The US Environmental Protection Agency: High Field Grade 1 Magnet for Separation Waste Water Purification Applications in Puerto Rico. A. Melt Block, U. Ortahat, Center for Energy and Environment Research, University of Puerto Rico, US Department of Energy.

Environmental Protection Agency: High Field Gradient Magnetic Separation for Waste Water Purification Applications. Submitted by: Center for Energy and Environment Research, University of Puerto Rico. Presented by: Dr. Arthur McB. Block.

Introduction: This proposal is the outcome of intense discussions among CER personnel, reflecting great concern about the effects of water pollution and potable water shortages on the health and welfare of the people of Puerto Rico. The current level of contamination of Puerto Rico's fresh surface water and groundwater, as well as its aquatic recreational areas and beaches, is alarming. Increased population pressures are anticipated to exacerbate the problem of pollution control.

Puerto Rico, an island 30 x 150 miles in size, has the 6th highest population density worldwide. With most of the population (approximately 90%) residing 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 Rico's 3.2 million inhabitants.

At several locations on the island, hazardous water pollutants from industry, municipalities, and communities are discharged into the environment with little or no treatment. In the past, numerous community activities and projects aimed to minimize adverse health conditions and social and aesthetic effects associated with water contamination. However, considering the existing conditions on the island, it appears obvious that conventional treatment methods are inadequate.

Management methods have failed to significantly reduce water pollution, much of this is attributable to non-point sources (e.g., 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 wastewaters at very high rates of throughput. HGMS utilizes "state of the art" technology and its applications worldwide now include Mineral Processing Effluent and Waste Water Treatment, Chemical Processing, Biochemical Processing, and 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 a very broad range of applicability.

PROJECT OBJECTIVES

The primary objective of this project is the testing and establishment of high gradient magnetic separation of industrial and domestic wastewater. The secondary objective is the utilization of the technique for water reclamation and reuse. The tasks necessary to achieve this goal are:

1. Acquire Sala Magnetic Mobile Laboratory demonstration trailer.
2. Training and familiarization with the equipment.
3. Select sites for wastewater testing.
4. Test magnetic separation on each effluent.
5. Assign "effectiveness of separation" for 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: Rent.

Overhaul and ship the already operational mobile lab from Sala Magnetics, Boston, MA.

2. The course offered by Sala Magnatics and Boliden Keni will be delivered by two specialists to a team of six persons: one scientist, one scientific associate, one technician, and three graduate students.

3. Contact industries and arrange (on a discrete basis) a demonstration for problem wastes. Reach out to municipalities and government agencies. Select ten distinctly different waste problems.

4. Station the laboratory for one week in a convenient location for the magnetic separation treatment demonstration. Experiment with varying seed and polyelectrolyte concentrations, matrix loading, residence times, magnetic field, and flow rate.

The operations will be as follows: Analyze influent and effluent in terms of suspended solids, pH, apparent color, turbidity, settleable solids, BOD, COD, coliform bacteria, and heavy metals. Conduct tests using a matrix of influent characteristics to evaluate the ability (or change) of magnetic separation to treat the waste.

Calculate the costs of separation based on estimated effluents per item. Using appropriate EPA data, calculate the cost of total upgrading and compare costs with conventional treatments.

Proposed methods will be divided into three separate phases, with the exception of the last task resulting in the final report and recommendations.

The four operational phases are: Task A, Task B, Task C, and Task D.

PROJECT 721: Approximately 12 months is estimated for the completion of this program section.

PROJECT MANAGEMENT PLAN: The proposed management plan for this project is shown in 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 as needed.

Supplemented where necessary with project supplies.

CENTER FOR ENERGY & ENVIRONMENT RESEARCH

General management plan of CEER attached organization chart

UGUR ORTABASI PROJECT ARTHUR McB BLOCK

Phase 1: Ortobasi, Phase: Block, Block; Scientific Assoc, & Consultants Scientific Assoc. Research Asst | Phase 1 Ortobasi & Consultants | Phase 2 Block, Scientific Assoc & Consultants:

PHASE I ORTABASI, BLOCK | Phase 2 Ortobasi & Block

Final Report - Page Break

PROJECT BUDGET (12 months period)

It's proposed to develop this project utilizing the matrix technique of project management and staffing. During the 12 month 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:

Principal Investigator: $4,000.00

Project Leader: $10,000.00

Scientific Assoc: $7,000.00

Research Asst: $6,200.00

3x Grad. students: $5,400.00

3x Consultants: $25,000.00

Total Salaries: $47,600.00

Fringe: $7,140.00

Operating expenses and services Materials & Supplies (estimated): $4,500.00

Equipment and Supplies *: $4,800.00

Shipping; Overhaul of Lab: $20,000.00

Sub Total: $79,240.00

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LITERATURE REFERENCES

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

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

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

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

Okuda, T., Sugano, I. and T. Tsuji. "Removal of Heavy Metals from Wastewater by Ferrite Co-Precipitation." Filtration and Separation, 12(5): 472-478, 1975.

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

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

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.

Allen D., M. and J.A. Oberteuffer. "Combined Storm Overflow Treatment with SALA-HGMS 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 are 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 supplementary ferronagnetic 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 within 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 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, IF, and many other types of mineral beneficiation. Waste reclamation and powders, field and recycling, ultra purification of chemical refractories.

Some of the recent problems that magnetic separators are or will soon be handling, are direct applications and do not require the addition of 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, onboard ship treatment of gray and black water, and almost any polluted stream in which the goal is to remove all solids from the water portions.

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.

Gradient magnetic separators effectively examine the force on even weakly magnetic particles. The magnetic force (Fq) on a particle is given by the following expression: y= WM grad B where y is the volume of the particle, M is its magnetization, and grad W 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 11-1. 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.

In order to achieve a balance, it is necessary to seed particles before their ‘The seeded water treatment (tag-seed) process is a unique application of gradient magnetic separation for 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 wastewater cases where certain standards must be met before disposal, as well as in some closed loop operations where corrosion is a concern.

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 (Herch 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 wastewater 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 co-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 function, required influent monitoring systems, etc.).

PRESENT CONTRACT GOALS

The present

The text appears to be a technical report about a pilot-scale study using a SALA-HOGD magnetic filter for CSO treatment. Here is the corrected version:

The filter material contributes to color and turbidity as it does its work. 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	Suspended Solids	COD	BOD
Raw Sewage	50%	32%	95%
Secondary Effluent	90%	-	-

Paper Mill Effluent | - | - | -

SALA Magnetics
247 Third Street, Cambridge, MA 02142.
Tel: (617) 868-2550
Telex: 12-1475

CURRICULUM VITAE
Ugur Ortabasi
Ankara, Turkey - June 1, 1938, U.S. Citizen
Spouse: Ilse Ortabasi, 2 Children

Presently the 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 PRA £6-78-D-04-0035.

United Nations assignment as consultant to Turkey in relation to "Re-Transfer of Technology Program" - 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 CEPRS. 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. - October 1977

Senior Research Physicist, Technical Staff Division, Corning Glass Works. "Heat Pipe as Solar Absorber."

1971-1973, 'Solar Experimental Techniques, High Performance Collectors, Physics of New Energy Resources and Their Impact on the Environment' in Turkey.

June 1976, SENIOR PHYSICIST, Technical Staff Division, Corning Glass Works. Involved in 2) Solar Research and Development. As TECHNICAL LEADER of Solar Energy Program, I worked on the theory, design, and experimental work on evacuated collectors, solar climate control of buildings, system computer simulations and cost analysis, and Monte-Carlo digital ray tracing studies for solar cell array design. I have experience in vacuum stable selective coatings, evacuation, and fabrication technology for high efficiency collectors. I've applied the Heat Pipe Concept to solar-thermal processes. I was the author and originator of an "Advanced Collector Development" proposal to NSF/ERDA and had associated interaction with NSF and ERDA personnel. I was an invited participant of the LASL meeting on the "Assessment of the Technology for Solar Heating and Cooling" at NBS, Gaithersburg, Maryland, 1975, where I summarized the section on "Advanced Collectors." I represented 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: I worked on a joint project with the Bio-Organic Department of CGN to develop a Nanosecond Fluorescence Spectrometer to study molecular kinetics of ligand - bio-polymer interactions. I also worked on single photon coincidence electronics and data reduction and analysis.

c) Academic Activities: I served as CONTINUING EDUCATION FACULTY at Elmira College, N.Y. I gave lectures on Nuclear Engineering, Solar Engineering, and Modern Physics.

In 1973, I was a RESEARCH FELLOW IN PHYSICS at Corning Glass Works R&D Laboratories.

From 1958-1969, I worked on the investigation of nuclear oxygen state phenomena. I studied the electronic structure of glass superconductors using Time-Differential Perturbed Gamma-Gamma Angular Correlations. I also studied the 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:
- 1971 ASSISTANT PROFESSOR at The University of Florida. Responsible for research and teaching at undergraduate and graduate levels. Delivered lectures on "Tradition Interaction with Matter" and "Application of Isotopes." Supervised Master of Science candidates. Managed the AEC Research Contract No. AT-(40-1)-3348 on "Chemical Structure Studied by Nuclear Techniques." Conducted summer work at Lawrence Radiation Laboratories, Berkeley, California as a Research Visitor.
- 1969 GRADUATE ASSISTANT at Western Reserve University and University of Florida. Earned a Ph.D. DEGREE IN NUCLEAR ENGINEERING from the University of Florida. Experienced in nuclear theory, fast nuclear electronics, computer analysis, automatic data processing, reactor experiments, and radiation physics as applied to radio-scanning of the body. Conducted theoretical work in crystal physics and electronic structure of metals.
- 1965 Undertook undergraduate and graduate study at the Universities of Gottingen and Hamburg, Germany. Obtained a DIPLO PHYSIKER DEGREE from the University of Hamburg in 1965. Experienced in experimental nuclear spectroscopy, nuclear electronics, theoretical work in nuclear models, and hyperfine interactions in metals. Conducted independent study in physical oceanography.

Published Reports:
- "An Evacuated Tubular Collector Utilizing a Heat Pipe," Report fig COS“ BOOST. ENON Contract EY T6-C-02-2008.
- "An Evacuated Tubular Collector Utilizing a Heat Pipe," Report Ro; COO-EEOU=Z, ERDE Contract BY=16-C-0F2008.
- "An Evacuated Tubular Collector Utilizing a Heat Pipe," Report fig; COo-2EOU=T, ERDE Contract BYT6-C-DRTO0E.

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

Continuation: 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 Complexes, September 24, Ales, France. "Analysis and Performance of an Evacuated Tubular Collector," 7th International Solar Energy Congress and Exposition UCLA, July 28, Los Angeles, California. "Effect of the Grain Size on the Quadrupole Interactions in Indium Tapered Ports Class Studied by Time Differential Regular Correlations," 1975 Northeast Hyperfine Interactions Meeting, Rutgers University, May 22, 1975, New Brunswick, New Jersey.

"Fluorescence Lifetime Study of N, S-Sulfonyl Bovine Albumin Conjugates," in preparation. "Hyperfine Electric Quadrupole Interactions in Some TM-Salts Studied by Fine-Differential Correlation Technique," 1969 Symposium on Radioactivity in Nuclear Spectroscopy and Applications, Nashville, Tennessee. "Perturbed Angular Correlation Studies of the Quadrupole Interactions in Electronic Environments and the Electric Quadrupole Moment of the 247-KeV State," Phys. Rev. B.8,8, 1964. "Nuclear g-Factor of the 5/2 Kev State in 207Pb," Phys. Rev. "g-Factor Measurements on the First Excited States of 207Pb, 208Pb and 209Pb," 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 (1962). "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-year CGW Fellowship Award in Physics as a result of a nationwide competition.

Several patents pending in the field of Solar Energy Conversion.

Soviet Sf bw Hexe Arthur McBride Block, Social Security No. 13-30-5543, 65th. Infantry Sta. P.O.B. 30918 San Juan, Puerto Rico 00929 809 - 761-9269 (Home) 809 - 767 - 0350 (Business)

Height = 5'20", Weight - 270, Health - Excellent

Place and Date of Birth: Newark, N.J., June 26, 1938. Citizenship: U.S.A.

Marital Status: Married, 2 children

Languages: English (spoken, written and reading), Spanish (spoken, reading), French (reading), German (reading), Russian (reading - dictionary supplemented).

Education:
- 1956 High School, Newark Academy, Newark, N.J.
- University: Cornell University, Ithaca, N.Y., A.B. 1962, 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 for Energy Environment Research, 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, Computer and Data Management (FORTRAN, RPGII; IBM 370 system); Grant and Proposal Submission, Administration of Program; 3 Laboratory Assistants, 11 Graduate Students. Salary: AM - 15.

- 1973 - 1975
- 1968 - 1972
- 1967 - 1968
- 1962 - 1967

Other: Scientist 1, Puerto Rico Nuclear Center: Ecology Division and Physical Sciences. Duties: Development of Irradiative (Gamma Co-60) Analytical Techniques, Theoretical Prediction of Matrix Isolated Fluorescence of Furans and Pyrimidines, Development of Background Radiological Data for Northwest Puerto Rico, Measurement of Radioactivity Background in Northwest Puerto Rico.

Carotenes (2963). Salary: $525.00/month. Position: 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 Iso-propanol 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 Silicone Rubber Samples. (96h). Salary: $558.00/month. This is a summer job only. (Subsequent to receipt of Ph.D., was offered the 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 Ongoing 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 Heights, Rio Piedras, Puerto Rico; Duties: Instruction of Course "Environmental Radioactivity" PRIC-550, required for M. Public 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, Journal of Physical Chemistry. Salary: No compensation. Chairman - Scientific Program Committee, Caribbean Chemical Conference, Dec. 8-11, 1977, Condado Holiday Inn, San Juan, Puerto Rico.
65. Colgate-Palmolive Research, Phi Sigma Xi Society: Associate Member 1965; Member 1972; Councillor San Juan University of Puerto Rico Club 1970-71, 1975-76. Association of Southeastern Biologists. International Society of Quantum Biologists. American Association for the...

"Center, Caparra Heights Station, Rio Piedras, Puerto Rico, May 1979. "Ground-State Electronic Properties of Plant-Growth Regulators", Mayaguez AM University, Mayaguez, Puerto Rico, First Union Church of San Juan, Santa Marta, San Juan, Puerto Rico, April 1976. Caguas Baptist Church, February 1977. Meetings, Symposia, and Conferences Attended: Eastern Analytical Symposium, American Chemical Society, New York, March 1969. 5th Congreso de Quimicos Latinoamericanos, San Jose, 1969. Costa Rica, February. Northeast Region Sub-Section Meeting, American Chemical Society- "Retrochases", San Juan, Puerto Rico, 1971. IV Structure-Theory Relationships Conference, National Science Foundation (NSF), Western Fiber Corp., San Juan, Puerto Rico, January 1971. XII 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, Department of Naval Research (DNR) University of Florida, Uppsala University, Uppsala, Sweden; Sanibel Island, Florida; January 1975. Inter-Island Conference on Hydrology and Trace Element Transport in Ecosystems, Puerto Rico Nuclear Center; Oak Ridge National Laboratory (ORL), Oak Ridge, Tennessee; U.S. Department of Agriculture,

Savannah River Plant, Aiken, South Carolina, May 1975. Project Funding, New Carolina: University Station (USERMA). Global Computer Management of Bio-environmental Data, Albuquerque, New Mexico; July 1975. American Chemical Society, Local Section Executive Orientation Meeting: Asheville, North Carolina; April 1976. American Chemical Society/Puerto Rico Section, Senior Technical Meeting (Meeting-in-Miniature); La Parguera, Lajas, Puerto Rico; December 1976. IV Quantum Biology and Pharmacology International Symposium, National Science Foundation, National Institute of Health (NIH), University of Florida, Uppsala University; Sanibel Island, Florida; January 1977. Research Students and Projects Supervised: Julio César Cruz Rosario (deceased);"

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. Fermin Sagerda, School of Medicine UPR; Ph.D. (1969-1972). Biochemistry. Narinder K. Metta: Theoretical evaluation of light-scattering as a probe for structure of adsorption complexes. M.Sc. (1969-1972) Physical Chemistry. Pura A. Rios; Inhibition kinetics of glycogen mobilization by

enzyme Glycogen phosphorylase isolated from the muscle of the blue crab (Callinectes danae) jointly supervised with Dr. Fermin Sagardia, School of Medicine UPR; Ph.D. (1968-1972). Biochemistry. Félix Santos; Turbidity of upper reaches of the Rio Espiritu Santo and Rio Sonodora Rivers, El Verde, Puerto Rico; Analysis of trace elements in the Rio Sonodora River system. (1971-1972). Environmental Chemistry. Neftali Perez 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 Letren Pitre; Experimental research on natural radiation exposure in Puerto Rico using thermoluminescence dosimetry. M.Sc. (Nuclear Engineering) (1973-1974). Nuclear Science. Edgardo Hernandez; Laboratory investigation of statistics of thermoluminescence dosimetry using calcium fluoride dysprosium-doped dosimeters. M. Publ. Health (1974-1975). Radiation Monitoring.

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