# Performance **REPORT**

**DOST-PHILIPPINE NUCLEAR RESEARCH INSTITUTE**
Department of Science and Technology


The Philippine Nuclear Research Institute (PNRI), formerly the Philippine Atomic Energy Commission, has been the center of nuclear science and technology activities in the country since 1958. The PNRI is mandated to develop and regulate the safe and peaceful uses of nuclear science and technology in the Philippines.

## Vision

The PNRI is an institution of excellence—a provider of innovative and effective nuclear and radiation science and technology for national prosperity.

## Mission

We contribute to the improvement of the quality of Filipino life through the highest standards of research and development, specialized nuclear and radiation services, technology transfer, and efficient and effective implementation of nuclear and radiation safety practices and regulations.

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# Message from the DOST Secretary

Living up to our mission of fostering Science for the People is best tested in times of crisis. The COVID-19 pandemic, almost unprecedented in our generation, has certainly highlighted the role of science and technology not only in facing the disease but, almost as important, in shoring up the country's economic and social pillars through innovative solutions.

In this light, the DOST Philippine Nuclear Research Institute did not disappoint, as it continues to harness the Atom not only in contributing towards the Department's efforts and response towards COVID-19, but also in its longstanding mandate to improve our agriculture, industry, medicine and the environment through nuclear science.

Perhaps the most immediate example is its radiation processing technologies. PNRI helped in the research on using irradiation to sterilize much-needed medical and personal protective equipment, which at some point faced severe shortages. At the same time, PNRI has not let up in the development of radiation-processed novel materials, such as the grafted abaca fabrics which can absorb toxic metal pollutants. An award-winning utility model at our DOST National Invention Contests and Exhibits (NICE) 2020, this is a testament to the wide variety of radiation-based innovations, but also the excellence of our researchers and scientists.

2020 is also a special year for nuclear energy, with the issuance of Executive Order 116 charging DOST as vice-chair of the Nuclear Energy Program Inter-Agency Committee (NEP-IAC), of which PNRI is an indispensable member. The NEPIAC, which is chaired by the Department of Energy, spearheads the study towards the country's decision to once again consider the inclusion of nuclear power in the energy mix.

As with her sister agencies, PNRI also remained steadfast in rendering its services and enforcing its regulations. In line with community quarantine guidelines, best efforts were given by our civil servants to make things more convenient for clients and customers availing of the unique advantages of nuclear and radiation-based technologies, and in ensuring the safety of workers occupationally exposed to radiation as well as the general public.

All in all, PNRI has remained productive and capable of advancing the nuclear field in the country despite the challenges posed by the global crisis. Its excellence in research is demonstrated again by its highest number of international publications in DOST. May it continue to sustain these efforts as it embodies our department's thrust towards Science for the People!

Congratulations and mabuhay!

**FORTUNATO T. DELA PEÑA**
Secretary

# Message from the PNRI Director

It is my pleasure to once again report on the accomplishments of the Department of Science and Technology – Philippine Nuclear Research Institute (DOST-PNRI) this 2020.

The year has proven to be an extraordinary challenge for PNRI and the rest of the country. The world was plunged into the COVID-19 pandemic, severely hampering economic progress, let alone the toll in health and lives.

The Institute did its part in the country's efforts to recover from the crisis. PNRI helped to ensure the safety of many of our medical frontliners through the provision of radiation protection services and virtual inspections and enforcement of regulations for radioactive materials and facilities. The resourcefulness of PNRI staff in combining online and limited physical avenues in line with community quarantine guidelines kept our doors open to all clients, whether physical or virtual.

Researchers also studied the possible use of irradiation facilities to sterilize medical devices and equipment, including personal protective gear which are essential to our frontliners' struggle in the early months of the community quarantine.

At the same time, the pandemic has caused collateral damage, delaying the treatment of many patients suffering from cancer and other severe diseases. We look forward to the establishment of a cancer staging center that will help save Filipino lives by lowering the diagnostic costs for early detection of cancer, having made progress towards the construction of a building to house its PET-CT and cyclotron facilities.

The middle of the year saw no less than President Rodrigo Duterte mandated the creation of the Nuclear Energy Program Inter-Agency Committee (NEP-IAC) through Executive Order 116, a new landmark in the history of nuclear energy in the Philippines.

NEP-IAC's study and recommendations on the prospective nuclear power program is being spearheaded by the Department of Energy, with the DOST as vice-chair and with PNRI as a member. Our Institute's researchers and regulators contributed greatly to this endeavor across the various aspects of the program, helping to ensure that the Philippines will be able to cover the 19 nuclear infrastructure milestones set by the International Atomic Energy Agency.

PNRI's bounty of research in nuclear science and technology once again bore fruit to many frontiers as well as accolades.

Our researchers made breakthroughs in developing new varieties of food crops as well as ornamentals which are sure to sell with our plantitos and plantitas.

New radiation-processed materials such as grafted fabrics, wound dressings and nanosensors are bound to provide better solutions to medical, industrial and agricultural sectors. Among these, our radiation-grafted abaca fabric for filtering toxic metals won the Outstanding Utility Model Award during this year's National Invention Contest and Exhibits (NICE).

Illustrating its excellence in research, PNRI has once again bagged the highest number of publications awarded during the DOST Intellectual Property Awards with 47 entries, half of the entire DOST output – a record number for the Institute for its productivity and contribution to the scientific body of knowledge.

During the pandemic, PNRI has also expanded its reach in sharing how nuclear science and technology works for the Filipino people. The quarantine season made virtual and online events almost indispensable, and the Institute maximized this opportunity by engaging further into webinars and social media.

This led to a wide reception of our courses and events especially among the youth and the academe, a promising start in our efforts to correct the public's negative misconceptions on nuclear science. The culmination of these digital activities was the virtual celebration of the 48th Atomic Energy Week and the 2nd Philippine Nuclear Research and Development Conference, whose success is evident in the great number of presentations and expanded internet reach.

We owe these accomplishments to the efforts of our scientists, researchers, regulators and support staff whom we cannot congratulate enough for giving the extra mile despite the challenges posed by the pandemic.

Our commitment remains to light the way towards the safe, peaceful and productive benefits of nuclear science and technology.

Mabuhay ang agham at teknolohiyang nukleyar para sa bayan!

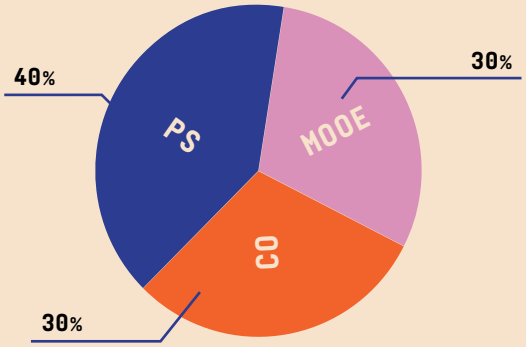
**CARLO A. ARCILLA**
Director

# Highlights of Accomplishments

## FINANCIAL RESOURCES

| | |
|---|---|
| PNRI Budget Allotment by Class | PhP 455,126,000.00 |
| PNRI Budget by Major Final Output | PhP 152,264,000.00 |
| Income Generated | **PhP 27,507,442.50** |

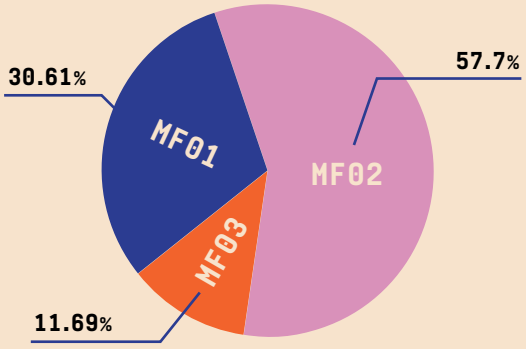
### 2020 EXPENDITURES BY EXPENSE CLASS




- 182,909,000 Personnel Services
- 136,760,000 Maintenance & Other Operating Expenses
- 135,457,000 Capital Outlay

Total **PhP 455,126,000**

### 2020 EXPENDITURES BY MAJOR FINAL OUTPUT (MFO)




- 46,607,000.00 Scientific Research and Development
- 87,863,000.00 Technical Advisory Services
- 17,794,000.00 Nuclear Regulatory Services

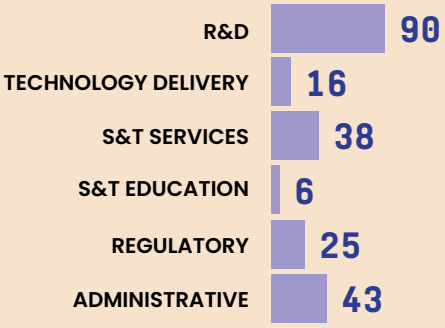
Total **PHP 152,264,000.00**

# HUMAN RESOURCES

117 MALE

101 FEMALE

218
Permanent

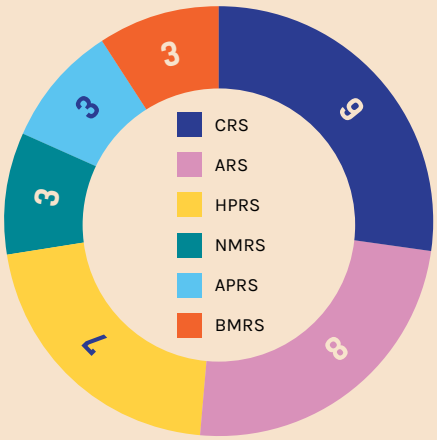



## AWARDS RECEIVED

| | |
|---|---|
| Presidential Lingkod Bayan Award<br>(Regional Level) | Carrageenan Plant Growth Promoter Team |
| Outstanding Utility Model Award<br>(First place, National Invention Contest and Exhibits) | Radiation-Modified Abaca/Polyester Fabric |
| Outstanding Filipino Researchers | Lucille Abad & Custer Deocaris |
| 2020 Outstanding Japan Society for the Promotion of Science (JSPS) Fellow | Lucille Abad |
| 2020 DOST Intellectual Property Awards | 32 PNRI scientists |
| | PNRI as Institute with the most number of scientific papers among DOST agencies<br>*(47 research outputs published in international journals)* |

# RESEARCH AND DEVELOPMENT

**33 ARD PROJECTS**




| SECTION | AMOUNT |
|---|---|
| Agriculture | 3,110,000.00 |
| Biomed | 2,392,629.00 |
| Chemistry | 15,163,981.00 |
| Health Physics | 15,266,381.75 |
| Nuclear Materials | 5,201,899.80 |
| **External funding for projects** | **P41,134,891.55** |

## ESTABLISHMENT OF NEW FACILITIES

- PRR-1 Subcritical Assembly for Training, Education and Research
- Cyclotron Facility and Cancer Staging Center
- Radiation Research Center

## SCIENTIFIC PUBLICATIONS

- **47** publications bagged the DOST International Publication Award
- **30** additional scientific publications in international journals *(based on SCOPUS)*

- R&D on new varieties of rice, sugarcane, and *Plumeria* (Calachuchi)
- Mutant variety of adlai applied for IP protection
- Mutation breeding and conservation of *Alocasia* species
- Award-winning abaca nonwoven fabric for extracting heavy metals
- Nonwoven fabrics for wastewater treatment, extracting uranium from seawater and chromium (column-packed absorbents), and for absorbing scandium
- Electron beam irradiation of beef patties extends shelf-life, no effect on taste, meets industry standards
- Gamma irradiation of strawberries prevents fungal infestation
- Carbon-13 isotope tracers distinguish authentic and synthetic honey; studies ongoing for soy sauce and fish sauce
- Honey Dressing from Philippine stingless bee sterilized with electron beam proven against *S. aureus*
- Hyaluronic acid-based hydrogels good for eye injuries, nasal defects, and skin wounds
- Studies on radiosensitivity of cancer patients will lead to personalized cancer therapies
- Nanoparticle studies to help improve protection against radiation exposure
- Sterile insect technique to lessen dengue mosquito population; radiation to affect mosquito lifespan
- Reference materials for toxin analysis for Harmful Algal Bloom Management
- Receptor binding assay for detecting and quantifying cholera toxin in PH setting
- Isotope techniques for soil erosion and pollutant contribution
- Environmental radiation and radioactivity monitoring
- Radionuclide detections at PHP52 Station
- Samples studied for radioactive contamination of corals
- Multi-shell neutron spectrometer for radiation safety and protection
- Novel computer program for calculation of multi-element analysis

## NUCLEAR S&T SERVICES

**250**
CLIENTS SERVED
(individual and institutional)

**4,576**
SAMPLES ANALYZED

**54,732**
SERVICES RENDERED

UPGRADING AND CONSTRUCTION OF PNRI BUILDINGS

### RADIATION PROTECTION SERVICES

- **3** new national standards developed
- **43,800** persons monitored
- **1,237** instruments calibrated
- **19** DSRS units dismantled and recovered
- **6** DSRS units encapsulated

## NUCLEAR REGULATORY SAFETY AND SECURITY OF RADIOACTIVE SOURCES

- Code of PNRI Regulations (*CPR Part 0 and CPR Part 30*)
- Legislative support for the Comprehensive Atomic Regulation Bill
- Ongoing international support for legal and regulatory infrastructure development

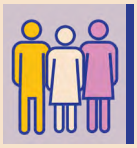
- **397** certificates of release issued
- **196** radioactive material licenses issued
- **4,013** permits to transport radioactive materials issued
- **74** inspections

- Ongoing state-level safeguards inspections, security inspection of research and medical facilities, establishment of Safeguards Laboratory and Training Room
- Memorandum of Agreement with Bureau of Customs for nuclear security and border protection
- Deployment of MEST Team during *Traslacion 2020*

- Continued safety assessments in support of regulations, IAEA CONVEX exercises, and emergency scenario drills
- Establishment of a national decision support system for nuclear and radiological emergency

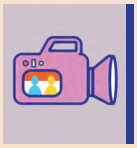
# DIFFUSION OF KNOWLEDGE AND TECHNOLOGIES

## NUCLEAR TRAINING AND EDUCATION



- **441** individuals trained
- **15** interns/OJTs
- **187** teachers trained
- **18** digital education resource materials developed
- Nuclear S&T module for DOST-SEI's NuLab
- Nuclear engineering program in UP Diliman and Mapua University

## NUCLEAR INFORMATION AND COMMUNICATION



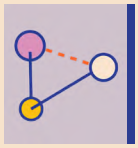
- **3** National S&T Events participated in
- **4** Webinars organized
- **3** NST contests launched
- **85** information & press materials
- **28** media interviews
- **5** educational tours

- **12,812** new Facebook page likes

## INFORMATION TECHNOLOGY AND NETWORK SYSTEMS

- **3** new online platforms
- **22** information systems

## S&T LINKING AND NETWORKING



- **28** linkages with international and foreign organizations
- **8** FNCA projects

## TECHNOLOGY TRANSFER

- **4** technologies with commercialization agreements
- **6** technologies filed for IP protection

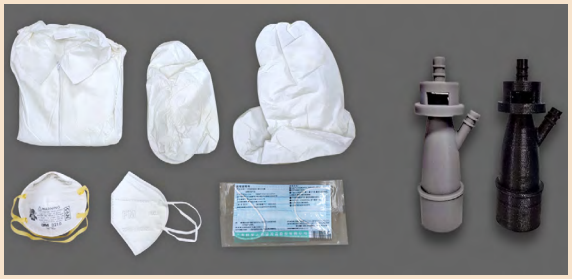
# PNRI Initiatives during the COVID-19 Pandemic

With the COVID-19 pandemic hitting full swing early in 2020, the PNRI has contributed to the country's response and initiatives, helping it rise from the crisis and adjust to the new normal.

## EXPERIMENTS ON IRRADIATION OF PPEs

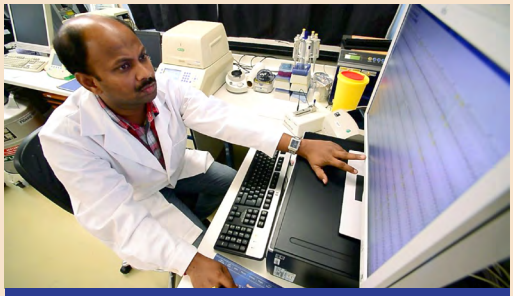
Researchers conducted irradiation experiments on Tyvek suits, cover shoes and several types of masks to estimate the throughput of the Electron Beam Irradiation Facility, and the Ob-Servo Sanguis Irradiator, particularly to determine if thousands of PPEs can be irradiated per day should the need arise.

PNRI also tested Venturi valves for respirators provided by DOST-Industrial Technology and Development Institute to determine the sterilization dose to be used in irradiating the valves.



*Personal protective equipment, masks and Venturi valves were tested for irradiation using electron beams and gamma rays.*

## DONATION OF RT-PCR KITS BY IAEA



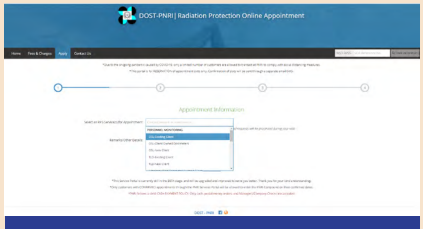
*RT-PCR detection kits provide more accurate COVID-19 test results. (Photo by IAEA)*

The International Atomic Energy Agency donated much-needed RT-PCR detection kits in the early months of the pandemic. The kits worth €84,000 includes a microcentrifuge for sample extraction, shaker vortex, thermocycler, scanner for cryotubes, fastvirus master mix, and personal protective equipment.

The donation was formally requested by the Department of Foreign Affairs for DOH, and was facilitated by the Permanent Mission of the Republic of the Philippines to the IAEA with the support of DOST-PNRI as part of a technical cooperation project.

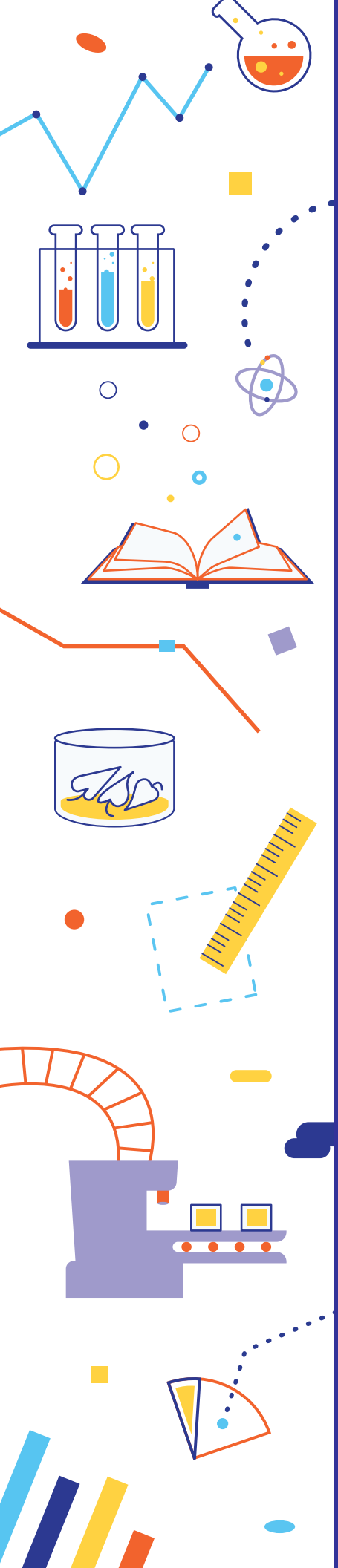
## SERVICES, REGULATIONS, AND OFFICE ADJUSTMENTS DURING THE NEW NORMAL

Consistent with the community quarantine guidelines, PNRI remained productive and kept its services available to the public while prioritizing the health and safety of its employees as well as its clients and customers. These measures include:




*PNRI's new Online Services Portal*

- Skeletal and work-from-home arrangements
- Regular disinfection of buildings, offices and laboratories
- Opening of the PNRI One-Stop Shop Office
- Online Services Portal for organized online appointments (https://services.pnri.dost.gov.ph/)
- New nuclear regulatory guidelines for licensees and license applicants during the pandemic
- Temporary relief from regulatory requirements during ECQ



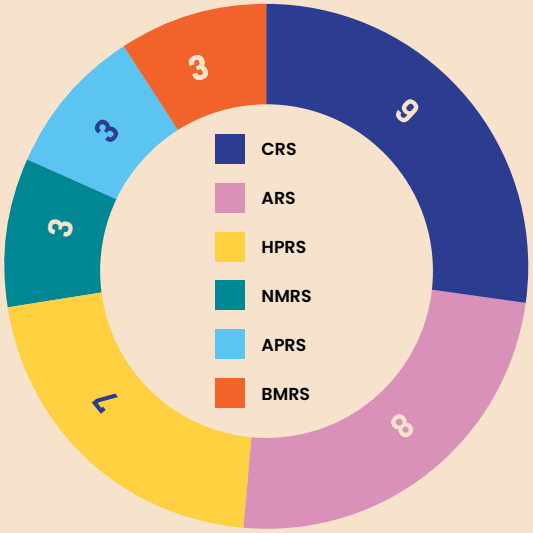
Generation of

# NEW KNOWLEDGE

Driving research efforts in contributing to national welfare, PNRI leads the development of nuclear and radiation applications in the country geared toward improving agricultural products and healthcare services, increasing industrial productivity, and protecting the environment.

PNRI continues to widen the applications of nuclear science and technology for the benefit of various sectors and fields – be it in agriculture, industry, medicine, environmental protection and the academe, to name a few.

For the year, the PNRI worked on 33 R&D projects with a total funding of P41,134,891.55 from external sources.




ARD Projects

**Amount from Externally Funded Projects**

| SECTION | AMOUNT |
|---|---|
| Agriculture | 3,110,000.00 |
| Biomedical | 2,392,629.00 |
| Chemistry | 15,163,981.00 |
| Health Physics | 15,266,381.75 |
| Nuclear Materials | 5,201,899.80 |
| Total | 41,134,891.55 |

# Nuclear Applications in Food and Agriculture

## DEVELOPMENT OF NEW PLANT VARIETIES VIA MUTATION BREEDING

New varieties of food crops and ornamentals are a boon to farmers and plant enthusiasts alike. PNRI develops these varieties through the marvels of mutation breeding, where gamma radiation is used to induce mutations in the plant, resulting in unique or improved characteristics, such as increased yield, resistance to pests and diseases, and changes in the color, size, form, or other traits of the plant.

*Note: Mutant plant varieties are different from genetically-modified organisms or GMOs. The new traits came from *within the plant's genes and not introduced from other organisms.*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## NEW VARIETIES OF RICE

- Licoy
- Umangan
- Native Borie

Research on mutation breeding of traditional rice varieties in the Philippines aims for improved traits in new varieties such as:

- ✓ Higher yield
- ✓ Earlier maturity
- ✓ Resistance to diseases
- ✓ Shorter plant height

## SEED TREATMENT AND RESURRECTION OF MUTANT RICE VARIETIES

*Quiescent seeds of some of the mutants were treated with the PNRI-developed Carrageenan Plant Growth Promoter (inset), improving the germination rate and seedling viability.*

PNRI scientists resumed the conservation of mutants produced from Bengawan, Azucena, and Milagrosa, as well as PARC 3. They also enhanced the system for seed inventory and maintenance of germplasm materials in cold storage.

Quiescent seeds of PARC 2 and Milagrosa Mutant were treated in various ways after these were stored in cold storage for up to 20 years under erratic condition. The application of Carrageenan PGP, as low as 200 ppm, improved the germination rate and the seedling viability in terms of root length.

| | MUTANT RICE VARIETY | YEAR REGISTERED | CHARACTERISTICS |
|---|---|---|---|
|  | Philippine Atomic Rice Cultivar (PARC) 2 | Registered with the Philippine Seed Board in 1973 as PSB PARC-2-2 | ▪ Matures at 5-10 days earlier than control (IR-8)<br>▪ Longer grains with less chalky area<br>▪ Better taste |
|  | Philippine Atomic Rice Cultivar 3 (PARC 3) | Not registered | |
|  | Milagrosa Mutant | Developed in 1974 and registered with IAEA MVD with ID No. 2394 | ▪ Higher yield than control (Milagrosa)<br>▪ Resistant to diseases |
|  | Bengawan Mutant | Developed in 1984 and registered with IAEA MVD with ID No. 2396 | ▪ 35% higher yield and early maturing than control (Bengawan)<br>▪ Shorter plant stature / Lodging resistant<br>▪ Drought resistant |
|  | Azucena Mutant | Not registered | |

## MUTANT VARIETY OF ADLAI

Adlai, or Job's Tears, can serve as alternative source of food to its better-known cousin crops such as rice and corn. Through gamma irradiation, its beneficial traits are further improved to become more valuable to farmers. The technology for producing adlai mutant variety was applied for IP protection as patent-invention with assistance from the DOST-Technology Application and Promotion Institute.

Gamma Irradiation

### ORIGINAL ADLAI
**TRAITS**

- Twice as rich in protein vs. rice
- Better alternative for diabetics
- Has anti-tumor and other medicinal properties
- More resilient against extreme conditions

### MUTANT ADLAI
**IMPROVED TRAITS**

- More yield
- Shorter height to make the crops easier to manage
- More resistant to lodging during typhoons

## PNRI SUGARCANE PROJECT

Using biotechnology and nuclear techniques, PNRI embarked on a research project funded by the Sugar Regulatory Administration (SRA) for the development of new sugarcane varieties.

Aims for improved traits in new varieties such as:

- ✓ Increased sugar
- ✓ Increased biomass
- ✓ Enhanced agronomic traits

*Putative mutants were grown in SRA research centers in Floridablanca, Pampanga and in La Granja, Negros Occidental. The plants were subjected to juice extraction and lignin analysis as well as collection of agronomic traits such as tiller count and cane diameter. (Photo from SRA)*

The recent quarantine measures during pandemic spurred a new craze for ornamentals among *plantitos* and *plantitas* alike! Mutation breeding opens more avenues for producing plant varieties with unique characteristics that add to the diversity of ornamentals in the Philippines.

## PLUMERIA

- Researchers successfully propagated two new mutant varieties of the *Plumeria acuminata* flower, known colloquially as calachuchi or frangipani.
- The varieties are already submitted for registration at the National Seed Industry Council.

### *Plumeria 'Radiance'*

- The flowers are smaller compared to *P. obtusa* and the original *P. acuminata*, but there are many in a bunch and are delightfully scented.
- The plant is ideal for landscaping because of the compact growth habit, desirable floral display, and profuse flowering.

### *Plumeria 'Illuminance'*

- The flowers are smaller compared with *P. obtusa* and the original *P. acuminata*, but there are many in a bunch and pleasantly sweet-scented.
- The plant is ideal for landscaping because of its compact growth habit, profuse flowering, attractive color, and desirable floral display. The flower color is quite unique and different from the other hybrids.

## ALOCASIA

PNRI is currently working with researchers from De La Salle University–Dasmariñas for mutation breeding of *Alocasia* as well as other aroids—a potential source of interesting and desirable characteristics that can be developed into new or improved varieties which can be introduced into our growing and competitive ornamental plant industry.

In vitro plantlets/calli, seeds and other propagules from different *Alocasia* species were exposed to gamma radiation and chemical mutagens which can lead to different mutations in plant morphology.

- Leaf cupping
- Leaf shape changes
- Growth habit modifications
- Variation in chlorophyll content distribution (variegation)

- The project is maintaining **27** accessions of *Alocasia*:

| | | | |
|---|---|---|---|
| **12** native species | **2** introduced species | **2** hybrids | **2** donations from collaborators |

## SMART FARMING USING NUCLEAR TECHNIQUES AND STABLE ISOTOPES

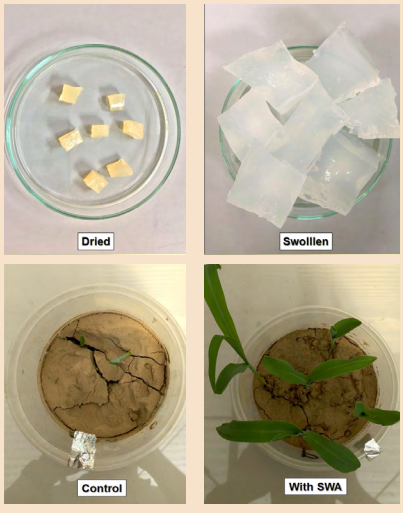
*Fertilizers are labeled with nitrogen isotopes during planting. Then samples from the plants and the soil are processed and analyzed using the IRMS to directly measure the amount of fertilizer absorbed and the soil composition, among others.*

To help improve traditional farming practices, PNRI researchers use stable isotopes and advanced analytical techniques to study soil nutrient and water use efficiency for various crops. These will allow farmers to use the right amount and proper timing for applying fertilizer and irrigation, among others.

PNRI collaborates with the Department of Agriculture-Bureau of Soils and Water Management to update fertilizer recommendations for major crops such as corn, adlai, cassava, eggplant, and tomato to increase their yield and minimize environmental impacts. Researchers "label" the fertilizer with stable isotopes of nitrogen so they can trace the uptake of crops later with an isotope ratio mass spectrometer.

Stable isotopes enable nuclear analytical equipment to distinguish between isotopes of the same element so that researchers can directly measure the difference. The isotopes are not chemically different and are not harmful to the environment. *Stable isotopes are safe and effective!*

## BIODEGRADABLE SUPER WATER ABSORBENTS FOR AGRICULTURAL USE




Aiming to save farmer's time, labor, and water for irrigating crops, PNRI researchers are currently developing biodegradable super water absorbent (SWA) materials that could retain more water in the soil.

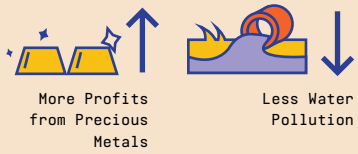
The absorbent was formed from a mixture of polyacrylic acid and cassava starch irradiated via gamma irradiation. The project team is currently testing the absorbent on various crops like okra, corn, and lettuce.

Current results show that the SWAs:

- ✓ are non-toxic
- ✓ hold more soil-water than commercial counterparts
- ✓ have more efficient re-swelling
- ✓ save much water, labor, and time spent for irrigating crops

# Nuclear Applications in Industry

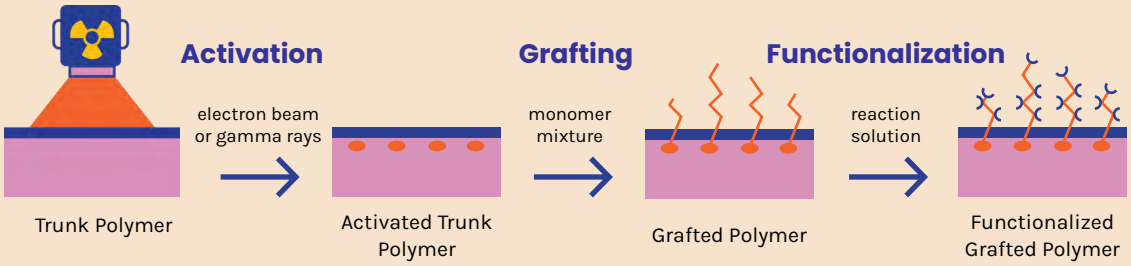
## NONWOVEN FABRICS FOR EXTRACTING HEAVY METALS




Heavy metals are both a boon and a bane to various industries—indispensable for production, yet its unwanted byproducts continue to burden companies with ever-increasing costs of keeping their processes environment-friendly.

Through the marvels of radiation grafting, PNRI researchers are developing more economical solutions such as nonwoven fabrics which can filter pollution in factories and harvest precious minerals and rare-earth elements useful in manufacturing the latest electronics and other products.

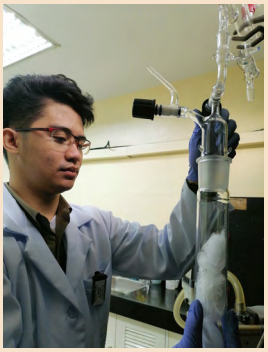
### How does radiation grafting work?




Radiation can be used to modify materials and graft various polymers with advanced properties. Electron beams or gamma rays are used to activate the base material, allowing the grafting of other polymers which enables the material to extract heavy metals.

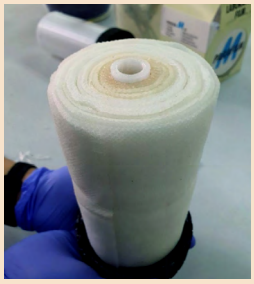
### Abaca Nonwoven Fabric

- Native fabric abaca serves as base material for the filter
- Deals with toxic heavy metals such as lead, cadmium, nickel, chromium, mercury, and arsenic
- Good for wastewater treatment
- Reusable, cheaper, and on par, if not better, than commercial resins
- Winner of the 2020 National Invention Contest and Exhibits



### Extracting Uranium from Seawater

- Seawater is an unconventional source of uranium
- Radiation-grafted nonwoven fabrics can be used to extract uranium from seawater, helping alleviate costs and importation challenges of nuclear fuel



### Column-packed Absorbent for Chromium

- Chromium is one of the major byproduct contaminants from tanning wastewater
- Lab-scale tests proved several fabric prototypes effective in filtering chromium
- With assistance from DOST-MIRDC, researchers are scaling up the tests by packing the fabrics in columns to better extract the heavy metal

### Nonwoven Fabric for Scandium Absorption

- Scandium is a rare-earth element used in various industries, such as in producing fuel cells, electronics, aerospace and lighting, among others
- Researchers started development of grafted polymers to extract scandium from nickel ore processing facilities

## EXTRACTING INDUSTRIAL ELEMENTS IN FERTILIZER PRODUCTION

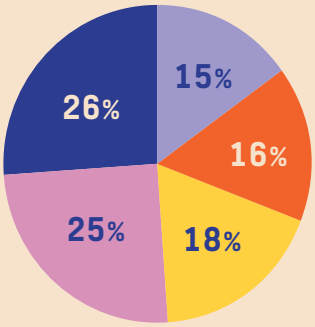
Valuable metals are found even in the most unlikely of places, such as phosphate rocks used in producing fertilizer. Phosphogypsum contains trace amounts of rare earth elements as well as radionuclides.

Extracting these resources will maximize these sources of industrial materials, while also doing farmlands and the environment a great favor by reducing the amount of technologically-enhanced, naturally-occurring radioactive materials (TENORMs) deposited in the soil.

Studies showed the presence of potentially hazardous heavy metals, useful industrial elements, and strategic rare earth elements in phosphogypsum samples. Development of the initial stages of extraction is already underway.

More Profits
from Precious Metals

Less Radionuclides
in Soil



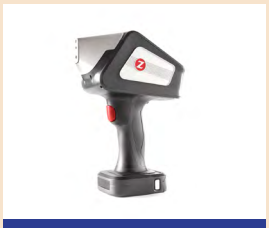

**Rare Earth Elements Extracted from Phosphogypsum**

- YTTRIUM
- LANTHANUM
- CERIUM
- OTHER REEs
- NEODYMIUM

# CHARACTERIZATION OF DIFFERENT MINERAL DEPOSITS USING RADIATION AND RELATED TECHNOLOGIES

*Sample collection of feldspar deposit in Northern Palawan which potentially has rare earth elements (REEs)*

*Demonstration of LIBS Analysis for skarn samples from Camarines Norte*



*A portable LIBS analyzer*

The increasing demand for smart and renewable technologies is expected to result in supply issues for critical metals such as rare earths and cobalt. To address this problem, researchers continue to survey the country's vast untapped mineral resources like coal, feldspar, skarn, and laterite deposits to identify areas with economically viable deposit of critical metals using radiation and related technologies, including X-ray fluorescence (XRF), X-ray diffraction (XRD), and Laser Induced Breakdown Spectroscopy (LIBS).

## LASER-INDUCED BREAKDOWN SPECTROSCOPY

PNRI recently acquired a portable LIBS analyzer in February via a PCIEERD-funded project. This is the only handheld equipment capable of determining all elements in the periodic table from hydrogen to uranium, allowing researchers to detect the presence of radionuclides and critical metals such as REEs and cobalt. It can also be used to map the elemental distribution of the sample.

*Project staff training with foreign experts to use LIBS*

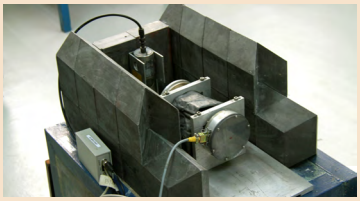
## MATERIALS CHARACTERIZATION LABORATORY

Under Project REHAB, the Institute is currently rehabilitating its X-ray Diffractometer (XRD) and Total Reflection X-Ray Fluorescence (TXRF) Spectrometer, aiming to restore more of its advanced capabilities and hopefully even serve customers in need of cutting-edge analysis of samples.

## URANIUM AND THORIUM IN PALAWAN SAND

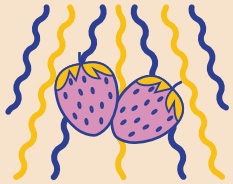
Recent studies using Mossbauer Effect Spectroscopy (MES) showed that sand samples found in Ombo and Erawan beaches in Northern Palawan may have traces of uranium and thorium.

Apart from determining the samples' economic value as natural sources of radioactive material, researchers are also investigating the radiation damage in the said samples, which may serve as a natural analogue for materials used in radiation waste disposal.



## FOOD IRRADIATION STUDIES

Food irradiation is a cold process. Unlike conventional treatment methods, such as heat treatment, which can degrade or change the taste of samples, irradiation decontaminates the product while retaining the original food quality.



### FRESH AND LONG-LASTING BEEF PATTIES

Burgers are always a hit with Filipino diners. Using electron beams, researchers are making significant progress in keeping raw beef patties fresh for extended storage periods!

- Up to 7 months shelf-life
- Same great taste
- Meets industry safety standards

*FDA acceptable limit on meat paste/pate for aerobic microorganisms (4 Log CFU/g)

*NMIS acceptable limit for total coliform (1 Log CFU/g)

### PREVENTING FUNGAL INFESTATION OF STRAWBERRIES

Good strawberries from Benguet spoil quickly due to fungal infestation happening after the harvest. PNRI's studies show that gamma rays can reduce the population of fungal pathogens in strawberries, such as *M. circinelloides* and *M. irregularis*. Thus, this technology allows us to enjoy more the post-harvest freshness of our northern products.

*Food irradiation does NOT make your food radiactive.* Operators around the globe use just the right amount of energy to kill the bacteria. Nor does radiation from electron beams or gamma rays contaminate the products with radioactive materials.

## CHAMPIONING AUTHENTIC HONEY WITH ISOTOPE TECHNIQUES

Worried of fake honey in supermarkets? PNRI's nuclear analytical techniques are serving various industries and regulators to ensure the authenticity of food products and condiments. Genuine honey from bees have different carbon-13 isotope signatures from those made from synthetic or adulterated sources such as sugar syrup, allowing researchers to trace the origins of a particular sample. Studies will later include the carbon-13 and nitrogen-15 content of soy sauce and fish sauce or patis sold in Filipino supermarkets.

*Researchers preparing honey samples for analysis using an Isotope Ratio Mass Spectrometer (IRMS)*

# Nuclear Applications in Medicine

## PRODUCTION OF RADIOPHARMACEUTICALS

Many lives have been saved through the use of radiopharmaceuticals in hospitals and medical centers. Radiation is used for the treatment of tumors and certain types of cancer, as well as for the quick and accurate diagnosis of diseases affecting the heart, lungs, thyroid, and kidney, among others.

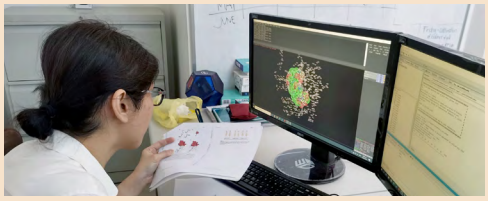
### TECHNETIUM-99M

Technetium-99m emits low levels of radiation and is used for imaging and scanning of various organs in the body in tandem with gamma cameras, of which around 30 such facilities are in use in the Philippines.

PNRI's Tc-99m Generator Facility is projected to restart the country's local production of the workhorse radiopharmaceutical, ultimately aiming to reduce the costs of diagnostic procedures.

### EARLY DETECTION OF PROSTATE CANCER

Radiotracers can also be used as imaging biomarkers for early detection of prostate cancer, which is among the top causes of morbidity and mortality in the country among males. With assistance from a private collaborator, PNRI is set to develop these materials under a Collaborative Research and Development to Leverage Philippine Economy (CRADLE) project under the DOST Science for Change Program. Researchers are currently preparing protocols for ligand synthesis and designs for the radiotracers, with more studies to be conducted.



## INNOVATIVE MEDICAL PRODUCTS DEVELOPED WITH RADIATION TECHNOLOGY

Radiation can also be used for making the latest medical marvels that can heal wounds and improve medical procedures, among others.

### HONEY DRESSING FROM PHILIPPINE STINGLESS BEE

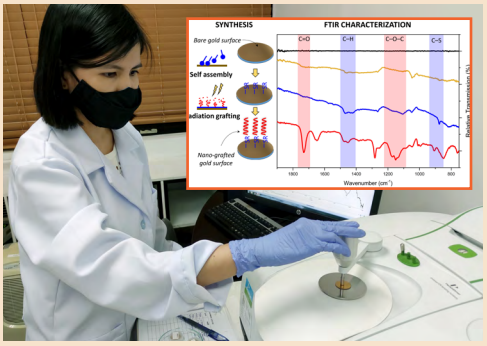
Inspired by the traditional use of honey in treating burns and wounds, PNRI recently developed a wound dressing made with honey from the Philippine stingless bee. The dressing has proven properties against *S. aureus*, a notorious bacterium that inhabits open wounds. The innovative wound dressing was irradiated using electron beams, ensuring its sterility for medical use.

### HYALURONIC ACID-BASED HYDROGELS FOR BIOMEDICAL USES

Did you know that natural sugars such as those found in our skin can be processed to treat eye injuries, nasal defects, and skin wounds? Radiation crosslinking made these hydrogels possible, thanks to PNRI's research. These hydrogels are so versatile, they may also see potential use in other medical procedures, such as preventing adhesions after surgery, slow release of drugs, and blocking abnormal urine flow in the body.


### RADIATION-GRAFTED NANOSTRUCTURES AS SENSORS

Nanotechnology-based sensors using surface plasmon resonance are used in food safety, biological studies, and medical diagnostics. Researchers are currently grafting gold-plated glass chips with polymers to make a locally-produced variant that is cheaper and comparable, if not better, than conventional sources. Graft polymerization was monitored using Fourier-transform infrared spectroscopy.

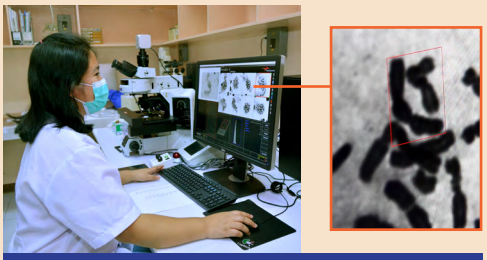



## STUDIES ON RADIATION PROTECTION

PNRI takes the lead in studying the biological effects of radiation in the Philippines, helping to ensure the safety of workers occupationally exposed to radiation and patients regularly undergoing teletherapy, among other sectors.

### RADIOSENSITIVITY OF CANCER PATIENTS

Radiation is an established tool to kill tumor cells. PNRI researchers study the blood samples of patients to monitor individual responses to radiation exposure. Armed with this knowledge, doctors in the future can tailor personalized cancer therapies and further improve treatment outcomes.



*Researchers use cytogenetic biodosimetry to identify dicentric chromosomes in blood samples (right) which are signs of radiation exposure*

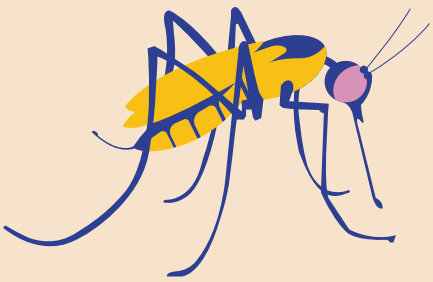
### NANOMEDICINE FOR RADIATION PROTECTION

Current advances in radiation biology involve the development of nanoparticles which can be used as medicine to help improve protection measures against accidental exposure of radiation workers, radiotherapy patients, and the general public to ionizing radiation. The Institute is currently building up its capabilities to produce nanomedicine for radiation protection in the near future, including the recent establishment of the Radiation Research Center (see section on *Establishment of New Facilities*).

# Nuclear Applications in Environmental Protection and Management

## STERILIZATION AND QUALITY CONTROL OF DENGUE MOSQUITO

PNRI continues to develop the Sterile Insect Technique against mosquitoes which serve as vectors for the deadly dengue virus. Started in the last quarter of 2020, this phase of the project aims to determine the sterilizing dose for *Aedes aegypti* and determine the effect of irradiation on the survival and mating performance of said mosquito species.



♂

- Increased irradiation, decrease in life span

♀

- Unirradiated female has increased lifespan when mated with irradiated males
- Irradiated female lays fewer eggs with lower hatchability

## CAPACITY BUILDING IN THE PRODUCTION OF MARINE REFERENCE MATERIAL FOR HARMFUL ALGAL BLOOM MANAGEMENT

Paralytic Shellfish Poisoning, commonly called as red tide, is still the leading seafood safety concern in the country. PNRI is continuously assisting monitoring and regulatory agencies for Harmful Algal Blooms (HABs) by providing high-throughput, highly specific, and very sensitive analytical techniques for marine toxin quantification. However, for reliable and accurate results, these methods require reference materials which are not locally manufactured. To address this need, PNRI experts are currently building capabilities in producing reference materials to manage HAB sustainably in the country. As an initial step, a reference material prototype is being produced and characterized to check its suitability with the existing regulatory method for toxin analysis.

*Research on early detection of red tide will go a long way in helping communities dependent on marine products such as mussels (right).*

## DETECTION AND QUANTIFICATION OF CIGUATERA FISH POISONING TOXIN IN COMMERCIALLY AVAILABLE PHILIPPINE REEF FISHES

The increasing cases of ciguatera fish poisoning is a global concern, but there are still no regulatory limits for cholera toxin in fish. Cholera toxin is produced by the bacterium *Vibrio cholerae* which is responsible for cholera epidemics, a major public health burden in developing countries. PNRI researchers optimized the use of their developed radio-ligand Receptor Binding Assay (r-RBA) which was found to be the best method in quantifying cholera toxin in the Philippine setting. The project aims to contribute to a more effective seafood monitoring program in the country.

## ASSESSMENT OF SOIL EROSION IN SELECTED SUB-BASIN OF MANILA BAY

By studying the traces of stable carbon and nitrogen isotope signatures as soil erosion indicators, PNRI researchers examined sediments to determine soil loss in different sub-watersheds of Manila Bay which contributes to the bay's pollution. This year, the area of study was in a forest woodlot area in Brgy. Buted, Talugtug, Nueva Ecija. Nutrient content, such as phosphorous (P) and potassium (K), of plant materials were also measured to document the nutrient content (P and K) of local vegetation in the said site.

The results will form part of the plant foliar nutrient (P and K) database of the Talugtug, Nueva Ecija study sites. The researchers found that the measured P and K nutrient levels of mango *(Mangifera indica)* and guava *(Psidium guajava)* plant tissues in said site are well within the generalized recommended plant tissue nutrient levels for some vegetable, fruit, and ornamental foliage; and flowering plants in other locations.


*The soil samples were analyzed using PNRI's Isotope Ratio Mass Spectrometer.*

# ENVIRONMENTAL RADIATION AND RADIOACTIVITY MONITORING

## RADIATION MONITORING IN PNRI

Researchers conducted the routine environmental radioactivity monitoring in PNRI particularly in areas near laboratories, facilities, and offices to ensure the safety of the employees against exposure to radiation. Measurements of ambient gamma radiation dose rates were carried out using a portable gamma spectroscopy system SAM-940 with 3x3 NaI(Tl) detector (Berkeley Nucleonics Corp., USA). The readings in each of selected sites were taken five times at one-minute interval at approximately one meter above the ground. Results show that the average ambient gamma radiation measurement on PNRI grounds is within the normal background level and does not pose any hazard to the employees and to the public.

*Note: Photos taken before the imposition of quarantine and health safety requirements*

## RADIATION MONITORING IN SURIGAO DEL NORTE AND SURIGAO DEL SUR

Analysis of the ambient gamma dose rate measurement in Butuan, Surigao del Norte, and Surigao del Sur showed that dose rate levels in mining sites are significantly lower than surrounding places in Surigao due to the geologic composition of soils in mining areas. Further, the values are within the normal background level and do not pose any hazard to the public and the environment.

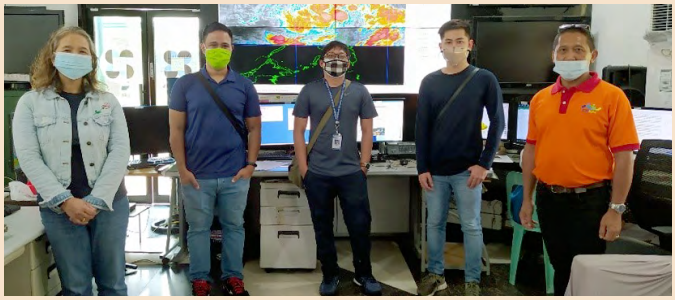
## EVALUATION OF RADIONUCLIDE DETECTIONS AT MONITORING PHP52 STATION

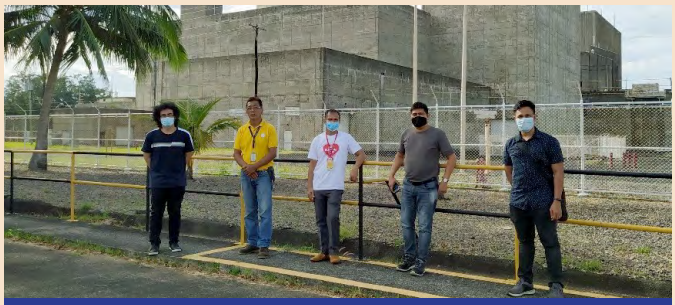
Air filter samples were continuously collected and processed at the Comprehensive Nuclear Test-Ban-Treaty Organization (CTBTO) Radionuclide Monitoring Station PHP52 in Tanay, Rizal. The samples were measured for radionuclide concentrations using a High Purity Germanium detector, with the concentrations compiled and evaluated monthly. Based on available data, natural radionuclides Beryllium-7 and Lead-212 family (Lead-212, Bismuth-212, and Thallium-208) were continuously detected throughout the year. Their concentrations mostly fall within the range of those obtained during the past five years.

Further elevated levels of the Lead-212 family of radionuclides in August and September 2020 can be explained by their production in farther locations, such as industrial plants, and transport to the station. Meanwhile, low concentrations of anthropogenic radionuclides Sodium-24, Iodine-131, Cesium-137, and Iodine-123 were occasionally detected.

## ESTABLISHMENT OF REAL-TIME RADIATION MONITORING SYSTEM IN THE PHILIPPINES (SOMER – SYSTEM FOR ONLINE MONITORING OF ENVIRONMENTAL RADIATION)

The Institute continues to establish real-time radiation monitoring stations across the country which would serve as an invaluable source of data in case of nuclear or radiological emergencies. The three radiation monitoring stations were initially planned to be installed this year in (1) Basco, Batanes, (2) Bato, Catanduanes, and (3) Coron or Busuanga, Palawan. But due to some concerns and restrictions, the Busuanga and Bato sites had to be changed, and the final approved sites are now the (1) PAGASA Station in Legazpi City, Albay, and (2) Bataan Nuclear Power Plant (BNPP) in Morong. The schedule of installation of said radiation monitoring stations, including Basco, Batanes, was also moved to year 2021. PAGASA Legazpi and BNPP were visited for siting on 20 October 2020 and 4 December 2020, respectively, while Batanes will be sited in 2021.





*Visit at PAGASA Legazpi Complex Station (top) and Bataan Nuclear Power Plant (bottom) to conduct coordination and siting for installation of radiation monitoring stations*

## NATURAL AND ANTHROPOGENIC RADIONUCLIDES IN THE MARINE ENVIRONMENT

Sampling activities were severely affected by the quarantine measures, especially in the last month of the first quarter and in the second quarter. But later in the last quarter, the processing of biota samples resumed. Fish samples were prepared, dried, pulverized, homogenized, and transferred to the required counting bottle for analysis of natural and anthropogenic radionuclides by gamma spectronomy using a High Purity Germanium detector.

*Collection of sediment samples in Coron, Palawan*

*Drying sediment samples from Coron, Palawan*

*Preparation of fish samples in the environmental laboratory*

## RADIOACTIVITY ANALYSIS OF NORMs IN BUILDING MATERIALS

Building materials such as cement, concrete, granite, bricks, marbles, natural stones, and wallboard obtained from commercial gardens and depots were analyzed for gamma-emitting natural radionuclides. The activity concentrations of radium-226, thorium-232, and potassium-40 were found to be below the recommended guideline values set by the IAEA International Basic Safety Standards. Data obtained from this study will be used to assess doses received by humans from external exposure to ionizing radiation in building materials used in the construction of dwellings in the country.

## DETECTING RADIATION AMONG CORALS

Exactly 10 years since the Fukushima Nuclear Power Plant accident, experts from the PNRI and UP-Marine Science Institute checked coral cores in the sea waters of Palaui Island in Sta. Ana, Cagayan. The meter-long cores contained information on human nuclear activities. Earlier, the project team was able to detect radionuclide contaminants among corals in Baler, Aurora and Vinzons, Camarines Norte by measuring the radionuclide iodine-129.

The presence of radiation among the corals in said locations suggests that radionuclide contaminants from the Fukushima nuclear accident might have already reached the Philippines. The radiation detected is low and is far from being a health concern.

Such confirmation on radioactive contamination from the Fukushima Accident site reaching the Philippine coasts provides vital information that can help the country prepare in the event of similar incidents in the future.

*Coral core sampling by Dr. Fernando Siringan of UP-MSI (left) and Dr. Angel Bautista VII of DOST-PNRI (right)*

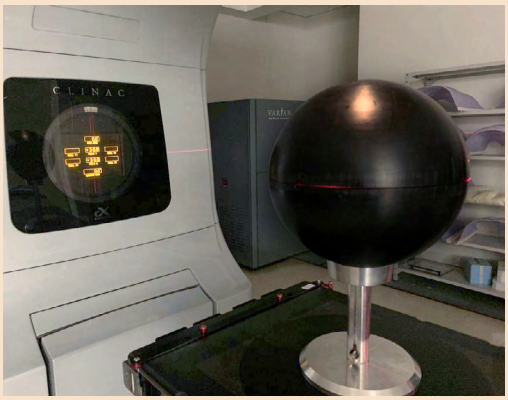
*All smiles from the Fukushima Project Team after the successful fieldwork and sampling*

*Collected coral cores from Palaui Island, Sta. Ana, Cagayan*

# Applied Physics and Neutron Studies

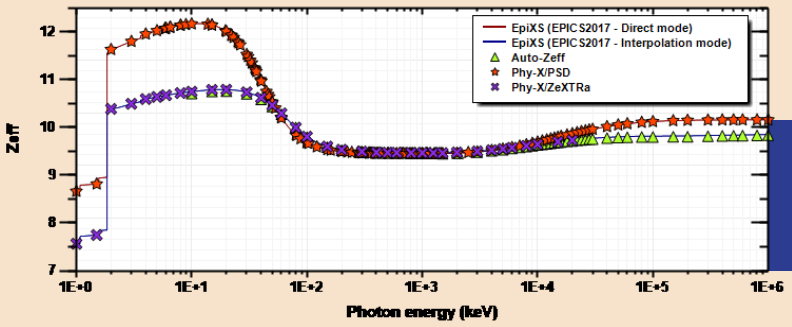
## DEVELOPMENT OF MULTI-SHELL NEUTRON SPECTROMETER

PNRI experts developed a device called the Multi-shell Neutron Spectrometer or MuNS which measures the energy distribution of neutrons. MuNS is more compact, portable, and flexible compared with conventional Bonner sphere spectrometers. It is compact because of its assembly-type design. It weighs significantly less compared with its conventional counterparts, making MuNS more portable. It can also accommodate passive and active neutron detectors in different configurations, which makes it a flexible system. MuNS can be used to evaluate and characterize neutron radiation fields for research applications and to address radiation safety and protection of personnel working with neutron sources.




## NOVEL COMPUTER PROGRAM FOR CALCULATION FOR MULTI-ELEMENT MATERIALS

With the release of the International Atomic Energy Agency's library called Electron Photon Interaction Cross Sections 2017 (EPICS2017), PNRI experts developed a software for calculation of photon attenuation parameters using said library. The software called EpiXS was modified, enhanced, pilot tested, debugged, and finally applied to several shielding materials for radiation shielding characterizations. Data generated by the software for several materials were compared with XCOM and from other programs based on the XCOM photon cross section libraries. PNRI researchers complemented with collaborations from several foreign researchers who are working with photon radiation shielding material fabrications.




*Comparison of EpiXS software with other XCOM based software, for obtaining effective atomic numbers for borosilicate glass.*

# Establishment of New Facilities

## PRR-1 SATER

The Subcritical Assembly for Training, Education and Research (SATER) being established at the Philippine Research Reactor-1 (PRR-1) is envisioned to be a science and technology infrastructure that will:

(1) Support the country's capacity building in nuclear and reactor science and technology;

(2) Provide a research facility for academic and research institutions;

(3) Demonstrate research reactor operation and utilization and;

(4) Provide support for nuclear human resource development in the event that the Philippine government decides to proceed with a nuclear power program.

Researchers conducted seismic hazard evaluations at the PRR-1 site early this year. The delivery and installation of major SATER structures were completed by September. Current preparations include the installation of various advanced instrumentation and equipment, as well as capacity building on neutron studies and reactor operations.

## CYCLOTRON FACILITY AND CANCER STAGING CENTER


PNRI continues to push for the establishment of a Center for Nuclear Medicine Research and Development, which aims to lower the diagnostic costs for early detection of cancer. The Institute has made progress towards initiating the construction of a building to house a cyclotron and Positron Emission Tomography/Computed Tomography (PET/CT) facilities.

## RADIATION RESEARCH CENTER

The Center will offer innovations for a wide range of radiation research, such as immediate and late effects of radiation; radiation oncology; drug discovery and development; DNA repair radiation dose- lethality and mitigation cellular radiobiology; tumor radiotherapy; and normal tissue response to radiotherapy, among others. The Center will help develop further the country's expertise in radiation research through training of new generation researchers and young scientists.

# List of Scientific Publications

## PUBLICATIONS WHICH GARNERED THE 2020 INTERNATIONAL PUBLICATIONS AWARDS

| | TITLE | AUTHORS | JOURNAL | PUBLICATION YEAR |
|---|---|---|---|---|
| 1 | Air particulate matter, black carbon, and elemental concentrations and source apportionment in Calaca, Batangas | Christian Amor T. Tuso, Remjohn Aron H. Magtaas, Jervee M. Punzalan, Jhon Robin Yee, Angel T. Bautista VII, Preciosa Corazon B. Pabroa | Philippine Journal of Science 149 (S1): 117-127 | 2019 |
| 2 | Iodine-129 for determining the origin of salinity in groundwater in Pampanga, Philippines | Sunshine V. Tan, Angel T. Bautista VII, Norman DS. Mendoza, Charles Darwin T. Racadio, Mamette Puthenpurekal, Augustus C. Resurreccion, Hiroyuki Matsuzaki | Journal of Environmental Radioactivity 218 (106239) | 2020 |
| 3 | Isotopic data for inferring groundwater Dynamics in Cagayan De Oro City, Philippines | Charles Darwin T. Racadio, Soledad S. Castañeda, Flerida A. Cariño, Norman DS. Mendoza | Philippine Journal of Science 149 (1): 215-225 | 2020 |
| 4 | Synthesis and characterization of mordenite-type zeolites via hydrothermal method using silica gel and sodium aluminate as Si and Al sources at varying temperature | Mon Bryan Z. Gili, Marlon T. Conato | Journal of Physics: Conference Series 1191 (1): 012038 (1-6) | 2019 |
| 5 | Absorption uptake of Philippine natural zeolite for Zn2+ ions in aqueous solution | Mon Bryan Z. Gili, Eleanor M. Olegario-Sanchez, Marlon T. Conato | Journal of Physics: Conference Series 1191 (1): 012042 (1-7) | 2019 |
| 6 | Effects of molarity variation on the optical property and topography of ZnO thin films deposited via spray pyrolysis | Mon Bryan Z. Gili, Ruizhi Chu, Mary Donnabelle L. Balela | Journal of Physics: Conference Series 1191 (1): 012050 (1-7) | 2019 |
| 7 | Effects of mechanical activation of precursors in the synthesis of Ca-doped BaTiO3 via conventional solid state reaction method | Mon Bryan Z. Gili, Ruizhi Chu, Rinlee Butch M. Cervera | Journal of Physics: Conference Series 1191 (1): 012053 (1-6) | 2019 |
| 8 | Changes in the structure, crystallinity, morphology and adsorption property of gamma-irradiated Philippine natural zeolites | Mon Bryan Z. Gili, Franklin A. Pares, Andrea Luz G. Nery, Neil Raymund D. Guillermo, Edanjarlo J. Marquez, Eleanor M. Olegario | Materials Research Express 6: 125552 (1-14) | 2019 |
| 9 | Assessment of temporal variations of natural radionuclides Beryllium-7 and Lead-212 in surface air in Tanay, Philippines | Paolo Tristan F. Cruz, Antonio C. Bonga III, Christian L. Dela Sada, Juanario U. Olivares, Fe M. Dela Cruz, Lorna Jean H. Palad, Alejandro J. Jesuitas, Edwin C. Cabatbat, Vanessa J. Omandam, Teofilo Y. Garcia, Chitho P. Feliciano | Journal of Environmental Radioactivity 208-209: 105989 | 2019 |
| 10 | Performance evaluation of a rectifier column using gamma column scanning | Denis D. Aquino, Janice P. Mallillin, Ramoncito F. Sulit, Frederick C. Hila, Ivy Angelica A. Nuñez, Adelina D.M. Bulos | Nukleonika 62 (4): 285-287 | 2017 |
| 11 | Treatment of small scale gold mining wastewater using pilot-scale sedimentation and Cocopeat filter bed system | Jessie O. Samaniego, Maria Antonia N. Tanchuling | Global Journal of Environmental Science and Management 5 (4): 461-470 | 2019 |
| 12 | Surface water characteristics in the vicinity of abandoned mercury mine site in Puerto Princesa City, Philippines | Jessie O. Samaniego, Cris Reven L. Gibaga, Alexandria M. Tanciongco, Rasty M. Rastrullo, Ma. Azileira V. Costa | Philippine Journal of Science 148 (3): 493-498 | 2019 |
| 13 | Environmental assessment of metal pollution in Manila Bay surface sediments | Ryan U. Olivares, Efren J. Sta. Maria, Elvira Z. Sombrito | Philippine Journal of Science 149 (S1): 183-195 | 2019 |
| 14 | Towards integrated management of a shallow tropical lake: assessment of water quality, sediment geochemistry, and phytoplankton diversity in Lake Palakpakin, Philippines | Ian A. Navarrete, Gerald P. Dicen, Teresita R. Perez, Shinelle M. Mendoza, Roland V. Rallos, John Leonard R. Labides, Clarissa T. Rivera, Arnold V. Hallare, Rene Juna R. Claveria | Environmental Monitoring and Assessment 191 (485): 1-16 | 2019 |

| | TITLE | AUTHORS | JOURNAL | PUBLICATION YEAR |
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| 15 | Indole-3-acetic acid Synthesis by plant growth promoting *Klebsiella sp.* (PGPB1) via Indole-3-pyruvic acid pathway and its uptake in plants | Paul Lloydson J. Alvarez, Florinia E. Merca, Lilia M. Fernando, Roland V. Rallos, Christopher O. Mendoza | Philippine Journal of Crop Science 44 (3): 1-9 | 2019 |
| 16 | Design of a multi-shell portable neutron spectrometry system based on indium foil detectors | Alvie Asuncion-Astronomo, Frederick C. Hila, Cheri Anne M. Dingle, Charlotte V. Balderas, Rafael Miguel M. Dela Cruz, Neil Raymund D. Guillermo | Radiation Measurements 132 (106248): 151-157 | 2020 |
| 17 | Assessment of the effect of gamma irradiation on total carotenoid content of *Mangifera indica* L. cv. Carabao Puree using Raman microspectroscopy | Jerome Carlo P. Garcia, Christy Mae T. Betos, Marie Josephine M. De Luna | Philippine Journal of Science 149 (S1): 53-60 | 2019 |
| 18 | Dependence of response of active personal dosimeters on different calibration methods | Ave Ann Nikolle M. Garalde, Camille U. Pineda, Jhenize Carvina A. Fernandez, Jhon Ray L. Amparado, Kristine Marie Romallosa | Philippine Journal of Science 149 (S1): 107-111 | 2019 |
| 19 | Experimental, computational, and analytical methods for the characterization of a neutron field for calibration of neutron monitoring instruments in the Philippines | Marianna Lourdes Marie L. Grande, Frederick C. Hila, Ave Ann Nikolle M. Garalde, Christy Mae T. Betos, Cheri Anne M. Dingle, Kristine Marie D. Romallosa | Philippine Journal of Science 149 (S1): 93-99 | 2019 |
| 20 | Management of spent high activity radioactive sources in the Philippines using mobile hot cell | Ronald E. Piquero, Editha A. Marcelo, Abelardo A. Inovero, Angelo A. Panlaqui | Philippine Journal of Science 149 (S1): 27-31 | 2019 |
| 21 | Development of the Philippine National Dose Registry as a tool for the tracking and assessment of occupational radiation exposures and risks in the Philippines | Kristine Marie D. Romallosa, Christy Mae T. Betos, Elisha John W. Pascual, Camille U. Pineda, Marianna Lourdes Marie L. Grande, Ronald E. Piquero, Angelo A. Panlaqui | Philippine Journal of Science 149 (S1): 77-86 | 2019 |
| 22 | Dose rate analysis of upgraded storage drums for disused sealed radioactive sources by a multivariate interpolation program developed Using MCNP5 | Frederick C. Hila, Ronald E. Piquero, Cheri Anne M. Dingle, Alvie A. Astronomo, Julius Federico M. Jecong, Editha A. Marcelo | Philippine Journal of Science 149 (S1): 65-75 | 2019 |
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| 24 | Development and validation of a Serpent-2 model for the former 3 MW TRIGA core configuration of the Philippine Research Reactor-1 | Julius Federico M. Jecong, Frederick C. Hila, Cheri Anne M. Dingle, Alvie A. Astronomo, Ronald Daryll E. Gatchalian, Kristine Marie D. Romallosa, Neil Raymund D. Guillermo | Philippine Journal of Science 149 (S1): 87-92 | 2019 |
| 25 | Capacity building in nuclear science and technology in the Philippines through the use and operation of Small Neutron Sources for Education, Training, and Research | Unico A. Bautista, Cheri Anne M. Dingle, Alvie A. Astronomo, Ma. Elina Salvacion Kristina V. Ramo, Frederick C. Hila, Julius Federico M. Jecong, Kristine Marie D. Romallosa, Ryan U. Olivares, Pablo P. Saligan, Neil Raymundo D. Guillermo | Journal of Science 149 (S1): 151-157 | 2019 |
| 26 | Chromium and cadmium adsorption on radiation-grafted polypropylene copolymers: regeneration, kinetics, and continuous fixed bed column studies | Girlie Eunice P. Lopez, Jordan F. Madrid, Lucille V. Abad | SN Applied Sciences 2 (400) | 2020 |
| 27 | Enhancing peanut productivity through application of irradiated κ-carrageenan | Mary Grace B. Gatan, Menrado T. Gatan, Fernando B. Aurigue | International Journal of Recent Technology and Engineering 8 (3): 6977- 6981 | 2019 |
| 28 | DOST-PNRI mutant variety: *Dracaena* 'Sun Beam' | Fernando B. Aurigue | Philippine Journal of Science 149 (S1): 11-14 | 2019 |

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| 29 | Effect of radiation-modified Kappa-carrageenan on the morpho-agronomic vharacteristics of Mungbean (*Vigna radiata* (L.) R. Wilczek) | Mary Grace B. Gatan, Djowel Rector V. Montefalcon, Fernando B. Aurigue, Lucille V. Abad | Philippine Journal of Science 149 (S1): 135-143 | 2019 |
| 30 | Methylene blue removal by poly(acrylic acid)-grafted pineapple leaf fiber/polyester nonwoven fabric adsorbent and its comparison with removal by gamma or electron beam irradiation | Janronel C. Pomicpic, Gian Carlo Dancel, Patrick Jay E. Cabalar, Jordan F. Madrid | Radiation Physics and Chemistry 172: 108737 | 2020 |
| 31 | Radiation-synthesized polysaccharides/ polyacrylate super water absorbents and their biodegradabilities | Lorna S. Relleve, Charito T. Aranilla, Bin Jeremiah D. Barba, Alvin Kier R. Gallardo, Veriza Rita C. Cruz, Carlene Rome M. Ledesma, Naotsugu Nagasawa, Lucille V. Abad | Radiation Physics and Chemistry 170: 108618 | 2020 |
| 32 | In vivo safety evaluation of granules and dressing hemostatic agents from radiation processed polymeric materials | Charito Tranquilan- Aranilla, Bin Jeremiah D. Barba, Lorna S. Relleve, Lucille V. Abad | Philippine Journal of Science 149 (S1): 15-26 | 2019 |
| 33 | Effect of gamma irradiation on Coconut Leaf Beetle, *Brontispa longissima* (Gestro) (Coleoptera: Chrysomelidae) | Glenda B. Obra, Mateo B. Zipagan, Abigaile Mia V. Javier | Philippine Journal of Science 149 (S1): 175-181 | 2019 |
| 34 | Pupal eye color of Peach Fruit Fly *Bactrocera zonata* (Saunders) as reference guide for radiation sterilization | Sotero S. Resilva, Preeaduth Sookar, Glenda B. Obra | Journal of Science 149 (S1): 33-41 | 2019 |
| 35 | Documented pupal eye color of the West Indian Fruit Fly, *Anastrepha obliqua* (Maquart), as a tool for radiation sterilization | Sotero S. Resilva, Emilio Hernandez, Glenda B. Obra | Philippine Agricultural Scientist 102 (3): 247-254 | 2019 |
| 36 | Exploring differences and correlation between Thermal-optical Transmittance Elemental Carbon (EC) and Reflectometer Black Carbon (BC) from an urban and a rural site in the Philippines | Jeff Darren G. Valdez, Angel T. Bautista VII, Preciosa Corazon B. Pabroa, Joseph Michael D. Racho, Gloria R. Jimenez, Flora L. Santos | Philippine Journal of Science 149 (1): 151-162 | 2020 |
| 37 | Carboxymethylchitosan hydrogel manufactured by radiation-induced crosslinking as potential nerve regeneration guide scaffold | Radoslaw A. Wach, Agnieszka Adamus-Wlodarczyk, Alicja K. Olejnik, Malgorzata Matusiak, Charito Tranquilan-Aranilla, Piotr Ulanski | Reactive and Functional Polymers 152: 104588 (1-13) | 2020 |
| 38 | Biodiscovery of antibacterial constituents from the endolichenic fungi isolated from *Parmotrema rampoddense* | Mario A. Tan, Sarleen G. Castro, Patricia Marie P. Oliva, Paul Raymund J. Yap, Atsushi Nakayama, Hilbert D. Magpantay, Thomas Edison E. dela Cruz | 3 Biotech 10 (212) | 2020 |
| 39 | Sedimentation patterns in Sorsogon Bay, Philippines using 210Pb | Efren J. Sta. Maria, Jordan F. Madrid, Ryan Joseph Aniago, Anie Day DC. Asa, Jennyvi P. Dayaon, Adelina DM. Bulos, Elvira Z. Sombrito | Philippine Journal of Science 149 (S1): 43-51 | 2019 |
| 40 | Determination of the REE content, geological age, and absorbed alpha dose of allanite mineral from Palawan, Philippines | Cheri Anne M. Dingle, Julius Federico M. Jecong, Frederick C. Hila, Ma. Elina Salvacion V. Ramo, Neil Raymund D. Guillermo, Magdaleno R. Vasquez, Jr., Vallerie Ann I. Samson | X-Ray Spectrometry 48 (5): 513-521 | 2019 |
| 41 | Predicting useful life of Cocopeat in a filter bed treating Wastewater with heavy metals using HYDRUS-1D | Jessie O. Samaniego, Maria Antonia N. Tanchuling | ASEAN Engineering Journal 9 (2): 44-56 | 2019 |
| 42 | Environmental assessment of soil erosion in Inabanga watershed (Bohol, Philippines) | Ryan U. Olivares, Adelina DM. Bulos, Elvira Z. Sombrito | Energy, Ecology, and Environment 1 (2): 98-108 | 2016 |
| 43 | Radiation crosslinking of carboxymethyl hyaluronic acid | Lorna S. Relleve, Alvin Kier R. Gallardo, Lucille V. Abad | Radiation Physics and Chemistry 151: 211-216 | 2018 |

| | TITLE | AUTHORS | JOURNAL | PUBLICATION YEAR |
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| 44 | Life history and biological control potential of *Snellenius manilae* Ashmead (Hymenoptera: Braconidae), a parasitoid of *Spodoptera litura* Fabricius (Lepidoptera: Noctuidae) | Abigaile Mia V. Javier, Flor A. Ceballo | Philipine Agricultural Scientist 101 (2): 145-157 | 2018 |
| 45 | Insecticidal activities of essential oils from different plants against the cabbage worm, *Crocidolomia pavonana* Fabricius (Lepidoptera:Crambidae) | Abigaile Mia V. Javier, Virginia R. Ocampo, Flor A. Ceballo, Pio A. Javier | Philippine Agricultural Scientist 101 (2): 158-166 | 2018 |
| 46 | Insecticidal activity of crude ethanolic extracts of five Philippine plants against Cabbage Worm, *Crocidolomia pavonana* Fabricius (Lepidoptera: Crambidae) | Abigaile Mia C. Javier, Virginia R. Ocampo, Flor A. Ceballo, Pio A. Javier | Philippine Journal of Science 147 (3): 513-521 | 2018 |
| 47 | Insecticidal activity of crude ethanolic extracts of selected Philippine plants against Diamondback Moth, *Plutella xylostella* Linnaeus | Abigaile Mia V. Javier, Virginia R. Ocampo, Flor A. Ceballo, Pio A. Javier | Philippine Journal of Science 148 (1): 33-43 | 2019 |

## OTHER SCIENTIFIC PUBLICATIONS FOR 2020*

| | TITLE | AUTHORS | JOURNAL |
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| 1 | Radiation-modified kappa-carrageenan improves productivity of peanut (*Arachis hypogaea* L.) in Bukidnon, Northern Mindanao, Philippines | Jerald B. Bongalos, Lorena V. Duna, Jemseal R. Tigbao, Fernando B. Aurigue | Philippine Journal of Science 149 (Special Issue): 101-105 |
| 2 | An annual time series of weekly size-resolved aerosol properties in the megacity of Metro Manila, Philippines | Connor Stahl, Melliza Templonuevo Cruz, Paola Angela Bañaga, Grace Betito, Rachel A. Braun, Mojtaba Azadi Aghdam, Maria Obiminda Cambaliza, Genevieve Rose Lorenzo, Alexander B. MacDonald, Preciosa Corazon Pabroa, John Robin Yee, James Bernard Simpas, Armin Sorooshian | Scientific Data 7 (1) : 128 |
| 3 | Measurement of ambient gamma dose rate in Metro Manila, Philippines using a portable NaI(Tl) scintillation survey meter | Rosario R. Encabo, Paolo Tristan F. Cruz, Antonio C. Bonga III, Christian L. Dela Sada, Vanessa J. Omandam, Juanario U. Olivares, Kazuki Iwaoka, Chitho P. Feliciano | Environmental Monitoring and Assessment 172 (6): 400 |
| 4 | Physico-chemical properties and heavy metal contents of Ino-Capayang Mine-made Lake in Marinduque, Philippines | Jellian L. Lanot, Jhoy Ann L. Lawig, Jayson A. Lecaros, Paul John L. Malagotnot, Panchito M. Labay, Jessie O. Samaniego | International Journal of Engineering Research and Technology 13 (6) : 1493-1496 |
| 5 | Monitoring of mercury in air from the abandoned mercury mine area using direct mercury analyzer | Jessie O. Samaniego, Cris Reven L. Gibaga, Alexandria M. Tanciongco, Rasty M. Rastrullo | International Journal of Engineering Research and Technology 13 (6) : 1373-1378 |
| 6 | Characterizing Weekly Cycles of Particulate Matter in a Coastal Megacity: The Importance of a Seasonal, Size-Resolved, and Chemically Speciated Analysis | Miguel Ricardo A. Hilario, Melliza Templonuevo Cruz , Paola Angela Bañaga, Grace Betito, Rachel A. Braun Connor Stahl, Maria Obiminda Cambaliza, Genevieve Rose Lorenzo, Alexander B. MacDonald, Mojtaba AzadiAghdam, Preciosa Corazon Pabroa, John Robin Yee, James Bernard Simpas, Armin Sorooshian | Journal of Geophysical Research: Atmospheres 125 (13) |
| 7 | Total mercury in soils and sediments in the vicinity of abandoned mercury mine area in Puerto Princesa City, Philippines | Jessie O. Samaniego, Cris Reven L. Gibaga, Alexandria M. Tanciongco, Rasty M. Rastrullo | Applied Sciences 10 (13) : 4599 |
| 8 | Vulnerability of soil organic matter to microbial decomposition as a consequence of burning | Gerald P. Dicen, Roland V. Rallos, John Leonard R. Labides, Ian A. Navarrete | Biogeochemistry 150 : 123-137 |
| 9 | Chemical speciation of scandium and yttrium in laterites: New insights into the control of their partitioning behaviors | Hai-Bo Qin, Shitong Yang, Masato Tanaka, Kenzo Sanematsu, Carlo Arcilla, Yoshio Takahashi | Chemical Geology 552 : 119771 |
| 10 | Experimental Determination of anisotropic emission of neutrons From $^{252}$Cf neutron source with the spherical protection case | Munehiko Kowatari, Sho Nishino, Kristine Marie D.Romallosa, Hiroshi Yoshitomi, Yoshihiko Tanimura, Tetsuya Ohishi | Radiation Protection Dosimetry 189 (4) : 436-443 |

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| 11 | Ni-co mineralization in the intex laterite deposit, Mindoro, Philippines | Carmela Alen J. Tupaz,Yasushi Watanabe, Kenzo Sanematsu, Takuya Echigo, Carlo Arcilla, Cherisse Ferrer | Minerals 10 (7) : 576 |
| 12 | Global impact of COVID-19 on nuclear medicine departments: An international survey in April 2020 | Lutz S. Freudenberg, Diana Paez, Francesco Giammarile, Juliano Cerci, Moshe Modiselle, Thomas N.B. Pascual, Noura El-Haj, Pilar Orellana, Yaroslav Pynda, Ignasi Carrió, Stefano Fanti, Cristina Matushita, Ken Herrmann | Journal of Nuclear Medicine 61 (9) : 1278-1283 |
| 13 | Biocompatible hydrogels of carboxymethyl hyaluronic acid prepared by radiation-induced crosslinking | Lorna S. Relleve, Alvin Kier R. Gallardo, Mariel G.Tecson, John Andrew A. Luna | Radiation Physics and Chemistry 179 : 109194 |
| 14 | Fabrication of cellulose acetate-based radiation grafted anion exchange membranes for fuel cell application | Angelo Jacob Samaniego, Allison Kaye Arabelo, Mrittunjoy Sarker, Felipe Mojica, Jordan Madrid, Po-Ya Abel Chuang, Joey Ocon, Richard Espiritu | Journal of Applied Polymer Science 138 (10) : 49947 |
| 15 | Effects of **γ**-irradiation on the $Cu^{2+}$ sorption behaviour of NaOH-modified Philippine natural zeolites | Mon Bryan Z. Gili, Eleanor M. Olegario | Clay Minerals 55 (3) : 248-255 |
| 16 | A review of abaca fiber-reinforced polymer composites: Different modes of preparation and their applications | Bin Jeremiah D. Barba, Jordan F. Madrid, David P. Penaloza Jr. | Journal of the Chilean Chemical Society 65 (3) : 4919-4924 |
| 17 | Mercury and other heavy metals in groundwater in the abandoned mercury mine in Puerto Princesa City, Philippines | Jessie O. Samaniego, Cris Reven L. Gibaga, Norman D.S. Mendoza, Charles Darwin T. Racadio, Alexandria M. Tanciongco, Rasty M. Rastrullo | Philippine Journal of Science 149 (3-a) : 897-901 |
| 18 | Cross-infectivity of a putative *Spodoptera picta nucleopolyhedrovirus* to *Spodoptera litura* Fabricius (Lepidoptera: Noctuidae) | Abigaile Mia V. Javier-Hila, Barbara L. Caoili | Philippine Journal of Science 149 (3-a) : 887-896 |
| 19 | Radiation dose in a reactor service area of the AP-1000 based on the Fukushima accident | Rokhmadi Ardani, Taswanda Taryo, Muhammad Subekti, Toshikazu Takeda, Arturo Failuga Salih | Philippine Journal of Science 149 (3-a) : 791-799 |
| 20 | Evaluation of time-dependent strengths of californium neutron sources by decay of $^{252}Cf$, $^{250}Cf$, and $^{248}Cm$: Uncertainties by Monte Carlo method | Frederick C. Hila, Cheri Anne M. Dingle, Alvie Asuncion-Astronomo, Charlotte V.Balderas, Marianna Lourdes Marie L. Grande, Kristine Marie D. Romallosa, Neil Raymund D. Guillermo | Applied Radiation and Isotopes 167 : 109454 |
| 21 | Hemostatic efficacy evaluation of radiation-crosslinked carboxymethyl cellulose granules and kappa-carrageenan/polyethylene oxide/ polyethylene glycol dressing in rat bleeding models | Charito Tranquilan-Aranilla, Bin Jeremiah Barba, Lorna Relleve, Maria Amelita Estacio, Lucille Abad | Journal of Biomaterials Applications : 1-10 |
| 22 | Dosimetric characterization of an X-ray irradiator for use with cells | Shalaine S.Tatu, Bernard Isaiah D. Lo, Judiel John M. Cortez, Merry Jaine T. Ortillo, Gio Ferson M. Bautista, Mary Joy V. Erojo, Chitho P. Feliciano | Radiation Physics and Chemistry 176 : 109065 |
| 23 | Gamma radiation-assisted: In situ synthesis of palladium nanoparticles supported on ethylenediamine-functionalized polypropylene fabric as an efficient catalyst for reduction of 4-nitrophenol | Girlie Eunice P. Lopez, Jordan F. Madrid, Drexel H. Camacho | New Journal of Chemistry 44 : 19337-19350 |
| 24 | A simple spreadsheet program for calculating mass attenuation coefficients and shielding parameters based on EPICS2017 and EPDL97 photoatomic libraries | Frederick C. Hila, Alberto V. Amorsolo Jr., Abigaile Mia V. Javier-Hila, Neil Raymund D.Guillermo | Radiation Physics and Chemistry 177 : 109122 |
| 25 | Response matrix validation of a 3He-based multi-shell neutron spectrometer | Alvie Asuncion-Astronomo, Cheri Anne M. Dingle, Frederick C. Hila, Charlotte V. Balderas, Carlitos P. Silvestre, Rafael Miguel M. Dela Cruz, Roberto Bedogni | Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment 989 : 164938 |

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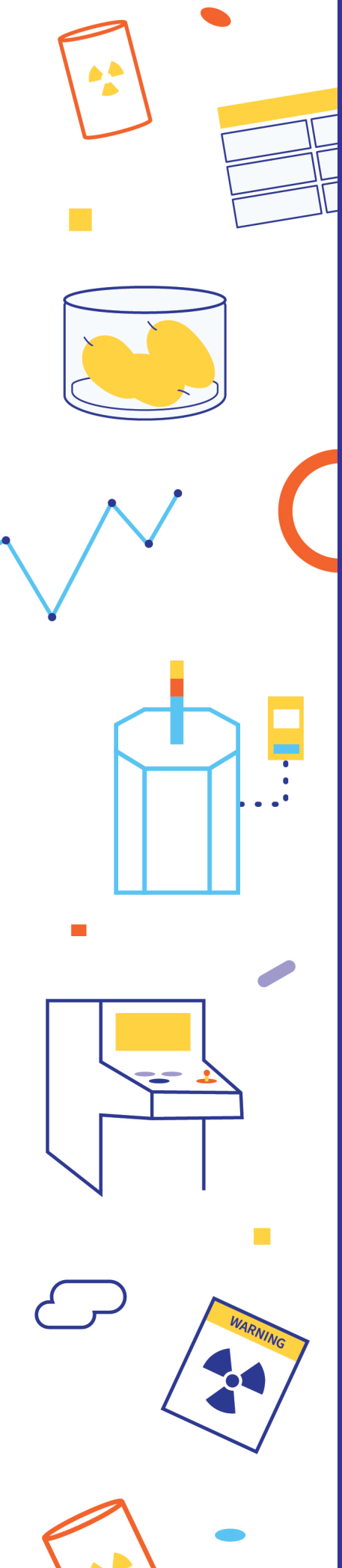
|---|---|---|---|
| 26 | Chromium occurrence in a nickel laterite profile and its implications to surrounding surface waters | Ruth Esther Delina, Carlo Arcilla, Tsubasa Otake, Jhonard John Garcia, Mark Tana, Akane Ito | Chemical Geology 558: (published online 12 September 2020; print available on December 2020) |
| 27 | AtHDA15 binds directly to COP1 positively regulating photomorphogenesis | Malona V. Alinsug, Amandine Radziejwoski, Custer C. Deocaris | Biochemical and Biophysical Research Communications 533 (4) : 806-812 |
| 28 | A historical record of the impact of nuclear activities based on 129I in coral cores in Baler, Philippines: An update | Angel T.Bautista VII, Sophia Jobien M. Limlingan, Mary Margareth T. Bauyona, Arvin M. Jagonoy, Joseph Michael D.Racho, Jeff Darren G.Valdez, Bee Jay T.Salon, Aldrin Jan E. Tabuso, John Kenneth C. Valerio, Edwin E. Dumalagan, Jr., Haruka Kusuno, Fernando P. Siringan, Hiroyuki Matsuzaki | Journal of Environmental Radioactivity 227 : 106508 |
| 29 | Volcanic rocks from the Central and Southern Palawan Ophiolites, Philippines: Tectonic and mantle heterogeneity constraints | Cris Reven L. Gibaga, Carlo A. Arcilla, Nguyen Hoang | Journal of Asian Earth Sciences: X 4 (1) : 10038 |
| 30 | Sources and characteristics of size-resolved particulate organic acids and methanesulfonate in a coastal megacity: Manila, Philippines | Connor Stahl, Melliza Templonuevo Cruz, Paola Angela Bañaga, Grace Betito, Rachel A. Braun, Mojtaba Azadi Aghdam, Maria Obiminda Cambaliza, Genevieve Rose Lorenzo, Alexander B. MacDonald, Miguel Ricardo A. Hilario, Preciosa Corazon Pabroa, John Robin Yee, James Bernard Simpas, Armin Sorooshian | Atmospheric Chemistry and Physics 20 (24) : 15907-5935 |

**Based on Scopus*




# Provision of **NUCLEAR S&T SERVICES**

Over the years, PNRI harnesses the tremendous advantages and benefits of nuclear and radiation applications to serve its clients from a wide range of sectors, from the academe to industry partners. Nuclear-related services offered by the Institute include the processing of commercial and industrial products, sample analysis, irradiation services, and radiation protection, among others.

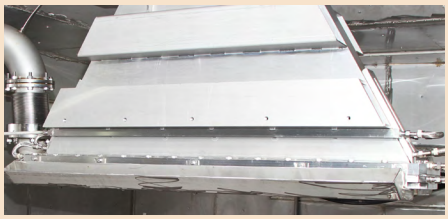
# Irradiation Services

PNRI's irradiation facilities continued to provide services to clients from the academe, industry, and research sectors in microbial decontamination and disinfestation of food products and other raw materials, and sterilization of medical devices, pharmaceuticals, and other packaging supplies or products.

## ELECTRON BEAM IRRADIATION FACILITY

| 10 | 89 | 1,557 | 88,000 |
|---|---|---|---|
| CLIENTS | SERVICES | SAMPLES | LITERS OF PGP |

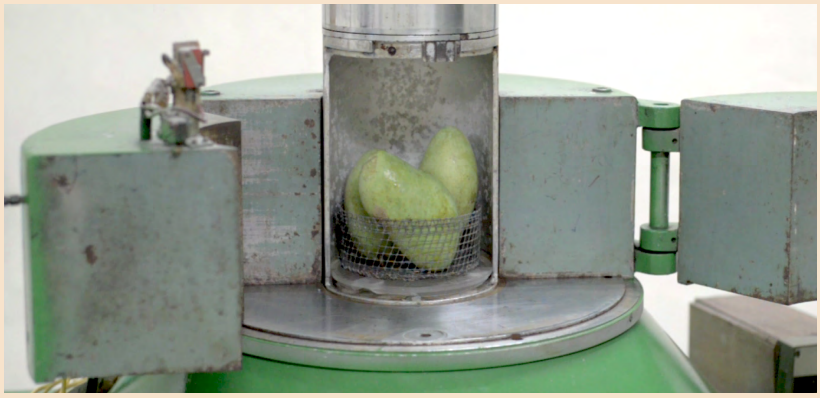
The 2.5 MeV Electron Beam Irradiation Facility (EBIF) with its advanced capacity for radiation processing has been offering its services for research and development as well as semi-commercial services since 2014. The EBIF is also used for the production of the award-winning PNRI-developed Carrageenan Plant Growth Promoter, which can increase the yield of crops and make these more resistant to plant diseases and infestations, and for the modification of other materials.

## GAMMACELL-220

| 7 | 28 | 247 |
|---|---|---|
| CLIENTS | SERVICES | SAMPLES |

The Gammacell-220 uses gamma radiation from Cobalt-60 source. The facility is mainly used for irradiation of small volumes of samples or those that require low radiation. This self-shielded irradiator is popular among researchers or students that conduct nuclear or radiation-related investigatory projects.

## OB-SERVO SANGUIS

**16**
**CLIENTS**

**81**
**SERVICES**

**1,246**
**SAMPLES**

Another type of self-shielded gamma irradiator is the Ob-Servo Sanguis. Initially intended for irradiating mosquitoes as part of the Sterile Insect Technique project of PNRI, this self-contained irradiator is also used for irradiating medical products and other research goods or samples in small quantities requiring high doses.

## COBALT-60 MULTIPURPOSE IRRADIATION FACILITY

The PNRI's Multipurpose Irradiation Facility was not operational in 2020 due to the full automation upgrade of the facility. The upgrade will help meet the increasing industrial demands and will have the following advantages:

(1) Safer working environment for facility operators

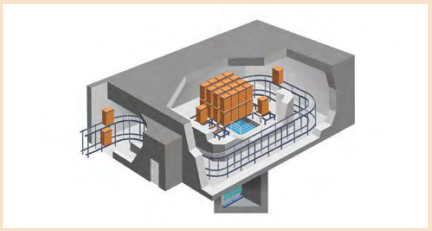
(2) Continuous mode of operation

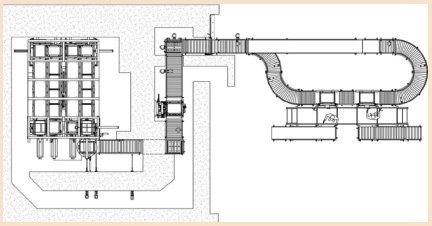
(3) Increased volume of products that can be irradiated

(4) Less shutdown time during operation

(5) Flexibility in irradiating products requiring low, medium, and high doses

(6) Higher income for industry partners





# Radiation Protection Services

**54,531** SERVICES

**43,800** PERSONS MONITORED

**1,237** INSTRUMENTS CALIBRATED

**601** SAMPLES ANALYZED

**29** OCCUPATIONAL EXPOSURE HISTORIES GENERATED

**112** NEW CLUSTERS

**3** NEW SERVICES

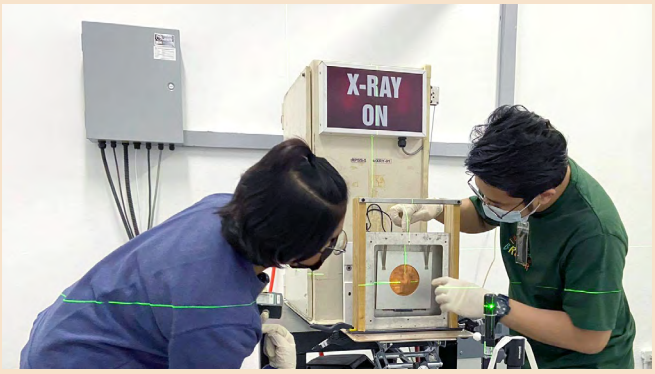
To help ensure the safety of occupationally exposed workers and the general public, PNRI continues to offer its personnel monitoring services, calibration of radiation instruments, radioactive waste management and radiation control services even during the community quarantine brought about by the COVID-19 pandemic.

All of PNRI's radiation protection services are now under the quality management system of the Institute. In addition, the TLD and OSL Personnel Monitoring services have been accredited to the ISO 17025:2017 Standard. New capabilities were also developed to help address the needs of the customers on occupational radiation protection and controls.


## DEVELOPMENT OF NEW NATIONAL STANDARDS THROUGH THE SECONDARY STANDARD DOSIMETRY LABORATORY (SSDL)

The PNRI-SSDL establishes and maintains the highest metrological standards for protection level of ionizing radiation in the Philippines. Researchers developed several new radiation fields, serving as the new standards for calibrating neutron and beta monitoring instruments as well as for calibration of low energy photons.

- Photon radiation X-ray narrow spectrum series: N-80, N-100, N-120, N-150
- Strontium-90 (Sr-90) reference beta radiation field
- Californium-252 (Cf-252) reference neutron field




## RADIOACTIVE WASTE MANAGEMENT

| 5 | 2 | 19 | 19 |
|---|---|---|---|
| UNITS OF DISUSED SEALED RADIOACTIVE SOURCES RECEIVED | SOLID WASTE PACKAGES RECEIVED | UNITS OF DSRS DISMANTLED & RECOVERED | UNITS OF DSRS ENCAPSULATED |

The Radioactive Waste Management Facility (RWMF) is a centralized facility authorized to treat, condition, and store radioactive waste generated from different nuclear and radiation applications. This year, PNRI completed the upgrades to its safety and security infrastructure, including the construction of the RWMF receiving area, improving its capability for handling waste packages.

# Nuclear-Based Analytical Services

PNRI offers the unique edge of its isotopic and other nuclear analytical services to provide precise analysis of samples for a range of purposes from research studies and projects to certification for regulatory requirements.

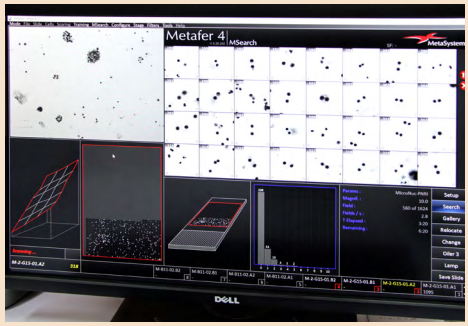
Unlike traditional methods, nuclear analytical techniques have various advantages (such as destructive and multi-element analysis, and analyzed samples can be archived and be made available for other analysis, among others) and can provide more accurate and precise information in various multidisciplinary research projects.

| NUCLEAR ANALYTICAL SERVICES | NO. OF CUSTOMERS | NO. OF SAMPLES |
|---|---|---|
| Gammametric Analysis | 16 | 45 |
| Liquid Scintillation Counting for Alpha and Beta Analysis of Water | 94 | 231 |
| Radon Analysis of Water | 82 | 434 |
| Carbon-14 Analysis for Detection of Vinegar Adulteration | 6 | 7 |
| X-ray Fluorescence Analysis | 1 | 3 |
| Total | 199 | 720 |

# Microbiological and Cytogenetic Analysis

The Institute offers various microbiological tests to various industries and sectors, helping customers ensure the freshness and quality of their products.

To ensure the safety of occupationally exposed workers, PNRI also continues to study blood samples for any signs of radiation exposure beyond the allowable regulatory limits. Using cytogenetic biodosimetry, researchers analyze the chromosomes in white blood cells to see if there are any aberrations that would serve as signs of radiation damage.



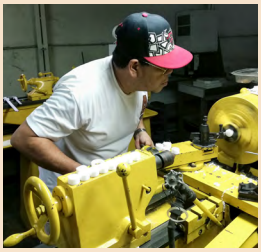
| | SAMPLES RECEIVED | CUSTOMER SERVED | | SAMPLES RECEIVED | CUSTOMER SERVED |
|---|---|---|---|---|---|
| Aerobic Plate Count | 25 | 7 | Physico-chemical analysis (pH) | 1 | 1 |
| Mold & Yeast Count | 25 | 7 | Moisture Analysis | 25 | 7 |
| Total Coliform | 25 | 7 | Cytogenetic Analysis | 3 | 3 |
| Sterility Tests | 21 | 6 | Total | 133 | 18 |

# Engineering and Instrumentation Services

PNRI engineers and technicians continue to provide technical assistance and support in the fabrication, machining, troubleshooting, repair, and maintenance of various equipment and radiation related instruments and devices inside PNRI offices, research facilities and served external clients.

They also handle the preventive maintenance of several equipment and facilities, supervise infrastructure projects for the Institute, and inspect buildings to ensure fire safety and structural integrity, among others.

## ENGINEERING SERVICES HIGHLIGHTS



- Draft building layout, scope of work and cost estimates for the project bidding establishment of the future Nuclear Medicine Research, Development and Innovation Center
- Devised, fabricated, and tested a radiation alarm and digital survey meter (subject for calibration)
- Upgrading of NART Building and PNRI Grounds
- Upgrading post-electrical construction, inspection, and installation of additional power supply for various laboratories of Atomic Research Center
- Upgrading and construction of new buildings such as the Entomology Modular Laboratory and the new two-story Radiation Protection Services Facility

Ensuring the

# Safety and Security of Radioactive Sources

PNRI serves as the national regulatory body for the licensing and regulatory inspection of atomic and nuclear energy-related activities by virtue of Republic Act 5207 or the Atomic Energy Regulatory and Liability Act of 1968, as amended, and Executive Order 128 of 1987. The Institute continues to uphold the country's nuclear safety, safeguards, and security regimes through its Nuclear Regulatory Division.

# Development of Nuclear Regulations and Standards

To help ensure the health and safety of workers as well as the general public, PNRI continues to uphold its legal mandate by issuing regulations, administrative orders, and other issuances in line with international standards for nuclear and radioactive materials.

## CODE OF PNRI REGULATIONS (CPR)

Serving as the main body of regulatory issuances by PNRI, the CPR is divided into several parts, setting forth the requirements for nuclear and radioactive materials, facilities and related activities, radiation protection standards, and security of radioactive sources, among others.

| | | |
|---|---|---|
| CPR Part 0 | PNRI as the Regulatory Authority in the Licensing and Regulation of Atomic Energy Facilities and Materials in the Philippines | Published in the Official Gazette (August 10, 2020) |
| CPR Part 30 | Safety Requirements for Research Reactors | Published in the Official Gazette (August 10, 2020) |

## ADMINISTRATIVE ORDERS AND OTHER ISSUANCES

PNRI also issues administrative orders, regulatory guides, regulatory bulletins, and information notices to inform the licensees on the recent developments regarding regulatory requirements and take appropriate actions, if necessary.

| | | |
|---|---|---|
| PNRI Administrative Order No. 20-01 | Schedule of Fees and Charges for the Conduct of Virtual Regulatory Inspection | Published in the Official Gazette (August 10, 2020) |
| PNRI Administrative Order No. 20-02 | Amendment to Applicable Code of PNRI Regulations (CPRs), Changing the Designations of Radiation Safety Officer (RSO)/Radiological Health and Safety Officer (RHSO) into Radiation Protection Officer (RPO) | Published in the Official Gazette (November 16, 2020) |
| PNRI Administrative Order No. 20-03 | Amendment to the CPR Part 13, "Licenses for Medical Use of Unsealed Radioactive Material", Rev. 2 | Approved on November 27, 2020 |
| PNRI Regulatory Bulletin No. 20-01 | Medical Event: Improper Dose for the Administration of Iodine-131 | Approved on November 23, 2020 |
| PNRI Information Notice No. 20-01, s. 2020 | Revised Regulation: CPR Part 7, "Licensing of Nuclear Installations, Rev. 01" | Approved on January 10, 2020 |
| PNRI Information Notice No. 20-02, s. 2020 | Guidance on PNRI Regulatory Services and on Provision of Relief from Regulatory Requirements During the COVID-19 Related Enhanced Community Quarantine (ECQ) | Approved on May 13, 2020 |
| PNRI Information Notice No. 20-03, s. 2020 | Guidance on Application for Radioactive Material License, Certificate of Release, Certificate of Non-Radioactive Material, and Permit to Transport | Approved on June 2, 2020 |
| PNRI Information Notice No. 20-04, s. 2020 | New Regulation: CPR Part 30, "Safety Requirements for Research Reactors" | Approved on October 19, 2020 |
| PNRI Information Notice No. 20-05, s. 2020 | Publication of PNRI Administrative Order No. 1, Series of 2020: Schedule of Fees and Charges for the Conduct of Virtual Regulatory Inspection | Approved on October 5, 2020 |

## LEGISLATIVE SUPPORT FOR THE COMPREHENSIVE ATOMIC REGULATION ACT

The Institute continues to push for the creation of the Philippine Atomic Regulatory Commission which will serve as a unified independent regulatory body for ionizing radiation consistent with international standards. In this light, PNRI supports the enactment of the bill for the Comprehensive Atomic Regulation Act before the Congress.

**MARCH**

- The House of Representatives' Joint Committee on Government Reorganization, Science and Technology and Energy moved to adopt the Comprehensive Atomic Regulatory Act on March 11, 2020.

*First row from right: Representatives Sergio Dagooc, Rufus Rodriguez, Erico Aristotle Aumentado, House Committee Chairperson for Government Reorganization Mario Vittorio Mariño, Ron Salo and Francis Gerald Abaya during the Joint Committee Meeting on Government Reorganization, Science and Technology and Energy at the House of Representatives for the bill on the Comprehensive Atomic Regulation Act. They are joined by officials and staff from DOST, PNRI, DOE and DOH.*


*PNRI officials and staff during a courtesy call at the office of Congressman Mario Vittorio Mariño, House Committee Chairperson for Government Reorganization, where the bill for the Comprehensive Atomic Regulatory Law is being taken up.*

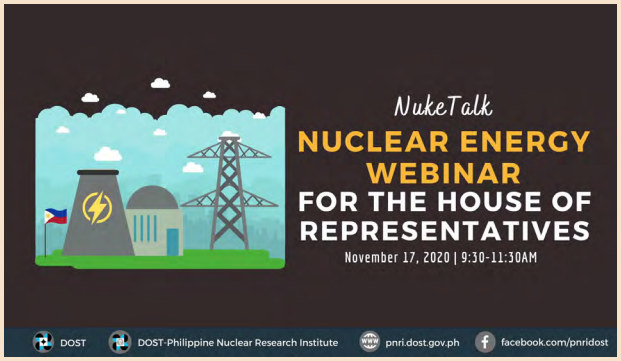
*Note: Photos taken before the imposition of quarantine and health safety requirements*

**JUNE**

- PNRI coordinates with the House of Representatives to consolidate the various House Bills on the Comprehensive Atomic Regulations Act to come up with the substitute bill.
- Online conference with the Senate S&T Committee and the DOST Department Legislative Liaison Office on the proposed bill on June 23

**NOVEMBER**

- PNRI featured the proposed bill for the Comprehensive Atomic Regulations Act during the NukeTalk Webinar for the House of Representatives on November 17. The webinar was attended by several House committee secretaries and legislative staff.




## INTERNATIONAL SUPPORT FOR NATIONAL LEGAL AND REGULATORY INFRASTRUCTURE DEVELOPMENT

The Philippines through PNRI receives support from international organizations to further develop and improve the country's legal and regulatory framework on nuclear and radioactive materials.

PNRI regulators participated in the International Atomic Energy Agency technical cooperation project RAS 9089 on Strengthening Radiation Safety Infrastructure, particularly in the preparations for the IAEA Occupational Radiation Protection Appraisal Service (ORPAS) mission.


*PNRI regulators and professionals representing various sectors engage in preparatory meetings in February for the IAEA ORPAS mission, which aims to assess the country's occupational radiation protection program vis-à-vis the international standards to ensure the safety of occupational workers working with radiation sources.*

*Note: Photos taken before the imposition of quarantine and health safety requirements*

# Licensing of Nuclear and Radioactive Materials and Facilities

| 397 | 196 | 110 | 76 | 10 |
|---|---|---|---|---|
| CERTIFICATES OF RELEASE ISSUED | RADIOACTIVE MATERIAL LICENSES ISSUED | RADIOACTIVE MATERIAL LICENSES RENEWED | RADIOACTIVE MATERIAL LICENSES AMENDED | NEW RADIOACTIVE MATERIAL LICENSES |

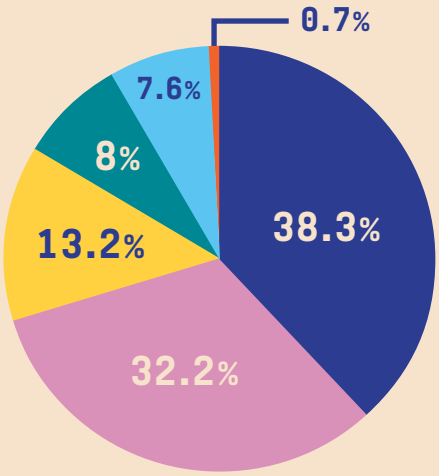
As a cornerstone of the Institute's regulatory functions, PNRI issues licenses across various sectors which use nuclear and radioactive materials, including its use, possession, transportation and other related activities.

The COVID-19 pandemic, which resulted in various regimes of community quarantine across the Philippines, understandably burdened both the licensees as well as the regulators in the securing or issuance of licenses.

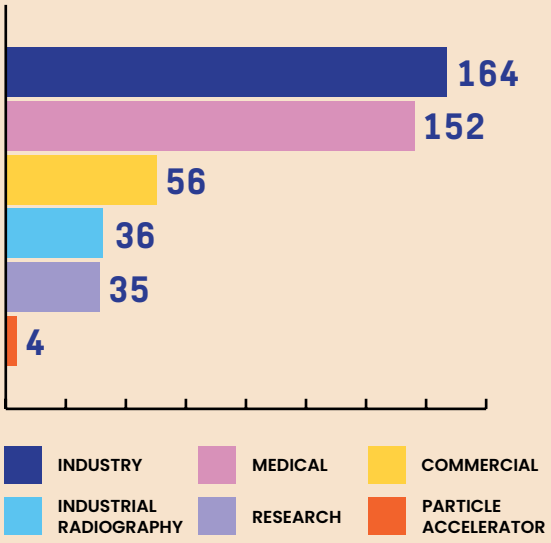
By May 2020, PNRI has already provided for the online submission of applications and requirements for the duration of the Enhanced Community Quarantine, as well as for possible exemptions and other relief for licensees unable to comply with some requirements due to the pandemic, on a case-to-case basis.

**Number of Licensed Users by Geographical Location**

| | |
|---|---|
| Region I | 9 |
| Region II | 8 |
| Region III | 44 |
| Region IV | 75 |
| Region V | 8 |
| Region VI | 13 |
| Region VII | 18 |
| Region VIII | 2 |
| Region IX | 5 |
| Region X | 16 |
| Region XI | 14 |
| Region XII | 4 |
| Region XIII | 4 |
| CAR | 4 |
| NCR | 223 |
| **Total** | **447** |




**Distribution of Licensees by Use**




**Distribution of Licensees by Sector**

# Inspection and Enforcement Activities

**4,013**
**PERMITS TO TRANSPORT RADIOACTIVE MATERIALS**

**3**
**ADMINISTRATIVE SANCTIONS**
(Demand for Information) issued for incidents of overexposure

**74**
**TOTAL NUMBER OF INSPECTIONS**

**61**
**REGULAR INSPECTIONS**

**4**
**UNANNOUNCED INSPECTIONS**

**2**
**REACTIVE INSPECTIONS**

**7**
**INTERVAL INSPECTIONS**
(PNRI Regulatory Control Program)

**45**
**EVALUATION REPORTS**

PNRI inspectors regularly visit licensed facilities to ensure compliance with the requirements of the national regulations and the conditions of their license.

Beginning July 2020, the difficulties posed by the community quarantine necessitated the conduct of virtual inspections in lieu of physical visits, ensuring the safe and peaceful use of radioactive sources even during the COVID-19 crisis.


# Nuclear Safeguards and Security

PNRI remains steadfast in upholding the Philippines' commitments to various international conventions and agreements to ensure that safeguards and security measures are in place in various facilities and events which will prevent nuclear materials from being used for non-peaceful applications.

## STATE-LEVEL SAFEGUARDS INSPECTIONS

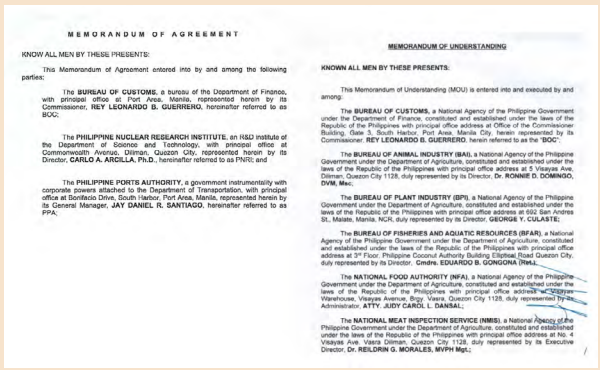

*Regulatory staff holds an inspection of the PNRI Radioactive Waste Management Facility where items such as radiographic cameras with depleted uranium are required to be declared under the Additional Protocol of the Comprehensive Safeguards Agreement with the IAEA.*

## SECURITY INSPECTION OF RESEARCH AND MEDICAL FACILITIES

- The Institute continues to collaborate with the US Department of Energy in the conduct of radiological security inspections to prevent theft, sabotage or unauthorized removal of high-activity radioactive sources.
- Security inspections were conducted in PNRI facilities as well as in several hospitals and medical centers.

## NUCLEAR SECURITY AND BORDER PROTECTION PARTNERSHIPS

- PNRI signed a Memorandum of Agreement with the Bureau of Customs (BOC) and the Philippine Ports Authority for ensuring nuclear security detection at the various ports of entry in the country such as Manila and Cebu, among others.
- The BOC is also partnering with the Institute along with other stakeholders through a Memorandum of Understanding for enhancing border protection.



MEMORANDUM OF AGREEMENT

KNOW ALL MEN BY THESE PRESENTS:

This Memorandum of Agreement entered into by and among the following parties:

The **BUREAU OF CUSTOMS**, a bureau of the Department of Finance, with principal office at Port Area, Manila, represented herein by its Commissioner, **REY LEONARDO B. GUERRERO**, hereinafter referred to as BOC;

The **PHILIPPINE NUCLEAR RESEARCH INSTITUTE**, an R&D institute of the Department of Science and Technology, with principal office at Commonwealth Avenue, Diliman, Quezon City, represented herein by its Director, **CARLO A. ARCILLA, Ph.D.**, hereinafter referred to as PNRI; and

The **PHILIPPINE PORTS AUTHORITY**, a government instrumentality with corporate powers attached to the Department of Transportation, with principal office at Bonifacio Drive, South Harbor, Port Area, Manila, represented herein by its General Manager, **JAY DANIEL R. SANTIAGO**, hereinafter referred to as PPA;

MEMORANDUM OF UNDERSTANDING

KNOWN ALL MEN BY THESE PRESENTS:

This Memorandum of Understanding (MOU) is entered into and executed by and among:

The **BUREAU OF CUSTOMS**, a National Agency of the Philippine Government under the Department of Finance, constituted and established under the laws of the Republic of the Philippines with principal office address at Office of the Commissioner Building, Gate 3, South Harbor, Port Area, Manila City, herein represented by its Commissioner, **REY LEONARDO B. GUERRERO**, herein referred to as the "**BOC**";

The **BUREAU OF ANIMAL INDUSTRY (BAI)**, a National Agency of the Philippine Government under the Department of Agriculture, constituted and established under the laws of the Republic of the Philippines with principal office address at 5 Visayas Ave, Diliman, Quezon City 1128, duly represented by its Director, **Dr. RONNIE D. DOMINGO, DVM, Msc**;

The **BUREAU OF PLANT INDUSTRY (BPI)**, a National Agency of the Philippine Government under the Department of Agriculture, constituted and established under the laws of the Republic of the Philippines with principal office address at 692 San Andres St., Malate, Manila, NCR, duly represented by its Director, **GEORGE Y. CULASTE**;

The **BUREAU OF FISHERIES AND AQUATIC RESOURCES (BFAR)**, a National Agency of the Philippine Government under the Department of Agriculture, constituted and established under the laws of the Republic of the Philippines with principal office address at 3rd Floor, Philippine Coconut Authority Building Elliptical Road Quezon City, duly represented by its Director , **Cmdre. EDUARDO B. GONGONA (Ret.)**;

The **NATIONAL FOOD AUTHORITY (NFA)**, a National Agency of the Philippine Government under the Department of Agriculture, constituted and established under the laws of the Republic of the Philippines with principal office address at Corporate Warehouse, Visayas Avenue, Brgy. Vasra, Quezon City 1128, duly represented by its Administrator, **ATTY. JUDY CAROL L. DANSAL**;

The **NATIONAL MEAT INSPECTION SERVICE (NMIS)**, a National Agency of the Philippine Government under the Department of Agriculture, constituted and established under the laws of the Republic of the Philippines with principal office address at No. 4 Visayas Ave. Vasra Diliman, Quezon City 1128, duly represented by its Executive Director, **Dr. REILDRIN G. MORALES, MVPH Mgt.**;

## ESTABLISHMENT OF SAFEGUARDS LABORATORY AND TRAINING ROOM

- Ongoing refurbishing of the Safeguards Laboratory, complete with a training room for regulators, operators and other stakeholders who will be involved in activities related to nuclear safeguards and security.


*The equipment and training rooms for nuclear safeguards laboratory and training activities by PNRI*

*Note: Photos taken before the imposition of quarantine and health safety requirements*

## DEPLOYMENT OF MEST TEAM IN MAJOR EVENTS

- The Institute regularly deploys its Mobile Expert Support Team (MEST) to monitor the presence of nuclear and radioactive materials during major public events.
- Before the pandemic caused the suspension of all forms of mass gatherings, PNRI was able to deploy MEST during the Translacion, the procession of the Black Nazarene in Manila and its surrounding areas. The monitoring included an aerial survey of the area around Quiapo Church, and another survey along the Pasig River.

*MEST, accompanied by the Philippine Coast Guard, monitor the Pasig River using the Spectral Advanced Radiological Computer System (SPARCS)*

*PNRI personnel at Villamor Airbase during a sortie for aerial radiation monitoring for Translacion 2020*


*Using an identifinder survey meter, PNRI staff monitored the radiation levels at the Plaza Miranda in Quiapo*

*Note: Photos taken before the imposition of quarantine and health safety requirements*

# Radiological Impact Assessment, Emergency Preparedness and Response

To support the PNRI's regulatory mandate, studies on the impact of the use of radioactive materials or sources in regulated facilities were continued to protect the health and safety of the radiation workers and the public from any radiological hazard. Capability building of the country in responding to nuclear and radiological emergencies is also ongoing.

## SAFETY ASSESSMENTS IN SUPPORT OF REGULATIONS

PNRI researchers conducted safety assessments in response to several purported incidents involving radioactive materials. The assessments were performed in consideration of enforcement actions on a radioactive source melt in a steel manufacturing company, the loss of a Polonium-210 source used as a static electricity eliminator in the electronic industry, and an allegedly abandoned radioactive material stored in a mining facility.

## IAEA CONVEX EXERCISES

The Philippines adheres to its commitment to the Convention on Early Notification for a Nuclear or Radiological Emergency and Convention on Assistance. Coordinating closely with the IAEA, PNRI serves as the Competent Authority and the National Warning Point for nuclear or radiological emergency.

PNRI regulatory staff participated in three IAEA Incident and Emergency Centre Exercises: ConvEx-1b for NWP confirmation of exercise message within 30 minutes, ConvEx-1a for CA (A) confirmation of exercise message, and ConvEx-2c for testing emergency arrangement in a transnational nuclear emergency.

## EMERGENCY SCENARIO DRILLS

Two capability building activities on emergency management with scenario drills and exercises were conducted for members of the Emergency Coordinating Council, emergency managers, technical support group, public information and media coordination, response initiators, and Fire Response Team. The capability support was also extended to several grade 12 senior high school and college students on Radiological Impact Assessment and Emergency Preparedness and Response as part of work immersion activity.


*Emergency management role-played by PNRI senior officials and other staff*

*Note: Photos taken before the imposition of quarantine and health safety requirements*

## ESTABLISHMENT OF A NATIONAL DECISION SUPPORT SYSTEM FOR NUCLEAR AND RADIOLOGICAL EMERGENCY

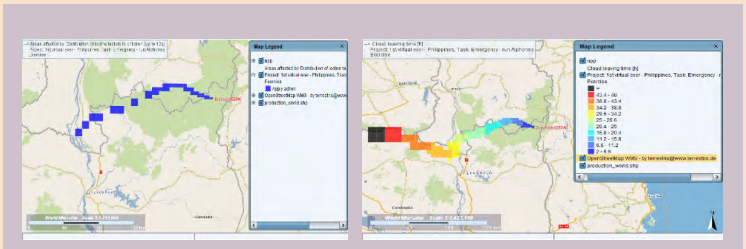
PNRI is implementing the European Commission Instrument for Nuclear Safety Cooperation (EC INSC)-ASEAN Network of Regulatory Bodies (ASEANTOM) regional project on strengthening emergency preparedness and response through the provision of technical support system tool for decision making by the ASEAN member states.

## RADIOECOLOGICAL DATA FOR THE JRODOS SYSTEM

The Java Real-time Online Decision Support (JRODOS) System is customized according to the radioecological region applicable also to national setting which will facilitate decision making for immediate response actions appropriate for risk mitigation for the public.

Researchers collected and processed radioecological data from various government agencies for the simulation of nuclear emergency prediction models embedded in the JRODOS System. The data were classified into agricultural (production, area, and yield), livestock (chicken, pork, and fisheries), meteorological population density, and radioecological region classifications.

A series of scenario-based online tabletop exercises was also participated in by the PNRI regulatory assessors in February, July, August, September, and November. The exercises provided real-time assessment of the progressing emergency, build-up of the capability for results analysis and recommendations, and the operations of the decision support system.



*Regulatory assessors participating in the JRODOS tabletop exercises*

*Note: Photos taken before the imposition of quarantine and health safety requirements*

## ESTABLISHMENT OF GAMMA DOSE RADIATION MONITORING STATIONS

Preparatory research was conducted for the installation and establishment of Gamma Dose Radiation Monitoring Stations in the western part of the Philippines. The monitoring stations are an integral component of the early warning radiation monitoring network in the country as the stations collect radiation data to be transmitted for simulation in the JRODOS system. Analysis of simulated data will be performed in the National Decision Support System (NDSS) for the creation of sound decisions during radiological or nuclear emergency in the ASEAN region.

*Concept of a National Decision Support System*


*At least 10 GDRMS are planned to be established as part of the NDSS.*

Diffusion of

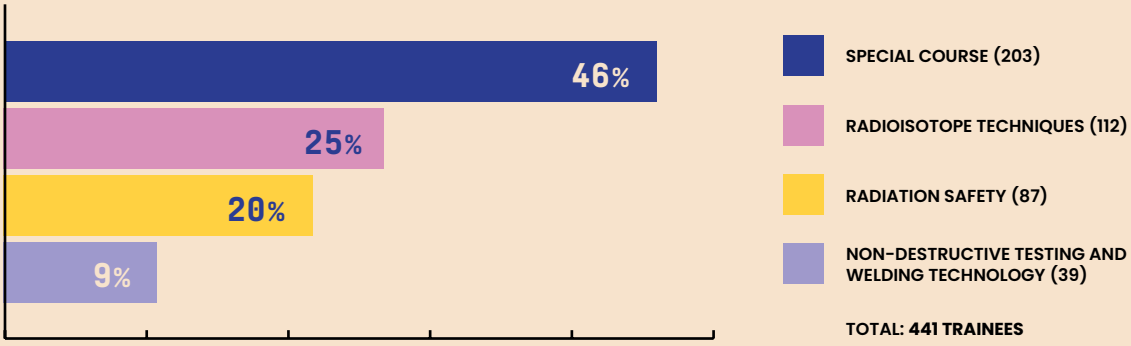
# Knowledge and Technologies

The Institute strives to bring the benefits of nuclear science and technology to the awareness of stakeholders in various sectors through the conduct of information, education, communication, and technology transfer activities.

# Capacity Building on Nuclear Science and Technology

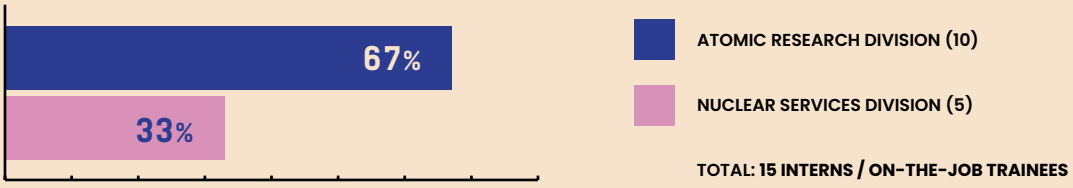
## NUCLEAR TRAINING AND OTHER SPECIALIZED COURSES

The PNRI, through the Nuclear Training Center, managed the conduct of traditional face-to-face and online training courses to continuously strengthen capacity building in nuclear science and technology. Fourteen courses were conducted and participated in by 441 individuals from the industrial, research, medical, and academic sectors. Among the areas covered by the courses were radioisotope techniques, radiation safety, and nondestructive testing. PNRI also conducted a specialized course in Reactor Engineering in partnership with the Japan Atomic Energy Agency.




## INTERNSHIP / ON-THE-JOB TRAINING PROGRAM

Fifteen high school and college/university students from five schools were accepted for on-the-job training and deployed to different sections of the Institute.




## THESIS ADVISORSHIP PROGRAM

One MS Physics student from the University of Santo Tomas availed of PNRI's research advisorship program.

# Nuclear Training Courses

## RADIOISOTOPE TECHNIQUES

| TITLE OF TRAINING | PLATFORM | NO. OF PARTICIPANTS |
|---|---|---|
| Course on Medical Use of Radioisotopes (CMR) – Three Sessions | Face-to-face / Online (Anent LMS-ESPRORAD, Canvas, MS Teams) | 112 |

*Note: Photos taken before the imposition of quarantine and health safety requirements*

## RADIATION SAFETY

| TITLE OF TRAINING | PLATFORM | NO. OF PARTICIPANTS |
|---|---|---|
| Radiation Safety Course - Sealed Sources in Industrial Devices (RSC-ID) – Four Sessions | Face-to-face / Online (MS Teams) | 61 |
| Radiation Safety Course – Medical Radioisotope (RSC-MR) | Face-to-face | 12 |
| Radiation Safety Refresher Course (RSRC) – Two Sessions | Face-to-face | 14 |



*Note: Photos taken before the imposition of quarantine and health safety requirements*

## SPECIAL COURSE *(Conducted in cooperation with the Japan Atomic Energy Agency)*

| TITLE OF TRAINING | PLATFORM | NO. OF PARTICIPANTS |
|---|---|---|
| Follow-up Training Course on Reactor Engineering (FTC-RE) Level 1 | Online (Canvas, MS Teams) | 203<br>***134** finished the course* |

## NON-DESTRUCTIVE TESTING *(Conducted in cooperation with the Philippine Society of Nondestructive Testing, Inc.)*

| TITLE OF TRAINING | PLATFORM | NO. OF PARTICIPANTS |
|---|---|---|
| Surface Methods (NDT-SM) - Level 2 | Face-to-face | 15 |
| Radiographic Testing (NDT-RT) - Level 2 | Face-to-face | 14 |
| Infrared/Thermographic Testing (NDT-TT) - Level 1 | Face-to-face | 10 |

**14**
**TOTAL NO. OF COURSES**

**441**
**TOTAL NO. OF PARTICIPANTS**

# Information, Education and Communication of Nuclear S&T

To better promote the Institute's technologies, services, events, and other activities, the PNRI continues to work on the conduct of the following information, education, and communication activities in increasing stakeholder knowledge and awareness in nuclear science and technology.

## SPECIAL EVENTS AND NUCLEAR AWARENESS SEMINARS

**3**

**National and Regional Science and Technology Week, National Biotechnology Week, and Atomic Energy Week celebrations**

**4**

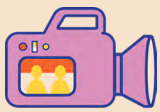
**Webinars**

- Two webinars organized in cooperation with the Philippine Young Generation in Nuclear
- *"NukeTalk: Nuclear Energy Webinar"* for the House of Representatives
- *"Regulating Nuclear Facilities and Activities in the Philippines"* webinar

## MEDIA PUBLICITY

**32**

**PRESS RELEASES**
prepared and published on the PNRI website and in daily broadsheets, including their online platforms



**20**

**MEDIA INTERVIEWS**
coordinated with PNRI officials and staff

**1**

**VIRTUAL PRESSER**
conducted during the 48th Atomic Energy Week celebration

## LIBRARY SERVICES

**200**

**CLIENTS**

composed mostly of students and researchers, provided with library assistance both on-site and via PNRI's online research support system

**240**

**PRINT AND DIGITAL INFORMATIONAL RESOURCES**

circulated and provided to clients on-site and online

## EDUCATIONAL TOURS

**5**

**GUIDED EDUCATIONAL TOURS**

to PNRI facilities and laboratories conducted to more than 200 clients from various sectors during the first quarter of 2020

**4**

**VIRTUAL TOURS**

produced as an alternative to on-site guided tours and published online

## DEVELOPMENT OF INFORMATION MATERIALS

**53**

**INFORMATION, EDUCATION AND COMMUNICATION MATERIALS**

on nuclear technologies developed in various formats such as flyers, press releases, exhibit banners, display materials, and video presentations

## SOCIAL MEDIA

**12,812**

**NEW FACEBOOK PAGE LIKES**

to a total of 56,112 likes by the end of 2020

## CONTESTS

**3**

**CONTESTS ON NUCLEAR S&T**

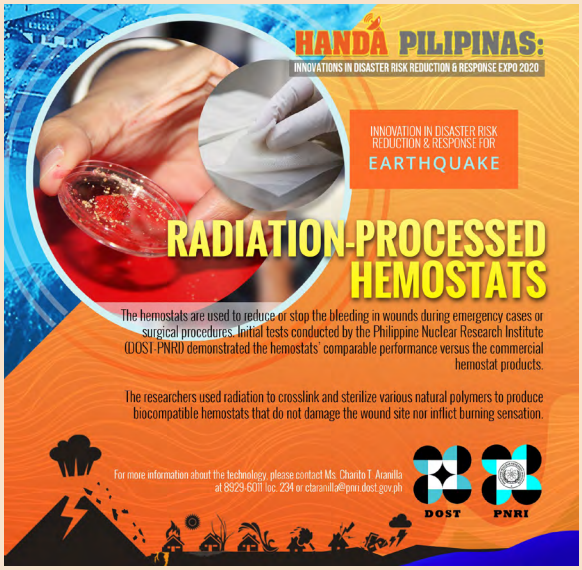
for high school students and Facebook followers


*Winning entries from the NucleArt 2.0: Digital Poster Making Contest: First place (left), second place (middle), third place (right)*

# S&T Events

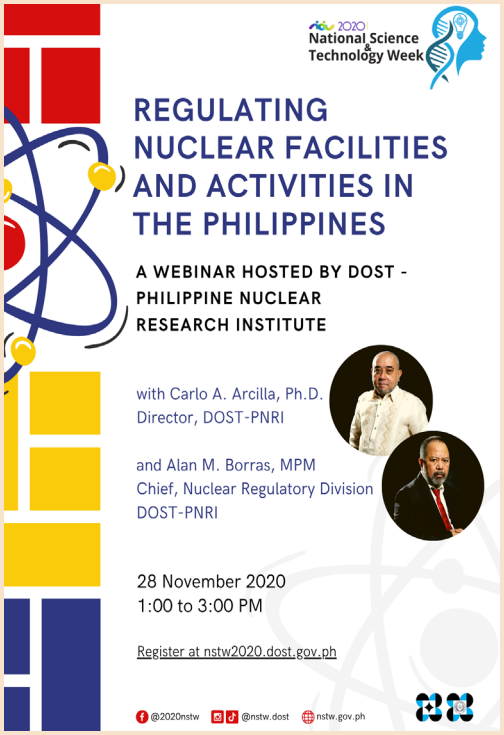
## NATIONAL

| EVENT | DATE AND VENUE / PLATFORM |
|---|---|
| HANDA PILIPINAS: Innovations in Disaster Risk Reduction and Response Expo | Physical event cancelled, technology posters were published and promoted on DOST-TAPI's Facebook page |
| Reference Managers in the Teaching of Research to K-12 Students | 18 June / Virtual via Zoom |
| NU-CLEAR: Webinar Series on Nuclear Power, (in partnership with Philippine Young Generation in Nuclear) | 23 October / Virtual via Zoom and Facebook<br>Speakers: Dr. Alvie A. Astronomo and Dr. Carlo A. Arcilla<br><br>20 November / Virtual via Zoom and Facebook<br>Speakers: DOE Asec. Gerardo D. Erguiza, Jr.<br>and Dr. Carlo A. Arcilla |
| National Inventors' Week (Webinar on Innovations and Inventions for COVID-19 and Disaster Risk Reduction) | 10 November / Virtual via Facebook<br>Speaker: Ms. Cecilia M. De Vera |
| NukeTalk: Nuclear Energy Webinar for the House of Representatives (in cooperation with NRD) | 17 November / Virtual via MS Teams<br>Speakers: Dr. Carlo A. Arcilla, Dr. Alvie A. Astronomo, and Ms. Teresita G. De Jesus |
| 15th National Biotechnology Week Celebration | 23-27 November / Virtual via NBW Platform |
| DOST National Science & Technology Week Celebration | 23-29 November / Virtual via NSTW Platform |
| 48th Atomic Energy Week | 7-11 December / Virtual via AEW Platform |

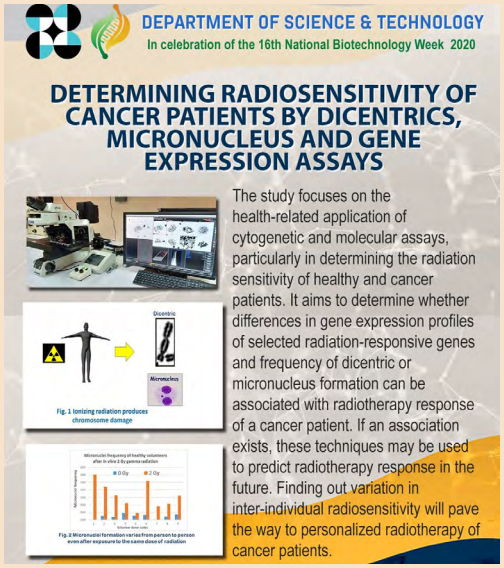



## INTERNATIONAL

| EVENT | DATE AND VENUE / PLATFORM |
|---|---|
| International Youth Nuclear Congress | 8-13 March / Sydney, Australia |
| 64th IAEA General Conference | 21-25 September / Vienna International Centre, Vienna, Austria & Virtual via IAEA Website |



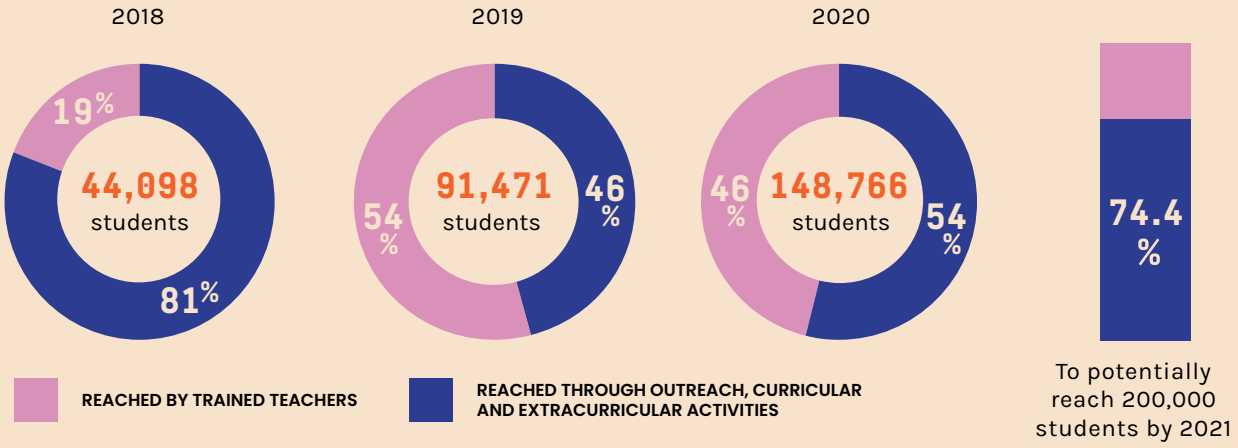


# Educating Secondary Students and Science Teachers on Nuclear S&T

Through the Nuclear Science and Technology Education Program (nSTEp+) for K-12 teachers and students, PNRI together with its partner institutions - the Department of Education, the Philippine Science High School System, and the DOST-Science Education Institute - were able to support, strengthen and sustain nuclear science and technology education in the country by providing opportunities to promote the peaceful uses and applications of nuclear science and technology, as well as enriching the knowledge, skills, and experiences in science of teachers and students.

## NUMBER OF TEACHERS TRAINED IN NST


## POTENTIAL IMPACT




**Number of students reached by trained teachers were computed based on a teacher-student ratio of 1:100.*

## OTHER OUTPUTS

**33**
Lesson exemplars developed by teachers

**10**
Digital education resource materials

**14**
Clients of research support services

**4**
Classroom kits available for teachers

**1**
NST module in DOST-SEI mobile learning facility (NuLab Bus)

# Integrating Nuclear S&T in Philippine Universities

The PNRI continues to succeed in furthering nuclear S&T in tertiary education as the Institute looks forward to bringing back nuclear engineering programs in the academe. In building its networks among members of the academe, the Institute has partnered with top universities that have integrated nuclear-related courses and electives in graduate programs in science and engineering.

## NUCLEAR S&T IN UNIVERSITIES AND COLLEGES

### NUCLEAR ENGINEERING PROGRAMS IN UNIVERSITY OF THE PHILIPPINES DILIMAN AND MAPUA UNIVERSITY

**COLLEGE OF ENGINEERING**

**MSc Energy Engineering Program**

Core Subject: Nuclear Energy (EgyE 225)

SY 2018-2019 – 17 students
SY 2019-2020 – 15 students
SY 2020-2021 – 12 students

**BSc in Chemical Engineering & Mechanical Engineering**

Elective Subject: Nuclear Technology for Engineers (ChE 197)

SY 2019-2020 – 23 students

**BSc in Chemical Engineering**

Elective Track - Nuclear Energy Track (NET)

SY 2020 (NET111) – 17 students
SY 2021 (NET112) – 14 students

### PARTNERSHIP WITH THE COUNTRY'S PREMIER UNIVERSITIES

*Despite the pandemic, the PNRI maintains its collaboration efforts in nuclear S&T education.*

# Technology Transfer and Commercialization

The PNRI connects its research activities and outputs to prospective technology adopters, bringing nuclear and radiation technologies to the Philippine market and closer to the Filipino people.

## TECHNOLOGY TRANSFER

PNRI successfully generated licensing term sheets for two PNRI technologies, as well as agreements for commercialization interests of four other technologies. The Institute also obtained the approval of the Fairness Opinion Board, upon the recommendation of the DOST Office of the Secretary, for the commercialization deal for Technetium-99m generation.

## INTELLECTUAL PROPERTY MANAGEMENT

Applications for intellectual property (IP) protection were filed with the Intellectual Property Office of the Philippines for six PNRI technologies. Further, a total of 35 on-going and completed R&D projects were audited for potential IP generation.

*Researchers from PNRI, headed by Director Dr. Carlo Arcilla (4th from right) join DOST Undersecretary for Research and Development Dr. Rowena Cristina Guevara (3rd from left) and Technology Application and Promotion Institute Director Engr. Edgar Garcia (3rd from right) during the launching of Project HIRANG (Honing Innovation, Research, Agreements and Negotiations of Government-Funded Technologies) at Hotel Jen, Pasay City on January 27, 2020*

*Note: Photo taken before the imposition of quarantine and health safety requirements*

# Information Technology and Network Systems

For 2020, the PNRI identified various strategic activities for the Institute to complement and improve its services to its personnel and staff and public clients. PNRI's IT technical support team has continuously proven to provide timely services in terms of information systems development and maintenance, local area network, internet and intranet services and IT Helpdesk activities.

## DEVELOPMENT OF INFORMATION SYSTEMS

The Institute saw a stronger need for remote online platforms to enable the staff to carry out all office operations and client services as usual. The IT technical support team responded to this demand by enhancing the PNRI Online Services Portal and developing three new online platforms, while continuing to maintain 22 other information systems.

The **PNRI Online Services Portal** was turned into a single take-off point for clients availing PNRI services in the new normal. The Portal now includes five new modules for laboratory and regulatory services:

| | |
|---|---|
|  | **NATALab Online Module**<br>For nuclear analytical services of the Nuclear Analytical Techniques Application Section |
|  | **ISS Online Module**<br>For services offered by the Irradiation Services Section in its Cobalt-60 Multipurpose Irradiation Facility and Electron Beam Irradiation Facility |
|  | **RPSS Online Module**<br>For survey equipment calibration, hazard monitoring, and other services of the Radiation Protection Services Section |
|  | **NRD Online Application Module**<br>For scheduling appointments for regulatory services handled by the Nuclear Regulatory Division such as license application, renewal, or amendment, and permit to transport radioactive materials |
|  | **ARD Online Appointment Module**<br>For booking appointments for microbiological analysis and cytogenetic analysis performed by the Biomedical Research Section |

MISS also started to develop the following platforms in 2020:

**e-Licensing**

A system for the Licensing, Review, and Evaluation Section's processing of requests for license application, renewal, and amendment services

**RPMS Calibration Module**

A module deployed within the Radiation Protection Management System (RPMS) to handle the processing of the calibration services of the Radiation Protection Services Section

Development and customization of the following platforms were also completed in the same year:

**Daily Online Health Check**

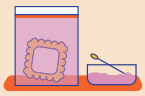
A website for recording and monitoring the health status of all PNRI staff, whether they were working from home or on-site. The system serves as a decision-making tool for managing the Institute's COVID-19 response among its staff.

**Website for the System for Online Monitoring of Environmental Radiation (SOMER)**

A dashboard dedicated to present real-time data from all SOMER stations across the Philippines

**Permit to Transport System**

A web-based application for the Inspection and Enforcement Section's issuance of permits and monitoring of the transport of radioactive materials



**RPMS Swipe Sample / Leak Test / Survey Rental Module**

A module within the RPMS used for services in swipe checks, leak tests, and survey rentals of the RPSS

**Integrated Library System**

An information system for managing the PNRI Library's operations, customized with modules for the online catalog, collections inventory, and client services

## NETWORK INFRASTRUCTURE AND INTERNET AND INTRANET SERVICES

To provide seamless and continuous flow of information within and outside the Institute, PNRI upgraded its network facilities, equipment and services and monitoring tools that effectively manage the PNRI Local Area Network cloud infrastructure, and Internet and Intranet services.

## IT HELPDESK SERVICES

**191**

**TOTAL NUMBER OF DOCUMENTED SERVICES PROVIDED TO CLIENTS**

S&T

# Linking and Networking

The Institute's strong linkages and networks are vital in furthering its mandate, as most of its projects receive support from various local and international organizations, particularly the International Atomic Energy Agency. PNRI also closely coordinates with other government agencies, academic and scientific institutions, and the private sectors to mutually enhance their capabilities in nuclear science and technology.

# Local and International S&T Networking

## LOCAL S&T NETWORKING

To further its mandate and enhance capabilities in nuclear science and technology, PNRI implements its various activities in partnership with various government agencies, medical institutions and scientific organizations, the academe and the private sector which include the following:

| | |
|---|---|
| Ateneo De Manila University | Luzon Agricultural Research and Extension Center in Floridablanca, Pampanga |
| Bureau of Customs | Manila Observatory |
| Civil Aviation Authority of the Philippines | National Disaster Risk Reduction |
| Coca Cola Philippines | Management Coordinating Council (NDRRMC) and member agencies of the National Radiological Emergency Preparedness and Response Plan (RADPLAN) |
| Davao City Water District | National Bureau of Investigation |
| De La Salle University – Dasmariñas, Cavite | National Kidney and Transplant Institute |
| Department of Agriculture | National Power Corporation |
| - Bureau of Animal Industry | National Water Resources Board |
| - Bureau of Fisheries and Aquatic Resources | Pampanga State Agricultural University |
| - Bureau of Soils and Water Management | Partnership for Clean Air, Inc. |
| - Cagayan Valley Research Center | Philippine Heart Center |
| - Central Visayas – Agricultural Training Institute | Philippine Rice Research Institute |
| - National Meat Inspection Service | Philippine Drug Enforcement Agency |
| - Northern Mindanao Agricultural Crops and Livestock Research Complex | Philippine Society for Nondestructive Testing, Inc. |
| - Regional Offices | St. Luke's Medical Center |
| Department of Education | Sugar Regulatory Administration |
| Department of Energy | Surigao Del Sur State University – Cantilan Campus |
| Department of Environment and Natural Resources– Environmental Management Bureau | United Nations Development Programme Philippines |
| Department of Health | University of the Philippines Diliman |
| Department of Science and Technology (DOST) and DOST Councils, Research and Service Institutes | University of Santo Tomas |
| Department of Education, Division of City Schools, National Capital Region | |
| Heart Center of the Philippines | |
| Jose Reyes Memorial Medical Center | |

## FOREIGN S&T NETWORKING

The Philippines, through the PNRI, continues to strengthen its collaboration with the International Atomic Energy Agency and other foreign scientific institutions including the following:

| | |
|---|---|
| Argonne National Laboratory, USA | Korea Advance Institute of Science and Technology |
| Asian Network for Education in Nuclear Technology | Korea Atomic Energy Research Institute |
| ASEAN Network of Regulatory Bodies | Korea Institute of Nuclear Safety |
| Asian Nuclear Safety Network | Ministry of Education, Culture, Sports, Science and Technology of Japan |
| Australian Nuclear Science and Technology Organization | National Nuclear Security Administration, USA |
| Comprehensive Nuclear Test Ban Treaty Organization | Nuclear Safety Research Association, Japan |
| Department of Foreign Affairs, Trade and Development of Canada | Regional Cooperative Agreement for Research, Development and Training Related to Nuclear Science and Technology for Asia and the Pacific |
| European Nuclear Safety Training and Tutoring Institute | RCA Regional Office in Korea |
| European Commission / European Union | Rosatom State Atomic Energy Corporation |
| Forum for Nuclear Cooperation in Asia, Japan | Texas A&M University |
| Hirosaki University, Japan | United States Department of Energy |
| International Atomic Energy Agency | United States National Nuclear Security Administration |
| Japan Atomic Energy Agency | University of Tokyo, Japan |
| - Nuclear Human Resource Development Center | Wakasa-Wan Energy Research Center, Japan |
| - Nuclear Safety Research Association | |

**8**
IAEA RESEARCH CONTRACTS

**43**
IAEA TECHNICAL COOPERATION PROJECTS


**59**
PNRI PERSONNEL

**1**
IAEA EXPERT MISSION DELEGATE

**1**
HOSTING OF REGIONAL WORKSHOP

**25**
NON-PNRI PERSONNEL

participated in traditional and virtual trainings and fellowship grants hosted by foreign institutions/agencies

# IAEA Research Contracts

## PHILIPPINE NUCLEAR RESEARCH INSTITUTE

| TITLE / DESCRIPTION OF RESEARCH | NAME OF RESPONSIBLE AGENCY STAFF |
|---|---|
| Development of Handling, Transport, Release and Trapping Methods of Dengue Mosquito Vector *Aedes aegypti* in the Philippines | Sotero Resilva |
| Collection and Analysis of Radiation Detection Data for Alarming Containers | Ma. Teresa Salabit |
| Assessment of the Levels, Distribution and Effects of Natural and Anthropogenic Radionuclides in the Philippine Marine Environment | Eliza Enriquez |
| Application of Cytogenetic Biodosimetry in Determining Radiosensitivity of Cancer Patients | Celia Asaad |
| Radiation-Induced Synthesis of Nanostructured Materials for Analytical Application | Jordan Madrid |
| Synthesis of Heterogenous Catalyst from Radiation-Synthesized Graft Copolymer for Cocomethyl Ester Production | Lucille Abad |
| Irradiation, Sterilization and Quality Control of Dengue Mosquito, *Aedes aegypti* in the Philippines | Glenda Obra |

## FOOD AND NUTRITION RESEARCH INSTITUTE

| TITLE / DESCRIPTION OF RESEARCH | NAME OF RESPONSIBLE AGENCY STAFF |
|---|---|
| Measurement of Breast Milk Intake Among Filipino Urban Children Aged 12-18 Months to Estimate Vitamin A Intake Amidst Multiple Large Scale Vitamin A Programs | Carl Cabanilla |

# IAEA Technical Cooperation Projects

## NATIONAL TECHNICAL COOPERATION PROJECTS

| TITLE / DESCRIPTION OF RESEARCH | NAME OF CONTACT PERSON |
|---|---|
| Building Capacity for the Safe Operation and Utilization of the Research Reactor's Subcritical Assembly for Training, Education and Research | Alvie Astronomo<br>PNRI |
| Establishing A Graduate Program in Nuclear Science, Engineering and Management for Accelerated Utilization of Nuclear Applications | Ana Elena Conjares<br>PNRI |
| Enhancing the Utilization of the Fully Automated Philippine Nuclear Research Institute Gamma Irradiation Facility | Haydee Solomon<br>PNRI |
| Enhancing Bench-scale Simulation for the Development of Continuous Extraction Technology of Uranium and Other Valuable Elements from Phosphates - Phase II | Jennyvi Ramirez<br>PNRI |
| Developing Nuclear Energy Infrastructure | Assistant Secretary Leonido J. Pulido III<br>DOE |
| Applying Nuclear Techniques in the Attenuation of Flood and Natural Disaster-Borne Contamination | Raymond Sucgang<br>PNRI |
| Advancing Laboratory Capabilities to Monitor Veterinary Drug Residues and Related Contaminants in Foods | Hernando Tipa<br>Bureau of Animal Industry |

## REGIONAL AGREEMENTS PROJECTS

| TITLE / DESCRIPTION OF RESEARCH | NAME OF CONTACT PERSON |
|---|---|
| Enhancing the Management and Implementation of Activities under the Framework (RCA) | Carlo Arcilla<br>PNRI |
| Strengthening Regional Capacity in Non-Destructive Testing and Examination Using Nuclear and Related Techniques for Safer, Reliable, More Efficient and Sustainable Industries Including Civil Engineering (RCA) | Renato Bañaga<br>PNRI |
| Promoting the Application of Mutation Techniques and Related Biotechnologies for the Development of Green Crop Varieties (RCA) | Ana Maria Veluz<br>PNRI |
| Enhancing Food Safety and Supporting Regional Authentication of Foodstuffs through Implementation of Nuclear Techniques (RCA) | Raymond Sucgang<br>PNRI |
| Assessing and Improving Soil and Water Quality to Minimize Land Degradation and Enhance Crop Productivity Using Nuclear Techniques (RCA) | Efren Sta. Maria<br>PNRI |
| Promoting Food Irradiation by Electron Beam and X Ray Technology to Enhance Food Safety, Security and Trade (RCA) | Celia Asaad<br>PNRI |

| TITLE / DESCRIPTION OF RESEARCH | NAME OF RESPONSIBLE AGENCY STAFF |
|---|---|
| Enhancing Crop Productivity and Quality through Mutation by Speed Breeding (RCA) | Fernando Aurigue<br>PNRI |
| Strengthening Cancer Management Programmes in RCA States Parties through Collaboration with National and Regional Radiation Oncology Societies (RCA) | Miriam Calaguas<br>St. Luke's Medical Center |
| Enhancing Medical Physics Services in Developing Standards, Education and Training through Regional Cooperation (RCA) | Jonathan Corpuz<br>Southern Mindanao Medical Center |
| Strengthening Capacity to Manage Non-Communicable Diseases Using Imaging Modalities in Radiology and Nuclear Medicine (RCA) | Dr. Asela Barosso<br>Dela Salle Medical<br>and Health Sciences Institute<br>University Medical Center |
| Empowering Regional Collaboration among Radiotherapy Professionals through Online Clinical Networks (RCA) | Nonette Cupino<br>UP PGH |
| Enhancing Capacity and Capability for the Production of Cyclotron-Based Radiopharmaceuticals (RCA) | Adelina Bulos<br>PNRI |
| Enhancing Regional Capabilities for Marine Radioactivity Monitoring and Assessment of the Potential Impact of Radioactive Releases from Nuclear Facilities in Asia-Pacific Marine Ecosystems (RCA) | Eliza Enriquez<br>PNRI |
| Assessing the Vulnerability of Coastal Landscapes and Ecosystems to Sea-Level Rise and Climate Change (RCA) | Angel Bautista VII<br>PNRI |
| Enhancing Regional Capability for the Effective Management of Ground Water Resources Using Isotopic Techniques (RCA) | Norman Mendoza<br>PNRI |
| Enhancing Wetland Management and Sustainable Conservation Planning (RCA) | Raymond Sucgang<br>PNRI |
| Strengthening the Capacity to Respond to Radiological Emergencies of Category II and III Facilities (RCA) | Alvie Astronomo<br>PNRI |

## REGIONAL NON-AGREEMENT PROJECTS

| TITLE / DESCRIPTION OF RESEARCH | NAME OF RESPONSIBLE AGENCY STAFF |
|---|---|
| Educating Secondary Students and Science Teachers on Nuclear Science and Technology | Jasmine Angelie Albelda<br>PNRI |
| Promoting Self-reliance and Sustainability of National Nuclear Institutions | Haydee Solomon<br>PNRI |
| Harnessing Nuclear Science and Technology for the Preservation and Conservation of Cultural Heritage | Neil Raymund Guillermo<br>PNRI |
| Developing and Upscaling of Radiation Grafted Materials for Water Treatment | Jordan Madrid<br>PNRI |

| TITLE / DESCRIPTION OF RESEARCH | NAME OF RESPONSIBLE AGENCY STAFF |
|---|---|
| Reutilizing and Recycling Polymeric Wastes through Radiation Modification for the Production of Industrial Goods | Jordan Madrid<br>PNRI |
| Managing and Controlling Aedes Vector Populations Using the Sterile Insect Technique | Glenda Obra<br>PNRI |
| Promoting the Preparation of Emerging Radiopharmaceuticals for Positron Emission Tomography-Base Molecular Imaging and Radionuclide Therapy | Glenda Obra<br>PNRI |
| Managing and Controlling Aedes Vector Populations Using the Sterile Insect Technique | Adelina Bulos<br>PNRI |
| Enhancing the Management of Non-Communicable and Communicable Diseases through Capacity Building under the IAEA Curricula for Nuclear Medicine Professionals | Eduardo Ongkeko<br>St. Luke's Medical Center |
| Using Stable Isotope Techniques to Monitor Situations and Interventions for Promoting Infant and Young Child Nutrition - Phase II | Carl Cabanilla<br>FNRI |
| Enhancing the Radioactive Waste Management Infrastructure in the Asia Pacific | Ronald Piquero<br>PNRI |
| Strengthening Radiation Safety Infrastructure | Alan Borras<br>PNRI |
| Establishing Sustainable Education and Training Infrastructures for Building Competence in Radiation Protection | Ana Elena Conjares<br>PNRI |

## INTERREGIONAL PROJECTS

| TITLE / DESCRIPTION OF RESEARCH | NAME OF RESPONSIBLE AGENCY STAFF |
|---|---|
| Supporting Capacity Building in Member States for Uranium Production and Safety of Naturally Occurring Radioactive Material Residue Management Member States for Uranium Production and Safety of Naturally Occurring Radioactive Material Residue Management | Jennyvi Ramirez<br>PNRI |
| Contributing to the Evidence Base to Improve Stunting Reduction Programmes | Amster Fe Baquira<br>FNRI |
| Strengthening Capacity for Cervical Cancer Control through Improvement of Diagnostic and Treatment | Miriam Calaguas<br>St. Luke's Medical Center |
| Supporting Member States to Increase Access to Affordable, Equitable, Comprehensive Cancer System | Ma. Elsie M. Dimaano<br>Batangas Provincial Cancer Center,<br>Batangas Medical Center |
| Sustaining Cradle to Grave  Control of Radioactive Materials - Phase II | Carl Nohay<br>PNRI |

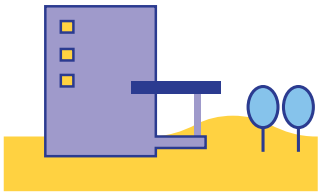
# PNRI-Hosted Event

| FIELD | PHILIPPINE PARTICIPANTS | AGENCY / INSTITUTE | ORGANIZER / VENUE / DATE |
|---|---|---|---|
| IAEA/RCA Workshop on Radiological Dose Assessment | Virgina Gruyal<br>Judelyn Patero<br>Rosario Encabo<br>Antonio Bonga<br>Christopher Mendoza | Surigao del Sur State University<br><br>PNRI | IAEA<br>Novotel Manila Araneta, Quezon City<br><br>24-28 February |

*Note: Photo taken before the imposition of quarantine and health safety requirements*

# FNCA Projects

| TITLE / DESCRIPTION OF RESEARCH | NAME OF CONTACT PERSON |
|---|---|
| Mutation Breeding of Major Crops for Low-input Sustainable Agriculture under Climate Change | Fernando Aurigue<br>PNRI |
| Radiation Processing and Polymer Modification for Agricultural, Environmental and Medical Applications Project | Lucille Abad<br>PNRI |
| Biofertilizer Project | Juliet Anarna<br>UPLB Biotech |
| Research on Climate Change using Nuclear and Isotopic Techniques | Angel Bautista VII<br>PNRI |
| Radiation Oncology Project | Miriam Joy Calaguas<br>St. Luke's Medical Center |
| Research Reactor Utilization Project | Neil Raymund Guillermo<br>PNRI |
| Radiation Safety and Radioactive Waste Management Project | Kristine Marie Romallosa<br>PNRI |
| Nuclear Security and Safeguards (Philippine Research Reactor-1, PNRI) | Ma. Teresa Salabit<br>PNRI |



# Special S&T Events

PNRI actively participates in local and international events on science and technology to engage the youth, industry partners, policymakers, and other stakeholders in promoting the wide-range potential of the atom in various sectors such as food and agriculture, health and medicine, environment, industry, and power generation.

# 64th IAEA General Conference


DOST Secretary Fortunato de la Peña officially headed the Philippine Delegation during the opening of the 64th International Atomic Energy Agency (IAEA) General Conference on September 21, 2020 in Vienna, Austria to represent the country's recent strides towards Atoms for Peace and Development.

Secretary de la Peña in his pre-recorded address to the plenary session, highlighted the current developments in nuclear and radiation technology applications in the Philippines. He cited the importance of isotope tracer techniques for food authentication and groundwater studies, upgrading of irradiation facilities, and integration of nuclear education in secondary, undergraduate, and graduate academic programs.

The DOST Secretary acknowledged the role of nuclear science and technology in fighting against COVID-19 pandemic and thanked the IAEA for its assistance to the country. The Philippines is one of the member states that was provided by the agency with advanced Reverse Transcription-Polymerase Chain Reaction (RT-PCR) machines and related diagnostic equipment including laboratory supplies for COVID-19 virus detection.

In his address, the Secretary also lauded the recent signing of Executive Order 116 directing the study adopting a national position for a nuclear energy program.


*Secretary de la Peña delivers his pre-recorded statement at the plenary of the 64th IAEA General Conference*


*Ambassador to Austria and Permanent Representative to the IAEA, Maria Cleofe Natividad, attends the plenary of the conference in person as the alternate head of the delegation. (Photo from the Philippine Embassy in Austria)*

# The Philippines at the International Youth Nuclear Congress


The Philippines through members of the Philippine Young Generation in Nuclear (PYGN) participated in this year's International Youth Nuclear Congress in Sydney, Australia. Researchers from the Institute and University of the Philippines Diliman served as presenters and demonstrated the progress of nuclear S&T in the country through various technical presentations.

The Philippines officially became a member of the IYNC in January 2019 through the PYGN, an independent organization composed of students and young professionals aged 16-40 years old. PYGN aims to promote the beneficial applications of nuclear science and technology to the Filipino youth. This is the first time for the country to attend the IYNC after becoming an official member of the international network.



*Note: Photos taken before the imposition of quarantine and health safety requirements*

# Atomic Energy Week

As mandated under Presidential Proclamation No. 1211 in 1973, the DOST-PNRI celebrated the 48th Atomic Energy Week to help generate awareness of the Filipinos on the beneficial uses of nuclear science and technology in food, agriculture, industry, medicine, and the environment.

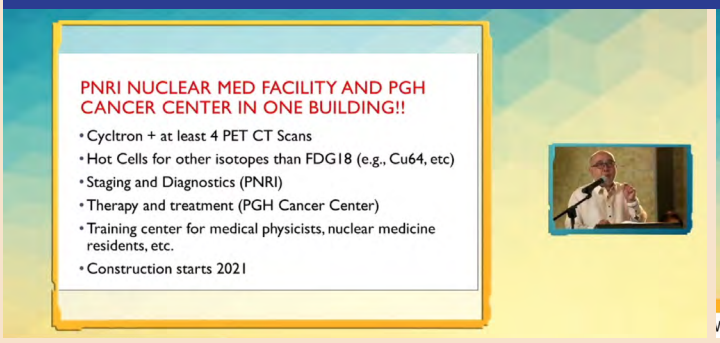
## OPENING CEREMONIES







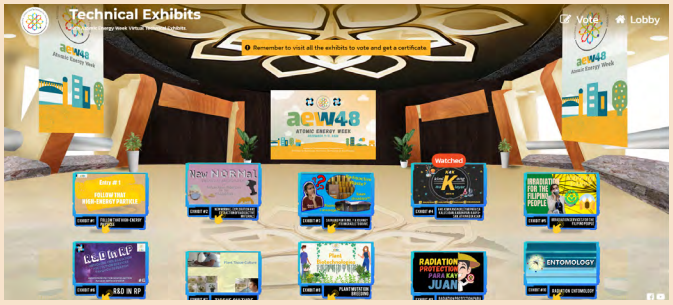
## VIRTUAL PRESSER






## TECHNICAL EXHIBITS AND VIRTUAL TOUR









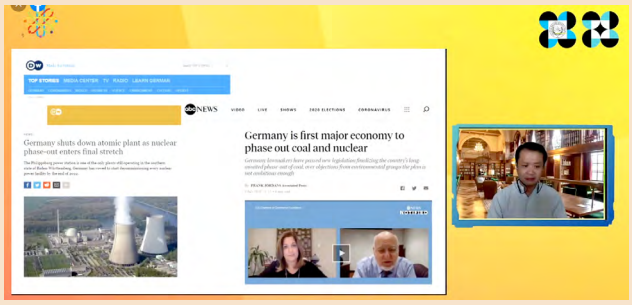
## PHILIPPINE NUCLEAR RESEARCH AND DEVELOPMENT CONFERENCE

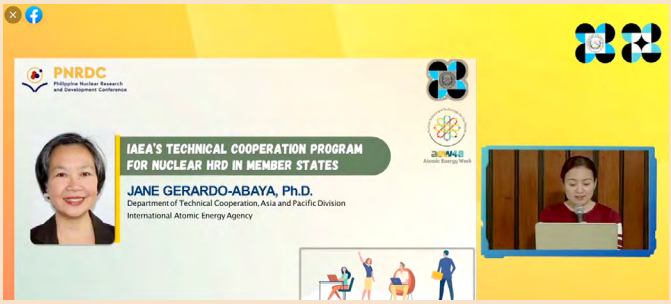

## CLOSING CEREMONIES

# Philippine Nuclear Research and Development Conference

The Philippine Nuclear Research and Development Conference (PNRDC) is a biennial event that brings together researchers in the nuclear field to present their respective studies, providing a glimpse of the latest developments in the nuclear science and technology community.

This year, the PNRDC, held during the 48th Atomic Energy Week celebration, brought together authors from all over the Philippines, as well as from Germany, Myanmar, Japan, South Korea, Thailand, Australia, and the United States, and served as a platform for 73 paper presentations on radiation protection, nuclear waste management, environment, theoretical and computational studies, nuclear engineering, health, education, policy, and radiation processing.


# Nuclear Video Making Contest

In celebration of the 48th Atomic Energy Week, the Nuclear Training Center organized a video making contest as a platform for Filipino students to delve into the wonders of nuclear science and technology in the country.

The video entries, illustrating several aspects of nuclear science and its applications, historical significance, and benefits to many sectors of the Philippine society and the world, were submitted by 30 teams of high school students from across the country. The following are the contest winners:

**1ST PLACE**

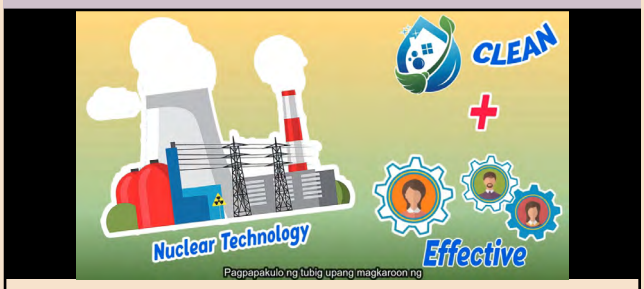

***"A Closer Look"***
Malabon National High School

Paolo Xavier Co
James Sablay
Nicus Charles Villaluna
Rendell Aaron Lateo

**2ND PLACE**

***"The Misunderstood History of Nuclear Energy"***
Malabon National High School

**3RD PLACE**




***"Atomic Energy Week Video Entry ANHS"***
Agusan National High School

**4TH PLACE**


***"Our Step to the Future Atomic World: Application of Nuclear Science and Technology"***
Malabon National High School - Manila

**5TH PLACE**


***"The Nuclear Power"***
Philippine Science High School - Cordillera Administrative Region Campus

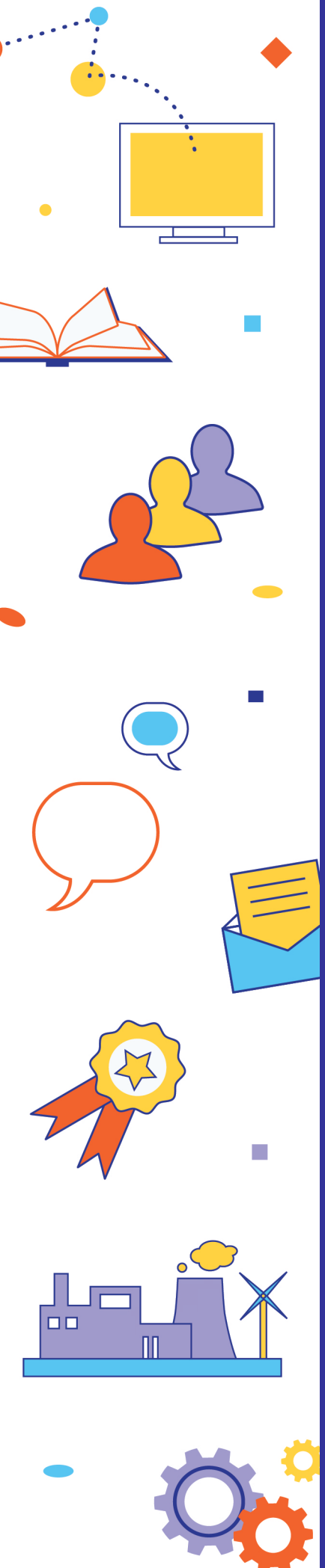
# NuCLEAR Webinar Series


In partnership with the Philippine Young Generation in Nuclear (PYGN), PNRI organized the NuCLEAR Webinar Series which aimed to start conversations on matters commonly misunderstood regarding nuclear power. Both episodes aired on the PYGN and PNRI Facebook Pages in October and in November 2020.

Discussions in Webinar 1, led by Dr. Alvie A. Astronomo, head of Nuclear Reactor Operations Section of PNRI, and Dr. Carlo A. Arcilla, PNRI director, debunked myths and misconceptions on nuclear power by exploring the engineering and operations of nuclear power reactors, as well as their environmental and economic benefits to communities.

Presentations by Department of Energy Assistant Secretary Gerardo D. Erguiza, Jr. and Dr. Arcilla in Webinar 2 contextualized nuclear power within the current energy demands and existing regulations and legal frameworks on nuclear safety and security in the Philippines.

On the PNRI Facebook page, Webinar 1 gained a peak of 2,200 views during the live broadcast and a total of 23,000 views on the same day, while Webinar 2 had a total of 14,000 same-day views and a peak of 1,800 live views during the broadcast. Based on the audience feedback, the webinar viewers were professionals from the private and public sectors and college and high school students from all regions of the country.

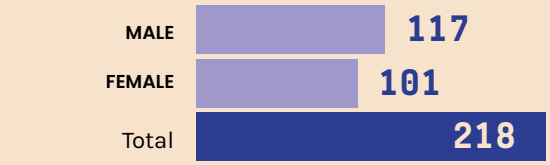
# Human Resources Development

Behind the PNRI's accolades and accomplishments are the competent and dedicated men and women of its workforce. To sustain and continually innovate research and services in nuclear science and technology in improving the Filipino life, the Institute continues to prioritize human resource development consistent with the standards of the Civil Service Commission.

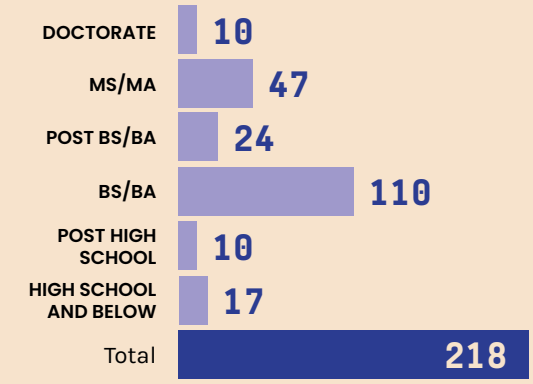
# Distribution of Personnel

## MANPOWER PROFILE 2020

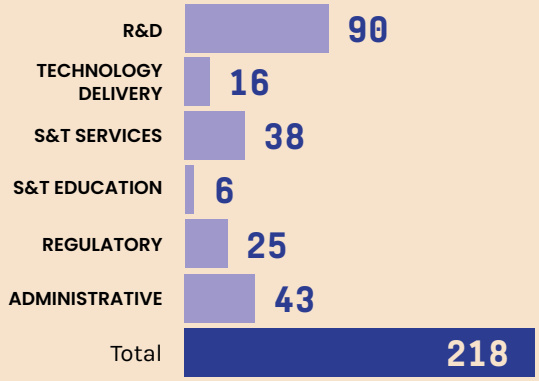
### By Gender



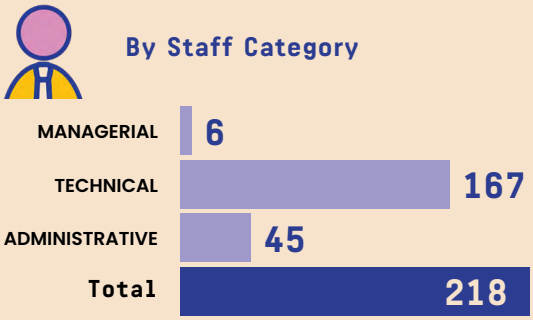

### By Education




### By Staff Activity




### By Staff Category




## MASTER'S DEGREE GRADUATES

| | |
|---|---|
| **Julius Federico M. Jecong**<br>Science Research Specialist II, Applied Physics Research Section, Atomic Research Division<br>***MS in Nuclear and Quantum Engineering***<br>***Korea Advanced Institute of Science and Technology*** | **Bin Jeremiah D. Barba**<br>Science Research Specialist II, Chemistry Research Section, Atomic Research Division<br>***MS in Chemistry***<br>***De La Salle University*** |
| **Cris Reven L. Gibaga**<br>Science Research Specialist I, Nuclear Materials Research Section Atomic Research Division<br>***MS in Geology***<br>***University of the Philippines Diliman*** | **Girlie Eunice P. Lopez**<br>Science Research Specialist I, Applied Physics Research Section, Atomic Research Division<br>***MS in Chemistry***<br>***De La Salle University*** |

| | | | | |
|---|---|---|---|---|
| **11**<br>Ongoing post graduate degrees through local/ foreign scholarships | **14**<br>Nuclear training courses conducted with **441 participants** | **15**<br>Senior high school and college students from **5 schools** on work immersion/on-the-job training at PNRI | **14**<br>Locally-sponsored trainings/seminars/ workshops in various fields participated in by PNRI employees | **62**<br>PNRI personnel and 22 non-PNRI personnel participated in physical and virtual training/ fellowship grants hosted by foreign institutions/agencies |

# National Awards

## PRESIDENTIAL LINGKOD BAYAN AWARD (REGIONAL LEVEL)

*Carrageenan PGP Team: Lucille Abad, Fernando Aurigue, Patrick Jay Cabalar, Francis Cyril Valdez, and Gil Magsino*

Won the Civil Service Commission Presidential Lingkod Bayan Award Regional Level for developing the radiation-processed Carrageenan Plant Growth Promoter that helped increase harvests in farmlands across the country. The project team was also a semifinalist in the national level.

## OUTSTANDING UTILITY MODEL AWARD


*Radiation-Modified Abaca/Polyester Fabric Team: Lucille Abad, Jordan Madrid, and Patrick Jay Cabalar*

Won first place during the National Invention Contest and Exhibits on March 5, 2020 at the SMX Convention Center Aura in Taguig City. PNRI's radiation-modified abaca fabric is a cheaper alternative in filtering toxic materials.

## OUTSTANDING FILIPINO RESEARCHERS

*Lucille Abad and Custer Deocaris*

Recognized for their significant contributions to their respective fields and research advancements that benefited the different sectors of economy under the National Research Council of the Philippines Achievement Awards.

# PNRI Awards

## OUTSTANDING JAPAN SOCIETY FOR THE PROMOTION OF SCIENCE FELLOW

Dr. Lucille Abad was awardee for the field of chemistry/chemical science.

## UTILITY MODEL REGISTRATION AWARD

**Isotope Techniques Section** (Adelina Bulos, Ma. Teresa Borras, and Rommel Mascariñas)

DOST recognition for the successful registration of the "*Method for Pretreating Alumina for Chromatographic Separation in Radionuclide Generator*"

## HIRANG DISTINGUISHED FELLOW AWARD

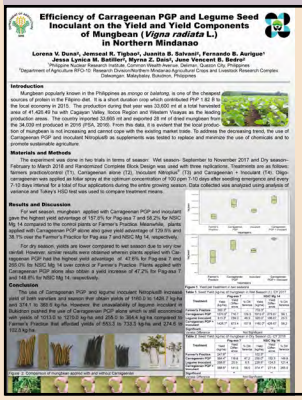

**Gregory Ciocson** (middle) was recognized by DOST-TAPI for his performance in the first program for technology transfer officers of DOST research and development institutes.

## INTERNATIONAL PUBLICATION AWARDS

Awarded **32 PNRI scientists and researchers** who were able to publish researches in internationally recognized journals. The awards were given by the National Academy of Science and Technology during the 5th 2020 DOST Virtual Flag Raising Ceremony

Recognized PNRI as the Institute with the most number of scientific papers among DOST agencies, having published **47 research outputs in international journals in 2020**

## BEST POSTER AWARD


Efficiency of Carrageenan PGP and Legume Seed Inoculant on the Yield and Yield Components of Mungbean (*Vigna radiata* L.) in Northern Mindanao

**"Efficacy of Carrageenan PGP and Legume Seed Inoculant on the Yield of Mungbean (*Vigna radiata* L.) in Northern Mindanao"**

Co-authored by Fernando Aurigue

Won the Best Poster Award at the 2nd Regional Symposium on Research and Development

# PNRI Recognition Awards

The PNRI Program on Awards and Incentives for Service Excellence (PRAISE) recognized employees, individually or by groups, for their inventions, superior accomplishments, and other initiatives which contribute to the efficiency, economy, or improvement in government operations, or for other extraordinary acts or services in the public interest.

## 2020 GAWAD KAGALINGAN AWARD

This award is granted to an individual or team in recognition of innovative ideas and outstanding accomplishment or contributions which resulted to the efficient operations and implementation of the Institute's programs and activities.

**GAWAD KAGALINGAN AWARDEE**

**Management Information Systems Section**

In recognition of the team's innovative strategies for the establishment of a more robust, easily accessible and reliable online platforms for the Institute during the COVID-19 pandemic.

**1ST RUNNER-UP**

**Nuclear Reactor Operations Section**

In recognition of the team's remarkable improvement in establishing the Philippine Research Reactor-1 Subcritical Assembly for Training, Education, and Research (PRR-1 SATER).

## DIVISION AWARDEES

This award is given to employees for their achievements, exceptional or outstanding performance, dedication, and valuable contributions in support of the goals of the Institute, and for contributing greatly to the accomplishment of the division's functions and goals.

**OUTSTANDING SENIOR TECHNICAL STAFF**

Nuclear Services Division

**Kristine Marie D. Romallosa**

Supervising Science Research Specialist, Radiation Protection Services Section

**OUTSTANDING JUNIOR TECHNICAL STAFF**

Technology Diffusion Division

**Sunrise B. Galan**

Science Research Specialist I, Management Information System Section

**OUTSTANDING SENIOR ADMINISTRATIVE STAFF**

Financial Administrative Division

**Joanrose N. Villanueva**

Administrative Officer I, Cash Section

**OUTSTANDING JUNIOR ADMINISTRATIVE STAFF**

Financial Administrative Division

**Luzviminda B. Muyco**

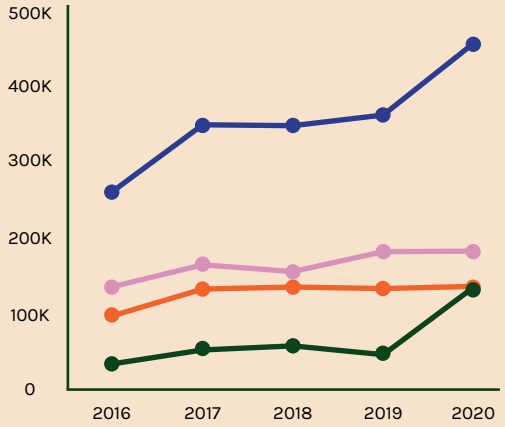
Administrative Assistant V, Property and Procurement Section

# Financial Resources

This year, PNRI had a budget allotment of PHP 455,126,000.00 by class and PHP 152,264,000.00 by major final output. The Institute generated an annual income of PHP 27,507,442.50 from licensing fees and the Institute's nuclear and allied services, among others. Additional resources were also generated through local and foreign-funded projects on nuclear science and technology applications.

# Annual PNRI Budget

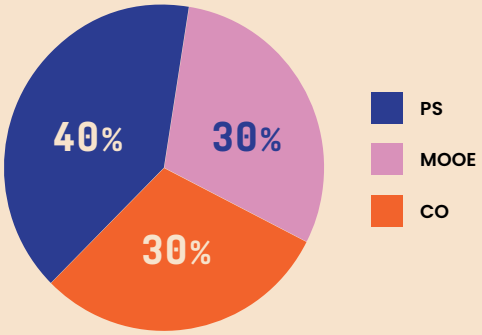
*(in PhP)*



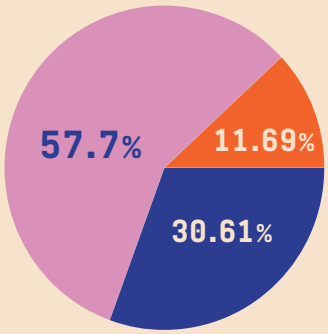

| YEAR | PS | MOOE | CO | TOTAL |
|---|---|---|---|---|
| 2016 | 131,949,000 | 93,839,000 | 30,865,000 | 256,653,000 |
| 2017 | 163,348,000 | 132,858,000 | 49,872,000 | 346,078,000 |
| 2018 | 153,645,000 | 135,809,000 | 55,443,000 | 344,897,000 |
| 2019 | 182,185,000 | 133,576,000 | 43,435,000 | 359,196,000 |
| 2020 | 182,909,000 | 136,760,000 | 135,457,000 | 455,126,000 |

Legend: **PS** (Personnel Services) **MOOE** (Maintenance & Other Operating Services) **CO** (Capital Outlay) **TOTAL**

## 2020 ALLOTMENT BY EXPENSE CLASS




## 2020 EXPENDITURES BY MAJOR FINAL OUTPUT (MFO)




**MFO1** 46,607,000.00 Scientific Research and Development

**MFO2** 87,863,000.00 Technical Advisory Services

**MFO3** 17,794,000.00 Nuclear Regulatory Services

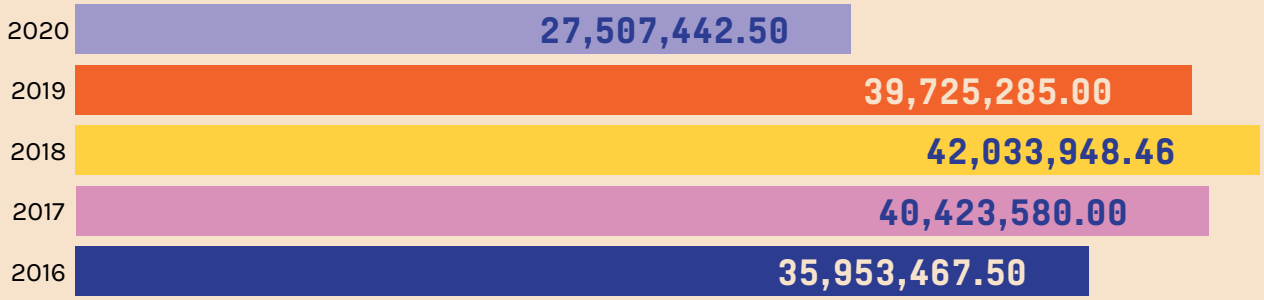
**TOTAL: 152,264,000.00**

## ADDITIONAL RESOURCES GENERATED FROM EXTERNAL SOURCES

| GRANT | AMOUNT |
|---|---|
| Local Grants-in-Aid | 57,103,206.84 |
| Foreign Grants | 2,792,810.00 |
| **Total** | **59,896,016.84** |

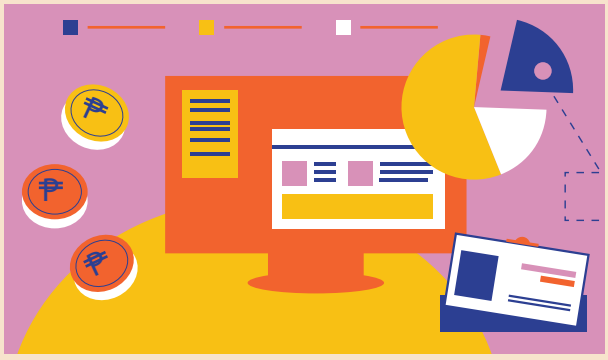
# Income from PNRI Services

*(in PhP)*




| SOURCE OF INCOME | INCOME GENERATED |
|---|---|
| A. PERMITS & LICENSES | 3,292,487.50 |
| Licensing Fees | 1,130,487.50 |
| Licensing Fees | 78,500.00 |
| Surcharge | 153,312.50 |
| Licensing Renewal | 232,550.00 |
| Licensing Amendment | 666,125.00 |
| Permit Fees | 2,162,000.00 |
| Transport Certificate | 1,963,000.00 |
| Release Certificate | 191,500.00 |
| Certificate of Exemption | 7,500.00 |
| B. SERVICE INCOME | 24,162,505.00 |
| Inspection Fees | 258,000.00 |
| Fines & Penalties | 194,650.00 |
| Other Service Income | 23,709,855.00 |
| Radiation Protection Services | 20,840,280.00 |
| ■ Monitoring films/OSL/TLD and Cassettes | 17,756,716.00 |
| ■ Calibration | 1,958,750.00 |
| ■ Leak Test/Spent-Sealed Sources | 15,700.00 |
| ■ Swipe Test | 714,400.00 |
| ■ Radiation Monitoring/ Hazards Evaluation | 19,050.00 |
| ■ Rental of Survey Meter | 180,864.00 |
| ■ Rental of Moisture Density Guage | 184,800.00 |
| ■ Repair of Survey Meter | 10,000.00 |
| Gamma Irradiation Services | 553,290.00 |
| Radioactivity Analysis | 1,659,100.00 |
| ■ Gammametric Analysis | 149,600.00 |
| ■ Gross Alpha-beta Analysis | 1,509,500.00 |

| SOURCE OF INCOME | INCOME GENERATED |
|---|---|
| Radioactive Waste Management | 151,000.00 |
| Biological Test | 62,085.00 |
| ■ Cytogenetic Analysis | 5,250.00 |
| ■ Sterility Test | 17,400.00 |
| ■ Aerobic Plate Count | 39,435.00 |
| Radioanalytical and Related Tests | 194,100.00 |
| ■ Vinegar Adulteration | 30,200.00 |
| ■ Radon Analysis | 150,400.00 |
| ■ Elemental Analysis | 13,500.00 |
| Traces Technique Services | 250,000.00 |
| C. BUSINESS INCOME | 52,450.00 |
| Other Business Income | 52,450.00 |
| Sale of CPR Compilation (Specific Part)/Infopac | 400.00 |
| Use of Dose Calibrator | 37,050.00 |
| Miscellaneous | 15,000.00 |
| TOTAL INCOME | 27,507,442.50 |



# Additional Resources Generated from External Sources

| PROJECT TITLE | PROJECT LEADER | AMOUNT | | FUNDING AGENCY |
|---|---|---|---|---|
| | | LOCAL | FOREIGN | |
| Building Capacity for the Safe Operation and Utilization of the Research Reactor's Subcritical Assembly for Training, Education and Research | Eliza Enriquez | | 221,989.00 | CRP-IAEA |
| Synthesis of Heterogenous Catalyst from Radiation Synthesized Graft Copolymer for Cocomethyl Ester Production | Jordan Madrid | | 220,197.00 | CRP-IAEA |
| Irradiation, Sterilization, and Quality Control of Dengue Mosquito, *Aedes aegypti* in the Philippines | Glenda Obra | | 320,129.00 | CRP-IAEA |
| Radiation-induced Synthesis of Nanostructured Materials for Analytical Application | Jordan Madrid | | 215,444.00 | IAEA |
| Collection and Analysis of Radiation Detection Data for Alarming Containers | Ma. Teresa Salabit | | 282,250.00 | IAEA |
| Mutation Breeding of *Alocacia* (*Araceae*) and other Aroids through Gamma Irradiation and Chemical Treatments (Colchine/EMS) | Jorge Sahagun | 2,640,729.00 | | PCAARRD |
| Characterization and Resource Estimation of Valuable Rare Earth Elements (REEs) and Natural Radionuclides in the Philippine Coal and Feldspar Deposits | Cris Reven Gibaga | 5,000,001.00 | | PCIEERD |
| Development of Novel Nanomedicine (Redox Nanoparticles) for the Protection of Radiotherapy Patients and Nuclear Workers | Chitho Feliciano | 6,775,738.40 | | DOST |
| Development of an Animal Model for Use in Radiation Research and Establishment of the Radiation Biology Research Center: Core Facility for Radiobiological Research | Chitho Feliciano | 10,687,150.00 | | PCHRD |
| The Use of Radon Technique in Mapping Geological Faults in the Philippines | Angelito Ramos | 1,621,353.00 | | PCIEERD |
| Assessing the Naturally Occurring Radioactive Materials (NORM) of Soils in the Rice Fields of Aliaga and Bongabon in Nueva Ecija | Arvin Jagonoy | 833,534.32 | | PCAARRD |
| Screening for Radionuclide Contamination from the Fukushima Accident by Iodine-129 Measurement in Corals from the Philippines | Angel Bautista VII | 2,247,559.00 | | PCAARRD |
| Assessment of Groundwater Dynamics and Water Quality in the East Zone Area using Isotope and Nuclear Techniques | Norman Mendoza | 5,234.433.00 | | MWCI |

| PROJECT TITLE | PROJECT LEADER | AMOUNT | | FUNDING AGENCY |
|---|---|---|---|---|
| | | LOCAL | FOREIGN | |
| DOST-Japan Society for the Promotion of Science (JSPS) Joint Research Program Preparation of Crown Ethers and a-aminophosphates Decorated Natural Fibers-based Hybrids Metal Ion Absorbents by Fusing Multicomponent-reaction and Radiation Grafting | Jordan Madrid | 343,810.00 | | PCIEERD |
| Development of a Column-packed Adsorbent for Chrome Recovery from Tanning Wastewater | Jordan Madrid | 9,000,000.00 | | PCIEERD |
| Enhancing Onelab for Global Competitiveness – RDI Component | Preciosa Corazon Pabroa | 3,503,362.00 | | PCIEERD |
| Single Laboratory Validation of Isotope-Based Toxicity Assay for the Detection and Quantification of Cigatuera Fish Poisoning (CFP) Toxin in Commercially Available Philippine Reef Fishes | Ma. Llorina Mestizo | 1,113,335.00 | | PCAARRD |
| Upgrading of PNRI Cytogenetic Biological Dosimetry Capability for Nuclear Incident Preparedness and Other Health-Related Services | Celia Asaad | 864,866.00 | | PCHRD |
| Application of Radiation Techniques in the Geochemical Characterization of Cobalt and other Valuable Metals in the Selected Philippine Metallic Deposits | Cris Reven Gibaga | 3,438,954.00 | | PCIEERD |
| Development of Biodegradable Super Water Absorbents for Agricultural Application | Lucille Abad | 1,768,645.00 | | PCAARRD |
| Extraction of Radionuclides, Rare Earths and other Valuable Industrial Elements for Phosphogypsum Tailings | Jennyvi Ramirez | 769,728.12 | | PCIEERD |
| | Total: | **55,843,197.84** | **1,260,009.00** | |

## FUNDING AGENCIES

**CRP-IAEA**
Coordinated Research Project – International Atomic Energy Agency

**DOST**
Department of Science and Technology

**PCHRD**
Philippine Council or Health Research and Development

**PCIEERD**
Philippine Council for Industry, Energy, and Emerging Technology Research and Development

**PCAARRD**
Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development

**MWCI**
Manila Water Company, Inc.

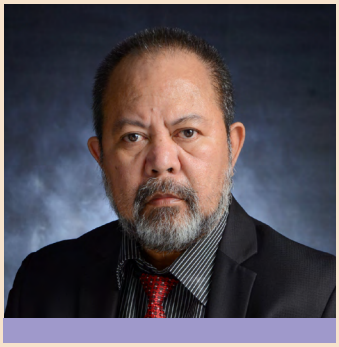
# PNRI Officials

**Carlo A. Arcilla, PhD**
Director

**Soledad S. Castañeda, PhD**
Deputy Director

**Lucille V. Abad, PhD**
Chief, Atomic Research Division

**Preciosa Corazon B. Pabroa, PhD**
Chief, Nuclear Services Division

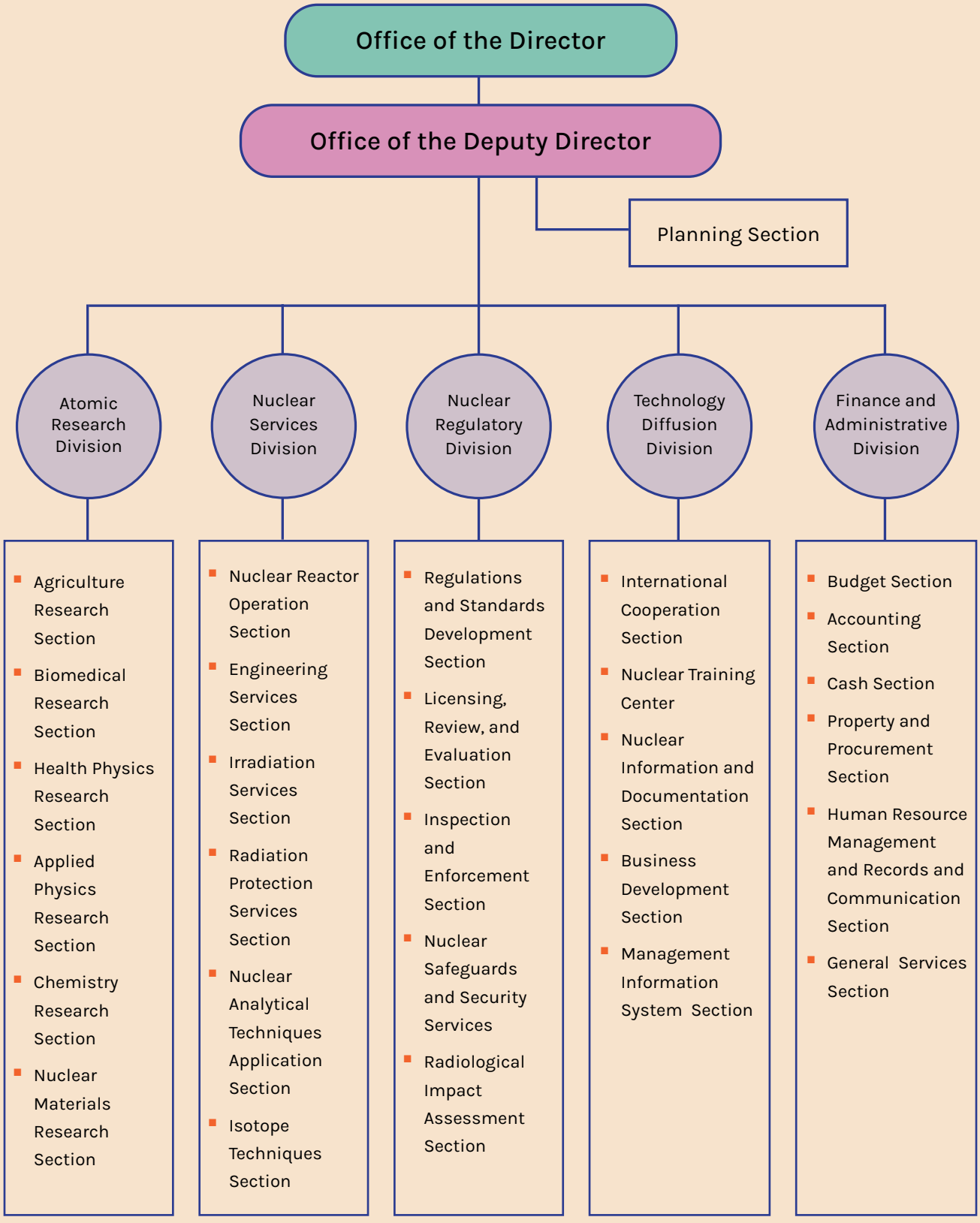


**Alan M. Borras, MSc**
Chief, Nuclear Regulatory Division

**Ana Elena L. Conjares, MSc**
Chief, Technology Diffusion Division

**Maria Celerina M. Ramiro, MEM**
Chief, Finance and Administrative Division

# PNRI Organizational Chart



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