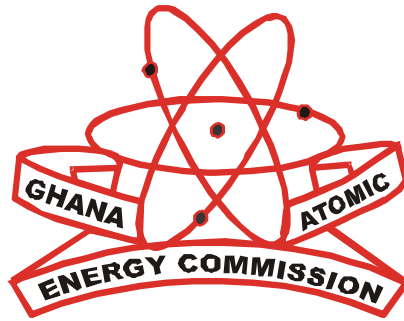


RADIATION PROTECTION INSTITUTE

ANNUAL REPORT FOR 2014

GHANA ATOMIC ENERGY COMMISSION



RADIATION PROTECTION INSTITUTE ANNUAL REPORT FOR THE YEAR 2014

Executive Summary

The Radiation Protection Institute (RPI) of the Ghana Atomic Energy Commission was established to provide the scientific and technical support for executing the operational functions of the Radiation Protection Board.

The operational activities of the Institute for the year 2014 include:

- One hundred and fifty-two (152) authorizations to possess and/or use irradiating devices, radiation sources and radioactive materials. There were also regular compliance inspections to ensure protection of radiation workers, patients, the public, and the security and safety of radiation sources. Sixty-five (65) permits were granted for import, export, and transport, construction and transfer of radioactive materials.
- A total of One thousand, Two hundred and Twenty-Three (1223) food samples and industrial raw materials were analyzed and certificates issued for radioactivity contamination.
- Individual or personal monitoring was provided for One thousand, Five hundred and Ninety-Three (1,593) occupationally exposed workers in Ghana.
- Forty-Eight (48) radiation survey meters were calibrated using the facilities at the Secondary Standards Dosimetry Laboratory (SSDL).
- Eight Hundred and Ninety-Eight (898) Base Stations were monitored during the year under review and permits issued for installation of masts were four-hundred and eighty-seven.
- Twelve (12) research projects were undertaken to enhance protection and safety of radiation workers, patients and the general public. Fourteen (14) articles in referred Journals, Seventeen (17) conference papers and nine (9) technical reports were published
- There were Six (6) National Training Courses organized by RPI for end user Institutions for their specific applications. In addition RPI hosted two (2) IAEA training workshops
- The internally generated funds from the service activities were used to support and sustain the regulatory, service, research and development activities of the institute.

1. ESTABLISHMENT

The Radiation Protection Board (RPB) was established in 1993 by PNDC Law 308 as the National Competent Authority for Authorization and Inspection of practices using radiation sources and radioactive materials in Ghana. The PNDC law 308 was an amendment of the Atomic Energy Act 204 of 1963, which has been replaced by the Atomic Energy Act 588 of 2000. The mandate and responsibilities of RPB are prescribed in the LI 1559 issued in 1993. The operational functions of the Board are carried out by the Radiation Protection Institute (RPI), which was established under the Board to provide technical support for the enforcement of the legislative instrument, LI 1559.

2. VISION AND MISSION

2.1 Vision

To be recognized internationally and nationally as the leading Ghanaian Competent Authority for the protection against ionizing radiation, safety and security of radioactive materials and nuclear installations.

2.2 Mission

To provide an effective national regulatory framework for the protection of people, property and the environment, and the safety and security of radioactive materials and nuclear installations.

2.3 Strategic Objectives

The strategic objectives of the RPI are based on the philosophy that the organisation must proactively respond to the external environment while being realistic in terms of its ability and resources to do so in the internal environment. This requires RPI to take advantage of opportunities, both existing and projected, while minimising the impact of threats. It must pursue the opportunities not only on the basis of their attractiveness, but must also be realistic about its internal strengths and weaknesses and all other constraints.

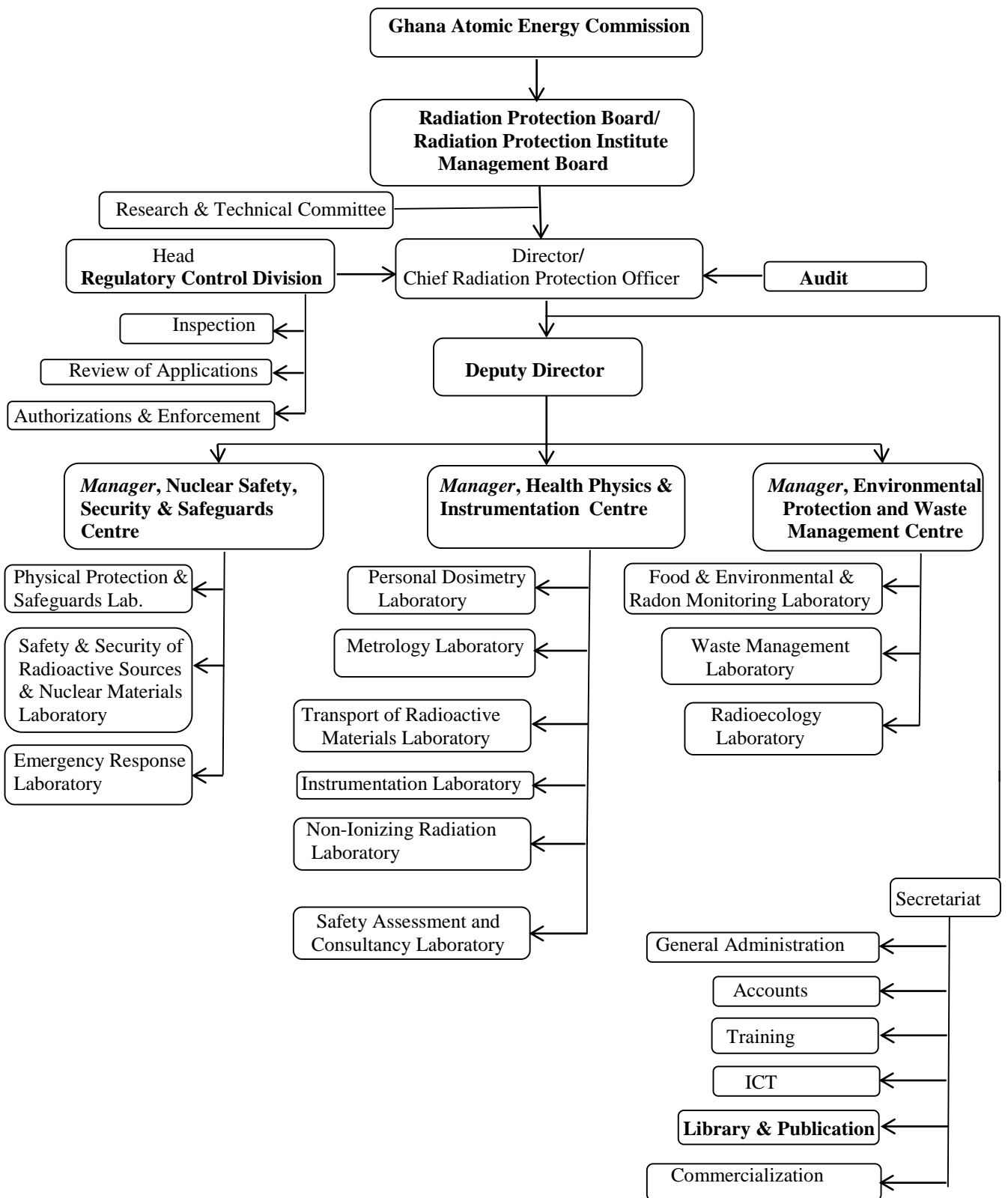
2.4 Specific Strategic Plans

- To initiate and draw up protection strategies on radiation.
- To harmonize the interest of state agencies concerned with the utilization of radiation.
- To license users, supervise and monitor the use of irradiating devices and radioactive materials.
- To ensure that operations relating to irradiating devices and radioactive materials are carried out without risk to public health and safety and that devices, plants, installations and facilities are designed, constructed, calibrated and operated in accordance with international and national standards.
- To advise the Secretary for Land and Natural Resources concerning granting of licenses for mining radioactive minerals.
- To keep a register of owners of irradiating devices, radioactive materials and other sources of ionizing radiation imported into or manufactured in Ghana and of premises licensed to dispose of radioactive waste.

3. PERSONNEL AND ORGANIZATION

The RPI operates under a Directorate and three Scientific and Technical centers shown in the following organizational structure:

Organizational Structure of Radiation Protection Institute



3.1 **Staffing**

The number of Staff in the Institute stood at eight-two (82) as at 31st December 2014, excluding four (4) casual workers.

<u>Position</u>	<u>No.</u>
Director	1
Deputy Director	1
Scientific Staff	47
Technologists/Technicians	11
Administrative Support Staff	<u>22</u>
Total	<u>82</u>

3.1.1 **Promotions / Separation**

The following members of Staff were promoted during the year under review:

No.	Name	Promoted	
		From	To
1.	Mrs. Clara Torto	Administrative Assistant	Senior Administrative Assistant
2.	Mr. Michael Obeng	Principal Technologist	Chief Technologist
3.	Ms. Lilian Agyeman	Technologist	Senior Technologist
4.	Ms. Bernice Agyeman	Technologist	Senior Technologist
5.	Mr. Kwame Appiah	Senior Technologist	Principal Technologist
6.	Dr. Owusu Banahene	Research Scientist	Senior Research Scientist

Separation

Mr. John Mensah Titiati a Technologist was relieved of his duties as a technologist in the Commission.

Transfer

Ophelia Abrafi Agyare (Mrs.) was transferred from GAEC Secretariat to RPI

3.1.2 **Study Leave**

The following officers were on study leave:

- Mr. James Annkah
- Mr. Daniel Adjei
- Mr. Cyrus Cyril Arwui
- Mr. Tajudeen Amadu Annafi

3.2 **Meetings**

The following meetings were held during the year under review:

<u>Board/Committee</u>	<u>No. of Meetings</u>
Management Board	1
Research & Technical	1
Administrative Committee	2
General Staff	2

3.3 Transport

One (1) Navara Pickup was acquired during the year to further facilitate the operations of the Institute.

4. MAJOR ACTIVITIES

The major activities undertaken by RPI for the year 2014 include:

- Authorize the possession and use of radiation sources and irradiating devices within practices
- Conduct regulatory inspections and safety assessments for purposes of authorization and enforcement of the requirements of the LI 1559 of 1993.
- Promote human resource development in radiation protection and safety by promoting training of regulatory staff and organizing courses for registrants and licensees.
- Carry out radiation and waste safety services, and
- Carry out relevant research to enhance protection of workers, patients, the public and the environment from the harmful effects of ionizing radiation and the safety and security of radiation sources.
- Carried out safety assessment and monitoring of mobile phone base stations in Ghana

4.1 Regulatory Activities

The Regulatory Control Division was set up to

- Implement a system of Notification and Authorization by registering or licensing established for the control of irradiating devices and radioactive materials imported into the country for medical and other purposes, radiation sources used for moisture/thickness/leveling gauging in industry, in agriculture, research and teaching.
- Review all application for Authorization
- Implement a system of pre-authorization inspection, safety assessments and regular inspections established.
- Implement a system of compliance monitoring and enforcement procedures established to ensure compliance with regulatory requirements.
- Prepare Radiation Protection and safety Guides, which are issued to assist registrants and licensees to comply with regulatory requirements.
- Conduct Research into Radiation Protection methods and other Health Physics issues

The regulatory activities undertaken during the year is summarized in the following sections.

4.1.1 Authorizations

During the year under review a number of facilities were authorized to use irradiating devices and radioactive sources. List of facilities authorized is shown in Appendix 2. Additionally, permits to construct facilities and to import, export and transport radioactive sources were issued. Details are shown in figure 1.

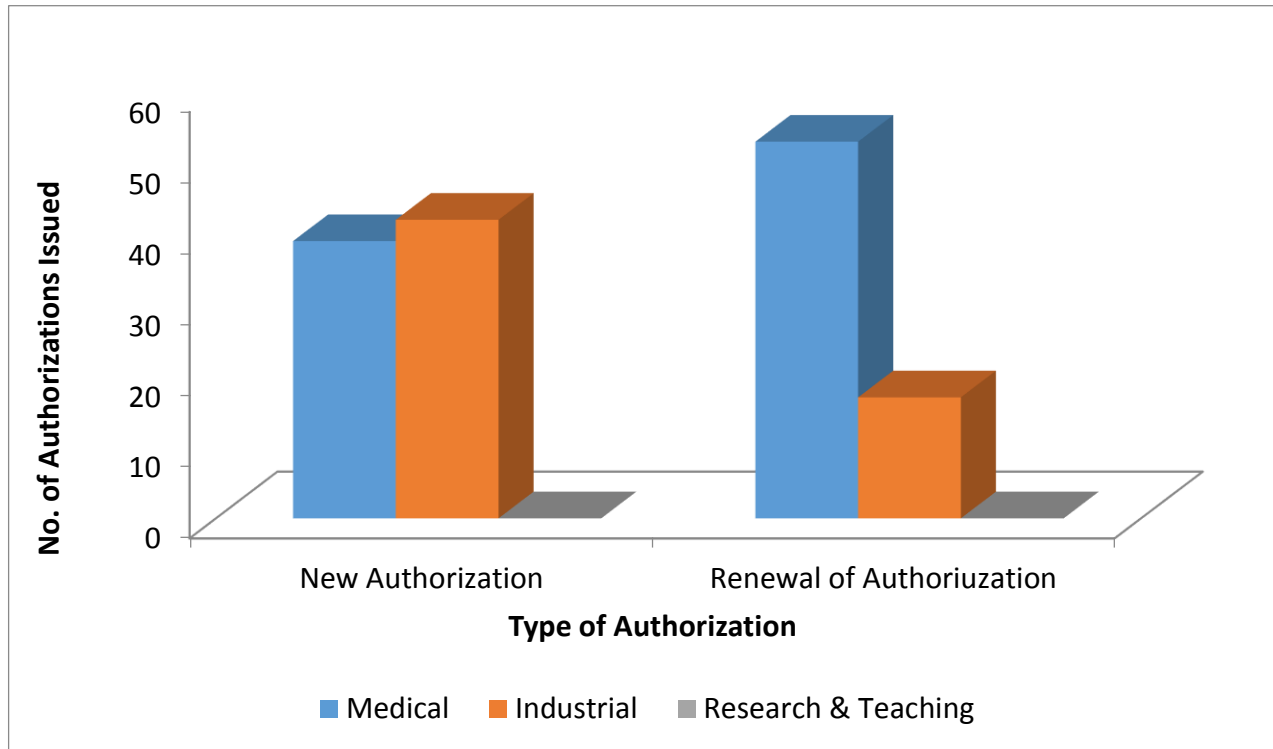


Figure 1: Different types of authorisation during the year 2014

Permits

During the year under review a total of 65 permits were issued. These consist of import, export, transport, construction, storage and installation. Figure 2 shows a break down of the different permits issued for the different practices.

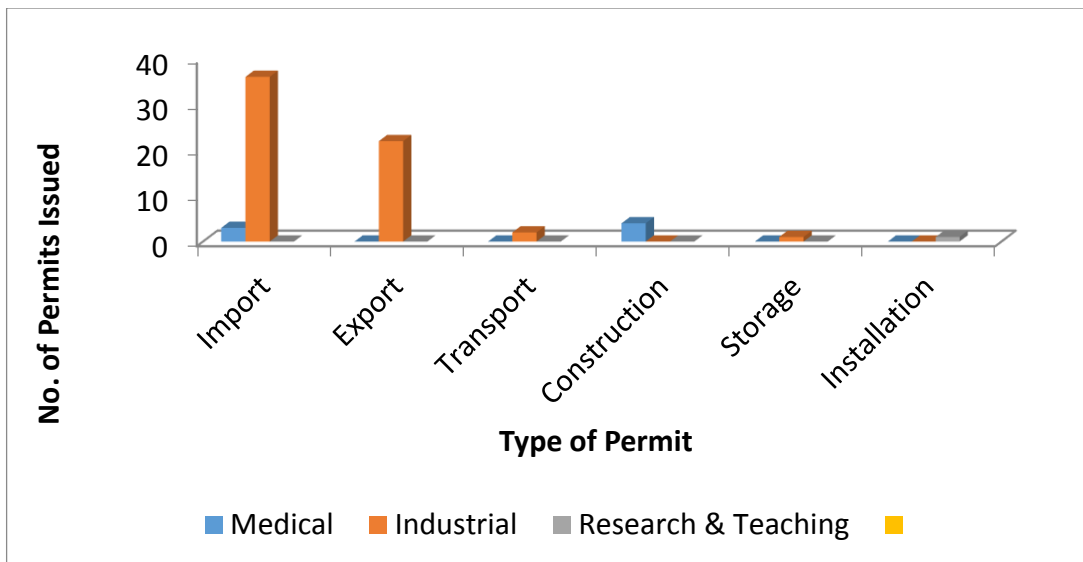


Figure 2: Different types of permits issued during the year 2014

4.2.3.1 Common Non-Compliance Issues Observed

Technical and Safety Infractions

- Absence of radiation warning light.
- Light leakage around the darkroom.
- Collimator field light was off.
- Absence of radiation protection door.
- Absence of a timer and thermometer for use in the darkroom during film processing.
- Absence of collimator light.
- Inappropriate positioning of safe light
- High temperature in x-ray room and darkroom due to absence or faulty air-conditioners
- Absence of radiation warning signs at access points to the X-ray facility.
- Absence of quality control procedures.
- Unavailability of a survey meter in the department to carry out scatter measurements.
- Survey meter out of calibration or not calibrated.
- Absence of lead aprons and other protective clothing

Security Infractions

1. Absence of emergency plan to deal with the following scenarios
 - The gauge or source that has been lost or stolen.
 - Physical damage to a source housing that has been crushed or involved in a fire or explosion.
 - Leaking of radioactive substance / material from the source.
 - The discovery of unacceptable high dose rates after a shutter or warning signal failure.
 - The exposure of a person because of failure of the requirements or procedures.
2. Absence of an area monitoring device.
3. Lost Source

Administrative Infractions

- Facilities operating without authorization.
- Absence of radiation protection programme.
- Absence of area and contamination monitoring records.
- Absence of local rules.
- Absence of a medical physicist and/or radiation safety officer.
- Warning signs and local rules are not translated into the local languages.
- Absence of emergency procedures.
- Authorization certificate not framed and posted within the control area of the facility.

4.2 Service Activities

The following were the service activities undertaken during the year 2014.

4.2.1 Food Monitoring

The Environmental Protection and Waste Management Center undertakes Radioactivity Contamination Tests on some imported food and food products and others destined for export to quantify the levels of radioactivity. Some of the products include meat, milk and milk products imported into Ghana and Nestle Products such as Milo, Nescafe, Cerelac and other food products exported to other countries. The monitoring is carried out to quantify the levels of Cs-137 and Cs-134 in the products. The monitoring became necessary as a result of past nuclear accidents such as the Chernobyl accident in 1986, the latest one in Fukushima as well as other past nuclear activities. During the year 2014, a total of **1223** samples were monitored to determine radioactivity in them. This includes both imports and exports with the breakdown as shown in Table 1 and Figure 1.

The details of the break down are as shown in Table 1.

Table 1: Radioactivity Contamination Monitoring data for 2014.

Products	Quantity Monitored	Cs-137 Range of Activity Concentration (Bq/kg)	Cs-137 Average Concentration (Bq/kg)
Beef/Meat	36	0.82±0.03 – 1.25±0.05	1.04±0.04
Poultry	93	0.95±0.05 – 1.53±0.04	1.24±0.05
Pork	2	0.89±0.03 – 1.04±0.02	0.96± 0.03
Tuna	118	0.35±0.01 – 0.90±0.05	0.63±0.03
Milo Actigen	17	0.20±0.01 – 0.45±0.03	0.33±0.02
Milk/Dairy	792	0.63±0.03 – 0.98±0.04	0.81±0.04
Nescafe	123	0.53±0.03 – 0.88±0.04	0.86±0.04
Cerelac	42	0.30±0.01 – 0.55±0.03	0.43±0.02
Total	1223		

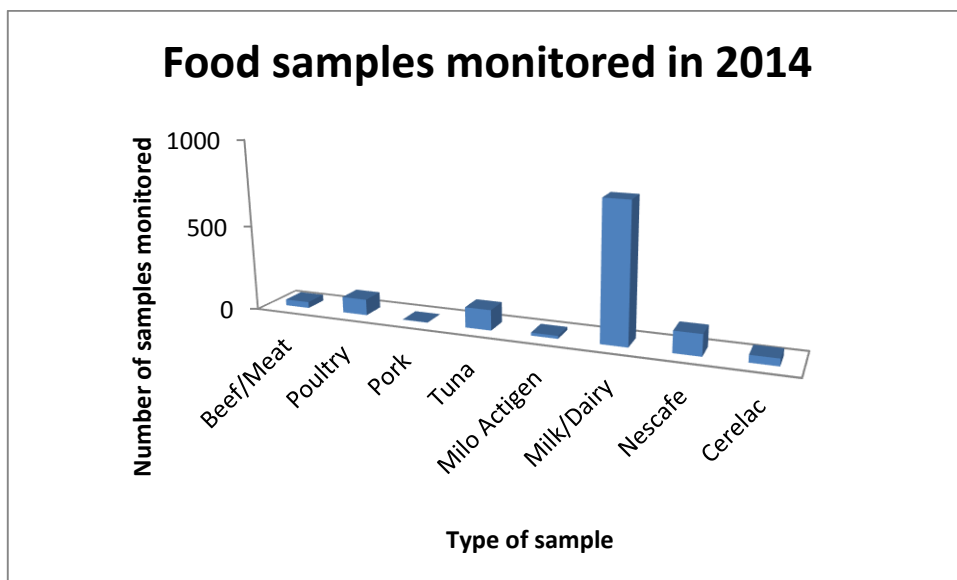


Figure 1: Number and types of food samples monitored in 2014

Table 2: Research activities undertaken by the Centre as well as students research project in 2014.

ACTIVITY/Client	PURPOSE	FREQUENCY	% USE	
GM TUBE				
MPhil Radiation Protection (SNAS)	SNAS Students Training	8	0.59	1.10
MPhil Nuclear Engineering and Applied Physics (SNAS)	SNAS Students Training	7	0.51	
NaI Detector				
MPhil Nuclear and Radiochemistry (SNAS)	SNAS Students Training	6	0.44	0.44
LSC				
MPhil Nuclear and Radiochemistry (SNAS)	SNAS Students Training	3	0.22	0.22
Imatic Gross-Alpha-Beta				
National Radioactive Waste Management Centre (NNRI)	Safety Assessment	10	0.73	8.78

Newmont Golden Ridge Ltd, Akyem	Commercial/Research: <i>Baseline radioactivity measurement in the vicinity of Akyem Gold Mine of Newmont Gold Ridge</i>	49	3.58
Radiation Protection (SNAS)	Student Research: <i>Radiological impact of small scale mining activities at Dunkwa-on-Offin in the Central region of Ghana.</i>	12	0.88
Kwame Nkrumah University of Science and Technology (KNUST)	Student/Research: <i>Concentration of heavy metals and radio nuclide in underground water in Ejisu Juabeng District</i>	8	0.59
Perseus Mining Ghana Ltd	Commercial/Research: <i>Assessment of natural radioactivity level in soil rocks and water of eastern pit operations and surrounding areas of Perseus Gold Mine, Ghana</i>	10	0.73

Other activities undertaken by the Centre in 2014 are shown in Table 3.

Table 3: Other activities carried.

ACTIVITY	PURPOSE	FREQUENCY	% USE	ACTIVITY
Voltic mineral water	Commercial	1	0.07	Assessment of natural radioactivity
Northern Region	Research	23	1.68	
Volta Region	Research	7	0.51	

4.2.2 The Health Physics and Instrumentation Centre consists of the following laboratories:

- Radiation Metrology Laboratory
- Personal Dosimetry Laboratory
- Instrumentation Laboratory
- Non-ionising Radiation Laboratory
- Safety Assessment and Consultancy Laboratory

The Mission of the Centre is to promote Health Physics Research and Application in ionising and non-ionising radiation for the protection of patients, workers, public and the environment.

Under the year under review the following service activities were undertaking:

- i. Calibration of radiation survey meters for industries
- ii. Personnel monitoring of occupationally exposed workers in Ghana
- iii. Mobile Phone Base station monitoring for some telecommunication companies in Ghana
- iv. Safety Assessment for telecommunication companies
- v. Repairs and Maintenance
- vi. Public Education

4.2.2.1 Calibration Services

In the course of the year, the centre calibrated 48 radiation monitoring instruments and 20 TLD badges for a number of institutions. These are shown in Table 1:

Table 1: Instruments Calibrated

Client	Number of Equipment calibrated	Type of Equipment
1. Golden Star Bogoso	1	Radiation Survey Meter
2. Halliburton Int Inc	4	Radiation Survey Meter
3. Ghana Revenue Authority	4	Radiation Survey Meter
4. Nick-TC Scan Ltd	2	Radiation Survey Meter
5. Gateway Services Ltd	2	Radiation Survey Meter
6. Perseus Mining Ghana Ltd	1	Radiation Survey Meter
7. Newmont Ghana Ltd	1	Radiation Survey Meter
8. NNRI	4	Radiation Survey Meter
9. Reactor Centre	2	Radiation Survey Meter
10. Waste Management Centre	3	Radiation Survey Meter
11. Baker-Hughes	6	Radiation Survey Meter
12. BIVAC International Ghana Ltd	1	Radiation Survey Meter
13. RTC, BNARI	1	Radiation Survey Meter
14. Goldfield Ghana Ltd	3	Radiation Survey Meter
15. EPWMC, RPI	1	Radiation Survey Meter
16. NSSSC, RPI,	1	Radiation Survey Meter
17. RCD, RPI	1	Radiation Survey Meter
18. WBHO Ghana	1	Radiation Survey Meter
19. Golden Star, Wassa	1	Radiation Survey Meter
20. Newmont Golden Ridge Ltd	4	Radiation Survey Meter

4.2.2.2 Personnel Monitoring

During the year under review 1593 occupationally exposed workers were monitored using TLD badges. Figure 1 shows the distribution of the different categories of workers being monitored.

Medical	906
Radiotherapy & Nuclear Medicine	148
Research & Teaching	246
Industrial	<u>293</u>
Total	1593

PERSONNEL MONITORED IN 2014

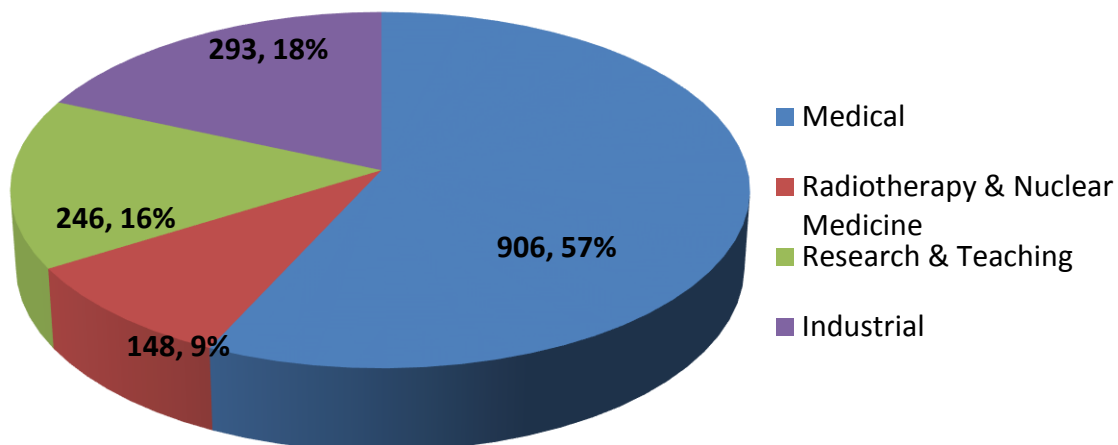


Figure 3: Distribution of Different Practices Monitored

4.2.2.3 Mobile Phone Base Station Monitoring

Safety evaluation and assessment were conducted on a number of Mobile Phone Base stations for a number of companies as shown in Table 1. ICNIRP Compliance certificates were issued for 498 sites as shown in Table 2

Table 1: Base Stations Monitored

REGION	MTN SITES	VODAFONE SITES	AIRTEL SITES	TIGO SITES	GLO SITES	TOTAL SITES
Upper East	21	2	7	2	3	35
Upper West	9	2	9	2	3	25
Northern	39	2	35	5	4	85
Ashanti	57	16	44	18	16	151
Western	40	7	28	12	6	93
Central	39	9	14	8	6	76
Brong Ahafo	52	7	27	8	4	98
Eastern	-	-	-	-	5	5
Volta	33	5	11	5	5	59
Eastern	40	11	21	8	5	80
Greater Accra	70	19	56	28	18	191
TOTAL	400	80	252	96	70	898

Table 2: Pre-installation Assessments and Permits

Permits	
Region	No
Accra	87
Eastern	36
Ashanti	75
Central	34
Western	71
Brong Ahafo	59
Northern	44
Upper East	31
Upper West	9
Volta	41
Total	487

4.3. Research Activities carried out in 2014

During the year under review undertook a number of research activities including:

- (a) Baseline radioactivity measurement in the vicinity of Akyem Gold Mine of Newmont Golden Ridge Limited, Ghana

Investigators: A. Faanu, O.K. Adukpo, C. Kansaana L. Tettey-Larbi, H. Lawluvi, D. O. Kpeglo, E. O. Darko, G. Emi-Reynolds, R.A. Awudu, P. Atta-Amoah, A. O. Efa, A. Ibrahim, B. Agyeman, R. Kpodzro, L. Agyeman

- (b) Assessment of natural radioactivity levels in soils, rocks and water of eastern pit operations and surrounding areas of Perseus Gold Mine, Ghana.

Investigators: A. Faanu, O.K. Adukpo, L. Tettey-Larbi, H. Lawluvi, D. O. Kpeglo, E. O. Darko, G. Emi-Reynolds, R.A. Awudu, C. Kansaana, P. Atta-Amoah, A. O. Efa, A. Ibrahim, B. Agyeman, R. Kpodzro, L. Agyeman

- (c) Radiological impact of small scale mining activities at Dunkwa-on-Offin in the Central Region, Ghana

Investigators: E. Marfo, E. O. Darko, A. Faanu, O.K. Adukpo, C. Kansaana L. Tettey-Larbi, H. Lawluvi, D. O. Kpeglo, G. Emi-Reynolds, P. Atta-Amoah, A. O. Efa, A. Ibrahim, B. Agyeman, R. Kpodzro, L. Agyeman

- (d) Dose Assessment of natural radioactivity in fly-ash and environmental materials from Mompule Coal Power Station, Botswana

Investigators: J. Mudiwa, E. O. Darko, A. Faanu, O.K. Adukpo, C. Kansaana L. Tettey-Larbi, H. Lawluvi, D. O. Kpeglo, G. Emi-Reynolds, P. Atta-Amoah, A. O. Efa, A. Ibrahim, B. Agyeman, R. Kpodzro, L. Agyeman

- (e) Determination of ^{222}Rn and ^{220}Rn in soil and water samples from Newmont Gold Mine, Ghana
- Investigators: W. Bekelei, A. Faanu, O.K. Adukpo, C. Kansaana L. Tettey-Larbi, H. Lawluvi, D. O. Kpeglo, E. O. Darko, G. Emi-Reynolds, P. Atta-Amoah, A. O. Efa, A. Ibrahim, B. Agyeman, R. Kpodzro, L. Agyeman
- (f) Modeling radionuclide transport and dose assessment in ground water system in a gold mine, Burkina Faso
- Investigators: K. Kabore, E. O. Darko, A. Faanu, O.K. Adukpo, C. Kansaana L. Tettey-Larbi, H. Lawluvi, D. O. Kpeglo, G. Emi-Reynolds, P. Atta-Amoah, A. O. Efa, A. Ibrahim, B. Agyeman, R. Kpodzro, L. Agyeman
- (g) Environmental and health related assessment of NORMS and trace elements from Pozzolana industry, Ghana
- Investigators: N. Natharius, S. Bamford, E. O. Darko, A. Faanu, O.K. Adukpo, C. Kansaana L. Tettey-Larbi, H. Lawluvi, D. O. Kpeglo, G. Emi-Reynolds, P. Atta-Amoah, A. O. Efa, A. Ibrahim, B. Agyeman, R. Kpodzro, L. Agyeman
- (h) Assessment of exposure of children to NORMS and trace elements from basic schools playing ground in the Ga-East District, Accra, Ghana
- Investigators: A. E. E.Taapopi, A. Faanu, O.K. Adukpo, C. Kansaana L. Tettey-Larbi, H. Lawluvi, D. O. Kpeglo, E. O. Darko, G. Emi-Reynolds, P. Atta-Amoah, A. O. Efa, A. Ibrahim, B. Agyeman, R. Kpodzro, L. Agyeman
- (i) Radiation Dose Rate measurements around portions of the residential area near a nuclear Installation using an Atomtex AT6101C
- Investigators: A. Daniel Nii Adjei, Ann Mensah, Paul Atta Amoah, Simon Adu, Kwame Appiah, Raymond Agalga, Sheila Victoria Gbormittah
- (j) Monte Carlo Investigation into Scatter Radiation from CT Fluoroscopy Gantry
- Investigators: Prince K. Gyekye, Frank Becker*, G. Emi-Reynolds, Stefan Poelz*
*Karlsruhe Institute of Technology, Germany
- (k) Investigating into dose reduction techniques for staff and patient during Computed Tomography-Fluoroscopy procedures
- Investigators: Prince K. Gyekye, Frank Becker*, G. Emi-Reynolds, Cyril Schandorf
*Karlsruhe Institute of Technology, Germany
- (l) Development of fundamental requirements for sustainable Security Regime for the application of nuclear and other radioactive materials in Ghana (“Search and Secure”).
- Investigators: A. Daniel Nii Adjei, Ann Mensah, Paul Atta Amoah, Simon Adu, Kwame Appiah, Raymond Agalga, Sheila Victoria Gbormittah

(m) Radiation dose rate measurements around portions of the residential area near a nuclear installation using an Atomtex AT6101C spectrometer (a study on portions of the residential area on the Ghana Atomic Energy Commission premises).

Investigators: A. Daniel Nii Adjei, Ann Mensah, Paul Atta Amoah, Simon Adu, Kwame Appiah, Raymond Agalga, Sheila Victoria Gbormittah

(n) Performance Characteristics of a Portable High Purity Germanium Detector (HPGe) compared with the Standardized High Purity Germanium Detector at the Radiation Protection Institute of the Ghana Atomic Energy Commissions.

Investigators: A. Daniel Nii Adjei, Ann Mensah, Paul Atta Amoah, Simon Adu, Kwame Appiah, Raymond Agalga, Sheila Victoria Gbormittah

(o) Security of Radioactive Sources: Observations and Recommendations on Two (2) Breweries in the Greater Accra Region of Ghana

Investigators: Daniel Nii Adjei, Ann Mensah, Paul Atta Amoah, Simon Adu, Kwame Appiah, Raymond Agalga, Sheila Victoria Gbormittah

(p) Radiation Exposure from Computed Tomography Practices in Ghana

Investigators: D.F. Charles, C. Schandorf, A. Nkansah, P. Manteaw

(q) Survey of Computed Tomography Doses and Establishment of the National Reference Dose Levels from Computed Tomography Examinations in Ghana

Investigators: D.F. Charles, C. Schandorf, A. Nkansah, P. Manteaw

5. ON-GOING RESEARCH PROJECTS AND PROGRAMS FOR 2015

Current on-going research activities and programs for 2015 are focused on five main thematic areas namely:

- (a) Medical exposure control in diagnostic radiology and radiotherapy
- (b) Public exposure to radioactivity in the environment and waste management
- (c) Occupational exposure control in medical, industrial, research and teaching
- (d) Exposure to non-ionizing radiation from mobile phones and base stations.
- (e) Nuclear Safety, Security and Safeguards

In the light of the aforementioned areas the following specific Projects are the planned Research Activities For 2015

1. Site Development of fundamental requirement for sustainable Security Regime for the application of nuclear gauges in Ghana (Search and Secure of orphan sources).
2. Development of modules for the Nuclear Security certificate training program for teaching at the School of Nuclear and Allied Sciences on nuclear security and also for training stakeholder Organizations.
3. Status of nuclear security at border points in Ghana; Destination Inspection

4. Development of Ghana Atomic Energy Commission Characterization.
5. Transit dosimetry in Co-60 high dose rate brachytherapy
6. Drafting a radiation protection program for a Radiation Protection program for LEU Miniature Source Reactor.
7. Estimating Lifetime Cancer Risks for Occupationally Exposed Workers at GHARR-1
8. Assessment of Occupationally Exposed Workers' (OEWs) satisfaction with the Personal monitoring services in Medical facilities within the Greater Accra Region
9. Developing an accelerometer which would be used in measuring variation in the earth's motion (with respect to acceleration) in researches related to geology and seismology.
10. A study to enhance the Regulatory supervision of the Radioactive and Waste Management Centre of the Ghana Atomic Energy Commission with the main aim of ensuring the safety of staff working in and around the centre.

6 Postgraduate Programs

Staff of the Radiation Protection Institute are involved in lecturing at the Graduate School of Nuclear and Allied Sciences (SNAS) and supervision of MPhil and PhD research projects.

7. INCOME AND EXPENDITURE STATEMENT

The following is a summary of the financial statement in the year 2014.

7.1 Income

		GH¢	GH¢
Government Subvention			
Compensation	-	NIL	
Goods & Services	-	NIL	
Internally Generated Fund	-	1,860,519.19	
Total			1,860,519.19
			=====

7.2 Expenditure

Compensation	-	NIL	
Administrative Activity	-	1,080,485.11	
Service Activity	-	718,054.94.	
Capital Expenditure	-	501,497.56	
Total			2,300,037.61
			=====
Excess Expenditure over Income	-		(439,518.42)
			=====

8. PHYSICAL DEVELOPMENT

The following physical development activities were carried out:

- a) Refurbishment of House No. 1 to accommodate staff of the new Regulatory Authority.

9. HUMAN RESOURCE DEVELOPMENT

9.1 National Training Courses/Seminars/Workshops/Conferences/Meetings organized by RPI

- (a) Radiation Safety Training for the RPO of Anglogold Ashanti-Iduapriem Ltd 10th-14th February, 2014
- (b) Radiation Safety training course for the staff of Adamus Resources Limited 10th – 19th February 2014
- (c) Workshop on fundamentals of Reactor Regulation and fundamentals of Reactor Safety Accra – Ghana 12th - 16th May 2014
- (d) Radiation Protection training course for the RPO of Sweden Ghana Medical Centre Limited 4th -6th November 2014
- (e) Radiation Safety Training for the Staff of Chirano Gold Mines Ltd
- (f) Editors' Forum to enlighten the Ghanaian media on Nuclear Power Development, Hephzibah Christian Centre, Aburi on 15th July 2014

9.2 IAEA Training Courses, fellowships workshops hosted by RPI

- (a) USNRC/IAEA Workshop on the Review of Application for the Siting of a Nuclear Power Station, Accra, Ghana from 25th to 29th August, 2014
- (b) IAEA Regional Workshop on the Control of Sources Network and RASIMS in Accra Ghana from 17th to 21st November, 2014

9.3 IAEA Fellowship Training/Training Courses, Workshops, Meetings, Conferences and Seminars attended by Staff of RPI

- (a) **G. Emi-Reynolds**
 - Technical Meeting on Topical Issues in the Development of Nuclear Power Infrastructure, 4th to 7th February 2014. Vienna, Austria
 - Annual Meeting of the International Network for Nuclear Security Training and Support Centres, 9th to 21st February 2014 Vienna, Austria
 - Consultancy Meeting for the Nuclear Security Document on Capacity Building, 24th to 28th February 2014 Vienna, Austria
 - 6th Convention on Nuclear Safety Review and the Commission on Safety Standards Meeting, 24th March to 12th April 2014, Vienna, Austria
 - Nuclear Security Guidance Committee Meeting, 16th – 20th June 2014, Vienna Austria

- International Conference on Nuclear Forensics, 7th to 11th July 2014 Vienna, Austria
- 2nd International Workshop on Additional Protocol Implementations in Chicago, USA, 4th to 8th August 2014
- International Network of Nuclear Security Support Centres and Centre of Excellence, 18th to 22nd August 2014, Vienna, Austria
- Technical Meeting of Review Draft Implementing Guide on Developing a National Framework for Managing Nuclear Security, 25th to 29th August 2014, Vienna, Austria
- General Conference, 21st to 26th September 2014 Vienna, Austria
- Core Conversion of the Research Reactor , 1st to 2nd October 2014, Vienna, Austria

(b) Emmanuel Ofori Darko

- IAEA Consultancy meeting related to the preparation of the IAEA Comprehensive Report on TEPCO's Fukushima Daiichi Accident, 22 - 24 January 2014, Tokyo, Japan.
- IAEA 5th Working Group Meeting of the TEPCO Fukushima Comprehensive Report, 10-14 February 2014 Vienna, Austria
- Organizational Meeting of the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, 14-15 May 2014, IAEA, Vienna, Austria
- Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management. Second Extraordinary Meeting of the Contracting Parties, 12–13 May 2014, IAEA, Vienna, Austria.
- First Regional Coordination Meeting of RAF9051 to Discuss National Radiation Protection Systems related to Thematic Safety Area 4 (TSA 4), 14-18 July 2014, Arusha, Tanzania.
- 6th Working Groups meeting of the IAEA Fukushima Comprehensive Report, IAEA, Vienna, Austria, 20-31, May 2014.
- Open-Ended Meeting of Legal and Technical Experts to Develop Internationally Harmonized Guidance for Implementing the Recommendations of the Code of Conduct on the Safety and Security of Radioactive Sources in relation to Long-Term Management of Disused Sealed Sources, 20-23 October 2014, IAEA, Vienna, Austria.
- IAEA Regional workshop on control of radiation sources network (CSN) and radiation safety information management system (RASIMS), Accra, Ghana, 17-21 November, 2014 (Course Director)

(c) Simon Adu

- NENE 2014: 23rd Conference Nuclear Energy for New Europe, 8-11 September, 2014, Portoroz, Slovenia
- Sub-Regional workshop to familiarize members states in africa to the Integrated Nuclear Security Support Plan (INSSP) Concept; 3-5 June, 2014 Accra Ghana
- IAEA International Training Course on Radiation detection Techniques: Team Leader Training, Vienna, Austria 25-27 March, 2014.

(d) Emmanuel Akrobortu

- **IAEA Regional Meeting (RAF9053)** as a Participant on Patient and Occupational Radiation Protection in Image Guided Interventional Procedures, Dar es Salaam, United Republic of Tanzania. From 7th – 11th April, 2014.

- **IAEA Regional Workshop C7-RAF-9.048-001** as a Participant on Train-the-Trainers for Radiation Protection Officers, Harare, Zimbabwe. From 24th – 28th November, 2014.
- (e) **Augustine Faanu**
- International Experts Meeting on Radiation Protection after the Fukushima Daiichi Accident at the IAEA Headquarters in Vienna, Austria from 17 to 21 February 2014 **co-chair of a session.**
 - IAEA Regional Workshop on establishing a National Strategy for Education and Training in Radiation, Transport and Waste Safety 17- 20 June 2014, Arusha, United Republic of Tanzania as a **participant and chair of a session.**
 - Workshop on the Application of the IAEA Methodology and Safety Assessment Framework (SAFRAN) Tool for Safety Case (SC) and Safety Assessment (SA) for Predisposal Management of Disused Sealed Radioactive Sources (DSRS) Athens, GREECE 23-27 June 2014
 - TC Support to Technical Meeting on the Harmonisation of Reference Levels for Foodstuffs and Drinking Water Contaminated Following a Nuclear Accident, Vienna, Austria, 8-12 September 2014
 - SCIENTIFIC VISIT to Malaysia at Malaysian Nuclear Agency from 22-26 September 2014 to under the overall organization of the PGEC.
 - United States of Americas’ National Nuclear Security Administration Outreach Workshop in Athens, Greece, 4-6 November 2014
 - Regional (AFRA) Training Course on Train-the-Trainers for Radiation Protection Officers, Harare, Zimbabwe, 24-28 November 2014 **as an Expert**
 - Regional Meeting of Focal Points of AFRA Regional Designated Centres (RDCs) And Project Scientific Consultants (PSCs), Vienna Austria, 1-5 December 2014
- (f) **Adriana Nkansah**
- Radiological accidents associated with the use of Gammagraphy Technique in NDT 3rd September, 2013
 - IAEA workshop on safe disposal of radioactive waste, Ghana in perspective. 9TH October, 2014
- (g) **Ann E. Amekudzie**
- Editors’ Forum on Nuclear Power as a source of energy in Ghana 15th July, 2014
- (h) **Prince Gyekye**
- IAEA PhD Sandwich fellowship in Karlsruhe Institute of Technology, Karlsruhe, Germany, 18th March – 18th September, 2014.
 - Training Programme for Radiation Protection Officer of Sweden Ghana Medical Centre, Accra. 4th – 5th November, 2014
- (i) **Abdel R. Awudu**
- International Experts’ Meeting on Severe Accident Management in the Light of the Accident at the Fukushima Daiichi Nuclear Power Plant Organized in connection with the implementation of the IAEA Action Plan on Nuclear Safety, Vienna, Austria, 17th -21st March 2014
 - Regional Training Course on Effective and Sustainable Regulatory Control of Radiation Sources, Port Louis, Mauritius, 21th -25th April 2014

- Technical Meeting on the Practical Application of the IAEA'S Nuclear Security Recommendations and Guidelines for the Domestic and Intentional Transport of Nuclear and other Radioactive Material, Vienna, Austria, 10th - 13th June 2014
- IAEA Regional Workshop on establishing a National Strategy for Education and Training in Radiation, Transport and Waste Safety, Arusha, United Republic of Tanzania, 17th -20th June 2014
- Regional Training Course on Self-Assessment of National Regulatory Infrastructures for Safety (SARIS), Tunisia, 23rd – 27th June 2014
- International Conference on Advances in Nuclear Forensics: Countering the Evolving Threat of Nuclear and Other Radioactive Material out of Regulatory Control, Vienna, Austria, 7th – 10th July 2014
- Regional meeting for mid-term review and endorsement of the regional action plan, Mauritius, Port Louis, 21th – 25th July 2014
- Technical Facilities and Activities, Vienna, Austria, 3rd – 7th November 2014

(j) Stephen Inkoom

- International Atomic Energy Agency (IAEA) Sandwich Fellowship Training in Diagnostic Radiology , Crete Greece, from 12th November 2013 to 26th May 2014
- 20th European Congress of Radiology (ECR). March 06-10 2014, Vienna, Austria
- 56th Annual Conference of Ghana Medical Association. November 06-08, 2014 Takoradi, Ghana
- Symposium to mark International Day of Medical Physics (IDMP) organized by the Ghana Society of Medical Physics. November 07, 2014 Accra, Ghana
- National Physics Conference. November 26-28, 2014 Accra, Ghana.

(k) Francis Otoo

- IAEA PhD sandwich fellowship, 30th September, 2013 to March, ARPA, Udine, Italy.
- Entrepreneurship for Scientists and Engineers' from 14-19 July 2014, Biriwa, C/R
- International Conference on Occupational Radiation Protection:Enhancing the Protection of Workers — Gaps, Challenges and Developments 1-5 December, 2014 Vienna, Austria

(l) Alexander Opoku Efa

- Fellowship on Postgraduate Educational Course in Radiation Protection and the Safety of Radiation Sources (PGEC) here in Ghana from 4th November 2013 to 3rd April 2014.
- Genie-2000 Gamma Spectroscopy Software Training Course by Dr. Durim Kryeziu Sales and Technical Support Engineer, 2nd to 6th August, 2014. Accra

(m) Charles Kansaana

- The Genesis of GAEC by Rev. Dr. Akoto Bamford: 25th November, 2014
- Genie-2000 Gamma Spectroscopy Software Training Course by Dr. Durim Kryeziu, Sales and Technical Support Engineer: 2nd to 6th August, 2014, Accra-Ghana

(n) Beinpuo Ernest Sanyare Warmann

- Post Graduate Education in Radiation Protection and Safety of Radiation Sources, October 2014 to February 2015
- (o) **Theophilus Adjirackor**
- A workshop on Control of Source Network (CSN) and Radiation Authority Source Information Management Systems (RASIMS). Organized by IAEA and GAEC/RPI from 17-22 November 2014.
- (p) **Henry Lawluvi**
- IAEA Fellowship, National Nuclear Regulator, South Africa, 18 August – 13 November 2014.
 - Genie-2000 Gamma Spectroscopy Software Training Course, Accra, 2ND – 6TH August, 2014
- (q) **Daniel N. Adjei**
- International Nuclear Security Education Network (INSEN) - King's College London (KCL), Professional Development Course (PDC) on Introduction to Nuclear Security, held in United Kingdom from 6th - 10th January, 2014
 - International School of Nuclear Security: organised by The Abdus Salam International Centre For Theoretical Physics (ICTP) and The International Atomic Energy Agency, (IAEA) in Trieste, Italy from the 28th April, 2014 – 9th May, 2014
- (r) **Oscar Kwaku Adukpo**
- Entrepreneurship Workshop for Scientist and Engineers at African Institute for Mathematical Sciences AIMS-Ghana: 14th to 18th July 2014, Biriwa Ghana
 - Resource person for a refresher Radiation Protection Training Course for the staffs of Chirano Gold Mines, at Chirano, Western Region, from 20th – 23rd October, 2014
 - Resource person for a refresher Radiation Protection Training Course for an officer from AngloGold Ashanti, Iduapriem Ltd, in Accra, from 10th to 14th February 2014.
- (s) **Samuel Wotorchi-Gordon**
- IAEA RAF/9/049 Regional (AFRA) Training Course on Self-Assessment of the National Regulatory Infrastructure for Safety (Saris) attended at Hammamet, Tunisia on 23-27 June 2014.
 - IAEA RAF 9042 Regional Training Course on Regulatory Enforcement held in Khartoum, Sudan, 3rd to 7th August 2014
- (t) **Philip Owusu-Manteaw**
- Regional Training Course on Dose Management and Intercomparison Methodology 19th July 2014,
 - Regional Training Course on Regulatory Enforcement, 25th September 2014.
- (u) **Cynthia Engmann**
- Third World Nuclear University school on Radiation Technologies from 7th – 20th March, 2014 at Doha, Qatar
 - International Workshop on the Lessons Learned from Design Basis Threat Workshops and the Use of a Threat-Based Approach for the Regulation of

Nuclear Material and Nuclear Facilities, Vienna, Austria, 30 June–4 July 2014 (J0-TR-47628)

- Regional Workshop on Control of Sources Network (CSN) and Radiation Safety Information Management System (RASIMS), Accra, Ghana, 17 – 21 November 2014.

(v) Isaac Owusu

- Advanced training course on the application of RAIS 3.3 Web to support the regulatory body management and to enhance the effectiveness of the regulatory system”, Abuja, Nigeria, 2 – 6 June 2014.
- Regional Workshop on Control of Sources Network (CSN) and Radiation Safety Information Management System (RASIMS), Accra, Ghana, 17 – 21 November 2014.

(w) Peter Atta Amoah

- Participation in a Genie – 2000, Gamma Spectroscopy Software Training Course held from the 2nd to 6th of August, 2014.
- Assessment of levels of occupational exposure to radiofrequency fields to workers of two television stations in Accra–Ghana by Samuel Osei: 6th November, 2014, RPI/GAEC.
- Workshop on Safety Assessment for Common Practices Involving the use of Radioactive Sources. As of the time of this report’s preparation, I was still yet to attend the workshop to be held in Mombasa, Kenya from the 8th to 18th of December, 2014

(x) Rita Kwabea Osei

- NORM studies in an offshore oil production field located in the coast of Ghana 23rd October, 2014
- Assessment of Levels of Occupational Exposure to Radiofrequency Fields to Workers of Two Television Stations in Accra – Ghana. 6th November, 2014

(y) Daniel Sika-Boafo

- Fundamentals of Reactor Regulation and Safety Workshop Ghana Atomic Energy Commission, Nuclear Security Support Centre, 12th - 16th May, 2014

(z) Afrifa Yamoah Kyei

- The African scientific renaissance day celebration on the topic Ensuring sustainable energy for accelerated economic growth and Nuclear energy for sustainable economic growth. 26th June 2014
- Division on Integrated Management Systems and Safety Culture. On the 14th to 18th July, 2014

(aa) Paul Atta Amoah

- Regional Meeting for Sharing Experience and Lessons Learned in Implementing the Code of Conduct on the Safety and Security of Radioactive Sources and its associated Guidance on Import and Export of Radioactive Sources, organized by the Radiation Protection Authority of Zimbabwe, from the 25th to 29th August, 2014.

(bb) Raymond Agalga

- International Atomic Energy Agency to the Regional Workshop on the Familiarization of African State with Nuclear Security Detection and Response Measures. in Yaoundé Cameroon 4th of August to the 8th of August, 2014

(cc) J. Owusu-Banahene.

- IAEA Post Graduate Education Course on Radiation Protection which started October 2014 to February 2015.
- Local training for Chirano Gold Mines Limited on ‘Refresher Radiation Protection Training Course’, for the period between 20th - 24th October 2014

(dd) Veronica Afriyie Boahene

- Regional Training Course on Dose Management and Intercomparison Methodology 19th July 2014

PUBLICATIONS

Journal Articles

The following papers were published in refereed journals:

1. A. Faanu, O.K. Adukpo, L. Tettey-Larbi, H. Lawluvi, D. O. Kpeglo, E. O. Darko, G. Emi-Reynolds, R.A. Awudu, C. Kansaana, P. Atta-Amoah, A. O. Efa, A. Ibrahim, B. Agyeman, R. Kpodzro, L. Agyeman. Distribution and assessment of radionuclides in sediments, soil and water from the lower basin of River Pra in the Central and Western Regions, Ghana. *Journal of Radio-analytical and Nuclear Chemistry*. DOI 10.1007/s10967-014-3637-5 (2014)
2. J. Owusu-Banahene, E.O. Darko, F. Hasford, E.K. Addison, J. Okyere: Film reject analysis and image quality in diagnostic Radiology Department of a Teaching hospital in Ghana. *Journal of Radiation Research and Applied Sciences* (2014) 1-6, journal homepage: <http://www.elsevier.com/locate/jrras>
3. J. Owusu-Banahene, E. O. Darko and J. H. Amuasi: Modeling radiation doses to critical organs of patients undergoing intracavitary brachytherapy treatment using the finite element method. *Elixir Nuclear & Radiation Phys.* 74 (2014) 26985-26987: J
4. J. Owusu-Banahene, E.O. Darko and J. Yeboah: Dose rate distribution around an irridium-192 brachytherapy source: from modeling point of view. *Elixir Nuclear & Radiation Phys.* 72 (2014) 25606-25609
5. Kyei AY, Annafi TA, Annor-Nyarko M, Quaye CR, Bansah C (2014) Modelling the Velocity Profile of Coolant Flow in the GHARR-1 Fuel Channel. *J Nucl Ene Sci Power Generat Technol* 3:2, 1000123
6. M. Annor-Nyarko, A.A Gyeabour 1, T.A. Annafi, C. R. Quaye, A. Y. Kyei, Control Volume Finite Difference Analysis of Thermal Stresses Induced in GHARR-1 Reactor Vessel by Coolant Heating, international journal of scientific & technology research volume 3, issue 8, august 2014, pg 165-174

7. T.Adjirackor, E. O. Darko, G. Emi-Reynolds, D.O. Kpeglo, R. Awudu and J. Owusu
Banahene Radiological study of soil, fertilizer and foodstuffs in some selected farming communities in the greater Accra region, Ghana. *Elixir Nuclear & Radiation Phys.* 77 (2014) 29112-29118_ 29112
8. S. Inkoom, C. Schandorf, M. Boadu, G. Emi-Reynolds and A. Nkansah, Adult medical x-ray dose assessments for computed tomography procedures in Ghana-a review paper, *J. Appl. Science and Tech*, 19 (1&2):1-9, 2014.
9. D.O. Kpeglo, J. Mantero, E.O. Darko, G. Emi-Reynolds, E.H.K Akaho, A. Faanu, R. Garcia - Tenorio, 2014. Radiological Exposure Assessment from Soil, Underground and Surface Water in Communities along the coast of a Shallow Water Offshore Oilfield in Ghana. *Radiation Protection Dosimetry*, Advance Access Publication, doi:10.1093/rpd/ncu197, 1-12.
10. D.O. Kpeglo, J. Mantero, E.O. Darko, G. Emi-Reynolds, G.Manjón, I. Vioque, E.H.K Akaho, A. Faanu and R.García-Tenorio, 2014. NORM studies in an offshore oil production field located in the coast of Ghana. Conference Poster , EU NORM conference, Prague, 20-23June
11. Kofi Ofori*, Samuel W. Gordon, Emmanuel Akrobortu, Adriana A. Ampene, Emmanuel O. Darko. Estimation of adult patient doses for selected X-ray diagnostic examinations
12. Mvoufo F., Amoako J.K, Schandorf C., Tagoe S.N and Dery T.B. (2014) Determination of Doses to Breast Cancer Patients during EBRT at KBTH. *J Am Sci* ;10(1):108-111.
13. C. Subaar, J. K. Amoako, E.O. Darko, T. Ansah – Narh and T. B. Dery (2014), Finite Difference Time Domain approach of Thermal effects on Paediatric Patients Undergoing Magnetic Resonance Imaging In Ghana, *Research Journal in Engineering and Applied Sciences* 3(2) 93-97
14. Indika Arachchi Appuhamilage, Daniel Adjei, Saleh S. Alatabi, Radhwan Alnaimi, Alan Michette, Slawka Pfauntsch. Development of a Soft X-Ray Microprobe for Radiobiology Studies, *Acta Physica Polonica A*, No. 4, Vol. 125 (2014)

Conference Papers

1. P. K. Gyekye, F. Becker, G. Emi-Reynolds, S. Pölz.
Monte Carlo Investigation into Scatter Radiation from CT Fluoroscopy Gantry: Effect on Staff Dose. *International Conference on Occupational Radiation Protection: Enhancing the Protection of Workers – Gaps, Challenges and Developments.* Vienna, Austria, 1-5 December, 2014 (IAEA-CN-223).
2. S. Inkoom, M. Raissaki, K. Perisinakis, T. Maris, J. Damilakis. Location of radiosensitive organs inside artificial pediatric anthropomorphic phantoms: data required for dosimetry. March 06-10 2014, Vienna, Austria.
3. S. Inkoom and P. K. Gyeke, *Nuclear Applications and Nuclear Safety in Medicine*, 56th Annual Conference of Ghana Medical Association, November 06-08, 2014. Takoradi, Ghana.

4. S. Inkoom, Radiation dose evaluation in adult head and neck MDCT examinations with ImPACT CT Patient Dosimetry Calculator, National Physics Conference, November 26-28, 2014, Accra, Ghana.
5. D. Adjei, M. Getachew Ayele, P. Wachulak, A., Bartnik, H. Fiedorowicz, I. Ul Ahad, L. Węgrzyński, A. Wiechec, J. Lekki, W. M. Kwiatek, "Laboratory laser-produced plasma source of soft X-rays for radiobiology studies", in *Synchrotron Radiation in Natural Science, Bulletin of the Polish Synchrotron Radiation Society* 13, 1-2, 57 and 106 (2014), Proc. 12th International School and Symposium on Synchrotron Radiation in Natural Science, Warsaw, Poland, 15-20th June, 2014.
6. D. Adjei, M. G. Ayele, P. Wachulak, A. Bartnik, L. Vysin, L. Juha, H. Fiedorowicz, L. Węgrzyński, A. Wiechec, J. Lekki, W. M. Kwiatek . "Laboratory Laser Produced Soft X-Ray Source for Radiobiology Studies", COST Action: MP1203: progress towards spatial coherence standardization, Standardization of wave front sensing, comparison of available technics, Visible metrology of optics compared to at-wavelength metrology and Spectro-temporal metrology. 13 – 14 March 2014, Bern, Switzerland.
7. P. W. Wachulak, A. Bartnik, L. Węgrzyński, T. Fok, J. Kostecki, R. Jarocki, I. U. Ahad, A. Szczurek, M. Szczurek, D. Adjei, M. G. Ayele, B. Korczyk and H. Fiedorowicz, "Desk-top soft X-ray microscopy based on a grazing incidence Wolter I type optics and a compact laser plasma X-ray source", Laserlab Europe III, Joint JRA Meeting, Warsaw, Poland, March 31-April 1, 2014
8. I. U. Ahad, B. Korczyk, B. Budner, D. Adjei, M. Ayele, P. Wachulak, A. Bartnik, J. Kostecki, and H. Fiedorowicz, "Extreme Ultraviolet Surface Modification for Biomedical Engineering Applications", Laserlab Europe III, Joint JRA Meeting, Warsaw, Poland, March 31-April 1, 2014
9. H. Fiedorowicz, P. Wachulak, A. Bartnik, R. Jarocki, J. Kostecki, M. Szczurek, D. Adjei, I. U. Ahad, M. G. Ayele, T. Fok, B. Korczyk, A. Szczurek, Ł. Węgrzyński, "High-order harmonic generation using multi-jet targets", Laserlab Europe III, Joint JRA Meeting, Warsaw, Poland, March 31-April 1, 2014
9. D. Adjei, M. Getachew Ayele, P. Wachulak, A. Bartnik, H. Fiedorowicz, I. Ul Ahad, L. Węgrzyński, A. Wiechec, J. Lekki and W. M. Kwiatek, "Laboratory laser produced plasma soft X-ray source for radiobiology studies", RARAF Microbeam Training Course, Nevis Laboratory, Columbia University, New York, USA, May 19th-21st, 2014
10. D. Adjei, M. Getachew Ayele, P. Wachulak, A., Bartnik, H. Fiedorowicz, I. Ul Ahad, L. Węgrzyński, A. Wiechec, J. Lekki, W. M. Kwiatek, „Design and Development of a Laboratory laser-produced plasma source of soft X-rays for radiobiology experiments” HIPOLIN 2014 Erasmus Intensive Programme: Introduction to High Power Light-Matter Interactions, Rethymno, Crete, Greece, 30 June – July 2014
11. H. Fiedorowicz, A. Bartnik, R. Jarocki, J. Kostecki, M. Szczurek, P. W. Wachulak, D. Adjei, I. U. Ahad, M. G. Ayele, T. Fok, A. Szczurek, A. Torrisi, Ł. Węgrzyński, "Laser plasma sources of soft X-rays and extreme ultraviolet (EUV) for application in science and

- technology”, EXTATIC 2014 Welcome Week Workshop, Warsaw, Poland, 20-24th October, 2014
12. D. Adjei, M. G. Ayele, P. Wachulak, A. Bartnik, L. Vysin, L. Juha, H. Fiedorowicz, L. Wegrzynski, A. Wiechec, J. Lekki, W. M. Kwiatek, “Development and application of a compact laser-produced plasma soft X-ray source for radiobiology experiments”, EXTATIC 2014 Welcome Week Workshop, Warsaw, Poland, 20-24th October, 2014
 13. M. G. Ayele, D. Adjei, P. Wachulak, A. Bartnik, L. Wegrzynski, M. Szczurek, R. Jarocki, H. Fiedorowicz, “Compact laser plasma soft X-ray source for contact microscopy experiments”, EXTATIC 2014 Welcome Week Workshop, Warsaw, Poland, 20-24th October, 2014
 14. Daniel Adjei, Mesfin Getachew Ayele, Inam Ul Ahad, Przemyslaw Wachulak, Andrzej Bartnik, Henryk Fiedorowicz, Lukasz Wegrzynski, Anna Wiechec, Janusz Lekki and Wojciech M. Kwiatek, “Development of a Compact Laboratory Laser-Produced Plasma Source of “Water Window” Soft X-Rays for Radiobiology Experiments”, 10th International Young Scientist conference “Developments in Optics and Communications” and Laserlab III Training School for Potential Users “Laser Applications in Spectroscopy, Industry and Medicine”, Riga, Latvia, April 9 - 12, 2014
 15. D. Adjei, M. G. Ayele, I. U. Ahad, P. Wachulak, A. Bartnik, H. Fiedorowicz, L. Wegrzynski, A. Wiechec, J. Lekki, W. M. Kwiatek, “Development of laser plasma X-ray source for radiobiology studies”, XIX Polish-Slovak-Czech Optical Conference on Wave and Quantum Aspects of Contemporary Optics, Wojanów Palace, Poland, September 8-12, 2014
 16. M. G. Ayele, D. Adjei, P. Wachulak, I. U. Ahad, A. Bartnik, H. Fiedorowicz, “Contact microscopy using a compact laser plasma soft X-ray source”, XIX Polish-Slovak-Czech Optical Conference on Wave and Quantum Aspects of Contemporary Optics, Wojanów Palace, Poland, September 8-12, 2014
 17. D. Adjei, M. G. Ayele, I. U. Ahad, P. Wachulak, A. Bartnik, L. Vyšín, H. Fiedorowicz, L. Wegrzynski, A. Wiechec, J. Lekki, W. M. Kwiatek, “Development and Application of a Compact Laser-Produced Plasma Soft X-Ray Source for Radiobiology Experiments”, COST Action MP1203: Training School for advanced X-ray spatial and temporal metrology, Dubrovnik, Croatia. 29 September – 1 October 2014

Manuscripts under Review

18. **P. K. Gyekye**, Radiation Dose to Patients Due to Some Selected Fluoroscopy Procedures and “Developing Diagnostic Reference Level for Common Radiographic Examinations in Ghana. (2014).
19. M. Boadu, S. Inkoom, C. Schandorf, G. Emi-Reynolds, E. Akrobortu, Image Quality and Patient Dose Assessment in Simple Radiographic Examinations in Ghana (2014).

20. Osei, S.; Amoako, J. K., and Fletcher, J. J.; **Assessment of Levels of Occupational exposure to RF to workers of two TV stations in Accra, Ghana**
Journal: Radiation Protection Dosimetry (RPD-14-0088.R2)
21. Subaar, C.; Amoako, J.K., Darko, E.O., Narh, P., Schandorf, C., and Dery, T.
A steady state solution of Penne's Bioheat Equation to determine Temperature Distribution in Paediatric Patients undergoing MRI in Greater Accra region, Ghana,
Journal: British Journal of radiology

TECHNICAL REPORTS

1. ESTIMATION OF RADIATION DOSE FOR GOLD MINE WORKERS WORKING WITH NUCLEAR GAUGES AND EXTERNAL IONISING RADIATION EXPOSURE DURING CARGO RADIOGRAPHIC INSPECTIONS IN GHANA.

Investigators: T. Adjirackor, F. Otoo, R. Awudu and E.O Darko

ABSTRACT

Absorbed dose rate and annual effective dose estimated for occupational workers for Goldmines in Ghana that uses nuclear gauges in their operations and external ionizing radiation exposure during cargo radiographic inspections were measured as part of the authorization process for the use of ionizing radiations sources in Ghana, according to the provisions of the legislative instrument, LI 1559 of 1993. The measurements reported in this paper were made with portable radiation monitor which employed GM tube and was calibrated against secondary standard dosimetry system and a data for a five year period (2010-2014) was compiled from the RAIS of the Ghana Radiation Protection Board. The average absorbed dose rate in air for Goldmine workers was $0.73\mu\text{Sv/h}$ with an annual effective dose of 1.45 mSv while the average external radiation dose for workers and members of the public during cargo inspection was $0.23\mu\text{Sv/h}$ for Cobalt 60 scanners and $0.1\mu\text{Sv/h}$ for x-ray scanners and the average absorbed dose for both workers and members of the public for both Cobalt-60 and X-ray scanners were 0.46mSv and 0.2mSv respectively. It was concluded that the prevalent radiation levels did not pose any significant radiological health hazard to workers and members of the public.

2. ESTIMATE PLUS UNCERTAINTY IN REVIEW OF RESEARCH REACTOR SAFETY ANALYSIS

Investigator: Simon Adu

ABSTRACT

To construct and operate a nuclear research reactor, authorization is required to be obtained by the licensee from the Regulatory Body. One of the tasks of the regulatory authority is to verify that the performed Safety Analysis fulfills the safety requirements. Historically, the compliance with safety requirements was assessed using a deterministic approach and conservative assumptions. This provides sufficient safety margins with respect to the licensing limits on boundary and operational conditions. Conservative assumptions were introduced into the framework of the safety analysis to account for the uncertainty associated with lack of knowledge. With the introduction of best estimate computational tools, safety analyses are usually carried out using best estimate approach. Results of such analysis can be accepted by the Regulatory Authority only if appropriate uncertainty evaluation is conducted. Best Estimate (BE) computer codes are capable of providing more realistic information

on the status of the plant, allowing the prediction of the real safety margins. The Best Estimate Plus Uncertainty (BEPU) approach has proven to be reliable and provide realistic results if all the conditions are carefully followed. This paper therefore presents the concept of BEPU approach and how it can be applied to research reactors in the safety analysis. The aim of the paper is to investigate unprotected loss-of-flow transients "core blockage" of Miniature Neutron Source Reactor (MNSR) research reactor applying BEPU methodology. The results of the calculations showed that the temperatures in the core are within the safety limits and do not pose any significant threat to the reactor. This paper also discusses the methodology of BEPU approach applied to research reactors to review safety analysis for licensing purposes.

3. RADIATION DOSE RATE MEASUREMENTS AROUND PORTIONS OF THE RESIDENTIAL AREA NEAR A NUCLEAR INSATALLATION USING AN ATOMTEX AT6101C SPECTROMETER

Investigators: Ann Mensah, Paul Atta Amoah, Daniel Nii Adjei, Kwame Appiah, Raymond Agalga, Simon Adu And Sheila Victoria Gbormittah

ABSTRACT

Natural background radiation has been measured around the residential flats and the School of Nuclear and Allied Sciences (SNAS) campus on the Ghana Atomic Energy Commission (GAEC) premises. This was done to comply with best practice and regulations around nuclear installations and also to obtain data that will serve as a baseline to which further environmental radiation surveillance would be compared. The comparison would give indication whether a nuclear security or nuclear safety incident or event has taken place at the GAEC laboratories and research facilities; Ghana Research Reactor-1, Gamma Irradiation Facility, and Radioactive Waste management Facility, etc., if future measurements in the same locations are significantly high. The results obtained in the study show that the lowest dose rate was obtained around the Nuclear Security Support Centre and along the southern road bordering the residential flats zones as 0.09 ± 0.025 $\mu\text{Sv/h}$ and 0.09 ± 0.010 respectively, while the highest was recorded the around SNAS administration block zone as 0.13 ± 0.017 $\mu\text{Sv/h}$. The average ambient background for the whole study area was 0.11 ± 0.017 $\mu\text{Sv/h}$ which is equivalent to 0.96 mSv/y. These results compare well with other works in literature and are lower than reported values elsewhere in the world.

4. MEASUREMENT OF ^{137}CS ACTIVITY CONCENTRATIONS IN IMPORTED AND EXPORTED FOOD SAMPLES IN GHANA

Investigator: Charles Kansaana

ABSTRACT

^{137}Cs is a fission product of nuclear fission of U-235 and other fissionable isotopes in nuclear reactors and nuclear weapons. It decays by emission of a beta particle and gamma rays to barium-137. It used in construction industry, oil well drilling and medical research and treatment. External exposure to large amounts of ^{137}Cs can cause burns, acute radiation sickness, and even death. ^{137}Cs reacts with water producing a water-soluble compound called CsOH. Internal exposure allows it to be distributed in soft tissues exposing them to beta particles and gamma radiation and increasing cancer risk. Following nuclear weapon tests and nuclear accidents, some amounts of ^{137}Cs were released into the environment. Countries and organizations started monitoring the levels of ^{137}Cs in

imported/exported foods. The Radiation Protection Board is the regulatory body with the mandate of monitoring the levels of ^{137}Cs in imported and exported foods in Ghana. In order to control ^{137}Cs activity concentrations in imported and exported foodstuffs in Ghana, poultry, meat and dairy products were selected and prepared for gamma spectrometry analysis. The average activity concentration of ^{137}Cs was in the range of 0.33 ± 0.02 to 1.24 ± 0.05 Bq/kg fresh weight. All samples monitored had ^{137}Cs activity concentration below the permissible limits. In general, products with ^{137}Cs activity concentration more than the permissible limits are not permitted for importation and exportation in Ghana.

5. VARIATION IN THE USE OF ARITHMETIC MEAN AND GEOMETRIC MEAN CALCULATION IN ANALYZING CONCENTRATION OF RADON GAS IN SOME PARTS OF GREATER ACCRA

Investigator: Peter Atta Amoah

ABSTRACT

The study to ascertain the variation in the use of arithmetic mean and geometric mean calculation in analyzing the errors obtained with the concentration of radon gas (^{222}Rn) at a relatively higher altitude and that of the concentration at a lower altitude was carried out at McCarthy Hill and GAEC using LR-115 solid state nuclear track detectors. A total of 180 track detectors were buried in a grid form at a depth of 75 cm covering an area of 576 sq. meters with intervals of 12 meters between the holes. Arithmetic mean analysis produced mean concentrations ranging from 0.27 ± 0.04 kBq m^{-3} to 86.30 ± 2.94 kBq m^{-3} for Site A, 0.72 ± 0.04 kBq m^{-3} to 51.98 ± 1.75 kBq m^{-3} for Site B and a variation from 1.22 ± 0.102 kBq m^{-3} to 123.23 ± 0.072 kBq m^{-3} was determined for Site C. With geometric mean analysis, radon concentrations varied from 1.181 ± 0.047 kBq m^{-3} to 10.665 ± 0.208 kBq m^{-3} for Site A, 2.489 ± 0.112 kBq m^{-3} to 12.522 ± 0.210 kBq m^{-3} for Site B, while a variation from 11.901 ± 1.075 kBq m^{-3} to 32.289 ± 0.645 kBq m^{-3} was determined for Site C. The observation in mean and standard deviation explains that geometric analysis is a better measure of central tendency and dispersion respectively as compared to the values with arithmetic analysis for this particular study.

6. NUMERICAL MODELLING OF THERMALSTRESSES IN GHARR-1 REACTOR VESSEL INDUCED BY GAMMAHEATING DURING FISSION PROCESS

Investigator: M. Annor-Nyarko, T.A. Annafi, A. Y Kyei, C. R. Quaye

ABSTRACT

A Numerical model based on control volume finite difference method (CVFDM) has been developed to investigate the non-steady radial temperature variations induced by gamma heating during fission process and subsequent thermal stresses evaluated to ascertain the structural integrity of Ghana Research Reactor-1(GHARR-1) vessel material after 15 years of operation. The volumetric heat generation rate of gamma radiations attenuated at the inner surface of the vessel was determined. Solution algorithms for Matlab code were implemented to generate data for transient analysis and simulation. Results obtained indicated that both temperature variations and thermal stress distributions were below the limits imposed by the vessel material (Aluminium alloy LT 21) specifications of 933 K melting point and allowable yield stress of 480 MPa. The low level of

induced thermal stresses indicated that the structural integrity of the reactor vessel has been maintained to forestall the incidence of premature failure modes over the operation period.

7. ANALYSIS OF ELEMENT CORRECTION COEFFICIENTS (ECCs) DATABASE OF THERMOLUMINESCENT DOSIMETERS (TLDs) FIELD CARDS USED FOR PERSONAL MONITORING FOR THE PERIOD 2010-2013.

Investigators: Philip Owusu-Manteaw, Joseph K. Amoako, Daniel Adjei, Edith A. Amoatey, Veronica Afriyie Boahene, Michael Obeng, Godfred Obeng Asiedu, Ben Doe Gbekor

ABSTRACT

Radiation dosimetry is defined as the measurement, usually, of the absorbed dose, or other relevant quantities like KERMA, exposure or equivalent dose, which is produced due to the interaction of the ionizing radiation with a material. That measurement can be achieved using a dosimeter. A dosimeter with its reader is called a dosimetry system. External dosimetry is a measure of absorbed doses, produced from radiation sources, which are outside of the body of the exposed worker. TLDs have been developed over the years and suitable applications have been investigated for different areas in dosimetry. The TL materials store energy inside their structure when they are irradiated, as electrons and holes are trapped in trapping centers due to defects. When the material is heated, electrons and holes recombine, at luminescence centers, and thus light is emitted. The emitted visible light is collected by the photomultiplier tube (PMT) inside the reader device which is the TL signal. TLDs are mainly used for personal monitoring of workers who are exposed to radiation that is higher than 3/10 of the dose equivalent limits. The dosimetry quantities of interest in the effective doses of $H_p(0.07)$ and $H_p(10)$. The effective dose, $H_p(0.07)$, is the measure of the dose to the skin and effective dose, $H_p(10)$, estimates the dose at a specific depth of the body. The TL efficiency is one of the material-dependent factors in determining the accuracy of the dose measured. However, not all TL dosimeters can be manufactured to have exactly the same TL efficiency. In estimating the TL efficiency (TLE) which is the emitted TL light intensity per unit of absorbed dose), the individual Element Correction Coefficients (ECCs) must be defined, developed and applied.

8. LOCATION OF RADIOSENSITIVE ORGANS INSIDE PAEDIATRIC ANTHROPOMORPHIC PHANTOMS IN THE HEAD AND NECK REGION

Investigators: Stephen Inkoom, Maria Raissaki, Kostas Perisinakis, Thomas George Maris, John Damilakis

ABSTRACT

Aims and objectives: The aim of this study was to determine the location of radiosensitive organs in the head and neck region in 4 paediatric anthropomorphic phantoms for dosimetric purposes.

Methods and materials: CT and MRI scans of all children aged 0-16 years performed during a 5-year-period in our institution were reviewed, and 225 were found to be eligible for normal anatomy. Four of the above children closely matched the anterior-posterior and transverse diameters of 4 commercially available paediatric phantoms representing the average individual as newborn, 1-year-old, 5-years-old and 10-years-old child. The mid-sagittal and mid-coronal planes were drawn on selected matching axial images of patients and phantoms. Multiple points outlining radiosensitive organs in patient CT images were identified at each slice level and their orthogonal distances from the mid-sagittal and mid-coronal planes were measured. In small organs, the orthogonal distances of

organs' centers were similarly measured. The outlines and centers of all identified radiosensitive organs were represented to the corresponding transverse image of the phantom.

Results: The locations of 4 radiosensitive organs in the head and neck region inside the 4 paediatric anthropomorphic phantoms were determined. These organs included the brain, eye lenses, salivary glands and the thyroid.

Conclusion: The radiosensitive organs' chart of 4 anthropomorphic phantoms was produced to provide medical dosimetrists reliable data for positioning of dosimeters during absorbed dose measurements.

9. REGULATORY STRATEGY FOR GHANA'S NUCLEAR POWER PROGRAMME ORGANIZATION

Investigator: Daniel Sika-Boafo

ABSTRACT

A resurgence of interest in new nuclear power generation as part of the energy mix has emerged around the world in the past few years. The reasons for this potential "nuclear renaissance" stem from a complex set of considerations, including the environmental benefits of no "greenhouse" gas emissions, the enhanced reliability of nuclear operations, advantageous fuel, operating costs and government incentives, among others. A major challenge in the deployment of the first nuclear power plant in a country is the development of the underlying nuclear safety, security and safeguards infrastructure and knowledge base. The IAEA Fundamental Safety Principle states that regulating nuclear and radiation safety is a national responsibility and that an effective legal and governmental framework for safety, including an independent regulatory body, must be established and sustained. Therefore, establishment and development of a competent regulatory body must be addressed at an early stage of the nuclear power programme and must not be constrained by lack of resources. The accident at the Fukushima Daiichi nuclear power plant has initiated an extensive re-examination of all aspects of reactor safety, including the regulatory framework. While the detailed lessons learned from the accident may take several years to be fully characterized and applied, it is evident that the ongoing development of an effective regulatory framework will be a key part of enhancing the global safety regime. Countries that decide to include nuclear power plants in their national development plans may have various levels of experience and understanding of the elements of the nuclear safety infrastructure required for a nuclear power programme. Some countries may be already operating nuclear installations (such as research reactors or subcritical facilities) and have, in general, a reasonable understanding of the role and responsibilities of both the operating organization and the regulatory body, with a licensing process in place, and the need for high quality standards in nuclear activities. For all new entrant countries, although their starting points are different, the resources (both human and financial) needed to secure a competent and fully functional regulatory body for licensing the first nuclear power plant are significant. In particular, to conduct the licensing process as well as to provide oversight of the construction activities for the first nuclear power plant, the regulatory body needs to develop an extensive set of specialized competencies and processes to ensure an informed decision making process.

11. CHALLENGES

The major challenges faced during the year include the following:

- (i) Enforcement of regulatory requirements and follow-ups of regulatory inspections has been a major challenge.
- (ii) Lack of adequate equipment to enhance effective regulatory work and research.

- (iii) Maintenance team lack appropriate training and skills to undertake routine maintenance of the specialised equipment at the centre
- (iv) In adequate number of relevant skilled technicians in the laboratory
- (v) The main challenge of the EPWMC was the cost of Liquid Nitrogen and this draining the limited resources of RPI. As a result, effort should be put in place to revive the Liquid Nitrogen Plant at the GAEC site.
- (vi) Some of the staff needs training in the field of alpha and gamma spectrometry.

12. CONCLUSION AND RECOMMENDATIONS

The challenges encountered during the year hindered smooth execution of all the activities in the Institute. Some significant progress was, however, made in some of the areas of activities. On-the-job training, and also training and re-training of staff through IAEA fellowships, workshops and other forms of training constitute a key component of an effective regulatory regime and development of research capabilities for continuity and growth of the Institute.

Maintenance and sustainability of some of the planned activities during the year have been possible with the support of the Government of Ghana (GOG) through the Ghana Atomic Energy Commission (GAEC) and the Internally Generated Fund (IGF) from service activities. Management is requested to make every effort to address the problems of the Institute by providing the necessary resources to improve staff performance in order to face greater challenges in the following year.

The year under review has been a fruitful one despite the numerous challenges encountered. It is hoped that during the year 2015 RPI would have a better working environment and the co-operation of Management and all staff to enable the Institute achieve its corporate goals.