Gradient Magnetic Separation." In that portion of the study, full descriptions and references are provided for the physics and concepts involved in magnetic filtration. In completing that work, both bench and continuous pilot plant runs were performed at Sala Magnetics, Inc. in Cambridge on CSO and raw sewage trucked in from the Cottage Farm Chlorination and Detention Facility (Cambridge) and the Deer Island Sewage treatment Plant (Boston). These tests showed clearly that the seeded water treatment process could effectively and efficiently treat these waste water samples. However, limitations in the pilot plant system and lack of freshness in the sample volume suggested that an on-site test with a slightly larger and more flexible system would be necessary before jumping to demonstration size. A mobile system also would allow the performance of on-site testing with several different effluent situations in order to provide a maximum amount of design and cost estimating input. Whereas in the previous study CSO had been slightly aged and relatively static within the test period, with a mobile trailer on location it would be possible to profile an actual storm event, as it occurred, in order to study in detail the possible problems and solutions unique to combined storm overflows (e.g., first flush loadings, multiple separator storm fuction, required influent monitoring systems, etc.).

PRESENT CONTRACT GOALS

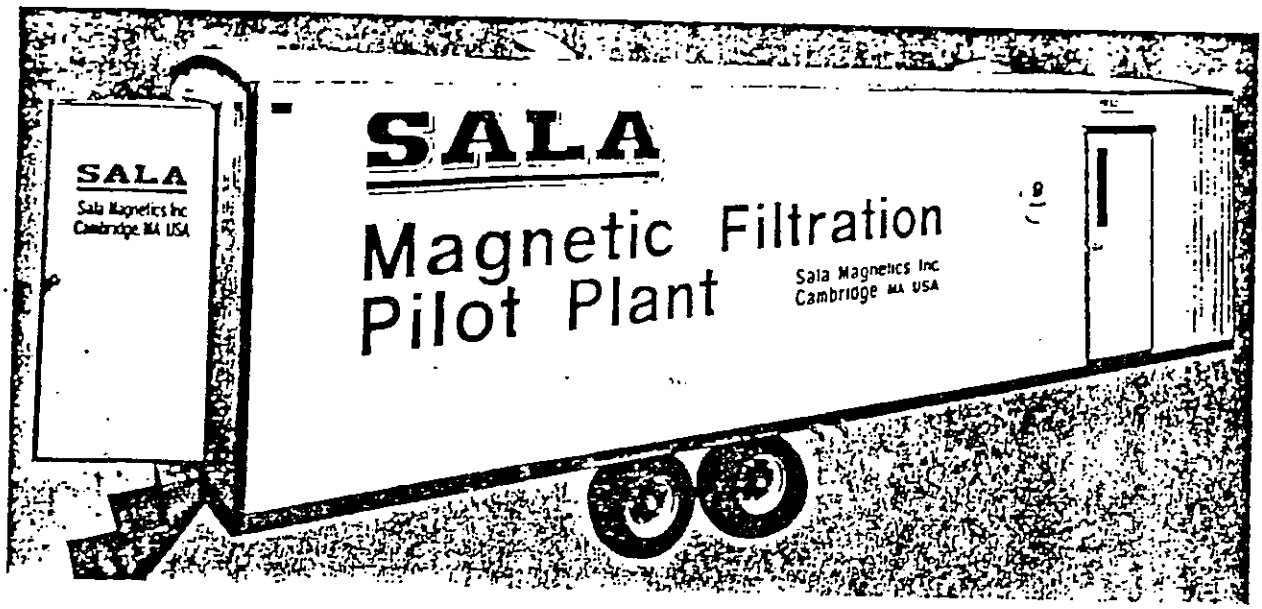
The present effort is designed to demonstrate the pilot-scale effectiveness of SALA-HGMF® magnetic filter treatment of CSO, and to use this information as a basis for further larger scale tests. Various design criteria and

te ic operating characteristics of the separator system were studied in some detail in order that accurate costing projections could be made for full-size integrated wet and dry weather treatment system.

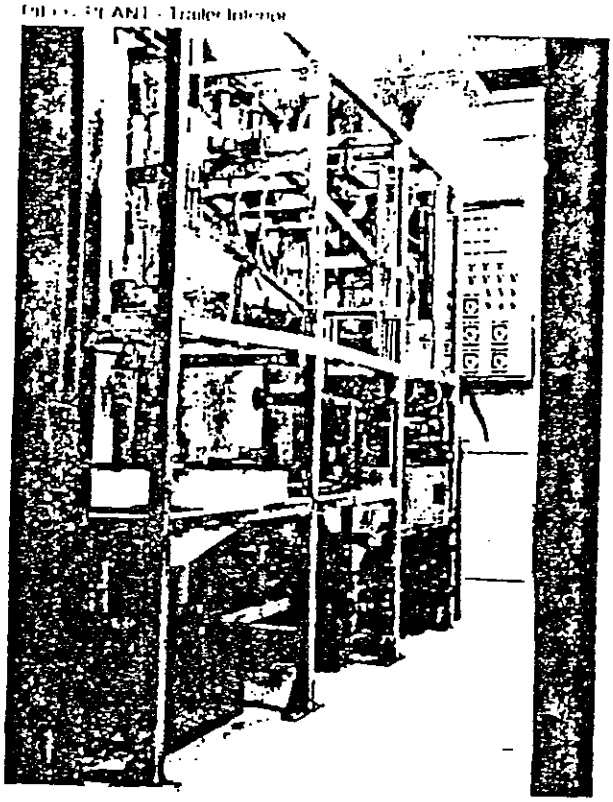
The extension of EPA Contract #68-03-2118 was performed in two parts: Effort I extended the data base of the previous work on the then-existing 1 gpm pilot plant with several specified tests, and upgraded that original pilot plant by means of a dual-magnet system, with more advanced controls, installed in a mobile unit; Effort II included on-site testing of the mobile unit, including several storm flows, as well as completion of the necessary backflushing, cleaning and sludge evaluations. With the information gained from these efforts and from previous testing using the seeded water technique, basic design and operating characteristics could be developed as a basis for the generation of costs and criteria for a demonstration-scale system.

APPENDIX B

SALA-HGMF®
AWT MAGNETIC FILTRATION PILOT PLANT TRAILER



PILOT PLANT - Trailer Interior



A fully automated, self-contained magnetic filtration Advanced Water Treatment pilot plant uses Sala's unique Mag-Seed™ flowsheet designed for the filtration of municipal and industrial waters containing nonmagnetic pollutants. The mobile trailer includes laboratory, office, and storage space. The laboratory can be equipped to measure a variety of water quality parameters.

The pilot plant is designed to operate automatically and continuously without attention for a period of 24 hours. A stripchart recording turbidimeter provides a continuous readout of effluent quality. The pilot plant includes two magnetic filters to simulate the operation of a full-scale variable flow capacity system. The larger magnet can reach a maximum background magnetic field of 5 kG. Usually much lower fields are required for seeded water treatment applications.

APPLICATIONS

- ☐ Municipal waste water
- ☐ Shipboard sewage
- ☐ Combined storm overflow
- ☐ Polishing step for secondary effluent
- ☐ Pulp and papermill process waste waters
- ☐ Chemical industry effluents

General Specifications
Trailer Dimensions 8'W X28 L x 11'H
(2 4m X 8 5m X 3 5m)
Laboratory-Office 8'W X 13'L *(2 4m X4m)*
Gross Weight 7000 lb *(3000 kg)*

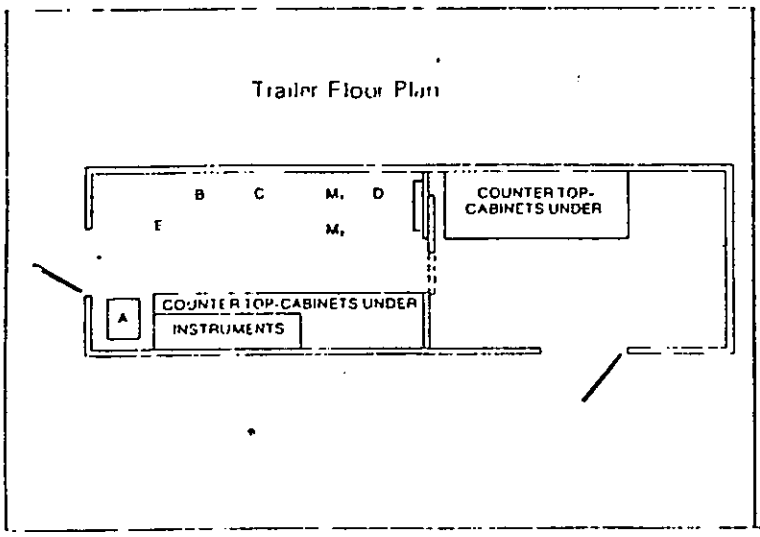
Pilot Plant Specifications
Flow Capacity: 10 gpm *(0.6 liter/s)*
Sludge Production: 1 lb/hour *(0.5 kg/hour)*

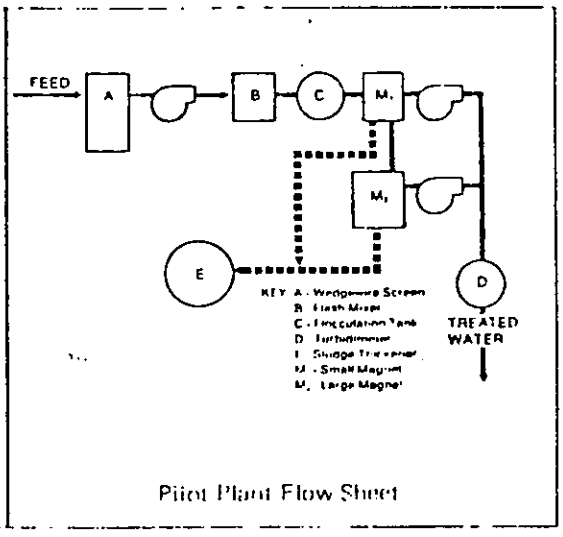
Utilities Requirement
The SALA-HGMF* magnetic filtration pilot plant trailer can be provided fully self-contained so that no utilities services are required.

If utilities services are available the following would be applicable

Electric Power: 8 8-22 kW
Tap Water: 5-25 gpm (exclusive of feed)
Compressed Air: 1-3 cfm at 40-60 psi
Appropriate Drainage

Typical Chemical Requirements
Magnetite: 0.6 lb/hour *(0.25 kg/hour)*
Alum: 0.25 lb/hour *(0 1 kg/hour)*
Polyelectrolyte: 0.04 oz/hour *(0.001 kg/hour)*





Pilot Plant Flow Sheet

The Sala Magnetics Mag-Seed™ magnetile seeded magnetic filtration process makes possible the magnetic filtration of nonmagnetic contaminants from waste waters Through this process contaminants such as coliform bacteria, viruses, organic material contributing to color and turbidity are coagulated and flocculated around a highly magnetic seeding material and are thus rendered susceptible to trapping on a magnetized filter bed. Even certain dissolved contaminants such as trace metals and phosphorous are trapped on the filter bed in this way.

Results obtained on combined storm overflow, on raw sewage, on secondary effluent from a conventional sewage treatment plant, and on paper mill aeration lagoon effluent are displayed in the following table.

PERCENT REMOVALS FOR TYPICAL APPLICATIONS

Application	BOD_5	Coliform	Color (apparent)	Turbidity	Suspended solids	COD
CSO	92	99.85	93	96	96	75
Raw Sewage	-	99	82	88	91	67
Secondary Effluent	-	98 3	71	85	88	-
Paper Mill	95	-	95	-	97	-

The SALA HGMF* Magnetic Filtration Pilot Plant is available for lease or sale. Requests for quotation for full-scale systems are invited. Specifications subject to change without notice. For further information contact the Sala Company or Sales Agent nearest you

SALA

Sala Magnetics 247 Third Street, Cambridge MA 02142 Tel (617) 868-2550 Telex 92-1475

SMI Bulletin 24200108 7718 GB

CURRICULUM VITAE

Name : Ugur Ortabasi

Born : Ankara, Turkey - June 1, 1938, U. S. Citizen

Married : Ilse Ortabasi, 2 Children

January 1978 - Present

HEAD OF THE ENERGY DIVISION OF THE CENTER FOR ENERGY AND ENVIRONMENT RESEARCH (CEER), University of Puerto Rico.

Responsibilities include; Research, Development and Planning in the fields of Solar Technology, OTEC, Conservation, Fossil Fuel, Nuclear and Biomass.

PROJECT DIRECTOR FOR CEER in the "Photovoltaic Concentrator Applications Experiment" awarded to the Energy Office of Puerto Rico in response to PRDA EG-78-D-04-0035.

UNITED NATIONS ASSIGNMENT AS CONSULTANT TO TURKEY in relation to "Re-Transfer of Technology Program"

October 1977 - January 1978

SENIOR VISITING RESEARCH SCIENTIST, Center for Energy and Environment Research (CEER), University of Puerto Rico

Director of Solar Energy Technology and Materials Research Program of CEER.

Responsibilities include; the organization of a developmental nucleus consisting of professors and graduate students from UPR Mayaguez and Rio Piedras campuses, preparation and development of a sound Solar Energy Technology program with the aim of its becoming strong and competitive.

June 1976 - October 1977

SENIOR RESEARCH PHYSICIST, Technical Staff Division, Corning Glass Works.

Principle Investigator of an ERDA Contract No. E-(11-1)-2608: "Evacuated Tubular Collector Utilizing a Heat Pipe as Solar Absorber."

and Turkey on Solar Experimental Techniques, High Performance Collectors, Physics of New Energy Resources and Their Impact on the Environment.

1973 - June 1976

SENIOR PHYSICIST, Technical Staff Division, Corning Glass Works.

a) Solar Research and Development, TECHNICAL LEADER of Solar Energy Program: Theory, design and experimental work on evacuated collectors, solar climate control of buildings, system computer simulations and cost analysis, Monte-Carlo digital ray tracing studies for solar cell array design. Experience in vacuum stable selective coatings evacuation and fabrication technology for high efficiency collectors. Application of Heat Pipe Concept to solar-thermal processes. Author and originator of an "Advanced Collector Development" proposal to NSF/ERDA and associated interaction with NSF and ERDA Personnel. Invited participant of the LASL meeting on the "Assessment of the Technology for Solar Heating and Cooling" at NBS, Gaithersburgh, Maryland, 1975. Summarized the section on "Advanced Collectors."

Representative of CGW Tech. Staff Division at the multi-industrial Solar Climate Control Project, conducted by Arthur D. Little, Inc., Boston (1973-1976).

b) Bio-Medical Research: Joint Project with Bio-Organic Department of CGW to develop a Nanosecond Fluorescence Spectrometer to study molecular kinetics of ligand - bio-polymer interactions. Single photon coincidence electronics and data reduction and analysis.

c) Academic Activities: CONTINUING EDUCATION FACULTY at Elmira College, N. Y. Lectures on Nuclear Engineering, Solar Engineering and Modern Physics.

1971 - 1973

RESEARCH FELLOW IN PHYSICS, Corning Glass Works R & D Laboratories.

Application of Nuclear Spectroscopy to Solid State Phenomena. Electronic structure of Glass Superconductors Investigated by Time-Differential Perturbed Gamma-Gamma Angular Correlations. Micro-Structure of Glasses. Other side projects included Vitrification of Nuclear Waste and Development of a Low-level Beta - Counter for Radio - Immuno Assay Techniques.

1969 - 1971

ASSISTANT PROFESSOR, The University of Florida.

Research and Teaching at undergraduate and graduate level. Lectures on "Radiation Interaction with Matter" and "Application of Isotopes." Supervision of Master of Science candidates. Responsible for the AEC Research Contract No. AT-(40-1)-3345 on "Chemical Structure Studied by Nuclear Techniques." Summer work at Lawrence Radiation Laboratories, Berkeley, California as Research Visitor.

1965 - 1969

GRADUATE ASSISTANT, Western Reserve University and University of Florida.

Received Ph.D. DEGREE IN NUCLEAR ENGINEERING from the University of Florida.

Experience in nuclear theory, fast nuclear electronics, computer analysis automatic data processing, reactor experiments, and radiation physics as applied to radio-scanning of the body. Theoretical work in crystal physics and electronic structure of metals.

1958 - 1965

Undergraduate and Graduate study at the Universities of Gottingen and Hamburg, Germany. DIPLOM PHYSIKER DEGREE from the University of Hamburg, 1965.

Experience in experimental nuclear spectroscopy, nuclear electronics, theoretical work in nuclear models, hyperfine interactions in metals. Independent study in physical oceanography.

PAPERS

An Evacuated Tubular Collector Utilizing a Heat Pipe, Report No. COO-2608-3, ERDA Contract EY-76-C-02-2608.

An Evacuated Tubular Collector Utilizing a Heat Pipe, Report No. COO-2608-2, ERDA Contract EY-76-C-02-2608.

An Evacuated Tubular Collector Utilizing a Heat Pipe, Report No. COO-2608-1, ERDA Contract EY-76-C-02-2608.

An Internal Cusp Reflector for an Evacuated Tubular Heat Pipe Solar Thermal Collector, accepted for the 1977 Annual Meeting American Section, International Solar Energy Society, June 6-10 1977, Orlando, Florida.

Simulation of a Residential Solar Air Conditioning System Using Evacuated Tubular Collectors and Chilled Water Storage, accepted for the 1977 Annual Meeting, American Section, International Solar Energy Society, June 6-10, 1977, Orlando, Florida.

Indoor Test Methods to Determine the Effect of Vacuum on the Performance of a Tubular Flat Plate Collector, 1976 ASME Winter Annual Meeting, December 5, New York, N.Y.

Energy and Environment, (In Turkish), 1976, publication of the Turkish Naval War Academy.

Optical Phenomena Associated with Tubular Collector, in preparation.

A Tubular Evacuated Solar Thermal Collector Utilizing a Heat Pipe as Absorber, 1976 Rencontre Internationale de la COMPLES, September 24, Ales, France.

Analysis and Performance of an Evacuated Tubular Collector, 1975, International Solar Energy Congress and Exposition UCLA, July 28, Los Angeles, California.

Effect of the Grain Size on the Quadrupole Interactions in Indium Impregnated Porus Glass Studied by Time Differential Angular Correlations, 1975 Northeast Hyperfine Interactions Meeting, Rutgers University, May 22, 1975, New Brunswick, New Jersey.

Fluorescence Lifetime Study of N,N-dimethyl-I-aminonaphtalene-5-sulfonyl Bovine Albumin Conjugates, in preparation.

Hyperfine Electric Quadrupole Interactions in Some TM-Salts Measured by Time-Differential Correlation Technique, 1969 International Conference on Radioactivity in Nuclear Spectroscopy and Applications, Nashville, Tennessee.

Perturbed Angular Correlation Studies of the Quadrupole Interactions of Cd in Different Metallic Environments and the Electric Quadrupole Moment of the 247-keV State, Phys. Rev. B.8,6, 2909 (1972).

Nuclear g-Factor of the 5/2 Kev State in Pd^{106} Nucl. Phys. (1965).

g-Factor Measurements on the First Excited States of Pd^{106}, Pr^{145}, Hg^{198}, and Pb^{207}. 1964 Congress Int. de Phys. Nucleaire, Paris, France.

BOOKS

Experimental Mechanics, translation from German into Turkish, Verlag Industries-Druck GMBH, Gottingen (1961).

Experimental Optics, translation from German into Turkish, Verlag Industries-Druck GMBH, Gottingen (1961).

Experimental Electricity, translation from German into Turkish Verlag Industries-Druck GMBH, Gottingen (1961).

AWARDS

DAAD Fellowship for 4 years, Germany, 1961-65.

Award of the University of Hamburg for Outstanding Foreign Students, Hamburg, Germany, 1965

American Nuclear Society Student Meeting Award for Outstanding Papers. Gainesville, Florida, 1967.

Recipient of the two years CGW Fellowship Award in Physics as a result of a nationwide competition.

PATENTS

Several Patents pending in the field of Solar Energy Conversion.

Revised [illegible] Apr. 1974

CURRICULUM VITAE

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Telephone No.	809 - 761-9389 (Home) 809 - 767 - 0350 (Business)
Physical Data	Height - 5'10" Weight - 170 Health - Excellent
Place and Date of Birth	Newark, N.J., June 26, 1938.
Citizenship	U.S.A.
Civil Status	Married, 2 children
Languages	English (spoken, written and reading), Spanish (spoken, reading), French (reading), German (reading), Russian (reading-dictionary supplemented).

Education

High School	Newark Academy, Newark, N.J.; Diploma 1956
University	Cornell University, Ithaca, N.Y.: A.B. 1961 Major: Chemistry and Physics
Advanced Degree	Rutgers - The State University, New Brunswick, N.J.; Ph.D. 1967 - Major: Physical Chemistry-Minor: Analytical Chemistry - Thesis: "Laser Light Scattering from Uniform Spherical Particles".

Professional Experience

Present - Scientist II, Center Energy Environment Res., Terrestrial Ecology Division; Duties: Chemical Program Development, Instruction of Analytical Techniques to Other Members of the Division, Maintenance and Repair of Instruments, Adaptation of Standard Methods for Field Work, Computerized Data Management (FORTRAN, RPGII; IBM 370 System); Grant and Proposal Submission, Administration of Programs; 3 Laboratory Assistants, 4 Graduate Students. Salary: $17K - 19K.

1973 - 1975	Scientist I, Puerto Rico Nuclear Center, Terrestrial Ecology Division and Physical Sciences Division: Duties: Development of Irradiative (Gamma Co-60) Analytical Techniques, Theoretical Prediction of Matrix Isolated Fluorescence of Purines and Pyrimidines, Development of Background Radiological Data for Northwest Puerto Rico, Measurement of Radioactivity Background in Northwest, Puerto Rico, Training of Field and Laboratory Technicians for Dosimetry and Monitoring Technical Measurements, Development of a Position Paper Concerning Chemical Data Necessary for the Assembly of a Trace Elements Transport Model of the Rio Espiritu Santo Drainage Basin, Computerized Data Management (FORTRAN); Supervision: 2 field technicians, no more than 6 laboratory aides. Salary: $12,000-15,500/year.
1968 - 1972	Assistant Professor, University of Puerto Rico, Rio Piedras, Puerto Rico; Duties: Instruction of Students at Graduate and Undergraduate Levels, Teaching of Physical Chemistry, Laboratory Instruction of Physical Chemistry, Admissions, Curriculum Committee, Grant Proposal Development and Submission, Original Investigation in Physical Chemistry, Publication of Scientific Articles in Chemical Journals, Participation in Scientific Conferences and Seminars; Supervision: Between 25 and 40 undergraduate students and 5 graduate students in research duties. Salary: $9,200-12,000/year.
1967 - 1968	Lecturer, University of Puerto Rico, Rio Piedras, Puerto Rico; Duties: Same as those 1968-1972; Supervision: About 28 undergraduate students in instructive duties. Salary: $8,000/year.
1962 - 1967	Laboratory Instructor, Rutgers - The State University, New Brunswick, N.J.; Duties: Laboratory Instruction to Undergraduate Students in General Chemistry, Quantitative Analysis and Instrumental Analysis, Student and Course Evaluation, Problem Grading in Graduate Courses, Tutoring of Students with Background Problems; Supervision: Between 15 and 30 students per class (usually 3 classes of 3 hours per week). Salary: $250-320/month.
Other	Chemist, Fluid Chemical Co., Newark, N.J.; Duties: Quality Control of Batch Process Manufacture of Lever Brothers Soap Products, Cosmetics, and Spray Aerosol Products. (1961). Salary: $2.50/hr.

Chemist, Analytical Development Section, Merck & Co., Inc., Rahway, N.J.; Duties: Development of Analytical Methods for the Analysis of Mononucleotides Used as Flavor Enhancers, Development of the National Bureau of Standards Thin Layer Chromatography Identification Procedure for Vitamin A Acetate, Palmitate, and Alcohol, Development of Micro Techniques for Analysis of Carotenes. (1963). Salary: $525.00/month.

Chemist, West Research, Johnson & Johnson Corp. East Brunswick, N.J.; Duties: Analysis and Development of Analysis of Low Molecular Weight Release Agents Used with Adhesives, Methanol in the Presence of Ethanol Using Gas Chromatography, Routine Analysis of Isopropanol in Aerosol Adhesives, Calibration X-Ray Fluorescent Method for the Determination of Zinc in the Presence of Titanium Using Polarography, Determination of Trace Elements in Uncured Silicon Rubber Samples. (1964). Salary: $558.00/month.
Summer job only. (Subsequent to receipt of Ph.D., offered position of group leader in a Physical Chemical Section Studying Ethylene Oxide Sterilization with this company).

Acting Head, Terrestrial Ecology Division, Puerto Rico Nuclear Center, Rio Piedras, Puerto Rico; Duties: Responsible for Maintenance of Programs On-going During Absence of the Head of the Division. (1973-1976, a total of approximately 30 weeks during this time period). Salary: No additional compensation.

Assistant Professor, Radiological Health Program of PRNC , University of Puerto Rico, Caparra Hgts., Rio Piedras, Puerto Rico; Duties: Instruction of Course "Environmental Radioactivity" PRNC-550, required for M. Publ. Health, Radiological Health Option. (1975). Salary: No compensation.

Proposal Reviewer, U.S. Environmental Protection Agency, Proposal dealing with design and testing of aerobic sewage sludge digester using low organic solids loading and thermophilic bacteria (1976).
Salary: No compensation.

Referee, Scientific publications, Jour. Phys. Chem.
Salary: No compensation

Chairman - Scientific Program Committee, Caribbean Chemical Conference IX, Dec. 8-11, 1977, Condado Holiday Inn, San Juan, Puerto Rico.

Society Memberships: Offices Held, Honors, Distinctions

Colgate-Palmolive Research Fellow 1964-65.

Sigma-Xi Society: Associate Member 1965; Member 1973; Councillor-San Juan University of Puerto Rico Club 1970-71, 1974-76.

Association of Southeastern Biologists

International Society of Quantum Biologists

American Association for the Advancement of Science

American Chemical Society - Puerto Rico Section Chairman 1978

Society of Microbiology of Puerto Rico

American Men & Women of Science

Public Conferences and Lectures

"Laser Light Scattering", Dept. Chem., University of Puerto Rico, Rio Piedras, Puerto Rico, Oct. 1967.

"Radial Distribution of Intensity from Laser and Super-Radiant Sources", Div. Phys. Sci., Puerto Rico Nuclear Center, Caparra Hgts. Sta., Rio Piedras, Puerto Rico, Feb. 1968.

"Starch - A Chemical Analog of Glycogen is Useful for the Separation and Purification of Glycogen Phosphorylase Present in the Muscles of Crustaceans", A.C.S. Student Affiliate Chapter, Interamerican University, San Germán, Puerto Rico, Mar. 1969.

"Chemical Applications of Laser", General Seminar, Puerto Rico Nuclear Center, Caparra Hgts. Station, Rio Piedras, Puerto Rico, Nov. 1970.

"Structure Determination of Adsorption Complexes in Suspension", Dept. Chem., University of Puerto Rico, Rio Piedras, Puerto Rico, Oct. 1971.

"Chemical Problems in the Generation of Electric Power Using Nuclear Fusion Energy", A.C.S. Student Affiliate Chapter, University of Puerto Rico, Rio Piedras, Puerto Rico, Nov. 1971.

"Preliminary Results of Delayed Luminescence Peak Emission Measurements for Gamma-Irradiated Glass Matrix Isolated DNA and DNA Analogs", Div. Phys. Sci., Puerto Rico Nuclear Center, Caparra Hgts. Sta., Rio Piedras, Puerto Rico, Mar. 1972.

"The Turbidity Measurement: Its Use in the Characterization of Opticaly Non-Absorbing Biological and Bio-Chemical Systems". School of Medicine, Rio Piedras Medical Center, Rio Piedras, Puerto Rico, Mar. 1973.

"Plant Growth Inhibitors", Puerto Rico Nuclear Center, Caparra Hgts. Sta., Rio Piedras, Puerto Rico, Aug. 1973.

"Coord Program: Its Use in the calculation of Molecular Parameters in the "EHT', 'PPP' and "CNDO/2' or 'INDO' Formalisms", Dept. Chem., University of Puerto Rico, Rio Piedras, Puerto Rico, Nov. 1973.

"Radioactivity Effects in the Natural and Contaminated Environments", Radiological Health Program, Puerto Rico Nuclear Center, Caparra Hgts. Sta., Rio Piedras, Puerto Rico, May 1974.

"Ground-State Electronic Properties of Plant-Growth Regulators", Dept. Phys., Mayaguez A&M University, Mayaguez, Puerto Rico, June 1974.

"The Environment and Some of the Environmental Problems of Puerto Rico", First Union Church of San Juan, Punta Las Marías, San Juan, Puerto Rico, Apr. 1976. Caguas Baptist Church, Feb. 1977.

Meetings, Symposia and Conferences Attended

Eastern Analytical Symposium, American Chemical Society, New York, N.Y., Mar. 1966.

X Congreso de Químicos Latinoamericanos, San José, Costa Rica: Feb. 1969.

Northeast Region Sub-Section Meeting, American Chemical Society-"Metrochem", San Juan, Puerto Rico, 1971.

IV Structure-Energy Relationships Conference, National Science Foundation (NSF), Western-Fher Corp., San Juan, Puerto Rico, Jan. 1974.

III Congress of Pesticide Chemistry, International Union of Pure and Applied Chemistry (IUPAC), Kemira Oy, World Health Organization (WHO); Helsinki, Finland, July 1974.

II Quantum Biology Symposium, Dept. Naval Research (DNR) University of Florida - Gainesville, Uppsala University, Uppsala, Sweden; Sanibel Island Florida; Jan. 1975.

Inter-lab Conference on Hydrology and Trace Element Transport in Ecosystems, Puerto Rico Nuclear Center; Oak Ridge National Laboratory (ORNL), Oak Ridge, Tennessee; U.S. Department of Agriculture,

Forest Service, Coweeta Hydrology Project, Franklin, No. Carolina: Savannah River Ecology Laboratory, Savannah River Plant, University of Georgia, Aiken, So. Carolina; May, 1975.

U.S. Energy Research and Development Administration (USERDA) Conference on computer management of bio-environmental data: Albuquerque, New Mexico; July, 1975.

American Chemical Society, Local section executive orientation meeting: Asheville, No. Carolina; Apr., 1976.

American Chemical Society/Puerto Rico Section, 1st senior technical meeting (Meeting-in-Miniature); La Parguera, Lajas, Puerto Rico; Dec., 1976.

IV Quantum Biology and Pharmacology International Symposium, Nat'l Science Foundation, Nat'l Inst. Health (HEW), University of Florida, Uppsala University; Sanibel Island , Florida; Jan., 1977.

Research Students and Projects Supervised

Julio César Cruz Rosario (dec.); Differential refractometry using a laser source with commercial instrumentation. (1968-1970). Chemistry.

David Santiago Mesa; Isolation and purification of enzyme glycogen phosphorylase-a isolated from the muscle of the blue crab (Callinectes danae) jointly supervised with Dr. Fermín Sagardía, Sch. of Med. UPR; Ph.D. (1969-1972). Biochemistry.

Narinder K. Mehta: Theoretical evaluation of light-scattering as a probe for structure of adsorption complexes. M.Sc. (1969-1972) Physical Chemistry.

Pura A. Ríos; Inhibition kinetics of glycogen mobilization by enzyme glycogen phosphorylase isoated from the muscle of the blue crab (Callinectes danae) jointly supervised with Dr. Fermín Sagardía, Sch. Med. UPR; Ph.D. (1968-1972). Biochemistry.

Félix Santos; Turbidity of upper reaches of the Río Espiritu Santo and Río Sonodora Rivers, El Verde, Puerto Rico; Analysis of trace elements in the Río Sonodora River system. (1971-1972). Environmental Chemistry.

Neftalí Pérez Contreras; Light-scattering from a concentric sphere model system. M.Ed. (1970-1971). Physical Chemistry.

Ignacio J. Ocasio; Light-scattering from adsorption complexes. (1972-1973). Chemistry.

Daniel Lebrón Pitre; Experimental research on natural radiation exposure in Puerto Rico using thermoluminescence dosimetry. M.Sc. (Nuclear Engineering) (1973-1974). Nuclear Science.

Edgardo Hernández; Laboratory investigation of statistics of thermoluminescence dosimetry using calcium fluoride dysprosium-doped dosimeters. M.Publ.Health (1974-1975). Radiation Monitorring.

Rolando Mosquera Moreno: "Rejection Criteria for Pairs of Experimental Values of Integrated Dose Inferred from Thermoluminiscence Dosimetry"; M. Publ. Health (1974-1975).

Karl L. Prado; "A Computer Program for Calculation of Field Dose Received by Thermoluminescence Dosimeters - TLDCALC (FORTRAN G)"; M. Publ. Health (1974-1974).

Antonio J. González: "Population Exposure to Natural Radiation in Puerto Rico"; Experimental Research; M.Sc. (Nuclear Engineering) (1974-1975).

Juan Estevez; "Single Electron Oxidation and Single Electron Reduction Energies for Twisted Boat Conformations"; (1974).

Grants and Contracts

Research Corporation, 1968. "Quaternary Structure Studies of Glycogen Phosphorylase Using Light-Scattering"; $6,500.

Westinghouse Gift Program, 1969. "Instrumental Aid for Research"; 1 Moseley X-Y Recorder.

Commonwealth of Puerto Rico; Department of Housing, 1969. "Grant of Surplus Electronic Equipment"; estimated value: $10,000.

U.S. Department of Health, Education and Welfare, 1972. "Equipment for Modernization of Undergraduate Laboratories"; Written by members of the department of chemistry, University of Puerto Rico and administered through the department. Physical chemistry section written by A.McB. Block, specifying equipment for an undergraduate experiment in photo-chemistry, estimated amount: $5,000.

Puerto Rico Water Resources Authority, 1973-1975. "Environmental Data for the Environmental Report in Support of Location of Thermonuclear Power Generation Facilities in Barrio Islote, Arecibo, Puerto Rico"; Contract awarded to Puerto Rico Nuclear Center, Principal administrator: Dr. Frank G. Lowman, responsible agent; Sub-director: Dr. Michael Cancy, negotiating agent; Research coordinator: Dr. James D. Parrish, liaison agent with contractors; Director of Terrestrial Ecology Studies: Dr. Richard G. Clements, principal investigator; Head of Radiological Background and Information Studies: Dr. Arthur McB. Block, co-principal investigator. Radiological information for U.S. Atomic Energy Commission Docket #50-376. Reporting in most cases was through Dr. Clements, though on a number of occasions, direct communication with Dr. Parrish, or with a contracting agent representative was requested. Contract duration: Nov. 1973 - June 1975. Total budget (estimated): Salaries (including overhead and fringe benefits) $90,000; Equipment, material and supplies $20,000. (Budgetary data reflects estimates, not committed funds, and applies only to the radiological section).

Unpublished Abstracts

"Angular Calibration of Laser Scattering Photometers Using Monodisperse Polystyrene - Water Suspensions", A.McB. Block, I. Tobias and A. Grimmison, Proc. X Cong. Latinoamer., San José, Costa Rica (1969).

"Effects of Surface-Sorbed Emulsifier on light Scattered by Polystyrene-Water Sols", N.K. Mehta, A. Grimison and A.McB. Block, Eastern Subsection Regional Meeting, Amer. Chem. Soc. (Metrochem), San Juan, Puerto Rico (1971).

"Purification and Properties of Glycogen Phosphorylase-A Isolated from the Muscles of Blue Crabs (Callinectes danae)", D. Santiago, P.A. Ríos de Santiago, A. McB. Block and F. Sagardía ibid.

"Light-Scattering Measurements on the Trypsin/Silica Adsorption Complex", A.McB. Block, A. Grimison, F. Santos and N.K. Mehta, Proc. XI Cong. Latinoamer., Santiago de Chile (1972).

"Cinética de la Polimerización de Glucosa a Glucogeno con Agente Catalítico de Fosforilasa de Glucogeno Aislado de los Musculos del Cangrejo Azul (Callinectes danae)", A.McB. Block, D. Santiago, P.A. Ríos de Santiago and F. Sagardía, ibid.

"Particle Size Distribution of Particulate Matter in the Río Sonadora River of El Verde Rain Forest", A.McB. Block and R.G. Clements, Terrestrial Ecology Program, Puerto Rico Nuclear Center, Ann. Rep't. U.S. Atomic Energy Commission, ID-4500 (1972).

"Ionization Potentials of Aryl Substituted N-t-Butyl Benzamides", A. McB. Block, R. Tsai and G.M. Rubottom, IV Structure - Energy Relationships Conference, National Science Foundation and Western-Fher, San Juan, Puerto Rico (1974).

"Molecular Orbital Calculations for the Alpha, Beta, Gamma (Lindane), and Delta Isomers of 1,2,3,4,5,6-Hexachlorocyclohexane (BHC)", A. McB. Block and L.W. Newland, invited communication, International Union of Pure and Applied Chemistry (IUPAC) Conference on Pesticides III, Helsinki, Finland (1974).

"Structure - Activity Correlations for Phenoxyacetic Acids and Indole-acetic Acids Used for Plant - Growth Regulation", A.McB. Block and R.G. Clements, International Symposium on Quantum Biology and Pharmacology, Sanibel Island, Florida (1975).

"Some Observations on Pesticide Uses in Puerto Rico and Other Tropical Areas: A Research Prospectus for Pesticide Technology",

[illegible] and F.F. Fernandez, Symposium on Recent Trends in Pesticide Research, Liverpool, England (1975).

"The Environmental Impact of Biologically Important Fission/Fusion Produced Radionuclides on a Small Locality on the North Coast of Puerto Rico", A.McB. Block, F. Santos and M.A. Gribble. First Sr. Tech. Meeting, American Chemical Society, Puerto Rico Section, Dec. 9-12, 1976, La Parguera, Lajas, Puerto Rico.

"Survey of the Elemental Burden of Benthic Organisms in the Río Espiritu Santo River Estuary", A.McB. Block, F.A. Santos, R.G. Clements and W. Bhajan, IX Caribbean Chemical Conference, San Juan, Puerto Rico, Dec. 8-11, 1977.

"Thioether Analogs of Plant Auxin (Indole-3-Acetic Acid)", A.McB. Block and F. Santos. IX Caribbean Chemical Conference, San Juan, Puerto Rico, Dec. 8-11, 1977.

Publications

A.McB. Block, "Dispersión no linear de luz de laser en soluciones", Rev. Col. Quím. Puerto Rico 28, 10 (1969).

A.McB. Block, "Use of a 6,328 Å scondary source in differential refractometry", Appl. Optics 10, 207 (1971).

N.K. Mehta, A. Grimison and A.McB. Block, "Effects of dispersing agents on the angular dependence of light scattered from polystyrene spere/water sols", Appl. Optics 10, 2031 (1971).

G. Stevenson, M. Colón, J.G. Concepción-Carcía and A.McB. Block, "The cyclooctatrieneyne anion radical", J. Amer. Chem. Soc. 96, 2283 (1974).

D. Santiago, P.A. Ríos de Santiago, A.McB. Block and F. Sagardía, Purification and properties of glycogen phosphorylase a from the muscles of blue crab (Callinectes danae)", Arch. Biochem. Biophys. 163, 679 (1974).

P.A. Ríos de Santiago, D. Santiago, A.McB. Block and F. Sagardía, "Kinetics of inhibition of glycogen phosphorylase a isolated from the muscle of blue crab (Callinectes danae)", Arch. Biochem. Biophys. 163, 688 (1974).

A.McB. Block, R.G. Clements and J.D. Parrish, "Background radiological characteristics (for Puerto Rico)", Puerto Rico Water Resources Authority Environmental Report for North Coast Nuclear Power Plant #1 (NORCO-1), USAEC Docket #50-376, 2.8 (1974).

A.McB. Block and R.G. Clements, "Preoperational monitoring program for NORCO-1 power plant", Puerto Rico Water Resources Authority Environmental Report for North Coast Nuclear Power Plant #1 (NORCO-1), USAEC Docket #50-376, 6.3 (1974).

A.McB. Block, R.G. Clements, J.D. Parrish and K. Pedersen, "Offsite radiological monitoring program (for NORCO-1 power plant)", Puerto Rico Water Resources Authority Environmental Report for North Coast Nuclear Power Plant #1 (NORCO-1), USAEC Docket #50-376, 11.6 (1974).

G.R. Stevenson, M. Colón, I. Ocasio, J.G. Concepción-García and A.McB. Block, "Electron distribution in some 1,2-disubstituted cyclooctatetraene anion radicals and dianions", J. Phys. Chem. 79, 1968 (1975).

A.McB. Block, R.C. Clements, L.I. Rosa, F. Santos, M.D. Banus, E. Hernández, K. Mosquer and K.L. Prado, "Thermoluminescence dosimetry in northwest Puerto Rico", USERDA Tech. Publ. PRNC-191 (1975).

G.R. Stevenson, A.E. Alegria and A.McB. Block, "Equilibrium studies by electron spin resonance XIII. The relationship between charge density and ion pair dissociation determined by the use of g values", J. Amer. Chem. Soc. 97, 4859 (1975).

A.McB. Block and R.G. Clements, "Structure-activity correlations for phenoxyacetic acids and indoleacetic acids used for plant growth regulation", Int. J. Quantum Chem. QBS 2, 197 (1975).

A.McB. Block and L.W. Newland, ".Molecular orbital calculations for 1,2,3,4,5,6-hexachlorocyclohexanes", in "Pesticides", P. Koivistoinen ed., Env. Qual. Safety (Suppl.) III, 569; Geo. Thieme Verlag, Stuttgart, FRG (1975).

F. Santos, A. McB. Block, R.G. Clements, L.I. Rosa and M.D. Banus, "Natural environmental radioactivity measurements in northwest Puerto Rico", Carib. J. Sci., accepted for publication, to appear.

A.McB. Block and R.G. Clements, "Radioactivity content of soil in Barrio Islote, Arecibo, Puerto Rico", USERDA Tech. Publ. PRNC-202 (1976).

A. McB. Block and N. García, "Commentary on the analysis of mercury in soil and sediment", J. Environ. Qual. 6, 232 (1977)

A. McB. Block, R. Concepción-García and G.R. Stevenson, "Substituted benzylidene malononitrile anion radicals", J. Phys. Chem. 81, 367 (1977)

A.McB. Block, W. Bhajan, L.W. Newland & J. Estevez, "The electrochemical reduction model of anaerobic degradation of the gamma isomer of 1,2,3,4,5,6-hexachlorocyclohexane (γ -BHC)", J. Water Poll. Control Fed. 49, 857 (1977).

A.McB. Block, E.Cuevas and R.S. Lamba, "Auxin structure-activity relationship. Preliminary results of studies of chemical control of an ecosystem in its steady state." Int. J. Quantum Chem. QBS 4, 127 (1977).

K. Bhargan, M. Canals, R.G. Clements, J.A. Colón and A.McB. Block, "A Limnological Survey of the Río Espiritu Santo River Drainage Basin.", U.S. ERDA Tech Publ in press (1977).

A. McB. Block, F. Santos and M.A. Gribble, "The Environmental Impact of Artificially-Produced, Biologically-Active Radionuclides in Barrio Islote, Arecibo, Puerto Rico. Estimates of the Surface Soil Burden of Cs-137, Ra-226 and Sr-90.", Carib. J. Sci. to appear 1978.

A.McB. Block, F.A. Santos and R.G. Clements, "Elemental survey of the Río Espiritu Santo River Estuarine Sediments", Proc. 9th Carib. Chem. Conf. in Ciencia (1978). To appear.

A. McB. Block, "The Human Waste Problem in Rural Zones of a High Rainfall Watershed." Proc. Sem. River Basin Energy and Environmental Planning: Method. and Inst., CEER, UPR Grad Sch. Planning, A.I.Ch.E., (sponsors), To appear Sept. 1978.