Available online at www.elixirpublishers.com (Elixir International Journal)

Nuclear and Radiation Physics

Elixir Nuclear & Radiation Phys. 126 (2019) 52378-52382

ISSN: 2229-712X

Radiation Doses at the Radioactive Waste Storage Facility of Ghana

Abdallah M.A Dawood*, Paul Essel, Eric T. Glover, Eric Akortia, Evan M. Ameho, Evelyn Duodo and E. A. Aberikae

Radioactive Waste Management Centre, Radiation Protection Institute, P.O. Box LG 80, Accra, Ghana.

ARTICLE INFO

Article history:

Received: 16 October 2018;

Received in revised form:

17 December 2018;

Accepted: 27 December 2018;

Keywords

National Radioactive Waste Management Centre, Ghana Atomic Energy Commission.

ABSTRACT

The National Radioactive Waste Management Centre (NRWMC) of the Ghana Atomic Energy Commission (GAEC) undertakes routine monthly radiation monitoring in and around the vicinity of its storage facility. In collaboration with the United States government, the Ghana Atomic energy Commission upgraded and intensified the safety and security systems at the radioactive waste storage facility located at the main site of the GAEC. Additional storage/decay rooms were built with more enriched and thicker concrete blocks to be able to contain the radiation. The sources were transferred from the old block to the new re-enforced block. Radiation levels were measured for a period of six months before and after the transfer of the sources and the results compared. An average dose rate of 0.13 nSv/y and 0.02 nSv/y were recorded around the walls of the storage facility before and after the transfer of the sources, respectively. The reduction in the dose rate was attributed to the increased thickness of the walls of the new storage block, and hence, providing enough shielding to the radiation. Comparing the results with the IAEA safety standard on dose limit of 1.0 mSv/y to the public and 20 mSv/y for the radiation worker, it was concluded that the radiation levels emanating from the facility are low and within the allowable limits.

Introduction

The use of radioactive sources in medicine, research, industry, agricultural and consumer products has been a common phenomenon in Ghana for over five decades [1, 2]. These sources contain different radionuclides in highly variable quantities.

A sealed radioactive source, typically called a sealed source, refers to radioactive material that has been sealed inside a capsule or is permanently bonded in a solid form [3, 4]. Sealed sources within devices are commonly used to deliver a defined dose of radiation such as that used in cancer therapy or in irradiators that sterilize food and medical equipment. There are other uses such as in industrial gauges, in radioisotope thermoelectric generators used to provide electric power in remote areas, in gamma radiography to check welds on pipelines, and in well logging sources used to explore for coal, oil, and natural gas.

Sealed radioactive sources within devices when used as intended are designed to limit radiation exposure to the user. Despite their design safety features, some sealed source devices may produce a potentially lethal amount of radiation if used improperly [4]. People using sealed source devices must be trained to have sufficient knowledge about their proper and safe uses. In untrained hands, such devices can cause injury or kill. Malevolent acquisition and use of radioactive sources may cause radiation exposure or dispersal of radioactive material into the environment. Such an event could cause significant social, psychological and economic negative consequences.

Some of these sources in various industries mentioned above have become either obsolete or damaged and are no longer serving their original purposes. Even though these radioactive sources are referred to as ‘‘disused’’, their activities could still be very high and deleterious to human health [4, 5]. It is as a result of this, that the NRWMC is mandated by the laws of Ghana to retrieve these sources from the users to the storage facility for proper management so as to prevent unauthorised access by humans and exposure to the larger environment; thus, protecting the radiation workers and the general public from the harmful effects of ionizing radiation. Sources in storage at the NRWMC include category 2 to 5 sources with activities ranging from 7.4x10+5 Bq to 6.85x10+14 Bq.

Safety and security now and in the future remain the fundamental goal of radioactive source management [6, 7]. In line with this, the NRWMC, undertakes a routine monthly radiation monitoring in and around the vicinity of the storage facility in order to keep an up-to-date record of radiation levels each month for the year round. This also serves as a modality to detect and attend promptly to incidence of leakage from any of the stored sources.

Characterization of the disused radioactive sources is an essential part of the source management process which include identification of radionuclides and their activities; external contamination, leakage status and physical properties. These are considered the most important features in the characterization process which are also a pre-requisite for conditioning and disposal of the radioactive sources [7]. Characterization can be used for other purposes such as identifying the potential hazards associated with a particular type of waste, designation of waste as suitable for storage to decay or specifying a particular processing, storage or disposal option, and planning and designing waste management facilities [5, 6, 7].

The national inventory is a reference material for radioactive waste management. Its publication is one facet of the continuing commitment of the authority responsible for radioactive waste to openness and transparency in matters

Tele:

E-mail address: dawuud2000@yahoo.ca

relating to the management of these wastes [7, 8]. The preparation of the inventory is also driven by the commitment to two international obligations: the EURATOM–Community Plan of Action in the Field of Radioactive Waste and the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management [8].

In collaboration with the United States government, the radioactive waste storage facility in Ghana was upgraded with intensified safety and security measures such CCTV; sensors and remote alarm systems. Additional storage/decay rooms of thicker walls were built with high grade concrete materials. Figure 1 shows the old and new storage facilities.

Old storage facility New storage facility

Figure 1. Old and new storage facilities for disused radioactive sources.

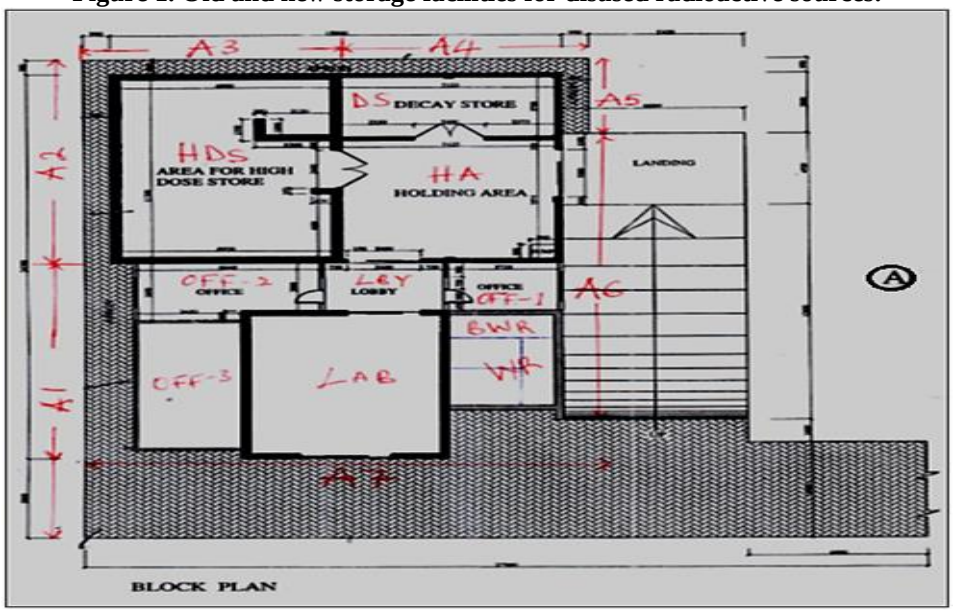

Figure 2. Structural plan of the storage facility showing the working areas.

Materials and Method

Gamma survey meter known as RadEye; model G-10 was used to measure radiation levels throughout the exercise. Figure 2 is a structural sketch of the storage block illustrating the working areas of the facility. Measurements were taken in the Laboratory (Lab) area; along the wall in front of the facility labelled A7, along the wall towards the east of the site labelled A6, along the wall at the back of the facility labelled A3 and along the wall towards the west of the site labelled A2. Until January 2011, the disused radioactive sources were kept in room 3, labelled OFF-3.

Dose rates were measured for a period of six months before and after transfer of the sources from the new to the old block and the data stored in an electronic database for future reference, update and further analysis. The data was subsequently analyzed using MATLAB software.

A high-resolution, electrically-cooled portable gamma-ray spectrometer consisting of an HPGe detector (Model BE2830-CPI) was used for the characterization of the sources in storage at the facility. The HPGe spectrometer comprises an internal Geiger-Muller tube with energy range between 30 keV and 30 MeV coupled to a computer based Multi-Channel Analyzer (MCA).

Results and Discussion

The national inventory at the time of this exercise is summarized as shown in Figure 3. The inventory was dominated by Am-241 (47%), followed by Cs-137 (14%) and Sr-90 (13%).

The inventory as summarized in Figure 3 covers legacy as well as current; characterized and uncharacterized radioactive sources that existed from 1952 to date. Additionally, list of radioactive isotopes and confirmatory sources were obtained. For each radioactive source, the following information (if available) was recorded in an electronic database:

•Name (radionuclide),
•Waste classification,
•Radioactivity concentration,
•Material composition and
•Application.

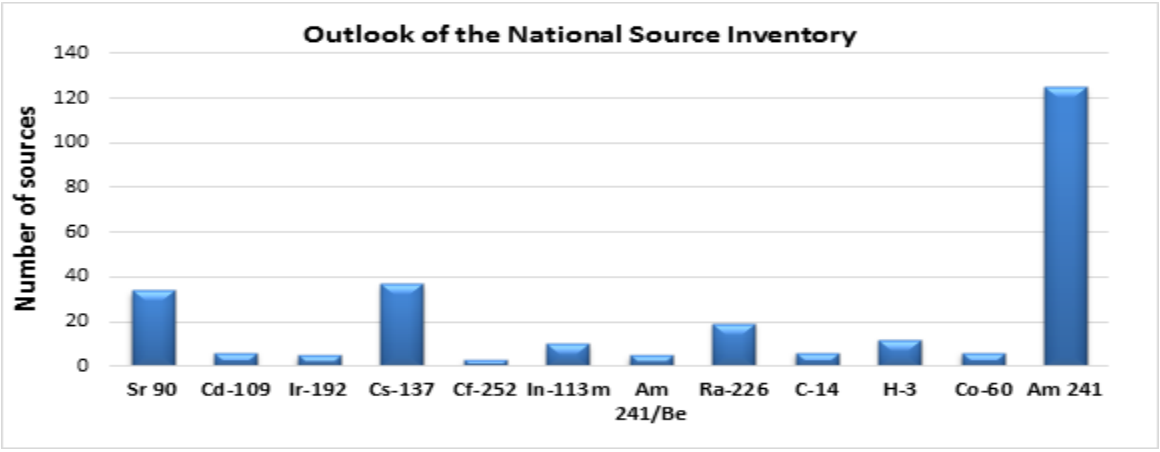

Figure 3. Chart of the national inventory of disused sealed sources.

Measured doses:

Even though radiation dose measurements were made at various microenvironments of the facility, results of only selected areas including A7, A6, A2, source characterization room also known as the Lab and back of the facility labelled A3 as shown in the structural plan above are presented in this manuscript.

Along the walls of the facility at A7, the dose rates before the sources were transferred ranged between 2.28 µSv/h in the first month and 1.71 µSv/h in the third month. Arrival of Cobalt-60 irradiator source in the fourth month raised the dose to 20.97µSv/h. The Cobalt-60 source was shielded leading to a reduced dose rate of 1.02µSv/h and 1.13 µSv/h in the fifth and sixth months, respectively. The average dose for the entire 6 month period stood at 4.99 µSv/h which translates to 0.57 nSv/y. After the transfer of the sources to the new storage rooms, the dose rates measured at the same area along the walls at A7 were found to have reduced significantly, about 31 times less than the previous recordings. The dose ranged from 0.12 µSv/h to 0.20 µSv/h with an average rate of 0.16 µSv/h translating to 0.02 nSv/y for the six month period. It is important to note that, A7 area of the facility also known as the Lab recorded the highest radiation doses as it is the room adjacent to the high dose area of the facility and also used as a temporary store during source characterization. Figure 4 illustrates the dose difference between the new and the old storage blocks.

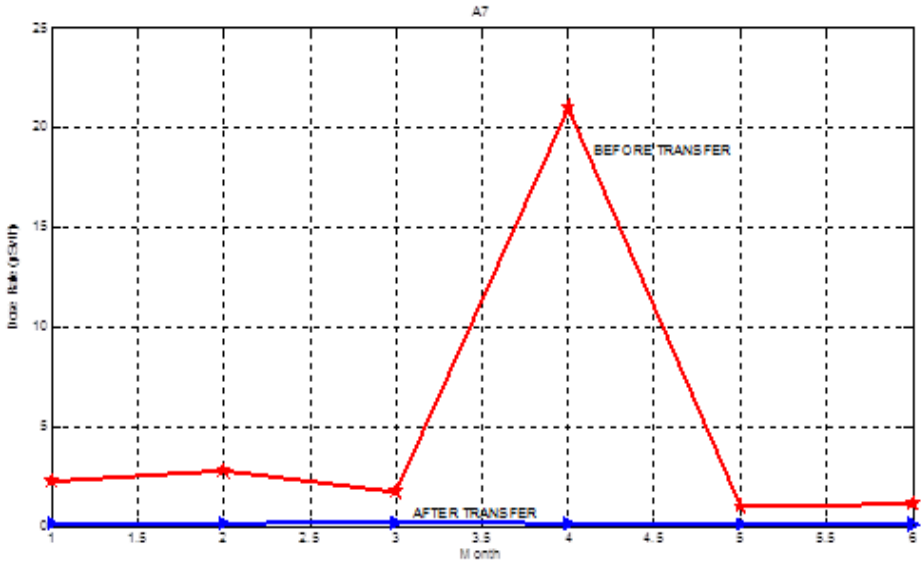

Figure 4. Dose rates recorded along the walls of A7 of the facility.

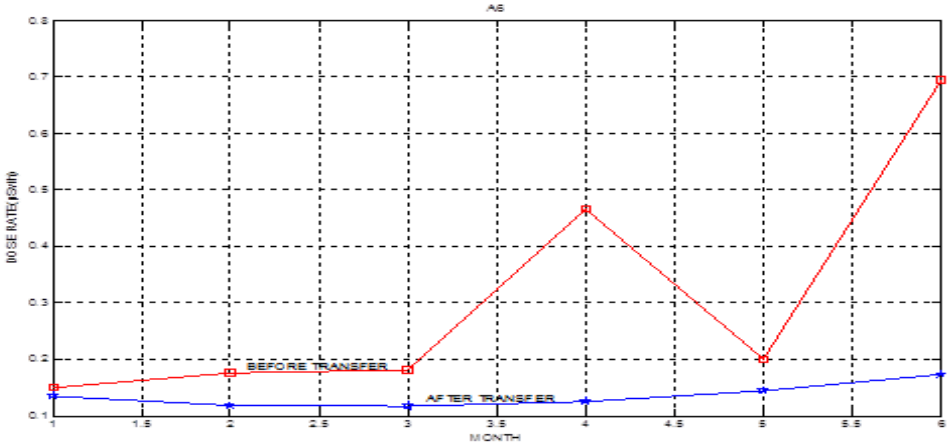

Figure 5. Dose rates recorded along the wall at A6 of the facility.

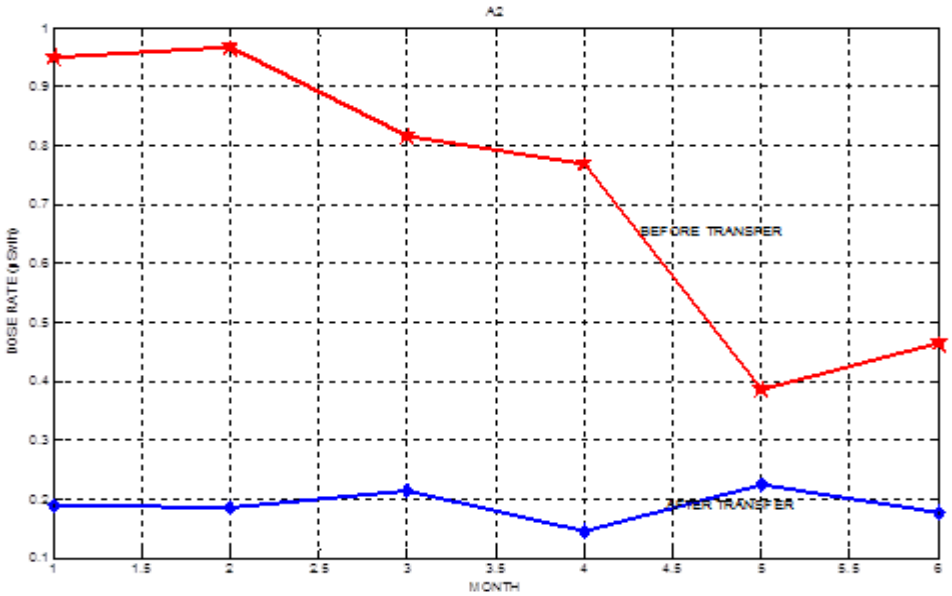

Figure 6. Dose rates recorded along the wall at A2 of the facility.

At A6 of the facility, the dose rates before the sources were transferred from the old to the new storage block ranged between 0.15µSv/h and 0.69µSv/h with an average dose of 1.73µSv/h. After the transfer of the sources, the dose recorded ranged between 0.12µSv/h and 0.17µSv/h with an average dose of 0.73µSv/h. Similarly at A2, the doses measured ranged between 0.39µSv/h and 0.97 µSv/h as compared to 0.14 µSv/h -0.19 µSv/h after the sources were transferred. The average dose rate at A6 was found to be 2.36 µSv/h whilst at A2 the average dose was 3.55 µSv/h. Attenuation of radiation by the walls of the building was as usual, higher and hence lower recorded doses after the transfer of the sources to the new block occurred. Results obtained at A6 and A2 are illustrated in Figure 5 and Figure 6, respectively. As can be seen from the charts, the dose difference between the new and the old block was higher at A2 than A6. This is because A2 is the wall of the high dose room and therefore releases high doses of radiation than A6 which is only a temporary loading area.

Dose rates at the back of the facility at A3 before the sources were transferred ranged between 0.26µSv/h and 0.39 µSv/h with an average dose of 0.29 µSv/h translating to 0.03 nSv/y. After the sources were transferred to the new block, dose rates of 0.12 µSv/h – 0.19 µSv/h with an average dose of 0.19µSv/h translating to 0.02nSv/y were recorded.

Radiation doses recorded in the Lab i.e. the characterization room depicted a trend similar to those recorded along its walls as stated earlier for A7. Before the sources were transferred, measured doses ranged between 0.31µSv/h in the first month to 0.21µSv/h in the third month. With the arrival of the Cobalt-60 irradiator source in the fourth month, the radiation dose shot up to 3.58µSv/h. After shielding the Cobalt-60 source, the dose rate reduced to 0.37µSv/h and 0.21µSv/h in the fifth and sixth months, respectively. The average dose for the entire 6 month period was 0.83 µSv/h translating to 0.09nSv/y. After the transfer of the sources to the new block, measured doses at the same area were found to have reduced significantly. The recorded doses ranged between 0.13µSv/h and 0.20 µSv/h with an average dose of 0.14µSv/h which translates as 0.02nSv/y. Thus, the doses measured after the transfer (in the new block) are ~ 6 times less than before the transfer (in the old block). Illustrated in Figures 7 and 8 are the measured doses at the back of the storage facility and in the characterization room, respectively.

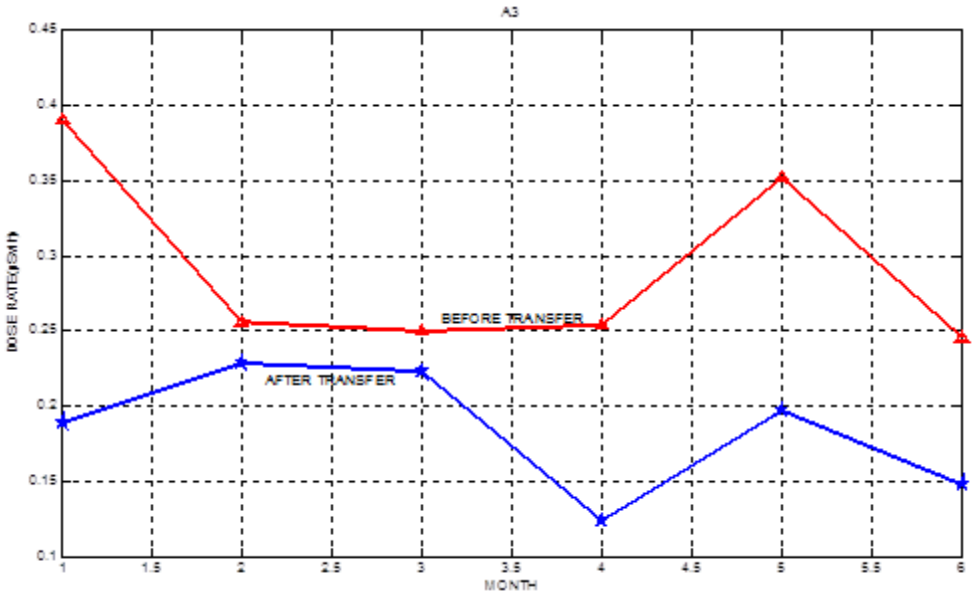

Figure 7. Dose rates measured at the back of the facility, A3.

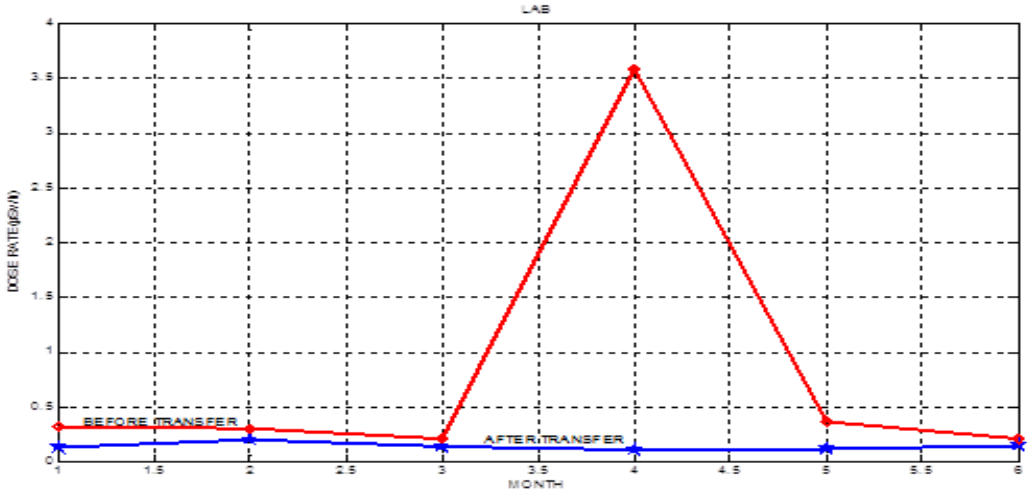

Figure 8. Dose rates measured in the source characterization room (Lab.).

Conclusion

The purpose for which the old storage facility was upgraded was to improve upon the security and safety of the radioactive sources; enhance the structural integrity of the facility as well as containment of radiation in order to protect human health and the environment at large. Generally, the dose rates measured before and after the source transfer were within the personnel dose limit but were found to be generally higher before the transfer of the sources took place. Cobalt-60 irradiator source which falls under category 2 of the disused sources was found to have contributed significantly to the dose rates in the facility. Comparing the levels of radiation measured before and after the transfer of the sources, it can be said that the purpose of the upgrade was achieved and that the walls of the new block provided enough shielding effect for radiation attenuation.

References

[1].Glover E. T.,Gbadago J. K., Addo M. A. (2009). Radioactive Waste Management in Ghana.J.Applied Science and Technology.

[2].Glover E. T., Gbadago J. K., Addo M. A., Management of disused Radium Sources in Ghana. Technical report submitted to the Ghana Atomic Energy Commission.

[3].IAEA (2005).Sealed Radioactive Sources: Issues for Government Agencies, IAEA/ RI/ A.79/05-09461.

[4].AquiSim Consulting (Pty) Ltd (2011) BOSS Concept: Long-Term Solution for the Management of Disused Sealed Radioactive Sources.

[5].IAEA (2005c), Disposal Options for Disused Radioactive Sources, Technical Report Series No. 436

[6].IAEA (2009b), Borehole Disposal Facilities for Radioactive Waste, Safety Standard Series No. SSG-1.

[7].Benitez J. C., Salgado M. (2004). ‘’Disused SRS Management in Cuba: Retrievable Conditioning’’.IAEA-WMDB-ST-4.

[8].IAEA (2007).Retrieval, Restoration and Maintenance of Old Radioactive Waste Inventory Records, TECDOC No 1548.

[9].ANDRA (2009). National Inventory of Radioactive Materials and Waste, www.andra.fr