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HIGH FIRL.D GRADE

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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.

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Environmental Protection

agency

HIGH FIELD GRADIENT MAGNETIC SEPARATION FOR

WASTE WATER PURIFICATION APPLICATIONS tN

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Submitted by:

?CENTER FOR ENERGY AND ENVINONMENT RESEARCH

UNIVERSITY OF PUERTO RICO

Presa by

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Dk. Arthur MeB. Bloc

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This proposal is the outcome of intense discussion among

CER 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 Rice. The present level

Of contamination of Puerto Rico's fresh surface water and ground-

water as well ac of its aquatic recreational areas and beache:

is already alarming and increased population pressures are an

ticipated to aggravate the problen of pollution control. The

population density of Puerto Pico, an island 30 x 150 mi. in

Size is rated the 6th highest woridwide 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 fo 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). Mew methods and technology development appear to be urgent priorities for reclamation of polluted water to meet Puerto Rico's requirenents by 1990.

BACKGROUND

In a new program, CEER proposes the application of @ novel and powerful technology, called High Gradient Magnetic Separa~

tions (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 Maste Water Treatment

Chemical Processing

Biochemical Processing

Pharmaceutical Procescing

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,

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continuous operation, improved siudge properties and very broad

Fange of applicability.

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PROJECT OBJECTIVE ox,

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The primary objective of this project is the testing and estab-

lishment 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 familisrization with the equipment.

3. Select sites for wacte water testing.

4. Test magnetic separation on each effluent.

5S. Assign ?effectiveness of separation par:

ach type of waste

©. Prepare cost estimates for "problem" industries and
for total upgrading (wator upgrading to potable qual-
sty).

eters to

PROJECT METHODOLOGY

?The objective of this project can be achieved by the utilization
of the following methods briefly outiined 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 Magnetics and Boliden Keni
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 munici~
palities 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 con-
centrations, matrix loading, resigence times, magnetic
field and fiow rate.

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operationa:

will be thi

?The planne

Analyze influent and effluent with respect to sus-
pended solids, pH, aparznt color, turbidity, set=
Eleable solids, Bop, cov, coliform bacteria and
heavy metals.

tes using a matrix of influent charac-

teristics with respect to ability (4 removal or change)

of magnetic separation to treat the waste. Calculate

costs of separation based on estimated effluents - per

@iem. Using appropriate EPA data, calculate cost oF

total upgrading and also compare costs with conventional

treatments,

Proposed methods will be divided into three separate

1 phases with the exception of the last task, which

final report and recommendations.

4 operational phases arc:

r

task

ask

task

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Task

ask

PROJECT 721

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ME SCHEDULE

eximately 12 months is estimated for the completion

?Ogram section.

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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 CER staff, University faculties, and other sources as required for specific tasks of predeter-?mined duration. CER facilities and equipment will be used and supplemented where necessary with project supplies.

CENTER FOR ENERGY & ENVINONMENT RESEARCH

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+ Ganeral management plon of CEER

tached organization chart

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PROWECT

ARTHUR McB ELOCK

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PHASET ORTABASI, PHASE BLOCK

BLOCK, ; ser

Scientific Assoc, & Consultants Scientific Assos... Research Asst]

| ase 1 Ortabasi & Consultants

|__ tase 2 Bock, Scientific Assoc

1X Consultants:

PHASE I

ORTABASI% BLOCK

| = vasx 6 Ortabasi&e Block

L___ vase (Final Report)

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PROJECT BUDGET (12 months period)

Xt 48 proposed to develop thie project utilizing the matrix
kechnique of project management and staffing. During the 12
gontha period, personnel will be used for varying periods of tim
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 re~
@ucing overall project costs and eliminating the sometines costly
?dead spots" in which personnel have finished a specific elenent
of their task and must wait for additional information or material.
The matrix approach allows for efficient team operation at minimus
Personnel costs. Items marked with an * are coste to supplement

equipment, supplies, and services supplied by CEER. This latter includes laboratory space, highly sophisticated laboratory equip-ent, vehicles and boats, and all administrative and accounting ervices.

ESTIMATED BUDGET for 12 months period

sonnel _(ermined time)

Principal Investigator) P.1.E. scientist 108 4,000.00

Project Leader > . So 10,000.00

Scien. Assoc. 508 7,000.00

Res. Asst. 1008 6,200.00

3x Grad. students 2008 5,400.00

3 x Consultants 25,000.00

47,600.00

Total Salaries 47,600.00

: 158 Fringe 7,140.00

Operating expenses and services?

Materials & Supplies (estimated) 4,500.00

4,800.00-

Equipment ana supplies * _

Castine owe

Rental © Shipping; Overhaul of Sala-zab. 20,000.00

end saturance ao

Sub Total 79,240.00

BPA Shures?95e?? 0S TeT Te

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LITERATURE REFERENCES

Weber, Walter J. Physiccochemical 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.

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. Detatour. Magnetic Separation: A?New approach to Water and Waste Treatment. 1 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.

6. Kolm, ¥., Oberteuffer, J.2. and?D. Xelland. High Gradient Magnetic Separation. Scientific American, 233 (5): 46-54, 1975.

7. Oberteuffer, J-a., Wechsler, T., Marston, P.G. and M. J. Me 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, 7., 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, 3. 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.

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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-HONS~(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+

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APPENDICES

Appendix A : Overview of High Gradient Magnetic
Filtration.
Appendix B : SALA- High Gradient Magnetic Filtra-

tion Pilot Plant Trailer.

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APPENDIX A
OVERVIEW OF HIGH GRADIENT MAGNETIC FILTRATION

The use of magnets to separate substances of varying character is not pew. 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 vide use today. These devices generally separate relatively coarse particles of highly magnetic naterial containing large avounts of tron from nonnagnetic 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 nigh flow rates. These so-called "high gradient magnetic separarers" have bea designed to waxinize the magnetic forces on fine, paramagnetic mate~ r.als. They are capable of efficient separation of even weakly magnetic Suspended solids or precipitates for which conventional magnetic separation techeiques are ineffective. This capability is the result of the development ct a ?ilapentary ferronagnetic matrix and a Jarge volune, high-field magnet. ye coubinazion of an efficient ragnet and high gradient aatrix permits che ?snomical production of strong magnetic forces over a large surfcce area 2 the active volume of the separator. he supararioas my he carried out economically, and at process rates of up fo several hundred gpm/ft?.

For normally nonmagnetic colloidal material in polluted water, the ad dition of magnetic 4ron oxide (magnetite) along vith a flocculating agent can render these colloids sufficiently magnetic to be renoved by high gradient magnetic separators (indirect filtration). The machines provide the rapid filtration of many polluants from water vith a small expenditure of energy. Renoval is auch more efficient than with sedirentation because the magnetic forces on fine particles may be cany times greater than gravitational forces.

This technology has a high potential for use in vater pollution control.

High gradient magnetic separation is used in the kaolin clay industry to renove weakly magnetic impurities of less than 2 micron size froa clay. In~ dustrial-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 uagnetic separators include iron ore, IF, and many other types of mineral beneficiation. Waste reclanation ?and powders,

feld

and recycling, ultra purification of cheaical refractoris

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© sone of the recent prouiane that

agnetic separators are or vit] soon le handling. #1] are eirect appli-

cations ang do not require the addition of 2 seed or flocculant to be effec~

Besides CSO and raw sevage, high gradient magnetic separation 4s appli-

catie to nunerous nonbagnetic waste vaters such as paper mill vastes, elec-

troplating waters, secondary effluent polishing, potable water processing, on

doard ship treatment of gray and black water, and almost any polluted stream

im vbich the goal 4s to renove all sol?ds from the vater portions

PRINCIPLES OF RIGH GRADIENT MAGNETIC FILTRATION

Magnetic and Competing Forces

Bigh gradient magnetic separators, like all magnetic separators, utilize

the interaction of magnetic and competing forces on a mixture of mgaetic and

nonmagnetic particles to provide separation based on the magnetic suscepti~
bilities of the particles. The magnetic forces of attraction ine high gra~
@ient magnetic separator hold the magnetic particles to the edges of the oa~
trix fibers Ghile the competing hydrodynazic forces carry the fluid and non-
nagretic particles through the separator. For suall particles the forces of
hyévodynanic drag are larger than gravitational forces, and increase vith
scurry velocity in the separator. The nagnetic forces necessary to trap
tiese particles must therefore be large.

teiztng the Magnetic Forces

High gradient magnetic separators effectively eaxinize the o:
force on even veakly magnetic particles. The magnetic force (Fq) on a
particle is given by the following expressio:

y= WM grad B

where y ts the volune of the particle, M is its magnetization, and grad W is the magnetic field gradient that acts on the pareicle. The cagectie fiand gradient appears in the expression for sagnatic force for the follouing Feason. Maced {n'a magnetic field, all particles develop north and south poles at either end as shown in Figure I1i-l. Ina uniform field the eet force on a particle vill be zero, since the field exerts an equal sed oppo site force on either end of the particle. In « gradient sogectie Euelse however, the force exerted by the stronger fleldvat one end of the pareicle wil produce a net force on the particles Thereforesehe larger the chaoge in £1618 across the particle (eagnetic field gradiese}e she geanten the force on the particle. Hg

?The magnetization of ferronagnetic fibers, 1ike those in the high gradi-ent magnetic separator matrix, produces extremely high magnetic field gradi~ents. It turns out that the greatest force is produced on the particles vhen

---Page Break---

MAGNETIC FORCE

Fiy:VM grad H

Lmagnetic field

gradient

particle magnetization

particle volume

COMPETING FORCE

hydrodynamic drag

Fo: 3mnbv

[slurry velocity

eon diameter

FIGURE XIT-1 CUT-AWAY VIEW oF HIGH slurry viscosity

GRADIENT MAGNETIC

SEPARATOR

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Too 12935 ssaruyerg 829K papudeg

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i balance sr order to achieve az 2

seed particles before their

?The seeded vater trezcwen: (zag-seed) ;rocess 4s a unique pplication of

radéen: eagnetic separation co the resoval of nonmagnetic suspendee an.

iloidal-sized particles suspended in a liguie cedive (usually vacer). Te

?has considerable potencial in a large nuuber of effluent vaste water czses

where certain standards must be wet defore éisposal, as vell as in some closed

slosp operations where corrosion products or contanination may result in Sesrad=

ation of liquid quality vithio the systes. The systen is of particular

Ineerest for dts possible application to CSO and raw sevage and a accber of

other areas. Calculations for effectiveness of separation, economics of

Capital dnvestuent and operating costs, land requirements, dependability,

process flow rates, and detention tines, erc., 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, "Treataent of Cosbined Storm Over!lows by Bigh Gradient Magnetic Separation." In that portion of the study, full desersacions and references are provided for the physics and concepts involved in sesnetic filtration.

In completing that vork, both bench and continuous pilot plant runs were per-Formed at Sala Magnetics, Inc. in Cambridge on CSO and rau se=age trucked in fr0a the Cottage Farm Chiorination and Detention Pacility (Cambridge) and the Seer Island Sevage treataent Plant (Boston). These tests shoved clearly that the seeded water treatment provess could offectivaly end ef?ictently treat these waste vater sarples. Hovever, limitat/ons in the pilet plant syste and. lack of freshnese in the eqxple volune suggested that an on-site test

a slightly larger and nore flexible system vould be necessary before Jumping fo demonstration size. A mobile syste also would allow the performance of co-sice testing with several different effluent situations in order to provide a vaximum 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 pobile tratler on location it would be possible to profile an actual storm event, af it occurred, in order to study in deta] the possible problens and solutions unique to coatined store overflows (e.g., first flush loadings, wuleiple separator storm fuction, required infiucnt monitoring systems, etc.).

ey

PRESENT CONTRACT GOALS

?The present effort is designed to denonstrate the pilot-scale effective

ness of SALA-HOGD magnetic filter treatment of CSO, and to use this informa-

_ thon ae a basis for further larger scale tests. Various design criteria and

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The extension of FPA Con:

1 extended the daze base of tne previout work on

pilot plant with several specified tests, ane uri

pilot plant by weans of a dual-nagnet system, nore advanced cont.

stailed in a gobile unit; Effort Ii included on-site testing of the mobile

anit, imeluéing several storm flows, as weli as complecicn of the necessary

back#lushing, cleaning and sludge evaluations. With the inforeetion gained

trop these efforts and from previous testing using the seeded witer technique,

ic design and operating characteristics could be developed 2s a basis ior

he generation of costs and criteria for a denonstration-scale systen,

a

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APPENDIX B

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SALA-HGMF*

AWT MAGNETIC FILTRATION PILOT PLANT TRAILER

SAL

Magnetic Filtr

Pilot Plant ®

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General Speciheations

Tenner Ormeneions BYE X28 Ly 11" ?anes ermees ave aaah he Kelomog woud Be

Dane on x9 0) ious

atmnaon-bice BW IDLE aan am) ee 7

Steer ean 760019200059) Sowa S28 gp tentiane tee)

Pot Plant Speciticatons Sino ed 93 cia £60 ge

Fass capac, a0 gpm(a 6 Key's) ?open Oranage

Sluage Progucton: 1 fo/hour (0.5 kg/hour)

?Typical Chemical Requirements

Tre SALAHGIF" maonetc fitiaton pilot lant Yagnenin 0 BlbvRout (0.25 Ag/hour)

howe can be provised tll selcontarned soho lum. C.25!then (01 phar)

= ?ines sersces are requied, Polyelectioiye 0.04 e2/hour (0.007 kg/nour)

?Toe Sala Magnencs Mag-Seed? magnetic seeded coagulated and tlacculated around a highly ?apnete tiraton proves makcr porsiie the niagneic seeding material and ave thus tendered ?ragrete livaton ol nonmagnelec Conlaninanis sceeephbie to trapping on a magnet fir Bed wom wale walers Through tvs process contami Even enrian dasolved contaminanis such a5 ace nants such 96, collotm bacteria, viuses. organic metals and phosphorous are Wapped on the filer fraterial contributing 1o eolor and Wwrbidly ae odin hie way,

Results oblained on combined slotm oveliow, on raw sewage, on secondary eluent om a con-

?entonal sewage Weslment plant, and.on paper mil seation lagoon eluent are displayed In he

Fotowing table

PERCENT REMOVALS FOR TYPICAL APPLICATIONS

?caer ?Suspended

Appleation 2090, | _comorm | caopacenn ole cov_|

. 50) 32 95.05 3 86 %

Raw Semage °° 2 °

?Secondary

+ | Etnuent 903, ? es

Paper Mi ss oe : 7 :

?+ TheSALA HOM? Mayr Fate Pic Pre abe ree orale Regu fr quoi orca ene ed.

prehenons tye ange est che, or hah wma corte Gta Cony Sale Agent nay

?SALA .

?Sala Magnetics 247 Thud Steet, Cambridge MA G21«2

omgh 7? Sea artes ne

Tel (617) 868-2550 Toler 12-1475

---Page Break---

Married

January 1978

October 1977

CURRICULUM VTA

Ugur Ortabasi

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

: Ilse Ortabasi, 2 Children

= Present

HEAD OF THE ENERGY DIVISION OF THE CENTER FOR

ENERGY ANO 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
Jn 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
Relesreh 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 end competitive.

- October 1977

ASENTOR RESEARCH PHYSICIST, Technical Staff Division,

Rcorning Glass Works.

jeat Pipe as Solar Absorber."

---Page Break---

1973

1971

?and Turkey on Solar Experimental Techniques,

High Performance Collectors, Physics of New

Energy Resources and Their impact on the Environ-

ment.

- dune 1976

SENIOR PHYSICIST, Technical Staff Division,

Corning Glass Works.

2) Solar Research and Development, TECHNICAL LEADER of Solar Energy Program: Theory, design Gnd experisentel work on evacuated collectors, solar climate contro? 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 nigh 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 ?Assess~ Rent 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,
Gonducted by Arthur D. Little, Inc., Boston (1373-
1976).

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

¢)_ Academic Activities: CONTINUING EDUCATION

FACULTY at Elmira College, N. Y. Lectures on

Nuclear Engineering, Solar Engineering and Modern
ysics.

1973

RESEARCH FELLOW IN PHYSICS, Corning Glass Works

R & D Laboratories. i

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1969

1965

1958

Ivcation oF _nuc oyeen x

State Phenomena. ?ctronic structure of Glass

Superconductors Investigeted by Time-Differential

Perturbed Gamma-Gamma Angular Correlations. Micro-

Structure of Glasses. Other side projects included

Vitriftcatton of Nuclear Waste and Development of

a Low-level Beta - Counter for Radio - Immuno Assay

Techniques.

- 1971

ASSISTANT PROPESSOR, The University of Florida.

Research and Teaching at undergraduate and graduate
Hee ettures ?on Tradiation Interaction with
Matter" and "Application of Isotopes." Supervision
of Master of Science candidates. Responsible for
he AEC Research Contract No. AT-(40-1)-3348 on
Chemfcal structure Studied by Nuclear Techniques.?
Summer work at Lawrence Radiation Laboratories,
Berkeley, California as Research Visitor.

- 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 electro-
nies, 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.

- 1965

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

Experience in experimental nuclear spectroscopy»
nuclear electronics, theoretical work in nuclear
fodels, hyperfine interactions in metals. Independent
Study in phystcal oceanography.

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An Evacuated Tubular Collector Utilizing a Heat Pipe, Report
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An Evacuated Tubular Collector Utilizing a Heat Pipe, Report
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An Internal Cusp Retlector for an Evacuated Tubular Heat Pipe
Solar thermal Collectors accepted for the 1577 Annual Mecting

Rmeritan Section, International Solar Energy Society, June 6-10

1977, Orlando, Florida.

Simulation of a Residential Solar Air Conditioning System Usin Evacuated Tubular Collecters and Chilled Water Storeye, accepted ?For the 1977 Renal Hecting, Anerican 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 Piate Collector, 1976 ASME Winter Annual Meeting, Decerber 5, New York, N.Y.

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

Optical Phenomena Associated with Tubular Collector, in prep-aration:

A Tubular Evacuated Solar Thermal Collector Utilizing a Heat Pipe as Absorber, 197¢ Rencontre Internationale de & COMPLES, Septenber 24, Ales, France.

Analysis and Performance of an Evacuated Tubular Collector, 7s Intemational Solar Energy Congress and Exposition UCLA, July'28, Los Angeles, California.

Effect of the Grain Size on the Quadrupole Interactions in

?indian Taproguated Ports Class Studied by Tine Differential

Raguiar Correlations. 1975 Northeast yperfine Interactions

Meeting, Rutgers University, May 22, 1975, New Brunswick, New

Jersey.

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Fluorescence Lifetime Study of N,

S=suifonyl Bovine Albumin Conjugeses, in preparation.

hyperfine Electric Quadrupole Interactions in Some TM-Salts

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cee Ee ea Pareiee on Radioactivity in Nuclear Spectros~

copy and Applications, Nashville, Tennessee.

Perturbed Angular Correlation Studies of the Quadrupole Inter-

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nuclear g-Factor of the 5/2 Kev State in pa?°S nel. Phys.

gcFactor Measurements on the First Excited States of pa®0t,

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pri, ug 38, and Pb*??, 1964 Congress Int. de Phys. Nucleaire,

Faris, France.

BOOKS

Experimental Mechanics, translation from German intu Turkish,

Verlag Industries-Drok GMBI, Gottingen (1961).

Experimental Optics, translation from German into Turkish,

Geblag Industries Druck GMBH, Gottingen (1962).

Experimental Electricity, translation from German into Turkish

FETs iaiusteies-bruck Guna, Gotcingen (1961).

AWARDS

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

award of the University of Hanburg 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.

---Page Break---

Several Patents pending in

PATENTS

the ficld of Solar Energy Conversion.

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Soviet Sf bw

Hexe Arthur MeBride Block

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San Juan, Puerto itieo 00929

809 - 761-9269 (tiene) 809 - 767 - 0350 (Business)

Resgnt = 5120"

Weignt - 270

Health - Excetiest

Plave and Date

of Birth Nevark, W.l., June 26, 1938.

citszenship U.S.A. .

Asi Status Married, 2 children

English (spoken, written and reading), Spanish (spoken, reading), French (rvading), German (reading), Russian (reuiing-dictionary sipplenented).

lena 1956

Mich School Newark Acadeny, Mewark, W.J.

University Cornel University, ithaca, N.Y: A.B. 2962

Major: Chenictry end Piysics

Advanced Degree Rutgers - The State Usiversity, New Brunowick,

NuJej Prod. 1967 - Major: Prysical Chesistry-

Minor: Analytical Chesistry ~ Thesis: "Laser

Light Seattering trom Uniferm Spherical Particles".

Profeccional Experience

Present - Scientist II, Center Energy Znvivonsent Kes, Terrestrial

Ecology Division; Dutics: Chemical Progras Developoent,

Instruction of Analytical Techniques to Other Mesbers

~ of the Division, Maintenance und Repair of Instruments,

Réaptation of Standard Methods for Pield Work, Computer

Sned Data Managencnt (FORTRAN, RPGII; TBM 370 systen);

Grant and Proposal Subsierion, Adminstration of Pro-

grant; 3 Laboratury Aucistants, ll Graduate Students.

Salary: AM - 15.

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173 - 15,

1968 - 1972

1367 - 1968

1962 - 1967

Other

Sciestist 1, Tuerte Fice Nuclear Cent:

Ecology Division and Pnysica? Science:

Dutiec: Development cf Irraéiative (Gamma Co-6C}

Analytical Techmiques, Theoretical Prediction of

Matrix Isolated Fluorescence of Furines ané Fyrinidines,

Development of Kuckgrcnnd kadlological Date for Ticrth-

?vest Puerto Rico, Mearurement of Kadioectivity Back-

ground in Northwst, Iueric Rico, Training of Field and

Laboratory Techti cians for Dosimetry ané Monitoring

?Technica? Measurenents, Develozaent of a Position Paper Concerning Chemical Duta Necessary for the Assently of fa Trace Flenents Transport Model of the Rio Espiritu Santo Drainage Basin, Computerized Data Manazenent (FORTRAN); Supervisicn: 2 field technicians, no more ?than 6 Istoratory aides. Salary: §22,000-15, 500/year.

Assistant Professor, University of Puerto Rico, Rio Piedras, Puerto Rico; Duties: instruction of Students at Graduate and Undergraduate Levels, Teaching of Physical Chemistry, Invoratory Instruction of Frysical Chemistry, Admissions, ?Curriculum Comittee, Grant Proposal development. and Subsiscion, Original Investi-gation in Miysical Chesistry, Piblication of Scientific Krticies in Chemical Journals, Participation in Scient~ Sf5e Conferences and Seminars; Supervirion: Between 25 and. jO undergradnate studerte and 5 craduate ctutente in research eutice. Calary: $9,700-12, 000/year.

Lecturer, University of Puerto Rico, Rio Piedras,

Puri Rico; Dutics: ame ec those 1968-1972: Super-

Vision: Avost 26 unécrcradvate students in instructive

Guties. Salary: $3, 00/year.

Laboratory Instructor, Rutgers - The State University,

New Branswick, N.J.5 Duties: Laboratory Instruction to

Undergraduate Students in General Chemistry, Quantitative

Analysis and Inst.runental Analysis, Student? and Course

Evaltation, Problem Grading in Graivate Coursee, Tutoring

of Students with Racarrowid Problems: Supervision: Bet~

ween 15 and 30 students per class (usually 3 classes of

3 hours per week). Selury: $250-320/month.

Chenist, Fluid Chemical Co.,Nevark, W.J.5 Duties Quality Control of Batch Process Manufacture of Lever Brothers Soap Product, Cormeties, and Spray Aerosol Products. (1961). Salary: §2.50/hr.

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Flavor Enhancers, Deveioment of the National Bureau of Standards Thin Layer Chromatograshy Identification Procedure for Vitwain A Acetate, Palmitate, and Jlcoho?, Development of Micro Techniques? for Analysis of Carotenes. (2963). Salary: $525.0%/month.

Chenist, West Research, Johnson & Johnson Corp. East Brunswick, N.J.; Duties: Analysic and Developoent. of Analysis Of Low Molecular Weight Release Agents Used with Adhesives, Methanol in the Presence of Ethanol Using Gas Chronatography, Routine Analysis of 1s0-propancl in Aerosol Advsives, Calibration X-Ray Fluo

Fescent Method for the Determination of Zine in the Presence of Titanius Using Polarography, Deterain ation of Trace Elesents in Uncured Silicon mivber Samples. (96h). Setery: $558.00/nontn.

Summer job only. (Subsequent to receipt of Ph.D., offered position of group leader in a Physical Checical Section Studying Ettylene Oride Sterilization with this company).

Acting Head, Terrestrial Ecclogy Bivirion, Puerto Rico Wuclear Center, Rio Tegres, Puerto Rico; Duties: Res~ ruusible for Maintenance of Frograns On-geing During Aocence of the Hesd of ?he Division. (1973-1976, e total of ayprexinately 30 vecks during this time perioa). Salary: No edditional cospensution.

Assistant Professor, Radiological Health Procre: of PRNC , University of Puerto Rico, Caparra ligts., Rio Piedras, Puerto Rico; Duties: Instruction of Course "Environmental Radioactivity" PRIC-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 sew-

age sludge digester using lov organic solids loading and

thermophilic bacteria (1976).

Salary: No compensation.

Referee, Scientific publications, Jour. Phys. Chea.

Salary: No compensation

Chairman - Scientific Progran Comittee, Caribbean

Chemical Conference Tk, Dec. 8-11, 1977, Condado

Holidsy Inn, San Juan, Puerto Rico,

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65.

Coigute-Talmolive Research, Fe

Signa-Xi Society: Associate Mesber 1965; Menber 1972; Councillor

San Juan University of Pueru Rico Club 1970-71, 1978-76.

Association of Suutheastern Boloricte

International Society of Quantum Biologists

American Aasocistion for the Advancement of Science

Averican Chenical Society - Puerto Rico Bection Chairman 1978

Soctety of Microbiology of Puerto Rico

Anerican Men & Wouen of Science

Public Conferences and Lectures

?laser Light Scattering", Dept. Chem., University of Puerto Rico, Rio Piedras, Puerto Rico, Oct. 197.

?Radial Dictribution of Intessity from Leser and Super-Radiant Sources", Div. Puys. Sci., Puerto Rico Nuclear Center, Caparra Hgts. St&., Rio Piedras, Puerto Rico, Feb. 1968.

?starch ~ A Chemical Anslog of Glycogen is Useful for the Serar-ation and Purification of Glycogen Phosphorylase Present in the Muscles of Crustaceans", A.C.S. Student Affiliete Chanter, IMter~ american University, San Germin, Puerto Rico, Mer. 19.9.

?Chenical Applications of Laser", General Seminar, Puerto Rico Nuc-

ear Center, Caparra Hgts. Stution, Rio Piedras, Puerto Rico, Nov.

a1.

?structure Determination of Adsorption Complexes in Suspension",

Dept. Chem., University of Puerto Rico, Rio Piedras, Puerto Rico,

oct. 1971.

?Chemical Problens in the Generation of Electric Pover Using

Wuelear 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 Measure-

ments for Gauma-Irradiated Glass Matrix Isolated DNA and DNA Anslogs",

~ Div. Phys. Sei; Puerto Rico Nuclear Center, Caparra Hgts. Sta., Rio

Piedras, Fuerto Rico, Mar. 1972.

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?tne Turbidizy Meesurenent:

Opricaly Non-Absorbing Bicloj-.cal end 3io-Chericu? Systeme?.

School of Nedicine, Rio Piedras Medical Center, Rio Picar

Puerto Rico, Mar. 1973.

?Plant Growth Inhibitors", Puerto Rico Nuclear Center, Caparra

Hgts. Sta., Rio Piedras, Puerto Rico, Aug. 1973.

?Coord Progran: Its Use in the calculation of Molecular Paranetors

in the "EHI', 'PPP' and "CNDO/2" or ?INDO? Formalisns", Dept. Chen.,

University of Puerto Rico, Rio Piedras, Puerto Rico, Nov. 1973.

?Radionctivity Effects in the Natural and Contaminated Environments",

Radiological Health Progran, Puerto Rico Nuclear Center, Caparra,

Hgts. Sta., Rio Piedras, Puerto Rico, May 197%.

?Ground-State Electronic Properties of Plant-Growth Regulators",

, Mayaguez AM University, Mayaguez, Puerto Rico,

First Union Church of Sen Juan, Panta Tar Merfes, San Juan,

Puerto Rico, Apr. 1976. Caguas Baptist Church, Feb. 2977)

Mectinrs, Symposia and Conferences Attended

Eastern Analytical Syspositm, Americen Chemical Society, New York,

Ney. Mar. 196.

% Congreso de Quimicos latinoanericanos, San Jo:

1969.

) Costa Rica: Feb.

Northeast Region Sub-Scction Meeting, American Chemical Society-

?Yetroches", San Juan, Puerto Rico, 1971.

IV Structure-tuerey Relationships Conference, National Science

Foundation (IGF), Western-Fher Corp., Gan Juan, Puerto Rico, Jan, 197,

XII Congress of Pesticide Chenistry, International Union of Pure and

Applied Chemistry (IUPAC), Kemira Oy, World Health Organization (WHO);

Helsinkl, Finland, July 197k.

II Quantum Biology Symposiua, Dept. Naval Research (DNR) University

. of Florida.- Gainesville, Uppsala University, Uppsala, Sweden; Sani-

bel Island Florida; Jan. 1975.

- Inter-1sb Conference on ilydrology and Trace Elenent ?Transport

in Ecosystems, Puerto Rico Nuclear Center; Oak Ridge National Lab-

oratory (ORL), Oak Ridge, Tennessee; U.S. Department of Agriculture,

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Aiken, So. Carolina: Muy, 2

Cject, Frundin, Ne. Cerciina:

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ob computer management of bic-envirormental dat.

gue, Nev Mexico; July, 1975.

Anerican Cheuical Society, Local section executive orientation meet~

ing: Asheville, No. Carolina; Apr., 1976.

American Chenical Society/Puerto Rico Section, et senior technical

meeting (Mecting-in-Miniature); La Farguers, Lajas, Puerto Rico;

Dec., 1976.

IV Quantua Biology and Pharmacology Internationa Symposium, Rat"]

Science Foundation, Nat'l Inst. Health (HEN), University of Florida,

Uppsala University; Sanibel Isiand , Florida; Jan., 1977.

search Students and Projects Supervised

Julio César Cruz Rosario (dec.); Differential refractometzy using @ Jaser source with comercial instrumentation. (1968-1970). Chenistry.

David Fantiago Mesa; Isolation and purification of enzyme glycogen phosphorylase-a isolated from the mscle of the blue crab (Cellincc= tes danae) jointly supervised with Dr. Fernln Sagerd{a, Sch. of Meds UPR; Ph.D. (1969-i972). Biochemistry.

Narinder K. Metta: Theoretical evaluation of light-scattering as a Probe for structure of adsorption complexes. M.Se. (1969-1972) Physi- ?cal Chenistry.

Pura A. Rios; Inhibition kinetics of glycogen mobilization ty enzyme Glycogen phosphorylase iscated from the mscle of the blue crab (Cal- Linectes danae) jointly supervised with Dr. Ferain Sagardfa, Sch. Med. UPR; Ph.D. (1968-1972). Biochemistry.

Félix Santos; Turbidity of upper reaches of the Rio Espiritu Santo and R{o Sonodora Rivers, E1 Verde, Puerto Rico; Analysis of trace elements ?in the Rio Sonodora River system. (1971-1972). Environmental Chenistry.

Neftelf Pérez Contreras; Light-scattering from a concentric sphere mo-

del system. M.Ed. (1970-1971). Paysical Chemistry.

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

Daniel Letrén Pitre; Experimental research on natural radiation exPosure in Puerto Rico using thermoluminescence dosinetry. N.Se. (Ihus Clear Engineering) (1973-1974). Nuclear Science.

Edgardo Hernéndez; Laboratory investigation of stetistics of thermoIuminescence dosimetry using calciun fluoride dysprosium-dopea docimeters. M.Publ.Health (1974-1975). Radiation Nonitorring.

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Grants

Relande Mosquera Moreno; ?Aejection Oriverie for Faire of

Experimental Valuce of Interzeved Lose Inferreé {rox Thermo-

Iuminiscence Dosinetry"; M. Publ. Kealth (1974-1975).

Karl L. Frado; "A Computer Procram for Calculation of Field

Dose Received by Thermoluminescence Dosineters - TIICALC

(PORTRAN G)"; M. Publ. Health (1974-1974).

Antonio J. Gonzdlez; "Population Exposure to Nature] Radiation

in Puerto Rico"; Experimental Research; M.Se. (Nuclear Eng!

ing) (1974-1975).

Juan Estevez; "Single Electron Oxidation and Single Electron

Reduction Energies for Twisted Boat Conformations"; (1974).

and Contracts

Research Corporation, 1968. "quaternary Structure Studies of

Glycogen Phosphorylase Using IAght-Scattering" ; $6,500.

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

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

U.S. Department of Health, Edueaticn and Welfare, 1972. "Equipment for Modernization of Undergratzate laborateries"; Written by mesbers of the deparinent of chenistry, University of Puerto Rico ané administered through the departnent. Thysical chemistry section written by A.MeB. Block, specitying equipment fur an undergraduate experiment in photo-chenistry, estimated amount: $5,000.

Puerto Rico Water Resources Authority, 1913-1975. "Environmental Data for the Environmental Report in Support of location of Therao-miclear Power Generation Facilities in barrio Islote, Arecivo, Puerto Rico"; Contract awarded to Puerto Rico Muclear Center, Principal administrator: Dr. Frank G. Jewman, responsible agent Suv-director: Dr. Michael Cancy, nevotiating agents Research c ordinator: Dr. Janes D. Parrish, Isaison egent with contractores Director of Terrestrial Ecology Studies: Dr. Richard G. Cleats, wrineipal investigator; Head of Radiological Buckground and Infora-Stion Studies: Dr. Arthur MeB. Block, co-principal investigstor.

Radiological inforustion for U.S. Atcnic Energy Cousission Docket ¥50-376. Reporting in most cazes vas through Dr. Clenents, though a a musber of oces: lons, direct communication with Dr. Parrish, oF with a contracting agent representative vas requested. Contract duration: Nov. 1973 = June 1975. Total budget (estimated): Salaries (including overhead and fringe benefits) $90,000; Equipnent, material and supplies $20,000, (Bidgetary data reflects estimates, not con-mitted finds, and applies only to the radiological section).

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Jar Calibration of iare> Scettering Thotoseters Usi

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To gobias and A. Grimmison, Proc. X Cong. latinouner., San

José, Costa Rice (1969).

?Enfects of Surface-Sorbed Emilsifier on lirh* Scattere? by Polystyrene-Water Sols", N-K. Mebta, A. Grinicon ant A.McE. Block, Eactern thibsection Regional Meeting, Amer. Cher. Soc. (Metroches), San Juan, Puerto Rico (1971).

?Purification and Properties of Glycogen Phosphorylace-A Tzolated froa the Muscles of Blue Crabs (Callinectes danse)?, D. Suntiaxo, PA. Rios de Santiago, A. MeB. Block and F. Sagardfa ibid.

?Light-Scattering Measurements on the Trypsin/Silica A¢sorption complex", A.MeB. Block, A. Grimison, F. Santos and N.K. Mehta, Proc. XI Cong. latinoamer., Santiago de Chile (1972).

?cinética de 1a Polinerizacién de Glucose = Glucogeno con Arente catalitico de Fosforilasa de Glucoyeno Aislado de los Musculos Gel Cangrejo Azul (Ca2linecter éanae)", A.McB. Block, D. Cantiago, PA. Rior de Santiago and F. Sapardie, ibid.

vparticle Size Distribution of ?articulate Heiter in the Rio Sonadora River of El Verde Rein Porcet?, Ante! . Block and RG. Clenente, Yerrertrial Peolory Tre ?erie ikico Nuclear Center, finn, Kep't. U.E. Meade Bnoryy Cosstseine ?iD-1500 (3972).

?Yonization Potentials of Aryl Substituted N-t-uty] enzwrides", A. MeB. Block, R. Tsai and G.4. Tubottom, IV Structure - Enenry Relationships Conference, National Science Foundation and Western-Fher, San Juan, Puerto Rico (197).

?Molecular Orbital Caleviations for the Alpha, Beta, Cama (Lindane), and Delta Ironers of 2,2, 3,1, 5,(-lexachlorocyelohexane (BAC)", A. NeB. Block and Lik, Newland, invited communication, International Unfon of Pure and Applied Chosiiry (IWC) Conference on Festicides TIT, Bieinki, Finland (97h).

"stmeture - Activity Correlations for Phenoxyacetic Actas and Indole-acetic Acids Used for Plant. ~ Growth Remulation, A.McB. Block and R.G. Clenents, International Symposium on Quantun Bicloy

?and Phareacology, Sanive) stand, Florida (1975).

?Seme Observations on Pesticsie Uses in Pucrto Rico and Other tropical Areas: A Research Prospectus for Pesticide Technolory",

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The Environment) Impact of Picioricully Imporvant Fission /Fusion Produced Radionuclides one Saul: Loculizy on the North Zoess of muerte Fico?. A.McE. Block, F. Santos und M.A. Grivble. First sr. Jech. Meeting, American Chemical Society, Fuerto Rico Section, Dec. 9-22, 1976, ia Farguert, Lajas, Puerto Sco.

?Survey of the Elenente? Burden of Yenthie Orgenisus in the Rfo piritu Santo River Estuary", A.Mc3. Block, F.A. Santcs, K.0. Cleneats and W. Bhajan, IX Caribbean Chenical Conference, San Juan, Puerto Rico, Dee. 8.11, °2977,

(thioether Analogs of Plant Auxin (Indole-3-Acetic Acid)", A.McB. Block and F. Santos. IX Caribbean Chemical Conference, San Juan, Puerto Rico, Dee. 8-12, 197.

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Publications

A.McB. Block, "Dispersicn no linear de tuz de inser en sclucio-nes", Rev. Col. Quis. Puerto Rico 26, 10 (1969),

AMeB. Block, "Use of a 6,328 scondary source in differential refractonetry", Appl. Optics 10, 207 (1971)+

N.X. Mehta, A. Grimison and A.McB. Block, "Effects of aispersing agents on the angular dependence of light scattered from polys~ tyrene spere/water sols", Appl. Optics 10, 2031 (1971).

G. Stevenson, M. Colén, J.C. Concepeién-Carefa and A.MeB. Block, "the cyclooctatrieneyne anion radical", J. Amer. Chem. Soc. 9, 2283 (1974).

D. Santiago, P.A. Rfos de Santiago, A.McB. Block ana F. Sagardfa, Purification and properties of glycogen phosphorylase @ fron the muscles of blue crab (Callinectes danae)", Arch. Biochem. Biophys. 163, 679 (1974).

P.A. Rfos de Santiago, D. Santiago, A.MeB. Block and F. Sagerdfa, "Kineties of inhibition of clycogen phosphorylase @ isolates fram the muscle of blue crab (Callinectes danae)", Arch. Diochea. Biophys. 163, 688 (1974).

AWMeB. Block, R.G. Clenents and J.D. Parrish, "Dackground reato-logical characteristics (for Puerto Rico)", Puerto Rico Water Resources Authority Enviromental Report for North Coast, Nuclear Fower Plant #1 (HORCO-1), USAEC Docket. #50-376, 2.8 (1974).

AMcB. Block and R.G. Clenents, ?Preoperationsl monitoring progran

?for NORCO-1 pover plant", Puerto Rico Water Resources Authority Enviromental Report for North Coast Nuclear Pover Plant #1 (WORCO-1), USABC Docket #50-376, 6.3 (1974).

A.McB. Block, R.G. Clenents, J.D. Parrish and K. Pedersen, "Oft-site radiological monitoring program (for NORCO-1 power plant)", Puerto Rico Water Resources Authority Enviromental Report for Worth Coast Nuclear Power Plant #1 (NORCO-1), USABC Docket #!50-376, 12.6 (297). =

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sk. Stevenson, M. Colin, 1. Yeasio, J.G. Concepeién-Garcta

and A.MeB. Block, "Electron éictribution in some 1,2-disubstituted cyclooctatetraens anion radicale and dianions", J.?Thys. Chen. 79, 1968 (2975).

AMeB. Block, R.G. Clenents, L.I. Rosa, F. Santos, M.D. Bams, E. Herndndez, K. Mosquer and K.L. Prado, ?thermoluminescence dosi-?etry in hortwent Puerto Riso", USEKMA Tech. Publ. #RIC=291 (975).

R. Stevenson, A,E. Alegria and A.McB, Block, ?Equilibrium siuddes by electron spin resonance XIII. The? relationship between charge Seneity ana ion pair Sissociation deversined ty the wae oF g values", J. Amor. Chon. Soe. 97, WBS9 (1975),

A.McD. Block and R.G. Clenents, ?Structure-activity correlations for phenoayacetic acids and indoleacetic acids used for plant grovth regulation", Int. J. quantum Chen. QBS 2, 197 (A915).

A.McB. Block and L.W. Nevland, "Molecular orbital calculation: for 1,2,3, 4, 5, 6-hexachlorocycichexanes", in "Pesticides", P. Koivistoinen ed., Env. Qual. Safety (Suppl.) TIT, 569; Geo. Thiene Verlag, Stuttgart, FRG (1975).

E. Santos, A. McB. Block, R.G. Clements, 1.1. Ruca and M.D. Banus, ?Natural enviromental radioactivity measuresents in northwest, Puerto Rico", Carib. J. Sci., accepted for publication, to eppear.

AMeB. Block and R.G. Clenents, "Radioactivity content of soil in Barrio Islote, Arceibo, Puerto Rico", USERDA Tech. Publ. FRNC-202 (1976).

A. McB. Block and WN. Garcfa, "Comentary on the analysis of mercury in soil and sediment", J. Environ. Qual. 6 232 (0977)

Stevenson, "Substituted

A. McB. Block, R. Concepeién-Garcfa and G.

-Phys. Chen. 8h, 367

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A.McB. Block, W. Bhajan, LW. Nevland & J. Estevez, "he electro-

chesical reduction nodel of anaerobic degradation of the gamma

Asomer of 1,2, 3, 4,5, 6-hexachlox ?lohexane (¥ -BHC)", J. Water

Poll. Control Fed?, "9, 657 QUT).

A.McB. Block, E.Cuevas and R.S. lesa, ?Ausin structure-activity

relationship. Preliminary renilts of studies of chemical control

of an ecosystem in its steady state.? Int. J. Quantum Chea, QBS

4 227 G77).

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Lanta Me Canale, KG. Chenems, I-A. Colin ano A.MeU, Bloch, ",

Di GA Se SITNEY Of the Rio Lapiritu Santo hiver Dieicagesethe .

U.5. FROA Tech Pub] in press (2977).

OF Artiste ety Tp, Santos and HLA. Crsbtve, ?me Environentar Impact

Faiotr, Aeitily Produced, Biclogically-ackive maser An Barrio

oF eh gnreeiba, Puerto Rico, Estimator of the see Sof Burden

OF C6237, Ra-226 and 8r-90.", Carib. J. Sel. to Coes 1978.

AiR Bock FA. Santos and R.G. Clenents, "lenental survey of the

2ao Hepiritu Santo River Estuarine Sediments, wee Sy, Carib. Chen.

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Aestrdin Meee "The, isan Waste Problem in Rural Zones of a High

Planing: faterahed." Proc. Sem. River Dacia feere aoa Enviromental

(auaming: Method. and Inst., CEER, UPR Gras wee Planning, A.1.Ch-2.,

(sponsors), To appear Sept.?1978.

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