

RCA/UNOSSC Project Final Report

Electron Beam Applications for Value Addition to Food and Industrial Products and Degradation of Environmental Pollutants in the Asia–Pacific region



November 2015

RCA Regional Office
Advanced Radiation Technology Institute/KAERI

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and Degradation of Environmental
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UNOSSC

November 2015

**RCA Regional Office
Advanced Radiation Technology Institute/KAERI**

This publication is the Final Report of the project implemented by RCA Regional Office in partnership with UNOSSC and Ministry of Science, ICT and Future Planning of Korea.

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Executive Summary

Electron beam technologies have enormous potential to many areas. Food safety & security are one of the most important areas, where this technology can play significant roles. Food irradiation destroys the microbes that carry diseases and reduces the need for harmful chemicals used to control insect pests in fruits and vegetables. In addition, treatment of environmental pollutants is another demanding area where electron beam technology could be used to effectively decompose, separate or remove toxic elements from wastewater and air pollutants. Moreover electron beam technology is being employed in processing industrial products to add overall value of the products. However due to lack of resources such as electron beam technologies and their application techniques, as well as skilled personnel and facility, the use of electron beam technology is not as widely available as desirable. Therefore, it is challenging but essential to effectively disseminate and promote this technology to the region.

In this regard, the Project on “Electron Beam Applications for Value Addition to Food and Industrial Products and Degradation of Environmental Pollutants in the Asia-Pacific Region” was implemented for three years in order to promote and disseminate the use of electron beams in food industry, industrial products and environmental conservation in the region. According to the work plan, the project was successfully implemented based on the “Two-Step Strategy.” At the first level, selected participants from each participating country were trained at Regional Training Courses (RTCs). At the second level, trained participants disseminated the gained knowledge, skills, and new technology to end-users in their respective countries. In addition to that, emphasis on the “south-south and triangular cooperation” was put to facilitate cooperation and network building among the participating countries and it played a pivotal role in scaling up the capability of the countries and accelerating the dissemination of the EB technology in the region.

Over the implementation period, five RTCs were held in food, industry, and environmental areas, training around 70 participants from 13 countries. Each RTC covered basic and advanced knowledge and provided experimental experiences in facilities in Advanced Radiation Technology Institute (ARTI) of Republic of Korea. The survey on the RTCs conducted by the RCARO after each course showed that the participants were very satisfied with the courses. At national level, around 3,447 participants (1,510 females and 1,937 males) were involved in national activities such as R&D activities, national training courses, scientific meetings, seminars, and exhibitions. Some exhibitions and conferences invited related end users as well as the general public, which contributed to the enhancement of the EB technology awareness and allaying the public concern about the nuclear technologies. Moreover, in some countries where the technology has been recently introduced, the establishment of EB facilities was discussed at governmental level and made good progress.

The outcomes from the participating countries indicate that the project has been accordingly implemented. It has scaled up the capability of the region by disseminating the technology and fostering regional partnerships and cooperation. However, considering increased establishment of EB facility in a few years and rising demand for distribution and sharing of EB technology from the Government Parties, a follow up project is recommended. The extension of the project is expected to further strengthen the practical application of this technology along with some necessary R&D activities in the participating countries.

List of Abbreviations/Glossaries

ARTI	Advanced Radiation Technology Institute
EB	Electron Beam
IAEA	International Atomic Energy Agency
KAERI	Korean Atomic Energy Research Institute
LCC	Lead Country Coordinator
MSIP	Ministry of Science, ICT and Future Planning
GP(s)	Government Parties(s)
NPC(s)	National Project Coordinator(s)
NPT(s)	National Project Team(s)
NTC(s)	National Training Course(s)
PNRI	Philippines Nuclear Research Institute
RCA	Regional Cooperative Agreement for Research, Development and Training Related to Nuclear Science and Technology for Asia and the Pacific
RCARO	RCA Regional Office
RTC(s)	Regional Training Course(s)
UNOSSC	UN Office for South-South Cooperation
UNOPS	United Nations Office for Project Services

I. Introduction

1-1 Project Background

Sterilization and Improvement of Agricultural Products

Consumer demand for safe, wholesome and nutritious foods is increasing on a worldwide scale. This demand, together with ever increasing global trade in foodstuffs, brings with it a number of related concerns: the possible contamination of foods by harmful micro-organisms; the need to protect crops from insect pests; and the need to support international trade and economic development. In response to these concerns, many countries have introduced stricter sanitary (human health) and phytosanitary (plant health) controls on the food industry. The increasing relevance of these controls for consumers and policy makers alike has resulted in a heightened interest in food irradiation as a valuable technique for dealing with food preservation and safety issues.

Cobalt-60, electron beam accelerators and X-ray machines are three kinds of source approved for food irradiation under Codex Alimentarius Commission (CAC) standards. Nowadays, most irradiated foods are treated by Co-60 sources, especially in the Asia-Pacific region. With the development of electron beam technology and regulation limits on radioactive Co-60 sources, it is widely recognized that electron beams will be one of the most important sources used for food irradiation.

Treatment of Environmental Pollutants and Industrial Products

Across the Asia-Pacific region, rapid growth in economies and population are causing serious problems such as overcrowding in urban areas, deforestation/desertification, global warming, air pollution, and shortages in clean water.

Air and water pollution is leading to an increase in the rate of respiratory diseases among the affected population and consequential medical costs. Pollution of drinking water sources and groundwater is causing digestive diseases and a depletion of drinking water supplies. Due to the enormous social costs caused by the environmental problems in many Asian countries, there is a strong need to treat waste waters and process air pollutants before they are released into the environment.

In order to effectively treat these air and water pollutants, developed countries have adopted electron beams in addition to traditional chemical methods in order to effectively decompose, separate or remove toxic elements from chemical wastes, wastewater, sewage sludge and air pollutants discharged from industries, power plants and everyday living before they are released into the environment. Developing countries can also take great advantage from the use of electron beams in enhancing their water and air quality. The hygienic state and quality of daily life for the people in developing countries will be greatly enhanced through stable supplies of clean drinking water and conservation of ground water.

Electron Beam Technologies

Electron beam accelerators have emerged as a promising technology for the processing of agricultural and industrial products and in the treatment of environmental pollutants.

Electron beam technologies have been extensively developed and commercialized in Korea and other developed countries in the irradiation processing of food and agricultural products; irradiation of electric cable and automobile tires; the treatment of waste water discharged from textile industries and urban living; removal of chemical surfactants in underground water; removal of air pollutants such as

SO_x, NO_x, VOC and dioxins; chemical decomposition of PCBs; and the sterilization of sewage sludge generated from fertilizer use.

By virtue of both its versatile applications and reduced cost, electron beam accelerators are now being developed for many purposes. Worldwide, 1,500 electron beam accelerators are being operated in research and industry.

1-2 Project Objectives

This project aims to improve the quality of environment and living conditions of the people in the Asia-Pacific region (the RCA region) and the quality of agricultural products as well as industrial products through facilitating and maximizing the application of the innovative technology of electron beam accelerators by transferring technology, knowledge and practical experiences of developed countries to developing countries.

The main goal of the project is to promote the use of electron beams in food industry, industrial products and environment conservation in the Asia-Pacific region at the national level. The project especially focused on the following goals:

- 1) To facilitate the application of electron beam accelerators for processing food and agricultural commodities. This will contribute to value addition to food and agricultural commodities in terms of insect disinfestations of grains, quarantine treatment of fruits and vegetables for exports, microbial decontamination of spices and dry ingredients, microbial decontamination of fresh, frozen, and dry meat and seafood, sterilization of processed ready-to-eat food products for ambient storage and special purposes ;
- 2) To facilitate the application of electron beam accelerators to hardening of electric cables, reduction of environment pollution by using irradiation techniques, and enhancing the durability of automobile tires, and development of light weight composite materials which will have immediate impact in adding value to industrial products;
- 3) To facilitate the application of electron beam accelerators in the treatment of environmental pollutants discharged from various industries, power plants and urban living before release into the environment, such as waste water, air pollutants(SO_x, NO_x, VOC and dioxins), municipal waste (PCB and sewage sludge), which will have immediate impact on improving the quality of air and water and living conditions;
- 4) To establish a regional network of experts and facilities. The network will provide channels to communicate and share information on electron beam accelerator technologies in the region;
- 5) To foster the capability of applications of electron beam accelerator technologies in research and development in the region.

II. Project Development and Implementation Strategy

2-1 Project Development

The RCA (Regional Cooperative Agreement for Research, Development and Training Related to Nuclear Science and Technology for Asia and the Pacific) consists of 22 Government Parties (GPs)¹ and has been recognized as an effective partner in providing nuclear technologies that enhance socio-economic well-being and contribute to sustainable development in the region.

Mandated by the RCA GPs, RCA Regional Office (RCARO) carries out activities to develop partnership projects to assist the GPs in addressing regional and national needs. This project was initiated by RCARO in July 2009 as a partnership project with United Nations Office for South-South Cooperation (UNOSSC).

Upon approval by the RCA General Conference Meeting in 2009, the proposal reflecting the views of the GPs was submitted to UNOSSC in 2011, but it was not selected.

In 2012, upon the call for proposals by UNOSSC, RCARO submitted a revised proposal on electron beam application on food irradiation, industrial products and treatment of environmental pollutants.

The proposal was signed on 5 December 2012 by United Nations Office for South-South Cooperation (UNOSSC) and subsequently a contract was concluded with United Nations Office for Project Services (UNOPS) in January 2013. The total funding of \$450,000 was contributed specifically \$300,000 by UNOSSC and \$150,000 by RCARO for three years from 2013. 16 RCA GPs i.e. Australia, Cambodia, China, India, Indonesia, Korea, Malaysia, Mongolia, Myanmar, New Zealand, Pakistan, Philippines, Singapore, Sri Lanka, Thailand, Vietnam, expressed their intention to participate in the project. (Australia, New Zealand, and Korea participated as technology providers.)

RCARO led the project with the support of RCA GPs and worked in conjunction with Dr. Ju-woon LEE (2013), Dr. Phil-hyun Kang (2014), and Dr. Seoung-ho Yu (2015) from Advanced Radiation Technology Institute (ARTI), Korea Atomic Energy Research Institute (KAERI).

ARTI, which is an IAEA Collaborating Center for Radiation Utilization Technologies since July 2012, is a host institute for this project and take charge of practical implementation of the project and provide necessary personnel, equipment, facilities and their expertise for the project as in-kind contributions.

2-2 Project Implementation Strategy

Over the period of project implementation, the main goal was to promote the use of electron beams in food industry, industrial products and environment conservation in the Asia-Pacific region at the regional/national level. In order to achieve this goal, the project focused on disseminating the electron beam technology from developed countries to developing countries and sharing experiences among developing countries through Regional Training Courses with on-site experiment, expert consultations and regional meetings based on the concept of “south-south and triangular cooperation.” This concept puts emphasis on cooperation and network building among developing countries as well as the involvement and collaboration with a third party, namely a developed country government or

¹ Currently, the GPs of the RCA are Australia, Bangladesh, Cambodia, China, Fiji, India, Indonesia, Japan, Korea, Laos, Malaysia, Mongolia, Myanmar, Nepal, New Zealand, Pakistan, Philippines, Palau, Singapore, Sri Lanka, Thailand, and Vietnam.

organization. The active participation of countries together with the financial assistance from the RCARO and UNOSSC and the technical assistance from technology provider countries were essential in the implementation the project. Altogether, the project played a pivotal role in scaling up the capability of the participating countries and accelerating the dissemination of the EB technology in the region.

The “Two-Step Strategy” was used for effective distribution of the technology. The first step was to train the NPCs (National Project Coordinator) and nominated participants from participating countries through the Regional Training Courses. And the second step was to disseminate the knowledge, skills and new technologies gained through the Regional Training Courses to their local end users/stakeholders by NPCs and NPTs (National Project Team). The national activities included R&D activities, training courses, workshops, awareness seminars and meetings.

The most important element in implementing the project was Regional Training Courses (RTC: Basic Training Course and On-site Training Course), while main beneficiaries of the project were the participants of the RTCs and national training courses and workshops held by NPCs and associated institutes/organizations. From 2013 to 2015, by successfully conducting RTCs and various national activities, the project achieved its objectives and contributed to the improvement of the quality of environment and living conditions of the people in the Asia-Pacific region.

III. Project Results and Analysis

3-1 Overview of Project Results

Overall, the project was implemented successfully according to the work plan.

According to the work plan of the project, a kick-off meeting was held on 2-3 May 2013 in Phuket, Thailand, inviting 23 participants including National Project Coordinators (NPCs) and alternate NPCs from 15 countries, namely Australia, Cambodia, China, India, Indonesia, Malaysia, Myanmar, New Zealand, Pakistan, Philippines, Korea, Singapore, Sri Lanka, Thailand and Vietnam, and participants from Office of Atoms for Peace of Thailand, UNOSSC and RCARO.

In cooperation with the LCC, two regional training courses (RTC) were held in ARTI, Jeongeup, Korea as follows:

- RTC on basic knowledge and hands-on experiment on electron beam application for value addition to industrial products was conducted for 10 trainees from 10 participating countries for one week on 19-23 August 2013
- RTC on basic knowledge and hands-on experiment on electron beam application for environmental remediation was conducted for 11 trainees from 11 participating countries for one week on 7-11 October 2013

Altogether, 21 participants participated in the RTCs and were trained with information on basic concepts and fundamental knowledge about EB irradiation and its applications by conducting experiments at the radiation facilities in ARTI.

Later in 2013, the Annual Review Meeting was held on 21-22 November in Cebu, Philippines, with total of 21 participants including LCC, NPCs and nominated participants from 13 participating countries and Director of Philippine Nuclear Research Institute (PNRI) and RCARO. At the meeting, representatives presented on the national achievements and outcomes in 2013 and work plan for 2014.

The meeting reviewed a draft annual report for 2013 and set a detailed work plan for 2014.

The number of participants in project implementation in 2013 is given in Table 1.

Table 1 Project Activities and Number of Participants of Government Parties in 2013

Country	Kick-off meeting	RTC for Advanced material	RTC for environmental remediation	Annual Review Meeting	Total
AUL	1	-	-	-	1
CAM	1	1	1	1	4
CPR	1	1	1	3	6
IND	1	1	1	1	4
INS	1	1	1	1	4
MAL	1	1	1	1	4
MYA	1	1	1	1	4
NZE	1	-	-	1	2
PAK	1	-	1	1	3
PHI	1	1	1	3	6
ROK	2	6(lecturer)	5(lecturer)	2	15
SIN	2	-	-	-	2
SRL	1	1	1	1	4
THA	3	1	1	1	6
VIE	1	1	1	1	4
Total	19	16	16	18	69

In 2014, two RTCs and Annual Review Meeting were conducted and achieved its targeted objective in facilitating the applications of the EB technologies for the areas of advanced material and food products. The courses transferred the basic concepts and advanced knowledge and technology on EB irradiation and its applications for advanced material and food products. The hands-on experiment designed with the RTCs provided excellent platform for researchers from the participating countries to improve their skill and advanced knowledge. Detailed information on RTCs are as follows:

- RTC on basic and advanced knowledge and hands-on experiment on electron beam applications for advanced material was conducted for 22 trainees from 11 participating countries for two weeks on 14-25 April 2014
- RTC on basic and advanced knowledge and hands-on experiment on electron beam applications for food products was conducted for 11 trainees from 11 participating countries for one week on 16-20 June 2014

The two RTCs were a great success with excellent feedback. The satisfaction survey showed that the courses reached their goals in terms of training programme, information sharing, training material, quality and content of lectures, as well as the expertise of the trainers; around 80% of participants were satisfied with the courses. Participating countries benefitted from increased knowledge and understanding of EB technology and applications.

The number of participants in project implementation in 2014 is given in Table 2.

Table 2 Project Activities and Number of Participants of Government Parties in 2014

Country	RTC for Advanced material	RTC for food	Annual Review Meeting	Total
AUL	-	1(lecturer)	-	1
CAM	2	1	1	4
CPR	2	1	2	5
IND	3(1 lecturer)	1	-	4
INS	2	1	1	4
MAL	2	1	1	4
MON	2	-	1	3
MYA	2	1	3	6
NZE	-	-	1	1
PAK	-	-	1	1
PHI	2	1	1	4
ROK	10(lecturer)	6(lecturer)	2	18
SIN	-	1	-	1
SRL	2	1	1	4
THA	2	1	1	4
VIE	2	1	-	3
Total	33	18	16	67

In 2015, one RTC and Final Review Meeting were conducted. The RTC achieved its targeted objective in distributing basic and advanced knowledge and experimental experience on electron beam applications for degradation of environmental pollutants. The training course provided trainees with not only the relevant techniques but also new ideas on how to use and apply those techniques in the field. Specifically, hands-on experiments allowed trainees to directly experience and acquire skills using electron beam technologies. Detailed information of the RTC is as follows:

- RTC on basic and advanced knowledge and hands-on experiment on electron beam applications for degradation of environmental pollutants was conducted for 23 trainees from 11 participating countries for two weeks on 11-22 May 2015

The Final Review Meeting was held on 28-29 October, in Siem Reap, Cambodia supported by the Ministry of Mines of Cambodia. 21 participants from 15 participant countries, UNOSSC, and RCARO participated in the meeting to discuss and evaluate the outcomes of the project and review follow up actions for the sustainable development after the completion of the project. The meeting also reviewed the draft final report. The meeting took note of the draft of the final report and approved to publish the report with changes to be sent by the NPCs and the participants of the meeting.

Table 3 Project Activities and Number of Participants of Government Parties in 2015

Country	RTC for environmental remediation	Final Review Meeting	Total
AUL	-	1	1
CAM	2	3	5
CPR	1	1	2
IND	3(1 lecturer)	1	4
INS	2	1	3

JPN	1 lecturer	-	1
MAL	2	1	3
MON	2	1	3
MYA	2	1	3
NZE	-	1	1
PAK	2	1	3
PHI	2	1	3
ROK	9(lecturer)	1	10
SIN	-	-	0
SRL	2	1	3
THA	2	1	3
VIE	2	1	3
Total	34	17	51

Although there have been continuous endeavors to implement the project, limitations existed at each stage. Regarding the RTCs, considering that there were 16 different participant countries, there existed differences of EB technology application in the level of human resources, technology, and equipment. This resulted in difficulty in preparing for course contents and programs in the RTCs to address the needs and demands of all countries. To cope with this problem, training materials were prepared covering a wide range of subject related to EB application to satisfy participants from different backgrounds. For some countries with no or little EB technology, the RTCs were open to not only the scientists and researchers in the area, but also the policy making related officials to enhance the awareness of the technology in different areas of each country.

At national level, in order to overcome the shortage in manpower and budget problems, active knowledge transfer through training courses, workshops, scientific meetings, conferences to related institutes was conducted. As for budget problems, financial commitment of concerned Government to establish EB facilities and organizing related national activities was encouraged. Furthermore, sorting scientific projects and calling for budget share from private companies for R&D activities were also suggested by the NPCs.

3-2 Analysis of Progress Review Meetings

In 2013, according to the work plan of the project, a kick-off meeting was held on 2-3 May in Phuket, Thailand, inviting National Project Coordinators (NPCs) and alternate NPCs who were nominated by the participating countries for project implementation. 23 participants attended in the meeting, including 18 NPCs and alternate NPCs from 15 countries, LCC, and participants from office of atoms for peace of Thailand, UNOSSC and RCARO.

Country reports received by the NPCs were analyzed by the LCC and presented at the kick-off meeting to establish work plan of the project. The meeting confirmed the work plan for 2013 and details of Annual Review Meeting and Regional Training Courses such as date, venue and qualification of the participants.

Especially, the LCC, at his presentation, indicated a wide technical gap existing among the participating countries and suggested organizing two workshops instead of having an Annual Review Meeting in 2013 to narrow the gap among the countries with/without EB facilities. The suggestion was welcomed by most of the participants, while some of participants hoped to have an Annual



Figure 1. Kick-off Meeting held on 2-3 May, 2013, in Phuket, Thailand

Review Meeting as planned. In this regard, RCARO, from the managerial point of view, pointed out the budget problem and suggested having only one workshop for the countries with no EB facility.

After discussions, it was concluded to have an Annual Review Meeting as planned and made a recommendation that a workshop be considered for the policy making bodies from the countries with no EB facilities with enhanced budgetary allocation from RCARO/UNOSSC.

Based on the discussion, precise date, venue, contents and qualification of the participants of the 2013 RTCs were agreed. Especially for participants, it was agreed that those who are practically involved in the technology development and establishment with over 3-5 years of R&D experience or work experience in their countries be invited. In order to stimulate the networking of the participants, RCARO agreed to update its website for the expert network. Participating countries were asked to implement national activities of respective work plan and timely submit precise progress reports to the RCARO.

Later in 2013, the Annual Review Meeting was held on 21-22 November in Cebu, Philippines, with total of 21 participants including LCC, NPCs and nominated participants from 13 participating countries and Director of Philippine Nuclear Research Institute (PNRI) and RCARO. Representatives presented on the national achievements and outcomes in 2013 and work plan for 2014. The meeting reviewed a draft annual report for 2013 and set a detailed work plan for 2014.



Figure 2. Annual Review Meeting held on 21-22 November, 2013, in Cebu, Philippines

At the meeting, regarding the training courses in 2014/2015, it was agreed that there would be one training course for two weeks instead of two separate training courses for one week each to train participants from basic to advanced knowledge in EB technology. It was also agreed that two participants attend the course from each country. Other details regarding the RTCs were discussed, including the date, venue, contents, and qualification of participants.

In 2014, the Annual Review Meeting was held on 19-20 November in Yangon, Myanmar, with total of 17 participants including LCC, NPCs and nominated participants from 12 participating countries, RCARO and observers from the Ministry of Science and Technology of Myanmar. At the meeting, representatives presented on the national achievements and outcomes in 2014 and work plan for 2015. The meeting reviewed a draft annual report for 2014 and set a detailed work plan for 2015.



Figure 3. Annual Review Meeting held on 19-20 November, 2014, in Yangon, Myanmar

As decided in the 2013 Annual Review Meeting, two RTCs of one week each were combined to one RTC in 2015. It was emphasized that the trainees are required to disseminate the knowledge gained from RTCs in each country. It was recommended by the meeting that the UNOSSC and the RCARO consider extending the project in view of the increasing demand for distribution and sharing of EB technology from the Government Parties such as Cambodia, Myanmar, Mongolia, Pakistan, Philippines, and Sri Lanka. The meeting recognized the value of the project considering the increase in the establishment of EB facilities in the region in the next few years.

Final Review Meeting was held on 28-29 October 2015 in Siem Reap, Cambodia with total of 21 participants including LCC, Regional Coordinator of UNOSSC, and NPCs from participating Government Parties. NPCs presented final report of their national activities and outcomes during the implementation period of the project. The meeting reviewed and evaluated the overall outcomes of the project. Also, the meeting discussed follow-up actions for further distribution and development of the EB technology after completion of the project. Opinions on the extension of the project were raised, considering the increase in the establishment of EB facilities and in the use of the EB technology. The meeting also drafted the final progress report which would be consolidated with national final reports.



Figure 4. Final Review Meeting held on 28-29 October, 2015, in Siem Reap, Cambodia

3-3 Analysis of Regional Training Courses

Throughout the project implementation period, five Regional Training Courses were conducted, involving 77 trainees from 13 countries. These training courses were divided into three different areas, namely industry, food, and environment.

In 2013, two RTCs in industry and environment areas were conducted. From 19 to 23 August 2013, one RTC in basic knowledge and hands-on experiment on electron beam applications for value addition to industrial products was conducted. The objective of the course was to provide basic knowledge and experimental experience on electron beam applications in industry area. The participants acquired knowledge and practical experience on radiation chemistry, experimental experience on advanced material, and experimental design methods on advanced material. Later in 2013, from 7 to 11 October, one more RTC in basic knowledge and hands-on experiment on electron beam applications for degradation of environmental pollutants was conducted. Lectures on basic radiation chemistry in environmental remediation, radiation microbiology for environmental remediation, and radiation application for environmental remediation were given. It included air pollution treatment, water and wastewater treatment, as well as waste treatment and recycling using radiation technology.

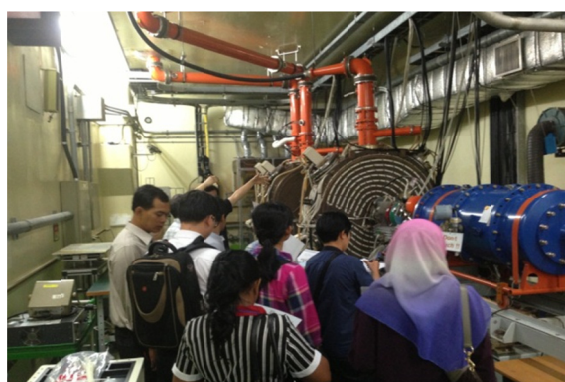


Figure 5. Regional Training Courses on Electron Beam Applications held in 2013

In 2014, RTCs in basic and advanced knowledge and hands-on experiment on electron beam applications for advanced material and for value addition to food products were conducted on 14-25

April and 16-20 June respectively. The RTC on advanced material was in continuation with the RTC conducted in 2013. 2014 RTC focused more on advanced knowledge on radiation chemistry, radiation technique, and experimental application of EB for hydrogels. The RCT in food area put emphasis on the experimental food chemistry, food microbiology and experiment, food rheology and sensory evaluation test, dosimetry for phytosanitary and other experimental applications.



Figure 6. Regional Training Courses on Electron Beam Applications held in 2014

In 2015, one RTC was conducted under the title of basic and advanced knowledge and hands-on experiment on electron beam applications for degradation of environmental pollutants. The contents of the training course included basic to advanced technology and experimental such as basic radiation chemistry, radiation chemistry in environmental remediation, and radiation detection and measurements. Also lectures on environmental analysis, air pollutants treatment, water and wastewater treatment, and waste treatment and recycling were given.



Figure 7. Regional Training Course on Electron Beam Applications held in 2015

The satisfaction survey on the Regional Training Courses conducted by the RCARO after each completion showed that the participants were very satisfied with the Regional Training Courses in terms of information sharing, training materials, quality and content of lectures, and hands-on experiments. All participants agreed that the training courses provided them with not only the relevant techniques but also new ideas on how to use and apply those techniques in the field. It was also mentioned that trainees had opportunities to interact with renowned scientists of ARTI throughout the course. There were positive comments on study visits such as EB-Tech, saying the visit was very informative and useful in learning the specific equipment.

3-4 Analysis of National Activities and Results

Based on the knowledge and skills gained from the five Regional Training Courses conducted in the implementation period, the participants were able to disseminate the knowledge and skills to each participant's country. Involving 3,447 participants (1,510 females and 1,937 males) for three years, the participants of regional training courses conducted various kinds of activities such as R&D activities, national training courses, scientific meetings, seminars and expert missions to disseminate the gained knowledge and skills to their local institutes and industries, carried out promotional activities to promote electron beam technology to the general public, and also organized meetings with government officials to introduce and establish EB facilities.

The overall participant numbers of national activities are given in Table 4.

Table 4 Number of Participants and Related Activities of Government Parties in 2013-2015

Country	Number of participants of National Activities		
	Female	Male	Total
AUL	-	-	-
CAM	9	37	46
CPR	41	131	172
IND	13	55	68
INS	270	465	735
MAL	406	374	780
MON	33	45	78
MYA	148	100	248
NZE	8	11	19
PAK	52	124	176
PHI	146	134	280
ROK	96	160	256
SIN	11	4	15
SRL	175	207	382
THA	85	43	128
VIE	17	47	64
Total	1,510	1,937	3,447

Seminars and meetings arranged for government officials fostered information sharing and policy making regarding the EB technologies and facilities. For Myanmar, a number of meetings were continuously held for the establishment of EB facility. On the other hand, promotional activities for general public such as exhibitions and awareness programs were a great success to enhance the technology in countries. For example, Sri Lanka, in 2014, held two exhibitions at the governmental level, inviting around 35,000 participants including end users, experts and also general public.

The project also facilitated establishing EB facilities in the participating countries: in 2014, 5 EB facilities have been/will be established in China; India set up two accelerators in private wire & cable industry; and the Philippines completed the establishment of an EB facility. The facility will provide the start of many applications and gain benefits using the EB technology.

Various R&D activities were carried out in each country. Thailand conducted research for herb, beans and natural rubber latex irradiation in 2014, and for herb irradiation and development of natural and synthetic polymers in 2015. Vietnam has designed and constructed a device for expansion of the applicable area density for 10 MeV electron beam and used 10 MeV accelerator for producing grafted nano-silver cottons used in hospitals in 2013-2015. As for the Philippines, with the completion of the establishment of EB facility at the PNRI, research and development studies were initiated such as R&D projects on radiation grafting and on the effects of EB on the shelf-life of honey alginate dressing in 2015.

Despite the novelty of the technology in some countries, there have been constant endeavors to enhance the use of EB technology. Successful stories of each year are introduced in part IV. Project Outcomes in this report.

IV. Project Outcomes

In 2013, progress reports were received from 11 participating countries. The participants of regional training courses and national activities conducted various kinds of activities such as R&D activities, national training courses, scientific meetings, seminars and official meetings to disseminate the gained knowledge and skills to their local institutes and industries, involving 482 participants (191 females and 291 males).

The number of participants and newly established facilities in each country in 2013 is described in Table 5.

Table 5 Number of Participants and Related Activities in 2013

Country	Number of participants of National Activities			Number of newly established facilities/ related activities
	Female	Male	Total	
AUL				
CAM	-	-	-	
CPR	23	72	95	
IND	2	10	12	1
INS	N/S	N/S		
MAL	64	75	139	
MYA	69	25	94	1
NZE	-	-	-	
PAK	17	76	93	1
PHI	7	6	13	

ROK	-	-	-	
SIN	-	-	-	
SRL	-	-	-	
THA	3	1	4	
VIE	6	26	32	
Total	191	291	482	3

Safety issue of radiation technology, especially for food products, was raised in the kick-off meeting as a substantial and essential part of the project for its implementation. India held seminars for increasing public awareness of its safety. Related promotional activities were provided not only to the general public, but to the area institutions and commercial sector and this facilitated collaborations among institutes and food, industrial sector in the Philippines, India and Malaysia.

In Indonesia, research on the effect of EB irradiation on edible mushroom and OPEFB(Oil Palm Empty Fruit Bunch) was undertaken and it was proved that EB technology is one alternative to improve the quality of mushroom and produce bioethanol from OPEFB with competitive price.

The project also facilitated establishing EB facilities in the participating countries; Philippines started the process of establishing an EB facility and China was to establish a pilot plant for waste water treatment using EB technology. Among countries with no EB facility, Myanmar and Pakistan took initiatives to introduce and further establish EB facilities in their countries. Myanmar initiated policy making meetings at the government level to establish an EB facility. In Pakistan, meetings were held with the high ranked officials of Pakistan Atomic Energy Commission for promotion of EB technology.



Figure 8. EB Accelerator for Pilot-scale Wastewater Treatment in China (Left) and Auricula(Edible Mushroom) Irradiated by EB in Indonesia

In 2014, among 16 participating countries of the project, 14 countries submitted their progress reports.

According to their respective 2014 national work plans, the participants of the RTCs and NPCs conducted various kinds of national activities to disseminate the gained knowledge and technologies to their local institutes and promote the EB technologies.

Involving around 1,937 participants (785 females and 1,152 males), 14 participating countries conducted national activities such as R&D activities, training courses, workshops, seminars, and meetings to disseminate the gained knowledge and skills to their local institutes and industries.

Table 6 shows the number of participants and newly established facilities in 2014.

Table 6 Number of Participants and Related Activities in 2014

Country	Number of participants of National Activities			Number of newly established facilities/ related activities
	Female	Male	Total	
AUL	-	-	-	
CAM	2	25	27	
CPR	18	59	77	5 under construction
IND	5	20	25	2 accelerators in industry
INS	190	364	554	
MAL	135	149	284	
MON	14	16	30	
MYA	46	55	101	
NZE	3	7	10	
PAK	-	-	-	
PHI	130	120	250	1 established
ROK	96	160	256	
SIN	11	4	15	
SRL*	108	140	248	
THA	34	23	57	
VIE	4	14	18	
Total	796	1,156	1,952	8

* Sri Lanka held exhibitions, inviting a wide range of end users, experts and general public. Around 35,000 participated in the event and had opportunity to experience the EB technology.

Various R&D activities were carried out: Indonesia carried out a research on EB application for cocoa; Thailand conducted research for herb, beans and natural rubber latex irradiation and Vietnam for topaz irradiation. Vietnam has designed and constructed a device for expansion of the applicable area density for 10 MeV electron beam and used 10 MeV accelerator for producing grafted nano-silver cottons used in hospitals.

In addition, as the EB technology is a novel and advanced technology to the most of participating countries, activities to promote EB technology and its safety to the general public and end users were carried out and meetings/seminars for government officials to introduce and facilitate establishment of EB facilities were organized. India undertook activities to introduce EB technology as an environmental-friendly and economically beneficial in producing many value-added products. It developed polymer insulation material and the technology was adapted in the industrial sector. Malaysia carried out a seminar on food safety in terms of radiation preservation of food for value addition, regulatory aspect of food irradiation. Mongolia, as a new comer in this field, carried out Study on EB application in various fields and its feasibility and possibility in its country. New Zealand published a Handbook for the EB accelerator at GNS.

Those countries with no EB facility such as Myanmar and Sri Lanka were very active in promoting the technology: Myanmar provided awareness seminars for policy level bodies in various Ministries to promote the EB technology for establishment of its facility and policy making meetings at the government level to establish an EB facility; Sri Lanka held two exhibitions at the governmental level, inviting a wide range of end users, experts and general public. In case of Singapore, technical sharing was held in Agri-Food and Veterinary Authority of Singapore, which helped 15 participants better understand the electron beam use as a food irradiation technology.

The project also facilitated establishing EB facilities in the participating countries: 5 EB facilities have been/will be established in China; India set up two accelerators in private wire & cable industry; and the Philippines completed the establishment of an EB facility. The facility will provide the start of many applications and gain benefits using the EB technology.

Indonesia provided irradiated ready-to-eat food to the people affected by the disaster such as landslide, flooding, earthquake and volcanic eruption.



Figure 9. Presentation on Electron Beam Technologies in Seminar for Officials in Myanmar in 2014



Figure 10. Irradiation Processing of Cocoa Using Electron Beam in Indonesia in 2014



Figure 11. Upgraded EB Accelerator at BARC (Left) and Polymer Insulation Material Under the Beam Window for Irradiation in India

In 2015, progress reports from 15 countries were submitted. Involving around 1,013 participants (523 females and 490 males), participating countries conducted national activities such as R&D activities, training courses, workshops, seminars, and meetings to disseminate the gained knowledge and skills to their local institutes and industries as shown in Table 7.

Table 7 Number of Participants and Related Activities in 2015

Country	Number of participants of National Activities		
	Female	Male	Total
AUL	-	-	-
CAM	7	12	19
CPR	-	-	-
IND	6	25	31
INS	80	101	181
MAL	207	150	357

MON	19	29	48
MYA	33	20	53
NZE	5	4	9
PAK	35	48	83
PHI	9	8	17
ROK	-	-	-
SIN	-	-	-
SRL	67	67	134
THA	48	19	67
VIE	7	7	14
Total	523	490	1,013

Training courses and workshops given by the regional/national experts contributed to enhancing EB technology and human resources development of the participating countries. Mongolia has conducted an education program and an open seminar in Nuclear Research Center, National University of Mongolia to disseminate the gained skills and knowledge, while Thailand gave a special lecture on applications of electron beam at Chemical Engineering Department of Chulalongkorn University. Myanmar opened a seminar to share practices and circulated training materials to develop human resources in the field. Pakistan has conducted several lectures, seminars, and one day workshop at Nuclear Institute for Food & Agriculture (NIFA) to introduce EB technology to scientists for food, industrial products and environmental remediation.

Malaysia successfully carried out various seminars on Food Safety Issues at the governmental level, inviting food industry, regulatory officers and public. As part of public awareness activities, these seminars helped transfer the fundamental knowledge on EB irradiation and its applications for industrial products, food industry and environmental remediation.

In case of India, an international conference on radiation processing, NICSTAR 2015, was held, which served as a meeting platform of user industry, manufacturers, scientists and experts. Also a national seminar involving universities and food industries on the 'Applications of Radiation Processing' was held for the enhancement of public awareness.

Indonesia disseminated irradiated chitosan for application as Plant Growth Promoter (PGP) and Plant Elicitor to the farmer group and local government staffs. Participants gained the knowledge and know-how on radiation technology especially for modification of natural polymeric (chitosan) for application in agriculture as PGP and Plant Elicitor.

In addition, in order to increase public awareness on EB technology, exhibitions and lectures were carried out for general public in Sri Lanka and Myanmar. In Sri Lanka, an awareness program for school children was conducted to disseminate the information on research and development of radiation processing and knowledge on EB technology. Also by contributing to school exhibition, more local students and general public were exposed to information on application of EB technology and research activities. Myanmar held a public awareness exhibition for radiation application technologies in order to promote irradiation application technologies including EB application.



Figure 12. Exhibitions in Sri Lanka, 2014-2015

Various R&D activities were carried out: Vietnam completed two scientific projects on nano-silver application at ministerial level; Thailand conducted research on herb irradiation and development of natural and synthetic polymers. As for the Philippines, with the completion of the establishment of EB facility at the PNRI, research and development studies were initiated. A R&D project on radiation grafting and on the effects of EB on the shelf-life of honey alginate dressing was conducted, where the irradiation of honey dressings to keep microbe-free and longer-lasting was studied. Also there has been active collaborative works between relevant industries and academe. It is noted that the new EB facility serves as an important tool in the implementation of R&D activities in the Institute.



Figure 13. Cottons with Grafted Nano-silver (140pp) (Left) and Sheets with Grafted Nano-silver Used in the Emergency Department of the Binh Dinh Hospital for Testing in Vietnam

Initiatives to utilize the technology outside the R&D were shown in various sectors in some countries. The Philippines, in cooperation with Philippine General Hospital, patients with a scald burn were cured with the honey alginate dressing developed by the PNRI. In Australia, research was completed on the radiation tolerance for more than ten new crops during the course of the project. After 10 years of negotiation, the first consignment of irradiated Australian mangoes was sent to the United States, while approval was granted for Australian lychee. In Indonesia, sterile Semur beef was delivered to earthquake victims in Nepal, May 2015. In Malaysia antimicrobial grafted film was introduced for commercial use in packaging breads, which contributed to food safety without directly irradiating the food itself.

In certain countries where EB application technology has been recently introduced, there have been constant endeavors to establish and improve EB facilities. In case of Sri Lanka, 16 Coal Power Plants are planned to be established where EB flue gas treatment is applied to reduce the emission of toxic gasses and reduce fuel cost. China has already constructed a pilot-scale wastewater treatment plant by EB technology, and has initiated to establish an industrial-scale facility for textile and dyeing wastewater treatment. Myanmar has submitted its national work plan to the IAEA on establishing an Electron Beam Irradiation Facility, and the plan is under implementation process. At the end of the year, a policy making meeting is being held for the establishment of EB irradiation facility by Ministry of Science and Technology. In Cambodia, projects are being initiated to facilitate the use of the technology, such as KAM9002 Building Capacity in Radioactive Waste Management which is supported by IAEA and host country Indonesia.



Figure 14. EB Facility in PNRI, Philippines (Left) and a 78/male Patient with a Scald Burn Healing with Honey Alginate Dressing in Philippine General Hospital

V. Conclusion and Recommendation

5-1. Conclusion

The project was implemented according to the work plan and achieved the objectives to promote the use of electron beams in food industry, industrial products and environment conservation in the Asia-Pacific region at the national level.

Aiming to effective and efficient dissemination of the EB knowledge and technology, the project applied the “Two-Step Strategy.” At the first level, designated participants from each participating country were trained at regional training courses. At the second level, trained participants disseminated the gained knowledge, skills, and new technology to end-users in their respective countries. This strategy proved to be effective in that it not only improved capacity building of each designated expert but also promoted the use of EB technology by various activities conducted at the national level by trained participants. It also contributed to the south-south and triangular cooperation by involving the developed countries as technology providers and RCARO and UNOSSC as financial supporters, and fostering the network building among the participant countries. As a result the project has scaled up the capability of the region by disseminating the EB technology.

In 2013, one Kick-off Meeting, two Regional Training Courses, and Annual Review Meeting were held. With work plans set from the Kick-off meeting, two RTCs were successfully conducted with over 97% and 94% of participants being satisfied in each respective course. At national level, 11 participating countries actively conducted national activities such as R&D activities, training courses, workshops, and scientific meetings to disseminate the gained knowledge and skills to their local institutes and industries, involving 482 participants and also carried out promotional activities to promote electron beam technology to the general public and organize meetings with government officials to introduce and establish EB facilities.

In 2014, two RTCs and Annual Review meeting were held. Based on the work plan set in the 2013 Annual Review Meeting, two RTCs on industrial and food products were conducted with around 90% and 80% of the participants satisfied respectively. The satisfaction survey showed that the courses reached their goals in terms of the programme, information sharing, training material, quality and content of lectures. According to their respective 2014 national work plans, the participants of the RTCs and NPCs conducted various kinds of national activities such as exhibition, R&D activities, training courses, workshops, seminars and meetings to disseminate the gained knowledge and technologies to their local institutes and promote the EB technologies, involving around 1,937 participants from 14 countries.

In 2015, one RTC and Final Review Meeting were implemented. As decided in the 2013 Annual Review Meeting, two separate RTCs were combined to one RTC programme consisting of two weeks, and two trainees participated from each participating country. The intention was to train trainees with both basic to advanced knowledge in EB technology in one RTC. The satisfaction survey showed that over 80% of the participants were satisfied with the course. In 2015, country reports from 13 countries were submitted. Involving around 1,241 participants, 13 participating countries conducted national activities such as R&D activities, training courses, workshops, seminars, and meetings to disseminate the gained knowledge and skills to their local institutes and industries.

Overall, the project has contributed to various levels and aspects of each country in the application of EB technology. At technical level, it provided researchers, scientists, experts, and end-users with knowledge and skills on EB technology through seminars, lectures, conferences, and exhibitions. Not

only the related experts, but also the general public had a chance to learn about EB technology through these activities. It also helped allay public concern on nuclear technology. Establishment of new EB facilities has been actively planned in many participating countries, leading to increasing demand for its technology to utilize the facilities.

Government parties are expected to continue the knowledge transfer activities for sustainability of the project. As the number of participants of national activities continues to increase, it is expected that the project will continue to make a considerable contribution to enhance the capability of human resources in the field. Considering that EB technology can make a strong contribution in many areas in society, this project will be the start point for improvement of the quality of environment and living conditions of the people in the Asia-Pacific region (the RCA region) and the quality of agricultural products as well as industrial products using EB technology.

5-2. Recommendation

Throughout the project implementation period, there has been increase in the interest of countries in the use of electron beam. On one hand, countries without electron beam facilities started policy making meetings and seminars in order to establish the equipment. Promotional activities both for experts and general public have been actively conducted for the dissemination of the technology. On the other hand, those countries which already had the electron beam facilities and the related technology have now developed to link their EB technology and enterprises for the expanded use of the technology in everyday life. Overall, the project has contributed to the introduction and wider use of the technology in the region.

However, in order to continue the development and utilize the achievements made during this project and to identify next steps to move towards the long-term vision, it is recommended that consideration be given to the extension of the project. In particular, it is recognized that with the network built and regional data accumulated from this project, the UNOSSC and the RCARO can play a strong role in the continuous progress of this program. In the Final Review Meeting held on 28-29 October, 2015, as a 2nd phase of the project, training courses on specific use of the EB, workshops on newly joined countries, and expert missions to evaluate the status and help establish necessary arrangements in certain countries were proposed.

In the following years, with the expected increase of EB facilities in the region, the need for manpower training will be the most crucial issue for the region. In addition, reinforcing and intensifying the network that has been built throughout the project period would be another important issue for the region. The extension of the project will contribute to further strengthening and widening the value-added application of this technology.



Annexes

Annexes

1. Annual Work Plan	25
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1-1. Annual Work Plan Year: 2013

EXPECTED RESULTS	PLANNED ACTIVITIES	TIMEFRAME			
		Q1	Q2	Q3	Q4
<p>Enhancement of the level of the technology, knowledge and the capability of human resources in the application of electron beam in the areas of industry and environment</p> <p>Target: Upgrading of the technology, knowledge in the application of electron beam in the areas of industry and environment</p>	<p>Kick Off Meeting</p> <p>(23 experts, 2 days), Phuket, Thailand</p>	X			
	<p>Development of training course protocol (designing curricula, teaching materials)</p> <p>(3 experts , 3 days), Korea</p>	X	X		
	<p>Basic knowledge and on-site training on Industrial Products:</p> <ul style="list-style-type: none"> • Basic radiation chemistry • Dosimetry • Radiation curing • Experimental application <p>(15 trainees, 5 days), Korea</p>			X	
	<p>Basic knowledge and on-site training on Environmental Remediation:</p> <ul style="list-style-type: none"> • Basic radiation biology and chemistry • Radiation sterilization • Waste water treatment • Experimental application • <p>(15 trainees, 5 days), Korea</p>				X
	<p>Annual Review Meeting</p> <p>(21 experts, 2 days), Cebu, Philippines</p>				X
	Project Monitoring	X	X	X	X

1-2. Annual Work Plan Year: 2014

EXPECTED RESULTS	PLANNED ACTIVITIES	TIMEFRAME			
		Q1	Q2	Q3	Q4
<p>Facilitation of electron beam application training for participants from the participating Member States in the areas of food and industry</p> <p>Target: Build-up of practices and skills for selected participants using Mobile Electron Beam Accelerator</p>	<p>Basic and advanced knowledge and on-site training on Advanced Material:</p> <ul style="list-style-type: none"> • Advanced radiation chemistry • Radiation crosslinking • Carbon composites • Experimental application • Experimental application of Electron Beam (EB) for electronic devices • Experimental application of EB for hydrogels • Experimental design for the application of EB on Advanced Material <p>(22 trainees, 10 days), Korea</p>		X		
	<p>Basic and advanced knowledge and on-site training on Food Products:</p> <ul style="list-style-type: none"> • Experimental food chemistry • Food microbiology • Food rheology • Experimental application <p>(11 trainees, 5 days), Korea</p>		X		
	<p>Annual Review Meeting</p> <p>(17 experts, 2 days), Yangon, Myanmar</p>				X
	Project Monitoring	X	X	X	X

1-3. Annual Work Plan Year: 2015

EXPECTED RESULTS	PLANNED ACTIVITIES	TIMEFRAME			
		Q1	Q2	Q3	Q4
<p>Enhancement of the level of the technology, knowledge and the capability of human resources in the application of electron beam in the area of environment</p> <p>Target: Upgrading of the technology, knowledge in the application of electron beam for participants from the participating Government Parties</p>	<p>Basic and advanced knowledge and on-site training on Environmental Remediation:</p> <ul style="list-style-type: none"> • Radiation biology & chemistry • Soil treatment • Radio hydrolysis • Practical application of mobile accelerator of EB • Air pollution control • Experimental application of EB for soil and waste water • Experimental design for the application of EB on Environmental Remediation <p>(22 trainees, 10 days), Korea</p>		X		
<p>Completing and evaluating the project</p> <p>Target: Review and evaluation conducted at the end of the project</p>	<p>Final Review Meeting:</p> <ul style="list-style-type: none"> • Review of the project achievements and outcomes • Final project evaluation <p>(23 experts, 2 days), Siem Reap, Cambodia</p>				X
	Project Monitoring	X	X	X	X

2-1. Programme for the 2013 Regional Training Course

Regional Training Course on Basic Knowledge and Hands-on Experiment on Electron Beam Applications for Value Addition to Industrial Products

19-23 August 2013, Advanced Radiation Technology Institute, Jeongup, Korea

Provisional Programme

Monday, 19 August 2013	
08:30 – 09:30	Registration
Inaugural Session	
09:30 – 11:00	Opening Ceremony
11:00 – 12:00	Introduction of the Training Course
12:00 – 13:00	Lunch
Lecture 1 : Basic Radiation Chemistry in Advanced Materials	
13:00 – 15:00	Radiation Chemistry I
15:00 – 15:30	Intermission
15:30 – 17:30	Radiation Chemistry II
17:30 – 18:30	Closing

Tuesday, 20 August 2013	
Lecture 2: Dosimetry & Experimental Application	
09:00 – 10:30	Radiation dose & Dose measurement
10:30 – 11:00	Tea/Coffee Break
11:00 – 12:30	Radiation units & Basic safety
12:00 – 13:00	Lunch
13:30 – 15:30	Dosimetry experiment 1 - Introduction on the irradiation facilities in KAERI-ARTI - Basics on dosimetry
15:00 – 15:30	Intermission
16:00 – 18:00	Dosimetry experiment 2 Hands-on training of dosimetry
18:00	Closing

Wednesday, 21 August 2013	
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Technical Visit at two EB facilities & Special Lecture	
09:00 – 11:00	Move to Daejeon from ARTI
11:00 – 12:30	Commercial EB facility (EB tech Co.) in Daejeon
12:00 – 13:00	Lunch
13:30 – 14:00	Linear EB accelerator facility in KAERI Headquarter
14:00 – 15:30	Tour
15:30 – 16:00	Intermission
16:00 – 17:30	Special lecture: Application of EB in Advanced materials in Korea
17:30 – 18:30	Closing

Thursday, 22 August 2013	
Lecture 3: Radiation Crosslinking	
09:00 – 10:40	Radiation Interaction with Polymer
10:40 – 11:00	Intermission
11:00 – 12:30	Radiation-Induced Crosslinking and Its Application: Basics
12:30 – 13:30	Lunch
Hand-on Experiment on Radiation Curing	
13:30 – 15:30	Laboratory Work and Demonstration Sample Polymer Sheet Preparation for Crosslinking
15:30 – 16:00	Intermission
16:00 – 18:00	Laboratory Work and Demonstration - EB-beam Irradiation Determination of Gel Content
18:00 – 18:30	Closing

Friday, 26 October 2012	
Meeting Reviewing, Conclusion & Closure of Meeting	
09:00 - 10:30	Meeting Review
10:30 – 11:00	Intermission
11:00 - 12:00	Meeting Conclusions & Recommendations
12:00 – 13:00	Lunch
13:00	Closure of Meeting and Final Remarks

Regional Training Course on Basic Knowledge and Hands-on Experiment on Electron Beam Applications for Degradation of Environmental Pollutants

7-11 October 2013, Advanced Radiation Technology Institute, Jeongup, Korea

Provisional Programme

Monday, 7 October 2013	
10:00 – 10:30	Registration
Inaugural Session	
10:30 – 11:30	Opening Ceremony
11:30 – 12:30	Introduction of the Training Course
12:30 – 13:30	Lunch
Lecture 1 : Basic Radiation Chemistry in Environmental Remediation	
13:30-15:00	Radiation Chemistry and Sources
15:00 – 15:30	Intermission
15:30 – 17:00	Radiation Chemistry and Sources
17:30 – 18:30	Closing

Tuesday, 8 October 2013	
Lecture 2: Basic Radiation Chemistry in Environmental Remediation	
09:00 – 10:40	Radiation Protection and Safety
10:40 – 11:00	Intermission
11:00 – 12:30	Radiation Application for Alternative Energetics and Environmental Remediation
12:30 – 13:30	Lunch
Lecture 2: Radiation Microbiology for Environmental Remediation	
13:30 – 15:30	General and Wastewater Microbiology
15:30 – 16:00	Intermission
16:00 – 18:00	Radiation Microbiology for Environmental Remediation
18:00	Closing

Wednesday, 9 October 2013	
Technical Visit at two EB facilities & Special Lecture	
09:00 – 10:30	Move to Daejeon from ARTI
10:30 – 11:00	Intermission
11:00 – 12:30	Linear EB accelerator facility in KAERI Headquarter
12:30 – 13:30	Lunch
13:30 – 14:00	Commercial EB facility (EB tech Co.) in Daejeon

14:00- 15:30	Tour
15:30 – 16:00	Intermission
16:00 – 17:30	Special lecture: Application of EB in Advanced materials in Korea
18:00	Closing

Thursday, 10 October 2013	
Lecture 3: Radiation Application for Environmental Remediation	
09:00 – 10:30	Water and Wastewater Treatment using Radiation
10:30 – 11:00	Intermission
11:00 – 12:30	Global Warming Gas Treatment using Electron Beam
12:30 – 13:30	Lunch
13:30 – 15:30	Volatile Organic Compounds Treatment using Radiation
15:30 – 16:00	Intermission
16:00 – 18:00	Micropollutant Treatment using Radiation
18:00 – 19:00	Dinner
19:00 – 20:00	Closing

Friday, 11 October 2013	
Meeting Reviewing, Conclusion & Closure of Meeting	
08:30 - 10:30	Meeting Review, Meeting Conclusions & Recommendations
10:30 – 11:00	Intermission
11:00 – 12:00	Closure of Meeting and Final Remarks
12:00 – 13:00	Lunch
13:00	Move to Seoul

2-2. Programme of the 2014 Regional Training Course

Regional Training Course on Basic and Advanced Knowledge and Hands-on Experiment on Electron Beam Applications for Advanced Material

14-25 April 2014, Advanced Radiation Technology Institute (ARTI), Jeongup, Korea

Provisional Programme

Monday, 14 April 2014	
08:30 – 09:30	Registration
Inaugural Session	
09:30 – 11:00	Opening Ceremony
11:00 – 12:00	Introduction of the project and the training course
12:00 – 13:00	Lunch
Lecture 1 : Advanced Radiation Chemistry	
13:00 - 15:00	Advanced Radiation Chemistry I
15:00 – 15:30	Intermission
15:30 – 17:30	Advanced Radiation Chemistry II
17:30 – 18:30	Closing

Tuesday, 15 April 2014	
Lecture 2: Hybrid composite materials	
09:00	Development of novel composite materials by radiation for organic electronic devices I
10:30 – 11:00	Intermission
11:00 – 12:30	Development of novel composite materials by radiation for organic electronic devices II
12:30 – 13:30	Lunch
13:30 – 15:30	Experiment for novel composite materials
15:30 – 16:00	Intermission
16:00 – 18:00	Experiment for novel composite materials
18:00	Closing

Wednesday, 16 April 2014	
Lecture 3: Radiation Detection and Measurements I	
09:00	Overall of the radiation measurements with different type of radiation detectors I
10:30 – 11:00	Intermission
11:00 – 12:30	Overall of the radiation measurements with different type of radiation detectors I
12:30 – 13:30	Lunch
13:30 – 15:30	Overall of the radiation measurements with different type of radiation detectors II

15:30 – 16:00	Intermission
16:00 – 18:00	Overall of the radiation measurements with different type of radiation detectors II
18:00	Closing

Thursday, 17 April 2014	
Lecture 4: Radiation Detection and Measurements II	
09:00	Experiment for radiation detector
10:30 – 11:00	Intermission
11:00 – 12:30	Experiment for radiation detector
12:30 – 13:30	Lunch
13:30 – 15:30	Experiment for radiation detector
15:30 – 16:00	Intermission
16:00 – 18:00	Experiment for radiation detector
18:00	Closing

Friday, 18 April 2014	
Technical Visit at two EB facilities & Special Lecture	
09:00 – 11:00	Move to Eumseong, Chungbuk from ARTI
11:00 – 12:30	Commercial EB facility (GEV)
12:30 – 13:30	Lunch
13:30 – 14:30	Move to Daejeon from GEV (Eumseong, Chungbuk)
14:30- 17:30	Linear EB accelerator facility in KAERI Headquarter Special lecture: Current status of EB application
17:30	Closing

Saturday, 19 – Sunday, 20 April 2014	
Weekend	

Monday, 21 April 2014	
Lecture 5: Radiation Grafting	
09:00	Development of Radiation-Grafted Membrane for Fuel Cell Applications I
10:30 – 11:00	Intermission
11:00 – 12:30	Development of Radiation-Grafted Membrane for Fuel Cell Applications I
12:30 – 13:30	Lunch
13:30 – 15:30	Experiment for radiation grafting
15:30 – 16:00	Intermission
16:00 – 18:00	Experiment for radiation grafting
18:00	Closing

Tuesday, 22 April 2014	
Lecture 6: Radiation Technique for Natural polymers	
09:00	Radiation processing of natural polymers I
10:30 – 11:00	Intermission
11:00 – 12:30	Radiation processing of natural polymers II
12:30 – 13:30	Lunch
13:30 – 15:30	Experiment for natural polymers
15:30 – 16:00	Intermission
16:00 – 18:00	Experiment for natural polymers
18:00	Closing

Wednesday, 23 April 2014	
Lecture 7: Radiolytic Surface Modification	
09:00	Radiolytic surface modification and patterning I
10:30 – 11:00	Intermission
11:00 – 12:30	Radiolytic surface modification and patterning II
12:30 – 13:30	Lunch
13:30 – 15:30	Experiment for surface modification
15:30 – 16:00	Intermission
16:00 – 18:00	Experiment for surface modification
19:00 – 20:00	Closing

Thursday, 24 April 2014	
Lecture 8: Advanced Biomaterials	
09:00 – 10:40	Development of advanced biomaterials by radiation I
10:40 – 11:00	Intermission
11:00 – 12:30	Development of advanced biomaterials by radiation I
12:30 – 13:30	Lunch
13:30 – 15:30	Experimental application for hydrogels
15:30 – 16:00	Intermission
16:00 – 18:00	Experimental application for hydrogels
18:00	Closing

Friday, 25 April 2014	
Meeting Reviewing, Conclusion & Closure of Meeting	
09:00 - 10:30	Meeting Review

10:30 – 11:00	Intermission
11:00 - 12:00	Conclusions & Recommendations
12:00 – 13:00	Lunch
13:00	Closure of Meeting and Final Remarks

**Regional Training Course on Basic and Advanced Knowledge and Hands-on
Experiment on Electron Beam Applications for Value Addition to Food Products**

16-20 June 2014, Advanced Radiation Technology Institute, Jeongeup, Korea

Provisional Programme

Monday, 16 June 2014	
08:30 – 09:30	Registration
Inaugural Session	
09:30 – 11:00	Opening Ceremony
11:00	Introduction of the project and the training course
12:00 – 13:00	Lunch
Lecture 1 : General Introduction & of Food Irradiation	
13:00 – 15:00	General Introduction of Food Irradiation
15:00 – 15:30	Intermission
Lecture 2 : Food Science	
15:30-17:30	Food Quality and Their Attributes

Tuesday, 17 June 2014	
Lecture 3: Food Microbiology	
09:00	Food Microbiology and Safety
10:30 – 11:00	Intermission
11:00 – 12:30	Food Chemistry
12:30 – 13:30	Lunch
13:30 – 15:30	Experiment for Food Microbiology
15:30 – 16:00	Intermission
16:00 – 18:00	Experiment for Food Microbiology
18:00	Closing

Wednesday, 18 June 2014	
Lecture 3: Dosimetry and Technical Visit	
09:00	Dosimetry for Phytosanitary X-ray Dosimetry for Korean Export Agricultural Products and Its Quality Evaluation
Technical Visit at two EB facilities & Special Lecture	
11:00 – 12:30	Move to Daejeon
12:30 – 14:00	Lunch
14:00 – 15:30	Move to Commercial EB facility (EB tech Co.)
15:30 – 17:30	Commercial EB facility (EB tech Co.) in Daejeon Special lecture: Application of EB in Advanced materials in Korea

17:30 – 19:00	Return to ARTI
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Thursday, 19 June 2014	
Lecture 4: Experiments for Food Chemistry and Rheology	
09:00	Experiment for Measurement of Food Antioxidative Activity
10:30 – 11:00	Intermission
11:00 – 12:30	Experiment for Measurement of Food Antioxidative Activity
12:00 – 13:00	Lunch
13:30 – 15:30	Experiment for Food Rheology and Sensory Evaluation
15:30 – 16:00	Intermission
16:00 – 18:00	Experimental Design for Food Irradiation
18:00	Closing

Friday, 20 June 2014	
Lecture 5: Experimental Design Meeting Reviewing, Conclusion & Closure of Meeting	
09:00 - 10:30	Experimental Design for Food Irradiation
10:30 – 11:00	Intermission
10:00 – 12:00	Satisfaction Survey for the Training Course
12:00 – 13:00	Lunch
13:00 – 15:00	Meeting Review, Conclusions & Recommendations
18:00	Closing and Final Remarks

2-3. Programme of the 2015 Regional Training Course

Regional Training Course on Basic and Advanced Knowledge and Hands-on Experiment on Electron Beam Applications for Degradation of Environmental Pollutants

11-22 May 2016, Advanced Radiation Technology Institute,
Jeongeup, Republic of Korea

Provisional Programme

Monday, 11 May 2015	
08:30 – 09:30	Registration
Inaugural Session	
09:30 – 11:00	Opening Ceremony
11:00	Introduction of the project and the training course
12:00 – 13:00	Lunch
Lecture 1 : Basic Radiation Chemistry	
13:30 – 15:30	Radiation Protection and Safety I
15:00 – 15:30	Intermission
15:30 – 18:00	Radiation Protection and Safety II
Tuesday, 12 May 2015	
Lecture 2: Radiation Chemistry Applications in the Environment	
09:00 – 10:30	Application of ionization radiation to environmental conservation
10:30 – 11:00	Intermission
11:00 – 12:30	Application of ionization radiation to environmental conservation
12:30 – 13:30	Lunch
13:30 – 15:30	Waste Treatment and Recycling using Radiation
15:30 – 16:00	Intermission
16:00 – 18:00	Waste Treatment and Recycling using Radiation
18:30	Closing
Wednesday, 13 May 2015	
Technical Visit	
09:00 – 11:00	Move to destination from ARTI
11:00 – 20:00	Technical Visit
20:00 – 21:30	Return to ARTI
Thursday, 14 May 2015	

Lecture 3: Radiation Detection and Measurements I	
09:00	Overall of the radiation measurements with different type of radiation detectors I
10:30 – 11:00	Intermission
11:00 – 12:30	Overall of the radiation measurements with different type of radiation detectors I
12:30 – 13:30	Lunch
13:30 – 15:30	Overall of the radiation measurements with different type of radiation detectors II
15:30 – 16:00	Intermission
16:00 – 18:00	Overall of the radiation measurements with different type of radiation detectors II
18:00	Closing

Friday, 15 May 2015	
Lecture 4: Radiation Detection and Measurements II	
09:00	Experiment for radiation detector
10:30 – 11:00	Intermission
11:00 – 12:30	Experiment for radiation detector
12:30 – 13:30	Lunch
13:30 – 15:30	Experiment for radiation detector
15:30 – 16:00	Intermission
16:00 – 18:00	Experiment for radiation detector
18:00	Closing

Saturday, 16 – Sunday, 17 May 2015	
Weekend	

Monday, 18 May 2015	
Lecture 5: Water and wastewater treatment using radiation	
09:00 – 10:30	Water and Wastewater Treatment using Radiation
10:30 – 11:00	Intermission
11:00 – 12:30	Livestock Waste and Wastewater Treatment using Radiation
12:30 – 13:30	Lunch
13:30 – 15:30	Experiment for wastewater treatment using mobile electron beam
15:30 – 16:00	Intermission
16:00 – 18:00	Experiment for wastewater treatment using mobile electron beam
18:00	Closing

Tuesday, 19 May 2015	
Lecture 6: Air pollutants treatment using radiation	

09:00 – 10:30	Global Warming Gas Treatment using Electron Beam
10:30 – 11:00	Intermission
11:00 – 12:30	Effects of E-beam on swine wastewater using an ion-exchange membrane bio reactor
12:30 – 13:30	Lunch
13:30 – 15:30	Experiment for air pollution treatment using radiation
15:30 – 16:00	Intermission
16:00 – 18:00	Experiment for air pollution treatment using radiation
18:00	Closing

Wednesday, 20 May 2015	
Lecture 7: Special lecture for environmental analysis	
	Visit at GIST(Gwangju Institute of Science & Technology)
	1. Analysis of organic pollutants <ul style="list-style-type: none"> - Sample preparation - Principles of HPLC and LC/MS and its application - Principles of GC and GC/MS and its application 2. Analysis of inorganic pollutants <ul style="list-style-type: none"> - Sample preparation - Principles of ICP/MS and its application

Thursday, 21 May 2014	
Lecture 8: Waste and Micro-pollutants Treatment using radiation	
09:00 – 10:30	Hazardous air pollutant treatment using radiation hybrid technology
10:30 – 11:00	Intermission
11:00 – 12:30	Micropollutant Treatment using Radiation
12:30 – 13:30	Lunch
13:30 – 15:30	Experiment for waste treatment and recycling using radiation I
15:30 – 16:00	Intermission
16:00 – 18:00	Experiment for waste treatment and recycling using radiation II
18:00	Closing

Friday, 22 May 2014	
Meeting Reviewing, Conclusion & Closure of Meeting	
09:00 – 10:30	Meeting Review
10:30 – 11:00	Intermission
11:00 – 12:00	Meeting Conclusions & Recommendations
12:00 – 13:00	Lunch
13:00	Closing and Final Remarks

2-4. Analysis of Regional Training Course Surveys

The satisfaction survey on the Regional Training Courses conducted by the RCARO after each completion showed that the participants were very satisfied with the Regional Training Courses in terms of information sharing, training materials, quality and content of lectures, and hands-on experiments. Tables below show the detailed results and views of the satisfaction survey.

Table 1 Result of the Satisfaction Survey on the RTC for value addition to industrial products in 2013

Questionnaires		Absolutely disagree	Somewhat disagree	Neutral	Somewhat agree	Absolutely agree
This course was GENERALLY beneficial to						
1.	Accumulate knowledge and skills				3 (30%)	7 (70%)
2.	Enhance my own career	1 (10%)			1 (10%)	8 (80%)
3.	Contribute to the organization I work at					10 (100%)
4.	Establish an international network with course participant(s) /presenter(s) /coordinator(s)				1 (10%)	9 (90%)
Total		1 (2.5%)			5 (12.5%)	34 (85%)
※ Some questionnaires were not answered by all participants.						

Table 2 Result of the Satisfaction Survey on the RTC for environmental remediation in 2013

Questionnaires		Absolutely disagree	Somewhat disagree	Neutral	Somewhat agree	Absolutely agree
This course was GENERALLY beneficial to						
1.	Accumulate knowledge and skills				4 (44.44%)	5 (55.6%)
2.	Enhance my own career		1 (11%)		4 (44.44%)	4 (44.44%)
3.	Contribute to the organization I work at				3 (33.3%)	6 (66.66%)
4.	Establish an international network with course participant(s) /presenter(s) /coordinator(s)			1 (11%)	2 (22.2%)	6 (66.66%)
Total			1 (2.75%)	1 (2.75%)	13 (36.1%)	21 (58.25%)

Table 3 Comments on the 2013 Regional Training Courses

Industry	Environment
<ul style="list-style-type: none"> - I would like to comment on hands on training on dosimetry. Actually it was well organized in advanced. - I gained clear idea about dose measurements correctly and plot the data. I must thanks for your well organizing of experiments Prof Sung Oh Cho. It is better to have his lecturers also on PPT. I must say his explanation on theorized aspects as excellent. - Very good. I widened my eyes and accumulated knowledge about radiation chemistry and skills of measurement 	<ul style="list-style-type: none"> - The content should explain more about chemical reaction during the treatment process and provide more technical data. Participants should have been working for more than five years in related topic. - All curriculums are effective for our country because Myanmar need human resource development assistance and infrastructure development for electron bem technology and its application, such as training courses and workshops, technical consultations and hand-on practices.

<ul style="list-style-type: none"> - As the first part of a series of training course, the curriculum is good for the starting records and knowledge. - In my opinion, these topics are essential and useful for me, these topics help me improve my knowledge and skills. - Basic Radiation chemistry in advanced material by Prof Sung Oh Cho. The lecture was well organized and easy to understand. What's more, it was information and benefit to my own reach. - They teach very well and easy to understand by taking many examples. They explained very detail every difficult topics. They give us a lot of new information, which is very useful for us. They interacted with participants very well by asking us many question. - May please be included to let the participants to know about the EB technology developments - I feel interesting here because is my first time in Korea and my first time to know about Electron Beam Application. Thank you very much for all Lead Host. - Thanks to all for this training course. I get so many technical knowledge and information. I will share to any organization. To attend the some participants for advanced course, should be part in the prospector proper. - I suggest that the materials used in the training course should be sent to the participants before the training by email, so that we can search the information and understand the lecture easier. Thank you very much for your kind help and efforts. 	<ul style="list-style-type: none"> - very comprehensive, very good delivery, well organized and intensity - Lecture by Mr. Boom Soo Han, CEO, EB-Tech, was very informative, well organized and easy to understand. He covered almost all the application areas along with functioning principles of electron beam accelerators. - To avoid overlapping content of the lectures, it is better if the lecture topic is specific. - It is the high technical and Scientific training, so by my opinion, it should take more time. - Organizer should consider about a study visit to a field to see the real situation on how waste water and air pollutant be treated by electron beam. Explain more on gas treatment. - The training course was very informative and knowledge importing and it will be very helpful to our country to plan for adopting this technology to solve the problems of environmental preservation including waste water treatment, effluent gas treatment, treatment of VOC's and other organic pollutants. Moreover, it will help us to use this technology for future applications the development of advanced materials. So, further such course should be offered to the member countries for betterment of human society and our world. I would like to have an advance course on this topic. - I hope that study visit will provide and enhance the knowledge, practical experiments and technology of electron beam and its application.
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Table 4 Result of the Satisfaction Survey on the RTC for value addition to industrial products in 2014

Questionnaires		Absolutely disagree	Somewhat disagree	Neutral	Somewhat agree	Absolutely agree
This course was GENERALLY beneficial to						
1.	Accumulate knowledge and skills			2 (9.1%)	8 (36.4%)	12 (54.5%)
2.	Enhance my own career				14 (63.6%)	8 (36.4%)
3.	Contribute to the organization I work at			3 (13.6%)	10 (45.5%)	9 (40.9%)
4.	Establish an international network with course participant(s) /presenter(s) /coordinator(s)			1 (4.5%)	8 (36.4%)	13 (59.1%)
Total				6 (6.8%)	40 (45.5%)	42 (47.7%)
※ Some questionnaires were not answered by all participants.						

Table 5 Result of the Satisfaction Survey on the RTC for value addition to Food products in 2014

Questionnaires		Absolutely disagree	Somewhat disagree	Neutral	Somewhat agree	Absolutely agree
This course was GENERALLY beneficial to						
1.	Accumulate knowledge and skills		1 (9.1%)		4 (36.4%)	6 (54.5%)
2.	Enhance my own career		1 (9.1%)	2 (18.2%)	4 (36.4%)	4 (36.4%)
3.	Contribute to the organization I work at		1 (9.1%)	2 (18.2%)	4 (36.4%)	4 (36.4%)
4.	Establish an international network with course participant(s) /presenter(s) /coordinator(s)		1 (9.1%)	1 (9.1%)	6 (54.5%)	3 (27.3%)
Total			4 (9.1%)	5 (11.4%)	18 (40.9%)	17 (38.6%)
※ Some questionnaires were not answered by all participants.						

Table 6 Comments on the 2014 Regional Training Courses

Industry	Food
<ul style="list-style-type: none"> - The curriculum must focus on the topic itself. Also the coordinator of the training course should consider the current knowledge of their participants better that they will accept participants who is in the field of the study so that it will be a useful tool for them in going back to their country. - Dosimetry is suggested to be included in the curriculum for advanced courses. - In my view the curriculum in this training course is well. I would like to suggest that before experiments you should give detail of experimental procedures. - I think this training program given broad overview of EB technology and it's applications on grafting hydrogels etc. In addition, I am got broader knowledge in terms of radiation detectors, mechanisms of EB accelerators, C60-gamma irradiators, ion-beam accelerators and cyclotrons which used in Korea. - This training course is very beneficial to me in improving my knowledge and view on the application of radiation technologies for various industries. It is much better if possible; the experimental part or time allocated for experiment is too short. The curriculum is pretty enough but some part is still overlap. - The curriculum is very nice and gives us more interesting point of view in terms of radiation processing application in advanced material. But somehow it is difficult bring back this technology to our home country regarding the limited equipment. 	<ul style="list-style-type: none"> - The course could have been more extensive and should have covered more areas in food application. Food processing at E-Beam facility would have been more appreciated. - The training course is useful to me and my job, but I can't learn some important information from curriculum. For example, food irradiation industry developed level in Korea such as how many foods irradiated annually. - Topics dealing with all lectures are very important for us and able to improve our knowledge in some topics, but it is not sufficient due to none of sufficient time. - Current topics are good, but we need more time (I think about 2 weeks) in order to be deeply in understanding the curriculum. - Should place more emphasis on E-Beam and its application on food and place less emphasis on food quality assessment. - The curriculum is good, but the hands-on experiment is quite short and lack of time. I suggest that the training course should be in 2 weeks so that all the experiment should have more time. To have more experiment on Dosimetry, Food Chemistry and Microbiology analysis. - This curriculum is provided me the basic information and knowledge. I never meat before food security and safety. - Experiment for Food Microbiology. It should prepare direction of laboratory before doing the experiment. It is easy to understand.

<ul style="list-style-type: none"> - The curriculum offered wide range of technical aspects from basic radiation chemistry to advanced applications. Strength point is facility visit that gave us a chance to see and experience real and practical applications in the industry. - The curriculum involves all kinds of aspects which are impressive. I have learnt a lot especially the application of electron beam on polymers and nanoparticles. If possible, I expect that the professors could give more details about their research including definite data. If possible, I wish to make more experiments by myself here. I think there are no other gaps, repetitions and imbalances. 	<ul style="list-style-type: none"> - The training course should include hands-on experiments on the irradiation process itself including the dosimetry practical. While the hands-on experiments in the laboratory are good to participants. Most of them do not experience in conducting irradiation process of the food item using E-Beam technology.
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Table 7 Result of the Satisfaction Survey on the RTC in 2015

Questionnaires		Absolutely disagree	Somewhat disagree	Neutral	Somewhat agree	Absolutely agree
This course was GENERALLY beneficial to						
1.	Accumulate knowledge and skills			2 (8.7%)	9 (39.1%)	12 (52.2%)
2.	Enhance my own career			3 (13.0%)	12 (52.2%)	8 (34.8%)
3.	Contribute to the organization I work at			5 (21.7%)	12 (52.2%)	6 (26.1%)
4.	Establish an international network with course participant(s) /presenter(s) /coordinator(s)			3 (13.0%)	10 (43.5%)	10 (43.5%)
Total				13 (14.1%)	43 (46.7%)	36 (39.1%)

Table 8 Comments on the 2015 Regional Training Course

Environment
<ul style="list-style-type: none"> - It is well organized and the efforts made by RCA team is highly appreciated. But there is always a space for improvement, my suggestion is that some topic may be specifically selected for E-beam machine i.e; installation or acceptance procedures of the machine and experiment for E-beam Analysis/Dosimetry. - The training course curriculum give me the knowledge related to radiation technology involving EB and gamma irradiation and its application in water, wastewater and air pollution treatment. The experiments are helpful to understand the knowledge. - Some topics were not very relevant to the course objectives. Nevertheless, overall quite satisfactory. - For curriculum, I would like to say about that it covered all of modern and crucial topics such as air pollution, environmental remediation and waste water treatment. For the experiment, it seems to me that if it would be divided a few participate in one group, and the hand on experiment will be more efficient and fruitful. - Altogether, lectures covered all topics relevant to the course on ebeam and its application in environmental remediation. The lecture topics were all appropriate for the course. - This training course curriculum is very valuable and help us to understand for making research by using electron beam for environmental remediation in our country. - Study visit to all facilities (EB tech, GIST and Sewage Treatment Plant) is very good to open up our mind and view on the practical application of EB tech - The lectures covered all topics for the training course. Basic and advanced knowledge were gained from the training. The two weeks period is just right for the training. The pacing of the lectures and demonstrations plus the study visits are just right. However, the course title implied “hands-in” experiment on eBeam

applications. This “hands-on” aspects of the course were mostly demonstrations and visits to the KAERI laboratories. Maybe doing actual experiments where all 23 participants can do real hands-on experiments is not easy to organize. The demos lab visits are also ok. The staff and researchers were all helpful and very accommodating.

- This training is very effective for me. I have strong desire to attend the training course that contain the design and construction of e-beam accelerator and facilities. This kind of training is very valuable for our country. Please forget me not, when this kind of opportunity happens.

All participants agreed that the training courses provided them with not only the relevant techniques but also new ideas on how to use and apply those techniques in the field. It was also mentioned that trainees had opportunities to interact with renowned scientists of ARTI throughout the course. All participants agreed that the study visits gave them a valuable opportunity to gain knowledge on electron beam application. There were also positive comments on a study visit to EB-Tech, saying the visit was very informative and useful in learning the specific equipment. All participants agreed that the training course was very helpful in extending the knowledge. However, as the main agenda for the training course includes ‘hands-on experiment,’ they suggested having more sessions where every participant can actually be involved in experiments.

3. Country Reports

Final Progress Report on

Electron Beam Applications for Value Addition to Food and Industrial Products and Degradation of Environmental Pollutants in the Asia-Pacific region

1. Participating Country: Australia

1.1 National Project Coordinator

Name	Title	Organization	E-mail
Peter Leach	Mr	Department of Agriculture and Fisheries	Peter.Leach @daf.qld.gov.au

1.2 National Project Team

Name	Title	Organization	E-mail
Richard Banati	Dr	Australian Nuclear Science and Technology Organisation	rib@ansto.gov.au

2. Period Covered: December 2012 to November 2015

3. National Activities

Australia does not receive funding to undertake national activities and as such does not have a national work plan. Activities listed below were undertaken as part of research projects funded by the Australian Government and industry bodies. Many of the activities have been running over several years and the outcomes are summarised in the 2015 activities list. In some cases the activities have been running for over ten years but outcomes were not achieved until 2015.

3.1 National Activities Undertaken

3.1.1 National Activities in 2013

Activity Name	Objectives	When	Where	Context : Topics, outcomes, accomplishments

3.1.2 National Activities in 2014

Activity Name	Objectives	When	Where	Context : Topics, outcomes, accomplishments

3.1.3 National Activities in 2015

Activity Name	Objectives	When	Where	Context : Topics, outcomes, accomplishments
Approval to use irradiation for phytosanitary purposes on 11 new fruit and vegetables.	Gain approval by Food Standards Australia New Zealand (FSANZ)	27th February, 2015	Australia	Queensland DAF undertook research on the impacts of irradiation on the nutritional value and quality of 11 fruits and vegetables. On the 27th of February FSA NZ gave approval for the use of irradiation for phytosanitary purposes for all 11 crops. These fruit can now be irradiated and sold on the domestic market within Australia. This takes the total number of crops approved to use irradiation to 24 and includes breadfruit, capsicum, carambola, custard apple, litchi, longan, mango, mangosteen, papaya, persimmon, tomato, rambutan, apple, apricot, cherry, nectarine, peach, plum, honeydew, rockmelon, strawberry, table grape, zucchini and scallopi (squash).
First Exports of Australian Mangoes to the United states of America	Market Access to the US market	February 2015	Australia	After more than 10 years of negotiation the first consignment of irradiated Australian mangoes was sent to the United States. Two consignments were sent (over 1000 cartons) and fruit was sold in Texas, Arizona, Missouri and New York. More consignments are planned in November this year. This work was funded by the Northern Territory Department of Primary Industry and Fisheries and funded by the Australian Mango Industry Association through Horticulture Innovation Australian Ltd.
Approval granted for Australian lychee exports to the United states of America	Market Access to the US market	2015	Australia	Market Access to the US market has been granted but no exports have occurred to date. The production season starts in November and will continue until February. The first exports are expected in December 2015.
First exports of Australian plums and grapes to Indonesian market.	Market Access to the Indonesian Market	2015	Australia	Indonesia has given approval for the use of irradiation on 44 fruit and vegetables from Australia. The first exports of irradiated Australian plums and grapes occurred in 2015. Volumes are still small but expected to increase next year.
First exports of Australian mandarins to the Vietnamese market.	Market Access to the Vietnamese Market	2015	Australia	Australian exports to Vietnam were suspended in late 2014 due to new requirements for the control of fruit fly. The market for Australian mandarins has reopened with the approval of the use of irradiation. The first exports of irradiated mandarins occurred in 2015. Volumes are still small but expected to increase next year.

Approval granted for Vietnamese litchi to the Australian market.	Market Access to the Australian Market	2015	Vietnam	After nearly a decade of negotiations Vietnamese litchi have been granted approval to export litchi to Australia. Litchi production in Vietnam is counter seasonal to Australia and the Australian lychee industry is not opposed to the imports. Previous imports from Thailand and China were not well received due to poor quality fruit after heat treatment or cold treatment. With irradiation now approved it is expected the quality of imports should improve dramatically.
Approval granted for Australian persimmons to Thailand	Market Access to the Thailand Market	2015	Australia	Thailand has granted approval for the use of irradiation on persimmons and the first exports occurred in 2015. Volumes are still small but expected to increase next year. Fruit can be found in major supermarkets and is selling for 1,550 Baht per carton.
Conference presentations	Provide talks to industry on market access projects	April, May June	Mildura, Melbourne, Darwin, and Shepparton	Talks on irradiation and market access were provided by Mr Leach at the Australian Citrus Growers Conference, the Produce Marketers Association conference, the Australian Mango Grower's conference and the Goulburn Valley Fruit Fly Task Force Meeting.
Research on Insect Labelling	Tracking the dispersal of mosquito species from and between non-compliant rainwater tanks in urban landscapes.	On-going	Queensland	<p>Non-compliant rainwater refer to tanks in various states of disrepair which are capable of producing mosquitoes (e.g. the seals, sieves and structural integrity designed to prevent mosquito breeding have been compromised by age, poor maintenance or poor installation). These non-compliant tanks are thought to be key harbourage and invasion foci for container breeding mosquito species. We are specifically interested in questions of mosquito movement around and between these tanks and we will use marked adult mosquitoes emerging naturally from tanks treated with stable isotopes to measure dispersal. We will also examine whether roads, fences and grassed areas act as barriers to movement. These measures will be used to inform network models that simulate and predict the speed and pattern of establishment of mosquitoes invading typical Brisbane landscapes with extensive networks of rainwater tanks.</p> <p>A preliminary study will identify the concentration of stable isotopes required to give an identifiable signal in mosquito adults emerging from treated water. We expect this to use ca 2 mg ¹⁵N / litre (5); equivalent to 7 – 10 g isotope per rainwater tank (3500-5000 litres).</p> <p>Samples will be sent to ANSTO for screening. ¹⁵N enrichment is routinely measured in their aquatic ecosystems laboratory</p>

				tories (using Isotope Ratio Mass Spectrometry) although some pre-sample calibration and testing will be required.
Research on bacterial colonisation of plastics	Investigating if the ageing/embrittlement of plastic influences bacterial colonisation rates in an estuarine environment.	On-going		Researchers are using gamma irradiation to age plastics and even though the work is not completed there are significant differences in the bacterial colonisation rates being recorded.

3.2 No. of Participants of National Activities NOT APPLICABLE

3.2.1 No. of Participants in 2013

Activity \ No. of Participants	No. of Female	No. of Male	Total
Activity 1			
Activity 2			
Activity 3			
Activity 4			
Activity 5			

3.2.2 No. of Participants in 2014

Activity \ No. of Participants	No. of Female	No. of Male	Total
Activity 1			
Activity 2			
Activity 3			
Activity 4			
Activity 5			

3.2.3 No. of Participants in 2015

Activity \ No. of Participants	No. of Female	No. of Male	Total
Activity 1			
Activity 2			
Activity 3			
Activity 4			
Activity 5			

4. Results NOT APPLICABLE

4.1 Analysis of National Activities and Results

- Summarize the national activities implemented - capacity development in terms of achievements (i.e.

- dissemination of new technologies, knowledge and skills, information to participants).
- Analyze the achievements of national activities implemented: augmentation of national capacity.
- Successful stories, etc.

4.1.1 Analysis of National Activities and Results in 2013

4.1.2 Analysis of National Activities and Results in 2014

4.1.3 Analysis of National Activities and Results in 2015 (※ Please describe in detail.)

4.2 Describe to what extent the objectives of the national work plan were accomplished:

4.3 Describe immediate benefits of national activities:

4.4 Describe long term benefits of national activities:

4.5 New Developments and unexpected difficulties/problems

4.6 Actions taken to solve them

4.7 Remarks/lesson learned

4.8 Photos



First Consignment of Australian mangoes sold in the United States



US Inspector with the first consignment of Australian mangoes

Final Progress Report on

Electron Beam Applications for Value Addition to Food and Industrial Products and Degradation of Environmental Pollutants in the Asia-Pacific region

1. Participating Country: Cambodia

1.1 National Project Coordinator

Name	Title	Organization	E-mail
Mr. Danh Serey	Director of EIA	Ministry of Environment	danhserrey@yahoo.com

1.2 National Project Team

Name	Title	Organization	E-mail
Mr. Chea Leng	Director Division	Ministry of Environment	lengmoe@gmail.com

2. Period Covered: December 2012 to November 2015

- RCA/UNDP Regional Training Course in Basic and Advanced Knowledge and Hands-on Experiment on Electron Beam Applications for Advanced Material in the Asia Pacific region on 14-25 April 2014, Jeongup, Korea
- RCA/UNDP Regional Training Course in Knowledge and Hands-on Experiment on Electron Beam Applications for Value Addition to Food Products in the Asia Pacific region on 16-20 June 2014, Jeongup, Korea
- Annual Review Meeting of the RCA/UNDP Project on Electron Beam Applications for Value Addition to Food and Industrial Products and Degradation of Environmental Pollutants in the Asia Pacific region on 19-20 November 2014, Yangon, Myanmar
- RCA/UNDP Regional Training Course in Basic and Advanced Knowledge and Hands-on Experiment on Electron Beam Applications for Environmental Remediation in the Asia Pacific region on 11-22 May 2015, Jeongup, Korea
- Co-organized the Final Review Meeting of the RCA/UNDP Project on Electron Beam Applications for Value Addition to Food and Industrial Products and Degradation of Environmental Pollutants in the Asia Pacific region on 28-29 October 2015, Siem Reap, Cambodia

3. National Activities

3.1 National Activities Undertaken

3.1.1 National Activities in 2013

Activity Name	Objectives	When	Where	Context : Topics, outcomes, accomplishments

3.1.2 National Activities in 2014

Activity Name	Objectives	When	Where	Context : Topics, outcomes, accomplishments
TC project KAM9002	Pre assessment on project	12 to 17 May, 2014	Phnom Penh	
Consultation with stakeholders	Inception report	Starting from May 12, 2014	Phnom Penh	

3.1.3 National Activities in 2015

Activity Name	Objectives	When	Where	Context : Topics, outcomes, accomplishments
Meeting and consultation with stakeholders	Expert Mission to advise on regulatory framework and regulations for radioactive waste management. And on principles and practice of radiation survey and radioactivity measurement.	January 12 to 16, 2015	Phnom Penh	
Final Meeting	Review the final meeting	28-29 October 2015	Siem Reap	

3.2 No. of Participants of National Activities

3.2.1 No. of Participants in 2013

Activity	No. of Participants	No. of Female	No. of Male	Total
Activity 1				
Activity 2				
Activity 3				
Activity 4				
Activity 5				

3.2.2 No. of Participants in 2014

Activity	No. of Participants	No. of Female	No. of Male	Total
Activity 1			9	9
Activity 2		2	16	18
Activity 3				
Activity 4				
Activity 5				

3.2.3 No. of Participants in 2015

Activity \ No. of Participants	No. of Female	No. of Male	Total
Activity 1			
Activity 2	7	12	19
Activity 3			
Activity 4			
Activity 5			

4. Results

- N/A

4.2 Analysis of National Activities and Results

- Summarize the national activities implemented - capacity development in terms of achievements (i.e. dissemination of new technologies, knowledge and skills, information to participants).
- Analyze the achievements of national activities implemented: augmentation of national capacity.
- Successful stories, etc.

4.1.1 Analysis of National Activities and Results in 2013

- NA

4.1.2 Analysis of National Activities and Results in 2014

- Cambodia is fall behind in term of using Electron Beam and and manage Radioactive Waste Management among in the Asia Pacific region; however, these activities to encourage Cambodian line agencies start to consider and propose more activities in the future.

4.1.3 Analysis of National Activities and Results in 2015 (※ Please describe in detail.)

- The Review Final Meeting in Siem Reap on 28-29 October was an important event and it disseminated knowledge and information to senior officers aware of new technologies. It encourage them to build up more human resources to catch up the using the new technology.

4.2 Describe to what extent the objectives of the national work plan were accomplished:

Cambodia will implement TC project KAM9002 and objective is:

- Increasing awareness of Radioactive;
- Collecting information of radioactive and gather sources;
- Consultation with stakeholders and share information;
- Identify other sources and control; and
- Coordinate the stakeholders.

4.3 Describe immediate benefits of national activities:

People are aware of radioactive and electron beam and it is possible to identify the stakeholders (gap of identify the stakeholder). It is possible to share information and know the point of contact for further data and information.

4.4 Describe long term benefits of national activities:

People understand and willing to cooperate with government agency. In addition, government agency can manage the sources and good facilitate with other stakeholders.

4.5 New Developments and unexpected difficulties/problems

Cambodia has not identified the stakeholders yet and unable to control sources and limitation of human capacity.

4.6 Actions taken to solve them

Cambodian needs more training course and workshop in Cambodia.

4.7 Remarks/lesson learned**4.8 Photos**

Final Progress Report on

Electron Beam Applications for Value Addition to Food and Industrial Products and
Degradation of Environmental Pollutants in the Asia-Pacific region

1. Participating Country: China

1.1 National Project Coordinator

Name	Title	Organization	E-mail
Shijun He	Associate professor	Tsinghua University	heshj@tsinghua.edu.cn
Gao Meixu	Head, Vegetable Processing Team	Institute of Agro-products Sci&Tech Processing, Chinese Academy of Agricultural Sciences	meixugao@263.net
Maolin Zhai	professor	Peking University	mlzhai@pku.edu.cn

2. Period Covered: January to December 2014

3. National Activities

3.1 National Activities Undertaken

3.1 National Activities in 2014

Activity Name	Objectives	When	Where	Context : Topics, outcomes, accomplishments
Activity 1 Expert mission	The dosimetry system for wastewater treatment	12-18 Jan 2014	Suzhou	Dr. Andras Kovacs, from Hungarian Academy of Science, was invited to China as an expert of TC project CPR1008.
Activity 2 Scientific visit	Irradiation technology for wastewater and sludge treatment	1-12 April 2014	Texas agriculture and machinery university	Mr. jieping Lu, from Dasheng electron Accelerator Ltd.Co., visited the Texas agriculture and machinery university.
Activity 3 Scientific visit	Irradiation technology for wastewater and flue gas purification	13-17 May 2014	Institute of Nuclear Chemistry and Technology (INCT), Warsaw, Poland	Prof. Wang and Dr.He visited Institute of Nuclear Chemistry and Technology (INCT), Warsaw, Poland
Activity 4 CRP meeting	Irradiation technology wastewater treatment	18-24 May 2014	Budapest, Hungary	Prof. Wang, Dr. Libin Chu and Dr.He participated in this annual meeting in Budapest, Hungary.
Activity 5 Technical meeting	Radiation technology for environmental remediation	16-20 June 2014	Vienna, Austria	Dr.He participated this technical meeting.
Activity 6 Seminar	New development of electron beam technology for wastewater treatment	25-26 Aug 2014	The city of Guiyang	Dr.He was invited to give a lecture about Electron beam technology for wastewater Treatment.

Activity 7 Seminar	Electron Beam Technology for Environmental Application	19-20 Nov 2014	Yangon, Myanmar	Dr.He was invited to give a lecture about Electron beam technology for wastewater Treatment. Wangjun also attended the conference as an observer.
Activity 8	Evaluation of research progress on food irradiation under project 201103007	May 27-29, 2014	Yangzhou, Jiangsu Province	Mrs Gao was invited to attend the conference. Topics: Mid-term evaluation meeting of MOA Public Welfare Project Outcomes: progresses on EB irradiation, irradiation destruction of allergens, irradiation effects on natural toxin, comparison study between EB and γ -ray irradiation; published 30 papers and 15 patents; summarized six potential achievements Accomplishments: the project was implemented as plan.
Activity 9 Seminar	Development of Advanced Grafted Materials for Industrial Applications and Environmental Preservation	23-27 June, 2014	Sri Lanka	Dr.Zhai participated this technical meeting.
Activity 10	RCARO/UNDP Regional Training Course in advanced knowledge and hands-on experiment on electron beam applications for value addition to food and agricultural products in asia pacific region	16-21 June 2014	Korea	Jianhui Qiu participated this training course.

3.2 No. of Participants of National Activities

3.2No. of Participants in 2014

Activity	No. of Participants	No. of Female	No. of Male	Total
Activity 1		5	14	19
Activity 2		0	3	3
Activity 3		0	2	2
Activity 4		1	2	3
Activity 5		0	1	1
Activity 6		12	37	49
Activity 7		6	11	17
Activity 8		16	20	36
Activity 9		/	/	/
Activity 10		5	15	20

4. Results

4.3 Analysis of National Activities and Results

- Summarize the national activities implemented - capacity development in terms of achievements (i.e. dissemination of new technologies, knowledge and skills, information to participants).
- Analyze the achievements of national activities implemented: augmentation of national capacity.
- Successful stories, etc.
- In 2014, we organized two scientific visits, one expert mission, one seminar and participated two international meetings.
- During these activities, we collected much information and expertise about the techniques used for wastewater treatment. We also get acquainted with techniques that are not available at my institute.
- China already finished the TC project (CPR1008). Next step is to establish an industrial-scale facility for textile and dyeing wastewater treatment.

4.2 Describe to what extent the objectives of the national work plan were accomplished:

- We have already constructed a pilot-scale wastewater treatment plant by EB technology.
- Evaluate the cost-effectiveness of electron beam technology for wastewater treatment.
- Next step is to establish an industrial-scale facility for textile and dyeing wastewater treatment.

4.3 Describe immediate benefits of national activities:

- The above national activities are directly helpful to design the industrial-scale textile and dyeing wastewater treatment.

4.4 Describe long term benefits of national activities:

In the long term, all these national activities will provide very important data for the industrial application of electron beam technology for environmental protection.

4.5 New Developments and unexpected difficulties/problems

Development: New EB irradiator is under construction in Zhejiang University in 2014, and four more EB machines are established or will be established soon. One of them is aimed for quarantine application, another three will mainly focus on foods.

Difficulties: We are in shortage of experiences on how to establish and operate an industrial-scale waste water treatment plant by EB technology.

4.6 Actions taken to solve them

Exchange technical information or experts through TC and CRP project.

4.7 Remarks/lesson learned

The cooperation among IAEA or RCA members will be encouraged.

4.8 Photos





Final Progress Report on

Electron Beam Applications for Value Addition to Food and Industrial Products and Degradation of Environmental Pollutants in the Asia-Pacific region

1. Participating Country: India

1.1 National Project Coordinator

Name	Title	Organization	E-mail
Mr. K S S SARMA	Head, Electron Beam Processing Section	Bhabha Atomic Research Centre	ksivas@barc.gov.in and kuppasarma@yahoo.co.in

1.2 National Project Team

Name	Title	Organization	E-mail
Mr. K P Rawat	Scientific Officer (F)	BARC	Krawat65@rediffmail.com
Mr. P G Benny	--- do----	BARC	
Mr. S R Chowdhury	Scientific Officer (E)	BARC	
Mr. S A Khader	Scientific Officer(E)	BARC	

2. Period Covered: December 2012 to November 2015

3. National Activities

3.1 National Activities Undertaken

3.1.1 National Activities in 2013

Activity Name	Objectives	When	Where	Context : Topics, outcomes, accomplishments
2MeV EBA utilization (industrial)	To identify and develop polymer materials for EB irradiation	Ongoing since 2012	ILU-6 EBA facility, BARC-BRIT, Navi Mumbai	EB Crosslinked Polymer O-rings, automotive parts for High temp applications; Industry involvement, Studies on Tyre pre-treatment etc.
2MeV EBA for environment	Studies on treating liquid & solid sludge for pathogen reduction	Ongoing since 2012	--do--	Parameter optimization carried out with 2MeV/20kW; Semi pilot scale studies initiated
2MeV EBA for food hygienization	Studies to hygienize pulses, spices and meat for shelf-life increase	Ongoing since 2012	--do--	Machine and product parameter optimization done. Possible to increase shelf-life of thin meat products under chilled conditions instead of frozen temp
Dosimetry	Studies on developing in house EB dosimetry methods	Ongoing since 2012	--do--	Complete facility dosimetry and familiarization in terms of QA/QC of irradiated products. dose mapping etc.
Operation and Maintenance & Planning for Upgradation of machine	Machine and irradiation management	--do--	--do--	Effective Troubleshooting and ensuring near trouble free operations; designed and planned, fabrication, modification and constructions w.r to upgradation of the facility to 5MeV EB machine

Indigenous development of industrial EB accelerators	10MeV and 3 MeV EB accelerators under testing	2001	In Navi Mumbai	The machines are being tested for trial operations
National funding for projects to Utilize EBA for research and development	EB irradiation related research and development for new polymer materials	2001	Indian research institutions and academic institutions	DAE-BRNS funded research

3.1.2 National Activities in 2014

Activity Name	Objectives	When	Where	Context : Topics, outcomes, accomplishments
2 MeV EBA Utilization for R&D and Industry	operations for R&D and Industrial utilization; Technological scale Demonstration	Continuation	BARC- BRT, Navi Mumbai	Industrial scale demonstration; semi-commercial operations for polymer products, rubber components, tyre pre-curing, EB crosslinked high temperature mouldable electrical insulation sheets etc.
--do--	Waste water treatment	Continuation	--do--	Semi-pilot scale irradiation gadget fabrication and used and Publication in reputed intl. journal.
--do--	Food irradiation	Continued	--do--	Demonstrated effectiveness of EB irradiation of chicken salami and thin meat products.
--do--	EB Dosimetry	Continued	--do--	Product dosimetry – uniformity of dose studies on pipes, powdered packets etc.
Upgradation of ILU- EB machine	Machine modifications to increase the energy to 5 MeV / 15 kW from 2MeV/20kW	Mid 2014	--do--	Shielding augmentation; upgradation; electrical and electronics circuit modifications; installation and commissioning.
Indigenous EB accelerators	10MeV and 3MeV	Continuation	-do-	10MeV up to 3kW and 3MeV at 1.5MeV/5mA being operated.
National funding for projects to Utilize EBA for research and development	EB irradiation related research and development for new polymer materials	2001	Various Indian institution and academic institutions viz. IIT, SRIIR Delhi, Universities etc.	DAE-BRNS funded research

3.1.3 National Activities in 2015

Activity Name	Objectives	When	Where	Context : Topics, outcomes, accomplishments
Machine upgradation	Beam Energy enhancement	2014-2015	BARC-BRT, Navi Mumbai	Completed upgradation of EB accelerator; Installation and commissioning;
Dosimetry	Facility qualification	-do-	--do--	Facility qualification, Performance qualification etc.. accomplished
Safety	Modified safety report preparation and submission to the regulatory authorities	-do-	-do-	Regulators inspection, in the process of obtaining regular operations approval.

Indigenous EB accelerators	10MeV and 3MeV	continuation	-do-	Being continued to operate and fixing bugs
National funding for projects to Utilize EBA for research and development	EB irradiation related research and development for new polymer materials	2001	Indian institution and academic institutions	DAE-BRNS funded research continued

3.2 No. of Participants of National Activities

3.2.1 No. of Participants in 2013

Activity	No. of Participants	No. of Female	No. of Male	Total
Activity 1		0	2	2
Activity 2		1	2	3
Activity 3		0	1	1
Activity 4		0	2	2
Activity 5		0	2	2
Activity 6		2	10	12
Activity 7		4	10	14
Conference/Seminar in relative topics		A seminar by DAE/INS... large number of collaborators and delegates from industry participated		

3.2.2 No. of Participants in 2014

Activity	No. of Participants	No. of Female	No. of Male	Total
Activity 1		0	2	2
Activity 2		1	2	3
Activity 3		0	1	1
Activity 4		2	10	12
Activity 5		0	2	2
Activity 6		2	10	12
Activity 7		4	10	14
Conference/Seminar in relative topics		NAARRI Seminar at Lucknow on the topic 'Radiation processing of food and allied products'... A large number of collaborators and delegates from industry participated		

3.2.3 No. of Participants in 2015

Activity	No. of Participants	No. of Female	No. of Male	Total
Activity 1		0	2	2
Activity 2		0	2	2
Activity 3		0	1	1
Activity 4		2	10	12
Activity 5		4	10	14
Conference/Seminar in relative topics		NICSTAR 2015 by NAARRI & IIA @ Mumbai; and another national seminar @ Bhopal, India by NAARRI/DAE...A large number of collaborators and national and international delegates participated		

4. Results

4.4 Analysis of National Activities and Results

- Summarize the national activities implemented - capacity development in terms of achievements (i.e. dissemination of new technologies, knowledge and skills, information to participants).
- Analyze the achievements of national activities implemented: augmentation of national capacity.
- Successful stories, etc.

4.1.1 Analysis of National Activities and Results in 2013

- a) Technology demonstration of EB irradiation to industry by BARC helped Indian industry in adapting such technology for their benefits esp. polymer industry (cables, Heatshrinkables etc)
- b) A **national seminar** was held in Mumbai on Radiation technology for industrial applications which has included a Session on the deliberations of EB technology and Applications
- c) Indian industry understood the benefits of EB Accelerator technology. Around 5 EB accelerators have been commissioned in India by wire & cable industry

4.1.2 Analysis of National Activities and Results in 2014

- a) Polymer sheet developed as part of technology demonstration by BARC in collaboration with Indian industry, has been taken up for processing at an local (private) EB accelerator facility on large scale.
- b) The Upgraded 5 MeV EB accelerator has been successfully commissioned and newer applications shall be taken up and demonstrated viz. food products, sterilization of medical products etc.
- c) The indigenous EBAs are put to trial operations and some utilization as part of performance testing

4.1.3 Analysis of National Activities and Results in 2015 (※ Please describe in detail.)

- a) The activities related to EB accelerator utilization has been very positive. Two indigenously developed 10MeV/10kW and 3 MeV/30kW industrial type machines in Mumbai are ready and being fine- tuned for their utilization on regular basis.
- b) Upgraded 5MeV accelerator is ready and trial operations begun
- c) 2 more EB accelerators are being installed by the private cable industry
- d) An **international Conference NICSTAR2015** was held in March 2015 in Mumbai jointly organized by **iiA** which has brought a public-private partnership in utilizing EB technology and applications.
- e) **National seminar (public awareness)** involving universities and nearby food & allied industries on the 'Applications of Radiation processing' at Bhopal, in north Indian city of India during June 2015

4.2 Describe to what extent the objectives of the national work plan were accomplished:

- The very objective of bringing awareness in the Indian industry about the benefits of EB processing has been accomplished.
- More and more companies are interested in setting up EB accelerators especially cable industry.
- Interest in industry to use EB irradiation in place of Gamma irradiator facility is growing.
- Lectures were delivered in National training courses (viz. gamma irradiators and EB accelerators), public awareness seminars etc by us
- Also delivered lectures by three scientists in Korea in this RCA project
- Four scientists have participated in the training course of this RCA project

4.3 Describe immediate benefits of national activities:

Indian industry is now able to bring out quality products and is made available to the society

4.4 Describe long term benefits of national activities:

Deployment of a number of EB accelerators for the societal benefits in the fields of industry, food & agriculture, medical health care and environmental remediation.; Suitable skilled man power and expertise availability to be generated

4.5 New Developments and unexpected difficulties/problems

Problems w r to availability of technological equipment and spares needs to be addressed.

4.6 Actions taken to solve them

Collaboration with international EBA manufacturer (BINP, Russia)

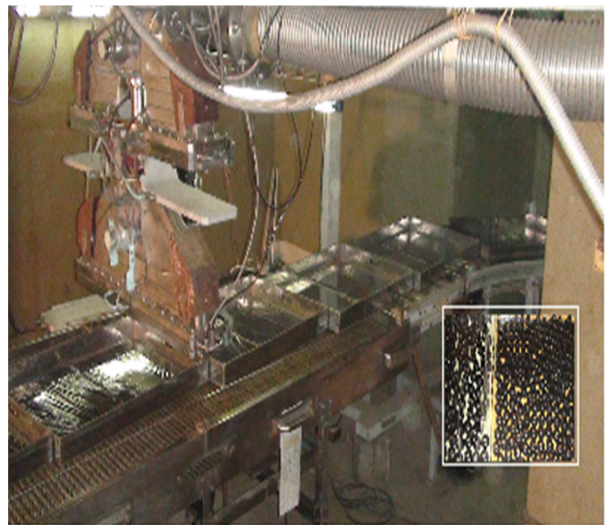
4.7 Remarks/lesson learned

NIL

4.8 Photos



A view of 2MeV/20kW EB Accelerator in BARC-BR IT Complex, Navi Mumbai



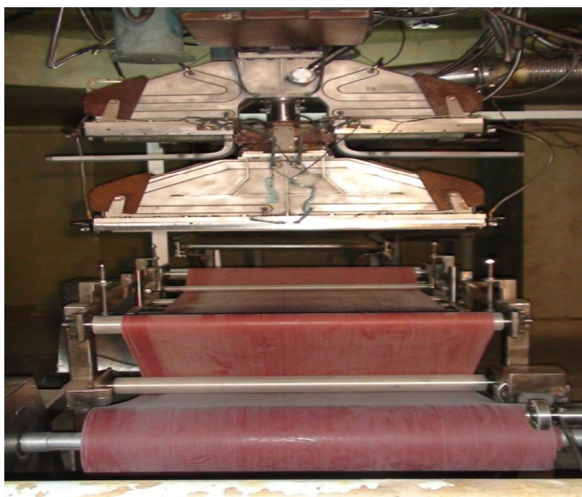
EB Processing of automobile polymer components at IL U-6EB Facility for crosslinking and high temperature stability(insert: photograph of the polymer samples)



EB Crosslinked O-rings for high temp dimensional stability



EB Crosslinking of nylon components



Polymer insulation material under the beam window for irradiation



Recently Upgraded EB Accelerator RF Cavity at BARC



Electron beam centre at Navi Mumbai – A facility with 10MeV and 3 MeV industrial EB accelerators (indigenously built)



National Seminar at Mumbai India (Dec.2013)



National Seminar at Lucknow, India (2014)



International Conference at Mumbai (2015)



Deliberations in NICSTAR 2015 (iia)

Final Progress Report on

Electron Beam Applications for Value Addition to Food and Industrial Products and Degradation of Environmental Pollutants in the Asia-Pacific region

1. Participating Country: Indonesia

1.1 National Project Coordinator

Name	Title	Organization	E-mail
Darmawan Darwis	– National Project Coordinator – Head of Radiation Processing	Center for Isotopes and Radiation Application, National Nuclear Energy Agency (CIRA BATAN)	Darmawan_p3tir@batan.go.id
Idrus Kadir	Alternate National Project Coordinator	Center for Isotopes and Radiation Application, National Nuclear Energy Agency (CIRA BATAN)	Ruskadir@batan.go.id

1.2 National Project Team

Name	Title	Organization	E-mail
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2. Period Covered: December 2012 to November 2015

3. National Activities

3.1 National Activities Undertaken

3.1.1 National Activities in 2013

Activity Name (Training Course, Workshop, Seminar, Education, Mentoring, etc.)	Objectives	When	Where	Context : Topics, outcomes, accomplishments
Activity 1. Preparation of Nation	Built up team member for the RCA/U	April, 2013	CIRA BATAN, J	Topics: National Team member and work plan of UNDP/RCA Project on EB

al Teamand settingup the program	NDP project on EB Applications for Value Addition to Food and Industrial Products and Degradation of Environmental Pollutants in the Asia-Pacific region		akarta	Application for Value Addition to Food and Industrial Products and Degradation of Environmental Pollutants in the Asia-Pacific region Outcomes: National team Member Accomplishments: discussion
Activity 2 Research on Application of EB for preservation of mushroom and cocoa. Research on Degradation of OPEFB by EB	To reduce the microbial contaminants and improve its hygienic quality, cocoa using high energy EB To degrade lignocellulose biomass of OPEFB by EB for production of bioethanol	June-December 2013	CIRA BATAN	Topics: Evaluation of Physico-chemical and microbial characteristics of irradiated edible mushroom Effect of combination treatment EB and hydrolysis on the glucose produced Outcomes: data on Physico-chemical and microbial characteristics of irradiated edible mushroom data on optimum irradiation doses and chemical concentration Accomplishments: laboratory research

3.1.2 National Activities in 2014

Activity Name (Training Course, Workshop, Seminar, Education, Mentoring, etc.)	Objectives	When	Where	Context : Topics, outcomes, accomplishments
Activity 1 Expert mission of IAEA/RAS/1/014 DR. Noriaki SEKO of JAEA, Japan on Radiation Grafting of Polymers	Providing lectures and laboratory experiment demo on radiation grafting of polymer for application in environment, industry and food	24-28 February	CIRA BATAN, Jakarta	Topics: Radiation Grafting of Polymers Outcomes: Many young researchers of Radiation Processing, CIRA BATAN gain their knowledge and knowhow on Radiation technology, radiation grafting and crosslinking as well as radiation degradation of polymers. In addition, they get experience on radiation grafting experiment Accomplishments: lectures, discussion, laboratory experiments
Activity 2 One day Seminar on Technology and Application of Electron Beam Machine by Bum Soo Han, EB Tech, Republic of Korea	To deliver the recent development of Radiation technology especially Electron Beam Technology for application in industry, food and environment	25 April 2014	CIRA BATAN, Jakarta	Topics: Recent Development in Industrial Electron Accelerator and Its Application on Radiation Processing Outcomes: Gain the understanding of participants (government officers and private sectors) on EBM technologies Accomplishments: lectures and discussion
Activity 3 Dissemination of irradiated Food for Victims of Landslides in the Region of Central Java Province	To help the victims of landslides in Pemalang, Central Java Province by providing hygienic and nutritious food	March-May 2014	Pemalang Regency, Central Java Province	Topics: Emergency rations for disaster victims Outcomes: The availability of good quality food for victim of landslides in Pemalang Regency

Activity 4 IAEA/RAS/1/012 Mid-term Review Meeting	Review Current activities of IAEA member states on radiotracer application and technology development to accomplish industrial problems	26-30 May 2014	Bali, Indonesia	Topics: Characterizing and Optimizing Process Dynamics in Complex Industrial Systems using Emerging Radiotracer and Sealed Source Techniques Outcomes: Utilized radiotracer techniques to overcome the problems in the refinery industry processes such as distillation unit, fractionation, boiler, heat-exchanger, Accomplishments: lectures, presentation and discussion
Activity 5 Seminar and Workshop FNCA on Rice Mutation Breeding	Review on Current activities of FNCA Member states on Radiation Mutation Breeding of Rice	4-7 April 2014	CIRA BATAN, Jakarta	Topics: Mutation breeding of rice for sustainable agriculture in Asia Outcomes: Increase food production and improve food quality in Asian Countries
Activity 6 Seminar on Past Method for Determination of Ra-226NPO-210 on Environmental Samples, Invited Speaker: Prof. DR. Henk Heijnis, ANSTO, Australia	Recent Status and Future Prospect of Radioisotopes application in Environmental	14-16 April	CIRA BATAN, Jakarta	Topics: Sedimentation and Climate Change Outcomes: Gain the understanding of participants (government officers and private sectors) on radioisotope technique for application in Sedimentation and Climate Change Accomplishments: lectures and discussion,
Activity 7 Dissemination of irradiated chitosan for application as Plant Growth Promoter and Plant Elicitor	To disseminate irradiated chitosan produced by CIRA BATAN to farmers group in Musi Rawas and Temanggung	4-6 April 2014 9 May 2014	- Musi Rawas, South Sumatra Province - Temanggung Central Java Province	Topics: Application of irradiated Chitosan for agriculture sectors Outcomes: Many farmers want to use irradiated chitosan as PGP and Plant Elicitor Accomplishments: lectures and discussion, field application
Activity 8 Research on Application of EB application for cocoa	To obtain hygienic and high quality of cocoa by using radiation treatment	January-June 2014	CIRA BATAN, Jakarta	Topics: Effect of EB radiation on Properties of cocoa Outcomes: Physico-chemical and microbiological properties of irradiated cocoa Accomplishments: laboratory experiment
Activity 9 IAEA/TC Project BKF 5013: Fellowship (BKF/14006): Mr. Nofou Ouedraogo from Institut de l'Environnement et de Recherches Agricoles (INERA). Ouagadougou	to identify sorghum mutant line tolerant to drought and striga	30 August-28 October 2014	CIRA BATAN, Jakarta	Topics: Enhancing Sorghum Productivity by Breeding Resistant Varieties to Striga Hermonthica Strains in Agroecological Zone Outcomes: 1. Enhancing knowledge and knowhow on mutation breeding by radiation in general and especially sorghum 2. Increasing laboratory skill on characterization of plant 3. Establishing research network between CIRA-BATAN and INERA Accomplishments: 1. Lecture on mutation breeding

04.BURKINA FASO Supervisor: DR. Soeranto Hoeman				2. Visiting farmer field involve in participatory variety selection 3. Participating in IAEA/RCA Mid-Term Project Assessment Meeting RAS5056 as observer 4. Planting shorgum and cowpea in Green house
Activity 10 IAEA/RCA Mid-Term Project Assessment Meeting RAS5056: Supporting Mutation Breeding Approaches to Develop New Crop Varieties Adaptable to Climate Change Local Organizer: Mr. Soeranto Hoeman	To discuss and summarize the project progress with regard to the activities, implementation strategies and scientific methodologies used to enhance national capacity for the application of isotopic and nuclear techniques for developing and using improved crop varieties with best practice soil, water, crop and nutrient management for increasing the crop productivity.	6-10 October 2014	Melia Purosani Hotel, Yogyakarta, Indonesia	Topics: Review the progress that has been made with regard to implementation of the individual country work plans and the expected outputs formulated in the first coordination meeting Identify and address gaps and needs for advanced mutation breeding approaches and techniques to develop new crop varieties adaptable to climate change and for the application of integrated mutation/soil and water management technology packages to spread new crop varieties adaptable to climate change Review and discuss the implementation of the project activities (technical meetings, workshops, training courses and national field studies) and evaluate the results achieved Refine/Adjust country work plans as well as the RAS5056 work plan for activities remaining in the lifetime of the project Outcomes: With improvements in soil fertility and management of water to reduce evaporation and divert more flows to transpiration, yields can be tripled Accomplishments: Presentation, discussion and field trip
Activity 11 First Coordinator Meeting of RAS Project RAS 5/061, Supporting Food Irradiation Technology to Ensure the Safety and Quality of Meals for Immuno-compromised Patients and Other	Revise and finalize the final version of the project document	24-28 November 2014	Bali, Indonesia	Topics: 1. Development of irradiated food for immuno-compromised Patients and other Target Groups 2. Define Project Implementation and monitoring strategy 3. Set the Project Baseline for measuring results 4. Agree in the expected results with their corresponding performing indicator, and 5. Establish the project work plan

Targets Groups, Bali Indonesia, 24-28 November 2014				<p>with detailed activities, input, timelines budget and roles and responsibilities</p> <p>Outcomes: report on the status of food for immune-compromised patients and on the status of food irradiation in member states</p> <p>Accomplishments: presentation and discussion</p>
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3.1.3 National Activities in 2015

Activity Name (Training Course, Workshop, Seminar, Education, Mentoring, etc.)	Objectives	When	Where	Context : Topics, outcomes, accomplishments
Activity 1 Innaguration of BATAN- IAEA Collaborating Center for NDE Technique by IAEA Director General Dr. Yukiya AMANO	To assist IAEA in promoting and implementing activities related to research and development and capacity building in the field of nondestructive diagnostics, testing and inspection technologies.	January 23, 2015	CIRA BATAN, Jakarta	<p>Topics: Industrial Application of Radioisotopes and Radiation Techniques.</p> <p>Outcomes:</p> <ul style="list-style-type: none"> – Capabilities in MSs improved for services providing and R&D through personnel trained and qualified in the related fields – Capacities of personnels improved in MSs <p>Accomplishments: exhibition, and public expose</p>
Activity 2 FNCA Seminar and Workshop on Electron Beam Application: Radiation Processing of Natural Polymer for Agriculture Application	To review the on going Activities of oligosaccharide as plant growth promoter/plant elicitor and SWA in FNCA MSs	09-12 February 2015	Melia Purosani Hotel, Yogyakarta	<p>Topics: Radiation processed polysaccharides for application in agriculture especially PGP, SWA and Animal feed supplement</p> <p>Outcomes: Capabilities and experience in FNCA MSs improved for radiation induces polysaccharide for agriculture application</p>
Activity 3 Scientific visit of Ms. Noronirina Victorine Rakotoarisoa from Madagascar, under framework of IAEA MAG/5/023: Promoting Climate Smart Agriculture to face Food Insecurity and Climate Change with Regarad to Basic National Food	To study the application of gamma irradiation for mutation breeding high resistant rice and mize mutants to Climate Change	16-20 February 2015	CIRA BATAN, Jakarta	<p>Topics: Promoting Climate Smart Agriculture to face Food Insecurity and Climate Change with Regard to Basic National Foods (Rice and Maize),</p> <p>Outcomes: Capacity, lesson learn of application of radiation technology for mutation breeding in Indonesia</p> <p>Accomplishments: lectures, presentation and discussion, field trip</p>
Activity 4 IAEA, Fellowship Myanmar (TC Project MYA 5022), Mr. M. Zaw Mai,	To Improve local diary and beef cattle production through the artificial incemination To conduct selection of superior bull semen in local cattle population	18 January-19 March 2015	CIRA BATAN, Jakarta	<p>Topics: Hands-on Training in improving Animal Productivity through the use of DNA-based Technology and Artificial Insemination, sub topics:</p> <ul style="list-style-type: none"> - Bull selection and management, - semen collection, evaluation and processing - Animal identification, AI and data management

				Outcomes: Improve knowledge and skill of trenii on animal production using radiation technique Accomplishments: lectures, presentation and discussion, field trip
Activity 5 IAEA/RAS/6/073 RTC on Data management, Analysis and Interpretation for Assessing Human Milk Intake	– To validate information on practice of exclusive breastfeeding collected using recall by mothers – To identify the use of salivary or urinary or faecal biomarkers of complementary foods	13-17 April 2014	CIRA BATAN, Jakarta	Topics: Using Stable Isotope Techniques to Monitor Situation and Intervension for Promoting Infant and Young Child Nutrition Outcomes: Number of well-trained participant from MS on data management, analysis and interpretation for assessing human milk intake increases` Accomplishments: presentation and discussion
Activity 6 APEC Project Workshop on Development of Bioenergy Crops as a Renewable Energy Sources for APEC Economies	Review and evaluate the current status of bioenergy crops as renewable energy sources	08-12 June 2015	Bali, Indonesia	Topics: Development of Bioenergy crops as renewable energy sources for APEC Economies Outcomes: Improved the used of crops as a bioenergy source
Activity 7 Dissemination of irradiated chitosan for application as Plant Growth Promoter and Plant Elicitor	To disseminate irradiated chitosan produced by CIRA BATAN to farmers group from Klaten district, Musi Rawas district and Polewali Mandar District	20-14 April 2015	CIRA BATAN and Education center BATAN, Jakarta	Topics: Application of irradiated Chitosan for agriculture sectors Outcomes: Gain the participants knowledge and know how on radiation technology especially for modification of natural polymeric (chitosan) for application in agriculture as PGP and Plant Elicitor Accomplishments: lectures and discussion, experimental

3.2 No. of Participants of National Activities

3.2.1 No. of Participants in 2013

Activity \ No. of Participants	No. of Female	No. of Male	Total
Activity 1	5	10	15
Activity 2	3	8	11
Total	8	18	26

3.2.2 No. of Participants in 2014

Activity \ No. of participants	No. of Female	No. of Male	Total
Activity 1	10	15	25
Activity 2	13	17	30
Activity 3	101	92	193
Activity 4	2	12	14

Activity 5	2	16	18
Activity 6	20	50	70
Activity 7	12	40	52
	10	52	62
	8	30	38
	3	17	20
Activity 8	1	3	4
Activity 9	0	1	1
Activity 10	6	21	27
Activity 11	5	15	20
Total	190	364	554

3.2.3 No. of Participants in 2015

Activity	No. of participants	No. of Female	No. of Male	Total
Activity 1		20	10	30
Activity 2 - Open Seminar - Workshop		20	30	50
		5	6	11
Activity 3		1	0	1
Activity 4		0	1	1
Activity 5		12	5	17
Activity 6		2	9	11
Activity 7		20	40	60
Total		80	101	181

4. Results

4.5 Analysis of National Activities and Results

- Summarize the national activities implemented - capacity development in terms of achievements (i.e. dissemination of new technologies, knowledge and skills, information to participants).
- Analyze the achievements of national activities implemented: augmentation of national capacity.
- Successful stories, etc.

4.1.1 Analysis of National Activities and Results in 2013

In 2013, the project was started by establishing of national team, preparation of work plan. All these action were reported at the Kick Off Meeting in Phuket, Thailand, 2-3 May 2013 and at the Annual Review Meeting of RCA-UNDP Project on Electron Beam Applications for Value Addition to Food and Industrial Products and Degradation of Environmental Pollutants in the Asia Pacific Region, Cebu, Philippines, 21-22 November 2013. From the preliminary results, it can be said that electron beam is potential to reduce the contamination of microbes on *A. auricula* mushroom at dose of 5 kGy and EB irradiation is effective to improve a hygienic of *A. auricula* mushroom. Irradiation using EB can be an alternative pretreatment of degradation of lignocellulose biomass of OPEFB for the further processes to produce bioethanol. However, doses needed is quite high about 200 kGy, so modification is needed to reduce the irradiation dose.

4.1.2 Analysis of National Activities and Results in 2014

National activities in 2014 as explained above resulted in many aspects such as:

1. In conjunction with IAEA/RAS/1/014 Project, we invite DR. Noriaki SEKO of JAEA, Japan to our institute to give lectures and experimental training on Radiation Grafting of Polymers. During this

mission, about 25 Radiation Processing staffs attended the class and actively involved in experiment on radiation grafting. By participating on these activities, they gain their knowledge and knowhow on Radiation technology, radiation grafting and crosslinking as well as radiation degradation of polymers. In addition, they get experience on radiation grafting experiment.

2. In line with revitalization planning of EBM in our institution, we conducted one day Seminar on Technology and Application of Electron Beam Machine on 25 April 2014. During this seminar, DR. Bum Soo Han, CEO of EB Tech, Republic of Korea gave lecture on Recent Development in Industrial Electron Accelerator and Its Application on Radiation Processing. He delivered Advantages of Radiation technology especially electron beam for application in polymer modification, health, industry and environment. This seminar was attended by about 30 people. The participants acknowledge to DR. Bumssoo Han for very excellence presentation which will gain their knowledge and know how on radiation processing by EB.
3. Helping the Indonesian Government in supply of healthy ready to eat food in disaster situation such as landsliding. This food is sterilized by radiation. This project was located in Pemalang Regency, Central of Java Province. About 190 people consumed the food. The local Government of as well as people of Pemalang were highly appreciated on the help of CIRA BATAN to provide irradiated food.
4. The IAEA/RAS/1/012 Mid-term Review Meeting was held in Bali, 26-30 May 2014. The meeting evaluate current activities of member states on radiotracer application and technology development in the countries to accomplish industrial problems. The outcomes of the meeting is utilization of radiotracer technics to overcome the problems in the refinery industry processes such as distillation unit, fractionation, boiler, heat-exchanger, stripper etc.
5. FNCA Seminar and Workshop on Rice Mutation Breeding was held on 4-7 April 2014 in Jakarta. The Current activities of FNCA Member states on Radiation Mutation Breeding of Rice was reviewed. Before the workshop, open seminar on Mutation breeding of rice for sustainable agriculture in Asia was conducted, which were attended by about 70 people from different institutions. The meeting outcomes was aimed to Increase food production and improve food quality in Asian Countries
6. Seminar on Past Method for Determination of Ra-226NPO-210 on Environmental Samples, was held on 14-16 April 2014 at CIRA BATAN, Jakarta. Prof. DR. Henk Heijnis, from ANSTO, Australia delivered his speech on Recent Status and Future Prospect of Radioisotopes application in Environmental. The outcomes of seminar was Gained the understanding of participants (government officers and private sectors) on radioisotope technique for application in Sedimentation and Climate Change
7. Dissemination of irradiated chitosan (oligochitosan) for application as Plant Growth Promoter (PGP) and Plant Elicitor to the farmer group and local government staffs was conducted in two places namely Musi Rawas Regency, South Sumatra Province and Temanggung Regency Central Java Province. DR. Darmawan Darwis gave his speech on production and application of oligochitosan to be used as PGP and Plant Elicitor. The farmers were very interested to apply oligochitosan produced by BATAN to various plants
8. Research on Application of EB application for cocoa was elucidated in 2014. The objective of this research is to obtain hygienic and high quality of cocoa by using EB radiation treatment In the first semester, the evaluation focused on Physico-chemical dan microbiological properties of irradiated cocoa. The results show that unirradiated cocoa contain microbes (contaminated by microorganisms), while cocoa irradiated by EB at 5 kGy reduced the number of microbes. The next program is evaluation of functionality and proximate of irradiated cocoa

4.1.3 Analysis of National Activities and Results in 2015 (※ Please describe in detail.)

National activities in 2015 as explained above resulted in many aspects such as:

1. National Energy Agency of Indonesia (BATAN), Center for Isotopes and Radiation Application (CIRA) was assigned as IAEA Collaborating Center in the field of research and development and capacity building in the nondestructive diagnostics, testing and inspection technologies. The inauguration of BATAN-IAEA Collaborating Center for the above subject was conducted on January 23, 2015 at

Center for Isotopes and Radiation Application (CIRA) BATAN by Dr. Y Amano (IAEA DG) and Dr. Djarot Wisnubroto (BATAN Chairman). The duration of collaborating center is for 4 years (2015-2018) with the possibility of resignation for additional terms. The objective of this CC is to assist IAEA in implementing activities related to research and development and capacity building in the field of nondestructive diagnostics, testing and inspection technologies.

2. In conjunction with FNCA project on Electron Beam Application: Radiation Processing of Natural Polymer for Agriculture Application, The seminar and workshop have been conducted at Yogyakarta, from 9 to 12 February 2015. On the first day, open seminar attended by 50 participants from various institutions such as universities, research institute, practitioners and private companies. The workshop was attended by 11 participants from FNCA MSs.
3. CIRA BATAN received one scientist, Ms. Noronirina Victorine Rakotoarisoa from Madagascar, under framework of IAEA MAG/5/023: Promoting Climate Smart Agriculture to face Food Insecurity and Climate Change with Regard to Basic National Food. The objective of her visit is to study on advanced and novel biotechnologies in rice breeding and genetics. Dr. Sobrizal of CIRA BATAN conducted as counterpart
4. Mr. M. Zaw Mai from Live stock Breeding and Veterinary Department, Myanmar has completed his IAEA individual training course at CIRA BATAN from 18 January to 19 March 2015 under supervision of Dr. Totti Tjipto Sumirat from CIRA BATAN. The subject of his training is Bull selection and management, semen collection, evaluation and processing, Animal identification, AI and data management.
5. As the implementation of IAEA Technical Cooperation Project RAS 6 073: *Using Stable Isotope Technique to Monitor Situation and Intervention for Promoting Infant and Young Child Nutrition*, Regional Training Course on Data management, Analysis and Interpretation for Assessing Human Milk Intake has been conducted at CIRA BATAN Jakarta on 13-17 April 2014. The RTC was attended by 17 participants (including observer) from member states. Two lecturers: Dr. Tinku Thomas from India and Ms. Wegapitiye Vithana Ralalage Thushari Dharnabhashinie GUNARATHNA BANDARA from Sri Lanka and one local lecturer Dr SISWANTO deliver their lectures during the course.
6. APEC Project Workshop on Development of Bioenergy Crops as a Renewable energy Sources for APEC Economies has been conducted in Bali, Indonesia, 08-12 June 2015. The workshop was participated by 11 participants from 11 countries.
7. Dissemination of irradiated chitosan (oligochitosan) for application as Plant Growth Promoter (PGP) and Plant Elicitor to the farmer group and local government staffs from three districts: Musi Rawas South Sumatra Province, Klaten Central Java Province and Polewali Mandar, West Sulawesi was conducted at CIRA BATAN. DR. Darmawan Darwis gave his speech on utilization of radiation processing for modification of polysaccharide to produce low molecular weight chitosan, production and application of oligochitosan as PGP and Plant Elicitor. The farmers were very interested to apply oligochitosan produced by BATAN to various plants

4.2 Describe to what extent the objectives of the national work plan were accomplished:

4.6 Describe immediate benefits of national activities:

- Improvement of capacity building of BATAN researchers
- To disseminate information on the potential use of electron beam as an alternative technology to improve safety and quality of food (cocoa and mushroom) as well as to degrade lignocellulose biomass of OPEFB for production of bioethanol
- Helping the government in providing healthy ready to eat food in response to the national disaster such as landslide, flooding, earthquake and volcanic eruption
- Lesson learned from IAEA, FNCA member state on radiotracer, mutation breeding, EB technology and radiation processing
- Assist IAEA in promoting and implementing activities related to research and development and capacity

building in the field of nondestructive diagnostics, testing and inspection technologies.

- Lesson learned from IAEA on Stable isotope technique to assess intake of human milk in breastfed infants, FNCA member state on EB technology and radiation processing

4.7 Describe long term benefits of national activities:

- To increase the national food security and food safety
- Improving national competitiveness
- Improve welfare of farmers by applying super quality of rice and other crops variety and oligochitosan
- Efficiency and effectivity of industrial process by using NDT technology

4.5 New Developments and unexpected difficulties/problems

Irradiated chitosan for food preservation and animal food supplement

The difficulties such as:

- limits of technical capability and information, experts/manpower, government support and other factors
- Need the support of Indonesia government on the budget allocation for R and D

4.6 Actions taken to solve them

Coordination with the ministry of research and technology as well as other stakeholders to find budget for R & D as well as for other activities

4.7 Remarks/lesson learned

Through UNDP/RCA project on EB Applications for Value Addition to Food and Industrial Products and Degradation of Environmental Pollutants in the Asia-Pacific region, member countries especially Indonesia get many beneficial such as sharing information from other member state, improvement of knowledge, skill and capacity building of our researcher through participation on RTC

1.8 Photos

Activities 2013



A. auricula packed with PE plastic, thickness 9 mm and 18 mm ready for EB irradiation

Total number of bacteria, mould and yeast on *A. auricula* before and after EB irradiation

type of microorganisms	dosis radiasi (kGy)		Unit	method
	0	5		
Total number of bacteria	$5,96 \times 10^5$	$6,28 \times 10^3$	CFU	TPC
Total Mould and Yeast	8.72×10^3	5.8×10^1	CFU	TPC

*Indonesian National Standard (SNI) No. 7388: the maximum contaminant of dried edible mushroom is 1×10^5 cfu for bacterial, and 1×10^2 cfu for yeast
Physico-chemical properties of *A. auricula* before and after irradiation

Parameters	Irradiation dose (kGy)		Unit
	0 kGy	5 kGy	
Water content	11,2	12.03	%
Fat content	0.26	0.54	%
Protein content	1.22	1.36	%
Carbohydrate content	83.35	83.91	%
pH	5.49	5.54	%
Aw	0.607	0.6	%
Density	0.116	0.167	g/cm3
Organic acid			
Propionate	76.1	84.45	ppm
Acetate	-	0.36	ppm
Citrate	299.49	-	ppm
Oxalate	10.11	0.11	ppm
Aminoacid total	6.11	4.67	%

Activities in 2014

Activity 1.



Picture 1: Photo of Classroom during IAEA expert mission of DR. N. Seko from JAEA Japan, Jakarta 24-28 February, 2014

Activity 2



Picture 2: Photo one day seminar on EB Technology at CIRA BATAN, Jakarta 25 April 20014

Activity 3



Picture 3: Photo dissemination of irradiated food for landslide in Pemalang, Central Java Province

Activity 4



Picture 4: Group photo on Mid-term Review Meeting of IAEA/RAS/1/012, Bali Indonesia, 26-30 May 2014

Activity 5



Picture 5: Photo FNCA Workshop and seminar on Mutation breeding at CIRA BATAN, Jakarta, 4-7 March 2014



Activity 6



Picture 6: Photo Seminar and Workshop on Past Method for Determination of Ra-226NPO-210 on Environmental Samples at CIRA BATAN, Jakarta, 14-16 April 2014



Activity 7

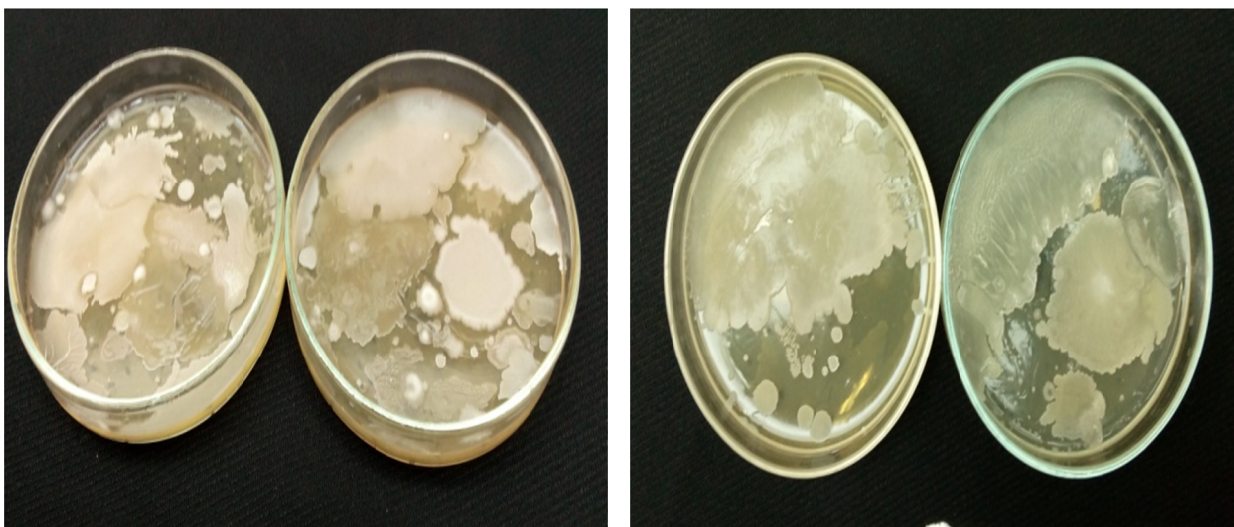


Picture 7: Photos dissemination of irradiated chitosan as plant growth promoter in Temanggung and Musi Rawas

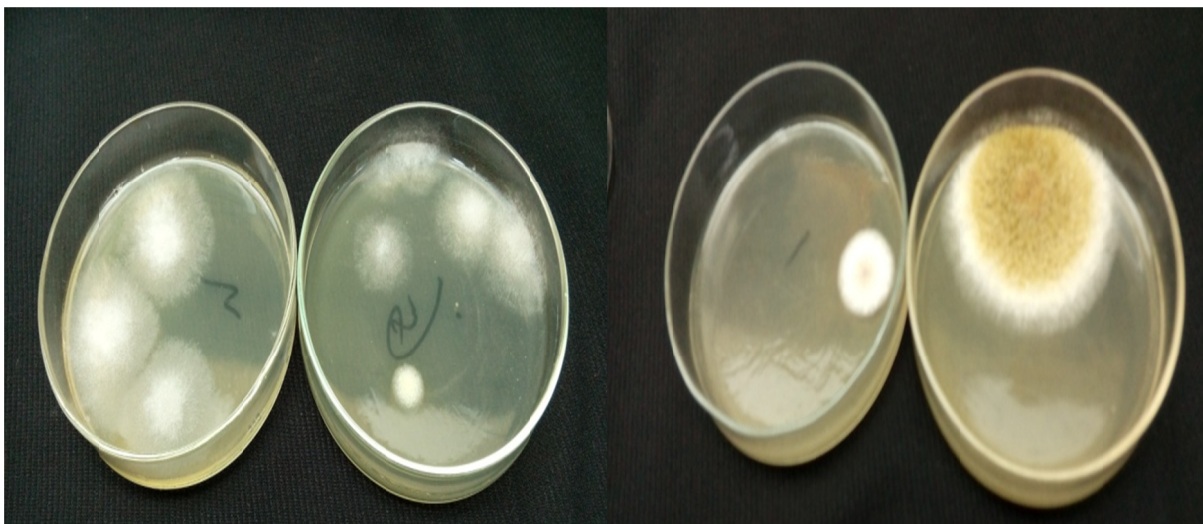
Activity 8



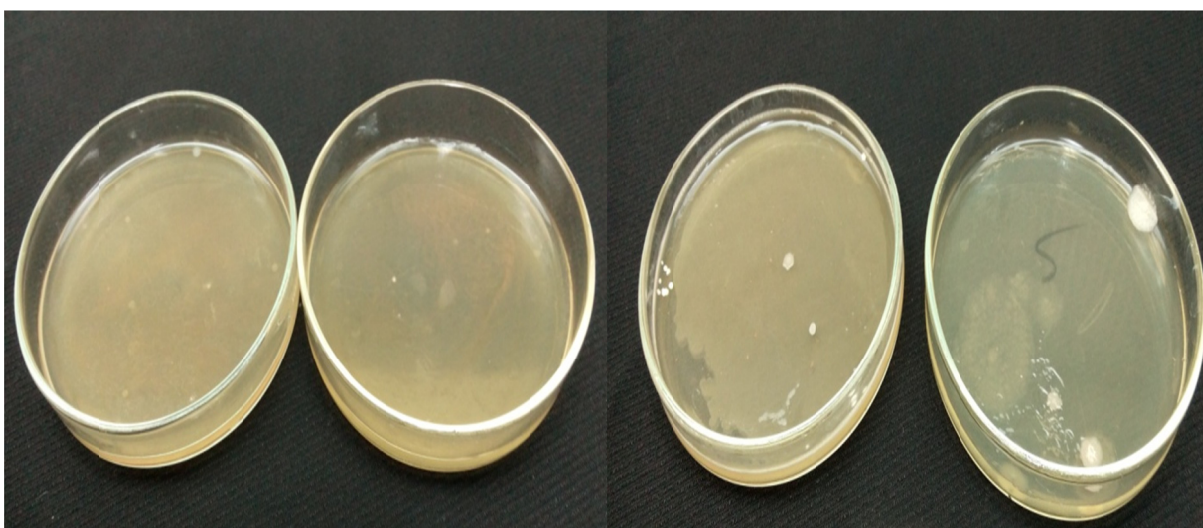
Picture 8.1: Photo irradiation processing of cocoa using Electron Beam



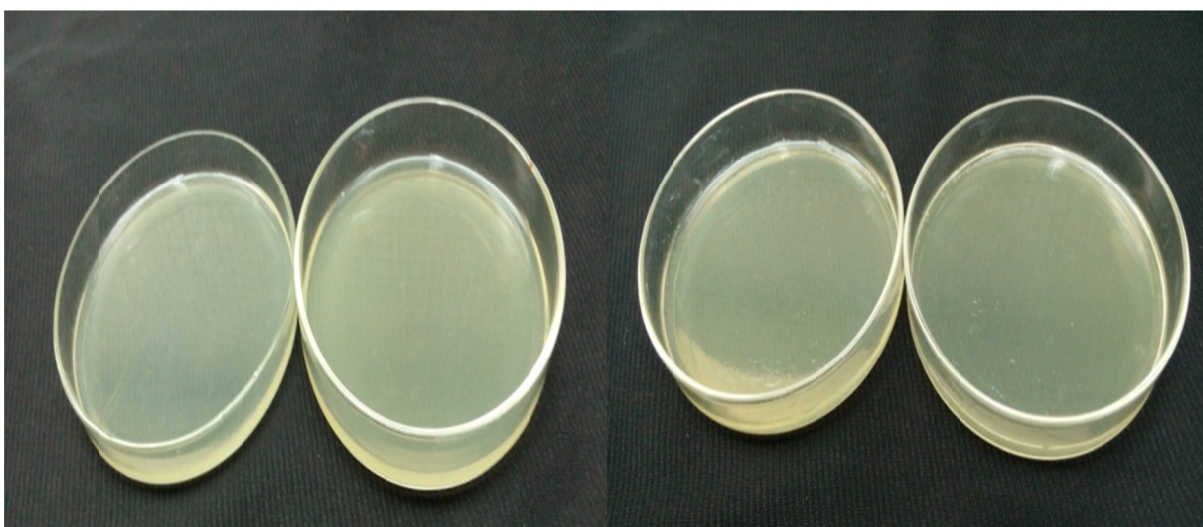
Picture 8.2: Total bacteria of unirradiated cocoa powder (left) and cocoa bean (right)



Picture 8.3: Total mould of unirradiated cocoa powder (left) and cocoa bean (right)



Picture 8.4: Total bacteria of irradiated with 5 kGy cocoa powder (left) and cocoa bean (right)



Picture 8.5: Total mould of irradiated with 5 kGy cocoa powder (left) and cocoa bean (right)

Table 1. physico-chemical properties of cocoa before and after irradiation with EB 5 kG

Parameters	Irradiation dose (kGy)			
	0 kGy		5 kGy	
	powder	bean	powder	bean
pH	6.4	5.0	6.1	5.1
Phenolic (mg/L)	1.34	1.01	14.80	4.09
FFA (%w/w)	0.17	0.12	0.14	0.11
Total amino acid (%w/w)	21.67	9.62	17.70	9.89

Activity 9



Picture 9: Planting of M1 mutant of sorghum and cowpea in green house of CIRA BATAN, Jakarta

Activity 10



Picture 10: Group foto of IAEA/RCA Mid-Term Project Assessment Meeting RAS5056 (left), and field trip to de mplot of sorghum Samurai variety at Playen, Gunung Kidul District, Yogyakarta (right)

Activity in 2015

Activity 1



Dr. Y Amano (IAEA DG) and Dr. Djarot Wisnubroto (BATAN Chairman) on inauguration of BATAN-IAEA Collaborating Center, CIRA BATAN, Jakarta, January 23 2015

Activity 2



Photo FNCA workshop on Radiation Processing of Natural Polymer, Yogyakarta 9-12 February 2015 (left) and Field trip to Demo farm of oligochitosan at Bantul District, Yogyakarta

Activity 3



Ms. Noronirina Victorine Rakotoarisoa during her technical visit to rice plantation using BATANs rice variety at Boyolali, Central Java Province

Activity 4



IAEA, Fellows from Myanmar (TC Project MYA 5022), Mr. M. Zaw Mai, CIRA BATAN, Jakarta 19 February to 18 March 2015

Activity 5



IAEA/RAS/6/073 RTC on Data management, Analysis and Interpretation for Assessing Human Milk Intake, CIRA BATAN, Jakarta, 13-17 April 2015

Activity 6



APEC Project Workshop on Development of Bioenergy Crops as a Renewable energy Sources for APEC Economies, Bali, 08-12 June 2015

Activity 7



Participants of training course Visited chitosan production laboratorium (left) and demonstration of chitosan application to chili plants at CIRA BATAN

Final Progress Report on

Electron Beam Applications for Value Addition to Food and Industrial Products and
Degradation of Environmental Pollutants in the Asia-Pacific region

1. Participating Country: MALAYSIA

1.1 National Project Coordinator

Name	Title	Organization	E-mail
Dr. Zulkafli Ghazali	Director	Radiation Processing Division, Nuclear Malaysia	zulkafli@nm.gov.my

1.2 National Project Team

Name	Title	Organization	E-mail
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Khomsaton Abu Bakar	Mrs.	Radiation Processing Division, Nuclear Malaysia (Environmental)	khomsaton@nm.gov.my
Zainon Othman	Dr.	Agro Biotech Division, Nuclear Malaysia (Food Irradiation)	zainon@nm.gov.my

2. Period Covered: December 2012 to November 2015

3. National Activities

3.1 National Activities Undertaken

3.1.1 National Activities in 2013

Activity Name	Objectives	When	Where	Context : Topics, outcomes, accomplishments
IAEA Fellowship	Preparation and Characterization of Grafted Nanomaterials using Radiation Induced Graft Polymerization	10 Jun - 6 Sept	Beijing University	Fellowship report

Fellowship training	Scientific visit to Beijing University	June 2013,	Beijing University	radiation grafting and nanomaterial
RCA/UNDP Program	Regional Training Course in Basic Knowledge and Hands-on Experiment on Electron Beam Applications for Value Addition to Industrial Products in the Asia Pacific Region	19-23 August 2013	ARTI, KAERI, Jeongup, Korea	<p>Trained personnel in</p> <ul style="list-style-type: none"> • Radiation dose & measurement • Radiation unit & safety • Interaction of radiation with matters • Dosimetry experiment • Application of EB in advanced materials in Korea • Radiation interaction with polymer • Radiation induced Crosslinking and its application • Laboratory work and demonstration
	Regional Training Course in Basic Knowledge and Hands-on Experiment on Electron Beam Applications for Environmental Remediation in the Asia Pacific Region	7-11 October 2013	ARTI, KAERI, Jeongup, Korea	<p>Trained personnel</p> <ul style="list-style-type: none"> • Basic knowledge on radiation chemistry. • Experimental experience on environmental remediation • Experimental design methods on environmental remediation
IAEA/EMS on best practices for sanitary applications of irradiation as a sanitary treatment (RAS/5/057)	To create awareness and exchange information on the best practices for sanitary and food quality applications of irradiation treatments.	28 – 31 October 2013	Hotel Royal, Kuala Lumpur	<p>Best practices for sanitary and awareness among the food control authorities.</p> <p>Good Irradiation Practice Manual – Recommended Practice for Sanitary, Phytosanitary and other Applications of Food Irradiation,</p>
FNCA Seminar	“Application Of Radiation Processing For Sustainable Development”	29th.Oct 2013	Nuclear Malaysia	trends of industrial application of radiation processing for sustainable development

Innovation in Polymer Science and Technology 2013 (IPST 2013)	International Conference and Exhibition TOPICS/SCOPES: <ul style="list-style-type: none"> • Nanostructure Polymers, Blends and Composites • Polymer Technology in New and Renewable Energy • Fiber and Fibrous Polymer Materials • Smart and Functionalized Polymers • Advanced Synthesis Polymers • Green, Sustainable and Bio-polymers 	7-10 Nov 2013	Yogyakarta Indonesia	Graft copolymerization of kenaf fibers for use as adsorbent
FNCA Workshop	Workshop on radiation processing Of Natural Polymer	30Oct – 1 Nov 2013	Nuclear Malaysia	<ul style="list-style-type: none"> • Production and Field Test of Plant Growth Promoter (PGP) or Elicitor Produced by Radiation Processing • Production and Application of Hydrogel Super Water Absorbent by Radiation Cross-linking and Grafting of Natural Polymers

3.1.2 National Activities in 2014

Activity Name	Objectives	When	Where	Context : Topics, outcomes, accomplishments
1. IAEA Fellowship attachment	Fellowship attachment	8 Dec 2013 – 28 Feb	RTDD-ISOMED BARC, India	<ul style="list-style-type: none"> • Grafting on cotton fibre • Antimicrobial • Dye Absorption
2. Malaysia-Japan International Conference On Nano-science, Nanotechnology & Nano-Engineering 2014	International Conference	28 Feb 2014	ILQAM, UiTM, Shah Alam, Malaysia	Acrylated palm oil nanoparticle synthesized by radiation-induced process as a controlled drug delivery system
3. IAEA/RCA Regional Training Course on Advanced Radiation Grafting of Polymeric Matrices for Environmental and Industrial Application	<ul style="list-style-type: none"> • RTC on radiation grafting of polymeric materials & utilization of radiation grafting technology in industrial and environmental application • Technology demonstration 	14-18 April 2014	Ho Chi Minh City, Vietnam	The topics include <ul style="list-style-type: none"> • requirement of various radiation grafting methods for industrial and environmental application and characterization techniques for grafted products such as • parameter study of

				<ul style="list-style-type: none"> grafting and optimization grafting in confined spaces, nano pores and molecular imprinting Advanced techniques for characterization of grafted surfaces RAFT-mediated grafting for controlling graft chain length preparation of specialty adsorbent by RIG, Industrial application for removal of toxic metal ion Demonstration of pre-irradiation grafting and simultaneous grafting (sample preparation and adsorption test)
4. RCA/UNDP Regional Training Course in Basic and Advanced Knowledge and Hands-on Experiment on Electron Beam Applications for Advanced Material	provide knowledge and experimental experience on electron beam applications in advance material & industrial products	14-25 April 2014	Advanced Radiation Technology Institute (ARTI), Jeongup, Korea	<ul style="list-style-type: none"> Advanced knowledge on radiation chemistry Hybrid composite materials Radiation detection and measurements Radiation grafting Radiation Technique for natural polymers Radiolytic surface modification Advanced biomaterials Experimental application of EB for hydrogels
5. 4th Asian and Oceanic Congress on Radiation Protection (AOCR-4)	International Conference	12-16 Mei 2014	PWTC, Kuala Lumpur	Radiation protection conference: a platform for exchange of information, knowledge and experiences in the field of radiation protection and nuclear safety
6. International Symposium on Advanced Polymeric Materials 2014 (ISAPM 2014 part of IMTCE 2014)	International symposium	14-15 May 2014	Kuala Lumpur Malaysia	<ul style="list-style-type: none"> Radiation processing of Natural Polymers The production of Hyper-branched Curable Palm oil Oleic acid. Advanced Polymeric Materials
7. 9th International Materials Technology Conference and Exhibition (IMTCE 2014)	International Conference	14-15 May 2014	Kuala Lumpur, Malaysia	<ul style="list-style-type: none"> radiation-induced crosslinking and radiation degradation of polymer Advanced Polymeric Materials International Materials Technology Exhibition

8. 3rd RCM on Radiation Treatment of Wastewater for Reuse with Particular Focus on Wastewaters Containing Organic Pollutants	IAEA CRP Meeting	23May 2014	Budapest	<ul style="list-style-type: none"> • Radiation Treatment For Recycling Of Industrial Wastewater For Industrial Usage - Biological And Irradiation Treatment Of Mix Industrial Wastewater In Flood Mitigation Pond • Radiation Treatment Of Wastewater For Reuse With Particular Focus On Wastewaters Containing Organic Pollutants
9. 2nd International Conference On Innovation And Technology	International Conference	27May 2014	Ipoh Malaysia	<ul style="list-style-type: none"> • Radiation Induced Degradation and De-coloration of Textiles Wastewater • Determination of Effective Operational Parameter', 2nd International Conference On Innovation And Technology
10. IAEA CRP Meeting on Radiation Curing of Nano-Composites for Enhancing their Functionality and Utility in the Coatings Industry,	CRP meeting	9-13 June 2014.	University of Palermo, Palermo, Italy	<ul style="list-style-type: none"> • Radiation Curing of Nano-composites for Enhancing their Functionality and Utility in the Coatings Industry
11. International Conference on Plastics, Rubber and Composites 2014 (ICPRC 2014).	International Conference	20-21 Jun 2014.	Langkawi Island, Malaysia	<ul style="list-style-type: none"> • radiation-induced crosslinking and radiation degradation of polymer • Advanced Polymeric Materials International Materials Technology Exhibition
12. RCA/UNDP Regional Training Course in Basic and Advanced Knowledge and Hands-on Experiment on in the Asia Pacific Region Electron Beam Applications for Value Addition to Food Products	<ul style="list-style-type: none"> • Provide knowledge and experimental experience on electron beam applications for value addition to food • Technical visit 	16-20 June 2014	Advanced Radiation Technology Institute (ARTI), Jeongup, Korea	<p>Lectures</p> <ul style="list-style-type: none"> • General introduction of food irradiation • Food Quality and their attributes • Food Microbiology and safety • Food Chemistry • Dosimetry for phytosanitary • X-ray dosimetry for Korean export agricultural products and its quality evaluation • Experimental Design for Food Irradiation <p>Experiment -----</p>

				<ul style="list-style-type: none"> Experiment for Food Microbiology (D10 value and SAL of Korean cherry tomato) Experiment for measurement for antioxidative activity (DPPH assays of Antioxidants from Korean cherry tomato) Experiment for food Rheology and sensory evaluation (Texture & sensory evaluation of Korean cherry tomato)
13. IAEA/RCA Project Review Meeting	Meeting	23 -27 June 2014	Colombo, Sri Lanka	Midterm review meeting on RAS/1014 on Development of Advanced Grafted Materials for Industrial Applications and Environmental Preservation
14. National Seminar on Food Safety 2014	Seminar to increase awareness on food irradiation as a sanitary and phytosanitary treatment to researchers, academia, policy makers and food industry	25 – 26 Jun 2014	Hotel Cititel, Midvalley, Kuala Lumpur, Malaysia	<ul style="list-style-type: none"> General food safety Radiation preservation of food for value addition Regulatory aspect of food irradiation 5 papers on food irradiation were presented by invited speakers
15. IAEA/CRP 2 nd . Research Coordinated Meeting	Meeting	8-12 September 2014	Bejaia, Algeria	Review of project progress from 11 participating countries on Application of Radiation Techniques in Development of Advanced Packaging Materials for Food Products
16. Seminar and Exhibition on Safe Food	Participated in exhibition and provide information, materials to public and food industry on food irradiation application and safety.	12-14 Sept 14	Melaka, Malaysia	public awareness and education program
17. USDA-APHIS Workshop on Irradiation as a Phytosanitary Treatment	To enhance capability of plant quarantine officials on the use of irradiation as a phytosanitary measure.	16 - 18 Sept 2014	Manila, Philippines	<p>Information on what, when, where and how irradiation can be used to provide protection against quarantine pests in agricultural trade</p> <p>3 quarantine officers from Malaysian Department of Agriculture and 1 food irradiation officer from</p>

				Nuclear Malaysia attended as participants.
18. The 11th meeting of the Ionizing Radiation and Polymers Symposium, IRaP 2014	Conference	5 th - 9 th October 2014.	Jeju Island, South Korea,	Conference on Ionizing Radiation and Polymers Symposium, IRaP 2014
19. RCARO/KAERI 2014 Regional Workshop on Radiation Technology & Its Application	Introduction of radiation application based on the experiences of RCA Member States and Korea including Food Irradiation Technology	13-24 October 2014	KAERI Daejeon, South Korea	Information on the Radiation Technology and its application in food industry such as Gamma Plant and Gamma House, Electron Beam application for foods, frozen foods and fruits Industry in Korea and other RCA Member states
20. Fellowship attachment of KACST researcher	Fellowship attachment	20 th Oct 2014 to 19 th Feb 2015	Nuclear Malaysia, Bangi	training on production and application oligo-chitosan as plant growth promoter and super water absorbance for agriculture for 4 months
21. International Conference on Material, Mechatronics, Manufacturing and Mechanical Engineering (ICMMMM 2014)	Conference	24-25 Oct. 2014.	Kuching Malaysia	Research and development activities in Material, Mechatronics, Manufacturing and Mechanical engineering
22. The International Conference on Advanced Material Engineering & Technology (ICAMET 2014)	conference	4-5 Nov 2014	Ho Chi Minh City, Vietnam	basic and applied aspects of the synthesis and characterization, modeling, processing and application of advanced engineering materials.
23. First RCM RAS 5061 "Supporting Food Irradiation Technology to Ensure the Safety and Quality of meals for Immuno-compromised Patients and Other Target Groups",	<ol style="list-style-type: none"> 1. To revise and finalize the final version of the project document of IAEA Coordinated Research Project D62009 "Development of Irradiated Food for Immune-Compromised Patients and Other Target Groups". 2. Define the project implementation and monitoring strategy, project baseline for measuring results, corresponding performance indicators; and 	24-28 November 2014	Bali, Indonesia	To create awareness and address gaps in transferring knowledge on the applicability of food irradiation in ensuring food safety to healthcare professionals, nutritionists and caterers dealing with diets for immune-suppressed patients.

	3. To establish the project work plan with detailed activities, inputs, timelines, budget and roles and responsibilities.			
24. annual review meeting of the RCA/UNDP project on Electron Beam Applications	meeting	19-20 November 2014	Yangon, Myanmar	Project review of activities by member states
25. IAEA/RCA Training Course on Best Practices for the use of Irradiation as a Phytosanitary Treatment (RAS/5/057)	<p>1. To create awareness and knowledge of senior officials from national plant protection organization and policy makers in international food trade on the potential of irradiation as a phytosanitary treatment and its growing international use for this purpose.</p> <p>2. To exchange of information on the best practices for irradiation treatments.</p>	2-5 December 2014	Manila, Philippines	<p>Expected outcome: At the end of course, participants from countries where irradiated products are not yet marketed, exported or imported should be convinced that irradiation is an effective treatment that leaves no residues or alter quality of fruits.</p> <p>2 Malaysian participants (1 from Department of Agriculture and 1 from Nuclear Malaysia)</p>

3.1.3 National Activities in 2015

Activity Name	Objectives	When	Where	Context : Topics, outcomes, accomplishments
1. Seminar on Food Safety Issues organized by Ministry of Health	To increase awareness on issues relating to food safety to food industry, regulatory officers, and public	15 Jan 2015	Kedah, Malaysia	<ul style="list-style-type: none"> Invited presentation on Food Irradiation
2. IAEA/RCA Regional Training Course On Advanced Characterization Methods Of Grafted Polymeric Matrix	Training Course	9–13 Feb 2015	Kuala Lumpur, Malaysia	<ul style="list-style-type: none"> Overview and highlights of two previous RTC programs, achievements, perspectives Preparation and characterization of radiation-grafted materials for environmental

				<p>applications</p> <ul style="list-style-type: none"> • Advanced spectroscopic techniques applied to characterization of grafted polymers • Characterization of grafted polymers by thermal analysis techniques • Preparation and characterization of radiation-grafted membranes for fuel cell application • Surface characterizations techniques for the analysis of grafted polymers • Development and characterization of boron-selective adsorbent using radiation induced grafting technique
3. First RCM RAS5071 "Strengthening Adaptive Climate Change Strategies for Food Security through the use of Food Irradiation"	<ul style="list-style-type: none"> • Revise and finalize the final version of the project document, • Define the project implementation and monitoring strategy, • Establish the project work plan with detailed activities, inputs, timelines, budget and roles and responsibilities 	16-20 Mac 2015	Bangkok, Thailand	<ul style="list-style-type: none"> • Finalized project document, LFM
4. RCA/UNDP PROJECT on Electron Beam Applications for Degradation of Environmental Pollutants in the Asia Pacific region	<p>Training course</p> <p>Objective is to provide basic and advanced knowledge and experimental experience on electron beam applications for degradation of environmental pollutants through lectures and hands-on experiment.</p>	11-22 May 2015	Advanced Radiation Technology Institute (ARTI), Jeongup, Korea	<p>Lectures</p> <ul style="list-style-type: none"> • Basic Radiation • Radiation Chemistry in Environmental Remediation • Radiation Detection and Measurements • Water and wastewater treatment using radiation • Air pollutants treatment using radiation • Special lecture for environmental analysis <p>1. Analysis of organic pollutants</p> <ul style="list-style-type: none"> - Sample preparation - Principles of HPLC and

				<p>LC/MS and its application</p> <ul style="list-style-type: none"> - Principles of GC and GC/MS and its application <p>2. Analysis of inorganic pollutants</p> <ul style="list-style-type: none"> - Sample preparation - Principles of ICP/MS and its application • Waste treatment and recycling using radiation <p>Experiment</p> <p>-----</p> <ul style="list-style-type: none"> • Experiment for wastewater treatment using mobile electron beam • Experiment for air pollution treatment using radiation • Experiment for Measurement of the microbial activity • Experiment for effect of radiation treatment using HPLC • Experiment scintillation photo detector (silicon diode) • Technical visit • EB-Tech company • Gwangju Institute of Science & Technology) • Sewage Treatment Plant -Combination treatment of Biological and UV.
5. Lecture on Food Irradiation Applications And Safety	Lecture to 40 graduated in Nutrition and Dietetic	12 Mei 2015	Faculty of Health Sciences, Mara Technology University (UiTM), Selangor	<ul style="list-style-type: none"> • Radiation effects on food • Benefits & application • Safety of irradiated food • Regulatory Control, Labelling & Detection • Acceptance/commercial application • Developments in Malaysia
6. 2nd. International Conference on Plastics, Rubber and Composites 2015 (ICPRC 2015).	International Conference	5-6 Jun 2015.	Langkawi Island, Malaysia	<ul style="list-style-type: none"> • radiation-induced crosslinking and radiation degradation of polymer • Advanced Polymeric Materials International Materials Technology Exhibition

7. Radiation Protection Conference & Workshop	International Conference	8-12 Jun 2015	Kota Kinabalu Sabah	Radiation protection conference: a platform for exchange of information, knowledge and experiences in the field of radiation protection and nuclear safety
8. National Seminar on Food Safety 2015	Seminar to increase awareness on food irradiation as a sanitary and phytosanitary treatment to researchers, academia , policy makers and food industry	15-16 Jun 2015	Hotel Istana, Kuala Lumpur, Malaysia	<ul style="list-style-type: none"> • General food safety • Radiation preservation of food for value addition • Regulatory aspect of food irradiation • 5 papers on food irradiation were presented by invited speakers
9. Regional Meeting on the Potential Benefits of Irradiation of Food for Relief Organizations and Security Forces' (RAS 5061)	To increase awareness to relief organizations and security forces at national and regional level on the potential of irradiated food.	16-18 June 2015	Chengdu, China.	<ul style="list-style-type: none"> • Irradiation: another tool in the food technologist's toolbox • Status of food irradiation worldwide • Irradiation technologies: gamma, electron beam and X rays • Food for Security Forces/disaster-Desirable characteristics and improvements • Experience with irradiated food for disaster relief and security services • Visit of the SIAE irradiation facilities
10. 2 days' workshop on response surface methodology by using design expert	To introduce response surface methodology as a tool to develop an experimentation strategy that maximizes learning using a minimum of resources.	16-17 Jun 2015	Universiti Teknologi Malaysia	The methodology of surface response ensures that all factors and their interactions are systematically investigated; thus, information obtained is much more reliable and complete than results from one-factor-at-a-time experiments that ignore interactions and may lead to misleading conclusions.
11. 2nd International Conference on Plastics, Rubber and Composites 2015 (2nd ICPRC)	The objective of the 2nd ICPRC 2015 is to provide a platform for researchers, engineers, academicians as well as industrial professionals from all over the world to present their research results and development activities in	05-06 Jun 2015	Hotel Adya, Pulau Langkawi	Presented a paper entitled <i>The effect of process parameter for graft copolymerization of sorbic acid onto polypropylene film by full factorial experimental design.</i>

	Plastics, Rubber and Composites.			
12. Nuclear Science, Technology and Engineering Conference 2015 (iNuSTEC 2015).	To promote the advancement and dissemination of nuclear science and technology and its application To provide a platform for researchers, engineers, academicians as well as industrial professionals from all over the world to present their research results and development activities in nuclear science and technology and its application	17-19 Aug. 2015	Universiti Sains Islam Malaysia (USIM), Nilai, Negeri Sembilan, Malaysia	Presented a paper entitled, "Properties of hyper-branched polyurethane acrylate from palm oil oleic acid.
13. International Workshop on Food Safety and Security 2015	To create awareness about global food crisis and challenges	26 Aug 2015	Universiti Teknologi Malaysia	A better understanding of regional food safety and security issues in global context.
14. IAEA/RCA Regional Executive Meeting for Policy Makers and End-user on Radiation Grafting (RAS/1/014)	to provide information on the advantages of radiation grafting and its industrial application to end user and policy maker to encourage consideration for commercialisation	7-11, Sep. 2015	IAEA Takasaki	<ul style="list-style-type: none"> • understanding of advantages of radiation grafting over conventional and cost • adapting technology for practical application and commercialisation
15. Workshop On Extrusion Process Technology For Wire And Cable Application	To provide intensive technical skill training and development program that will be highly participative and focused on the real issues and challenges in the extrusion process.	03-05 Nov 2015	Wonderful Ebeam Cable Johor Bharu Malaysia	Focused on technical skill and techniques to create long lasting technical knowledge and awareness mainly on single screw extrusion process.
16. RCM on Radiation Treatment of Wastewater for Reuse focusing on Wastewater Containing Organic Pollutants	Review and summarized work carried out under CRP Project F23029 and to finalised meeting report	16-20 Nov 2015	Beijing, China	Progress report
17. IAEA/RCA Final Review Meeting of RAS/1/014	Final review meeting of IAEA/RCA radiation grafting project	30 Nov - 4 Dec 2015	Bangkok, Thailand	Final report Recommendations for 2018 project proposal

3.2 No. of Participants of National Activities

3.2.1 No. of Participants in 2013

Activity \ No. of participants	No. of Female	No. of Male	Total
IAEA Fellowship	1		1
Fellowship training	1		1
RCA/UNDP Program I	1		1
RCA/UNDP Program II	1		1
IAEA/EMS	20	30	50
FNCA Seminar	30	30	60
FNCA Workshop	10	15	25
Total	64	75	139

3.2.2 No. of Participants in 2014

Activity \ No. of participants	No. of Female	No. of Male	Total
Activity 1	1		1
Activity 2	3		3
Activity 3	2		2
Activity 4	1		1
Activity 5	3	5	8
Activity 6	3		3
Activity 7	1	4	5
Activity 8	1		1
Activity 9	1		1
Activity 10		1	1
Activity 11	2	1	3
Activity 12		1	1
Activity 13		1	1

Activity 14	60	30	90
Activity 15		1	1
Activity 16	50	100	150
Activity 17	2	2	4
Activity 18		1	1
Activity 19		1	1
Activity 20	1		1
Activity 21	1		1
Activity 22	1		1
Activity 23		1	1
Activity 24	2		2
Total	135	149	284

3.2.3 No. of Participants in 2015

Activity \ No. of participants	No. of Female	No. of Male	Total
Activity 1	20	15	35
Activity 2	15	15	30
Activity 3	1		1
Activity 4	1		
Activity 5	25	15	40
Activity 6	3		3
Activity 7	30	15	45
Activity 8	55	25	80
Activity 9	1		1
Activity 10	2		2
Activity 11	4		4
Activity 12	1		1
Activity 13	45	55	100
Activity 14		1	1
Activity 15	3	8	11
Activity 16	1		1
Activity 17		1	1
Total	207	150	357

4. Results

4.1 Analysis of National Activities and Results

- Summarize the national activities implemented - capacity development in terms of achievements (i.e. dissemination of new technologies, knowledge and skills, information to participants).
- Analyse the achievements of national activities implemented: augmentation of national capacity.
- Successful stories, etc.

4.1.1 Analysis of National Activities and Results in 2013

R&D activities at Radiation Processing Technology Division of Nuclear Malaysia involved mainly on;

- *Environment Application - radiation grafting and radiation treatment on industrial waste water*
- *Radiation Coating – synthesis of radiation curable resin and nano hybrid coating*
- *Biomedical Application – nano gel for drug delivery and tissue scaffold*
- *Blend and Composite – bio-composite and nano composite for industrial application*

Grafting for Environmental & Industrial Application

- *LCC RAS/1/014, Supporting Radiation Processing for the Development of Advanced Grafted Materials for Industrial Applications and environmental Preservation,*
- *Development of graft copolymer as metal ion adsorbent from wastewater (grafted kenaf fibre)*
- *Development of boron-selective adsorbent using radiation induced grafting technique (amine functionalize on grafted nylon)*
- *Radiation Modified Polymeric Material for Active Packaging Applications.*
- *CRP on Application of Radiation Techniques in Development of Advanced Packaging Materials for Food Products*
- *Functionalize nano-fibrous chitosan (Cs)/poly(glycidal methacrylate) (PGMA) with N-methylglucamine (NMG) for boron adsorbent.*
- *Radiation Induced Grafting Glycidyl Methacrylate on Kenaf Fiber*

Waste Water Treatment for Environmental Application

- *Radiation Treatment for Recycling of Industrial Wastewater for Industrial Usage*
- *Treatment of Textiles Industrial Wastewater by E-Beam: Effect of Decolouration on Biodegradability.*
- *Development of starch and cellulose waste as super water absorbent for the treatment of palm oil mill effluent (POME).*

Radiation Curing/Coating

- *IAEA/CRP Research Contract MAL-16697 on Radiation Curing of Nano Composites for Enhancing their Functionality and Utility in the Coating Industry*
- *Science Fund: Radiation Curing of Composites for Enhancing their Functionality and Utility in the Coating Industry*

- *Science Fund: Development of Hyper branched Curable Resin from Palm Oil.*
- *Science Fund: UV Spot OPV based on Acrylated Palm Oil Resin (EPOLA).*

Biomedical Application

- *IAEA/RCA Research Agreement No 15464 - Radiation synthesis of nanogel for bioactive in capsulation*
- *Science Fund: Development of Nano Particles of Epoxidized RBD Palm Olein Acrylate (EPOLA) As Drug Carrier In Delivery System Using Ionizing Radiation Technique*
- *Synthesis of Nanogels from Radiated Functional Copolymers for Drug Delivery System*
- *The development of 3 Dimensional Tissue Scaffolds for Tissue Engineering Application via Micro stereo lithography Technique.*

Blend and Composite

- *Science Fund: Application of Radiation in the Development of Microwave Absorbing Ferrite-TPNR Nano composite. Science Fund: Radiation effects on the thermo mechanical, electrical and magnetic properties of copper filler reinforced nylon 66 nano composites for electromagnetic interference (EMI) shielding application.*
- *Science Fund: Application of Nano-hybrid Biocomposite for Development of Integrated Aquaculture Cage Via Radiation Induced Process.*
- *Science Fund: Development of Polyvinyl Chloride/Epoxidized Natural Rubber /Carbon Nano tubes Nano composites by using Electron Beam Irradiation*
- *Science Fund: Development of electrospun polymer nano-fibers based natural rubber (NR) using electrospinning technique.*

Collaboration and Networking

- *LCC IAEA/RCA RAS/1/014, Supporting Radiation Processing for the Development of Advanced Grafted Materials for Industrial Applications and Environmental Preservation, 2013 – 2015*
- *LCC IAEA/RCA RAS/8/109, Supporting Radiation Processing of Polymeric Materials for Agricultural Applications and Environmental Remediation (RCA),*
- *IAEA/TC MAL/1010 - Development of green materials and processes using ionizing radiation and nanomaterials for environmental remediation*
- *IAEA/TC MAL 8022- Establishing a Laboratory for the Application of Radiation in Nanotechnology,*
- *IAEA/RCA Research Agreement No. 14760, Application of Radiation Degraded Chitosan as Plant Elicitor.*
- *IAEA-CRP MAL-13173. Electron Beam treatment of organic pollutants contained in gases stream*

4.1.2 Analysis of National Activities and Results in 2014

The National activity implemented is wide ranging and they still within the research areas as reported in 2013.. The activities related to human capital development such as workshop,

seminar, meeting was conducted with great success with excellent feedback received from most of the participants. The workshop and seminars help transferred the basic concepts and fundamental knowledge on electron beam irradiation and its applications for industrial products, food industry and environmental remediation. The hands-on experimental designed with the workshop activities provide excellent platform for researchers to improve their skill and advanced knowledge.

It also provided our researchers opportunity to interact with local and the regional scientists. The knowledge gained and networking established will be beneficial for the betterment of R&D output.

4.1.3 Analysis of National Activities and Results in 2015 (※ Please describe in detail.)

The National activity implemented in 2015 include many area of radiation processing. Only those activities related to human capital development are reported here. The workshop and seminars are also part of public awareness activities to help transferred the fundamental knowledge on electron beam irradiation and its applications for industrial products, food industry and environmental remediation. Besides updating them on the new information, this will also help allay public fear on nuclear technology.

It also provided our researchers opportunity to interact with local and the regional scientists. The knowledge gained and networking established will be beneficial for the betterment of R&D output.

4.2 Describe to what extent the objectives of the national work plan were accomplished:

The national work plan achieved targeted objective of enhancing human capital development with respect to knowledge enhancement in application of electron beam processing in advance material, environmental preservation and value addition to food and biotechnology.

The extend of successful commercialisation objectives set forth can be seen from many collaboration and commercialization accomplished;

Commercialisation and Collaboration with University, Government and Private Sector

- *Development of crosslinked and flame retardant cable with PROTON (National Car Manufacturer) and establishment of Nuclear Malaysia-PROTON Centre of Excellent (COE)*
- *Commercialisation of Riverprotec, nano bio-composite material (pre-commercialization funded project with Polycomposite Sdn. Bhd)*
- *Radiation Crosslinkable Thermoplastic Elastomer (TPE) from Waste Rubber (pre-commercialization funded project with Rivercomm Sdn. Bhd)*

- *Pre-commercialization funded project with Hyklaz Sdn. Bhd. on the Development of Manufacturing Process for Production of the Nanohybride Biocomposite Aquacage*
- *Radiation resistance extrusion medical grade PVC - NDA with Polylo Engineering Sdn Bhd.*
- *NDA with Ijima Sdn. Bhd. on OPV – supply contract*
- *Field test on oligochitosan and its application as plant growth promoter and elicitor - NDA with FELCRA Bhd*
- *Up-Scaling of Moisture Based Polymer Processing Prototype – Collaboration with Budi Feed Sdn. Bhd*
- *Development of boron adsorbent and its application for leached water – UTM and JAEA*
- *Development of advanced EB crosslink HF/FR cable for EV and Hybrid car with PROTON for enhanced properties, light weight, and cost saving*
- *Commercialization of Chitosan Derivative for Wound Dressing, clinical trial in collaboration with Hospital of National University and University Science Malaysia*
- *Upgrading of commercial manufacturing capabilities of the fibre reinforced plastic composites (FRPC) production using kenaf Fibre for interior automotive component –CRDF MTDC fund – UPM, Nuclear Malaysia and Polycomposite Sdn. Bhd*
- *Pilot production of Wound Management Products from Water-soluble Chitosan Derivatives for Pre-Clinical, Clinical and Market Evaluation. Techno fund MOSTI (TF0908D123) _ SIRIM Bhd, Nuclear Malaysia and USM. Clinical trial has been carried at government hospital, HUSM, HUKM and HKL.*
- *Development of halal food thickener from sago starch. Technofund funded project (MOA TF03010F096 – My Synergy Factor Sdn. Bhd. and Nuclear Malaysia)*
- *Commercial trial of oligochitosan and its application as plant growth promoter and elicitor in organic rice production*

4.3 Describe immediate benefits of national activities:

National activities spear headed by radiation processing division of Nuclear Malaysia has seen many positive and encouraging results. Many companies especially the SMEs have approach Nuclear Malaysia to collaborate and put R&D products in commercialization path. Many project has been approved for pre-commercialization process through technofund funding mechanism provided by ministry (MOSTI)

The RCA activities meanwhile provide opportunity for exposure to knowledge in radiation processing and its applications, regulatory aspect of food irradiation and hands on experiment especially those who attended the workshop organized under the RCA program.

4.4 Describe long term benefits of national activities:

Nuclear Malaysia is a leading national R&D organization under Ministry of Science, Technology & Innovation (MOSTI), focusing on the application and promotion of nuclear and related technologies for national development. Nuclear Malaysia has also been entrusted to developing and utilizing STI for wealth creation and societal well being towards achieving a

high income advanced economy that is competitive, sustainable and inclusive. In the economic era where knowledge is the key source of competitive advantage, it is crucial for RI organization to continuously facilitate acquisition and knowledge transfer to ensure uplifting of socio economic of the country especially on the application of radiation processing.

Some of the R&D product developed has been applied for the benefit of public through CSR program in which case the selected community will received funding to install the product developed.

The ongoing RCA workshop, training course, seminar and conference provide a platform for researchers to enhance their knowledge and help established networking with fellow researchers. This will provide avenue for them to exchange ideas to help improve research methodologies and output.

4.5 New Developments and unexpected difficulties/problems

- 1. Nuclear Malaysia has been appointed by PROTON as a Centre of Excellent in polymer composite and powertrain. Nuclear Malaysia will play a crucial role in localisation of car component and improvement of car component and safety.*
- 2. Nuclear Malaysia will also be appointed Centre of Excellent in Nanotechnology with emphasis on R&D in nano-cellulose and graphene as nanomaterial*
- 3. Availability of radiation processing facilities is crucial in the promotion of industrial application of radiation processing. At the moment only Nuclear Malaysia provides irradiation services to SMEs but machine time for commercial use is very limited. The cost of setting up EB services centre still enormous and thus make it impossible for SMEs to install themselves*
- 4. Only a limited number of participants can attend all activities due to budget and cost constraint. This will be overcome with continuous program organized and will eventually give opportunity to those unable to participate and especially new researchers.*
- 5. Technical capability of National Laboratories will be substantially reduced due to lack of fund to maintain the equipment needed to carry out research work. This perhaps can be overcome through inter-laboratories collaboration of member states.*

4.6 Actions taken to solve them

There is still much effort need to been done to further disseminate the advantages of radiation processing for adoption by industry especially in developing countries. Perhaps RCA should consider organizing seminar or conference to highlight competitive advantage of radiation processing as well as

to serve as awareness program in selected country. Organising seminar such as national executive seminar will give opportunity for more participant to attend.

4.7 Remarks/lesson learned

4.8 Photos (※ Please kindly note that photos are important in publishing the Project Final Report. It would be appreciated if you could send as many photos as possible.)



Campsite Program at Nuclear Malaysia where School Children were educate on nuclear science and technology and carry out some experiments



Technology and R&D product show case with industry



International Conference of non-ionising radiation organised by Nuclear Malaysia



Pre-commercialisation of Nanohybrid composite for aquacage and erosion protection of river



Handing over of PROTON car for R&D Activities at Nuclear Malaysia, September 2015



IAEA/RCA (RAS/1/014)



**Regional Executive Meeting for Policy Makers and End-user on
Radiation Grafting for Industrial Applications and Environmental Preservation**

7-11, Sep. 2015, in Takasaki JAEA



Final Progress Report on

Electron Beam Applications for Value Addition to Food and Industrial Products and Degradation of Environmental Pollutants in the Asia-Pacific region

1. Participating Country: Mongolia

1.1 National Project Coordinator

Name	Title	Organization	E-mail
Ts.Zolbadral	Researcher	Nuclear Physics Research Center in Mongolia	ts.zolbadral@yahoo.com

1.2 National Project Team

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2. Period Covered: December 2012 to November 2015

3. National Activities

3.1 National Activities Undertaken

3.1.1 National Activities in 2013

We could not join in Electron Beam Application project, RCA/UNDP in 2013.

3.1.2 National Activities in 2014

Activity Name	Objectives	When	Where	Context : Topics, outcomes, accomplishments
First time Mongolia joined to EBA project in RCA/UNDP	To increase public acceptance as safety and useful of radiation technology and application. To get the state of	In May, 2014.		Outcomes: In frame of this project, we expect that - To enhance the capability of human resource by participating in regional and international training course of Electron Beam Applications in food, industrial products, agricultural com

	art knowledge about electron beam application and to seek the way to use in various sectors. To establish and extend cooperation local institutes, end-users as E-beam applications and with participating countries in this project.			<p>modities, advanced materials and degradation on environment pollutants.</p> <ul style="list-style-type: none"> - To increase the public acceptance of and the experts awareness as safety and fruitful of Electron Beam application and technology by national activities such as meeting, training course, workshop, seminar, education - To introduce, adopt and develop the E-beam technology in food, agricultural and industrial sectors as well as to use it in degradation of environmental pollutants and gemstone irradiation by national activities. Especially, in field of air pollution and waste water in Mongolia. - To establish and to extend cooperation and network of local and regional experts and facilities. - To contribute the specific aims of his project.
Two people participated in RCA/UNDP Regional Training Course in Basic and Advanced Knowledge and Hands-on Experiment on Electron Beam Applications for Advanced Material in the Asia Pacific	To develop human resource.	14-25 April 2014	Jeongup, Korea	<p>Training covered following topics</p> <ul style="list-style-type: none"> - Advanced Radiation Chemistry - Hybrid Composite Materials - Radiation Grafting - Radiation Technique for Natural Polymers - Advanced Biomaterials - Experimental application for hydrogels - Radiolytic surface modification - Radiation Detection and Measurements - Technical visit: Linear electron beam accelerator facility in KAERI (Daejeon) <p>Outcome: Human resource developed. Introduced high technology.</p>
Meeting between representatives of Nuclear Energy Agency and Nuclear Research Center	To determine the objectives of national activities in the frame of this project and create team to implement national activities	2014.06.10	Nuclear energy agency	<p>Creating national work plan. Including:</p> <ul style="list-style-type: none"> - To study electron beam application in various fields and identify the appropriate application in Mongolia. - To study feasibility and possibility of equipment, technology, methodology and other factors of proposed application in Mongolia. - To create a team for implementing national activities.
First time progress report of national coordinator was submitted.	progress report	2014.06.15		It allowed some opportunities to summarize the implemented national activities for first half of 2014 and to make a national future plan, which more extending and activating for our participation, in frame of this project.
Study on electron beam application in various fields	To identify previous and current situations of	May.2014-up to now.	in Mongolia	In Mongolia, E-beam applications in various fields such as mining mineral, botanic, biotechnology, crystal structure and medicine have been studied for m

and identify the appropriate application in Mongolia.	E-Beam application in various fields for Mongolia.			any years. But no any practical applications.
Study on feasibility and possibility of equipment, technology, and other factors of proposed application in Mongolia	To identify technical situations of E-Beam application in various fields for Mongolia.	May.2014-up to now.	in Mongolia	In 1993, A Microtron MT-22 Electron Cycle Accelerator was installed at Nuclear Research Center, National University of Mongolia. For the past years, this accelerator has been used as gamma and neutron sources in training and research field. It means there is no any direct application and technologies of the electron beam such as in food industry, agricultural commodities and environment pollutants, exclude a few research works, in Mongolia so far.
Creating a team for implementing national activities.	A team for implementing and developing of E-beam in various fields as national activities.	May.2014-up to now.	in Mongolia	<p>Main issue is lack of information, knowledge and experience on EB technology and experienced human resources. Therefore, we interests to acquire Electron beam applications and technologies and to apply on local products and other areas, and to participate in regional and international training for radiation processing technologies to enhance the capability of human resource.</p> <p>We are trying to cover as possible as various sectors such as Gemstone, Agriculture, Industrial, environment pollutants, research and technology, and other sectors. Our national team consists of 6 members for implementing national activities.</p>

3.1.3 National Activities in 2015

Activity Name	Objectives	When	Where	Context : Topics, outcomes, accomplishments
Dissemination of gained skills and new knowledge by education program	To give new knowledge and introduce with new technologies and applications of electron beam for advanced materials.	March 2015	Nuclear Research Center, National University of Mongolia (NUM).	We could share the knowledge of E-beam applications in advanced materials to students as NUM education program using some lecture materials of UNDP/RCA Regional Training Course – 2014.
UNDP/RCA Regional training course on E-beam applications on environmental remediation.	To develop the national human resource	11-22 on May 2015	ARTI, Korea Atomic Energy Research Institute, Jeongeup, Republic of Korea	Gained the new knowledge and skills of E-beam applications on environmental remediation as well as introduced some emerging technologies of E-beam.
Open seminar	To introduce and to share new knowledge and information	June 2015	Nuclear Research Center, National University of Mongolia (NUM).	- Shared the new knowledge and skills of E-beam applications on environmental remediation. More than 30 people /

	obtained by UNDP/RCA Regional training course -2015 to researchers and students.			researchers and students. /were participated. - discussed and obtained some idea on E-beam applications in waste water treatment for Mongolia.
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3.2 No. of Participants of National Activities

3.2.1 No. of Participants in 2013

Activity	No. of Participants	No. of Female	No. of Male	Total
Activity 1				
Activity 2				
Activity 3				
Activity 4				
Activity 5				

3.2.2 No. of Participants in 2014

Activity	No. of Participants	No. of Female	No. of Male	Total
Participation in Training Course in Basic and Advanced Knowledge and Hands-on Experiment on Electron Beam Applications for Advanced Material.		2	-	2
Internal Seminar on electron beam application.		4	3	7
Meeting between representatives of Nuclear energy agency and Nuclear Research Center.		3	3	6
Study on electron beam application in various fields and identify the appropriate application in Mongolia.		1	3	4
Making of a team for implementing national activities.		2	4	6
Study on feasibility and possibility of equipment, technology, and other factors of proposed application in Mongolia.		2	3	5
Total		14	16	30

3.2.3 No. of Participants in 2015

Activity	No. of Participants	No. of Female	No. of Male	Total
Dissemination of gained skills and new knowledge by education program		7	6	13
UNDP/RCA Regional training course on E-beam applications on environmental remediation.		-	2	2
Seminar		12	21	33
Total		19	29	48

4. Results

4.8 Analysis of National Activities and Results

- Summarize the national activities implemented - capacity development in terms of achievements (i.e. dissemination of new technologies, knowledge and skills, information to participants).
- Analyse the achievements of national activities implemented: augmentation of national capacity.
- Successful stories, etc.

4.1.1 Analysis of National Activities and Results in 2013

4.1.2 Analysis of National Activities and Results in 2014

Two people participated in regional training course at ARTI in Korea. The training was a great opportunity to introduce with basic and advanced technology and hand on experiments at high developed research institutes such as linear electron beam accelerator facility in KAERI. After coming back into Mongolia, they organized a seminar to colleagues at Technology Innovation division of NEA. By organized the seminar, they were able to disseminate gained new knowledge, information, new technology, experience of electron beam application for various fields.

We held a meeting between representatives of NEA and Nuclear Research Center to discuss regarding activities to be implemented in future. For the meeting, the decision to study about activities to be implemented in future was made.

A Study on electron beam application in various fields and technical status in Mongolia was executed. For this study, the present status of electron beam application and technology were identified. Mongolia is one of the importing countries as industrial products. The radiation technology is available to use in food and agriculture products under special acceptance in our country. For our country, E-beam applications and technologies in various fields, such as mining mineral, botanic, biotechnology, crystal structure and medicine have been researched for the number of years as researching & developing. Unfortunately, it was not introduced in any practical applications. As E-beam facility in Mongolia, there is Microtron MT-22, an electron cycle accelerator, to produce E-beams in 1-22 MeV. This accelerator has been used as gamma and neutron sources in education and research field. However, it has no any direct applications and technologies of the electron beam such as in food industry, agricultural commodities and environment pollutants so far.

For creating a national team in EBA of RCA/UNDP project, it has been comprised of 6 members from Nuclear Energy Agency, environment pollutants, research and technology sections so far. It will be able to extend for covering various fields of E-beam applications.

4.1.3 Analysis of National Activities and Results in 2015 (※ Please describe in detail.)

In this year, we have successfully implemented a few activities about the dissemination of gained knowledge and developing human resources. The lecture materials of UNDP/RCA Regional Training Course in 2014 were very useful for lessons about e beam application for students in Mongolia. Also we have attended in Regional Training Course on E-beam applications on environmental remediation in this year as well as have organized an open seminar, introducing and sharing the knowledge to researchers and students in Nuclear Physics Research Center of Mongolia. We are much more interested in the technology of sewage treatment and some hazardous chemicals in air pollution by E-beam or other radiations. Therefore, we are discussing some ideas that to find some way to introduce the fruitful technologies into our country and researching it. Finally we interested India's treatment system as a good example for sewage treatment. So that identifying our situations and problems in domestic as well as contacting to some organizations in India are in progress.

4.2 Describe to what extent the objectives of the national work plan were accomplished:

We are much more interested in the technology of sewage treatment and some hazardous chemicals in air pollution by E-beam or other radiations. Therefore, we are discussing some ideas that to find some way to introduce the fruitful technologies into our country and researching it. Finally we interested India's treatment

system as a good example for sewage treatment. So that identifying our situations and problems in domestic as well as contacting to some organizations in India are in progress.

Also we identified that there is some demands to use E-beam technology in agriculture field in our country. However, because of lacking of E-beam facilities and technologies in domestic, we have been taken the helping of neighbouring countries to irradiate the products for our end users and researcher.

4.3 Describe immediate benefits of national activities:

For immediate benefits,

- Enhancing of capability of human resource in the application of E-beam technology.
- Sharing gained new technologies, skills, new knowledge.
- Increasing public and experts understanding as safety and fruitful aspects of radiation technology and application
- Identifying our current situation of E-Beam application and the technical possibility.
- Activating and extending national capability in the future.

4.4 Describe long term benefits of national activities:

- In improving the capability of human resource in the application of E-beam technology by disseminating the gained knowledge and skills.
- In developing electron beam devices and facilities specifications and their practical applications.
- In introducing and adopting the fruitful E-beam technologies into agricultural and industrial products and degradation environmental pollutants in our country.
- In extending the cooperation of regional experts and facilities.

4.5 New Developments and unexpected difficulties/problems

In frame of this project, by joined as a member of EBA project in RCA/UNDP, we participated in two courses and enhanced the capability of human resource in this field. Also, in certain amount, we would like to say that disseminated new technologies, skills and new knowledge, which gained from training courses in EBA project in RCA/UNDP to domestic experts in this field.

In time of this project implementing, we faced with some unexpected difficulties and problems such as:

- We could not participate in activities of EBA project in RCA/UNDP for 2013.
- We could not participate in Regional Training Course on Electron Beam Applications for Value Addition to Food Products on 16-20 June 2014, Jeongup, Korea.
- During 2015, we could not actively implement the seminar, workshop, and training courses in cooperation with some policy and government agency because this agency is restructured in this term.

4.6 Actions taken to solve them

4.7 Remarks/lesson learned

4.9 Photos



Final Progress Report Final Progress Report on

Electron Beam Applications for Value Addition to Food and Industrial Products and
Degradation of Environmental Pollutants in the Asia-Pacific region

1. Participating Country: Myanmar

1.1 National Project Coordinator

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1.2 National Project Team

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2. Period Covered: December 2012 to November 2015

This reports covers from December 2012 to November 2015

3. National Activities

3.1 National Activities Undertaken

3.1.1 National Activities in 2013

Activity Name	Objectives	When	Where	Context : Topics, outcomes, accomplishments
National project team	To implement the electron beam irradiation technology in country	June, 2013	MOST	Establishment of an National Project Team
Activity 1. Workshop	To submit the electron beam irradiation project to the government	July, 2013	MOST	Electron beam technology and its Applications
Activity 2. Seminar	To understand the electron beam application for improvement of the quality of industrial products	September, 2013	MOST	Basic Knowledge and Hand-on Experience on Electron beam application for Value Addition to Industrial Products
Activity 3. Seminar	To understand the electron beam application on environmental pollutants	October, 2013	MOST	Basic Knowledge and Hand-on Experience on Electron beam application on Environmental pollutant
Activity 4. Meeting	To initiate Electron Beam Irradiation Facility	December, 2013	MOST	Electron beam Facility for R& D applications

3.1.2 National Activities in 2014

Activity Name	Objectives	When	Where	Context : Topics, outcomes, accomplishments
Activity 1 Seminar	Electron Beam Application Technologies Awareness Seminar for Heads of Sections under Departments of Ministry of Science & Technology (MOST).	January, 2014	MOST, Nay Pyi Taw, Myanmar	Awareness Seminar for Electron Beam Application Technologies - Sharing knowledge & information - Awareness of electron beam application technologies to Heads of Sections under the departments - Applicable products of departments from Ministry of Science and Technology are considered
Activity 2 Seminar	Electron Beam Application Technologies External Awareness Seminar for Senior Level (Director and above) of Various Ministries of Myanmar	March 2014	Yangon, Myanmar	Awareness Seminar for Electron Beam Application Technologies -Sharing knowledge & information -Awareness of electron beam application technologies to Senior Level (Director and above) of Ministries. -Applicable products from different ministries are considered. -Introduction to the establishment of national network.
Activity 2 Training	To enhance the capability of human resource development	April, 2014	ARTI/ KAERI Korea	Training Course in Advanced Knowledge and Hands-on Experiment on Electron Beam Application for Value Addition to Industrial Products. - Enhancement of the capacity of human resource development in electron beam application for ind

				ustrial products
Activity 4 Seminar	Human resource development program	May, 2014	MOST, Myanmar	National Project Team acquires - Sharing best practices on basic t o advanced knowledge and han d-on experiences. - Circulating training materials - Preparing for implementing of p ractical research work
Activity 5 Workshop	To initiate Establishment of a n Electron Beam Irradiation Facility	May, 2014	MOST, Myanmar	Electron Beam Irradiation Facility & Technology - Preparing policy making meetin g to initiate Electron beam irradi ation facility - Preparing cooperating programso f electron beam application tech nologies for infrastructure and h uman resource development
Activity 6 Training	To enhance the capability of human resource development	June, 2014	ARTI/ KAERI Korea	Electron Beam Application on Food Irradiation - To enhance the capacity of hum an resources

3.1.3 National Activities in 2015

Activity Name	Objectives	When	Where	Context : Topics, outcomes, accomplishments
Activity 1 Meeting	Discussion with IAEA Exper t for Electron Beam and X r ay application technologies in the Country Program Fra mework (CPF)(2015-2020).	March, 2015	MOST, Nay Pyi Taw, Myanmar	•Confirmation of Irradiation Techn ology in Country Program Frame work (CPF) (2015-2020) •To apply radiation application te chnologies in country(including G amma, EB and X ray)
Activity 2 Training	To enhance the capability of human resource development.	11-22 May 2015	ARTI/ KAERI Korea	RCA/UNDP Regional Training Course in Basic Knowledge and Advanced Knowledge and Han ds-on Experiment on Electron B eam Applications for Environme ntal Remediation in the Asia-Pa cific Region •Enhancement of the capacity of human resource development in el ectron beam application for Envir onmental Remediation
Activity 3 Seminar	Human resource development program	June 2015	MOST, M yanmar	National Project Team acquires •Sharing best practices on basic t o advanced knowledge and hand- on experiences of Environmental remediation by Electron Beam Ap plication Technologies •Circulating training materials •Preparing for implementing of pr actical research work using Gam ma Irradiator
Activity 4 (Research Work)	Doing Research of radiation application for food and agri cultural products, industrial p roducts, Environmental waste	2015	MOST, M yanmar	By using Irradiation technology, t he research work are carried out for-sterilization of microbes, exten ding the shelf-life and evaluating

				the nutritional values of irradiated food and agricultural products -Testing for quality and durability of industrial products -Analysis on characteristics of Adsorbent as industrial product for removal of toxic pollutants found in waste water, microbe sterilization and dissociation of chemical products of the waste water from the textile industry.
Activity 5 Discussion	preparation for Honey Hydrogel Wound Dressing research	September - October 2015	MOST, Myanmar	Doing Research for increase rate of wound healing and skin epithelization.
Activity 6 Meeting	Final Review Meeting	October 2015	Siem Reap, Cambodia	Final Review of the RCA/UNDP project of on Electron Beam Applications for Value Addition to Food and Industrial Products and Degradation of Environmental Pollutants in the Asia-Pacific Region
Activity 7 Policy Making Meeting on the Establishment of Electron Beam Facility	To Establishment the Electron Beam irradiation Facility	December 2015	MOST, Myanmar	Establishment the Electron Beam irradiation Facility

3.2 No. of Participants of National Activities

3.2.1 No. of Participants in 2013

Activity	No. of Participants	No. of Female	No. of Male	Total
Activity 1		18	6	24
Activity 2		21	7	28
Activity 3		20	6	26
Activity 4		10	6	16

3.2.2 No. of Participants in 2014

Activity	No. of Participants	No. of Female	No. of Male	Total
Activity 1		14	6	20
Activity 2		14	34	48
Activity 3		1	1	2
Activity 4		5	5	10
Activity 5		7	4	11
Activity 6			1	1

3.2.3 No. of Participants in 2015

Activity	No. of Participants	No. of Female	No. of Male	Total
Activity 1		16	6	22
Activity 2		1	1	2
Activity 3		5	5	10
Activity 4		5	4	9
Activity 5		5	4	9
Activity 6		1		1

4. Results

4.10 Analysis of National Activities and Results

4.1.1 Analysis of National Activities and Results in 2013

The outcomes of these activities are extensive understanding of electron beam technology and its applications in various fields. These activities are intended to support the establishment of Electron beam irradiation facility for R&D application on various fields and also commercial scale. Most of the participants are very interesting for this innovative technology and effective questions and discussion will be included for national work plan.

4.1.2 Analysis of National Activities and Results in 2014

The NPC of the national project team presented two seminars in January and March, 2014 , one for Electron beam application technology awareness seminar for the Heads of Sections under Departments of Ministry of Science & Technology and the other is external awareness seminar for senior level (director and above) of different ministries of Myanmar. Two members of national project team conducted the basic to advanced knowledge and hand-on experiment training for industrial products and one member will conduct on Electron beam application on food irradiation. Workshop on implementation of electron beam irradiation facility is held at MOST. Such activities are intended to extensive understanding of electron beam application technologies and to support for establishment of the electron beam irradiation facility and to strengthen and enhance the capability of human resources.

4.1.3 Analysis of National Activities and Results in 2015 (※ Please describe in detail.)

As a National Project, Establishing of an Electron Beam Irradiation Facility is submitted to International Atomic Energy Agency to get the human resource development program and infrastructure development program. Seminars of Annual Review Meeting documents are very effective for project team member to get knowledge. The two team members share their knowledge and hand- on experiences that got from RCA/UNDP training course to team members. By applying on the training course materials and hands -on experiences of this RCA/ UNDP project, our team have done many researches of radiation application for studying on value addition to food and agricultural products, industrial products and degradation of environmental pollutants.

4.11 Describe to what extent the objectives of the national work plan were accomplished:

Establishing of an Electron Beam Irradiation Facility (including both human resource development and infrastructure development) is submitted to international atomic energy agency as national project (IAEA) (2016-2017, 2018-2019). The plan to establish electron beam irradiation facility is under implementation process.

4.3 Describe immediate benefits of national activities:

Human resource development program for the electron beam application technologies for national project is approved from IAEA and will start 2016-2017. Enhancement of the capability of human resources for electron beam application technologies are got through the trained participants. Currently, the national project teams are preparing for implementing the hand-on experiences from the trainings of RCA/UNDP project to the practical research work by using low level, research scale gamma irradiator.

4.4 Describe long term benefits of national activities:

National activities are to support to extensive understanding of electron beam application technologies and to establish the Electron beam irradiation facility. From the seminars, the national project can get the sustainable knowledge about electron beam application technologies; the public can understand what electron beam application technologies is and which area can apply by it. These activities support not only sustainable human resources development but also research and technical development.

4.5 New Developments and unexpected difficulties/problems

Currently, Myanmar has no electron beam irradiator and only one small scale gamma chamber. Implementation of national activities, there are limitation of technical capability and information as well as experts advices and hand-on experiences. Human resource developments as well as infrastructure development are required.

4.6 Actions taken to solve them

Before the establishment of an Electron beam Irradiation facility, Myanmar will participate regional and international projects on IAEA/RCA as well as RCA/UNDP and FNCA projects on radiation processing technology to get information, knowledge and hand-on experiences. Human resources are being developed.

4.7 Remarks/lesson learned

The strategic implementation of this RCA/UNDP project including hand-on experiences of training courses and technical visits can enhance the capacity building and infrastructures development through the trained participants.

4.8 Photos



Consulting Meeting with PMO (IAEA)



Country Program Framework (2015-2020) Meeting



Presentation on Electron Beam Technology



Presentation for Heads of Sections under Departments



Presentation on Electron Beam Application Technologies for Senior level officers from various ministries



Question and Discussion on Electron Beam Application Technologies



Technical Visit to EB Tech Company RCA/UNDP training (June-2013)



Technical Visit to EB Tech Company RCA/UNDP training (Oct-2013)



RCA/UNDP Training (April 2014)



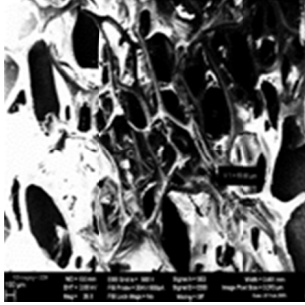
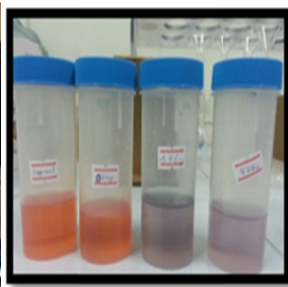
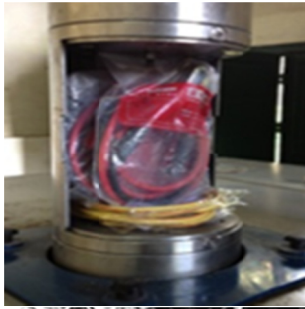
Technical Visit to EB Tech Company RCA/UNDP Training (June 2014)



Technical visit to EB Tech Company RCA/UNDP Training (May 2015)



Irradiation of Food and Agricultural product using low level gamma chamber



Irradiation of Industrial products using low level gamma chamber

Final Progress Report Final Progress Report on

Electron Beam Applications for Value Addition to Food and Industrial Products and Degradation of Environmental Pollutants in the Asia-Pacific region

1. Participating Country: New Zealand

1.1 National Project Coordinator

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1.2 National Project Team

Name	Title	Organization	E-mail
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2. Period Covered: December 2012 to November 2015

This report covers the period from December 2012 to November 2015. Over the period of time, the electron beam annealer at GNS Science was returned into operation and used for annealing of industrial materials. Most recent developments were in the annealing of coatings on metal samples. The system continues to provide leading edge laboratory style testing. A significant amount of students, early career researchers and staff were trained in electron beam annealing of industrial materials. A base of well trained personnel is available to tackle current and future research ideas and opportunities. The handbook on electron beam annealing of the system at GNS Science is now frequently used by new project participants and proved to assist well in reducing training and mentoring time requirements.

3. National Activities

3.1 National Activities Undertaken

3.1.1 National Activities in 2013

Activity Name	Objectives	When	Where	Context : Topics, outcomes, accomplishments
Operational system	System testing	Jan – June 2013	GNS Science	The electron beam annealer system was returned into a functioning system.
Mentoring	Training	June 2013	GNS Science	Mentoring of internship student Berit Mohr and Konrad Suschke in electron beam annealing. Outcomes are a well-trained early career operators.

3.1.2 National Activities in 2014

Activity Name	Objectives	When	Where	Context : Topics, outcomes, accomplishments
Mentoring	Training of staff and students	June – August 2014	GNS Science	Mentoring of internship student Morgane Rondeau in electron beam

				annealing. Outcomes are a well trained operator and lead author of the GNS Science report “Handbook for the electron beam annealer at GNS Science”.
Workshop	Technology awareness raising	6 August 2014	GNS Science	1-day workshop on electron beam annealing at GNS Science with participation from students and team members. Outcomes include well trained personal, technology awareness, opportunity to add ion beam technology to electron beam products.

3.1.3 National Activities in 2015

Activity Name	Objectives	When	Where	Context : Topics, outcomes, accomplishments
Mentoring	Train staff and other interested persons	June-August 2015	GNS Science	Provided training to students and staff in use of electron beam technology and interaction with ion beam technology.
Workshop	Awareness raising	August 2015	GNS Science	Raised awareness and capabilities of electron beam technology.

3.2 No. of Participants of National Activities

3.2.1 No. of Participants in 2013

Activity \ No. of Participants	No. of Female	No. of Male	Total
Activity 1	1	5	6
Activity 2	1	2	3

3.2.2 No. of Participants in 2014

Activity \ No. of Participants	No. of Female	No. of Male	Total
Activity 1	1	2	3
Activity 2	2	5	7

3.2.3 No. of Participants in 2015

Activity \ No. of Participants	No. of Female	No. of Male	Total
Activity 1	3	2	5
Activity 2	2	2	4

4. Results

1.2 Analysis of National Activities and Results

- Summarize the national activities implemented - capacity development in terms of achievements (i.e.

dissemination of new technologies, knowledge and skills, information to participants).

The electron beam annealer at GNS Science was developed to high accuracy annealing of semiconductor and metal samples. Details were disseminated in a large report in 2014. Mentoring, training and workshop assisted in developing national capability in electron beam annealing.

- Analyze the achievements of national activities implemented: augmentation of national capacity.

The national activities assisted in implementing the goals and milestones as planned. New national capability was developed. Details are given in the 2013 – 2015 national activities as detailed in section 4.1.1 - 4.1.3

- Successful stories, etc.

The electron beam annealer at GNS Science is now not only used for research in semiconductor science but also in developing functional coatings on metal samples. Even diamond like carbon coatings on stainless steel were successfully annealed at 1000 C for minutes using our system operating at ultra-high vacuum condition.

4.1.1 Analysis of National Activities and Results in 2013

Summary: Andreas Markwitz and national project team, 11 November 2013. We use electron beam to develop new materials, nanostructures and new properties for New Zealand Industry. Electron beam annealing (EBA) is a very useful tool for materials annealing in a high vacuum environment. It allows very controllable heat treatment for more than 1000 °C. Furthermore, energetic electron beams can interact with the material and potentially changing its chemistry. Even at low temperatures, long exposure to a focused electron beam induces changes in materials. Those changes are particularly important on organic-based materials where the beam can induce great modification through formation of radicals, backbone rupture and crosslinking. Electron beam annealing has also been shown to induce surprising changes of the surface topography of flat silicon substrates. Nanowhiskers and Nanoboulders of Si were observed after high temperature EBA [1,2]. EBA was shown to induce a higher activation rate of the implanted species observed for p-type doping in ZnO [3,4]. We use electron guns to generate an beam from heated filaments. The electrons are accelerated towards the sample to be annealed by a negative potential. Electrostatic lenses or magnetic quadrupole lenses and a scanner are used to focus and scan the beam on the sample and increase the electron density for more efficient heating. The temperature range is usually limited by the ability of measuring the temperature accurately on target. We have built our own EBA system to serve industry needs for small scale sample annealing under extremely controlled conditions. At energy of 20 – 40 kV, the maximum penetration range in SiO₂ is in the micrometre range [5]. In contrast to ions, which have a Gaussian distribution profile, the electrons have a quasi hemispherical distribution within the materials. This leads to a near uniform distribution of the electrons within the oxide layer and below during the annealing. The electrons have a short lifetime in the matrix before being captured or carried away to the closest ground potential (the back of the sample). As the beam constantly scans the sample the material can reasonably be considered to have a constant excess of free electrons. It is then possible that the electrons act in the solid solution very similarly to radicals in liquid solutions. Hence the electron-beam has potential for acting as a reducing atmosphere during annealing. Progress 2013: We have observed that using EBA for annealing of metal implanted SiO₂ surfaces was leading to the protruding of nanoparticles on the surface [6]. The protruding of the nanoparticles from the SiO₂ surface was explained in term of desorption of the SiO₂ layer. Under electron beam annealing the SiO₂ layer thickness is observed to decrease with an initial rate of about 20 nm s⁻¹. While no change in surface topography is observed under 4h of annealing, the formation of holes is observed for longer durations; those holes appear to be as deep as the remaining oxide layer. The effect of the electron beam annealing is explained in terms of excitation of core electrons under energetic electron bombardment leading to transient ionization of O atoms and Coulomb repulsion leading to the enhancement of the SiO formation reaction. Near the surface, O atoms and SiO can leave the film which leads to a decrease of the thickness. The observed enhancement in desorption clearly evidence the reducing effect of the electron beam annealing. In materials where redox reactions are driving the diffusion and atomic reorganization during annealing, EBA is likely to have a dramatic effect on the kinematics of reactions. We managed to bring the system back into operation and used it for testing.

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- [5] R. Shimizu, Y. Kataoka, T. Ikuta, T. Koshikawa, H. Hashimoto, J. Phys D: Appl. Phys., 9 (1976) 101.
- [6] J. Kennedy, J. Leveneur, G.V.M. Williams, D. Mitchell, A. Markwitz, Nanotechnology, 22 (2011) 115602.

4.1.2 Analysis of National Activities and Results in 2014

Summary: This report summarises progress in electron beam annealing at GNS Science in 2014. The report is structured in science, technology and industrial connectivity chapters. Key results in science are: first successful electron beam annealing to 1000 °C of diamond-like carbon coatings produced by direct ion implantation. From a technology point of view, the electronics and software of the electron beam annealer were changed and the system was in operation again in June 2014. A handbook on electron beam annealing was produced as an outcome of the technical development.

Scientific developments: The electron beam annealer at GNS Science is historically used for surface engineering of semi-conductor and insulator surfaces. Common samples include silicon, silicon dioxide, silicon nitride and other insulation layers on silicon. The research laboratory leader Dr Andreas Markwitz has published 92 publications in international journal using electron beam annealing for creation of nanostructured silicon surfaces, magnetic nanoclusters and other surface engineering projects (sum of times cited: 822; citing articles 508; average citations per item: 8.93; h-index: 14; taken from Web of Science on 21.10.14 using ‘A Markwitz’ & ‘Electron’). In the reporting period, this was extended to diamond-like carbon coating produced by direct ion deposition. Often in DLC fabrication a subsequent annealing process is required to achieve high hardness and elasticity values. The coatings have been exposed to a high current electron beam to 1000 °C for minutes. Heating and cooling ramps (cycles) of 5 °C s⁻¹ were used. Under high vacuum conditions, the coatings behaved very well and did not evaporate or disintegrated even when exposed to these high temperatures and considering the high current bombardment of the surfaces with energetic electrons. Results of the studies are pending for publication.

Technical developments: The 20 kV electron beam annealer at GNS Science was upgraded in terms of electron source operation and computer control. The electron source is now able to run at higher power enabling research samples to be annealed to more than 1300 °C for hours. The stability of the electron beam was improved over a longer period of time. Successful annealing time of more than 4 hours was tested at 1000 °C. The computer control was upgraded to enable better fine control of the electron gun parameters contributing significantly to long runs. The new system enables temperature controls of temperature gradients (heating and cooling cycles) from seconds to minutes. The accuracy of the annealing at peak temperature was proven to ± 2 °C at 1000 °C for 4 hours. The technical developments also improved annealing at low temperature. The later was used to test diamond-like carbon coatings up to 1000 °C. The samples are located in a high vacuum chamber on a rotating wheel allowing sequential annealing of up to 20 samples in an annealing cycle. Operation and results of electron beam annealing are published in “Handbook for the electron beam annealer at GNS Science”; GNS Science Internal Report 2014; 53 pages.

Industrial connectivity: Electron beams are commonly used in technology development and for manufacturing. Electron beam sintering (additive manufacturing) would be among the most recent established applications. In the laboratory at GNS science we now receive biomedical implants fabricated with electron beam sintering on a regular basis for adding a nano-layer coating to the implants. Our knowledge and experiences with electron beams in the laboratory are useful in understanding electron beam sintering processes and how we modify our ion beam technology to suit biomedical implants.

4.1.3 Analysis of National Activities and Results in 2015 (※ Please describe in detail.)

Scientific developments: The electron beam annealer at GNS Science is historically used for surface engineering of semi-conductor and insulator surfaces. Common samples include silicon, silicon dioxide, silicon nitride and other insulation layers on silicon. The research laboratory leader Dr Andreas Markwitz has published 92 publications in international journal using electron beam annealing for creation of nanostructured silicon surfaces, magnetic nanoclusters and other surface engineering projects (sum of times cited: 822; citing articles 508; average citations per item: 8.93; h-index: 14; taken from Web of Science on 21.10.14 using ‘A Markwitz’ & ‘Electron’). In the reporting period, this was extended to diamond-like carbon coatings and other non-semiconductor materials produced by direct ion deposition and ion implantation. The coatings and modified thin films have been exposed to a high current electron beam to 1000 °C for many minutes. Heating and cooling ramps (cycles) of a few degree Celsius were used. Under high vacuum conditions, the coatings behaved very well and did not evaporate or disintegrated even when exposed to these high temperatures and considering the high current bombardment of the surfaces with energetic electrons. Results of the studies are pending for publication.

Technical developments: The technical upgrade in terms of electron source operation and computer control that took place in 2014 turned out to be very successful. The electron source is now able to run at higher power enabling research samples to be annealed to more than 1300 °C for hours. The stability of the electron beam was successfully tested over a long period of time. The computer control upgrade enabled better fine control of the electron gun parameters contributing significantly to long runs. The technical developments also improved annealing at low temperature. New parameters developed for industrial electron beam annealing of coatings on steel and stainless steel samples.

Industrial connectivity: Electron beams are commonly used in technology development and for manufacturing. Electron beam sintering (additive manufacturing) would be among the most recent established applications. In the laboratory at GNS science we now receive biomedical implants fabricated with electron beam sintering on a regular basis for adding a nano-layer coating to the implants. Our knowledge and experiences with electron beams in the laboratory are useful in understanding electron beam sintering processes and how we modify our ion beam technology to suit biomedical implants.

4.2 Describe to what extent the objectives of the national work plan were accomplished:

All objective accomplished

4.3 Describe immediate benefits of national activities:

Trained staff, new technology, industry connectivity

4.4 Describe long term benefits of national activities:

The national activities have enabled GNS Science to continue use of electron beams in materials science, extending the use from semiconductors to metals. The understanding gained has enabled industry connectivity. The core capability of ion beam technology was linked to electron beam technology. Long term relationships with industry are an expected outcome from the national activities.

4.5 New Developments and unexpected difficulties/problems

New developments: Protocol for annealing of coatings on stainless steel and steel developed.

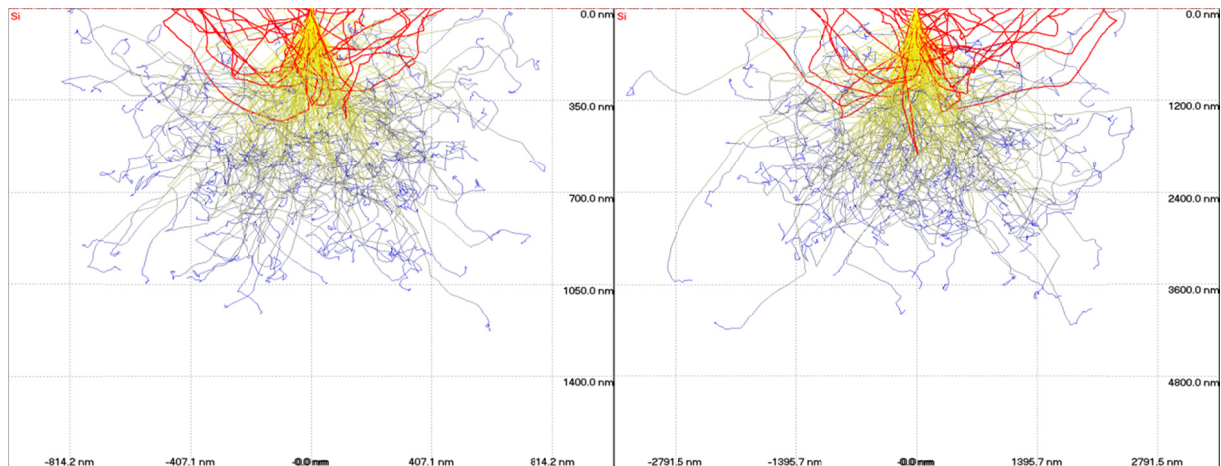
Difficulties/problems: No major issues to report.

4.6 Actions taken to solve them

Not applicable.

4.7 Remarks/lesson learned

Electron beam technology can make a strong contribution to many areas. In materials development and product development areas, we have learned that a scientific understanding of the technology is very beneficial in adaption additional technology to improve products. It is very important to have good documentation of the system and its core capabilities in order to cope with changing students and staff. The handbook that we developed for the electron beam annealer is in frequent use by new project participants and assisted in reducing training and mentoring time requirements.



4.8 Photos

Figure Trajectory of backscattered electrons for 10keV (left) and 20 keV (right) beams in a 100 μm thick Si Layer, with a Rutherford model. The trajectory coloration depends on the energies of electrons. The simulation is done with Casino software.

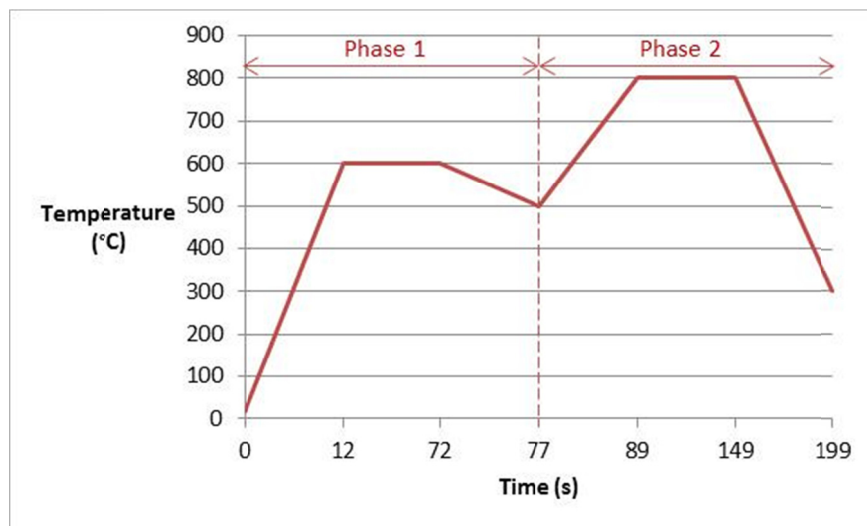


Figure Evolution of temperature according to time with 2 annealing cycles

Final Progress Report on

Electron Beam Applications for Value Addition to Food and Industrial Products and
Degradation of Environmental Pollutants in the Asia-Pacific region

1. Participating Country: Pakistan

1.1 National Project Coordinator

Name	Title	Organization	E-mail
Alamgeer Khan	(Mr) Senior Scientist	Nuclear Institute for Food & Agriculture (NIFA), Peshawar	alamgeer_khan86@yahoo.com

1.2 National Project Team

Name	Title	Organization	E-mail
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Kifayatullah	Mr. Project manager	PARAS, PAEC, Lahore (Food Irradiation)	kifayat57@yahoo.co.uk
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Muhammad Inaamul Hassan	Mr., Senior Scientist	AEMC, PAEC, Lahore (Environmental Remediation)	inaamulhasan@hotmail.com
Tariq Nawaz Khattak	Mr., ARO	NIFA, PAEC, Peshawar	tariq_libra34@yahoo.com

2. Period Covered: December 2012 to November 2015

3. National Activities

3.1 National Activities Undertaken

3.1.1 National Activities in 2013

Activity Name	Objectives	When	Where	Context : Topics, outcomes, accomplishments
Activity 1	Nomination of national project team	April 2013	Pakistan	
Activity 2	Participation in the kick-off meeting	May 2013	Phuket, Thailand	
Activity 3	Meetings	June-July 2013	Pakistan	Meetings of NPC with the high ranked officials of Pakistan Atomic Energy Commission were held for the promotion of EB tech in the country.
Activity 4	Participation in the training course on EB applications in	October 2013	South Korea	Participation in the training course on EB applications in en

	environmental remediation			vironmental remediation (only one scientist could participate)
Activity 5	Seminar	26 June, 2013	Optics labs	Electron beam applications in value addition to food and industrial products
Activity 6	Seminar	16 Sep, 2013	PIEAS	Electron beam applications in value addition to food and industrial products.

3.1.2 National Activities in 2014

Activity Name	Objectives	When	Where	Context : Topics, outcomes, accomplishments
Nominations for the training courses	Selection of trainees in the selected fields	Feb. 2014	Pakistan	Selection of trainees from different institutes of the country for the upcoming training courses.
Training course-1	Basic knowledge and on-site training on Food Irradiation	Apr. 2014	ARTI-KAERI, Korea	Basic understanding of food treatment with radiation and on-sight experimental application of EB technology in food processing
Training course-2	Basic knowledge and on-site training on Advanced Material	May. 2014	ARTI-KAERI, Korea	To learn experimental applications of EB technology through on-sight training in the field radiation cross-linking (advanced materials)
Training course-3	Basic knowledge and on-site training on Environmental Remediation	Jun. 2014	ARTI-KAERI, Korea	To learn the experimental application of EB technology in soil treatment and radio hydrolysis using a mobile EB accelerator
Submit of progress report	Report of half-year progress of the project	Jun. 2014		Evaluation of the progress of project
Lectures/seminars	To conduct lectures and seminars on EB applications at different institutes/ universities of the country	October. 2014	Pakistan	Introduction of EB technology to scientists
Annual Review Meeting	Report of national activities and discussion of next plan	Nov. 2014		Evaluation of the past period and review of next step

3.1.3 National Activities in 2015

Activity Name	Objectives	When	Where	Context : Topics, outcomes, accomplishments
Training course-1	Basic knowledge and hands-on experience on degradation of environmental pollutants	11-22 May, 2015	ARTI,KAERI, Korea	The objective of the training course was to provide basic and advanced knowledge on electron beam applications for degradation of environmental pollutants for major stakeholders of the project through lectures and hands-on experiment.
Lectures/	To conduct lectures/semi	July, 2015	Pakistan	Introduction of EB technology

seminars	nars on EB applications for environmental remediation at NIFA and different universities			to scientist for environmental remediation
Workshop	One day workshop at NIFA, on EB applications	August, 2015	Pakistan	Introduction of EB technology to scientist for Food, Industrial products and environmental remediation
Final review meeting	Overall progress from 2013-2015	28-29 October, 2015	Siem Reap, Cambodia	National achievements and outcomes of the project for 2013-2015

3.2 No. of Participants of National Activities

3.2.1 No. of Participants in 2013

Activity \ No. of participants	No. of Female	No. of Male	Total
Activity 1			
Activity 2			
Activity 3	0	15	15
Activity 4	0	1	1
Activity 5	02	10	12
Activity 6	15	50	65
Total	17	61	93

3.2.2 No. of Participants in 2014

Activity \ No. of Participants	No. of Female	No. of Male	Total
Activity 1			
Activity 2	0	01	01
Activity 3	0	01	01
Activity 4	0	01	01
Activity 5			
Activity 6	12	15	27
Activity 7	0	01	01
Total	08	16	31

3.2.3 No. of Participants in 2015

Activity \ No. of Participants	No. of Female	No. of Male	Total
Activity 1	0	02	02
Activity 2	15	20	35
Activity 3	20	25	45
Activity 4	0	01	01
Total	35	48	83

4. Results

1.3 Analysis of National Activities and Results

- Summarize the national activities implemented - capacity development in terms of achievements (i.e. dissemination of new technologies, knowledge and skills, information to participants).
- Analyse the achievements of national activities implemented: augmentation of national capacity.
- Successful stories, etc.

4.1.1 Analysis of National Activities and Results in 2013

Meetings of NPC with the high ranked officials of Pakistan Atomic Energy Commission were held to elaborate the applications of EB technology in different fields. Young scientists were selected for the training courses.

4.1.2 Analysis of National Activities and Results in 2014

Awareness seminars/lectures were organized at different universities and other relevant places to emphasize the importance of Electron Beam technology for value addition to food, industrial products, colour enhancement of gemstones and environmental remediation. Meetings of the NPC with high officials of PAEC were conducted to convince them for the useful applications of Electron Beam in the above relevant fields. Successful results have been achieved from these meetings and finally the competent authority gave approval to prepare pre-feasibility report for the purchase of three number of Electron Beam machines.

4.1.3 Analysis of National Activities and Results in 2015 (※ Please describe in detail.)

Food Science Division (FSD) of Nuclear Institute for Food & Agriculture (NIFA), PAEC drafted a PC1 for a 10MeV Electron Beam having a power of 20-25 kW. The high ranked officials of PAEC appreciated the efforts made by the NPC team and responded positively to their proposal for the commissioning of Electron Beam technology for value addition to food, gemstones and other commercial products of interest. In continuation to this All Technique Cooperation Pakistan (ATCOP), PAEC have contacted to one of the famous Chinese Electron Beam manufacture company. The deal is in final stages and hopefully it will successfully completed in the nearest future. Besides this lectures, seminars and workshops were arranged not only in NIFA but also in other relevant places for the scientist to know about the importance and useful applications of Electron Beam technology for value addition to food, gemstones, and industrial products. The feedback received from scientific community is highly appreciable and promising to avail this technology for their commercial products of interest to give benefits not only to the country but also to the humanity. NPC team hopes that RCA will continue their efforts to solve the issues of developing countries related to Electron Beam technology by providing opportunities to participate in such projects and support them in technical backgrounds.

4.2 Describe to what extent the objectives of the national work plan were accomplished:

- Due to lack of funds, it is difficult to arrange workshops for the awareness of EB applications.
- Due to passport issues, the first training course was missed.

1.4 Describe immediate benefits of national activities:

These activities helped to introduce modern applications of electron beam especially in the field of food security, value enhancement of polymer materials and removal of pollutants from environment.

1.5 Describe long term benefits of national activities:

Pakistan will have trained man power in field of EB technology, which would be helpful in introduction and spread of this technology in the country.

1.6 New Developments and unexpected difficulties/problems

- Two EB facilities are under consideration.
- Due to lack of funds, it is difficult to arrange workshops/conferences for the awareness of EB applications.
- Due to passport issues, the first training course was missed.
- Due to policy of PAEC, NPC could not attend both training courses.
- Due to lack of technical expertise of this emerging technology and high investment the developing countries are not in the position to adopt this technology.

1.7 Actions taken to solve them

Meetings were held with the officials of PAEC to solve visa issues and to provide funds to conduct workshops to introduce this technique in the country. But PAEC refused to allocate funds for the conferences. Also applied for funds in Higher Education Commission (HEC) of Pakistan, their decision is pending.

1.8 Remarks/lesson learned

Since Pakistan is a new country in this field and such kinds of projects would help a lot for better understanding of EB applications especially in the field of food security. Being an agricultural country, we can fulfil country's food requirements by properly preserving the food and also by reducing post-harvest losses. In the field of advanced materials and environmental sciences, there is a lot of potential of EB technology in this country.

This project is also offering many training courses. Trained manpower would help to form basic infrastructure of EB technology in the country.

1.9 Photos



At inauguration session of the training course



Experiment of waste water treatment using mobile Electron beam Facility at KAERI



Ebtech visit



During the lecture session at KAERI



**After the completion of training course certificates
distribution ceremony**

Final Progress Report on

Electron Beam Applications for Value Addition to Food and Industrial Products and
Degradation of Environmental Pollutants in the Asia-Pacific region

1. Participating Country: Philippines

1.1 National Project Coordinator

Name	Title	Organization	E-mail
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1.2 National Project Team

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Neil Guillermo	Supervising Science Research Specialist	PNRI	ngguillermo@pnri.dost.gov.ph

2. Period Covered: December 2012 to November 2015

3. National Activities

3.1 National Activities Undertaken

3.1.1 National Activities in 2013

Activity Name (Training Course, Workshop, Seminar, Education, Mentoring, etc.)	Objectives	When	Where	Context : Topics, outcomes, accomplishments
Activity 1 Establishment of EB Facility	To demonstrate the applications of EB technology	2013	PNRI	<ul style="list-style-type: none"> 60% completion of EB building 80% completion of EB shielding
Activity 2 Training of Personnel	To enhance the capacity of the personnel in the use of EB	2013	Korea Korea Vietnam	<ul style="list-style-type: none"> J. Madrid- Training Course on EB Applications for Industrial Products P. Pabroa- Training Course for Environmental Applications Z. de Guzman-Scientific Visit Vinna Gamma EB Facility
Activity 3 Information Dissemination and Linkages	To inform the end-users about the EB tech. applications	2013	Manila	<ul style="list-style-type: none"> Presentation of the EB tech to food association and industries Initial collaborations with food industry and wires and cables

3.1.2 National Activities in 2014

Activity Name (Training Course, Workshop, Seminar, Education, Mentoring, etc.)	Objectives	When	Where	Context : Topics, outcomes, accomplishments
Activity 1				Topics:
A. National Seminar Technical Forum on Electron Beam Applications held in connection with the DOST, National Science and Technology Week.	To disseminate information about the benefits of EB Technology	July 2014	Manila	Lecture 1: Establishment of EB facility at PNRI and Status and Trends Worldwide Lecture 2: Applications of EB Outcomes: Enhanced knowledge and capacity of concerned stakeholders researchers and academe Output: more than 200 participants from various sectors participated actively in the technical session
B. Training Course “Phytosanitary Treatment of Irradiated Food”, A USDA Seminar to Quarantine Officers of Philippines and Malaysia”	To inform the quarantine officers about Gamma and Electron Beam Application for Phyto. Purposes	Sept. 15-18, 2014	Intercon Hotel, Makati	Outcomes: Capacity building of quarantine officers on food irradiation using- E.beam and Gamma technology Output: 40 participants underwent dose mapping exercises using mango boxes for EB and gamma irradiation and resulted to better appreciation and understanding of the activity
Activity 2:				
Electron Beam Establishment				
a. Continue establishment of EB facility		July 2014	PNRI	Output: Phase 1-Building-100% completion
b. Installation of EB Accelerator		July 2014	PNRI	Output: 2.5 MeV Accelerator Installed - 100% completed
c. Installation Qualification (IQ)		Aug.'14	PNRI	Output: Demonstrated that the irradiator, equipment and devices are installed in accordance with specs
d. Operation Qualification (OQ)		Sep.'14	PNRI	Output: Showed the capability of the equipment to deliver operating parameters and limits set according to specs
e. Process Qualification (PQ)		Oct.'14	PNRI	Output: Actual dose mapping of samples confirms the performance of equipment as expected
f. EB Inauguration		Dec.'14	PNRI	Output: A Demonstration Facility for R&D and other Semi-commercial Applications

3.1.3 National Activities in 2015

Activity Name (Training Course, Workshop, Seminar, Education, Mentoring, etc.)	Objectives	When	Where	Context : Topics, outcomes, accomplishments
Activity 1 Training 1.Regional Training Course (RTC) on EB Applications for Degradation of Environment Pollutants	To disseminate information about the theoretical and applications of radiation in environment	May 11-22, 2015	ARTI, Jeongup, Korea	Lectures: Radiation Chemistry in Environment 1. Water Waste Treatment Using Radiation 2. Air Pollutants treatment using radiation 3. Environmental Analysis 4. Electron Beam Facility Visit Outcomes: Enhanced knowledge and capacity of researchers
Activity 2 Electron Beam Establishment 1.Start R&D Studies a. 2 R&D projects funded by DOST on radiation grafting b. R&D on the effects of EB on the shelf-life of honey alginate dressing	Radiation grafting using electron beam facility Efficacy of EB on the quality of irradiated dressing	Jan-June 2015 January to June 2015	PNRI laboratory PNRI laboratory	-R&D on polyester abaca using dose of 40 kGy, 5 mm depth penetration -R&D on the effects of EB on polypropylene using 10-40 kGy dose for the purpose of radiation grafting (1 tanning industry was tapped as project collaborator) Honey alginate dressing was irradiated at the electron beam facility with sterilizing dose of 25 kGy. After irradiation, sterility test, tensile strength, moisture and gel fraction were tested.

3.2 No. of Participants of National Activities

3.2.1No. of Participants in 2013

Activity	No. of Participants	No. of Female	No. of Male	Total
Activity 1		5	5	10
Activity 2		2	1	3
Activity 3				

3.2.2 No. of Participants in 2014

Activity	No. of Participants	No. of Female	No. of Male	Total
Activity 1 1.Tech. Forum 2 Training Course		100 25	100 15	200 40
Activity 2 EB Establishment		2	5	7
Activity 3				

3.2.3 No. of Participants in 2015

Activity \ No. of Participants	No. of Female	No. of Male	Total
Activity 1	2	0	2
Activity 2	7	8	15
Activity 3			

4. Results

1.10 Analysis of National Activities and Results

- Summarize the national activities implemented - capacity development in terms of achievements (i.e. dissemination of new technologies, knowledge and skills, information to participants).
- Analyze the achievements of national activities implemented: augmentation of national capacity.
- Successful stories, etc.

1.10.1 Analysis of National Activities and Results in 2013

- Summarize the national activities implemented – workshop, training course, capacity building (disseminated new technologies, knowledge and skills, information)
- The regional training courses attended by our two scientific staff enhanced the building of technical capacities on the applications of EB technology. The training programme for the national working team developed strong baseline information and knowledge geared towards proper implementation of the research works on the technology.
- Analyze the achievements of national activities implemented: augmentation of national capacity (technologies, skills and manpower development, expert network, new equipment/facilities, etc.). The current establishment of the electron beam facility will provide hands-on experience on how to adopt and E-beam technology for food, industry and environment. The skills and training gained from attendance to regional training courses and scientific visits will assist the local technical personnel to implement the project well.
- Successful stories, etc.

1.10.2 Analysis of National Activities and Results in 2014

- The technical forum conducted by the scientists of PNRI have provided the different stakeholders (exporters, manufacturers, regulators and academe) the clear understanding about the EB technology
- The completion of the establishment of the PNRI EB facility will provide grater implementation of the R&D works on radiation processing for polymers, food industrial and environmental purposes. The Institute will be initiating its research works in EB and the skills and hands-on experiences obtained will greatly impact in the better outputs of the study.
- Successful stories
The completion of the EB facility this year is a milestone in our accomplishment.

4.1.3 Analysis of National Activities and Results in 2015 (※ Please describe in detail.)

- With the completion of the establishment of EB facility at the PNRI, the research and development studies was initiated. The training and hands-on experiences gained by the researchers in other countries on the use of and applications of EB is now being applied in the Institute.
- The new EB facility served as an important tool in the implementation of R&D activities in the Institute.
- The researchers are currently collaborating with the relevant industries and academe in connection with the work being undertaken in the EB researches.

- Many industries (medical, pharmaceutical and packaging) now are interested to use EB facility in their products.

1.11 Describe to what extent the objectives of the national work plan were accomplished:

We attained our main objective to establish our electron beam facility in the country. Although at this point in time it has not been completed yet, but we are expecting to complete the work by the second quarter of 2014. There were several personnel trained on the use of the technology including scientific visit to a commercial facility. Initial linkages with academe and food industries were also undertaken.

The successful completion of the establishment of the EB facility served as demonstration plant for various end-users in the application of radiation processing. The provision of proper training of the technical staff will provide successful implementation of the target work plans and linkages with stakeholders to spread the news about the importance of the technology.

The successful completion of the establishment of the EB facility served as demonstration facility for various end-users in the application of radiation processing.

1.12 Describe immediate benefits of national activities:

2013

- The establishment of the EB facility will definitely mark the beginning of novel applications of the technology in various fields of studies and will demonstrate the actual benefits to the end-users. Training of personnel will definitely enhance the capacity of the local scientists on the applications of the technology.

2014

- The completion of the EB facility will certainly provide the start of the many applications and gain benefits on the use of the technology. The training of personnel will definitely enhance the capacity of the local scientists.

2015

- Several applications of EB technology such as sterilization, grafting and enhance material property would be attained using this process. Continuous training on the use and application of EB will enhance the capacity of the local scientists in the Institute.

1.13 Describe long term benefits of national activities:

2013

- Describe how the activities will be beneficial in the long term and expected impacts through the national activities during or after completion of the project.

The expected impacts that will be gained from this project in the national level will be as follows:

- Increasing the body of knowledge concerning the applications of the technology in various fields of studies
- Establishing contacts and linkages from various end-users
- Attracting the interest of industries with the purpose of encouraging future commercial implementation of the technology
- Will create socio-economic development in the country

2014

- Enhance capacities of technical staff will provide better implementation of R&D activities on radiation processing

- Socio-economic benefits gained from the utilization of the EB technology
- Sustainable development of radiation processing technology in the national level
- Enhance market and commercial applications of the technology

2015

After the completion of the facility the following long term benefits could be gained:

- A. enhanced market and commercial applications of the technology
- B. socio-economic benefits from the use of the EB technology
- C. capacities of the local scientists will be enhanced.

4.5 New Developments and unexpected difficulties/problems

- With the initiation of the R&D activities in the Electron beam facilities, the researchers will be able to demonstrate the effectiveness of the use of the technology to various stakeholders. Several private and government sectors have strongly indicated their support to the use of electron beam.
- At this early, the EB facility has not encountered yet major technical problems on the operations because the technical staff can still address the problems encountered.

4.6 Actions taken to solve them

4.7 Remarks/lesson learned

4.8 Photos



Fig.1. Philippine Nuclear Research Institute Electron Beam Facility



Fig.2. Inside EB Facility



Fig.3. Information Dissemination of Electron Beam Technology to Food and Medical Industries, Academe, private and government institutes

Final Progress Report on

Electron Beam Applications for Value Addition to Food and Industrial Products and Degradation of Environmental Pollutants in the Asia-Pacific region

1. Participating Country: Singapore

1.1 National Project Coordinator:

Name	Title	Organization	E-mail
Chew Meng Choon	Head	National Environment Agency	chew_meng_choon@nea.gov.sg

1.2 National Project Team

Name	Title	Organization	E-mail
Khoo Gek Hoon	Director	Agri-Food and Veterinary Authority of Singapore (AVA)	Khoo_gek_hoon@ava.gov.sg

2. Period Covered: December 2012 to November 2015

3. National Activities

3.1 National Activities Undertaken

3.1.1 National Activities in 2013

Activity Name	Objectives	When	Where	Context : Topics, outcomes, accomplishments
No Activity				

3.1.2 National Activities in 2014

Activity Name	Objectives	When	Where	Context : Topics, outcomes, accomplishments
Regional Training Course in Basic and Advanced Knowledge and Hands-on Experiment on Electron Beam Applications for Value Addition to Food Products	To provide knowledge and experimental experience on electron beam applications for value addition to food products.	16 to 20 June 2014	Advanced Radiation Technology Institute, Jeongup, Republic of Korea.	Topics: i) General Introduction of Food Irradiation ii) Food Quality and Their Attributes iii) Food Microbiology and Experiment iv) Food Chemistry and Experiment v) Experiment of Food Rheology and Sensory Evaluation Test vi) Dosimetry for Phytosanitary vii) X-ray Dosimetry for Korean Export Agricultural Products and its Quality Evaluation <i>*Refer to section 4 for outcomes and accomplishments</i>
Technical Sharing in AVA	To share acquired technical knowledge	31 Jul 2014	Post-Harvest Technology	Topic: Electron Beam Technology Outcomes: Participants have a better

	knowledge acquired from the R CARO/UNDP Regional Training Course (16 - 20 June 2014)		Centre	understanding of the Electron Beam as a food irradiation technology. Accomplishments: 15 people benefitted from the sharing
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3.1.3 National Activities in 2015

Activity Name	Objectives	When	Where	Context : Topics, outcomes, accomplishments
No Activity				

3.2 No. of Participants of National Activities

3.2.1 No. of Participants in 2013

Activity \ No. of Participants	No. of Female	No. of Male	Total
Activity 1	-	-	-
Activity 2			
Activity 3			
Activity 4			
Activity 5			

3.2.2 No. of Participants in 2014

Activity \ No. of Participants	No. of Female	No. of Male	Total
Training Course	-	1	1
Technical Sharing Session	11	3	14
Activity 3			
Activity 4			
Activity 5			

3.2.3 No. of Participants in 2015

Activity \ No. of Participants	No. of Female	No. of Male	Total
Activity 1	-	-	-
Activity 2			
Activity 3			
Activity 4			
Activity 5			

4. Results

1.14 Analysis of National Activities and Results

- Summarize the national activities implemented - capacity development in terms of achievements (i.e. dissemination of new technologies, knowledge and skills, information to participants).
- Analyze the achievements of national activities implemented: augmentation of national capacity.
- Successful stories, etc.

4.1.1 Analysis of National Activities and Results in 2013

No activity

4.1.2 Analysis of National Activities and Results in 2014

4.1.2.1 The knowledge and practical experience acquired during the RCARO/UNDP Regional Training Course in Advanced Knowledge and Hands-on Experiment on Electron Beam Applications for Value Addition to Food and Agricultural Product in Asia Pacific Region such as in the areas of food irradiation and dosimetry would be incorporated into research projects (on application of electron beam technology on food irradiation) and programmes (to promote electron beam application on food irradiation among the local food industry).

The training course also afforded the participant the opportunity to establish networks with regional counterparts for potential collaboration in application of electron beam technology on food irradiation.

4.1.2.2 The knowledge acquired from the training course was shared with the staff of Post-Harvest Technology Centre in a technical sharing session conducted on 31 July 2014.

A presentation with the following topics was presented by the officer who attended the Regional Training Course:

- food irradiation,
- electron beam (E-beam) technology,
- comparison between electron beam and other irradiation technology,
- effects of irradiation on food constituents,
- food approved for irradiation
- benefits of electronic pasteurisations, and
- examples of irradiated food.

A total of 14 participants benefitted from the technical sharing session with a better understanding electron beam technology.

4.1.3 Analysis of National Activities and Results in 2015 (※ Please describe in detail.)

No activity

1.15 Describe to what extent the objectives of the national work plan were accomplished:

Objectives of the national work plan included acquiring knowledge in application of electron beam technology on food irradiation via training courses and workshops; and establishing a regional network of experts in this area, for which the training course was a good starting point. In addition, we have achieved the objective of sharing the information of E-beam application in food industry to local government officials and research institutes (NTU, IMRE).

4.3 Describe immediate benefits of national activities:

The immediate benefit from the technical sharing is the understanding of the electron beam technology for research purpose and for regulating import food which might be irradiated.

4.4 Describe long term benefits of national activities:

The national activity (that consisted mainly of training courses for application of electron beam technology on food irradiation) is part of the long term plan for Singapore to build up its knowledge in this area for promotion of this technology to the local food industry. The long term benefit from the technical sharing is that the knowledge was disseminated to a larger pool of technical officers who have the role to provide advisory to the food industry. Where relevant, the E-beam technology can be transferred to the food industry sector.

4.5 New Developments and unexpected difficulties/problems

Currently, the cost of the technology outweighs the potential benefits which the technology can bring about in food application.

4.6 Actions taken to solve them

To constantly look out for advancement in the electron beam technology which may reduce the cost of the technology to the point where it is reasonable for food application.

4.7 Remarks/lesson learned

Evaluation of Electron Beam Processing in Food Application

AVA has participated in the RCA/UNDP Regional Training Course in “Basic and Advanced Knowledge and Hands-on Experiment on Electron Beam Applications for Value Addition to Food Products” held on 16-20 Jun 2014 at Advanced Radiation Technology Institute, Jeongup, Korea. The training has provided AVA a better understanding of the Electron Beam (E-beam) technology in food application and the requirements for establishing such facility.

E-Beam technology for the processing of fresh produce such as edible food crops and ornamental plants is useful for Singapore as it is an alternative disinfestation method which can replace those environmentally unfriendly methods such as chemical fumigation and chemical pesticides dipping. Fruits, vegetables, grains, orchid flowers, aquatic plants, and other food items can be processed by Electron Beam to disinfest fruit flies, thrips, whiteflies, and other insects that use these commodities as a host for propagation, or as product for exporting. In addition, E-Beam processing as a disinfestation method has its advantages using in the herb and spice industry. These commodities are valued for their distinctive flavors, aromas and colors. They can be processed by this technology to reduce bacterial contamination without compromise to their sensory properties.

However, E-Beam processing has limitations in processing certain types of food such as food with high fat content tends to go rancid with development of off-flavour and fresh fruits will experience slight softening. Current examples of food that utilizes E-Beam are limited to high-value food such as astronaut food, spices and minced beef due to the high cost involved for setting up the facilities, utilities and maintenance, and very skilled manpower for operating the E-Beam. Although, the potential benefits that the technology can bring about (ie safe food) may outweigh the cost of setting up the facility with specialized manpower to operate, the initial investment might be too high for any local food SMEs to embark on.

AVA has surveyed several food research institutes (National University of Singapore, Nanyang Technological University, Singapore Polytechnic – Food Innovation and Resource Centre, Nanyang Polytechnic, Institute of Materials Research and Engineering) on their expertise and research capabilities of E-beam application in food. While E-beam technology is available and used in our semi-conductor industries, none of the food research institutes surveyed possess any expertise and facilities for food research although there are some interest in some groups to pursue the technology.

4.8 Photos



Participants during one of the practical sessions

Final Progress Report on

Electron Beam Applications for Value Addition to Food and Industrial Products and Degradation of Environmental Pollutants in the Asia-Pacific region

1. Participating Country: Sri Lanka

1.1 National Project Coordinator

Name	Title	Organization	E-mail
Anoma Kumari Ratnayake	Deputy Director Radiation Processing	Sri Lanka Atomic Energy Board (previously Atomic Energy Authority)	anoma.r@ae.gov.lk

1.2 National Project Team

Name	Title	Organization	E-mail
Mrs. Anoma Kumari.Ratnayake (NPC)	DD- Radiation Processing Section	Sri Lanka Atomic Energy Board	anoma.r@aea.gov.lk
Mrs. C.Kularathna	Senior Scientific Officer -Life Science Division.	Sri Lanka Atomic Energy Board	champa@aea.gov.lk
Mr.K.R.C.De Silva	Scientific Officer Radiation Processing Section	Sri Lanka Atomic Energy Board	ruwan@aea.gov.lk
Mrs.S.Ratnayake	SO- Radiation Processing Section	Sri Lanka Atomic Energy Board	saduni@aea.gov.lk
Mr.R.N.R Jayarathna	Assistant Director	Central Environmental Authority	-
Mr. L. Jayasooriya	Senior Environmental Officer	Central Environmental Authority	jayasuriya@cea.lk
Mr.S.N.Thalawala –	Technical Officer	University of Peradeniya	-

2. Period Covered: December 2012 to November 2015

3. National Activities

3.1 National Activities Undertaken

3.1.1 National Activities in 2013

Activity Name	Objectives	When	Where	Context : Topics, outcomes, accomplishments
Activity-1 Participating RTC on EB	To train team members to disseminate the	19-23 Aug 2013	ARTI KAERI- Korea	Senior Scientific officers of AEA, Ms. Champa Dissanayake has under gone

Application for value addition to Industrial product	knowledge on EB Technology			the training.
Activity 2 Participating EB application for degradation of environmental pollutants	To train team members to disseminate the knowledge on EB Technology	7-11 October 2013.	ARTI-KAERI, Korea.	Mr..R.N.R.Jayarathna From the Central Environmental Authority has undergone the training.
Activity 3 Awareness program was conducted by Mrs.C Kularathna and Mr. R.N.R Jayarathna CEA to AEA staff.	To disseminate the knowledge gained through the two Regional Programs	15.10.20`13	SLAEB	Awareness program was conducted for the Scientific Staff of the SLAEB
Activity 4 Team members meeting	To discuss the Action plan of year 2014 and activities carried out through the year	07.19.2013	SLAEB	To discuss the future activities of the project

**SLAEB- Sri Lanka Atomic Energy Board

3.1.2 National Activities in 2014

Activity Name	Objectives	When	Where	Context : Topics, outcomes, accomplishments
Activity-1 “Deyata Kirula” National Exhibition	Introducing Radiation Technology including Electron Beam to public	On 22nd February to 02nd March 2014	At Kuliapitiya Sri Lanka	“Deyata Kirula” National Exhibition was conducted annually parallel to the independence day celebration of Sri Lanka. Main objective of this programme is to introduce new technologies and innovations to the general public. Every Government institutions, Ministries and Department were participated in the exhibition. Atomic Energy Authority also participated the exhibition and demonstrated peaceful applications of Nuclear technology to the general public and including students in, high school universities, industrialists, professionals etc. In fact that we explained the mechanism of Electron beam accelerators and advantages of its applications.
Activity-2 Team Members Meeting	To discuss the National Work Plan which was finalized at the Meeting Cebu, Philippine.	10th march 2014	Atomic Energy Authority	7 team members were participated in the meeting. Director General of the AEA has explained the objective of the project. Team members were highlighted the importance of Electron Beam technology

				gy for multipurpose activities. Decided to conduct one day workshop during 3rd quarter with assistance of IAEA expert.
Activity-3 Presentation on EB application for Activity Day programme	To improve the basic knowledge on Electron Beam Technology and it's applications	29th April 2014	Atomic Energy Authority	A presentation on "Introduction of Electron Beam Technology and it's applications" was done by Ms. Champa Dissanayake in order to enhance the basic knowledge of Electron Beam Applications among the AEA staff members including newly recruited scientific staff
Activity-4 Basic Knowledge on site training on Advanced Material	To train team members under the train the trainers program of the project	21-25 April 2014	ARTI KAERI-Korea	Two officers of AEA, Ms. Champa Dissanayake and Mr. Malinda Ranaweera were under gone the training.
Activity-5 Basic Knowledge on site training on Food Irradiation	To train team members on EB technology	16-20 June 2014	at ARTI /KAERI-Korea	One Scientific Officer of AEA Mr. K.R.C.De Silva has undergone the training.
Activity-6 Activity Day Program. Presentation has been done by Mr. K.R.C. De Silva.	To improve the basic knowledge on Electron Beam Technology in food irradiation.	22nd July 2014	At the AEA Auditorium	To disseminate the knowledge on food irradiation using Electron Beam Technology among the AEA staff members.
Activity-7 Team members meeting	To discuss the work carried out under the project and future activities. To fixing a date for EB workshop	28th July 2014	Board Room of AEA	Finalized the dates for the workshop on EB application. Mainly focused to introduce EB technology in flue gas treatment. As it is planning to introduce EB technology to Flue gas Treatment in coal power plant will be established in Sampoor The matter was discussed in the last Activity Day Program in AEA with Chairman and senior staff members (on 22nd July 2014).
Activity-8 Activity Day Programme, Presentation by Mr. Malinda Ranaweera	To improve the basic knowledge of Electron Beam Technology and it's applications	27th August 2014	At Main Auditorium of Atomic Energy Authority of Sri Lanka	To "Introduction of Electron Beam Technology and it's applications" To Enhance the basic knowledge of Electron Beam Applications among the AEA staff members including newly recruited scientific staff.
Activity-9 Conducted Workshop on Application of Electron Beam Technology	To introduce the EB technology among stakeholders from Industrial and food sector	12th November 2014	At Main Auditorium of Atomic Energy Authority	To Introduce EB technology for treatment of Flue gas emitted from factories, Waste management in palm oil industry and Food preservation. Especially to sterilizing tape worm in red meat
Activity-10 Participated Science Week organized by Ministry of Technology and	Introducing Radiation Technology to public, including Electron Beam	from 4rd to 8th November 2014	At the Industrial Technology Institute	Disseminated knowledge on EB technology through demonstrations, poster presentation and video presentation.

Research.				
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3.1.3 National Activities in 2015

Activity Name	Objectives	When	Where	Context : Topics, outcomes, accomplishments
Activity 1 Team members meeting	To discuss the national work plan which was finalized at the Annual Review Meeting in Myanmar	19th Feb 2015	Sri Lanka Atomic Energy Board	Discussed the future activities of the project. It was planned to prepare concept paper on EB technology in flue gas treatment in coal power plants to be established in Sri Lanka during next few years.
Activity 2 Awareness program on EB technology in Flue Gas treatment	To introduce on the benefits of EB treatment on flue Gas treatment to end users	10 th March 2015	Sri Lanka Atomic Energy Board	Discussed the matters relevant to prepare above concept paper on FGTEB. Accepted levels of toxic gases emitted from existing coal power plants in Sri Lanka and method used to control the toxic gases from above plants were discussed with the CAE member. Also cost and purity of the coal used in existing plants was discussed.
Activity 3 Conduct an awareness for school children (Keppetipola Maha Vidyalaya, Valimada)	To provide information on Research and development of Radiation Processing Section of SLAEB	24 th April.2015	Radiation Processing (RPS) Lab, Sri Lanka Atomic Energy Board	Disseminated knowledge on the on-going projects under the Radiation Processing Section including RCA/UNDP project on Electron Beam Application.
Activity 4 Provide information to school exhibition at Theldeniya National School	To disseminate the knowledge on EB technology and the R&D activities of RPS	05.04.2015	Radiation Processing Lab, Sri Lanka Atomic Energy Board	Application of Electron Beam Technology and research activities of Radiation Processing Laboratory.
Activity 5 Team members meeting to finalize concept paper on use of Electron Beam technology for flue gas treatment in Coal Power plants.	To introduce EB technology to Flue gas treatment for Coal Power Industry	1 st April 2015/5 th June/6 th May	Atomic Energy Board	Concept paper is being prepared with the assistance of Dr. Chmielewski,, Expert on FG treatment using EB. Discussed on the concept paper in detail. Discussed to meet responsible officers of Coal Power Generation plant at CEB and Lanka Phosphate PVT Ltd.to finalize the proposal. (CEB-Ceylon Electricity Board)
Activity 6 Participate in the RTC on EB Application for degradation of Environmental Pollution	To improve the knowledge on EB application	11 th to 22 nd May 2015	KAERI, Korea	Conduct an awareness program for team members and staff
Activity 7 Conducted a Committee meeting	To obtain information from Lanka Phosphate (PVT) to finalize the concept paper	9 th June 2015	SLAEB	Fixing dates for the meetings with CEB and Lanka Phosphate officers to discuss on the proposal.
Activity 8	To discuss the status	18 th July	Lanka	Met General Manager of LP (PVT)

Visit Lanka Phosphate (PVT) Ltd	of fertilizer production using appetite	2015	Phosphate (PVT) Ltd.	Ltd. At present ground phosphate from in raw form is used to limited cultivations as fertilizer. They have no facility to produce soluble fertilizer using phosphate due to unavailability of Acids. FG treatment using EB technology is highly useful for this industry
Activity 9	Participated in the exhibition held in DOA Gannoruwa.	24 th -26 th August 2015	Department of Agriculture - Gannoruwa	Exhibition was held in Agriculture Centre at Peradeniya for General Public. Poster presentation was done at the event to transfer knowledge on EB technology in the field of Agriculture
Activity 10	Conduct a meeting with CEA/CEB// Lanka Phosphate PVT (Ltd.)	22 Sept 2015	SLAEB	To finalize the concept paper and discuss the further development of the plan to establish EB facility in Coal Power plants to be established in Sri Lanka.

3.2 No. of Participants of National Activities

3.2.1 No. of Participants in 2013

Activity	No. of Participants	No. of Female	No. of Male	Total
Activity 1		1		1
Activity 2			1	1
Activity 3		16	14	30 around
Activity 4		3	4	7

3.2.2 No. of Participants in 2014

Activity	No. of Participants	No. of Female	No. of Male	Total
Activity 1		10,000Nos. (Approx.)	15,000Nos. (Approx.)	25,000 Nos. (Approximately)
Activity 2		3Nos.	4Nos.	7Nos.
Activity 3		30Nos.	35Nos.	65 Nos.
Activity 4		01	01	02
Activity 5			01	01
Activity 6		30	40	70
Activity 7		4	4	08
Activity 8		30	25	55
Activity 9		10	30	40
Activity 10		4,000	6,000	10,000 No.approximately

3.2.3 No. of Participants in 2015

Activity	No. of Participants	No. of Female	No. of Male	Total
Activity 1		4	3	7

Activity 2	14	11	25
Activity 3	18	17	35
Activity 4	6	4	10
Activity 5	4	4	8
Activity 6	16	14	30
Activity 7	02	03	05
Activity 8	01	03	04
Activity 9	100	120	220
Activity 10	02	08	10

4. Results

1.16 Analysis of National Activities and Results

4.1.1 Analysis of National Activities and Results in 2013

Basic knowledge on EB technology has been obtained by the team members through the participation of training programs organized under the project during first year. Knowledge dissemination has been carried out some extend.

4.1.2 Analysis of National Activities and Results in 2014

- Conducted three presentations on EB Technology to AEA staff in the Activity Day Program which is the monthly program organized by the training unit to review the achievements of the work carried out by Scientific officers. Around 70 members of Scientific and administrative staff of AEA were participated in each events.
- Also Team members of the project has participated Annual Exhibition organized by the Government of Sri Lanka, in parallel to Independence Day celebration. It was nearly 10 days period. Many students and general public visited the stall and gained knowledge on EB technology in addition to knowledge on nuclear technology.
- Demonstration on EB technology was done by the Officers of the Radiation Processing Section for the Science week exhibition held during 4th to 8th November 2014. The exhibition was organized by the Ministry of Technology and Research. Approximately 30,000 no of students and general public visited the exhibition. Poster and video on EB technology was present in the exhibition.

4.1.3 Analysis of National Activities and Results in 2015

Conducted three awareness programs by the staff, who has been trained under the Regional training programs which were organized under the RCA/UNDP project on Electron Beam Application. Also information on EB technology as well as research activities carried out under Radiation Processing was given to school children visited to SLAEB and to the student to conduct an exhibition in their school.

Through the exhibitions more students and general public has gained the knowledge on EB application. Also many stakeholders and general public received knowledge on EB technology at the exhibition conducted at Department of Agriculture at Peradeniya during the month of August.

1.17 Describe to what extent the objectives of the national work plan were accomplished:

The activities planned under the National work plan for the year 2014 has been implemented 100%. Three staff members have been trained under the project on EB technology. Approximately 10,000 general public including school children and end users were got aware on the new technology on Electron Beam application in different fields.

The objectives of the national plan for the year 2015 have been achieved partially. It was planned to participate in the National level exhibition “Dayate Kirula” organized by the government every year. The exhibition was cancelled by the new government to reduce government expenses. Therefore it was unable to achieve the expected target.

1.18 Describe immediate benefits of national activities:

It is more appreciated that the team members gained much knowledge on EB technology through the Training programs conducted under the project. They are much competent to deliver lectures on the EB application to the different categories of audience.

Large crowd of general public as well as stakeholders have gained knowledge on EB technology through the exhibitions, workshops and presentations carried out during this year.

The knowledge on EB technology and its application in different fields was disseminated to the students and general public through the awareness programs and school exhibitions by the staff of the SLAEB.

4.4 Describe long term benefits of national activities:

As a long term benefit, it is planning to introduce EB technology in flue gas treatment, in coal power plant to be established in Sri Lanka in near future.

- We are planning to introduce EB technology to flue gas treatment in coal power plants to be established in Sri Lanka .
- The main objectives of this proposal are conservation of environment, reduction of unit cost of electricity using impure coal as a fuel, converting SO_x and NO_x emitted from burning of coal to sulfuric and nitric acid using Electron Beam Technology, production of fertilizers using these acids and Phosphate from the Apatite (at present unprocessed Apatite phosphate uses for coconut and tea plantations in Sri Lanka due to lack of required acids produced in our Country.).

4.5 New Developments and unexpected difficulties/problems

We are planning to introduce Electron Beam flue Gas treatment for the Coal Power Plant which will be established in Sri Lanka near future. It is planning to establish 16 Coal Power Plants in Sri Lanka during next fifteen years.

Problems Identified in the Coal Power industry:

- Emission of toxic gasses such as SO_x and NO_x
- Use of purified coal may high cost
- Use of high purified coal may increase unit cost of power

In fact that we are seeking for the following outcomes using EB flue gas treatment:

- i) Reducing fuel cost and decreases the unit cost of electricity in Sri Lanka.
- ii) Producing Sulfuric and Nitric acids in high efficiency from SO_x and NO_x which emitted from Coal Power Plants.
- iii) To utilize the above prepared Sulfuric and Nitric acids to manufacture highly soluble fertilizers using phosphate from apatite rock phosphate mine in Sri Lanka.
At present phosphate available in the mine is used as raw form, as fertilizer for tea and coconut plantations. Use of by product from EBFGT to produce soluble fertilizer using phosphate and is a new pathway to properly utilize the phosphate mine in new directions.
- iv) To add additional income to the National GDP and enhance the development of agricultural sector in Sri Lanka.
- v) To reduce the Green House Gas (GHG) emission and make independent of Carbon credit issues while generating low carbon electricity with create eco-friendly environment strategy according to the Kyoto protocol by using EB Technology.
- Vi) To create new job market within several fields such as chemical production, fertilizer production, distribution and marketing etc.

Difficulties:

At present Sri Lanka has no EB facility for research and development work. A proposal to be established an EB facility for research development activities submitted to National Planning was not approved.

Lack of proper practical knowledge among the team members to establish EBFGT in Sri Lanka. Also it was no opportunity to improve their knowledge on EBFGT through participation of the RTC on application of Electron

Beam technology for degradation of environmental pollution in Korea.

4.6 Actions taken to solve them

Necessary information was obtained from Prof. Andrzej Chmielewski, Institute of Nuclear Chemistry and Technology, Poland, on flue gas treatment and production of fertilizer using apatite, presence of sulfuric and nitric which are the by-products of EB treatment for NO_x and SO_x gasses emitting from coal power plants. The concept paper was prepared according to the instruction of Prof. Chmielewski.

4.7 Remarks/lesson learned

Team members of the project have been trained under the UNDP/RCA project and gained sufficient knowledge to conduct workshop for end users. But it is essential to obtain hands on experience on EB Technology. For that they must undergo on the job training for long term at least one month in a Facility having EB, under supervision of an expert. Especially it is necessary to provide comprehensive knowledge on EBFGT and knowledge on food preserving using EB technology including, package materials, packaging systems and storage etc.

1. The Knowledge gained through the participation of the TC organized under the project was much useful to disseminating knowledge on EB Technology. But it was not able to get knowledge on the use of EB technology in flue gas treatment through the TC organized under the project. As member country of the project, we expect that UNDP and RCA will make arrangements to extend the project for next two years to obtain comprehensive knowledge on above fields
2. Before we introduce EB technology to Coal power plants in Sri Lanka, we are planning to establish a demonstrative EB unit like 20,000 Nm³/h to observe possibilities of production of fertilizer using apatite presence of sulfuric and nitric acid produced using SO_x and NO_x.
3. It is necessary to obtain expert assistance in connection with implementation of the above project. So that we are seeking RCRO/UNDP support to funding to obtain expert assistance.
4. Also we are seeking funds to establish a demonstrative EB unit in pilot scale to producing acids using SO_x and NO_x to produce fertilizer from apatite available in the Appetite Ore in Sri Lank.

4.8 Photos





Final Progress Report on

Electron Beam Applications for Value Addition to Food and Industrial Products and Degradation of Environmental Pollutants in the Asia-Pacific region

1. Participating Country: Thailand

1.1 National Project Coordinator

Name	Title	Organization	E-mail
Phiriyatorn Suwanmala	Dr.	Thailand Institute of Nuclear Technology (Public Organization) (TINT)	Phiriyatorn@hotmail.com

1.2 National Project Team

Name	Title	Organization	E-mail
Kasinee Hemvichain (Public Organization)	Dr.	TINT	Kasineeh@yahoo.com
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Jaruratana Eamsiri	Miss	TINT	Jarurattt@gmail.com
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Sirilak Chookaew	Miss	TINT	Sirilakchookaew@gmail.com
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2. Period Covered: December 2012 to November 2015

3. National Activities

3.1 National Activities Undertaken

3.1.1 National Activities in 2013

Activity Name	Objectives	When	Where	Context : Topics, outcomes, accomplishments
1.Appointment of National Project Coordinator and National Project Team	To establish national work plan	Jan 1, 2013	TINT, Nakorn-Nayok Province	Establishment of national work plan
2.R&D activities for herb	To study the effect of electron beam and gamma ray on the microbiological decontamination, and	Jan 1-Dec 2013	TINT, Nakorn-Nayok Province	It is consistent with national strategy and the organizational main mission to achieve a sustainable development with an

irradiation	functional ingredients of Herbs			emphasis on developing scientific and technological strength for natural and environmental restoration.
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3.1.2 National Activities in 2014

Activity Name	Objectives	When	Where	Context : Topics, outcomes, accomplishments
1.Training course on Applications of Electron Beam	To promote electron beam applications for food ,industrial products and environment	Feb 11, 2014	TINT, Nakorn-Nayok Province	The participants understand the principle of electron beam and its application. This can promote electron beam applications for end users as well as to establish network of researchers in Thailand.
2.R&D activities for herb irradiation	To study the effect of electron beam and gamma ray on the microbiological decontamination, and functional ingredients of herbs and beans	Jan-Dec, 2014	TINT, Nakorn-Nayok Province	It is consistent with national strategy and the organizational main mission to achieve a sustainable development with an emphasis on developing scientific and technological strength for natural and environmental restoration.
3.Development of electron beam technology for vulcanization of natural rubber latex in Thailand	To find optimum conditions for vulcanization of natural rubber latex by electron beam irradiation	Feb-Dec, 2014	TINT, Nakorn-Nayok Province	Sustainable income for the country from exports of latex and latex products

3.1.3 National Activities in 2015

Activity Name	Objectives	When	Where	Context : Topics, outcomes, accomplishments
1.Special Lecture on Applications of Electron Beam for Food, Industrial Products and Environment	To promote electron beam applications for food ,industrial products and environment	April 21, 2015	Chulalongkorn University	The participants understand the principle of electron beam and its application. This can promote electron beam applications for students and researchers as well as to establish a research network between nuclear research institute and university in Thailand.
2.Development of natural and synthetic polymers as suitable packing materials for food products sterilized by radiation processing	To study the effects of gamma irradiation on commercially available polymers currently being used for food products sterilized by radiation processing. To develop natural polymer based packing materials suitable for	Jan-Nov 2015	TINT, Nakorn-Nayok Province	This research project aims to study the effects of gamma irradiation on commercially available polymers currently being used for food products sterilized by radiation processing at Thailand Irradiation Center (TIC). Parameters that will be used for the study include type of radiation, radiation dose, radiation atmosphere, type of

	food irradiation			polymer and type of additive. After irradiation, changes in mechanical and thermal properties, chemical structure and color will be examined, along with the study of volatile radiolysis products. The obtained information will subsequently be used to determine the most suitable packaging materials for food irradiation as well as to develop natural polymer-based packaging materials suitable for food irradiation. Radiation processing will be utilized to improve the properties and enhance the performance of natural polymer-based packaging materials.
3. R&D activities for herb irradiation	To study the effect of electron beam and gamma ray on the microbiological decontamination, and functional ingredients of Herbs	Jan-Nov 2015	TINT, Nakorn-Nayok Province	It is consistent with national strategy and the organizational main mission to achieve a sustainable development with an emphasis on developing scientific and technological strength for natural and environmental restoration.

3.2 No. of Participants of National Activities

3.2.1 No. of Participants in 2013

Activity \ No. of Participants	No. of Female	No. of Male	Total
Activity 1	7	1	8
Activity 2	5	1	6

3.2.2 No. of Participants in 2014

Activity \ No. of Participants	No. of Female	No. of Male	Total
Activity 1	29	22	51
Activity 2	5	1	6
Activity 3	4	1	5

3.2.3 No. of Participants in 2015

Activity \ No. of Participants	No. of Female	No. of Male	Total
Activity 1	38	17	55
Activity 2	4	1	5
Activity 3	6	1	7

4. Results

- **Analysis of National Activities and Results**

1.18.1 Analysis of National Activities and Results in 2013

NPC, alternative NPC, and national project team were appointed. In addition, the national work plan was established.

R&D Activities

Thailand has a variety of herbs which is very useful both in the field of food and in the field of health. Herbs have long been used in traditional medicine in Thailand. During cultivation, post-harvest, post-processing, storage and transportation, herbs are always contaminated with microorganisms. These microorganisms can later contaminate end products. Avoiding high levels of microbial contamination in herbs may be impossible. Herbs are relatively sensitive to treatment of any kind and are particularly damaged by fumigation with ethylene dioxide gas (ETO). Herbs are currently treated with ionizing radiation to eliminate microbial contamination without causing significant chemical or sensory alterations and chemical residues on products. Many R&D activities for herb irradiation are carried out in Thailand. These activities are as follows:

Effect of Electron Beam Irradiation on the Properties of *Kaempferia Parviflora* (KP)

KP is a herbal plant which is commonly referred to Thai name, Kra Chai Dum. The rhizome of this plant is used as a traditional medicine to alleviate male potency, induce an energizer, balance blood pressure and reduce stomach pain. KP has famous as a Thai Viagra or ginseng and use it to promote healthy sexual function in men. Electron beam is one of the ionizing radiation that has been widely recognized as a practiced methods of microbiological decontamination and shelf-life extension in spices and herbs. However, informations on the effect of electron beam on the microbiological decontamination, antioxidant activity, total phenolics and isoflavonoid contents (daidzein and genistein) of KP have not been investigated. Irradiation with electron beams was carried out at Thailand Institute of Nuclear Technology (Public Organization, TINT) using an accelerator (MB 20-10 S/N 021, Mevex Corporation, Canada). The accelerator operated at the energy of 8 Mev, beam current of 100 mA and dose rate of 20 kGy/pass. KP powder was irradiated at total dose of 5, 10, 15 and 20 kGy. The irradiated samples were extracted with methanol using ultrasonic bath for 1 hour. The effect of electron-beam on the antioxidant activities were examined by 1,1-diphenyl-2-picrylhydrazyl (DPPH) assay. Total phenolics were determined using Folin-ciocateau reagent assay. Isoflavonoids were analyzed by HPLC analysis using gradient system. In addition, the microbiological assays were determined using the method of AOAC 1995.

The study revealed that total bacterial count and total yeast and mold of KM powder were 9.8×10^5 cfu/g and 2.4×10^3 cfu/g, respectively. After irradiation, the microbial level decreased with an increasing dose. Irradiation dose of 5 kGy induced the reduction of the microbial level higher than 2 log cycle. No significantly changes in the antioxidant activity and total phenolics were observed. The DPPH radical scavenging activity (IC_{50}) of irradiated samples were 60-70 mg/ml while that of non irradiated sample was 65 mg/ml. The total phenolic contents were 2.60-2.94 mg gallic acid equivalent/g. The content of daidzein and genistein did not change after irradiation. The irradiation up to 20 kGy does not affect the antioxidant activity, total phenolics, daidzein and genistein of KM.

Comparison of Electron Beam and Gamma Irradiation on the Antioxidant Activity, Total Phenolics and Functional Ingredients of *Pueraria Mirifica* (PM)

PM is a phytoestrogen herb. This herb grows in forest regions in northern Thailand. It has also been called Kwao Krua kaow and Thai Kudzu. The herb's tubers consist of phytoestrogen such as daidzein, estradiol, genistein and microestrol. PM plays a valuable role in helping to maintain a healthy hormone balance in menopausal women when estrogen levels drop. In addition to its hormone supporting effects, this substance has a high level of antioxidant activity due to its ability to increase the cell protective substance. The Thailand Ministry of Public Health officially endorses PM, due to scientific data that supports its safety and efficacy. Radiation technology is normally used to preserve the quality and enhance the shelf life of foods, herbs and spices. It has been proven safe and reduced the economic losses in commercial. The purpose of this research is to compare the effects of electron beam and gamma irradiation on antioxidant activity, total phenolics and functional ingredients (daidzein and genistein) of PM. KM tuber powder was irradiated by electron beam and

gamma ray with dose of 5, 10, 15, and 20 kGy. The irradiated samples were extracted with methanol using ultrasonic bath for 1 hour. The effects of electron beam and gamma irradiation on the antioxidant activities were examined by 1,1-diphenyl-2-picrylhydrazyl (DPPH) assay. Total phenolics were determined using Folin-ciocateau reagent assay. In addition, daidzein and genistein were analyzed. The DPPH radical scavenging assay of irradiated *PM* exhibited high antioxidant activities at dose of 10 and 15 kGy (more than 150 µg ascorbic acid equivalent/g). Total phenolics of samples irradiated by gamma ray and electron beam were 750-950 µg gallic acid equivalent/g. These values increased significantly by gamma and electron beam irradiation. Daidzein and genistein contents in non irradiated and irradiated samples were not significant difference at $p \geq 0.05$. Increasing antioxidant activity and total phenolics without altering the daidzein and genistein content in *PM* were obtained after irradiation at dose of 10-15 kGy. No significant difference between electron beam and gamma irradiation on the effects of antioxidant activity, total phenolics and functional ingredients of *PM*. In addition, the effects of electron beam irradiation on the antioxidant activities, total phenolics and functional ingredients of *PM* during a six-month storage were studied. *PM* powder was irradiated at the total dose of 5, 10, 15 and 20 kGy and stored at room temperature for six months. The alteration in their properties was determined every three months. The irradiated and unirradiated samples were extracted with methanol using ultrasonic bath for 1 hour. After irradiation, the DPPH radical scavenging assay of irradiated *PM* exhibited high antioxidant activities at the dose of 10 and 15 kGy (more than 0.15 mg ascorbic acid equivalent/g), whereas there was no change at the dose of 5 and 20 kGy. The storage periods of three and six months did not significantly ($p \geq 0.05$) affect its antioxidant activities. The total phenolics, daidzein and genistein contents of unirradiated and irradiated samples were not significantly different throughout six-month storage.

Effect of Electron Beam Irradiation on Antioxidant Activity, Total Phenolics and Functional Ingredients of Ginger (*Zingiber Officinal*, ZO)

The effects of electron beam irradiation on the microbial population, color, antioxidant activity, total phenolics and functional ingredients of ZO were investigated. ZO powder was irradiated at total dose of 5, 10, 15 and 20 kGy. After irradiation, the samples were extracted with methanol in an ultrasonic bath for 1 hour. The methanolic extracts were evaluated for antioxidant activities by DPPH assay and total phenolics by using Folin-ciocateau reagent assay. The functional ingredients, including 6-gingerol, 8-gingerol, 10-gingerol, 6-shogaol and 8-shogaol were analyzed by HPLC using a gradient system. The color indicated in b value was measured by using Chromameter. In addition, the microbiological assay was performed according to AOAC 1995. It was found that total bacterial counts were reduced by 3 logs, while total yeast and mold were decreased only 1 log at the dose of 5 kGy. Total bacterial counts and total yeast and mold were below detected limit ($< 1.0 \log \text{ cfu/g}$) after irradiation at dose of 15 and 5 kGy, respectively. The contents of total phenolics, 6-gingerol and DPPH scavenging activities of unirradiated and irradiated samples were 9.58-10.18 mg gallic acid equivalent, 2.5-2.69 mg/g of sample and 6.57-8.98 mg/ml (equivalent to ascorbic acid 3.96-5.10 mg AAE/g), respectively. There were no significant differences between unirradiated and irradiated samples. The Hunter color value was decreased after irradiation. Electron beam irradiation was suitable for microbial decontamination without any adverse changes in antioxidant activities, total phenolics and functional ingredients (6-gingerol) of ZO powder. The color value of irradiated samples was significantly decreased.

1.18.2 Analysis of National Activities and Results in 2014

Training course on Applications of Electron Beam

The training course on applications of electron beam was held by TINT in Nakorn-Nayok province to promote electron beam applications for food, industrial products and environment. 50 participants and one Lecturer from TINT were participated in this training course. The training course consisted of lectures and exercises which provided the basic knowledge and electron beam applications for food, industrial products and environment.

R&D activities for herb and bean irradiation are carried out in Thailand. These activities are as follows: **Effect of electron beam and gamma ray on microbial load and stability of phytochemical components of ground black pepper (*Piper nigrum* L.)**

The effects of electron beam and gamma ray on microbial decontamination and phytochemical components of black pepper (*Piper nigrum* L.) were studied. The results showed that gamma ray and electron beam

eam gave the similar effects on microbial contamination and phytochemical components. The optimum dose of irradiation to diminish the microbial contamination was 5 kGy. Irradiation at 20 kGy could eliminate total bacteria, total yeast and mold, coliform bacteria, *Escherichia coli*, *Salmonella* sp. and *Bacillus cereus* in ground black pepper. Whereas, there was no significant changes in total phenolic content (TPC), ferric reducing antioxidant potential (FRAP), free radical scavenging activity (DPPH) and piperine contents after irradiation up to 20 kGy.

Influence of gamma radiation and electron beam on microbial load of *Pueraria mirifica* at various storage time

The purpose of this study is to investigate and compare the effects of ionizing radiation, gamma ray versus electron beam, with the dose of 0, 5, 10, 15 and 20 kGy at various storage time of 0, 3, 6, 9 and 12 months. The irradiated and non-irradiated samples were analyzed for total bacteria, total yeast and mold, Coliform bacteria, *Escherichia coli*, *Salmonella* sp., *Bacillus cereus* and *Clostridium perfringens*. The results exhibited that both ionizing radiation treatments significantly reduced microbial contamination in which the reduction linearly decreased with absorbed dose. The dose of 5 kGy was sufficient to eliminate the pathogens and decrease the total bacterial count to meet the standard. Additionally, we found that total bacteria, total yeast and mold and pathogens was not significantly changes in various storage time.

Effect of gamma radiation and electron beam on microbiological quality and protein patterns of 4 selected beans

The effect of gamma and electron beam on microbiological quality and protein patterns of four selected beans: mung beans, soy beans, peanuts and black beans were evaluated. All beans samples were exposed to irradiation at doses of 0, 0.5, 1, and 2 kGy before evaluated for their microbiological quality using AOAC method and protein analysis by gel electrophoresis. Results showed that the amount of bacteria, yeast and mold of irradiated mung beans and peanuts were reduced, whereas these microbiological quality values remained relatively the same for irradiated soy beans and black beans compared to non-irradiated samples. In terms of protein analysis, the protein patterns of the irradiated beans were of the same quality as the nonirradiated samples. To further tested the effect of irradiation on the bean's protein at higher doses, all four selected beans were exposed to gamma rays at 10, 50, 100, 150 and 200 kGy. It was found that the protein patterns of mung beans, peanuts and black beans were altered at doses above 50 kGy.

Development of electron beam technology for vulcanization of natural rubber latex in Thailand

Thailand is the world's leading producer and exporter of concentrated natural rubber latex and the world's number two manufacturer and exporter of latex products after Malaysia. Therefore, research and development of latex technology is important for Thailand in order to maintain and continuously improve the competitiveness of the Thai latex and latex products industry. The results would be sustainable income for the country from exports of latex and latex products and also to maintain the country as the world leader in latex technology.

The electron beam technology (EBT) can be used to vulcanize natural rubber latex without the uses of chemicals. Therefore, the latex produces can be used to manufacture safe rubber products freed of potentially allergic proteins or carcinogenic compounds in contrast to the latex vulcanized by sulfur (SVNRL). Furthermore, the EBVNRL product wastes can safely be treated by incineration without generating toxic gases. Therefore, EBVNRL technology should provide the Thai industry with competitive advantage over their competitors in other countries.

However, before the EBVNRL technology can be introduced in Thailand, for example to produce prevulcanized latex, research and development is first required *i.e.* 1) finding optimum conditions for vulcanization of natural rubber latex, 2) study factors affecting vulcanization of natural rubber latex 3) Apply sensitizer for improving prevulcanization efficiency and properties of rubber film and 4) comparing electron beam technology with γ -ray technology. On-going activities was conducted by research teams from Thailand Institute of Nuclear Technology (Public Organization) and National Metal and Materials Technology Center (MTEC), Ministry of Science Technology.

1.18.3 Analysis of National Activities and Results in 2015

Special Lecture on Applications of Electron Beam for Food, Industrial Products and Environment

The special lecture on applications of electron beam for Food, Industrial Products and Environment was given by Dr. Phiriyatorn Suwanmala at Chemical Engineering Department, Chulalongkorn University to promote electron beam applications for food, industrial products and environment. 55 participants were

participated in this event. The lecture consisted of basic knowledge of electron beam and its applications which can help the participants to understand electron beam applications for food, industrial products and environment.

Development of natural and synthetic polymers as suitable packing materials for food products sterilized by radiation processing

The effects of gamma irradiation on commercially available polymers currently being used for food products sterilized by radiation processing at Thailand Irradiation Center (TIC) were studied. The chosen product is fermented pork sausages. The effects of gamma irradiation on packaging material of fermented pork sausages were investigated using FTIR, DSC and universal testing machine. FTIR and DSC revealed changes in chemical and thermal properties of the packaging material, respectively, where the universal testing machine showed changed in mechanical properties. The results showed that the high fat content, the direct contact between acidic fermented pork sausages and the packaging material as well as irradiation led to changes in chemical and mechanical properties of the packaging material. In addition, the effects of irradiation by gamma and electron beam (EB) on an emerging biodegradable polymer which is a good candidate for food packaging as well as its blends with a natural polymer were studied. The chosen polymer is poly(butylene succinate) (PBS), whereas the chosen natural polymer is cassava starch. The effects of gamma and EB irradiation at different doses on the mechanical properties of polymer blends between PBS and cassava starch were investigated. Two types of starch were used to prepare thermoplastic starch (TPS), native cassava starch (NS) and hydrophobic starch (HS). PBS-TPS blends were compounded at three different weight ratios using a twin-screw extruder. Results indicated that the incorporation of TPS deteriorated the mechanical properties of the blends. For pure PBS samples, gamma and EB irradiation led to enhanced properties, in terms of tensile strength and Young's modulus. For PBS-TPS blends, mechanical properties of the blends basically decreased with increasing content of TPS, however, at the same content of TPS, Young's modulus seemed to be increasing with dose, while tensile strength remained roughly the same and elongation at break declined with dose. The maximum value for Young's modulus and tensile strength, for gamma and EB irradiation, was at 150 and 120 kGy, respectively

R&D activities for herb irradiation.

R&D activities for herb irradiation are carried out in Thailand. These activities are as follows:

Influence of electron beam irradiation on hygienic quality and antioxidant activities of ground sea holly (*Acanthus ebracteatus*).

In Thailand *Acanthus ebracteatus* Vahl., and *Acanthus ilicifolius* Linn. have been used as traditional medicine. They are used as a purgative and anti-inflammatory for arthritis. The whole plant is boiled in water used for bathing in order to heal rash and skin diseases. The fresh plant is crushed and applied as a poultice in boils or taken orally as depurative. Roles of electron beam irradiation on improving hygienic quality and antioxidant activities of ground sea holly (*Acanthus ebracteatus*) were studied. The radiation processing was carried out at the doses of 0, 5, 10, 15 and 20 kGy using an electron beam accelerator (Mevex, MB 20/16) at the energy of 8 MeV, beam current of 10 mA and dose rate of 5 kGy/pass. The irradiated and unirradiated samples were analyzed for microbiological aspects and antioxidant properties. Results indicated that irradiation using electron beam significantly reduced microbial contamination. After irradiation at 5 kGy, total viable bacterial count (TVC) and total yeast and mold (TYM) were diminished by 2 and 1 log cycle, respectively. The dose of 5 kGy was adequate to diminish TVC and TYM to meet the Thai Community Product Standard of Dry herbs (TCPS.480/2557) and to purge of pathogens such as Coliform bacteria, *Escherichia coli*, *Salmonella* spp. and *Clostridium perfringens*. The antioxidant properties such as total phenolic content (TPC), ferric reducing antioxidant potential (FRAP) and free radical scavenging activity (DPPH) displayed insignificant changes for all doses applied in this study.

Application of Electron Beam Irradiation to Reduce of Microbial Load and Antioxidant Activity of *Cassia alata* (L.) Roxb.

Cassia alata (L.) Roxb. is a pantropical, ornamental shrub, distributed from tropical America to Asia and some parts of Africa. It has the interesting biological and pharmacological activities, such as antimicrobial, antioxidative, anti-inflammatory, antitumor as well as cytotoxic activities. Leaves or sap of

Cassia alata (L.) Roxb. are used to treat fungal infections such as ringworm, scabies, ulcers, and other skin diseases such as pruritis and itching. Dried herb samples of *Cassia alata* (L.) Roxb. were exposed to electron beam at dose of 0, 5, 10, 15 and 20 kGy. They were evaluated for microbial contamination and antioxidant activity. The total aerobic microbial count (TAMC), total fungi count of non-irradiated samples were obtained higher as 5.3×10^6 CFU/g, 1.60×10^5 CFU/g, respectively and enterobacteria were found as less than 10^3 and more than 10^2 (probable number of bacteria/g). Electron beam irradiation at dose of 10 kGy reduced microbial load to TAMC of 2.40×10^4 CFU/g, total fungi count to less than 10 CFU/g and enterobacteria less than 10 (probable number of bacteria/g) which indicated these samples conformed to criterion of microbial limit test as indicated in Thai pharmacopoeia (2005) (TAMC $< 5.0 \times 10^5$ CFU/g, total fungi count $< 5.0 \times 10^4$ CFU/g, not more than 10^4 enterobacteria (probable number of bacteria/g) and absence of specified microorganisms). Total phenolic content (TPC), antioxidant activity of plant extract were measured using Folin-Ciocalteu assay, free-radical scavenging assay with DPPH and ferric reducing antioxidant potential. The results showed that non-irradiated samples and irradiated samples had high total phenolic content, antioxidant activity by free-radical scavenging assay with DPPH and ferric reducing antioxidant potential. Irradiated samples of electron beam at dose of 5, 10, 15 and 20 kGy were not significantly difference in total phenolic content (TPC), antioxidant activity by free-radical scavenging assay with DPPH and ferric reducing antioxidant potential when compared with the controls. This study reveals that electron beam irradiation at dose of 10 kGy up to 20 kGy can be considered as an effective method for controlling microbial flora and remains unchanged total phenolic content and antioxidant activity of *C. alata* (L.) Roxb.

4.2 Describe to what extent the objectives of the national work plan were accomplished:

The national work plan were accomplished about 96%.

4.3 Describe immediate benefits of national activities:

The special lecture on applications of electron beam for Food, Industrial Products and Environment attended by participants from university was an important activity in promoting electron beam applications for students and researchers as well as to establish a research network between nuclear research institute and university in Thailand.

4.4 Describe long term benefits of national activities:

- Consistent with national strategy and the organizational main mission to achieve a sustainable development, with an emphasis on developing scientific and technological strength for natural and environmental restoration.
- Promotion of electron beam applications for value addition to food and industrial products and degradation of environmental pollutants
- Established network of Thai scientist between Thailand Institute of Nuclear Technology (Public Organization), university and research institute.

4.5 New Developments and unexpected difficulties/problems

For Thailand, there are only a few numbers of researchers working in the field of food irradiation and radiation processing.

4.6 Actions taken to solve them

A training course and special lecture were held by TINT to promote electron beam applications for end users as well as to establish network of researchers in Thailand.

4.7 Remarks/lesson learned

-

4.8 Photos

Final Progress Report on

Electron Beam Applications for Value Addition to Food and Industrial Products and Degradation of Environmental Pollutants in the Asia-Pacific region

1. Participating Country: Socialist Republic of Vietnam

1.1 National Project Coordinator

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1.2 National Project Team

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2. Period Covered: December 2012 to November 2015

3. National Activities

3.1 National Activities Undertaken

3.1.1 National Activities in 2013

Activity Name	Objectives	When	Where	Context : Topics, outcomes, accomplishments
Activity 1: Setting up the national work plan for 2013	Finding competent group for the project implementation; Setting up the nation work plan with the reality and applicability	QTR 1	VINAGAMMA, Vietnam	<ul style="list-style-type: none"> - Research activities defined - Assignment for staff to implement the work plan
Activity 2: Selection of 2 researchers for participation in the training courses	Selecting competent people to participate on the training courses	From 17 to 24 August and from 05 to 12 October	Jeongup, Korea	<ul style="list-style-type: none"> - Participants have fulfilled the programs of the training courses. - The knowledge and skills gained from the training courses are useful for R&D activities at VINAGAMMA, especially for the applications of the present

				EB accelerator.
Activity 3: Carrying out experiments for measurement of main parameters of the EB accelerator at VINAGAMMA	The results of the measurements should be used for the exploitation of the accelerator	QTR 1	VINAGAMMA	<ul style="list-style-type: none"> - The following parameters have been determined: Beam energy, Beam currents of the upper and lower scanner, dose uniformities along the scanning lengths for 02 scanners, stabilities of the beam energy, currents and conveyor speed and other ones - These works are important for the irradiation service of the center but also also for training technical staff working with the accelerator
Activity 4: Design and construction of the system for adding area density to product in order to increase the irradiation ability of the EB accelerator	Expanding the possibility of irradiation of the accelerator with 10 MeV energy for products with area densities more than 4.5 g/cm ²	From QTR3 to QTR4	VINAGAMMA	<ul style="list-style-type: none"> - In order to enhance the irradiation possibility of the accelerator of 10 MeV, expanding the range of area density of products for 10 MeV EB irradiation is important for its exploitation. - The system has been designed, constructed, tested. - Thanks to this system the bigger volume and more types of products could be irradiated by the accelerator at VINAGAMMA
Activity 5: Two pilot projects: grafting nano-silver on cloth cotton used in hospitals; Application of nano-silver as an immobilizer for fertilizers sprayed on tree leaves (2013-2014)	Application of Radiation technology in the national economics, especially in healthcare and agriculture. Two products are expected to be commercialized.	From QTR 1 to QTR 4	VINAGAMMA	<ul style="list-style-type: none"> - Two project are implemented in due time. - Their products hopefully are commercialized and have social-economical effects to the healthcare and agriculture fields.

3.1.2 National Activities in 2014

Activity Name	Objectives	When	Where	Context : Topics, outcomes, accomplishments
Activity 1: Selection of 3 researchers for participation in the training courses	Selecting competent people to participate on the training courses	From 14 to 25 April and from 16 to 20 June	Jeongup, Korea	<ul style="list-style-type: none"> - Participants have fulfilled the programs of the training courses. - The knowledge and skills gained from the training course are useful for R&D activities of the participants
Activity 2: Designing and	The process and equipment could be	February and April	VINAGAMMA	<ul style="list-style-type: none"> - Two experiments have been implemented for origin-

constructing the equipment for topaz irradiation by using 10 MeV electron beam	treat at least 10 kg/month			<p>difference of topaz to assess the colour change effect and economic aspect. It seems not economical by using an EB accelerator 10 MeV with 7.5 kW for gemstone processing.</p> <ul style="list-style-type: none"> - There are some improvements needed for reduce of irradiation time and effectiveness of irradiation
Activity 3: Continuing implementation of two scientific projects at ministerial level.	Production of cotton with surface- grafted nano-silver Application of nano-silver as an immobilizer for fertilizers sprayed on tree leaves	From QTR 1 to QTR 4	VINAGAMMA	<ul style="list-style-type: none"> - Two projects have been accomplished in due and completely fulfilled their assigned duties. - Two products are applied at fields and accepted by users. They are going to be commercialized

3.1.3 National Activities in 2015

Activity Name	Objectives	When	Where	Context : Topics, outcomes, accomplishments
Activity 1: Selection of 2 researchers for participation in the training course	Selecting competent people to participate on the training course	From 11 to 22 May	Jeongup, Korea	<ul style="list-style-type: none"> - Participants have fulfilled the programs of the training course. - The knowledge and skills gained from the training course are useful for R&D activities of the participants
Activity 2: Study on processing gas pollutants	Gathering data and information on processing gas pollutants (aimed at gas gas pollutant from a coal electricity plant	From QTR 1 to QTR 4	VINAGAMM, SON SON Company	The scientific and technical data and knowledge gained from the training course and from studies are used for preparation of further scientific activities of VINAGAMMA. The activity has been set up at the Kick-off meeting but implementation is limited due to the low demand and it seems not timely for Vietnam
Activity 3: Study on production of advanced materials by using EB	Studying ability of the accelerator for production of advanced materials	From QRT 3 to QRT 4	VINAGAMMA	Some products containing nano particles have been produced such as NanoPolidon, NanoStach fertilizers for tree leaves, plant protector Nanokito.

3.2 No. of Participants of National Activities

3.2.1 No. of Participants in 2013

Activity	No. of Participants	No. of Female	No. of Male	Total
Activity 1		1	3	4
Activity 2		1	1	2

Activity 3	0	6	6
Activity 4	0	6	6
Activity 5	3	9	12

3.2.2 No. of Participants in 2014

Activity	No. of Participants	No. of Female	No. of Male	Total
Activity 1		1	2	3
Activity 2		0	6	6
Activity 3		3	5	8

3.2.3 No. of Participants in 2015

Activity	No. of Participants	No. of Female	No. of Male	Total
Activity 1		2	0	2
Activity 2		2	2	4
Activity 3		3	5	8

4. Results

○ Analysis of National Activities and Results

4.1.1 Analysis of National Activities and Results in 2013

- Concerning to the training courses, the participation of Vietnamese in two training courses has important meanings for promotion of the EB application in industry, especially, in environment conservation. In connection with these training courses the activities have been implemented as follows:
 - + The participants have gained useful knowledge and information on EB application in industry, especially, in the field of environment conservation.
 - + The participants have done two seminars at the Research and Development Department of VINAGAMMA and circulated document to researchers at two other institutions.
- Concerning to the work national plan, the above listed activities will be continued in 2014

4.1.2 Analysis of National Activities and Results in 2014

- Three researchers sent to the training courses in 2014 are actively participating in scientific project of the R&D department of VINAGAMMA. It expected that the training course could be valuable for the research activities of the center.
- Experiments of gemstone irradiation (topaz) have shown that it is not economical in the case of EB irradiation at 10 MeV ad 7.5 kW. It only becomes economical if topaz stones should be selected by origin and the EB power should be increased.
- To overcome the problem the present gemstone irradiation equipment should be modified so that its irradiation throughput should be enhanced. Beside this renovation selection of gemstones before irradiation must be done in aspects of their sizes and origin.
- Two project stated in Activity 3 are successfully accomplished with prospectus results. Products are marketed and the technologies are hopefully transferred to private companies.

4.1.3 Analysis of National Activities and Results in 2015

- Two researchers sent to the first training course are actively participating in scientific project of the R&D

department of VINAGAMMA

- Studying on processing gas pollutants have been carried out. It is a stage of gathering information on scientific and technological aspects. The practical application is not yet conducted due to no approved project. It seems that this application is still far the government interest.
- Some research activities for producing products with nano particles (Silver and Gold) are successful. These products are mainly used in agriculture.

4.2 Describe to what extent the objectives of the national work plan were accomplished:

The national work plan for the project has been actively done. Almost objectives are met and results of projects in the plan are applicable and prosperous for further developments.

4.3 Describe immediate benefits of national activities:

The results of project carried out during 2013-2015 have two meanings namely increasing turnover and reputation of the centre.

4.4 Describe long term benefits of national activities:

The participants who had participated in training course have got a lot of knowledge and skills in the field of radiation technology. These people will play important roles in research activities of the center in future.

4.5 New Developments and unexpected difficulties/problems

- In order to exploit the accelerator at the center technical renovations should be considered and implemented. It requires the competent engineers and researchers. Unfortunately, the knowledge in technology of LINAC accelerator is still new for us.
- Application of accelerators for solving environmental problems is near future for Vietnamese researchers. It requires good preparation in knowledge and technology. It is difficult for us if the environment problem is still not enough interested by law makers. The research policy for fighting with environment problem is being set up.

4.6 Actions taken to solve them

- The channels for education of technical engineers working with LINAC accelerator should be found (in Vietnam and abroad)
- Technology for solving Application of accelerators for solving environmental problems is near future for Vietnamese researchers. It requires good preparation in knowledge and technology. It is difficult for us if the environment problem is still not enough interested by law makers. The research policy for fighting with environment problem is being set up.

4.7 Remarks/lesson learned

The project has booted the tendency of electron beam application in food processing, industry and environmental conservation fields in Asian countries. There is the following aspects maybe member countries interest: Food irradiation and sterilization of healthcare products, feasibility study for EB investment, application of EB in industry in more details (type of accelerator, its parameters for each application, EB accelerator suppliers at present in the world, etc.).

This RCA/UNDP project provided good opportunities for member countries to send their researchers to participate in training course with high quality and helpfulness. The knowledge and skills gained from these training courses surely have very important meanings for the application of EB accelerators in member countries today and also in future.

Upon the above assessment it is necessary to set up other RCA/UNDP project to promote the application of EB accelerator in member countries. .

4.8 Photos



Equipment for production of Production of cotton with surface- grafted nano-silver at VINAGAMMA



Bedspreads made from cotton with surface- grafted nano-silver are tested in a hospital in Vietnam



Fertilizers NanoPolodon and NanoStach produced by EB irradiation at VINAGAMMA



Bedspreads made from cotton with surface- grafted nano-silver are tested in a hospital in Vietnam



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