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Developing Radiation Safety Culture in Ghana: The Role of the Radiation Protection Institute of Ghana

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Abstract

Due to the harmful nature of ionizing radiation, the Radiation Protection Institute (RPI) of the Ghana Atomic Energy Commission (GAEC), among other objectives provides radiation protection and consultancy; public exposure control; nuclear safety and security and radioactive waste management. In line with these objectives, the Radioactive Waste Management Center of the RPI conducts on-site radiation safety assessment for sectors of the economy where radiation sources are applied. The Center also retrieves and transports Disused Sealed Radioactive Sources (DSRSs) from end users to the Centralized Radioactive Waste Management Facility (CRWMF) for further management. Through the Radiation Protection Training and Consultancy Centre (RPTCC), the RPI conducts training program for occupationally exposed workers and sensitization of the general public on radiation safety. These activities of the RPI are guided by its comprehensive radiation protection program and robust quality management system which are systematically exploited to establish radiation safety culture in Ghana. Data from the RPI indicates that, between 1993 and 2020, about 984 occupationally exposed persons from 85 local firms have acquired radiation safety/protection training. This article further highlights other activities relating to quality service and radiation safety mechanisms for users, transporters and managers of radiation sources.

Keywords: Ionizing radiation; Radiation safety; Radioactive sources; Radiation protection program

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Introduction

HIn Ghana, radiation sources are applied mainly at medical diagnostic centers for cancer treatment and x-ray imaging; in industry and civil constructions for moisture and level gauge determination; and in agriculture for pest control and extension of shelf life of foods. Other sectors where radiation sources are used in the country include the gold mines and oil and gas exploration fields. The use of these sources are strictly under institutional control and regulatory monitoring to ensure safety of users/workers (i.e. occupationally exposed people), the public and the environment from the harmful effects of ionizing radiation emanating from the sources.

When radiation source becomes deficient, breaks down or does no longer serve the purpose for which it was manufactured and imported into a country, it becomes a disused source or a radioactive waste. Despite being disused, activity of such sources could still be high enough to cause radiation injury when mishandled and/or overly exposed to [1]. Ionizing radiation has sufficient energy to affect the atoms in living cells and thereby damage their genetic material (i.e. the DNA) [1,2].

Medical, nuclear power and radioactive waste management facilities are among the leading sources of ionizing radiation [1]. The World Health Organization (WHO) report indicates that, human exposure to ionizing radiation comes mainly from medical devices in radiation therapy for diagnosis and treatment of cancer [1,3]. Beyond certain thresholds, radiation can impair the functioning of tissues and organs and can produce acute effects such as skin redness, hair loss, radiation burns, or acute radiation syndrome [4]. Acute radiation syndrome is as a result of a very high level of radiation exposure over a short period of time resulting to symptoms such as nausea and vomiting within hours and can sometimes result in death over the following days or weeks [4]. Detrimental effects of radiation can, however be prevented by ensuring that recommended doses are not exceeded and that radiation exposures are kept as low as reasonably achievable [5].

Disused sealed radioactive sources are major sources of ionizing radiation. Despite their socio-economic benefits, improper

handling of ionizing radiation can lead to over-exposure which in turn can cause serious bio-physical health conditions including erythema, epilation and dermal necrosis [1,2]. They therefore need to be properly managed to prevent in advertent exposure to people.

The Radioactive Waste Management Centre (RWMC) of the of the Radiation Protection Institute (RPI) of Ghana operates the only licensed radioactive waste management facility known as the Centralized Radioactive Waste Management Facility (CRWMF), where all DSRSs and other radioactive waste generated in the country are managed.

In order to protect the people from inadvertent exposure to ionizing radiation; and to secure radioactive sources from unauthorized use, the RWMC was established as a Center under RPI with a mandatory function of collecting and consolidating all radioactive waste generated in the country for further management at the CRWMF. Through this core function, other auxiliary functions such as environmental radiation monitoring, geochemical and radionuclide analysis of surface and groundwater are routinely undertaken to ensure safety.

Other functions of the RPI towards radiation safety include safety assessment of radioactive sources in use as well as those decommissioned but not yet repatriated; training of occupationally exposed people and sensitization of the general public. Education and training in all aspects of radiation protection is recognized and viewed as essential radiation safety tools by key international organizations including the International Atomic Energy Agency (IAEA), the International Labor Organization (ILO), the United Nations Educational, Scientific and Cultural Organization (UNESCO), the WHO, and the Pan American Health Organization (PAHO) [6].

Safety Culture is the assembly of characteristics and attitudes in organizations and individuals which ensures that priority is given to safety warranted by its significance to prevent accidental exposures and mitigate their consequences if they occur [7].

All training programs and consultancies relating to radiation safety and protection are under the auspices of the Radiation Protection and Consultancy Centre, also of the RPI of Ghana. This makes the radiation protection program of the RPI a robust and comprehensive as it brings on board all its Centers and stakeholders of occupational and public safety. The pragmatic training programs of the RPI are designed in a systematic and integrated manner; delivered with hands-on practical sessions. This article presents the major activities of the RPI of Ghana that contribute to the development of radiation safety culture in Ghana.

Materials and Methods

Study location

The RPI is one of the GAEC's institutes located at Kwabenya, in the Ga East Municipal Assembly of Ghana. It shares same premise with the National Nuclear Research Institute, which moderates the only nuclear research reactor of the country; the Biotechnology and Nuclear Research Institute; the Nuclear Power Institute among others. **Figure 1** shows the location of the GAEC and the surrounding areas to the Ga East Municipal Assembly.

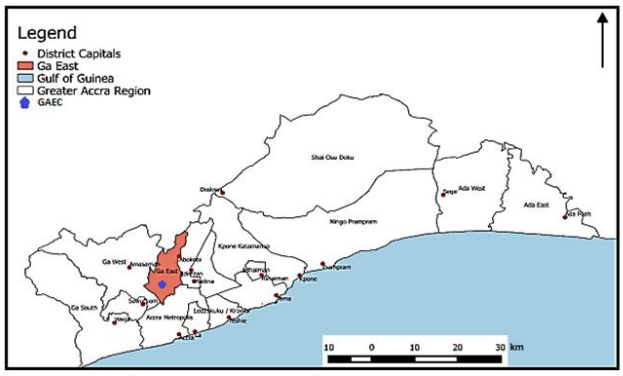

Figure 1: Location of GAEC in the Ga East Municipal Assembly (Source: GEMA News).

Tools and devices

Sustainable safety operation is a fundamental objective of the RPI and its subsidiaries. In accordance with international safety principles [8,9], operations involving the use or handling of radiation sources requires application of shielding, reasonable distance and limited time. In addition to good judgement based on hands-on-experience, the use of personal protective equipment (PPEs) such as vinyl and woolen gloves, safety boots, Lead apron/jacket, overall coat, helmet, goggles etc. are strictly recommended.

Radiation monitoring devices required for determination of radiation dose rates i.e. radiation exposure at a given time include: radiation dose meter also referred to as radiation survey/radiation monitoring meter; personal dosimeter badge (thermal luminescent dosimeter, TLD), HPGe neutron and gamma detectors as well as alpha and beta detectors.

Safety assessment

As required by the Nuclear Regulatory Authority of Ghana (NRA), on-site safety assessment are conducted bi-annually for both radiotherapy and gamma irradiation facilities; and annually for industries including the mines, civil engineering companies and oil and gas extraction companies. Upon request by end users of radiation sources, technical team of experts are constituted to carry out the safety assessment at the source location.

Retrieval and transport of disused source

Retrieval and transport of disused radioactive source is a process that commences with the end user of the source. The ultimate goal and every step of the process is to ensure safety of people and security of the source(s) [10,11]. The following are the required steps towards retrieval and transport of disused radioactive sources:

End user of source first applies for a permission from the NRA to decommission the source and transfer same to the RWMC for

further management.

RWMC seeks permission from NRA to retrieve and transport the source from the end user to its facility for further management.

Prior to retrieval of the source, RWMC conducts safety assessment of the source and its microenvironment to ascertain the actual current conditions of the source and safety of the site.

Source is retrieved by trained and experienced personnel of the RWMC at a predetermined date.

Radiation dose rates are measured and recorded before and after the source is securely placed on the transporting truck as follows:

a) Measure and record background dose rate at ~50 m away from the source (this is regarded as background dose)

b) Measure and record dose rate at source surface

c) Measure and record dose rate at 1 m radius of the source

d) Determine transport index

Training of the occupationally exposed

As regulatory requirement, occupationally exposed staff needs to be trained to acquire skill and technique in safe handling of radiation sources and general radiation protection safety measures. Upon request by end users and transporters of radiation sources, the RPI through its Radiation Protection Training and Consultancy Centre (RPTCC) delivers a robust radiation protection training designed for low, intermediate and high-level staff of various organizations. The training covers but not limited to the following modules:

- Types of radiation exposure; risks and benefits,
- Biological effects of ionizing radiation,
- Radiation detection and measurements,
- Principles of radiation protection,
- Occupational radiation protection in nuclear gauging,
- Public radiation protection in nuclear gauging,
- Legal framework for control program of radioactive materials
- Radioactive waste management,
- Safe transport of radioactive materials,
- Safety and security of radioactive sources and
- Practical sessions imbibing skill and technique in radiation safety mechanisms.

Results and Discussion

Radiation protection program

Protection of people and the environment from the harmful effects of ionizing radiatiation is a fundamental objective of the RPI. As a result, the RPI came up with a radiation protection programme, outlining the general and specific radiation safety measures. The measures touch on avoidance of dispersion of radioactive materials and prevention or minimization of radiation exposure. In relation to this, an explicit clarification of the ALARA principle which tied to the distance, time and shielding principle.

The program recommends a well trained and certified Radiation Protection Officer (RPO), for all entities that use or transports radioactive materials/sources. The RPO supervises the facility; leads all operations and to whom all radiological incidents are reported at first hand. They are responsible for developing their working rules in accordance to national and international requirements; and demarcation of their facilities. Typically, the facility is generally classified as the 'controlled' and 'uncontrolled' areas. The 'controlled' area is the radiation zone – comprising low-to-high dose storage facilities. The 'uncontrolled' area is the non-radiation zone – comprising the offices for administrative works, changing and wash rooms etc. Both working areas (controlled and uncontrolled) are visibly marked and labeled with appropriate signs. Importantly, radiation caution signage should be visibly posted at all vantage points and there must be non-obstructive exit routes and an emergency assembly point.

The principle of distance, time and shielding is an important strategy for minimization of exposure for every operation involving use or handling of radiation sources. At the CRWMF, jobs are shared with specific allocations to be executed at a specific given time by a specific personnel. As much as possible, reasonable distance is kept away from the radioactive source; and personnel directly handling the source is mandated to wear a Lead apron/jacket. It is a policy at RWMC that, no single person handles a radioactive source continuously for more than 5 minutes. The more critical the dose rate, the more the number of workers to execute the job – one at a time. By this arrangement, the level of exposure is reduced for each worker and no single person is over-exposed.

Training and sensitization

As the number of radioactive sources being used in a country increases, risk to radiation exposure will naturally increase if proper care is not taken. It has been gathered through the radiation training and sensitization programs held by the RPI of Ghana that, significant number of industry players including transporters and end users of ionizing radiation have little knowledge about radiation effects, and implementable safety measures during operations. Emergency response during radiological accident and/or incidence at site or on the road during transport is another area that scored very low and therefore requires much attention. In view of these and in line with the strategic plan of the RPI, radiation protection training, sensitization and advocacy for radiation safety; and compliance to safety standards have been intensified in the last five years.

On average, 4 disused sealed sources are retrieved and transported annually to the CRWMF for further management; and 12 on-site safety assessments are conducted for various radiation source users. In the last 5 years (2016-2020), over 500 trainings have been conducted for individuals from different firms including the mines, freight forwarders, medical services, industries, security agencies and research institutions. This does not include sensitization and advocacy programs held on national

and regional radio and television during the same period. All persons who undergo radiation safety/protection training at the RPI of Ghana are assessed at the end of their trainings and certified accordingly. Boadu et al. [5] indicated that, between 1993 and 2008, the RPI of Ghana in collaboration with the IAEA conducted hundreds of radiation protection trainings in the form of training courses, workshops, seminars and fellowships. During these period, over 400 individuals from 38 local firms acquired radiation safety and protection training and certifications.

Managing radioactive materials/sources

The RWMC undertakes pre-disposal radioactive waste management operations such as leak test, re-containerization (in case of leakage), source/waste characterization, conditioning and storage. About 90% of all retrieved sources including legacy sources have undergone these processes awaiting the final stage of the waste management process, i.e. disposal.

The RWMC in collaboration with the International Atomic Energy Agency (IAEA) is embarking on a project known as the borehole disposal system (BDS). The BDS is a radioactive waste disposal facility; a geological repository with several engineering features and barriers to assure safety. The project is ongoing; its completion and approval of its safety case document by the NRA will further entrench radiation safety culture and radioactive source security in Ghana. Ghana becomes a case study and a leading country worldwide in the implementation of the BDS.

Whilst Ghana becomes a Centre of excellence in radioactive waste management in the sub-region, the BDS project will be tailored to the country's nuclear power agenda with an enhanced technology to process and recycle disused radioactive sources and spent nuclear materials for research purposes. It is important to note that, the level of safety as well as safety mechanism(s) at each stage of the radioactive waste management process; during their transport and applications are designed and applied in an integrated manner. Certain features of the BDS including depth of the borehole is dependent on country specific circumstances or needs. For example the outlook of the national radioactive source inventory i.e. type, category and quantity of sources available for disposal; and local or regional water table. **Figure 2** gives an illustration of the BDS with a standard waste package. The waste package is a conditioned radioactive source, encapsulated in a standard stainless steel capsule. The borehole repository is designed to receive radioactive sources only in this form. The system is incorporated with both safety and security mechanisms with no intention of retreiving the sources after disposal.

Another outcome of the strategic plan of the RPI towards building radiation safety culture in Ghana is the development of Quality Management System (QMS) for the RWMC. The QMS is an important development as it provides protocols aimed at attaining safety and provision of quality services through the adherence of best practices i.e. standard operating principles. The QMS is not only a working document for the RWMC but also serves as a reference document for users and transporters of radioactive materials. It is the basis for ensuring quality is applied and standards maintained during research and technical service provision. The QMS also makes provision for emergency response in the event of radiological incidents and/or accidents.

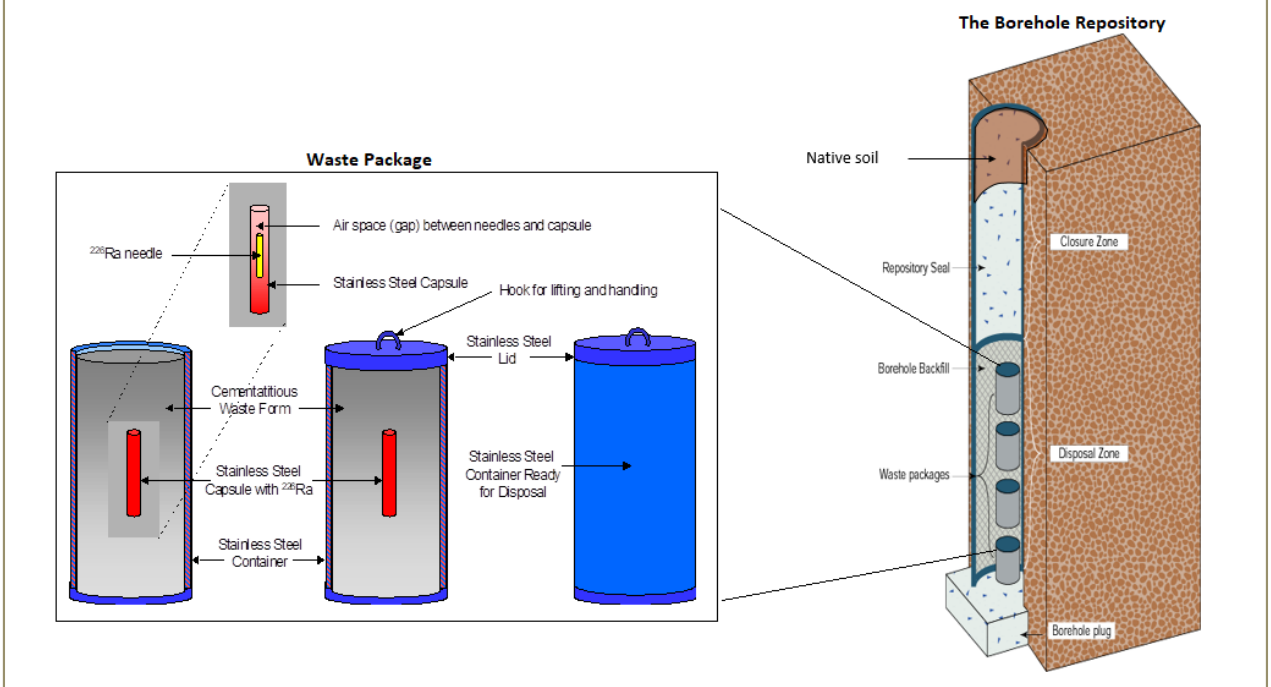

Figure 2: The borehole disposal system featuring a typical waste format and the borehole repository.

Transport of radioactive materials/sources

There are hundreds of radioactive materials in transit or shipment each day across the globe. Transport of radioactive materials is associated with potential radiological exposure; risks of accident, attack, sabotage, theft and unauthorized use. These risks can, however, be reduced to the barest minima when the appropriate laid down safety protocols espoused in the IAEA's Safety Standard Series [12,13] and those designed specifically for transport of radioactive materials [14-16] are strictly followed. Ghana as a member State of the IAEA is signatory to its conventions and actually implements them together with local regulations set out by the NRA of Ghana. Implementation of the transport safety regulations [17,18] is highly recommended to all stakeholders by the NRA of Ghana. These regulations provide for the safe and secure transport of radioactive materials right from the manufacturer to the end user.

The scope of the IAEA's transport regulations covers transport package design and composition, material categorization, consignment documentation, labeling and container marking. The regulations deal with specific transport activities including actual shipments, special arrangements and the transport index number assigned to a package to provide control over radioactive exposure.

Conclusion

Pragmatic radiation protection program including training, sensitization and quality management system have been identified as tools for attaining radiation safety. Radiation protection training for the occupationally exposed people are a regulatory requirement, making it a regular activity at the RPI of Ghana. These activities have been linked to maintenance of high standards and provision of quality technical services. Regulations for transport of radioactive sources and protocols for radiological emergency are all hinged on safety. Ultimately, the RPI of Ghana seeks to establish radiation safety culture in the country.

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References

1 World Health Organization (WHO 2016). Ionizing radiation, health effects and protective measures.

2 Aberle DR, Adams AN (2011) Reduced lung-cancer mortality with low-dose computed tomographic screening. N Engl J Med 365: 395-409.

3 Atkinson WD, Law DV, Bromley KJ, Inskip HM (2004) Mortality of employees of the United Kingdom Atomic Energy Authority, 1946-97. Occup Environ Med 61: 577-585.

4 Socol Y, Vaiserman A, Koliada A, Zabuga O (2018) Health impacts of low-dose ionizing radiation: Current scientific debates and regulatory issues. Dose-Resp 16: 155932581879633.

5 Boadu M, Schandorf C, Emi-Reynolds G, Faanu A, Inkoom S, et al. (2011) Systematic approach to training occupationally exposed workers in ghana and the rest of Africa. Health Phys 101: S116-S120.

6 International Atomic Energy Agency (2001) Training in radiation protection and the safe use of radiation sources. Vienna: IAEA.

7 International Atomic Energy Agency (2007) Terminology used in nuclear safety and radiation protection. Vienna: IAEA.

8 International Atomic Energy Agency (1996) International basic safety standards for protection against ionizing radiation and for the safety of radiation sources, safety series No. 115, IAEA, Vienna.

9 International Atomic Energy Agency (1995) The principles of radioactive waste management, safety series No. 111-F, IAEA, Vienna.

10 International Atomic Energy Agency, IAEA (2008) Security in the transport of radioactive material, IAEA Nuclear security series No. 9.

11 International Atomic Energy Agency (2008) Nuclear Security Culture, IAEA nuclear security series No. 7, IAEA, Vienna.

12 International Atomic Energy Agency (2005) Categorization of radioactive sources, IAEA safety standards series No. RS-G-1.9, IAEA, Vienna.

13 International Atomic Energy Agency, IAEA (2007) Safety glossary: Terminology used in nuclear safety and radiation protection, IAEA, Vienna.

14 International Atomic Energy Agency (2005) Guidance on the import and export of radioactive sources, IAEA, Vienna.

15 International Atomic Energy Agency, IAEA (2006) Safe transport of radioactive material.

16 United States Environmental Protection Agency, EPA (2017) Transportation of radioactive material.

17 International Atomic Energy Agency (2005) Regulations for the safe transport of radioactive material, Safety standards series, safety requirements No. TS-R-1, IAEA, Vienna.

18 International Atomic Energy Agency, IAEA (2018) Regulations for the safe transport of radioactive materials IAEA's safety standard series, SSR-6 Rev-1.