Management and Control of Radioactive Wastes in Ghana

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Abstract
Radioactive materials have been in use in Ghana for more than five decades. They are been used for diagnostic and therapeutic procedures in medicine, measurement and processing techniques in industry, irradiation techniques for food preservation and sterilization of medical products as well as for teaching and research. Most of these radioactive materials are in the form of sealed radiation sources and generate waste that must be managed. Management of spent or disused radiation sources is considered to be one of the greatest challenges in radioactive waste management. A national system for the management and control of radioactive waste is essential for the security and safety to safeguard and protect the citizens of Ghana from radiation exposure. In this paper the national system of control of radioactive waste is presented. The roles of the National Radioactive Waste Management Centre (NRWMC) of Ghana Atomic Energy Commission (GAEC) as the institution responsible for carrying out radioactive waste safety operations and the Radiation Protection Board (RPB) as the national regulatory authority are specified. The profile of radioactive sources in active use are also presented, in addition to spent radioactive sources currently in the custody of the NRWMC as part of the inventory for creating databases on radioactive wastes in Ghana. The disposal option for the spent sources is also discussed

1. Introduction

Radioactive materials have been in use in Ghana for more than five decades. They are been used for diagnostic and therapeutic procedures in medicine, measurement and processing techniques in industries in the form of nuclear gauges and are used for industrial radiography, analytical techniques in mining, tobacco, road construction, exploration, manufacturing, petrochemical and telecommunication industries; irradiation techniques for food preservation and sterilization of medical products as well as for teaching and research in higher institutions of learning. They contain radionuclides such as cobalt-60 (Co-60), strontium-90 (Sr-90), cesium-137 (Cs-137), tritium (H-3), americium-241(Am-241) and also americium in association with beryllium (Am/BE).The types of radioactive wastes generated are mostly spent sealed sources but includes also unsealed sources, contaminated items such as vials, papers, plastic gloves and glassware, liquid and organic wastes and geological samples. Others are ion-exchange resins for water purification and incompatible solid wastes from mechanical filters for the research reactor.

The National Radioactive Waste Management Centre (NRWMC) of the Ghana Atomic Energy Commission (GAEC) was established in July 1995 to undertake radioactive waste safety operations in Ghana [1]. The NRWMC is engaged in research activities to develop

safe and sound radioactive waste management protocols and provides technical services of collection, segregation and transportation of radioactive wastes to the centralized storage facility at Kwabenya. Additionally, the Centre undertakes environmental radiation surveys of localized interim storage sites and registration of spent and disused radiation sources using the Radioactive Waste Management Registry, software for recording and governing information on radioactive waste management. It is developed by the International Atomic Energy Agency (IAEA). The National Radioactive Waste Management regulation which is in its final stage of promulgation set up the basic technical and organizational requirement to be complied with by waste generators and makes provisions for penalties for non-compliance with the regulation.

2. National System For Radiation Safety and Security

The Radiation Protection Board (RPB) was established in 1993 by the amendment of the Atomic Energy Act, Act 204 of 1963 by the Provisional National Defence Council Law, Law 308. The Primary Law was strengthened by the enactment of the Radiation Protection Instrument, LI 1559 in January 1993. The RPB is the National Competent Authority in Ghana mandated to license, register, authorize and inspect radiation sources as well as enforce code of practices for the purposes of radiation safety [2, 3, 4]. Facilities which are subjected to licensing include, the Ghana Research Reactor-1 and operations, Radiotherapy Centers in Korle Bu and Komfo Anokye Teaching hospitals, Gamma Irradiator facility at GAEC, Gamma ray scanners at Tema Harbour and the Centralized Radioactive Processing and Storage facility. Facilities which are only registered are facilities that undertake diagnostic radiology, X-ray fluorescence analysis, X-ray diffractometry, nuclear density and level gauge, industrial radiography, diagnostic nuclear medicine and radiotracer for monitoring industrial processes.

To track radioactive sources and waste generated, records of sources and radioactive materials imported into and exported from the country are kept by the RPB using the IAEA registration software called Regulatory Authority Information System (RAIS). Table 1 shows the inventory of radiation sources in active use taken from RAIS records. RAIS also involves a system of notification to possess and use radiation sources and irradiating devices; authorization by registration on and/ or by licensing; safety assessment for authorization and regular inspection.

The need for co-operation and coordination with other state bodies to safeguard and protect the citizens of Ghana from radiation exposure was recognized. The RPB therefore liaises with the Customs Excise and Prevention Services, the National Security Council, the Bureau of National Investigation, Standard Board and Environmental Protection Agency. Representatives of these state organizations are trained in radiation detection and protection to monitor and prevent illegal acquisition of radioactive materials.

3. Radioactive Waste Safety Operations

The NRWMC as the authorized radioactive waste management and control establishment in Ghana coordinated nationwide safety and security programmes. With the collaboration of RPB, NRWMC have collected a number of radioactive waste materials (Table 2) from

users for management at the Central Radioactive Waste Processing and Storage facility at GAEC premises. NRWMC staff does collection and transportation of the radioactive waste from the waste generator. Transportation of the waste from the waste generation site is done in accordance with the Radiation Protection and Safety Guide on safe transport of radioactive materials [5]. The NRWMC notifies the RPB in writing of the transfer of the radioactive waste to the NRWMC facility. All wastes are accompanied by a document with detailed characteristics of the waste. Primary control of waste to check for acceptance criteria by NRWMC staff is carried out at the waste generation site. At the waste processing facility, an additional control and analysis is carried out, for treatment purposes. Decay storage is considered for short-lived low activity spent sources that will decay to clearance levels within one year from the time of its generation.

Radium needles which were in use at the Radium Therapy Centre (RTC) of Komfo Anokye Teaching Hospital (KATH) for treatment of cervical cancer from 1992 – 1997 were conditioned with the help of the African Regional Co-operative Agreement (AFRA) Specialised Radium conditioning team from South Africa. A total of 190 mg (7.03 GBq) of radium was safely conditioned in one concrete package [6].

4. Disposal Option

The current waste management practice in Ghana is storage which is considered unsustainable due to the long half life of some of the radionuclides and the threat to nuclear security in the country. There is therefore the need for a repository taking into consideration the quantity of waste in the country. The **B**orehole disposal **O**f **S**ealed **S**ources (**BOSS**) system developed in South Africa under IAEA Technical Cooperation project presents the best option. Effects are been made to implement the BOSS concept in Ghana. The BOSS disposal concept is designed to provide a solution for the disposal of both short- and long life radionuclides such as Ra-226 and Am-241.

It consists of a standard 165mm diameter borehole drilled to a depth of 100m with a 150 mm casing of mild steel or high density polyethylene [7]. However wider and deeper (or shallower) boreholes will be drilled if required depending on site-specific conditions. The borehole will be sealed off with cement plug at the bottom to ensure that the disposal volume remains dry during the operational period.

The source is placed inside a 3 mm thick 304 stainless steel capsule which is 110 mm long and 22mm in diameter and the lid welded. The capsule is then placed a hole in a pre-cast concrete in a 316 stainless steel container which is 114 millimetres diameter and 250 millimetres long. The container also has a welded lid. Leak testing of both the capsule and container guarantees that the radionuclides are safely contained. The capsule and container assembly constitutes a waste package (fig.1) [7].

Before the first waste packaged is disposed off, a layer of concrete 375 mm in depth is poured into the borehole. The first disposal package is then lowered using a crane or winch into the concrete so that it sinks through the fresh concrete and stands on the concrete plug. This is followed by another layer of concrete, which will cover the container (250 mm in length) and up to 375 mm on top of the container. When the

concrete is set, the top of the concrete forms the platform for the next disposal package. The process is repeated until the required number of packages has been emplaced. A single waste package and its backfill occupy a length of 1 m in the borehole. The topmost disposal package will be 30 meters below ground level. 50 waste packages can be disposed off in the borehole. The limiting factor for the number of waste packages will be the waste inventory and the site characteristics.

With all the packages in place, the section of borehole lining above the topmost package is removed. A steel deflection plate is placed above the topmost package to prevent inadvertent drilling into the disposal zone and the (now unlined) top of the borehole is filled with concrete to within 2 metres of the surface (fig.2). The final 2 metres is filled with native soil. The intention is that, while the general location of the borehole may be well known, its precise location (to within a few metres) will not. The aim is to improve security by making the borehole difficult to locate without specialised knowledge and equipment. The 'one-size-fits-all' design can be deployed at a wide range of sites and for a wide range of radionuclides. The BOSS concept employs readily available constructional techniques and requires limited land and infrastructure. Have a low probability of human intrusion and future disruptive events due to the small footprint of the borehole.

5. Conclusion

The programme for controlling radioactive waste exposure and contamination in Ghana has been presented. Most of the radionuclides will remain active for a very long time and will continue to be potentially dangerous. The NRWMC is collaborating with the RPB and other state owned agencies to effectively and efficiently safeguard and protect human health in Ghana. Illegal disposal of radioactive waste would pose disaster for the nation. The BOSS disposal option is therefore been pursued to ensure a complete radioactive waste safety regime in Ghana.

Reference

[1] Ghana Atomic Energy Commission (GAEC), Annual Report, Documentation & Publication Committee, Kwabenya-Accra, 2001

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[5] Safe Transport of Radioactive Materials, Radiation Protection and Safety Guide, GRPB-G6:2000, Radiation Protection Board, Accra 2002

[6] Hordihk, L, Expert Mission Report on Radium Conditioning in Ghana, Vienna, IAEA 1998

[7] Van Blerk,J.J and Kozak, M.W. Borehole Disposal of spent radiation sources: 1. Principles, in Proceeding of International Conference on the Safety of Radioactive Waste Management organized by the International Atomic Energy Agency, March 13-17 2000, Cordoba (Spain).

Table 1: Inventory of licensed radiation sources in use in Ghana

Radionuclide	Quantity	Total Activity (Bq)	Application
Am-241	12	5.50E+10	Industrial gauges
Am241-Be	18	3.37E+10	Well logging
C-14	1	3.70E+07	Research
Cd-109	3	3.33E+08	X-ray Fluorescence Analysis
Cm-244	3	2.22E+12	Industrial radiography
Co-60	6	2.27E+15	Teletherapy, industrial radiography
Cs-134	3	1.29E+09	
Cs-137	53	2.39E+11	Brachytherapy, industrial radiography
Fe-55	1	7.40E+08	
H-3	4	4.44E+09	Research
Ir-192	6	1.48E+13	Industrial radiography
Ni-63	1	3.70E+08	
Pu-238	1	1.11E+09	Industrial gauge
Ra-226	1	1.48E+09	Brachytherapy
Sr-90	28	1.44E+10	Thickness gauge

Table 2: Inventory of Radioactive Waste at the Central Waste Storage facility

Isotope	Half-life	Total Activity (GBq)	Type	Form	Quantity
Sr-90	28y	9.55E+00	Sealed	Solid	27
Cd-109	463d	5.55E-01	Sealed	Solid	5
Ir-192	73.8d	1.85E-01	Sealed	Solid	1
Fe-59	44.5d	2.22E+01	Sealed	Solid	2
I-129	1.6E+7y	4.25E+02	Sealed	Solid	1
Co-57	271.8d	1.11E-01	Sealed	Solid	3
Co-60	5.3y	1.11E-01	variable	Solid	3
Sr-89	50.5d	4.77E+02	Sealed	Solid	1
Tl-204	3.7y	7.40E-02	Sealed	Solid	2
Cs-137	30.0y	4.01E+02	Sealed	Solid	31
Cf-252	2.64y	2.22E+00	Sealed	Solid	3
P-32	14.3d	3.70E-01	Unsealed	Liquid	1
Tc-99m generators	6.01h	3.85E+02	Unsealed	Liquid	77 (decommissioned)
In-113m generators	1.66h	2.22E+01	Unsealed	Liquid	12
Ra-226	1600y	7.03E+00	Sealed	Solid	19 (conditioned)*
Am-241	432.2y	4.63E+02	Sealed	Solid	125
H-3	12.3y	3.70E-02	Unsealed	Liquid	250 L
C-14	5730y	2.60E-01	Sealed	Gaseous	7

* The radium sources were conditioned in 1998

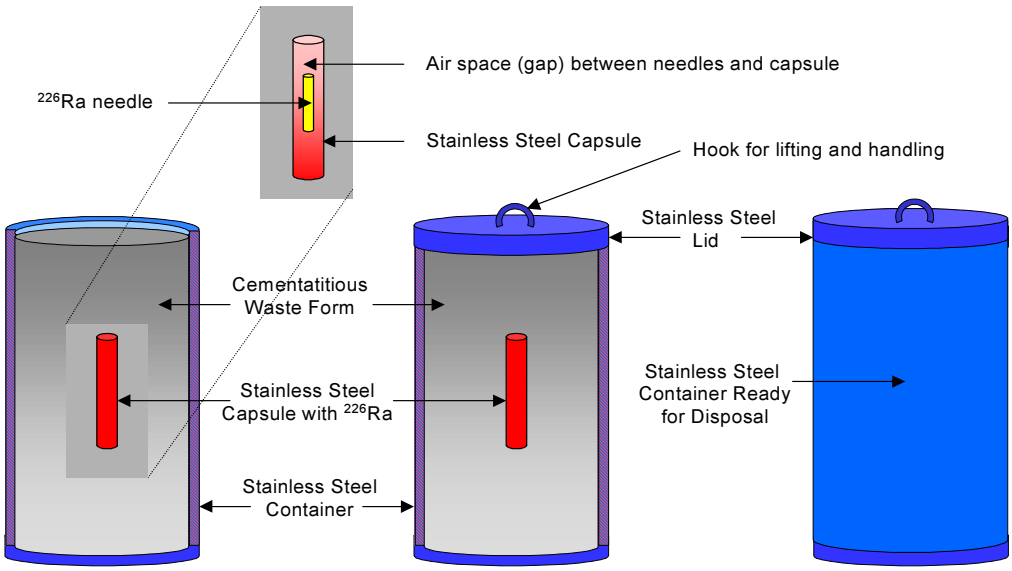

Fig. 1. Waste Package preparation

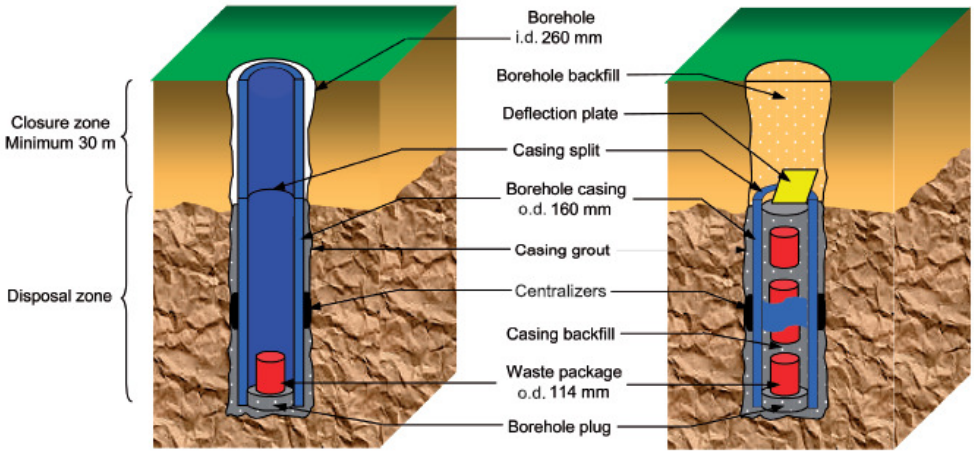

Fig.2. Schematic representation of the BOSS Disposal concept, i.d.: inside diameter; o.d.: outside diameter