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RESEARCH REACTOR UTILIZATION IN CHEMISTRY PROGRAMMES

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RESEARCH REACTOR UTILIZATION IN CHEMISTRY PROGRAMMES

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INTRODUCTION

The Philippine Atomic Energy Commission was established by law in 1958 and was given the twin responsibility of promoting and regulating the use of atomic energy in the Philippines. Staffed initially with a handful of Filipino scientists and technologists taken from the academe and science agencies, trained in the early training courses at the Oak Ridge School of Reactor Technology and the Argonne National Laboratory in the US, initial efforts consisted of the installation of a 1 MW research reactor donated by the US Government under a bilateral agreement in 1955, and the establishment of the associated research and training laboratories. A modest program was developed on the use of radioisotopes and nuclear techniques in PAEC's early AIMS: Agriculture, Industry, Medicine and Sciences (chemistry and physics). To support this, a national nuclear manpower training and development scheme was started with an aggressive and tough program of recruiting the best graduates of top universities in the country for overseas and local training in atomic energy.

From that modest beginning, the PAEC built up its resources and capabilities with the following programme thrusts:

1. Nuclear research and development in the physical and life sciences as well as in nuclear technology, carried out principally by the Philippine Atomic Research Center.

2. Manpower development program, including foreign fellowships and local training courses in specialized areas of nuclear science and technology thru its Nuclear Training Institute.

3. Production of radioisotopes for medical, industrial, research and training applications.

4. Irradiation services; utilizing the research reactor (PRR-1) and various gamma irradiation facilities:

   a. 20,000 Ci Co-60 Source immersed in the reactor's intermediate power pool for irradiating samples in the dry gamma room.

   b. Gamma Cell 220- a high intensity self-contained 7,000 Ci Co-60 source with a chambered drawer for irradiating samples.

   c. Gamma Garden, 7 m diameter irradiation facility with a 150 Ci Co-60 source for agricultural research.

   d. A 1,000 Ci Cs-137 gamma source used mostly for bio-medical researches.

5. Promotion of nuclear techniques and radioisotope applications in nuclear medicine, manufacturing, processing, and other industrial operations.

6. Development and fabrication of nuclear detection and instruments for use in training and research laboratories.

7. Special nuclear services as analytical services; industrial applications in quality control and non-destructive testing; radiation protection service such as film badge service, nuclear instrument calibration and evaluation, secondary standards laboratory, radiation control, and nuclear materials/radwaste management.

8. Surveillance of the Philippine environment for environmental pollution and radioactive fallout effects.

9. Technical and economic feasibility studies which led to the early introduction of nuclear power in the Philippines.

10. Preliminary exploration for uranium deposits in the Philippines.

11. Nuclear licensing and regulatory activities; periodic monitoring and inspection of facilities such as nuclear and radioisotope laboratories; safety evaluation; standards development and nuclear safeguards especially of the Philippines first nuclear power plant which is to be operational in 1985/86.

12. Expansion of Research Facilities:

   a. Conversion of the PRR-1 to a pulsing TRIGA reactor.

   b. Construction and expansion of reactor-associated laboratories -

      1. Integrated Radioisotopes Production Laboratory to meet the increasing demand for radioisotopes especially radioimmunoassay kits and also for industrial uses.

      2. Industrial Applications Laboratory including a non-destructive testing lab, hydraulic lab, calibration and counting room.

      3. Radwaste Treatment Lab-consisting of the radiation lab; facilities for pilot scale waste treatment and decontamination; demo facilities for the management of radwaste for the Nuclear Fuel Cycle Center, (a nationwide centralized system for the handling, storage and eventual disposal of radwaste from the Nuclear power plant and labs).

   c. Co-60 Facility - a demonstration plant for the radiation sterilization of medical products, food irradiation and other pilot projects using a 30,000 Ci. Co-60 source.

   d. Computer Facility, an IAEA assisted project with a VAX-11/750 computer system (512 kilobytes plus virtual memory of 2 gigabytes).

13. Grants-in-Aid Program of researches given to institutions outside of PAEC to promote and enhance the application of nuclear techniques in research and development.

In the changing and enhanced roles which PAEC play in the nuclear science and technology program of the country, the researches in chemistry utilizing the reactor, has also evolved and kept pace.

1. The Research Reactor, PRR-1

The principal research facility of PAEC is a heterogenous open-pool type reactor. It is moderated and cooled by light water, and graphite reflected. The 30 fuel elements, in a combination of 20% and 93% enriched uranium are loaded in an aluminum grid box in a 6 x 5 configuration. Each consists of 18 aluminum cladded plates and has an active dimension of about 3" x 3" x 24".

Surrounding the fuel elements are nineteen graphite reflectors. There are four control blades of boron with aluminum casing, a regulating rod, an antimony-beryllium neutron source and neutron detectors consisting of three compensated ionization chambers, one boron-lined proportional counter and a fission chamber.

All the principal reactor components are loaded in the aluminum grid box to form the reactor core. The grid box is welded to an aluminum suspension frame which is bolted to a movable bridge.

The reactor core configuration shown in Figure 1. It contains the fuel elements, graphite elements, control blades and instrumentation detectors.

The reactor core is submerged in a pool of demineralized water, with an average depth of 30 feet. The aluminum-lined concrete pool is divided into three sections: the low power pool section (less than 100 KW), the intermediate or fuel storage section and the high power pool section (more than 100 KW).

The present maximum operating thermal power of the PRR-1 is one megawatt, with a thermal neutron flux of about 1×10^{12} n/cm^2/sec.

1.1 Experimental Facilities

Presently in use are two vertical aluminum dry pipes which are made available at any power setting of the reactor system, the standard neutron irradiation facility (SNIF) available only at low power operation; and the following which are available at all power levels provided the core is positioned in the high power pool section; a two-station pneumatic tube system, six beam ports and a graphite thermal column.

1.2 Reactor Data Summary:

Reactor Materials:

Fuel: Uranium (six-20%, twenty-9⁻ .enriched fuel elements).
Moderator: High Purity water
Reflector: Graphite
Coolant: Light Water
Control: Boral

Structural Materials: Aluminum

Shielding: Concrete, water and steel

Dimensions:

Core (active part): 15" x 18" x 24"
Reflector: 3" x 3" x 30"
Grid box: 9 x 7 array of 3" x 3" modules

Experimental Facilities:

Thermal column: 5' x 5' x 8' graphite
Beam ports: two 8-inch and four 6-inch diameter
Pneumatic tubes: Two, 2-inch diameter
Dry pipes: Two, 2-inch diameter (located in core)
Standard Neutron Irradiation Facility (SNIF): One

The PRR-1 attained initial criticality on August 26, 1963 and started operating at full power of 1 MW on August 11, 1964.

1.3 PRR-1 Conversion to TRIGA

PRR-1 is being converted to TRIGA, to meet the increasing demands for higher flux.

TRIGA (Training, Research, Isotopes, General Atomic) research reactor concept was developed to provide an inherently safe, economic (better fuel economy) and flexible reactor (higher power) for the conduct of a wide spectrum of neutron-based experiments. The basic characteristics of the TRIGA reactor are:

1. Use of homogeneous, uranium-zirconium-hydride solid/fuel moderator elements with a prompt negative temperature coefficient of reactivity.

2. Light-water, open pool design

3. Power pulsing capability

Conversion will be undertaken by General Atomic, the company which developed the TRIGA reactor, and the PAEC. Under the conversion agreement, GA will provide the TRIGA fuel and certain components and services. PAEC will provide all other conversion components and will do all installation and field assembly and other technical work.

The conversion work has six phases: namely, preparation, desi... component procurement and fabrication, installation testing and long term testing. It is expected to be completed in 1985.

2. The Chemistry Research Program: A Brief Retrospect

The research programme in chemistry reflects the evolution of PAEC from a research and development organization to its presently expanded role as a licensing and regulatory body for nuclear facilities, principally the country's first nuclear power plant (a 600 MW pressurized water reactor), as a producer of radioisotopes (mainly for medicine and research) and as the only organization in the country offering specialized nuclear services (film badge service, analytical tests and measurements, secondary standards lab, etc.).

2.1 Pre-PRR-1

Within the year that PAEC was established, the core of top scientists and technologists recruited to head the various operating units of PAEC, started researches which could be made with the limited equipment available, relying heavily on the facilities and resources of the university where most of the scientists were formerly teaching. Studies were those expected to yield needed information to insure the safe operation of the research reactor still in the works, and the safety of the research personnel and general public. Some researches were preparatory to the expanded research program soon to be initiated when the research reactor became operative.

Early researches in chemistry reflected the research interest in organic chemistry of the head of the Chemistry Research Department, as well as the R and D needs for radioisotope production:

- Labelling or organic compounds with C-14 including DDT, benzoic acid and acetic acid.

- Tracer studies involving the Sandmeyer Reaction using Cl-36.

- Biochemical sythesis, isolation and purification of cystine and methiopine proparatory to labelling with C-14

- Labelling of compounds of medical intorest with 1-131

- Studies on airborne fission products and radioactive fallout.

The beginnings of a radiochemical laboratory was established with a $23,000 IAEA grant for a radiochemistry expert and equipment. The laboratory was initially set up in August, 1960 with the assistance of Dr. A.G. Maddock. He also conducted a radiochemistry course for 22 chemists from government and private research and educational institutions who have already taken the PACE basic course in radioisotope techniques patterned after the Oak Ridge courses.

Establishment of a neutron activation laboratory was made possible with a $ 20,000 equipment grant from the US International Cooperation Agency in 1960.

2.2 The First Years OF PRR-1

After the research reactor became critical in 1963 and started operating at full rated power in 1964, the test production of radioisotopes became an intensive activity in PACE. Microcurie quantities of p-32, Ni-65, S-35, Na-24, Au-198 and Cr-51 were first produced experimentally. Within 5 years of operation, some 30 radioisotopes and labelled compounds were routinely produced. Other radioisotopes, especially the short-lived types which are either uneconomical or impossible to import could be produced within short notice.

During the period of the criticality testing of the reactor, a 600 Ci Co-60 facility was installed and a 1000 Ci Cs-137 facility was acquired which further expanded the research capabilities of PAEC.

2.3 Decade of Development and Achievement

Within the decade after the PRR-1 became operational, the vigorous programme of researches in all fields of nuclear research produced major breakthroughs. PAEC enjoyed an almost ideal climate for scientific research:

1. There was a group of dedicated and highly trained scientific and technical manpower with Ph.D's and M.S. degrees, products of PAEC's enlightened training program, who came back from their training abroad and took up the challenge and were proud of their involvement in the relatively new and prestigious field of atomic energy.

2. There was a steady infusion of new funds for research in terms of equipment and expert services from international sources such as the IAEA, Colombo Plan, US-AID, and other Bilateral Agreements.

3. More new facilities and modern laboratories were acquired or were planned which stimulated progressive planning of new research directions and efforts.

4. Management policies encouraged the full utilization of the capabilities of the research organization by way of valuable support and guidance.

In this highly supportive atmosphere for scientific creativity, the researches in chemistry utilizing the reactor expanded into all areas of research and the latest methodologies :

2.3.1 Hot Atom Chemistry

The work on zinc and copper phthalocyanines produced a breakthrough. In the PAEC Chemistry Lab it was discovered that when ^{65}Zn Pc is mixed with a biphasic system composed of carbon tetrachloride and dilute ammonium hydroxide, $^{65}Zn^{++}$(ions) are liberated into the ammonium hydroxide (aqueous) layer. Other such organic solvents, "crystallizinc solvents" were tried which produced yields as high as 80%. The results of such studies were valuable in the production of hifh specific activity radioisotopes.

2.3.2 Geochemistry

Nuclear and radiochemical techniques were developed for the analysis of major and minor constituents of Philippine ores and minerals.

Neutron activation analysis played a key role in the analysis of hundreds of samples of ores from all over the Philippines in search of mineralized areas for gold, copper and molybdenum. Results of the study produced the map of the metallogenic provinces of the Philippines as defined by the trace element distribution in chalcopyrite, sphalerite and pyrite The metallogenic map proved valuable in the mineral exploration of the country.

2.3.3. Archaelogical Chemistry and Carbon Dating

The origin of clay and clay products from sufficiently different geographical regions were determined by analyzing differences in trace elements, specifically manganese and titanium by neutron activation analysis. Distinguishing between origins of ceramic artifacts dug from one site is of special importance to archaelogists in establishing ancient trade routes and social contacts of the people associated with the era in which the particular potteries were made and used.

Shards dating back to the 14th and 15th century from a known archaelogical site in the Calatagan Caves in Batangas province were analyzed, and characterized from modern clays obtained from different geological areas in the Philippines.

A radiocarbon dating laboratory was established to determine the age of carbon-containing materials by liquid scintillation techniques after synthesis of the carbon content into methyl alcohol.

Samples of wood artifacts dug from another archaelogical site, the St. Francis Square in the Sta. Ana Church in Manila were analyzed and compared with standard wood samples obtained from the US Geological Survey Radiocarbon Dating Laboratory and the Institute Venezolano de Investigaciones Cientificas.

2.3.4 Radiation Chemistry

A considerable amount of chemistry research efforts was directed towards the solution of the problems of agro industries based on the coconut, tobacco and lumber using nuclear techniques.

Thus in the field of radiation chemistry, the following researches flourished :

1. Radiolysis of Coconut Oil - to determine the effects of gamma radiation on various fatty acid components of coconut oil, radiation polymerization of unsaturated fatty acids such as linoleic acid would increase resistance to rancidity.

2. Gamma Irradiation of Coconut Coir Dust Prior to Pyrolysis - better efficiencies of extracting guaiacol and other industrial and pharmaceutical chemicals from the pyrolysis of coir dust, were indicated after gamma irradiation of the coir dust prior to pyrolysis. Optimum conditions to give maximum yields were studied.

12) Sombrito, E.Z., R.B. Banzen, A. dela Mines, E. RB Bautista, "Uptake of I-131 in Mussels (Mytilus Smaragdinus) and Algae (Caulerpa Racemosa) Nucleus, Jan 1983.

13) Garcia, G., E. RB Bautista, J. Casyao "Bioaccumulation Factor of I-131 in Biomedia (Tilapia Nilotica), Nucleus, Jan 1983.

14) De la Cruz, B., L.M. Lansangan, S.C. Bautista, "The Physiological Labeling of Schistosoma japonicum cercariae with C-14," Journal of the Phil. Medical Asso., 44 (8) 451-462, August 1968.

15) Tom, R., E.RB Bautista and L. Lucas. "Pesticide Residue Analysis of Human Abdominal Fat of Filipines. PAEC Report (D) 76003.

16) Alejandrino, A.L., C.B. Goze, L.M. Lansangan, R.R Paradero & G. Asprer. "A Report on the Copper, Molybdenum, Zinc, and Cadmium Levels in Normal, Cirrhotic and Cancerous Liner Tissues Among Filipines." PAEC Report (D) 76011.

17) Dela Cruz, B., L.M. Lansangan, R.R. Paradero and G. Asprer, "A Report on the Trace Element Investigation in Relation to Cardiovascular Disease." PAEC Report (D) 76014

18) Cunanan, S.A., L.S. Bonoan, F.P. Verceluz and E.A. Azucena. "Wood Plastic Combination" NSDB-PAEC 7203 Ps. PAEC Report.

19) Cunanan, S.A., L.S. Bonoan, E.A. Azucena and F. Verceluz, "Graft Polymerization of Vinyl Monomers with Cellulosic Materials," PAEC Report.

20) Paz, L.R. dela "Effect of Gamma Radiation on some Salicylates. I. Steady State Studies". Philippines Nuclear Journal, Dec. 1976

21) Santos, G., O. Palabrica, E. Hernandez and C. Bernido. "Uranium Exploration Stepped-up", Asia Mining, V. IX, No. 3, pp. 38-39, 1976.

22. Kapauan, P.A., "Nuclear Techniques to Monitor Pollution", Business Day, December 21, 1976.

23. Pascual, G.S. and J.C. Ramos, "Pyrolysis of Coir Dust," Philippines Nuclear Journal, 2, 137-154. (1969).

24. Tojada, C.A., M.B. Yoshisaki and V.R. Santiago, "Economic Feasibility Study on the Conversion of PRR-1 into Triga Type Reactor, PAEC Report (C) IF 77003

25. Bautista, E. RB, B.J. Maralit, "Pesticide Residue Content of Some Marine Living Resources of the Philippines. PAEC Report (A) IE 79004

26. Hernandez E.C. "Exploration for Uranium by Carbon-Radiometric Methods in the Philippines", PAEC Atomic Bulletin, Mar-Apr 1978.

27. Juliano, P.O., "Solvent Effects on Free Radical Chlormation", The Chemists Quarterly 7 (1 & 2): 41 (1965)

28. Terrado, E.N., A.T. Davila, M.R. Eugenio, "Radiation-Induced Splitting of Coconut Oil". Asian Atomic Newsletter 2: 6 (1965)

29. Davila, A.T. and M.R. Eugenio, "Radioisotope Production in the Philippines," Asian Atomic Newsletter 2: 6 (1965)

3. Graft Polymerization of Plastic Monomers with Coconut oil-

This project was aimed at producing a synthetic material out of coconut oil and monomers, with properties comparable to those produced abroad. Coconut oil mixed with methyl methacrylate (MMA) and styrene was irradiated with a Co-60 source to induce polymerization. The process produced a white plastic-like solid (m.p, 180-200°C) which can be worked into films of various thickness and/or molded to the desired sizes and shapes. The polymerized product, which was thermoplastic in nature, was soluble in chloroform and acetone, insoluble in petroleum, ether and benzene.

4. Studies on the gamma radiolysis of tobacco leaves determined the differences in the chemical composition particularly the nicotine content, as an index of quality and between locally produced imported virginia tobacco, and also among the different grades of local virginia tobacco. Neutron activation analysis was used in conjunction with other conventional methods of analysis such as gas-liquid and thin layer chromatography, for the analysis of the radiolytic products (aniline and nicotinic acid).

5. Radiation Grafting of Plastic Monomers for Wood Plastic Combinates-

Philippine semi-hard woods (almon, lauan and tangile, apitong, mayapis) and cellulosic materials used for compressed wall boards such as sugarcane, bagasse, sawdust, agricultural waste (rice straw), were combined with a monomer and the impregnated wood of compressed board, were exposed to Co-60 gamma radiation to induce polymerization. Monomers used were a crytonitrile, styrene, methylmethacrylate.

Some improvement was made on the structural properties of the wood plastics and compressed wall boards by radiation-induced graft polymerization: increased hardness, water resistance, mechanical strength, density, resistance to insects and fungsi.

6. Other research departments also contributed to the research efforts on the coconut.

The Nuclear Engineering Department which was in charge of radioisotope production, studied the radiation-induced splitting of coconut oil. Irradiation of four types of samples were made using a beam port of the PRR-1 with a dose rate of about 10^6 rads/hour from gammas, fast and thermal neutrons at 1MW reactor power. Results were compared with irradiations using a 500 Ci CO-60 source. The studies indicate that the splitting of oil was induced mainly by heavy particle (neutron) interactions and that splitting depends on dose rate rather than on total absorbed dose.

The study of the adsorption of Fission Products on Radiation-Polymerized Vegetable Oils provided valuable experience on the behavior of fission products. It was found that the Reactor-Irradiated Coconut of Corn Oil Resin (RICOR) seems to possess adsorptive properties comparable to activated chaecoal, silica gel, or activated alumina when tested with I-131, Zr-95, Nb-95, Mo-99 and Ce.

2.4 Reorganization and Shifting Priorities

The seventies in PAEC were marked with shifting R and D priorities while trying to keep up with the rapid technological changes.

New national development goals presaged the need for somewhat drastic changes in the functions and organizational structure of PAEC.

When in July 1973, President Marcos, on the basic of the UNDP-IAEA Feasibility Study for the Establishment of the Nuclear Power Plant in the Luzon Grid, signed the order to establish the first nuclear power plant immediately, those changes became urgent. The presidential decision had far reaching effects on the programs and organization of PAEC.

Thus as the nuclear power activities gained prominence in government as well as public attention, the PAEC was reorganized to conform with its added functions of lice. and regulating the nuclear power plant. PAEC was transfer from the National Science Development Board (NSDB) to the Office of the President of the Philippines, and then to the newly Department of Energy, with the concomitant shift in program thrusts in nuclear research as well as priorities.

Researches in chemistry followed that shift from projects which contribute to countryside development under the NSDB, to projects which probed the possibilities of exploiting the indigenous energy resources in the search for alternative sources of energy following the oil crisis.

1. Comparative analysis of the radioactive emissions of nuclear and non-nuclear power plants using nuclear technique (NAA). The study included analysis of geothermal waters from two operating geothermal plants, coal samples from three local coal mines, fossil oil from an exploration oil well and oil ash from a thermal power plant.

2. Alcohol from Agricultural Cellulosic Waste (rice straw, rice hull, corn husk) by Gamma irradiated Microorganisms. This research was geared towards increasing the enzymatic saccharification of cellulose by gamma radiation pretreatment, and also to induce the collulolytic activity of certain microorganisms by gamma radiation.

The body of researches in chemistry utilizing the reactor was also spread over the newly created units in the reorganized structure. Most of the original research units were split into two, with the new unit acquiring service functions.

Thus the Chemistry Research Department was divided into the Chemistry Research Division which retained its research functions; and the Analytical Service and Measurements Division which was tasked with analytical service functions for the needs of industry.

Nevertheless, carried by the research momentum, these new service units continued with their research activities, notable among which were:

1. NAA of hair in relation to geographical location and extent of industrialization. Hair from residents of Metro Manila were compaired with those from residents in a volcanic region in Southern Luzon and from those in mining towns on a southern island. Results show

that residents in areas near the open pits from mercur mining operations exhibited elevated mercury levels. Range of values obtained from the whole sample population is as follows :

Cd - 0.05 to 1.35 ppm

Pb - 1.13 to 119.8 ppm

Hg - 0.179 to 22.61 ppm

2. Radioactive Tracer studies in the siltation of Philippine Harbors. I. Surface Labelling of Bodload Sediments.

Nuclear techniques are being developed to study the silt movement in Philippine harbors and coastal areas. This particular study aims to develop procedures for Sc-46 surface labelling of muddy sediments (particles less than 40 microns in diameter), which was done at 70°C to increase fixation efficiency.

Labelling sand surface with Sc-46 was done at 00°C for greater stability. Agitation with 3% NaCl solution at rpm for varying periods of time. Cr-51 was alternately used for the study of the properties of the sediment when Sc-46 was unavailable.

3. Current Researches and New Challenges

The current R & D program of PAEC was geared to the National Atomic Energy Plan covering the period 1977 to 2000. The Plan has the following components:

I. Nuclear R & D Program:

Subprograms : Food & Agriculture
Energy & Water Resource
Industry & Engineering
Public Health & Nutrition
Improvement of Human Environment
Basic Objective Research

II. Nuclear Safeguards

Subprograms : Radioligical Survcillance of the environment
Nuclear Regulations & Safety

III. Suppertive Technology

Subprograms: Nuclear Education
Technical Extension
Nuclear Promotions

The goals set for the new atomic energy plan were:

- Increased Agricultural productivity
- Accelerated Industrial Development
- Improved National Health
- General Economic Development

Rs PAEC completes its quarter of a century of existence, one finds that the whele genre of basic researches undertaken in the early days have spinned off into what are now routine functions of PAEC, or have been expanded into a national program. Some of these are:

1) The development work on prototype model for the delayed NAA on Philippine Uranium ores done by the Chemistry Research Gr and the original NAA Group of the Physics Department has evolved into the Nuclear Fuels Division which undertakes the Uranium Exploration and Development of the Philippines.

Now using an automated uranium analyzer system, a delayed neutron activation analysis set-up, the Nuclear Fuel Division has the capability to analyze hundreds of drill core & geochemical samples such as mineral concentrates, strear sediments and water samples.

The uranium project provides the mining industry with indicating highly prospective areas for locating and developing uranium deposite by:

1) Maintaining a modern and fully operational capability in geochemical, rqdiometric and analytical methods for yhe efficient and systematic exploration of large areas and selected localities for uranium.

2) Conducting uranium regional or reconnaissance and semi-detailed surveys.

It also provides the government with data in assessing Philippine Uranium resources by developing computer programs for computer map plotting of statistically treated geochemical data, including possible airborne radiometric and magnetic data.

2) The intitial studies on the labelling of schistosoma japonicum cercarine with C-14 undertaken by the Bic-Medical Department has expanded into a nationwide project for the control of the endemic disease, schistosemiasis.

Results of the study indicated that ionizing radiation can be used in the reduction or eradication of the Oncomelania quadrasi snails, the intermediate host of schistosoma japonicum, the parssite causing schistisomiasis.

The chemistry researches utilizing the reactor have been determined by such factor as

1. indigenous resourses - availability of trained manpower; the existing equipment available and the use of local materials.
2. relevance - to the national goals and PAEC program and direct applicability to urgent local problems and needs. Those relating to the nuclear power project also enjoy the highest priority because of PAEC's commitments.
3. costs - the economic feasibility of undertaking the project has been stressed in view of the cost/benefit ratio required in getting research funds, Also projects were to be programmed within a one year time frame, within a certain budget allocation.

To illustrate, given below are the researches being conducted by the Chimistry Research Division, in cooperation with the other PAEC research groups and/or outside cooperating agencies, following the "team approach" to scientific undertakings and the "linkages" which PAEC encourages as a matter of policy.

The researches can be classified into four sections corresponding to the four informal groupings among the research personnel as determined by their expertise, as well as the facilities available at the Chemistry labs at the present time:

I Radioanalytical Chemistry

1. Study of trace elements in the marine environment of a nuclear power plant.

This project will study the natural concentration of trace and minor elements in the "boundary area for liquid releases of PNPP-1", described as an area of the South China Sea circumscribed by 1 km radius from the reactor (V. 1, Sec. 2.122 of the PAEC.

The elements of interests to be determined by NAA from sea water, suspended particulates & bottom sediments are: eosium, cobalt, iron, strontium, manganese, zinc, cerium, chromium, hafmium, scandium and thorium.

The resulting data will be inputed to the studies of the critical pathways of these radionuclides.

2. NAA of Trace Elements in Philippine Medicinal Plants & Beverages.

The Philippines has an active program in herbal medicine based on a huge number of known medicinal plants which when properly utilized can reduce dependence on imported and patented drugs. However, data on the active constituents of most of these plants are lacking.

Instrumental neutron activation analysis and atomic absorption spectrophotometry are useful techniques in the determination of the elemental composition of plants, which will be useful in the characterization of the active components of Philippine medicinal plants.

3. Determination of Potential Pollutants in Indigenous Geological Fuel Resources.

The project attempts to determine by nuclear techniques the radioactive contents of Philippine Coal, fossil oil and geothermal waters from operating plants, and to assess the environmental impact of radionuclides released from such power plants. Samples include water, air particulates and fuels at different points in the fuel cycle.

The data resulting from this study can be inputed in the environmental impact assessment (EIA) of power plants using indigenous geological energy resources.

II. Radiochemistry

1. Study of Transuranium Elements from Power Generation

In line with the PAEC commitments, this study aims to develop and establish the capability of PAEC in the analysis of critical radionuclides, including the transuranics(np, Pu, Am, Cm) from the nuclear power plant, as an independent check on the monitoring work to be done by the utility; the PNPP-1.

This project involves the development of radioanalytical procedures for the transuranic elements of environmental concern (viz. Pu, Np, Am, Cm), plus reliable control type methods for Ru, Zr/Nb, to include field monitoring, standardization and quality control; both for the purpose of environmental radiological surveillance, as well as for nuclear safeguards.

2. Hot Atom Chemistry

This project will undertake the R & D work on the investigation of parameters for the production of high specific activity radionuclides by the "hot-atom" technique. It will also initiate a programme for the radiolabelling of organic compounds and biomolecules that will be used as radiotracers in medical and biochemical research.

III Radiobiochemistry

1. Assessing the Wholesomeness of Irradiated Fish (Rastrclligen Sp.) with Special Reference Studies on Carcinogenic/Mutagenic Radiolytic

The project aims to establish the Wholosomeness of irradiated smoked mackerel (R. trachysomum) by chemical and biochemical analysis of radiolytic products complemented with short term in vitro and in vivo mutagenicity studies using microbial and mammalian systems.

The mutagenicity of smoked mackerel exposed to gamma radiation of 0, 2.0, 4.0, 6.0 and 8.0 K Gy was studied. The DMSO extract of non-irradiated smoked fish was found to be mutagenic towards TA 100 and TA 98 in the Ames pour-plate assay. The radiation treatment did not alter the observed mutagenic activity of the smoked fish. Radiation induced lipid peroxidation under *in vivo* and *in vitro* conditions was investigated as a function of dose. Results show that the formation of thicbarbituric acid-reactive radiolytic products increased with lower radiation dose, and decreased at doses of 6.0 KGy and above.

2. Chemical Investigations of Radiolytic Products of Agricultural Cellulosic Waste.

The study aims to increase the enzymatic saccharufucation for alcohol production of agricultural waste (rice straw, rice hull, sugar cane bagasse, corn husk) by exposure to gamma radiation. The observed changes in the structure of cellulose may increase the interaction of enzyme with cellulose, with an increase in the conversion to glucose.

Gamma radiation caused cleavage of glycosidic bonds in cellulosic polymer resulting in the release of reducing sugars.

Results indicate that a radiation dose of 16 m rads may trigger the "melting" of the crystal line structure to effect an increase in the enzymatic conversion of cellulose to glucose.

IV Environmental Chemistry

1. Bioaccumulation Factor for I-131 in Biomedia (Mussel)

To be able to assess the potential radiological impacts to man of the Philippines nuclear power plant, an estimate of the dose contribution of each of the radionuclides in the plants effluents is needed. The bioaccumulation factor C

III

3. Radiation Effects on Biomolecular Structure and Processes

Studies on the Radiobiochemical and Radiobiological Effects of Neutron Irradiation.

Subprogrammes-

1). Effects of neutron ϕ γ radiation on the bioenergetic machinery of the cell membrane, specifically the active transport system, and the electron transport system.

Transmutation and radiation effects of recoil atoms (metals) bound in cytochromes, ubiquirones, forredexins, on the integrity of the electron transport system will be studied.

Contribution of membrane injury to radiation - induced aging will be assessed in accordance with the membrane hypothesis of aging.

2). Effects of n & γ on the biosynthesus and repair of DNA after radiation injury. Cytogenetic analysis will be undertaken. Contribution of DNA damage by neutron irradiation to and aging will be assessed.

Research Activities:

- Study of radiolytic products of biomolecules exposed to n & γ
- Determination of radiosensitivity of lymphocytes of Filipinos to n & γ
- Study of the differential inactivation of distinct transport systems in the E. Coli membrane by n & γ
- Neutrons & γ irradiation of seeds for induced mutation breeding.

for aquatic biota enters into the calculation of dose as a representation of the relationship between the concentration of the radioactivity in the biota relative to the water environment (S.V. Kaye, IAEA - SM - 172174):

$$C = \frac{uCi/g\ hiota}{uCi/g\ water}$$

All concentrations measured at steady state condition.

Mussels (mytilus edulis) were reared in the laboratory in synthetic sea water (Biomix solution), I-131 uptake studies were done using the mussels kept in aerated synthetic sea water which was maintained at a concentration of uCi/li of I-131. The I-131 content ih mussels were measured by measuring the activity of the whole organism, using a NaI detector.

The mussels were found to accumulate I-131 steadily, reaching concentration factors ranging from 8-11 in three weeks.

In a 15 day exposure period, the bioaccumulation factor reached values ranging from 7-13 with an average value of 0.9$\pm$ 2.1.

Approximately 65% of the radioiodine in mussel is contained in the shell which accounts for 40% of the organism's weight. The large concentration factor in the shell, attest to the ability of this tissue to accumulate I-131. The shell accumulated practically twenty times more iodine than the whole body. This is in agreement with the work of Patel et.al. that in mollusks, radioiodine is concentarated in shells.

The bioaccumulation factor C of I-131 in algae was determined using marine algae, caulerpa racemosa, cultured in natural sea water. The concentration of the medium was also kept of 1 uCi/li.

The algae steadily accumulated I-131 for about 7 days, after which there was an apparent steady or equilibrium state.

The boiaccumulation factor found to have a range of 150, higher than in mussel, which is as expected since algae are known sources of iodine in the diet.

3. Fate of Persistent Pesticides in a Tropical Paddy Rice Ecesystem.

This study will trace the translocation and persistence of radiolaoelled endosulfan in a paddy rice ecosystem, bt radiotracer techniques.

Concentrations of pesticide residues in some components the paddy rice ecosystem such as the irrigation water, soil, rice straw, rice grains, aquatic weeds, snails will be analyzed by LSC following either a wer or dry combustion method of connecting the C-14 labelled endosulfan.

References

1) Santos, Gabriel, Jr. and J.E. Seguis. "Uranium Distribution In Northwestern Mindoro Island, Philippines" PAEC (C) IB 82007

2) Santos, Gabriel, Jr.; M.S. Yulo; L.G. Fernandez; A.N. Cilindre; L.E. Ilagan. "Regional Element Distribution in Philippine Mineral Studies" PAEC (A) ID 82003

3) Marzan, Anita M. and M.E. Buendia, "In Search of Vehicle (S) for Food Iron Fortification in the Philippines" Philippine Journal of Nutrition, Vol. 4, 1982.

4) Juan, Normita, T. Garcia, D. Vallejo & J.M. Eduardo, "Bioaccumulation Factor of Tritium in Oysters", Philippine Atomic Bulletin, Nov-Dec, 1982.

5) Kapauan, P.A., I.L. Beltran & C.C. Cruz, "Trace Metal Pollutants in Filipine Human Head Hair", Philippine Journal of Science Vol. III, No. 3-4 July-December 1982.

6) Kapauan, P.A., E.Z. Sombrito, J.M. Pastolere, "Chitin as a Chromatographic Support for the Collection of Metal Ions I. Collection of Copper Ions", Fish Research Journal of the Philippines, Vol. 6, No. 2, 1981.

7) Leopando, Leenardo S., "The Philippine Research Reactor and Its Conversion to TRIGA", Philippine Atomic Bulletin, May-June 1982.

8) Lumba, Linda G., E.G. Cablfin, S.I. Abaya, R.L. Santos, J.S. Barz "Animal Feeds Mixing Tests with Zn-69 M", Philippine Atomic Bulletin, Mar-Apr 1982, PAEC, Diliman, Q.C.

9) Valdezco, E.M. and L.R. dela Paz "Radioecology and Environmental Sciences Investigations Related to Nuclear Science & Technology : The Philippine Situation". The Nucleus, Jun. 1982, RSP, Diliman, QC.

10) Asper, G.A., L.M. Lansangan and L.R. dela Paz, "Uptake of I-131 by Some Crops", Nucleus, Jan 1983.

11) De la Rosa, A., A.S. de la Mines, R. B. Banson, Z.F.S. Nuguid, "Radiation Pretreatment of Cellulose for Energy Production" Radiation Physical Chemistry 23.