PNRI – RDC 2018

The 1st Philippine Nuclear Research Institute – Research and Development Conference

1st PNRI – RESEARCH AND DEVELOPMENT CONFERENCE

10 – 11 DECEMBER

Manila, Philippines

Book of Abstracts

Nuclear Research & Development for Every "Juan"

PNRI – RDC 2018

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Day 1
December 10, 2018
12:30 PM – 5:00 PM
PNRI – Auditorium

12:30 – 1:00 **Registration** (Chair: Ms. Melissa Ramo)

1:00 – 2:00 **Opening Ceremonies** (Chair: Dr. Jesse Samaniego)

Session 1 - Agriculture (Chair: Mr. Arvin Dimaano)

2:00 – 2:30 **Plenary Lecture 1**
Nuclear Research & Development for Every "Juan"
Lucille V. Abad, Ph.D., Scientist I
Chief, Atomic Research Division – PNRI

2:30 – 2:50 Effect of Gamma Irradiation on Coconut Leaf Beetle, *Brontispa longissima* Gestro
Glenda B. Obra, Mateo B. Zipagan, Cynthia Gallego and Abigaile Mia V. Javier

2:50 – 3:10 Carrageenan PGP for Mungbean: From Pots to Farms
Fernando B. Aurigue, Mary Grace B. Gatan and Lucille V. Abad

3:10 – 3:20 **Break**

3:20 – 3:40 Carrageenan PGP Improves Productivity of Peanut in Bukidnon
Jerald B. Bongalos, Lorena V. Duna, Jemseal R. Tigbao, and Fernando B. Aurigue

3:40 – 4:00 Enhancing Agricultural Productivity in Mindanao through Radiation and *In-Vitro* Culture Technology. Fruit Crops: I-Mangosteen
Ana Maria S. Veluz and Arvin O. Dimaano

4:00 – 4:20 Characterization, Flowering Behaviour and Effects of irradiation on Philippine Native *Phalaenopsis* Orchids
Pablito M. Magdalita, Alangelico O. San Pascual and Ruben L. Villareal

4:20 – 4:40 Caballero - A Promising Mutant Cashew
John Faustus C. Vidal and Fernando B. Aurigue

4:40 – 5:00 PNRI Mutant Variety: *Dracaena* 'Sun Beam'
Fernando B. Aurigue

Day 2
December 11, 2018
7:00 AM – 5:20 PM

7:00 – 8:40 **Registration**

Session 2 – Industry (Chair: Dr. Alvie Astronomo)
PNRI – Auditorium

9:00 – 9:20 Development and Applications of Neutron Spectroscopic Techniques and other related Techniques in the Characterization of Advanced Materials: Capacity Building in the use and operation of Small Neutron Sources Phase I
UA Bautista, CAM Dingle, AA Astronomo, MESKV Ramo, FC Hila, JM Jecong, KMD Romallosa, RU Olivares, PP Saligan, NRD Guillermo

9:20 – 9:40 Predisposal Management of Disused Sealed Radioactive Sources (DSRS) in Preparation for a Secure and Safe Final Repository
Ronald E. Piquero, Angelo A. Panlaqui, Robert C. Dacoco, Eileen Beth A. Hernandez, Abelardo A. Inovero, Kristine Marie D. Romallosa and Editha A. Marcelo

9:40 – 10:00 Re-operation of the Philippine Research Reactor – 1 as a Subcritical Facility
Alvie A. Astronomo, John M. Marquez and Kristine Marie D. Romallosa

10:00 – 10:20 Radiation grafted polymers as adsorbents for toxic metal ions in contaminated waters
Jordan F. Madrid, Patrick Jay B. Cabalar, Girlie Eunice P. Lopez, Janronel C. Pomicpic, Lucille V. Abad

10:20 – 10:30 **Break**

10:30 – 10:50 Design and selection criteria for the establishment of a neutron dosimetry laboratory for the PNRI-SSDL
Marianna L. Grande, Andrew Barrida, Frederick Hila, and Kristine Marie D. Romallosa

10:50 – 11:10 Characterization of Radiation Damage and Applications of Thorium/Uranium-bearing Heavy Mineral Using Nuclear and Other Related Techniques Phase I
Cheri Anne M. Dingle, Ma. Elina Kristina V. Ramo, Julius Federico M. Jecong, Frederick C. Hila, Ryan U. Olivares, Unico Bautista, Neil Raymund D. Guillermo, and Pablo P. Saligan

11:10 – 11:30 Enhancing National Capacity in Industrial Radioisotope Techniques
Denis Aquino, Janice Mallillin, Adelina D.M. Bulos

11:30 – 11:50 Design of a low-cost shadow cone for the neutron dosimetry laboratory of the PNRI-SSDL
Marianna Grande, Frederick Hila, Vinz Michael Calija, and Kristine Romallosa

11:50 – 1:00
Lunch

Session 2 – Industry (Chair: Dr. Alvie Astronomo)
Audio Visual Room (Continuation)

1:30 – 1:50 The Application of Gamma Radiography to Validate Pieces of Californium-252 Radioactive Sources Inside a Disused Source Rod
Carl M. Nohay, Ramoncito F. Sulit, Andrew C. Barrida, Norman Jay V. Barro, Mary Rose Q. Mundo, Joseph R. Tugo, and Cecilia M. De Vera

1:50 – 2:10 Comparison of Two Different Methods Used to Calibrate Personal Dosimeter
Ave Ann Nikolle Garalde, Camille Pineda Jhenize Carvina Fernandez, Jhon Ray Amparado, Kristine Marie Romallosa

2:10 – 2:30 Design Calculation of Storage Drum for Encapsulated Disused Sealed Radioactive Sources using Monte Carlo N-Particle Transport code
Ronald E. Piquero, Frederick C. Hila, Julius Federico M. Jecong, Abelardo A. Inovero, Jhenize Carvina A. Fernandez, and Editha A. Marcelo

Session 3 – Environment (Chair: Ms. Shalaine Tatu)
PNRI – Auditorium

1:00 – 1:30 **Plenary Lecture 2**
Applications of Nuclear Technologies for Research and Development
Preciosa Corazon B. Pabroa, Ph.D.
Chief, Nuclear Services Division – PNRI

1:30 – 1:50 Application of Isotope Techniques in Verifying Groundwater Recharge Processes in Bulacan Province, Philippines
Soledad Castañeda, Norman Mendoza, Raymond Sucgang

1:50 – 2:10 Estimation of Radon Concentration in Soil Gas and Ground Water
Fe M. dela Cruz, Estrella U. Tabora, Lorna Jean H. Palad, and Christopher O. Mendoza

2:10 – 2:30 Nuclear analytical techniques: unraveling air particulate pollution in Metro Manila
Preciosa Corazon B. Pabroa, Flora L. Santos, Joseph Michael D. Racho, David Cohen, Armand Atanacio, Craig Thompson, Gloria R. Jimenez and John Robin Yee

2:30 – 2:50 Contributions of Terrestrial Radiation to Ambient Gamma Dose Rate and Occurrence of Temporal Variation in Aparri, Cagayan, Philippines
Ryan Joseph Aniago, Christopher Mendoza, Charles Darwin Racadio and Teofilo Garcia

2:50 – 3:00 **Break**

3:00 – 3:20 Monitoring and Evaluation of Radiation Dose Rate Levels in PNRI Grounds and Vicinities
Rosario R. Encabo, Teofilo Y. Garcia, Paolo Tristan F. Cruz, Juanario U. Olivares, Vanessa J. Omandam, Christian L. Dela Sada, Chitho P. Feliciano

3:20 – 3:40 Assessment of Temporal Variations of Natural Radionuclides Beryllium-7 and Lead-212 Concentrations in Surface Air in Tanay, Philippines through the CTBTO Radionuclide Monitoring Station PHP52
Paolo Tristan F. Cruz, Lorna Jean H. Palad, Fe M. Dela Cruz, Juanario U. Olivares, Christian L. Dela Sada, Antonio C. Bonga III, Alejandro J. Jesuitas, Edwin C. Cabatbat, Chitho P. Feliciano, Teofilo Y. Garcia

3:40 – 4:00 Radioactivity Monitoring in the Philippine Marine Environment after the Fukushima Nuclear Power Plant Accident
E.B. Enriquez, R.J. Aniago, L.J.H. Palad, R.R. Encabo, C.O. Mendoza, P.T.F. Cruz, J.U. Olivares

4:00 – 4:20 Reconstructing impacts and transport pathways of anthropogenic radionuclides in the western equatorial Pacific Ocean and South China Sea using ^{14}C and ^{129}I in corals
Angel T. Bautista VII, Sophia Jobien M. Limlingan, Fernando P. Siringan, Yoko S. Tsuchiya, Hiroyuki Matsuzaki

4:20 – 4:40 Incorporating OCEC Data in Source Apportionment Positive Matrix Factorization of Air Pollution in Valenzuela, Metro Manila
Angel T. Bautista VII, Klarence Anne M. Feri, Jhon Robin D. Yee, Joseph Michael D. Racho, Preciosa Corazon B. Pabroa

Session 4 – Food, Health and Medicine (Chair: Dr. Celia Asaad)
NTC – Lecture Room

1:30 – 1:50 Establishment and Validation of Dose Response Curve for Micronucleus
Gerardo Jose M. Robles, Celia O. Asaad, Gloriamaris L. Caraos, Ma. Lucia C. Cobar, Gilbert T. Diano, Djowel Recto Montefalcon

1:50 – 2:10 Development of the National Dose Registry for the assessment of occupational exposure in the Philippines
E.J. Pascual, M.L. Grande, R. Piquero and K.M. Romallosa

2:10 – 2:30 Development of Sterile Insect Technique Against Dengue Mosquito Vector: Colony Establishment and Population Monitoring
Glenda B. Obra, Sotero S. Resilva, Arvin O. Dimaano, and Abigaile Mia V. Javier

2:30 – 2:50 Hemostatic Agents from Radiation-Modified Polysaccharides and their Derivatives: Product Development and Efficacy/Safety Evaluation in Animal Model
Charito T. Aranilla, Bin Jeremiah D. Barba and Lucille V. Abad

2:50 – 3:00 **Break**

3:00 – 3:20 Radiation sterilized alginate-based wound dressing using stingless bee honey as active ingredient.
Davison T. Baldos, Joseph Puno, Gilberto T. Diano, Levelyn Mitos M. Tolentino, Djowel Recto Montefalcon, Celia O. Asaad

3:20 – 3:40 Effect of Gamma Radiation, Packaging Material, Age of Paddy, and Storage Time on the Molds and Yeasts Counts of Brown Rice varieties, RC-160 & SL-7
Maria Lucia Cobar, Levelyn Mitos M. Tolentino, Zenaida M. De Guzman, Gina B. Abrera, Gloriamaris L. Caraos, and Cristina Gragasin

3:40 – 4:00 Effect of Electron Beam Irradiation on Microbial and Sensorial Qualities of Frozen Vacuum-Packed Ground Beef Burger Patties
Levelyn Mitos M. Tolentino*, Zenaida M. de Guzman, Gina B. Abrera**, Gloriamaris L. Caraos, Ma. Lucia C. Cobar, Djowel Recto V. Montefalcon, and Gerardo Jose M. Robles

4:00 – 4:20 Effect of gamma radiation, age of paddy and packaging material on the storage quality of brown rice: surface free fatty acid (FFA) analysis
Gilberto T. Diano, Davison T. Baldos, Zenaida M. De Guzman, and Cristina Gragasin

4:20 – 5:20 **Closing Ceremonies** (Chair: Dr. Jesse Samaniego)
PNRI Auditorium

Effect of Gamma Irradiation on Coconut Leaf Beetle, *Brontispa longissima* Gestro

Glenda B. Obra[1], Mateo B. Zipagan,[2)] Cynthia Gallego[2)] and Abigaile Mia V. Javier[1]
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[2)]Philippine Coconut Authority(PCA), Region V, Rizal St., Old Albay District, Sagpon, Legaspi City
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Introduction

The coconut leaf beetle, *Brontispa longissima* (Gestro) is one of the most serious insect pests of coconut in Southeast Asia. *B. longissima* is a leaf scraping insect pest of palms that was introduced into the Philippines most probably via the ornamental trade route. Its life span from egg to adult is close to a year and occurs in unopened leaflets in overwhelming numbers. Severely damaged leaves appear burned or scorched as a result of larval and adult feeding (Zipagan 2008). Infestations of the beetle turn the leaves brown and decrease fruit production. Successive severe defoliations will lead to death of the tree. The sterile insect technique (SIT) is an environmentally-friendly method for management of insect pests. However, no study has ever been conducted on gamma sterilization of *B. longissima.* The use of SIT for *B. longissima* can be promising since the insect can be easily reared using coconut leaves. Moreover, the beetles are mostly confined on younger leaves of coconut and do not move from one coconut to the other quite easily. The paper reports on the effects of ionizing radiation on egg fertility and adult survival. This information will be useful for possible use of radiation–induced sterility in *B. longissima* for management of this pest.

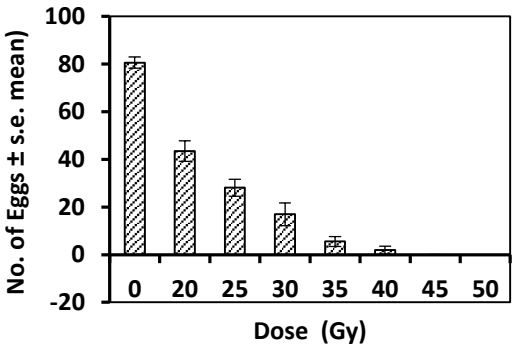

Fig. 1 Effect of irradiation on egg sterility of *B. longissima* females mated with irradiated males.

Materials and Methods

Rearing of *B. longissima* for use in the irradiation tests was done at Philippine Coconut Authority (PCA) Albay Research Center in Bicol using coconut leaflets. Adults (males and females) and pupae of *B. longissima* were irradiated with different doses of gamma radiation. Untreated adults or pupae served as control. After irradiation, the pupae were allowed to develop into adult stage for fecundity study. The efficacy of treatment was based on the dose that prevented hatchability of eggs laid by the adult females. Competitiveness of irradiated B. *longissima* was determined using different ratios of irradiated male, unirradiated male and unirradiated female and varying number of irradiated female. Either unirradiated or irradiated male was marked with white water-based paint on the distal part of the elytra to distinguish from the irradiated/unirradiated male/s.

Results and Discussion

Pupa was more radiosensitive than adults based on mortality. Adult females are more radiosensitive than adult males. Results of the irradiation of adult males showed that egg hatch decreased with increase in dose. The number of eggs laid by females mated with irradiated males at different doses was significantly lower compared with the unirradiated pair (control) (Fig. 1). Although complete sterility was observed at 50 Gy, longevity of adult males, however, was significantly affected. Hence, lower doses of 40 or 45 Gy can be considered for mating competitiveness studies. At these doses, larvae from hatched eggs failed to develop into viable adults.

Conclusion/Recommendation

Based on results of the study, the use of radiation induced sterility for sterile insect technique may be possible for the management of *B. longissima*. Further studies on competitiveness of irradiated adult males under semi-field condition is recommended.

References:

1) Zipagan, M. 2008. Updates on PCA's Brontispa Control Program. PCA, Diliman. Quezon City, Special Report.
2) Giang, H.T.T. and S. Nakamura. 2009. The study on biological characteristics of *Brontispa longissima* (Gestro) (Coleoptera: Chrysomelidae). J. Sci. Dev. 7(2): 159-164.

Carrageenan PGP for Mungbean: From Pots to Farms

Fernando B. Aurigue, [1)*] Mary Grace B. Gatan [2)] and Lucille V. Abad [1)]
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Introduction

Mungbean (*Vigna radiata* [L.] R. Wilzeck) with 22-27% protein content is the cheapest source of protein that can be readily incorporated in the Filipino diet. Despite the recommendation of using high-yielding varieties, the actual yield of commercial varieties being used by farmers falls short of the potential yield due to several factors, including the use of inoculants and fertilizers, which constitutes the Farmer's Practice for a given cropping system. In 2015, the national average yield of 810 Kg/ha totaled 33,620 mt only from 41,450 has (PSA, 2017). To increase seed yield, Carrageenan PGP, a radiation-modified product derived from kappa-carrageenan extracted from the edible red seaweed *Kappaphycus alvarezii* (Doty) Doty, was supplemented to the Farmer's Practice.

Fig. 1. Comparison of mungbean varieties treated with Carrageenan PGP

Materials and Methods

Pot experiments to test the effects of Carrageenan PGP as foliar spray every two weeks were conducted at PNRI, Diliman, Quezon City. The varieties Pagasa 21 (NSIC Mg 13) and Kulabo (NSIC Mg 14) were used. The frequency of application was reduced to only three: 7, 21 and 35 days after germination for Kulabo. Plot experiments employing 100 ppm Carrageenan PGP and inoculant on the varieties Labo, Pagasa 7, and Pagasa 19 (NSIC Mg 12) were done in Pampanga State Agricultural University, Magalang, Pampanga. Finally, on farm trials were set up in Barangay Navaling, Magalang, Pampanga to compare the Farmer's Practice with foliar spraying of Carrageenan PGP as supplement for Pagasa 19. Data were analyzed using One-factor ANOVA and Fischer's LSD. Analyses were made at 95% level of significance.

Results and Discussion

In the pot experiments, plants treated with inoculant and foliar application of Carrageenan PGP every 14 days gave 419% and 310% yield advantages over the control plants or Farmer's Practice for Pagasa 21 and Kulabo, respectively. Limiting the frequency of application of Carrageenan PGP to three times still afforded 105% increase in seed yield for Kulabo compared to Farmer's Practice. In plot experiments, all varieties treated with inoculant and Carrageenan PGP gave even higher increases in seed yield: Labo - 754.4%; Pagasa 7 – 388.0%; and Pagasa 19 – 485.0%. The results were attributed to more branches, more flowers that become fruits (higher number of pods), longer pods with more seeds, larger and heavier seeds, and extended flowering and fruiting so longer harvesting time (number of priming increased from 3 to 6). In the farmer's field, Pagasa 19 gave only 33.4% as the number of priming was limited to three only. Nevertheless, seed yield increased from 1,353 kg/ha to 1,805 kg/ha. Other observations for plants treated with Carrageenan PGP include larger and greener leaves and extensive or better roots system. These findings are similar to the report on rice treated with Carrageenan PGP (Abad, et. al., 2018).

Conclusions

Supplementing the Farmer's Practice with 100 ppm Carrageenan PGP foliar spray every 14 days for three applications increased the yield of different mungbean varieties. About 160 liters of the solution or 10 loads of 16-liter knapsack sprayer are needed for one hectare. The use of legume of inoculant as seed treatment is helpful where no fertilizer is applied such as after rice and after corn farming systems.

References:

1. Abad, L. V., et al. Semi-commercial scale production of carrageenan plant growth promoter by E-beam technology. Radiation Physics and Chemistry. 2017. Volume 143. pp. 53-58.
3) Philippine Statistics Authority. Crops Statistics of the Philippines (2011-2015) National and Regional. 2017. pp. 49-50

Carrageenan PGP Improves Productivity of Peanut in Bukidnon

Jerald B. Bongalos, [1)] Lorena V. Duna, [2)] Jemseal R. Tigbao, [2)] and Fernando B. Aurigue [1) *]
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Introduction

In the Philippines**,** the annual production of peanut (*Arachis hypogea* L.) is 1,116 Kg/ha based on 2014 statistics (PSA, 2015). That year, Bukidnon ranked 16th among peanut-producing provinces and contributed 1.81% of peanut production with an average of 1,226 Kg/ha in 430 hectares. Over time, a gradual decrease in annual production was observed and as of 2018 there was a drop of 0.3% in yield due to weather and environmental factors such as drought and frequent rains during pod formation (PSA, 2017). To counter the decreasing trend, the use of Carrageenan PGP as supplement to the Farmer's Practice was tested with or without the inoculant Nitroplus.

Materials and Methods

Randomized Complete Block Design was used with three replications. Foliar application of 100 ppm Carrageenan PGP solution was tested for the varieties Ilocos Pink (NSIC Pn12) and Namnama 2 (NSIC Pn14) 7-10 days after seedling emergence and every 7-10 days after the previous application for a total of four applications during the entire growing season. The experiment was done in two trials in terms of season: Season 1 - September to December 2017; and Season 2 - January to April 2018. For yield parameters and other agronomic characteristics, Box Plot analysis was used to show and describe the distribution of the data per treatment as well as per season trials. For inference, data was analyzed using One-factor Analysis of Variance and followed by a multiple comparison test using Tukey's HSD. Analyses were set at 0.01 alpha, tests of significant difference on the observed parameters across variety per treatment and varietal effect are reported.

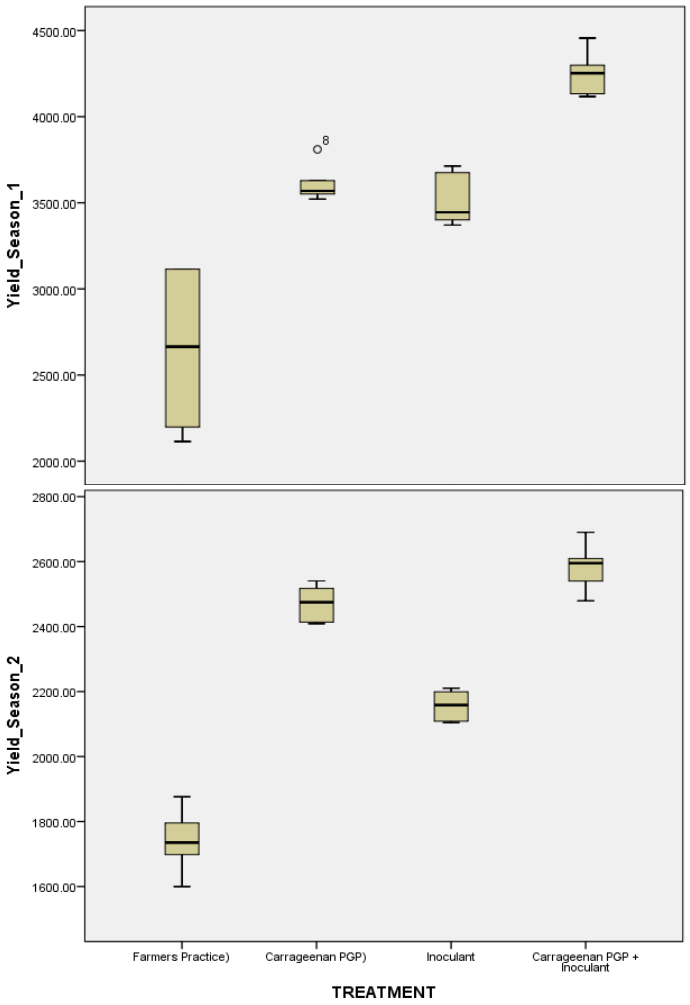

Fig. 1. Yield per treatment in two seasons.

Results and Discussion

For Season 1, plants sprayed with Carrageenan PGP had 17.3% increase in yield for Ilocos Pink and 63.70% increase in yield for Namnama 2 compared to the control plants or Farmer's Practice. However, the combination of Carrageenan PGP and inoculant gave the highest yield advantage of 33.5% and 99.7% over the Farmer's Practice for Ilocos Pink and Namnama 2, respectively. For Season 2, similar results were obtained: supplementing the plants with Carrageenan PGP resulted in 36.7% for Ilocos Pink and 47.7% for Namnama 2 higher yield than plants under Farmer's Practice. The combination of Carrageenan PGP and inoculant caused a yield increase of 41.9% and 55.6% for Ilocos Pink and Namnama 2, respectively.

Conclusions

For both seasons, supplementing plants with Carrageenan PGP alone increased the yield of Ilocos Pink and Namnama 2 by 17.3-63.7%. Carrageenan PGP in combination with an inoculant further increased the yield of both varieties but not practical nor economical due to the unavailability of inoculant. Compared to Farmer's Practice that afforded yields of 1,690.0 to 3,311.3 Kg/ha, the use of Carrageenan PGP realized the yield of 2,446.0 to 4,346.7 Kg/ha.

References:

1. Philippine Statistics Authority (PSA). Major Crop Statistics of the Philippines (2010-2014) Regional and Provincial. 2015. Retrieved from: https://psa.gov.ph/sites/default/files/MajorCrops10-14.pdf. pp 223-224.
2. PSA. Vegetables and Root Crops Quarterly Bulletin, 11(4). 2015. Retrieved from: https://psa.gov.ph/sites/default/files/Major Vegetables and Root crops Q4 Bulletin, October- December 2017.pdf

Enhancing Agricultural Productivity in Mindanao through Radiation and *In-Vitro* Culture Technology. Fruit Crops: I-Mangosteen

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Introduction

Induced mutation breeding holds promise for producing genetic variability with ionizing radiation i.e. gamma rays as the mutagenic agent. Reports have been published on the successful use of radiation for inducing variation on plants that lead to the development of improved mutant varieties (FAO/IAEA Database,2000). Moreover, combination of mutation induction techniques and biotechnologies especially *in-vitro* culture techniques have been done. With the application of *in-vitro* culture system to mutation breeding, many advantages in material treatments, rapid mass propagation of good mutant cultivars or line can be achieved.

Figure 1. Shoot formation of control & irradiated half cotyledon mangosteen.

In line with the government's effort to help Mindanao agricultural transformation through research and development, the Philippine Nuclear Research Institute (PNRI) is applying nuclear and related techniques for agricultural development particularly in fruit crops like mangosteen (*Garcinia mangostana,* L.). It is an important high-value tropical crop grown in Mindanao with worldwide market. Considered as the "Queen of Fruits" due to its delicious taste, it is a tall tree that usually flowers in 10-15 years after planting and bears fruit only during the peak period of four months. The recalcitrant behavior of the seed causes difficulties in producing planting materials throughout the year. To add up, the life cycle of fruit trees is quite long and the conventional breeding approach is time consuming.

Radiation induced mutation coupled with *in-vitro* culture techniques was used in this study specifically to induce mutations in mangosteen seeds and establish protocol for *in-vitro* culture (tissue culture) for rapid and multiple propagation of plantlets that can be used as planting materials.

Materials and Methods

Selected mangosteen seeds from Davao were cleaned and dried before batch irradiations of gamma rays using 10, 20, 30, and 40 Gy doses at the PNRI Co-60 Gamma Cell. Immediately after irradiation seeds were surfaced-sterilized and cut into one-half cotyledon and inoculated in Murashige and Skoog's (MS) basal medium in half strength and in full strength concentrations. Percentage germination and survival of these cotyledons, control and irradiated were compared and evaluated.

Results and Discussion

Irradiation dose for *in-vitro* germination of mangosteen seeds cultured in MS basal medium in half and whole strength concentration treatments showed that shoots formed in 10 Gy and 20 Gy gamma dose treatment using half cotyledons. Shoots were also formed in unirradiated cotyledons while no germination or shoots were formed in irradiated with 30 and 40 Gy. One month after irradiation and inoculation, 28.57 % shoots were formed in irradiated with 10 Gy dose and 20 Gy with 16.66% shoot formation. No shoot or protocorm developed in 30 Gy and 40 Gy dose treatments (Fig.1). Studies in fruits have shown that percentage germination and survival, decreases with increasing dose of gamma radiation (Lapade, et. el, 2004).

Conclusions

Best irradiation dose and medium concentration for shoot formation for seeds irradiated and inoculated using half cotyledons attained in this study were 10 Gy and 20 Gy inoculated in MS basal medium in half strength concentration. This was achieved one month after irradiation and inoculation.

Reference:

1. Lapade, A., A. Barrida, AM.Veluz, F.Aurigue, L.Marbella and M.Rama. The Effects of Gamma Radiation on Cashew and Mangosteen. Philippine Nuclear Journal, 2004, 14, pp.1-11.

Characterization, Flowering Behaviour and Effects of irradiation on Philippine Native *Phalaenopsis* Orchids

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Introduction

Twelve different species of *Phalaenopsis* or butterfly orchids collected from different places in the country were characterized for their flower traits, foliation and growth habit, evaluated for flowering behavior, tested for self-compatibility and poor setting under Los Baños conditions, and further used for mutation breeding via irradiation of gamma rays. Subjecting the progenies in the form of protocorms generated by self-pollination to irradiation will generate mutants with potential for breeding and selection.

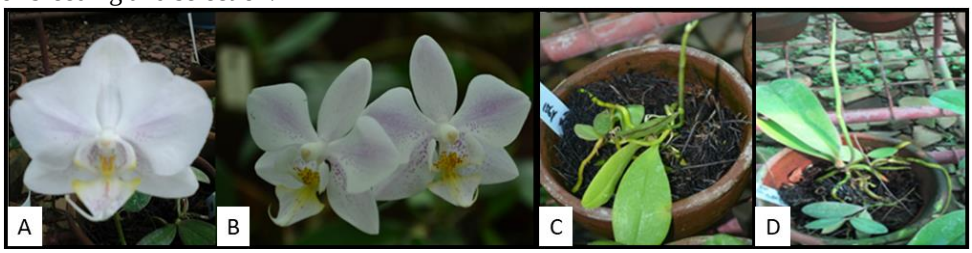

Figure 1. Early flowering of *Phalaenopsis aphrodite* whose protocorms were irradiated with 15Gy Gamma radiation. The plant on the left flowered one year and eight months after protocorms were irradiated while on the right flowered two years after protocorms were irradiated.

Materials and Methods

Collected Phalaenopsis orchids from different parts of the country were characterized and allowed to flower in Los Baños conditions. Test of self-compatibility was done by self-pollinating of the flowers and observe pod setting. Seeds were then planted in vitro and germinated and proliferating protocorms were subjected to different levels of gamma irradiation, 0, 10, 15, 20 and 25 Gy. Difference in root and shoot characteristics and flowering behavior were observed.

Results and Discussion

Twelve *Phalaenopsis* species flowered successfully under Los Baños conditions consistently for two years. The degree of self-compatibility and pod setting varied from 3.8 to 50%. *P. aphrodite* and *P. heiroglyphica* embryos cultured in vitro in Knudson C medium germinated into protocorms successfully at 80-90% within 3-4 weeks after explanting. The number of regenerated plants with roots and shoots, and those with shoot only, also differ significantly among the treatments but not leaf thickness after two years of growth. Natural variation for the mottled leaf patterns or tiger-like blotched on the leaves of *P. schilleriana* was detected. *P. schilleriana* exhibited distinct mottled band patterns across their leaves that significantly differ in numbers among the leaf types such as long, medium, slightly short and short. The number of mottled band patterns has medium correlation with the long-type leaf. While tissue-cultured orchids generally flower 3 years after potting-out, initial observation indicated that irradiation using 15 Gy induced earlier flowering of 1 plant of *P. aphrodite* by only 1 year and 8 months after potting out, while another plant of the same species flowered 2 years after potting out.

Summary and Conclusion

Twelve different *Phalaenopsis* species were collected and evaluated for flowering ability, self-compatibility, pod characteristics, embryo germinability under Los Baños conditions and growth in Knudson C medium and explored for mutation breeding. Ten *Phalaenopsis* species flowered different in Los Baños, Laguna. Varying flowering time and self-compatibility were also observed.

Proliferating protocorms of *P. aphrodite* subjected to different levels of gamma irradiation responded differently to the treatments. Significant differences on the different morphological characteristics were observed. While tissue-cultured *P. aphrodite* orchids generally flower three years after potting-out, preliminary observation indicated that irradiation of protocorms using 15 Gy induced earlier flowering of one plant of *P. aphrodite* by only one year and eight months after potting-out, while another plant of the same species irradiated also with 15 Gy flowered two years after potting-out. On the overall, irradiation significantly affected regeneration and growth of *P. aphrodite* and induced early flowering.

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Caballero - A Promising Mutant Cashew

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Introduction

Cashew (*Anacardium occidentale* L.) originated from north-eastern Brazil. As a plant, it was brought by the Spaniards to the Philippines in the 17th century. Since then, cashew has been cultivated for its fruit, technically called nut, although its swollen, fleshy fruit stalk or pedicel, referred to as apple, has many uses too. The provinces of Mindoro, Marinduque, Romblon, and Palawan or Region IV-B led in cashew production with 198,360 mt in 2015, which is 96.5% of the national yield of 205,530 mt (PSA, 2017).

Figure 1. Samples of Caballero cashew.

Four out of eight varieties of cashew registered with the National Seed Industry Council are mutants produced by gamma irradiation of seeds of the variety Guevara. These are: (1) Zambales Beauty; (2) Magsaysay; (3) DLR; and (4) Gene all developed by Ramon Magsaysay Technological University (NSIC, 2003). With the extinction of Makiling as a double-purpose cashew variety, a new variety should be developed as its replacement.

Materials and Methods

Fruiting trees derived from seeds of Makiling irradiated with increasing dose levels of gamma radiation from a Cobalt-60 source (Gammacell 220) at 100 Gy/hr in 2004 were evaluated based on the agronomic traits of the M_1 plant (Makiling strain), earliness to flower, yield, and fruit characteristics for 3 years (2011, 2013 and 2015). As early as 2011, seeds from pre-selected trees (Nos. 28, 43, and 50) were germinated as M_2 populations to generate more putative mutants. Data from 2013 and 2015 served as confirmatory tests for choosing No. 28, irradiated with 100 Gy, as the best source of putative mutants.

In the absence of a control plant of the same age and the confirmation that the original parent material was not preserved, data gathered from semi-dwarf, early-flowering, and well-fruiting M_2 trees derived from No. 28 were compared with published information about Makiling (NSIC, 2003). After three consecutive years (2016-2018) of harvesting the fruits and evaluating samples for color and flavor of both the apple and nut, the tree designated as S-1 was considered the best candidate for variety registration with the NSIC to replace Makiling as a double-purpose cashew.

Results and Discussion

The fresh apple weighs 85.0 g, and measures 5.4 cm in length and 6.4 cm in width. It is orange red to red yellow orange. The juice has a pH of 4.4, a density of 1.06, 10.6° Brix total soluble solids, and 0.25% titratable acid (w/v). Meanwhile, the dried nut has a weight of 7.5 g, a length of 3.7 cm, and a width of 2.7 cm. Its color is grey. The kernel weighs 2.25 g and light yellow orange to white in color, while the shell weighs 4.82 g with a thickness of 3.00 mm. Edible portion is 31.8% and the flavor is nutty. The characteristics or measurements obtained are different and distinct from those of Makiling, so the selected tree will be registered with the NSIC as Caballero, which symbolizes chivalry, after propagation by cleft grafting in sufficient quantity.

Conclusions

A new mutant cashew, to be registered with the NSIC as Caballero, that is different and distinct from its parent material, Makiling, was developed by gamma irradiation of seeds and growing of the M_2 populations derived from the pre-selected M_1 tree. The selected mutant is the only known candidate to replace Makiling, confirmed to be extinct, as a double-purpose cashew.

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PNRI Mutant Variety: *Dracaena* 'Sun Beam'

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Introduction

In 2001, the Philippine Nuclear Research Institute (PNRI) developed and registered with the National Seed Industry Council (NSIC) of the Bureau of Plant Industry, Department of Agriculture *Dracaena* 'Marea' as NSIC 2001 Orn 56 through mutation induction by gamma irradiation of *D. braunii*. From the same batch of planting materials treated with acute gamma radiation way back in 1997, PNRI researchers continued to observe and purify selected mutants to develop a new mutant variety for the Philippine Floriculture Industry.

Figure 1. *Dracaena* 'Sun Beam'.

Materials and Methods

Remnants of experiments conducted prior to 2004 were utilized for an additional 10 years. All variations from the control plant observed were considered putative mutations because only one mutant (*D.* 'Marea') was selected from this lot. The putative mutants were classified based on the type of chlorophyll mutation exhibited as reported by Lapade et al. (2001). A putative mutant with novel characteristic was chosen for its rarity. It was propagated asexually to advance the vegetative generation. The mutated trait was checked after generation advancement which took from 9 to 12 months per generation. Aurigue (2008) and Poole et al. (1991) were followed for care and maintenance of the plants.

Results and Discussion

The herbaceous, evergreen, shrubby plant has slender stem and loose spiral arrangement of leaves. The narrowly elliptic leaves measure up to 29.5 cm long and up to 5.3 cm wide with aristate tip, sheathing base, and entire margin. The upper surface of the leaf blade is moderate olive green (146A) with strong yellowish green (144A-B) band of various width at the center, but usually about 1/3 of the blade width. The strong yellowish green (144A-B) center is also visible underneath that is moderate yellowish green (147B-C) on both sides. The plant is about 1 m tall and still growing. It forms a clump by producing suckers that can be separated for propagation. Top cuttings and stem cuttings are other vegetative means of multiplication. Higher light intensities but lower temperatures result in better color combination.

Conclusions

Genetic variations induced by acute gamma irradiation can be utilized to develop new or improved varieties of crop plants by identification and selection of mutants with desirable characteristics. *Dracaena* 'Sun Beam' is the seventh NSIC-registered mutant variety of ornamental plant developed by PNRI using 20 Gy of acute gamma radiation. It was officially registered as NSIC 2014 Or 85 on August 29, 2014 and listed in the FAO/IAEA Mutant Variety Database (MVD) with MV ID No. 3439 (FAO/IAEA, 2018). Its picture was featured in the cover of the third edition of Manual on Mutation Breeding published by FAO/IAEA this year.

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Development and Applications of Neutron Spectroscopic Techniques and other related Techniques in the Characterization of Advanced Materials: Capacity Building in the use and operation of Small Neutron Sources Phase I

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Introduction

This project was conceptualized as part of the Institute's initiative to reestablish, develop and sustain knowledge and expertise in nuclear science and technology for the new generation of science workers. Much importance was given to this initiative in view of the retirement of key experienced personnel, the urgency of establishing a transfer of knowledge and knowledge management procedure, and the pressing need to address the issue of how to reuse the decommissioned reactor within the nuclear mandate of the Institute (Leopando, 2006). The main objective of this project is to provide the training and teaching environments for the young personnel who are starting their careers in the nuclear sector and the potential users and partners from the academe and industry, all of whom will be the ones to operate and utilize future facilities.

Methodology

The capacity building initiatives of this project were focused on the following activities: (1) Setting up a facility for training and education, (2) Setting up a training program for basic neutron and nuclear techniques, (3) Initiate and perform research and development using neutron techniques and (4) Present a proposal to build or acquire one or more major nuclear facilities in PNRI.

Results and discussion

The outputs of this project were the following:

- Established Neutron Laboratory for training and education of basic nuclear science
- Established Annual Neutron School (ANS), a training program for basic nuclear science
- Research and development (R&D) outputs on the characterization of small neutron sources in PNRI
- Project proposal to utilize the used TRIGA fuel as a subcritical assembly for training and education

Conclusion

The goal to reestablish the expertise in nuclear science in PNRI was achieved by setting up learning system which consists of basic neutron laboratory, training syllabus, and research topics on small neutron sources designed for young undergraduate student who are just starting their career in science and technology. These outputs including the proposal to utilization of spent TRIGA fuel have a very great potential to sustain the knowledge in nuclear science and technology in the country.

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Predisposal Management of Disused Sealed Radioactive Sources (DSRS) in Preparation for a Secure and Safe Final Repository

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Introduction

The applications of radioactive sources in the medical, industrial and research facilities result to the generation of radioactive wastes which can cause unfavorable effects to human health and the environment if not managed properly. The PNRI operates and maintains the centralized Radioactive Waste Management Facility (RWMF) in the Philippines that is authorized to treat, condition and store waste generated from different applications of radioactive materials contained in mobile or stationary devices. This article focuses on the strategies and projects initiated and performed in the Philippines in providing the safe and secure processing of DSRS in preparation for its final disposal.

Materials and Methods

I. The SHARS Conditioning Project

It was initiated in 2013 in under the Nuclear Security Fund of IAEA that aimed to condition Spent High Activity Radioactive Source (SHARS). More importantly it also aimed on reducing the volume of the generated waste due to the size of the teletherapy head. In this activity, a mobile hot cell was constructed to facilitate the conditioning process.

II. Conditioning of Category 3-5 Sources through the IAEA RAS9085 Project

Two IAEA expert missions were conducted in 2015 to train the operators of the RWMF in the dismantling and conditioning of Category 3, 4 and 5 DSRS, as well as the record keeping procedures of all operations.

III. Repatriation of sources to the USA

Last 2017, the Los Alamos Laboratory physically verified the PNRI-RWMF inventory of Am-241 and neutron sources. After which in 2017, the PNRI requested an assistance from the IAEA on the repatriation of Am-241 and neutron sources coming from different equipment with its origin coming from the USA.

Figure 1. Category 3-5 Sources and a stainless steel capsule used in conditioning.

Results and Discussion

A total of 16 units of teletherapy and irradiator sources with a total of 2.04×10^{14} Bq were conditioned throughout the SHARS projects. The retrieved sources were stored safely in stainless steel capsules and placed inside a long-term storage shield awaiting for final disposal. On the other hand, the RWMF operators have conditioned a total of 341 units of Category 3-5 sources, mostly of Co-60, Cs-137 and Sr-90, with a total activity of 2.2×10^{11} Bq. The sources were stored in stainless steel capsules placed at the center of a standard 200-L drum lined lead and concrete. Finally, a total of 849 units of Am-241 foils, 44 units of Am-241 sources from nuclear gauges and 26 units of AmBe from well logging and moisture-density gauges were successfully repatriated to the USA. Overall, there were a total of 1,206 units of radioactive sources conditioned over the span of these three projects performed in the Philippines.

Conclusions

All of the sources retrieved in these projects of the PNRI-RWMF are successfully conditioned and safely stored inside the engineered trenches of the facility. The implementation of radioactive waste management methods that were learned throughout all these projects contributed in ensuring the protection of people and the environment.

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Re-operation of the Philippine Research Reactor – 1 as a Subcritical Facility

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Introduction

A subcritical facility (SCF) contains a reactor core that produces neutrons without achieving criticality. This means that the amount of neutrons in the core is continuously decreasing and an external external neutron source is required to sustain fission chain reaction. As such, SCFs are inherently safe due to lesser radiation exposure and lower risk of criticality accident compared to critical nuclear facilities [1], [2]. This makes SCFs an ideal facility for training and basic research especially for a country like the Philippines, which is restarting a nuclear science and technology program. PRR-1, which was the only nuclear facility operated in the country, has been shutdown since 1988. This rendered the country unable to perform nuclear science and reactor physics research for three decades. In this paper, we present the ongoing activities to re-establish the Philippine Research Reactor – 1 (PRR-1) by using the slightly irradiated TRIGA fuel rods in a subcritical facility. TRIGA fuel rods are known as one of the safest type of reactor fuel and TRIGA-fueled reactors are the most common type of reactors in the world [3].

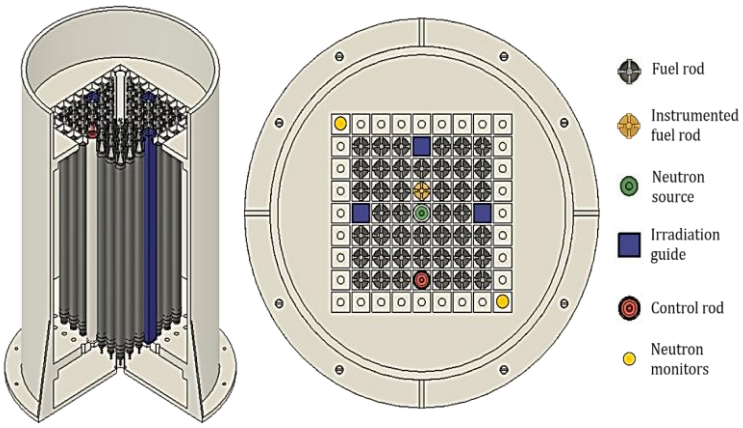

Figure 1. Illustration of the proposed PRR-1 SATER core configuration in (a) cut-away view and (b) top view indicating the location of the core elements.

The PRR-1 SCF Design

A recent publication [4] reports the proposed fuel configuration for the PRR-1 SCF. The configuration consists of 44 TRIGA fuel rods arranged in a 7×7square lattice with 5 empty[3] slots. The maximal neutron multiplication factor of this fuel configuration is calculated to be$k_{eff} = 0.95001 \pm 0.0009$. The fuel rods will be held in place by a cylindrical aluminum core tank (Fig. 1), which is 101.5 cm long, 1.5 cm thick and 60 cm in diameter. The tank will be installed concentric to the circular section of the PRR-1 reactor pool. It will feature lower and upper grid plates with 81 slots to accommodate different core elements. Sufficient slots are provided for the subcritical configuration but with provisions for a low power subcritical assembly. This is to support the phased approach in implementing the re-establishment of PRR-1.

Implementation Plan for the Re-Establishment of PRR-1

PRR-1 will be re-established by phase as the facility gradually transitions from its current state to the target goal of having a safely operated and fully utilized reactor facility. The phase approach will also take into account PNRI's current capabilities and capacity building activities. As a subcritical facility, PRR-1 will be utilized to: (1) build capacity in reactor and nuclear science and technology; (2) enhance various stakeholder engagement; (3) demonstrate capability to safely utilize the facility; and (4) investigate the feasibility of the facility to proceed to the next phase. The goal is to build a critical mass of qualified human resources and increase stakeholder engagement before proceeding to a critical assembly. This will ensure that the facility will be safely operated and well utilized at each phase.

Conclusions

For thirty years, the Philippines have lagged behind its counterparts in the nuclear field partly due to the absence of an operating nuclear facility. The recent initiative of PNRI to revive PRR-1 will provide access to an operating nuclear reactor, which can be utilized for training and education, reactor physics research, basic irradiation services, and neutron activation research, among others. The PRR-1 SRF is projected to open the whole scientific field of reactor physics and engineering for Filipinos and to pave the way for the Philippines to strengthen its niche in the nuclear field.

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Radiation grafted polymers as adsorbents for toxic metal ions in contaminated waters

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Introduction

The formation of functional hybrid polymeric materials by attaching graft polymer chains with desirable and advantageous tailored properties to the surface of a base polymer with desirable bulk character is an attractive application of graft polymerization. The resulting graft copolymer creates significant opportunities to develop new hybrid platforms for a number of applications. In this work, toxic metal ion adsorbents were prepared from natural and synthetic base polymers through the radiation-induced graft polymerization (RIGP) in solution and emulsion phases.

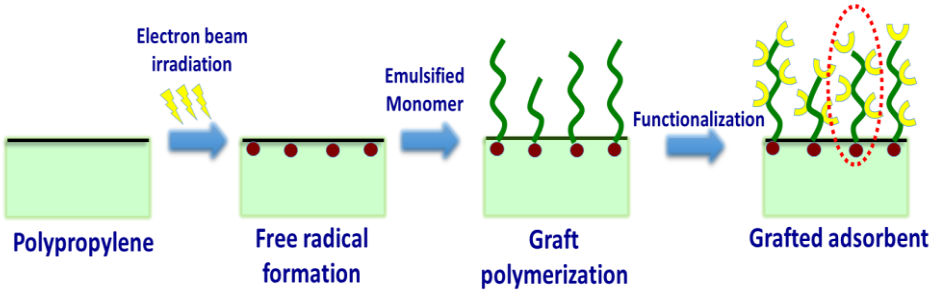

Figure 1. Preparation of adsorbent through radiation-induced grafting

Materials and Methods

All grafting and adsorption experiments were performed in PNRI. Adsorbents bearing the amino-, carboxylic- and iminodiacetic acid- functional groups were developed from polypropylene (PP) and abaca-polyester (AP) nonwoven fabrics through the RIGP technique. The monomers glycidyl methacrylate (GMA) and acrylic acid (AA) were selected, with the epoxide groups of GMA serving as anchor for the immobilization of amino and iminodiacetic acid groups. Optimization of the grafting and functionalization parameters were carried out by either the full-factorial or "one-variable at a time" design. The adsorption performance of the grafted adsorbents was evaluated by batch and column experiments using synthetic and actual waste waters from the laboratory and leather tanning companies.

Results and Discussion

Adsorbents with at least 150% degree of grafting and more than 2 mmol per gram functional group density were successfully prepared using electron beam-induced pre-irradiation grafting *in vacuo*. The adsorption of Pb(II), Cr(VI), Cd(II), Ni (II), and Hg(II) onto the grafted adsorbent were found to be pH- and concentration-dependent. The synthesized adsorbents described in this work performed on a par with, if not better than commercial ion-exchange resins. The column packed amino-modified PP and AP adsorbents were successfully applied in the treatment of Cr(VI) and Cd(II) contaminated waters, respectively, at flow rates that are significantly higher than those used in ion-exchange resin treatments. The standard for Cr (VI) set in DAO No. 35 was met after treating the waste waters of leather tanning companies with the amino-modified PP.

Conclusions

Through radiation grafting, toxic metal ion adsorbents with the following properties were produced: (a) relatively high adsorption capacities, (b) operational at high flow rates, (c) reusable, and (d) facile preparation at ambient conditions. The new adsorbents have considerable potential for industrial applications in waste water treatment and in metal recovery from aqueous solutions.

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Design and selection criteria for the establishment of a neutron dosimetry laboratory for the PNRI-SSDL

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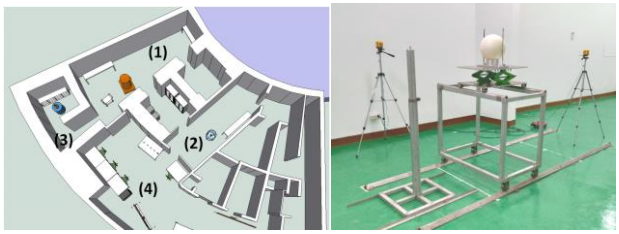
Introduction

With the advancements of technology, several radiation facilities in the country are already using high-energy radiation fields in the workplace. Radiation exposure in the workplace can potentially give radiation dose to the workers. One way to ensure the safety of the workers and the facility is through conducting radiation monitoring in the workplace. Instruments must be calibrated in the fields which they are normaly used in to ensure the accuracy of the instruments when being used in the field. The Secondary Standards Dosimetry Laboratory (SSDL) of the Philippine Nuclear Research Institute (PNRI) is mandated to establish and maintain the standard for protection level of ionizing radiation in the Philippines. The laboratory had just recently completed the construction and setting-up of the neutron dosimetry facility for calibration of neutron radiation monitoring instruments and neutron physics research. The laboratory has a reference Cf-252 neutron source, and a reference neutron detector traceable to the National Physics Laboratory (NPL). However, because neutron radiation is highly scattering, the irradiation room, its location, design, and technical components were carefully studied to ensure that the activities to be performed will meet international standards and national safety requirements. This paper presents the design and selection criteria for the establishment of a neutron irradiation room for the PNRI-SSDL.

Materials and Methods

Based on ISO 8529:2001, the minimum room lengths required for 40% room return would be 3m x 3m x 3m (LxWxH). This means that the instrument reading will increase by 40% due to the scattering characteristic of the neutron source based on the room dimensions. A calibration bench made of light materials was also needed to place the instrument in a reproducible set-up that can be adjusted on the x-, y-, and z-axis, utilizing platforms mounted on stainless steel wheels, to ensure detectors are centered along the beam axis. The source can be placed on a stand that can be adjusted along the x- and y-axis and held in position by an alloy vertical adjustment lock. The neutron dosimetry facility is to be placed in the first floor west wing area of the PRR-1, and the layout of the facility was studied to ensure safety of the people outside of the facility in a secure location.



(a) (b)

Figure 1. (a) Layout of the neutron dosimetry facility (1) AmBe/Cf Irradiation Room; (2) PuBe Howitzer room; (3) Source storage; (4) Control room; (b) Irradiation room with the reference instrument on a low-scatter calibration bench.

Results and Discussion

Following the ISO IEC 8529:2001 minimum room dimensions of 3m x 3m x 3m for a 40% room return, an irradiation room inside the neutron dosimetry facility was selected with dimensions that meet these criteria. A low-scatter calibration bench that is moveable on 3 axes, and a versatile source holder was designed and fabricated using aluminum, which is technically transparent to neutrons further reducing the scattering component of the source. The location chosen for the facility was designed for spent nuclear fuel processing, hence the dense solid cement walls specifically in the irradiation room ensures that there is no leakage from radiation inside the room to outside of the facility.

Conclusions

A neutron dosimetry facility under the authorization of the SSDL is established to enable the calibration of neutron radiation monitoring instruments. The facility meets ISO 8529 requirements, and utilizes a low-scatter calibration bench to decrease the scattered components from within the room. The new facility is located in a building that is designed to handle very high activity sources, and this ensures the safety of people outside of the facility will not be unnecessarily exposed to radiation.

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Characterization of Radiation Damage and Applications of Thorium/Uranium-bearing Heavy Mineral Using Nuclear and Other Related Techniques Phase I

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Introduction

Geochemical reconnaissance and exploration identified certain areas in Northern Palawan, Philippines of high background radiation, associated with the presence of a thorium/uranium-bearing mineral on shore sands and stream sediments [1]. The mineral – allanite, contains appreciable amount of radioactivity that is believed to significantly damage its crystal structure and the amount of alpha dose absorbed by the mineral suggests to a certain extent, the level of damage within its structure. In the issue of long-term disposal of radioactive waste material, the radioactive minerals, such as allanite, could serve as natural analogue for evaluating the long-term radiation damage to the stability and integrity of disposal methods. [2]. This paper attempted to study the influence of long-term radiation effects on the atomic structure of crystalline materials by estimating the value of the accumulated absorbed alpha dose from individual measurements of Uranium (U), Thorium (Th), and Lead (Pb) in the sample using spectroscopic techniques.

Figure 1. Allanite grains as viewed under a stereomicroscope at ~20x magnification.

Materials and Methods

Allanite samples were collected from San Vicente Palawan. Characterization was conducted on the following: degree of crystallinity was investigated using x-ray diffraction (XRD), elemental composition, particularly the Th, U and REE content, using ^{241}Am-radioisotope excited XRF, radiometric analysis of Th and U using gamma-ray spectrometry, and identification of Fe^{2+} and Fe^{3+} sites (and ratio) using Mossbauer Effect Spectroscopy (MES). The absorbed alpha dose was estimated using the concentrations of Th and U, and the geological age (estimated by Th/U/Pb radiometric dating).

Results and Discussion

The allanite sample from the stream of Ombo, Palawan contains 1.247 ± 0.027 %wt Th and 0.015 ± 0.0008 %wt U, and ~26.32 %wt REEs. The geological age was estimated to be around 115.5 ± 4.5 million years and is close to the age of the Palawan island as published. [3] At such age, the mineral has only accumulated a relatively low α-dose of $1.13 – 1.27 \times 10^{15}$ α-decaycs/mg. Data from bulk powder diffraction analysis exhibit high intensity peaks and low FWHM values. MES results show a lower Fe^{3+}/Fe ratio suggesting that the mineral has low amount of absorbed dose to cause the Fe^{2+} atoms to be radiation-oxidized.

Conclusions

The results suggested that the mineral has not undergone enough radiation damage, due to its low amount of absorbed alpha dose as verified by the low Fe3+/Fe ratio and high crystalline structure – indicated in the MES and XRD patterns, respectively. The geological age of the sample has been estimated using U-Th-Pb ratio, and compared from published references, the sample from Palawan is relatively younger.

References:

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3. J. Encarnación and S. B. Mukasa. "Age and geochemistry of an 'anorogenic' crustal melt and implications for I-type granite petrogenesis". Lithos 42 (1997), pp.1–13.

Enhancing National Capacity in Industrial Radioisotope Techniques

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Introduction

The expansion of the major refineries in the Philippines has motivated the Philippine Nuclear Research Institute (PNRI) to enhance its capacity on relevant radiation technologies to be able to provide support to industries when the need arises. Initiatives were implemented to develop capacity on industrial radioisotope techniques which are widely known for online inspection of process vessels and investigation of anomalies in refineries and petrochemical plants. Implemented projects enhanced manpower capability and augmented infrastructure resources for the provision of services and undertaking of research studies.

Materials and Methods

Two complementing projects – one funded by the International Atomic Energy Agency (IAEA) and another by the Philippine Council for Industry, Energy, and Emerging Technology Research and Development of the Department of Science and Technology (DOST-PCIEERD) – were implemented to develop manpower and infrastructure capacity of PNRI. Benchmarking and SWOT analysis were undertaken to assess needs and requirements to enhance capacity in various industrial radioisotope techniques.

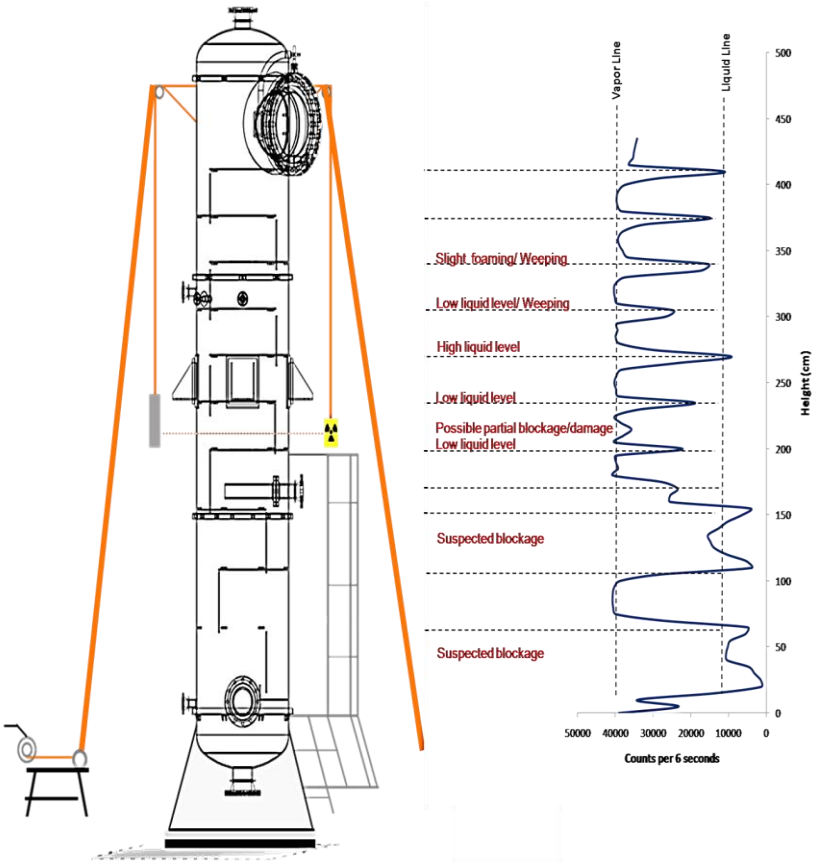

Figure 1. Gamma column scanning provides information on online conditions of distillation columns.

Results and Discussion

Training of the core members of PNRI team in various industrial radioisotope techniques enabled them to conduct in-house training for the other personnel. Facility for conducting research and experiments was upgraded and system for the provision of gamma scanning service is enhanced. Basic knowledge on radiotracer techniques were acquired through training and visiting benchmark organizations.

Conclusion

The two implemented projects paved the way for the availability of gamma column scanning service for local industry, and the capability to conduct research studies on gamma computed tomography and other gamma scanning techniques. Capacity on radiotracer techniques is yet to be developed as this is limited by the availability of radiotracers and appropriate facility for performing studies and experiments.

References

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Design of a low-cost shadow cone for the neutron dosimetry laboratory of the PNRI-SSDL

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Introduction

The neutron dosimetry laboratory of the Philippine Nuclear Research Institute (PNRI) is operated under the authorization of the National Secondary Standards Dosimetry Laboratory (SSDL). The neutron dosimetry laboratory is mandated to establish and maintain protection level of ionizing radiation in the country for neutron fields. As part of establishing and characterizing a neutron field, a shadow cone is used for shielding the primary beam of a neutron source, to determine the scattered components from the environment (eg. Air, walls, floor, etc.). A standard shadow cone is made up of 20-cm of solid iron, and 30-cm of solid polyethylene, as recommended by international guidelines. However, purchasing a solid polyethylene block is twice the amount as purchasing a single sheet of polyethylene with the same volume. This paper presents a) the comparison of utilizing a shadow cone between solid polyethylene, and spliced polyethylene, both with the same volume and dimension; and b) effects of covering a shadow cone enveloped with a 2 mm stainless steel sheet.

Materials and Methods

The Monte-Carlo Neutron Particle (MCNP) program was used to simulate the neutron flux at a point with and without a shadow cone. Simulating the neutron flux at a reference point in a bare field produced a baseline flux for comparison. The fluxes of a shadow cone with solid iron and solid polyethylene, and a shadow cone with solid iron and spliced polyethylene was compared at the same reference point. Neutron fluxes were also determined at reference points between a shadow cone without stainless steel covering, and a shadow cone with stainless steel covering. The results were then evaluated.

Results and Discussion

Upon comparison, the neutron fluxes at a point from using solid polyethylene and spliced polyethylene varies by 1%. In addition, the neutron fluxes at a point from a bare shadow cone, and a stainless steel-covered shadow cone, has a difference of 1%. The fluxes of the recommended shadow cone and the designed shadow cone are agreeable within 1%.

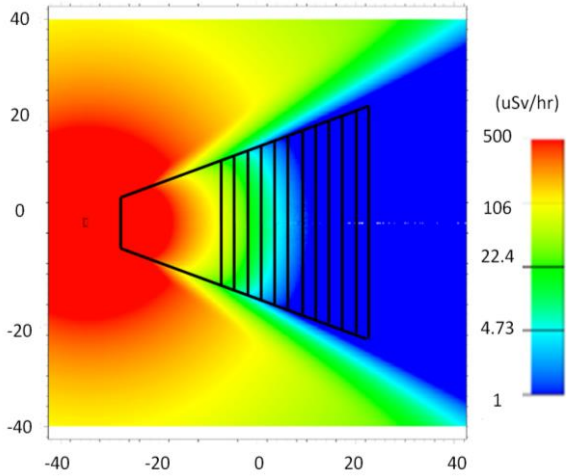

Figure 1. Simulated spliced shadow cone in a neutron field with no stainless steel cover.

Conclusions

A low-cost shadow cone to support the establishment and characterizing a reference neutron field for the neutron dosimetry laboratory is designed. Simulated results with parameters that were set by the team, which was 20-cm solid iron and 30-cm spliced polyethylene, with the whole cone encapsulated in 2mm of stainless steel values that differed by 1% from the recommended international guidelines. This shows that the designed shadow cone is agreeable within 1% from the recommended design, and is acceptable for use in the neutron dosimetry laboratory of the PNRI-SSDL.

References:

1) International Standard Organization. ISO 8529:2001-1 Reference neutron radiations – Characteristics and methods of production. 2001.
2) International Atomic Energy Agency. Technical Reports Series No. 285: Guidelines on Calibration of Neutron Measuring Devices. 1988.

The Application of Gamma Radiography to Validate Pieces of Californium-252 Radioactive Sources Inside a Disused Source Rod

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Introduction

The PNRI licensees have 3 options once their radioactive sources become depleted or disused, either to a) return back the source to foreign supplier, b) transfer to an authorized end-user, or c) dispose of to RPSS, PNRI for proper waste management. The concern begun when it cannot determine the exact pieces of Californium-252 (Cf-252) piled inside a disposed source rod at RPSS due to conflicting records and lack of coordination. The possibility of applying the industrial radiography has been realized as the most practical, fastest, and safest way to determine and validate the exact quantity of Cf-252. Two (2) radiographic shots were performed at 2 different angles using an Iridum-192 (Ir-192) radiographic exposure device or industrial gamma camera.

Materials and Methods

The radiographic procedure was undertaken at the NDT Training Laboratory. Due to limited film available and the time to use the radiographic exposure device, 2 exposure shots were only performed. The NDT team had to establish the source object distance and exposure time to come up with the radiographic exposure set-up (Figure 1). The source rod's active part was laid bare on top of the film. After the 1st shot, the team had to turn the source rod at another rotational angle (from 0° to 90°) to get a different impression of the rod internal. As far as radiation protection of the personnel involved in performing the test, the doses during handling the source rod and during the actual radiographic testing were assessed according to time and distance from the source and from the results of the personal dosimeters.

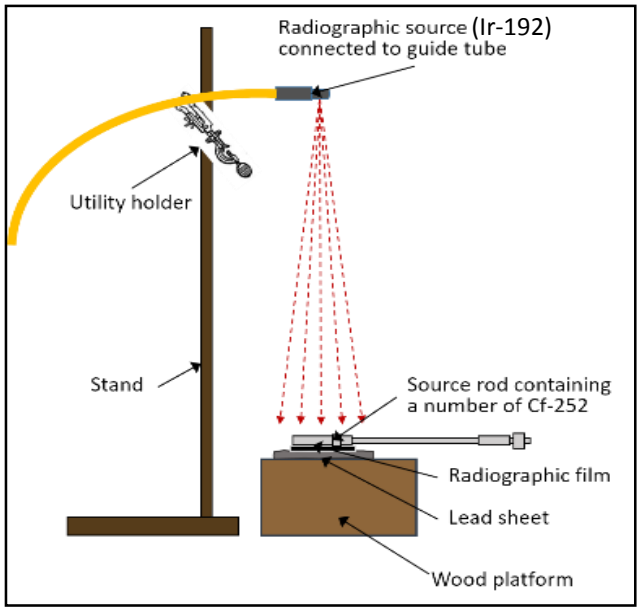

Figure 1. The radiographic exposure set-up.

Results and Discussion

Using the formula $U_g = \frac{F \, x \, OFD}{SOD}$, where, F is the focal size, OFD is the object film distance, the assigned source object distance (SOD) is 20", the calculated U_g which is the geometric unsharpness, is 0.003". The set time as calculated by the formula, $Exposure\ time = \frac{Exposure\ Factor \ x \ SFD^2 x \ FF}{Source\ Activity}$, is 55 seconds for each shot. With the thickness of 10 mm, the exposure factor was 0.115 and the optical density is 2.5. Figure 2 is the actual images (radiographs) of the specimen source rod. It is evident that the source rod contains three (3) units of Cf-252 and are doubly encapsulated. The Cf-252 sources #1 and #3 are identical in shape and structure while source #2 is completely different due to their suppliers. The NDT team only received minimal doses. Electronic personal dosimeters worn by each member indicated slight increase of their accumulated dose by a value of 2 uSv, not to mention neutron exposure.

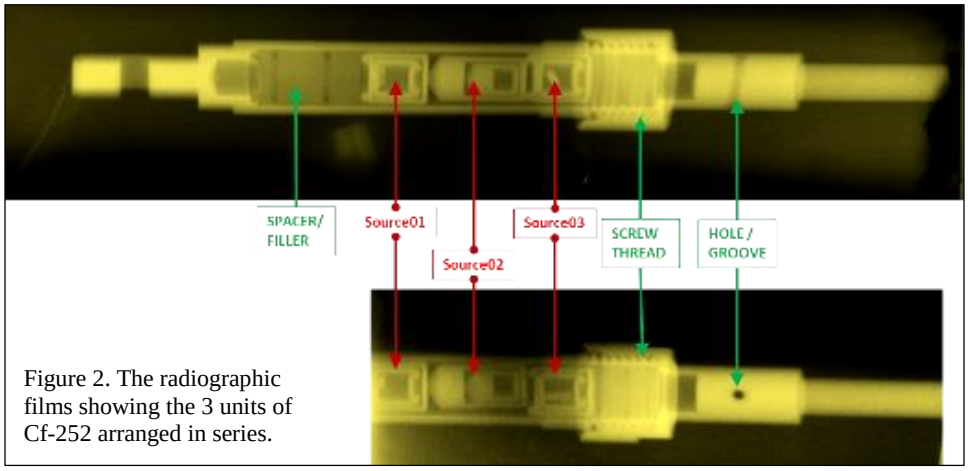

Figure 2. The radiographic films showing the 3 units of Cf-252 arranged in series.

Conclusion

The radiographic films have validated the actual content of the source rod that is, three (3) units of Cf-252, with no physical property effect to the source encapsulation and the source rod itself. With proper implementation of the procedure as planned, it posed no significant health effect as indicated in the dosimeters of the NDT team. The concern whether a piece of Cf-252 is missing or not, is now considered closed.

References:

1) ASME CODE Section V, Article 2: Radiographic Examination 2010
2) Practical Radiation Safety Manual, Manual on Gamma Radiography, IAEA, March 1996

Comparison of Two Different Methods Used to Calibrate Personal Dosimeter

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Introduction

The Radiation Protection Services Section of the Philippine Nuclear Research Institute maintains and operates the Secondary Standard Dosimetry Laboratory (SSDL) and utilizes Cs-137 as standard source for calibration of radiation monitoring instruments including personal dosimeter. A personal dosimeter can be calibrated either by accumulative or staggered method. The accumulative method is exposing the dosimeter up to maximum possible value by increment while the staggered method is exposing the dosimeters in different doses varying on exposure time. The response or quotient of the conventional true value divided the indicated value of the instrument was then computed whichever method is used. The acceptable limit is 0.8 to 1.2 and 1.0 is the most certain. Since there is no prescribed method, the Section may develop a calibration protocol by comparing the two (2) methods through the result of this work.

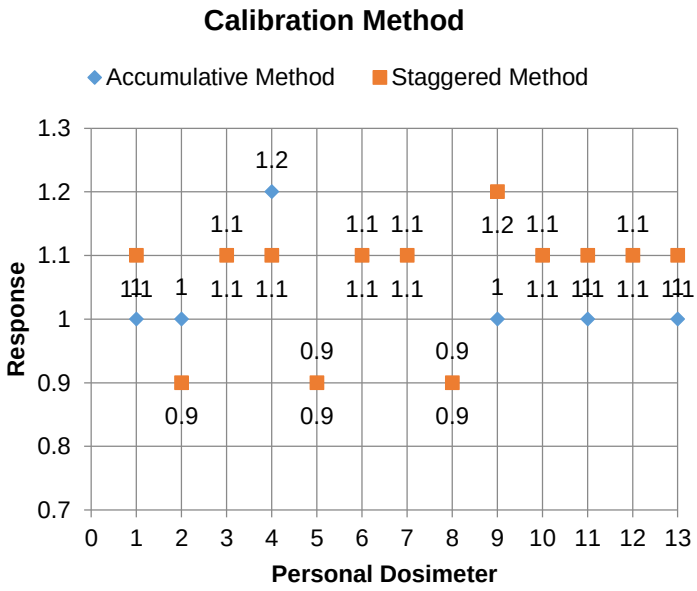

Figure 1. Response of every dosimeter in the two (2) calibration methods.

Materials and Methods

The measurements were carried out at the SSDL. Thirteen (13) units of calibrated ion-chamber 200mR Gamma & X-ray DOSIMETER Model 862 were set for both accumulative and staggered method and exposed at a fixed distance. The response of every dosimeter per set-up was computed, and then the results were compared.

Results and Discussion

Five (5) or 38.46% out of 13 dosimeters have the same response and eight (8) or 61.54% dosimeters have different response in both methods. In comparison, five (5) or 38.46% of the dosimeters in accumulative method while none of the dosimeters in staggered method have a response of 1.0.

Conclusions

The similarity and difference of response can be observed in accumulative and staggered method through the exposure. Having the most certain response, the accumulative method is better than staggered method.

References:

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Design Calculation of Storage Drum for Encapsulated Disused Sealed Radioactive Sources using Monte Carlo N-Particle Transport Code

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Introduction

Radioactive waste must be managed in such a way as to avoid imposing an undue burden on future generations; that is, the generations that produce the waste have to seek and apply safe, practicable and environmentally acceptable solutions for its long-term management. The Philippine Nuclear Research Institute maintains and operates a centralized national Radioactive Waste Management Facility to provide better conditions for long term storage of radioactive waste. It is designed so that the waste can be received, handled, stored, inspected or monitored and eventually retrieved without undue occupational or public radiation exposure or environmental impact. Equipment, such as industrial gauges, containing disused sealed radioactive sources (DSRS) are dismantled and the recovered DSRS is conditioned by encapsulation. These stainless-steel capsules are stored in 200-liter steel drums awaiting for a final repository. Currently, there are three capsules containing Category 3 to 5 gamma and beta sources. In order to maximize the capacity of the storage drum, the existing design was optimized and calculated using Monte Carlo N-Particle (MCNP) Transport code to contain all three capsules in one storage drum without exceeding the regulatory limit of 2.0 mSv/h dose rate at contact from the external surface of the package.

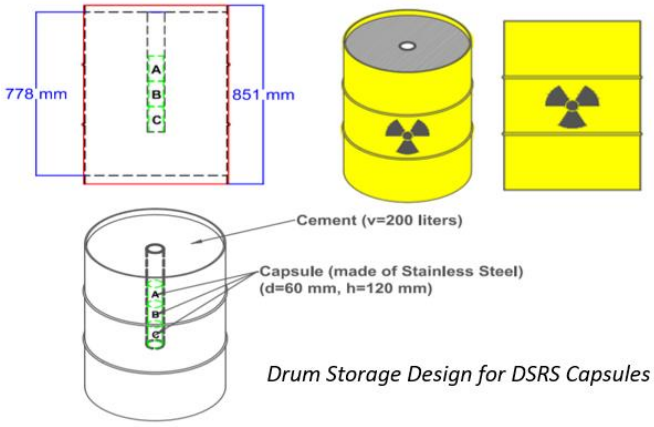

Figure 1. Drum Storage Design for DSRS Capsules.

Materials and Methods

MCNP-5 was used to get the maximum dose rate at the surface of the drum. The F4 tally feature was used with the detector geometry as a "ring" encompassing the drum diameter. The ANSI/ANS-6.1.1 photon flux-to-dose conversion values [1] was used to set the F4 tally output directly to dose rate. All material compositions were taken from McConn, et al [2] and the Fmesh4 tally was used to generate a 3D dose rate plot. Results were run with enough particles to achieve relative errors of less than 1% and beta radiations pose negligible dose rates as compared to gamma from Cs-137.

Results and Discussion

The calculations for the 200-liter steel drum prelined with concrete and a 0.5 cm thickness lead pipe and with the capsule configuration of Capsule A on top, B at the middle and C at the bottom, showed that the maximum dose rate at the surface of the drum is 1.4608 mSv/h and at 1-meter from the surface is 0.0583 mSv/h.

Conclusions

The calculation using the MCNP-5 indicates that the design of the storage drum to be used in storing the stainless-steel capsules is in accordance with the regulatory limit.

References:

1. American Nuclear Society. Working Group ANS-6.1.1 and American National Standards Institute, American National Standard Neutron and Gamma-ray Flux-to-dose-rate Factors, ANSI/ANS (American Nuclear Society, 1977), https://books.google.com.ph/books?id=uV5GHQAACAAJ.
2. R. J. McConn, C. J. Gesh, R. T. Pagh, R. A. Rucker, and R. G. Williams, Compendium of Material Composition Data for Radiation Transport Modeling (2011), https://www.pnnl.gov/main/ publications/external/technical_reports/PNNL-15870Rev1.pdf

Application of Isotope Techniques in Verifying Groundwater Recharge Processes in Bulacan Province, Philippines

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Introduction

Bulacan Province is one of the fastest growing provinces in the Philippines in terms of development and population. Groundwater has been the main source of water supply and water shortages, owing to the deterioration of water quality, mainly from high salinity, have been commonly experienced. A rapid hydrogeological assessment of the province was conducted based on secondary data. In conjunction, field investigations were conducted for the chemical and isotopic characterization of water sources to verify the process of groundwater recharge in the study area and evaluate current trends in freshwater quality in the area.

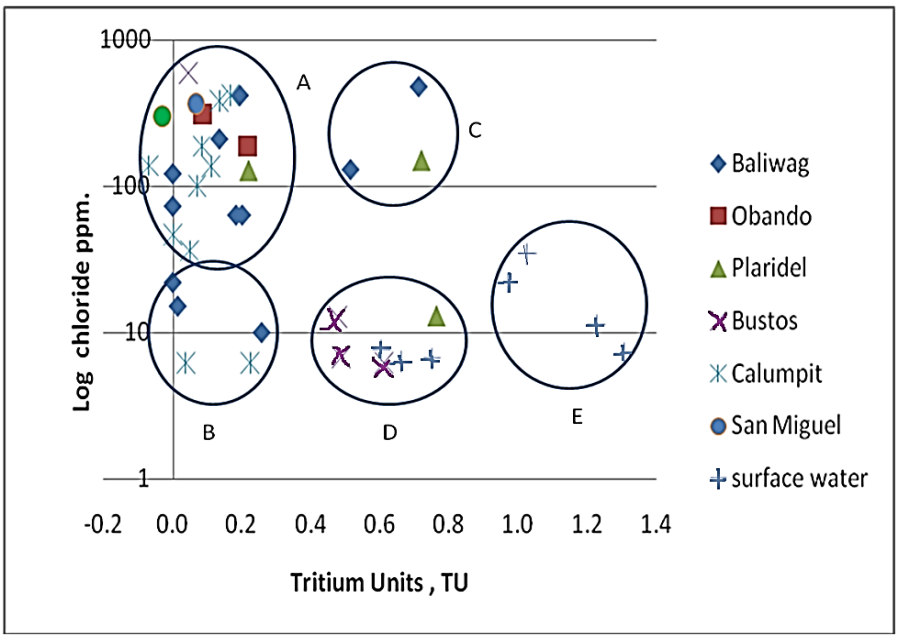

Figure 1. Water groups in Bulacan province, Philippines inferred from correlating tritium and chloride data.

Materials and Methods

Water samples were collected from selected production wells, domestic wells, and surface water sources in the localities of Angat, Balagtas, Baliwag, Bustos, Calumpit, Obando, Plaridel, San Ildefonso, and San Miguel. Groundwater samples were collected from production wells which are generally mixtures of water originating from the different multilayered aquifers with depths ranging from 30 to 300 m. Physico-chemical properties (pH, conductivity, salinity, temperature) of the water were determined on site. Chemical analyses for major ions were performed by ion chromatography (IC) and titrimetry. Tritium concentrations were determined by electrolytic enrichment followed with liquid scintillation counting (LSC) and hydrogen and oxygen isotopes were determined by isotope ratio mass spectrometry.

Results and Discussion

The results of chemical and isotopic investigations showed that in general, the trends in groundwater quality with time are shown to be fairly constant, and that the isotopic results confirm the inference from hydrogeological assessment of the recharge and salinization process of the groundwater in the study area. Stable isotope data indicates mixing with sea water and shallow groundwater in the coastal area, while in the hilly area, both meteoric water recharge and mixing with connate water are indicated. Correlation of tritium concentration with chloride concentration yielded four groups of groundwater (Figure 1): **a)** low tritium, 0 to 0.2 TU with high salinity; **b)** old water with low salinity- mainly from freshwater from the regional flow, **c)** moderately young water (0.4 -0.8 TU) with high salinity. **d)** moderately young water with low salinity; groundwater with recent freshwater recharge from precipitation and/or surface water

Conclusions

Groundwater in Bulacan Province has been verified to be coming from several processes: direct rainfall infiltration into the top soil and exposed permeable rocks; infiltration of meteoric and irrigation water into agricultural lands; seepage of connate water from ancient rocks, and recharge from remote sources, specifically the Pampanga river basin.

Estimation of Radon Concentration in Soil Gas and Ground Water

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Introduction

This study aims to establish radon levels in the two major sources of indoor radon and to estimate annual effective dose due to inhalation and ingestion of radon. The health hazard associated with radon arises from the inhalation and ingestion of short-lived decay products of radon. Radon measurements were done in water samples in Mt. Pinatubo Lahar-affected areas in Region 3 and provinces of Region 4A using an electronic-based RAD7 detector. The measured radon concentration in water samples Region 4A and Region 3 ranged from 0.30 to 6.20 Bq L^{-1} and 0.4 to 1.40 Bq L^{-1} with a total mean values 2.50± 0.41 and 0.87 ± 0.05 Bq L^{-1} respectively which lies between the safe limit from 3 to 40 Bq L^{-1} by UNSCEAR, 2008. The total annual effective dose estimated due to radon concentration in water ranged from 2.46 to 7.76 with a total mean values of 5.04 ± 2.56 µSv y^{-1}. It was observed that the soil and water in measured sites are suitable for drinking water and construction purpose for without posing any health hazard.

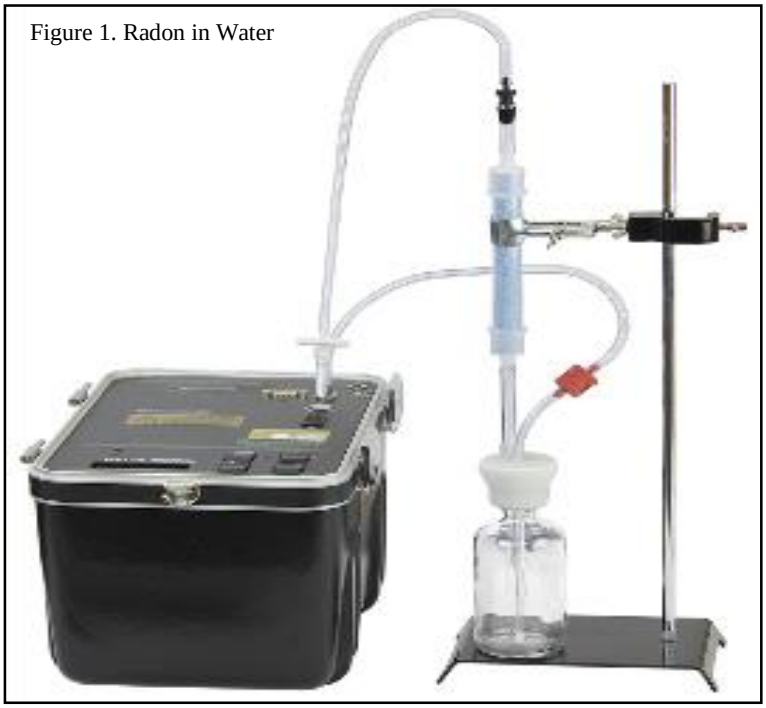

Figure 1. Radon in Water

Materials and Methods

Radon Concentration was measured using an electronic-based Durridge RAD7 detector which uses a solid state alpha detector. Figure 1 shows the schematic diagram of Rad H20 assembly. A radon tight reagent bottle of 250 ml capacity has been used to collect the water samples. The radon detector RAD7 was coupled with a bubbling kit. WAT 250 protocol and grab mode was used for radon measurements. Initially the built-in pump of RAD7 runs automatically for 5 minutes' duration to aerate the sample and deliver the degassed radon to the RAD7 measuring chamber. After this time period the pump stops automatically and the system wait for another 5 min interval to start counting. After the 5 min counting period, the data are printed out on the printer attached with the instrument. The counting process repeats for a total of four min cycles to obtain precise results. For soil measurement, a stainless metal accessory was inserted in the soil at a specific depth of about 100 cm. The probe was then connected to RAD7 through dessicant tube containing CASO4 and inert filters for sucking the soil gas from the underground soil. (Figure 2).

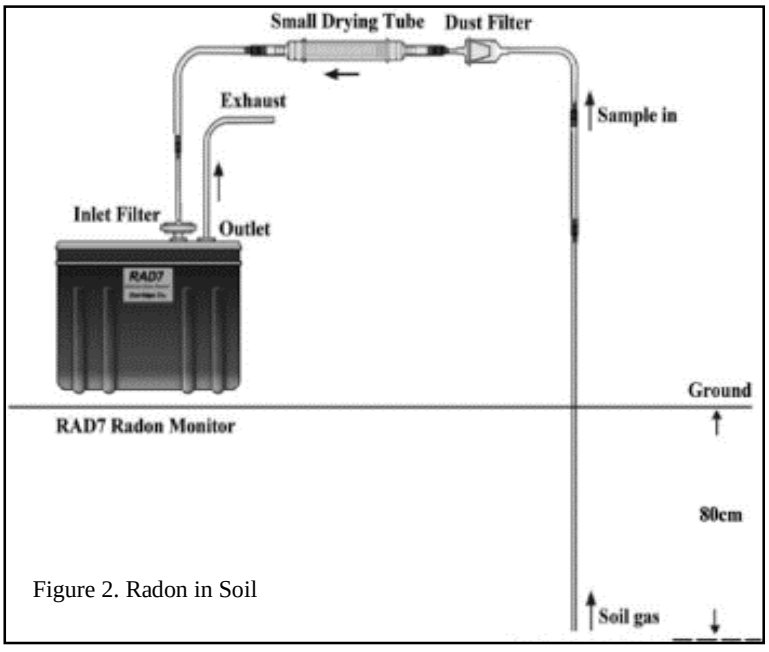

Figure 2. Radon in Soil

Results and Discussion

The annual mean effective doses for drinking water samples due to ingestion was calculated by using the parameters established in UNSCEAR 2000**:**

E_{wIg} (nSv y^{-1}) =CRn x C_w x EDc

Where: Ew_{Ig} is the effective dose for ingestion,
CRn is the radon conc (KBq m^{-3}),
C_w is the weighted estimated water consumption (60 l y^{-1}) and
EDC is the Effective Dose Coefficient for ingestions 3.5 nSv Bq^{-1}.

The annual mean effective doses of drinking water samples due to inhalation was calculated by:

E_{wIh} (µSv y^{-1}) = CRn x Ra x w x F x O x (DCF)

Where E_{wIh} is the effective dose for inhalation,
CRn is the radon concentration in water (kBq m^{-3}),
Ra is the ratio of radon in air to radon in tap water (10^{-4}),
F is the equilibrium factor between radon and its decay products (0.4),
O is the average indoor occupancy time per person (7000 h y-1) and
DCF is the Dose Conversion Factor for radon exposure 9 nSv h^{-1} (Bq m^{-3})$^{-1}$.

The annual effective dose due to inhalation and ingestion were estimated from radon concentration in water samples which ranged from 2.10 to 7.16 with a mean value 4.65 ± 2.37 56 µSv y^{-1} for inhalation and 0.18 to 0.60 with a mean value of 0.39 ± 0.20 µSv y^{-1} for ingestion. The radon concentration in soil and water and gamma ambient dose in Region 4A were higher than in Region 3 maybe accounted for its volcanic characteristics and the presence of several hot spring. The total mean radon concentration in all sites of two regions ranged from 0.9 to 10.21 Bq L-1 with a total mean value of 1.84 ± 0.94 Bq L^{-1}. Radon concentration in all water samples studied area is found within the safe limit recommended by Environmental Protection Agency (USEPA, 1991) of 11 Bq L-1 which was also included in the 1993 Philippine National Standards for Drinking Water. However, there were two hot spring water collected in the survey at Region 4A with a radon concentration of 32.02 and 31.12 Bq L-1 but still lies between the safe limit from 3 to 40 Bq L^{-1} by UNSCEAR 2008.

Conclusions

1. The measured radon concentration in ground water in representative sites are well within the safe limit recommended by UNSCEAR 2008
2. The total annual effective dose estimated due to radon concentration in water ranges from 2.46 to 7.76 with a mean value of 5.04 56 µSv y^{-1}, which is lower than the safe limit of 0.1 mSv y-1 as set by World Health Organization (WHO, 2004) and European Council (EU, 1998).
3. Further studies should be done on the different hot springs water due to the fact that some of the bottled mineral water were collected in spring water. When considering the USEPA and Philippine Standard for Drinking water (Maximum concentration limit), 11 Bq L-1 for radon in drinking water, the mineral water should be stored for at least 8-9 days after bottling before selling to the market.

References:

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3. WHO 2004 (World Health Organization)
4. P. Sok, K. Srisuksawa, Loaherjane et. Al. "Radon Concentration in air, hot spring water and bottled Mineral Water in Thailand, Journal of Radio analytical and Nuclear Chemistry, August 2013, Vol. 297, Issue 2

Nuclear analytical techniques: unraveling air particulate pollution in Metro Manila

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Introduction

Air particulate pollution is a serious and continuing problem in Metro Manila affecting health, environment and climate. Effective strategies in the reduction of air pollutants does not rely simply on determining the levels of particulate mass but on knowing the sources, its contribution and the direction from which these are coming from. However, receptor modelling techniques such as positive matrix factorization (PMF) relies on multi-elemental data that can be provided by nuclear analytical techniques (NATs) which are rapid and non-destructive. Elemental concentrations revealed using these NATs are effectively used in the source apportionment of air pollutants as exhibited and shown in the 17-year source apportionment study at the Ateneo de Manila University (ADMU) sampling site.

About 49% of the fine particulates come from vehicular emissions. Other sources are smoke (14%), secondary S (22%), fine soil (8%) and industry (7%).

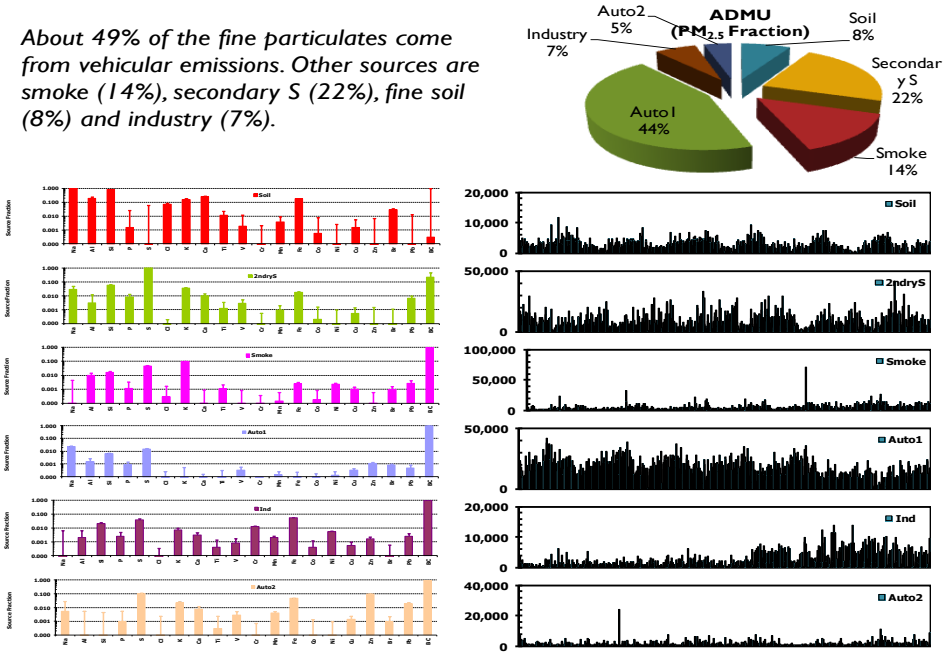

Figure 1. $PM_{2.5}$ source apportionment profile at ADMU sampling site. Vehicular emissions making up to 49% of the fine air particulate fraction.

Materials and Methods

Respirable air particulate matter or the fine fraction ($PM_{2.5}$) were collected using Gent air samplers for a 24-hr period on Wednesdays and Sundays for the period of 2001 to 2017. Multi-element profiles from PIXE measurements were done at ANSTO. Black carbon analysis used the Smoke-stain reflectometer. Source identification and apportionment was done using the PMF2 DOS version with ANSTO macros.

Results and Discussion

$PM_{2.5}$ levels are in exceedance of the WHO 1-year guideline values indicating the ambient air quality at ADMU site as unhealthy by the WHO standards. Black Carbon, a fingerprint of incomplete combustion products, can reach up to 80% of $PM_{2.5}$. Multi-element profiles (from PIXE measurements done at ANSTO) show Sulfur having very high contribution to the fine air particulate pollution. Source apportionment show six (6) sources—fine soil, secondary sulfur, smoke or biomass burning, industrial and vehicular (auto1 + auto2). Vehicular emissions comprise 49% of the apportioned sources and can go as high as 71% if including secondary sulfur.

Conclusions

In Metro Manila, traffic was found to be a major source of air pollution. The findings showed that addressing the traffic problem could lead to less pollution, healthier air and contribute to the mitigation of climate change.

Contributions of Terrestrial Radiation to Ambient Gamma Dose Rate and Occurrence of Temporal Variation in Aparri, Cagayan, Philippines

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Introduction

Exposure to ambient gamma radiation comes mainly from terrestrial radionuclides potassium-40 (^{40}K) and decay daughters of uranium-238 (^{238}U) and thorium-232 (^{232}Th) that are present in soil and rocks. In addition, events such as nuclear accidents and weapons explosion can result to radiation exposure through the release of artificial radionuclides in the atmoshphere. A real-time radiation monitoring system can continuously measure ambient gamma dose rate to immediately detect increased levels due to such events. However, variations in ambient gamma dose rate occur naturally and therefore must be assessed.

Materials and Methods

This study assessed the one-year ambient gamma dose rate in Aparri, Cagayan, and the occurrence of seasonal variations using time series data collected by a real-time radiation monitoring station. The equipment used to measure ambient gamma dose rate and ^{40}K, ^{238}U and ^{232}Th dose rates in this study was a 3x3" Thallium activated Sodium Iodide (NaI(Tl)) detector. Seasonal variations were assessed from the monthly mean dose rates collected from January to December 2016.

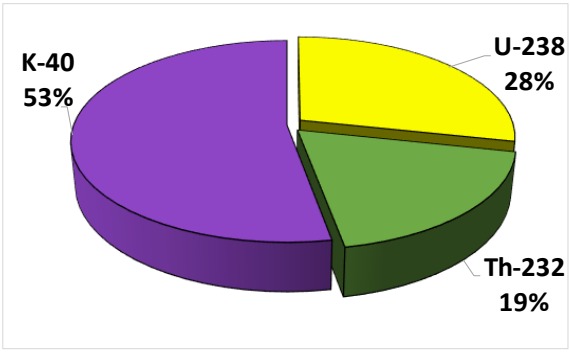

Figure 1. Percent contributions of Potassium-40 (K-40), Uranium-238 (U-238), and Thorium-232 (Th-232) to the 1-year average ambient gamma dose rate measured using the radiation monitoring station in Aparri, Cagayan, Philippines.

Results and Discussion

The baseline of total ambient gamma dose rate is 15.0 nSv h^{-1}, with a range of 14.2 to 16.3 nSv h^{-1}. ^{40}K contributes the greatest fraction to the total ambient gamma dose rate at 53%, followed by ^{238}U at 28%, and ^{232}Th at 19%. Standard deviations of total ambient gamma dose rate correlates strongly with standard deviation of ^{238}U (correlation coefficient, r = 0.9971) but correlates weakly with standard deviations of ^{232}Th (r = 0.7720) and ^{40}K (r = -0.2180).

Conclusions

It was shown in this study that ambient gamma dose rate measured by monitoring station in Aparri, Cagayan is contributed primarily by potassium-40. However, its temporal variation is affected more strongly by uranium-238 dose rate than potassium-40 and thorium-232.

Monitoring and Evaluation of Radiation Dose Rate Levels in PNRI Grounds and Vicinities

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Introduction

Environmental radioactivity monitoring is being conducted in PNRI grounds and vicinities for detection of anomalous levels of radiation in the environment following the occurrence of a nuclear event and for dose assessment of the general public due to exposure to radiation. Despite having no nuclear facilities currently in operation within our country, having a well-established nuclear safety programme backed by up-to-date environmental radioactivity monitoring data is crucial to ensure the safety of the public and the environment within its territory. The radioactivity data generated will serve as a baseline data in monitoring radioactive releases in the environment to ensure the safety of radiation workers and the public.

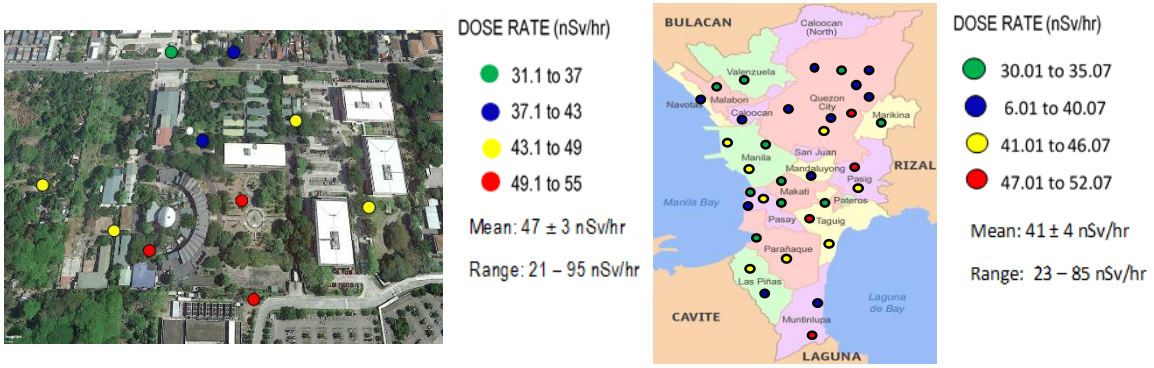

Figure 1. Radiation map of PNRI and Metro Manila (2014-2018) showing Ambient Air Gamma Dose Rate Measurements.

Materials and Methods

Measurements of ambient equivalent dose rates in PNRI grounds and Metro Manila were carried out using a portable gamma spectroscopy system *SAM-940* portable gamma meter with 2x2 NaI(Tl) detector. The readings in each of selected sites were taken five times at one-minute interval at approximately one meter above the ground. A global positioning system (GPS) reading was recorded to determine the exact location of the sites. The time of day and weather condition during the monitoring were also recorded.

Results and Discussion

Result of ambient gamma radiation measurements within PNRI grounds and perimeter was found to have an average of 47±3 nSv/hr, which is within the normal background radiation level ranging from 42 to 70 nSv/hr. The average level of radioactivity on selected monitoring sites within Metro Manila was found to be 41±4 nSv/hr. This shows that PNRI has higher dose rate levels than Metro Manila since PNRI houses various research and service facilities containing radioactive sources. However, these values are within the normal background levels and do not pose any hazard to the general public.

Conclusions

The radioactivity data obtained from environmental monitoring will serve as baseline for future studies on long term changes of radioactivity in the environment as well as an essential tool in monitoring radioactive discharges resulted from nuclear accidents that could possibly affect the Philippines in the future. Hence, regular ambient gamma monitoring in PNRI and vicinities is necessary to ensure the safety and security of its workers and the public against radiation hazards.

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Assessment of Temporal Variations of Natural Radionuclides Beryllium-7 and Lead-212 Concentrations in Surface Air in Tanay, Philippines through the CTBTO Radionuclide Monitoring Station PHP52

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Introduction

Physico-chemical processes occurring in the atmosphere play an important part in the global distribution of radionuclides. The detection of primordial cosmogenic and terrestrial radionuclides in surface air provide researchers the opportunity to understand these processes occurring in the atmosphere as well as to evaluate the total exposure of the public to ionizing radiation. In this study, radionuclide concentrations of cosmogenic and terrestrial radionuclides Beryllium-7 and Lead-212 in surface air and meteorological data collected by the CTBTO Radionuclide Monitoring Station PHP52 in Tanay, Philippines were assessed to understand the atmospheric conditions involved in radionuclide distribution in tropical climates.

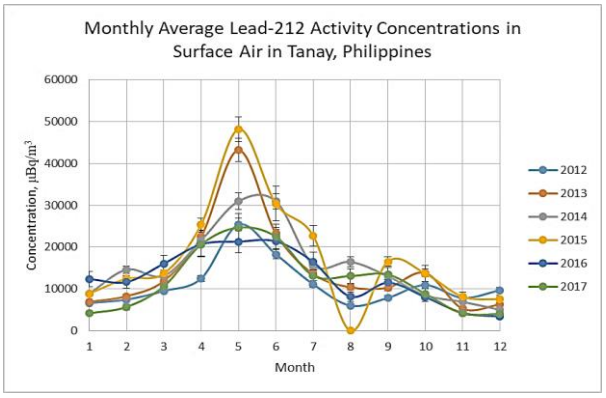

Figure 1. Monthly average activity concentrations of Lead-212 in surface air in Tanay, Philippines from 2012 to 2017.

Materials and Methods

Air particulate samples were collected daily for 24 hours on a 57cm x 46cm Whatman GF/A glass fiber air filter using a high-volume air sampler located 1.5 meters above ground with a sampling rate of 900-950 m^3/hr. The collected air filter sample was then compressed to a 5-cm diameter disc using a hydraulic press, placed on a plastic sample holder, and allowed to decay for 24-hours. The sample is then analyzed for 24 hours using a high-purity Germanium (HPGe) gamma spectrometer. Daily activity concentrations of ^{212}Pb and ^{7}Be from 2012 to 2017 were retrieved from the CTBTO Concentration Reporting Tool (CRTool), plotted against sample collection date. Radionuclide concentrations and meteorological data were then evaluated for possible correlations.

Results and Discussion

Surface air concentrations of ^{7}Be and ^{212F}Pb in 2017 were found to range from 0.025 to 9.877 mBq/m^3 and from 1.718 to 55.549 mBq/m^3, respectively. Surface air concentrations of ^{7}Be and ^{212F}Pb show a consistently similar trend annually from 2012 to 2017. Positive and negative correlations were also observed between radionuclide concentrations and meteorological data, supporting observations from other literature regarding the effects of meteorological factors to variations in radionuclide activity concentrations in surface air.

Conclusions

Radionuclide concentrations in surface air are affected by atmospheric conditions such as temperature, humidity, and amount of precipitation, which also varies depending on the season. This is further supported by the observed annual trends on radionuclide activity concentrations which follow the dry and wet season observed in tropical climates such as the Philippines. Analysis of radionuclide concentrations in rainfall collected in the study site could also be considered in the future to further validate the results acquired in this study.

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Radioactivity Monitoring in the Philippine Marine Environment after the Fukushima Nuclear Power Plant Accident

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Introduction

The nuclear power plant accident that occurred in Fukushima, Japan in 2011 resulted in the release of radioactivity to the atmosphere and to the marine environment. Immediately after the accident, the IAEA organized a technical cooperation project aimed to assess the possible impact of this nuclear accident to the marine environment in the Asia-Pacific region. In support of the RAS 7021 project, the Health Physics Research Section (HPRS/PNRI) conducted intensive surveillance and monitoring activities in selected marine areas in the country. Samples of seawater, sediment and biota were collected and analyzed by gamma spectrometry for anthropogenic radionuclides, Cesium-134 and Cesium-137.

Materials and Methods

Water samples (150L) were collected by bucket sampling in locations 3-5 km offshore. Sample pre-treatment was done in-situ. The sample was acidified; added with carrier and Ammonium Molybdenum Phosphate (AMP) cation exchanger to which Cesium will bind. Sediment samples were collected by grab sampling. About 1 kg of sediment was collected and put in labelled ziplock for transport to PNRI. Fish samples were collected by market sampling. Commonly-eaten fish species (3-5 kg fresh/species) were bought from the public market in a locality. Only the edible part was taken, dried, ground for homogeneity. All samples were analyzed by gamma spectrometry for 24 hours.

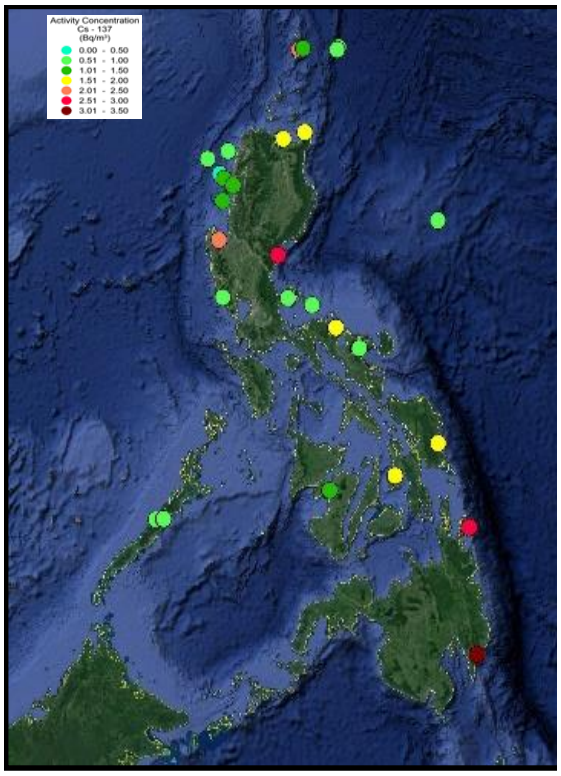

Figure 1. Cs-137 concentration in Philippine marine environment, 2011-2015.

Results and Discussion

Average Cs-137 activity concentration in surface seawater samples (n=40) collected from 2011-2015 was found to be 1.33 ± 0.81 Bq/m^3. This value was lower than the mean activity concentration of Cs-137 reported in ASPAMARD in 2004. The mean activity concentration of Cs-137 surface seawater samples (n=239) in the Asia-Pacific region was 2.40 ± 1.40 Bq/m^3. Cs-137 mean activity concentrations in sediment (n=41) and biota samples (n=130) were found to be 0.50 ± 0.38 Bq/kg and 0.75 ± 0.27 Bq/kgw, respectively.

Conclusions

The results of the analyses done in surface seawater, sediment and biota samples from the period 2011 to 2015 suggested that there was no significant increase in the levels of anthropogenic radionuclides (Cs-137) in the Philippine marine coastal environment that could be attributed to contamination brought about by one of the worst nuclear accidents in recent times. Cs-134 concentrations in all three types of samples analyzed were below the Minimum Detectable Concentration (MDC), an indication that there was no fresh input from the Fukushima accident reaching the Philippine shores.

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Reconstructing impacts and transport pathways of anthropogenic radionuclides in the western equatorial Pacific Ocean and South China Sea using ^{14}C and ^{129}I in corals

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Introduction

Coral cores are excellent natural archives that contain historical information about the physical and chemical conditions of the marine environment wherein the corals grow. This information is stored within coral skeletons in the form of elemental and isotopic proxies such as ^{14}C and ^{129}I. ^{14}C and ^{129}I mainly come from human nuclear activities (HNA) such as nuclear weapons testing and manufacture, nuclear fuel reprocessing, and nuclear accidents. Magnitude and timing of appearance of these radionuclides in coral cores can be used to reconstruct impacts of HNA on coral locations and to better understand transport pathways of radionuclides and associated ocean processes.

Materials and Methods

In this study, we measure ^{14}C and ^{129}I by accelerator mass spectrometry in corals from the east and west sides of the Philippines, Baler and Parola. We primarily focus on the juxtaposition of ^{14}C and ^{129}I time series profiles in the same cores and compare applications of ^{14}C and ^{129}I in corals as HNA proxies and oceanographic tracers to examine their unique capabilities, strengths, and limitations.

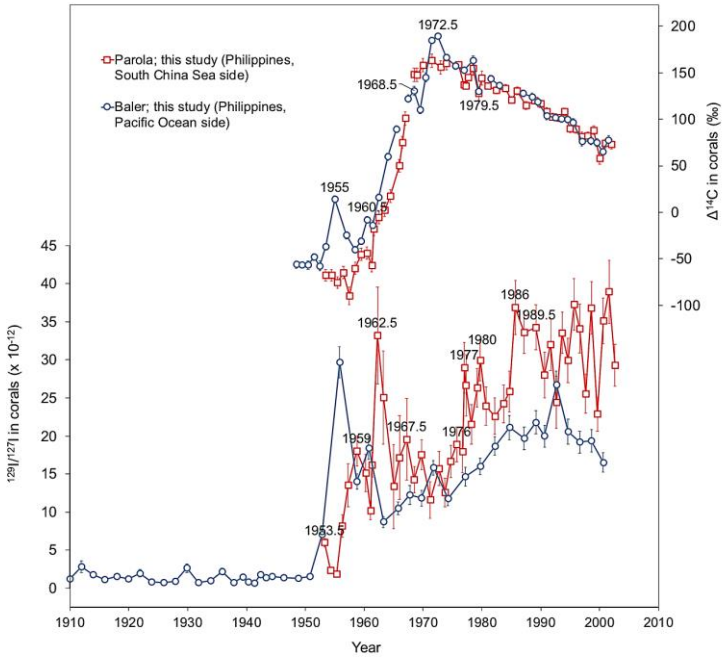

Figure 1. ^{14}C and ^{129}I in coral cores from the Philippines

Results and Discussion

Results show nuclear weapons testing signals in both ^{14}C and ^{129}I time series in Baler and Parola. Radionuclides from nuclear weapons tests done in the Pacific Proving Grounds Testing Site (PPG) take 1.2 and 6 years from the PPG to Baler and Parola, respectively. Moreover, we found that contamination is reduced 82% and 94% from Guam to Baler and Parola, respectively. A detailed look at the ^{14}C and ^{129}I time profiles show that for every Megaton fission of test performed in the PPG in year *y*, we can expect an increase of about 0.3, 1, and 1.5 of $^{129}I/^{127}I$ (x 10^{-12}) in Parola in years, *y* (through the atmosphere), *y+5* (through the northward bifurcation of NEC), and *y+9* (through the southward bifurcation of NEC), respectively. In addition, we can estimate concentrations of other bomb radionuclides from coral ^{129}I levels.

Other information that can be derived from ^{14}C and ^{129}I in corals include: (1) signals from nuclear fuel reprocessing and the Chernobyl Accident. Timing discrepancies between these signals can be used to elucidate transport pathways and estimate current velocities; (2) after 1996, consistently high ^{129}I ratios in Parola, contrary to decreasing trends in Baler and in ^{129}I release records. This shows possible unknown nuclear point sources around the South China Sea; (3) information on ocean variabilities such as El Niño Southern Oscillation, Pacific Decadal Oscillation, and upwelling events and strengths.

Conclusion

^{14}C and ^{129}I in coral cores act as excellent HNA proxies and oceanographic tracers. They can also be used for nuclear activity detection, safety, and security.

Incorporating OCEC Data in Source Apportionment Positive Matrix Factorization of Air Pollution in Valenzuela, Metro Manila

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Introduction

Past studies in receptor modelling have constantly utilized black carbon (BC) concentrations alongside multi-elemental data. Because the Philippines has overwhelmingly high BC concentrations, BC cannot be used to differentiate pollution sources in source apportionment studies. With Organic Carbon Elemental Carbon (OCEC) data now at hand, utilizing these to be treated alongside multi-elemental concentrations in positive matrix factorization (PMF) presents a potential in improving source apportionment resolution and results.

Materials and Methods

In this paper, we incorporated OCEC components and their fractions in PMF; and (2) compared the different runs accompanying elemental analysis data. Data were gathered and processed with the use of a nuclear analytical technique photon–induced X–ray emission (PIXE) in multi- elemental analysis, a Sunset Laboratory OCEC Aerosol Analyzer in an IMPROVE_A protocol with reflectance correction, and positive matrix factorization dos (PMF2) for receptor modelling.

Results and Discussion

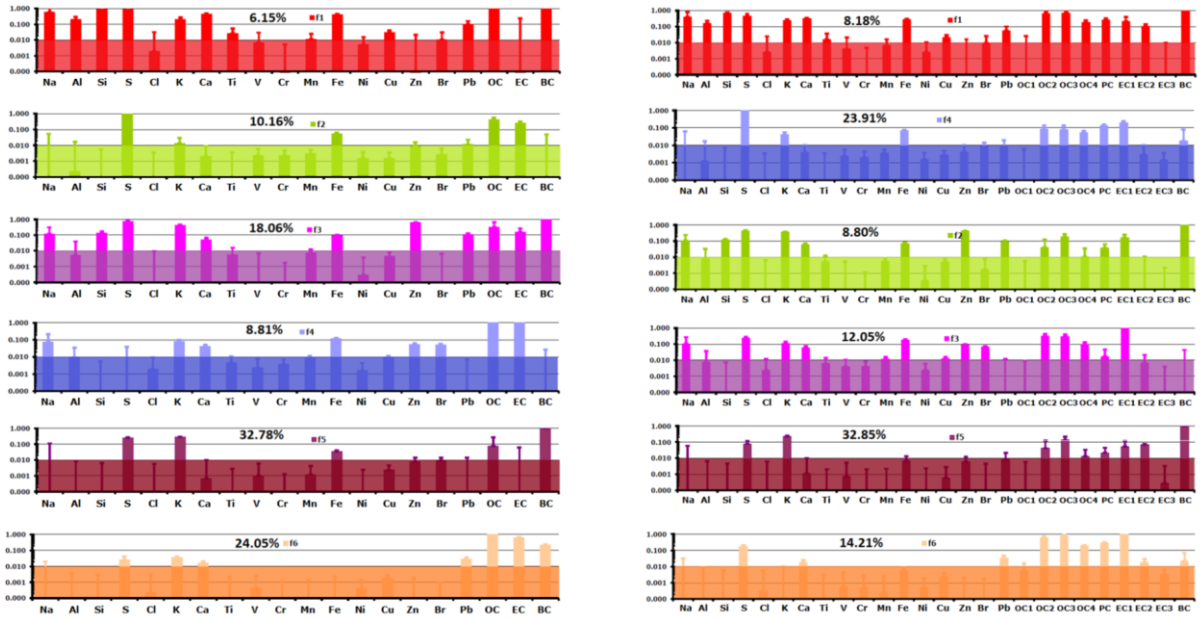

Figure 1. PMF results using multi-element, BC and bulk OCEC (left), and OCEC fractions (right). Left: f1=6.15%, soil with aged industrial sulfur; f2=10.16%, heavy oil burning/smoke; f3=18.06%, industrial; f4=8.81%, burning fraction 2; f5=32.78%, vehicular; f6=24.05%, vehicular fraction 2; Right: f1=8.18%, soil with aged industrial sulfur; f4=23.91%, heavy oil burning/ smoke; f2=8.80%, industrial; f3=12.05%, burning fraction 2; f5=32.85%, vehicular; and f6=14.21%, vehicular fraction 2.

Conclusion

In this study, we showed that integrating multi-elements with OCEC data in PMF was feasible. It enabled better identification of source factors and combustion sources, which was previously impossible to do in PMF runs using only multi-element and BC data. This new information will help pinpoint the primary culprits of combustion air pollution. This can also assist policymakers focus their efforts towards managing these identified combustion activities.

Establishment and Validation of Dose Response Curve for Micronucleus

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Introduction

Chromosome aberrations in lymphocytes are used to estimate absorbed dose to overexposed persons. The estimation of absorbed dose is done by reference to a dose response calibration curve established by in-vitro irradiation study of human blood samples from volunteer donors. Micronucleus is one of the chromosome aberrations that can be used as a biomarker to measure absorbed radiation dose in accidentally exposed persons. It is formed from lagging chromosomal fragments or whole chromosomes at anaphase which are not included in the nuclei of daughter cells. They are therefore seen as distinctly separate small spherical objects that have the same morphology and staining properties of nuclei, within the cytoplasm of the daughter cells (IAEA, 2011).

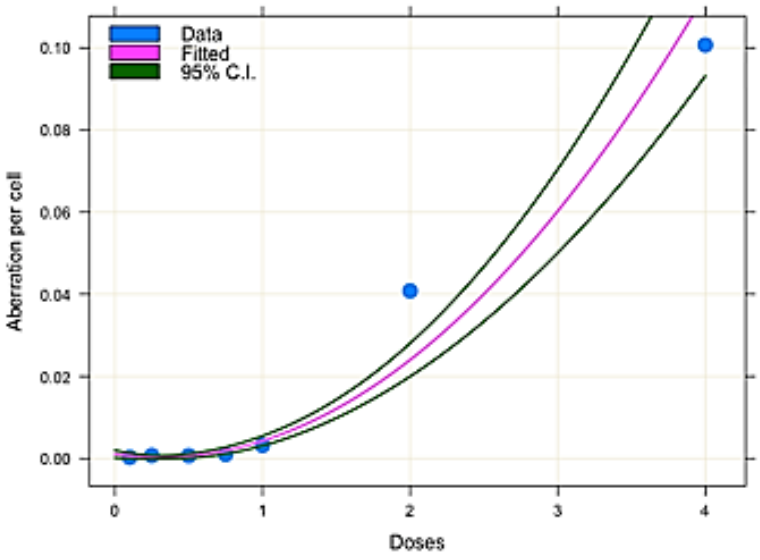

Figure 1. Dose response curve (Donors 2 & 3).

Materials and Methods

Three (3) volunteer donors who were non-smoker males, aged 23 to 35 years old, with no history of radiation exposure and have signed informed consent forms were the source of blood samples. The Blood samples and Optical Stimulated Luminescence (OSL) dosimeters were irradiated at 0.0, 0.1, 0.25, 0.5, 0.75, 1, 2 and 4Gy using the Gamma cell irradiator of St. Luke's Medical Center. Irradiation time was computed based on the dose rate of the source at the time of irradiation. Blood samples were incubated and harvested following the procedure of IAEA EPR 2011-Biodosimetry manual. Five to six drops of mixed cell suspension were dropped on the slide. Four slides were prepared per sample. The slides were coded for identification and stained in 2% Giemsa staining solution for 8 -10 minutes and were rinsed in distilled water and air-dried. The slides were analyzed by microscopy and the micronucleus images were captured using the built-in microscope camera, saved and counting of binucleated cells and micronucleus scoring were done in the computer.

Results and Discussion

Analysis of the pooled data from the three donors resulted to a dose response curve that fits well into the data but the outlier at dose 2 was not captured at 95% confidence interval. Donors 2 and 3 computed individually and combined have chi-square p-value which indicated that fitted data points were statistically not different from the observed ones, indicating good fit. The best dose response curve was the result from the combination of donors 2 and 3, shown in Figure 1. The purple color is the dose-response curve. The dark green lines are the bounds of the 95% confidence interval estimated using Equation (7) of Section 9.7 from (IAEA, 2011).

Conclusion

The model fits well into the data however, the 95% confidence interval did not capture the outlier at dose 2. The number of cells (micronucleus in binucleated cells) has to be increased in order to increase statistical confidence of dose response curve.

References:

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Development of the National Dose Registry for the assessment of occupational exposure in the Philippines

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Introduction

There are thousands of workers occupationally exposed to radiation in the Philippines. Workers who work closely with radiation must undergo personnel monitoring and exposure control, a type of service once solely rendered by Philippine Nuclear Research Institute (PNRI). However, over the course of years, different companies also started to provide monitoring services which resulted in a decentralized database. There is no tracking of cumulative doses, particularly for those who worked at different facilities or facilities that availed monitoring service from various providers. Also, there is no harmonized system for reporting of doses.

To address this issue and as recommended by the International Atomic Energy Agency (IAEA), countries such as Canada, Switzerland, and others, have developed a National Dose Registry (NDR), which is a centralized database for monitoring results. The system collects data from several monitoring service providers, process received data into information, and then present them into different reports. Currently, the Philippines does not implement this kind this system. The Radiation Protection Services Section, therefore, developed a dose registry to maintain a centralized Dose repository of occupational exposure.

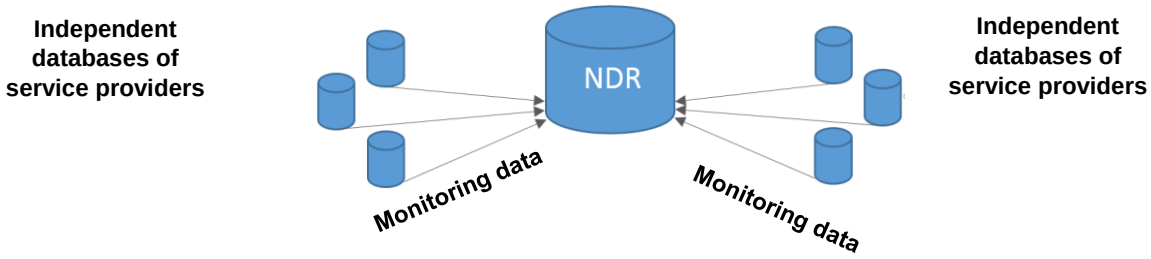

Figure 1. Creating a centralized database for radiation monitoring results.

Materials and Methods

The project was designed to be a web-based system which can be accessed by authorized personnel through an Internet browser. It utilizes the use of the latest version of PHP programming language and CodeIgniter framework. Radiation monitoring data were collected and put in excel files and then uploaded to the NDR.

Results and Discussion

The principal purpose of the registry was to maintain centralized radiation exposure records in the country, particularly on occupational exposures. As of today, only two exposure monitoring service providers have submitted their data, the PNRI OSL and TLD monitoring services, due to legal concerns. The current functions of the NDR include the tracking of dose history of every radiation worker in the country, and providing means to assess and report levels of radiation exposures and evaluate radiation risk. The system also sends overexposure notifications and was made accessible to regulatory bodies.

Conclusions

The NDR is an essential tool that determines radiation worker dose profiles in the country. The system's ability to communicate overexposure to regulatory bodies makes it a significant help in developing regulations. The various reports and summaries produced by the system aids in decision making and work planning.

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Development of Sterile Insect Technique Against Dengue Mosquito Vector: Colony Establishment and Population Monitoring

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Introduction

Dengue has been a major international public health concern. Over 100 million people are infected with the dengue virus every year. Dengue is transmitted by several species of mosquito within the genus *Aedes*. Currently, the primary method of controlling or preventing dengue virus transmission is to combat the vector mosquitoes (*Aedes*) using chemical methods which can be effective but with major environmental costs. Sterile insect technique (SIT), a species-specific, effective and environmentally-friendly method of pest suppression or eradication involves rearing, sterilization and release of insects rendered sterile by gamma radiation (Dyck et al., 2005; Knipling, 1955). The ability to mass produce the target pests in the laboratory is important since SIT involves the colonization of the target species and the large-scale rearing of viable and competitive males for release. The aim of the study is to establish a colony of the target pest and improve its rearing methods, and establish baseline data on mosquito population in selected sites in Quezon City.

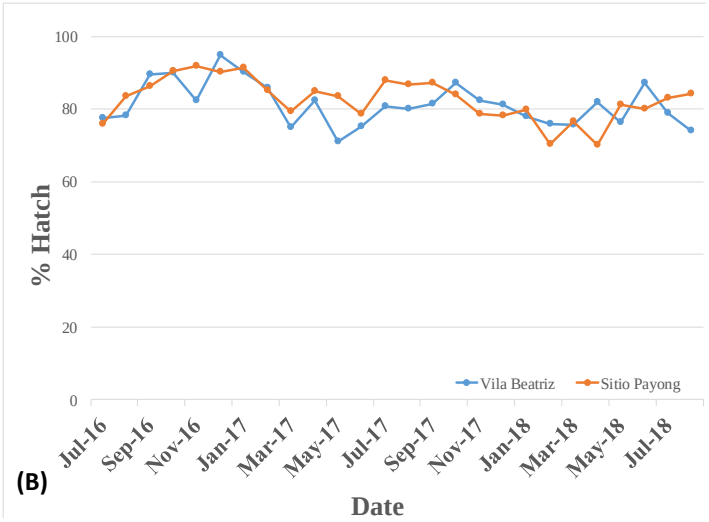

Figure 1. Monthly hatch rate of *Aedes* eggs collected from two sites.

Materials and Methods

The stock colony of *Aedes aegypti* was established at the PNRI from collections made in Quezon City. Quality control tests were conducted per generation of *Ae. aegypti*. Different trapping devices were tested. *Ovitraps* were used as monitoring tool for surveillance of dengue mosquito vector population, *Aedes* mosquito in two selected sites in Quezon City. The ovitraps were set on different locations in 10 selected houses from each site. Egg collection was done at weekly interval. The eggs were hatched and were allowed to develop up to adults to determine species and hatch rate.

Results and Discussion

Two colonies of *Aedes* mosquito are being maintained at PNRI. Blood feeding of adult females was done using both live mice and fresh animal blood. Larvae diets that are commercially available locally were identified to replace the IAEA diet. Based on results, vacuum aspirator trapped more dengue mosquitoes than BG sentinel in a selected pilot site. Using the *ovitrap*, similar proportions and patterns of dengue mosquito population were observed in both pilot and control sites. The ovitrap proved to be a reliable and a more specific method for surveillance and long-term monitoring of dengue mosquito population density in real life conditions in urbanized areas. These results will serve as baseline information for sterile mosquito releases for the planned sterile insect technique program.

Conclusions/Recommendation

A stock colony of *Ae. aegypti* has been established and maintained and can be used for mass-rearing and in the establishment of sterilizing dose. Baseline data on Aedes population on selected sites in QC have been generated needed for planned future SIT Program.

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Hemostatic Agents from Radiation-Modified Polysaccharides and their Derivatives: Product Development and Efficacy/Safety Evaluation in Animal Model

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Introduction

With the lack of inexpensive and accessible hemostatic devices in the country, the healthcare sector remains in need of products to aid uncontrolled hemorrhaging in military and civilian casualties. Polysaccharides and other polymers are prime renewable materials for biomedical applications. Using radiation technology, these polymers can be processed and modified into materials with enhanced properties that can be developed into hemostatic materials.

Methods and Materials

A number of natural and synthetic materials were screened for hemostatic property through *in vitro* coagulation assays. Materials that exhibited high coagulation property were used as stand-alone or combined to prepare hydrogels. These were prepared by simply mixing the polymer powders in water and subjecting it to different doses of gamma radiation for crosslinking. The hydrogels were processed into granular and dressing (reinforced with cotton gauze) hemostats. The final prototypes were subjected to biocompatibility and animal tests.

Results and Discussion

Whole blood clotting and platelet adhesion tests have managed to identify potential formulations based on carboxymethyl cellulose (CMC) and polyethylene oxide-kappa carrageenan blends (PEO-KC). Optimization studies were carried out to finalize initial prototype - granules (20% CMC) and dressing (5% PEO, 2.5% KC). The biocompatibility and efficacy tests of both granules and dressing prototypes revealed very promising results that supported their suitability as medical devices for bleeding control. Prototypes were found to be non-cytotoxic, non-sensitizing, non-irritating and did not produce systemic toxic signs (LD_{50}=0). Efficacy tests of the hemostatic granules and hemostatic dressing to control bleeding of punctured femoral artery, aorta, deep wound and caudal pole nephrectomy with a 97.5% and 100% survivability rate respectively, both performing better than commercial hemostat.

Conclusion

Hemostatic agents made from radiation modified polysaccharides were successfully synthesized, and passed related compatibility testing for a biomedical device. Animal studies revealed that the prototype dressing was more efficient than Celox gauze in controlling bleeding time with a 100% survival rate while the prototype granules was as efficient as Celox granules in controlling bleeding time but with better survival rate, lesser adhesion and easier removal.

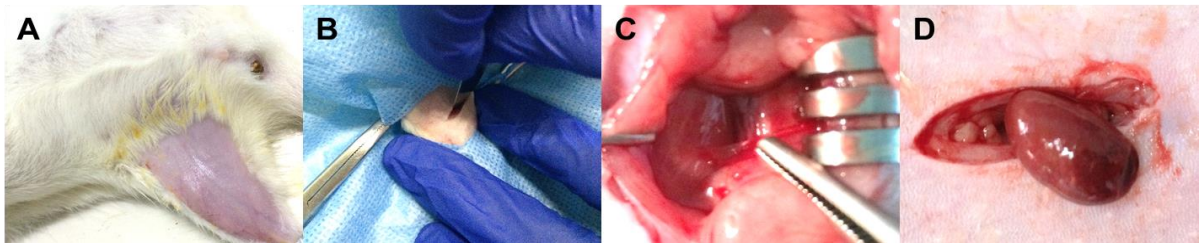

Figure 1. Rat hemorrhage models used for efficacy study to emulate different bleeding modes: (A) femoral artery bleeding; (B) deep wound bleeding; (C) aorta bleeding; and (D) bleeding from kidney surgery

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Radiation sterilized alginate-based wound dressing using stingless bee honey as active ingredient.

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Introduction

Honey has, since ancient days, been used for medicinal purposes. It contains high levels of flavonoids, polyphenols, vitamin B and C, riboflavin and niacin and primary enzyme constituents. Alginate are highly absorbent material that contains sodium and calcium fibers derived from seaweed. Medical devices are required to be sterile. The primary way in which they are sterilized is by irradiation. Ionizing radiation inactivates microorganisms very efficiently and ensures that healthcare products are safe from microbes, especially pathogens.

Materials and Methods

Different types of local honey and New Zealand Manuka honey were investigated for their antimicrobial properties (minimum inhibitory concentration and minimum bactericidal concentration). Highest antimicrobial activity was obtained from stingless bee honey hence this was used in the production of alginate-based wound dressing sterilized using electron beam irradiation. The effect of irradiation on the wound dressing was investigated. Physical properties of the alginate-based stingless bee honey dressing were determined using standard test with minor modifications (Mirel et al., 2013).

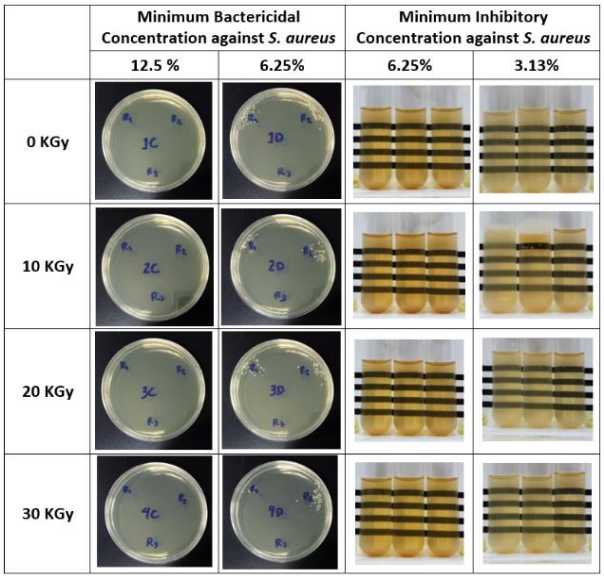

Figure 1. Minimum Inhibitory Concentration (MIC) and Minimum Bactericidal Concentration(MBC) of Stingless bee honey irradiated at different doses.

Results and Discussion

Results of the screening based on antimicrobial properties of the three types of local honey and the New Zealand Manuka honey evaluated against *Staphylococcus aureus* showed stingless bee honey has the highest antimicrobial activity. Also, physico-chemical characterization showed stingless bee honey is acidic and has higher total flavonoid contents almost twice as that of Manuka honey. Test result showed that irradiation of stingless bee honey did not significantly affect its antimicrobial property against *S. aureus.* There was no significant turbidity at 6.25% honey concentration and no bacterial growth at 12.5% honey concentration in all the irradiation doses (0, 10, 20, 30 kGy), thus 6.25% is the minimum inhibitory concentration and 12.5% is the minimum bactericidal concentration. Sterility test of alginate-based stingless bee honey wound dressing showed that 25 kGy of radiation dose is effective in removing any trace of microbial contaminations. Physical properties of the sterile dressing (gel fraction, moisture vapor transmission rate and fluid handling capacity) were not significantly affected by EB irradiation. Acidity also remained the same but there was an increase in the total phenolic content which could be due to radiation degradation of phenolic compounds into much simpler molecules.

Conclusions

Our local stingless bee honey has superior antimicrobial activity compared to other local honeys and even in comparison with the New Zealand Manuka honey. Electron beam irradiation at 25 kGy is sufficient to sterilize the dressing without any significant effect on the antimicrobial property of the honey and the physical properties of the dressing.

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Effect of Gamma Radiation, Packaging Material, Age of Paddy, and Storage Time on the Molds and Yeasts Counts of Brown Rice varieties, RC-160 and SL-7

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Introduction

Rice is the most important staple food for a large part of the world's human population, providing more than one fifth of the calories consumed worldwide. Brown rice has become more popular because of increased awareness of its health benefits. However, mold contamination shortens the shelf life of brown rice. This study determined the individual and interaction effect of gamma radiation dose, packaging material, age of paddy, and storage time on the Molds and Yeasts Count (MYC) of brown rice varieties, RC-160 and SL-7.

Materials and Methods

Two-week old and 8-week old rice paddies were packed in either Polyethylene or Superbag, irradiated at doses of 0, 0.5, and 1 kGy, and stored at ambient conditions (26 ± 1˚C) from 0 to 8 months. At 2-month intervals, MYC was conducted. Factorial and one-way Analysis of Variance (ANOVA) were conducted followed by Tukey's HSD to determine interaction effects and significant differences between group and treatment means at an alpha level of 0.05.

Results and Discussion

Statistical analysis showed no interaction among the factors for both varieties. Individual effect on MYC was detected for radiation dose and storage time for both varieties and the age of paddy for RC-160 ($p<0.05$). Packaging material did not affect the MYC for both varieties. MYC of 1.0 kGy-irradiated RC-160 (2.61 ± 0.34 log cfu/g) was significantly lower than non-irradiated (2.85 ± 0.4 log cfu/g). Likewise, MYC of 1.0 kGy-irradiated SL-7 (2.56 ± 0.22 log cfu/g) was significantly lower than non-irradiated (2.68 ± 0.24 log cfu/g). A significant decrease in MYC was observed against time. Age of paddy had an effect on MYC of RC-160 such that 2-week old (2.81±0.38 log cfu/g) was significantly higher than 8-week old paddies (2.63±0.35 log cfu/g).

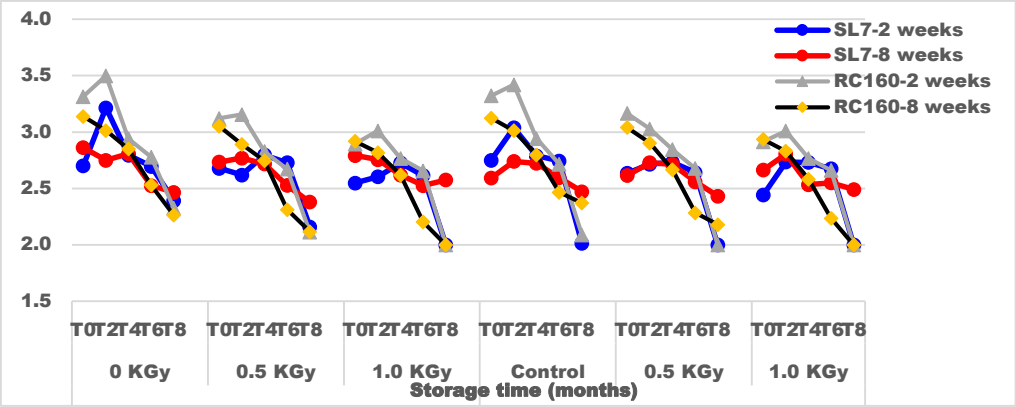

Figure 1. Plot of interaction of radiation dose, packaging material, storage time, and age of paddy on the MYC of brown rice variety (a) RC-160 and (b) SL-7.

Conclusion

Gamma irradiation of 1.0 kGy was found to be effective in reducing the molds and yeast counts of both varieties (RC-160 and SL-7) of brown rice but not for totally eliminating the counts. The type of packaging material does not affect the microbial load on both varieties. However, the age of paddy has an effect on RC 160 variety only wherein higher counts on the molds and yeasts were seen on 2-week old paddy as compared with 8-week old paddy. Both varieties exhibited a decrease in MYC against time.

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Effect of Electron Beam Irradiation on Microbial and Sensorial Qualities of Frozen Vacuum-Packed Ground Beef Burger Patties

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Introduction

Radiation technology using gamma ray or electron beam has been known to be an effective method to improve food safety. This study aimed to determine the effects of electron beam irradiation on the microbial and sensorial qualities of frozen ground beef burger patties.

Materials and Methods

Beef burger patties were prepared, molded, vacuum packed and stored at -18^0 C and were irradiated at 2, 4, and 6 kGy. Monthly analysis for Aerobic Plate Count (APC), Molds Yeast Count (MYC) and Total coliform counts were done. Cooked patties were evaluated monthly for 6 months for color, juiciness, texture, flavor/taste and overall acceptability fifteen untrained panelists. Statistical analysis was done.

Results and Discussion

At 2 kGy APC & MYC were significantly lower compared to non-irradiated (2.8 ± 0.009 log cfu/g vs. 5.0 ± 0.015 log cfu/g and 2.0± 0.0 log cfu/g vs. 3.4 ± 0.043 log cfu/g, respectively), at 6 months of storage (Figs 1 & 2). Statistical analysis showed that APC means of 2 kGy patties were significantly higher than 4 kGy and 6 kGy throughout the storage. APC of 4kGy and 6kGy-irradiated patties have no difference. 4 kGy and 6 kGy further reduced APC to 2.4 ± 0.0 log cfu/g. Dose of 6 kGy further reduced MYC to 1.0 ± 0.0 log cfu/g, from 0 to 6 months of storage. Total coliform counts of all irradiated groups were also decreased compared to non-irradiated controls at 1.0 ± 0 log cfu/g vs. 2.37± 0.87 log cfu/g at 6th months. No significant differences in total coliform count were observed between 2 kGy, 4 kGy and 6 kGy. There was no significant difference in overall sensorial acceptability of cooked beef patties between irradiated and non-irradiated control until 4th month storage (mean score: 4.66 to 5.66($p>0.05$)). At 5th month of storage, mean score for flavor attribute for 2 kGy and 6 kGy irradiated beef patties were 5.2 and 5.73, respectively. There were no significant differences between 2 kGy and 6 kGy for flavor attribute. At 6th month of storage, irradiated beef patties showed significantly higher mean scores than control in terms of flavor and juiciness.

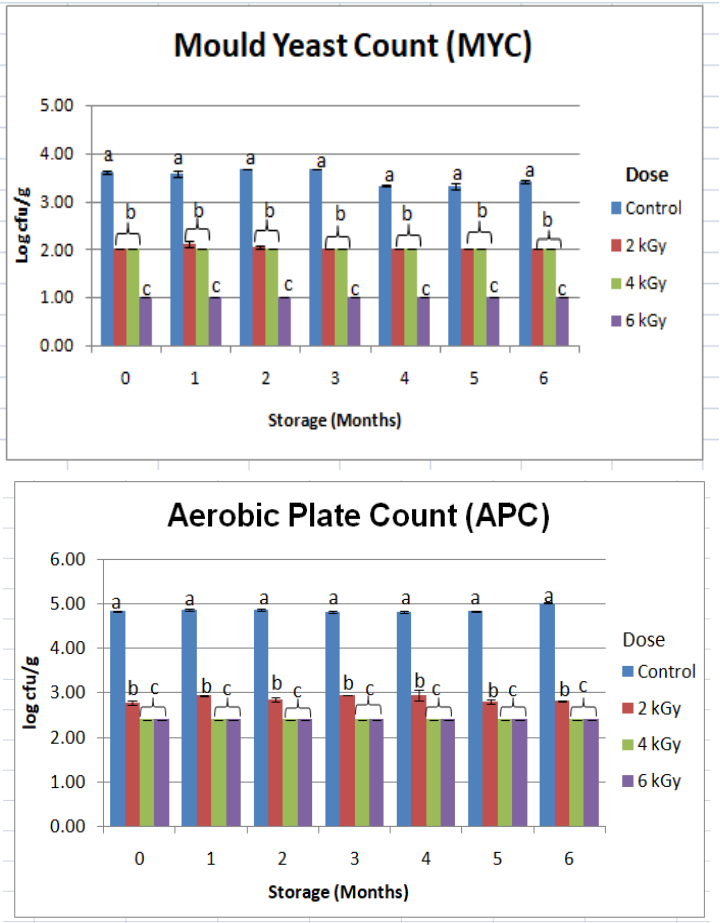

Figure 1-2. Effect of E. beam irradiation on the MYC & APC of burger beef patties, irradiated at different doses, stored for 6 mos. Means with different letters are significantly different between groups *($p<0.05$).*

Conclusion

Electron beam irradiation is effective in reducing the microbial load of frozen vacuum-packed ground beef patties with a dose as low as 2 kGy, from 0 to 6 months of storage 2 kGy maintained the sensorial attributes of beef burger patties throughout 6th month storage. These results are comparable with APC acceptable limit on meat pate (heat treated), which is 10^4 cfu/g and coliform counts of 10 cfu/g, based on FDA Circular 2013. The recommended dose is within the limits applicable for meat, which is 1 to 7 kGy, based on the Philippine National Standard on Code of Hygienic Practice for Radiation Processing of Food.

References:

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Effect of gamma radiation, age of paddy and packaging material on the storage quality of brown rice: surface free fatty acid (FFA) analysis

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Introduction

Brown rice is considered as a superior alternative to milled white rice because it has low glycemic index, high-fiber content and it contains various vitamins and minerals. However, it remains disagreeable to the general public due to longer cooking time, harder grains, and shorter shelf life. One of the factors affecting the quality of brown rice is the free fatty acid produced from its surface lipids. Oxidation and degradation of free fatty acids leads to the formation of hydroperoxides, which are responsible for the unpalatable flavor of brown rice. This study determined the individual and interaction effect of gamma radiation dose, packaging material, age of paddy, and storage time on the surface FFA of brown rice varieties, RC-160 and SL-7.

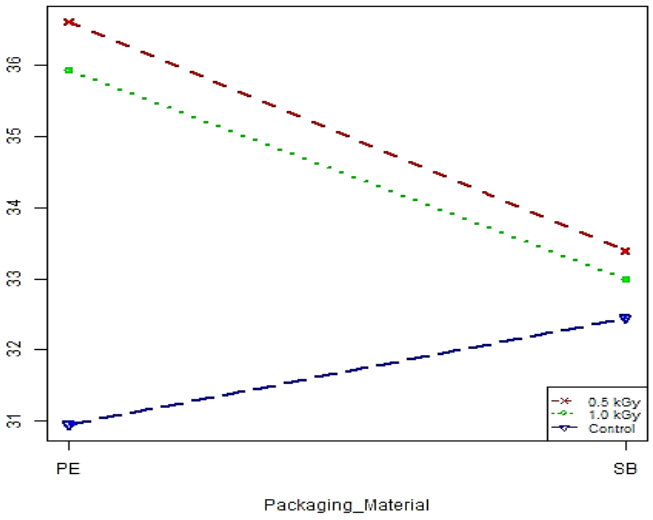

Figure 1. Interactive effect of packaging material to radiation dose on FFA content in SL-7 brown rice (α=0.05).

Materials and Methods

Two-week old and 8-week old rice paddies were packed in either Polyethylene or IRRI Super Bag, irradiated at doses of 0.5, and 1.0 kGy, and stored at ambient conditions (26 ± 1˚C) from 0 to 8 months. The experiment was laid out using Split-Plot RCBD and surface FFA analysis was conducted in a monthly basis. Factorial and two-way Analysis of Variance (ANOVA) were conducted followed by Tukey's HSD at α=0.05 to determine interaction effects and significant differences between groups and treatments.

Results and Discussion

Statistical analysis showed that the age of paddy, storage time and the interaction of both variables were significant. Eight-week old paddy have higher surface FFA than the 2-week old paddy regardless of packaging material and radiation dose. The surface FFA of both varieties packed increased significantly up to the 4th (RC-160) and 6th (SL-7) month and remained almost the same until 8th month of storage. On the other hand, radiation dose did not significantly affect the surface FFA content of RC-160 brown rice for all storage/sampling time while the packaging material significantly interacted with the type of variety and radiation dose. It was also observed that gamma radiation had significant effect in the eight-week old paddy of SL-7 varieties in which the irradiated samples had higher surface FFA than control samples. Significant interaction with the type of packaging material and age of paddy for SL-7 variety was also observed.

Conclusions

Gamma radiation has no significant effect on the surface FFA content of brown rice for RC-160 and it significantly increased the surface FFA of eight-week old SL-7 varieties. Eight-week old paddy have higher surface FFA than two-week old paddy for both varieties and SL-7 varieties than RC-160. Significant interactions were observed between the type of packaging materials and radiation dose. Further analyses are needed to determine the effects of gamma radiation on the integrity of the packaging material and to the lipase enzyme activity of brown rice at low dose radiation.

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