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REVIEW ON WASTE INVENTORY, WASTE CHARACTERISTICS AND CANDIDATE SITE FOR LLW. DISPOSAL IN THAILAND

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1. INTRODUCTION

It is a worldwide practice that radioactive waste has to be kept under control to be ensured of low potential impact on man and his environment. In Thailand, the OAEP is responsible for all radioactive waste management activities, both operation and the competent authority.

The radioactive waste in Thailand is compose of low level wastes from the application of radioisotopes in medical treatment and industry, the operation of the 2 MW TRIGA Mark III Research Reactor and the production of radioisotopes at OAEP. The Wastes from these activities are collected and treated by OAEP using chemical precipitation methods for liquid waste and volume reduction process viz. compaction and incineration for solid waste. In addition, the high activity of sealed radiation sources i.e. Cs-137, Co-60 and Ra-226 are also accumulated. Since The volume of treated waste has been gradually increased, the general needs for a repository become apparent. Therefore, a plan for central disposal site has been set up. The near surface disposal method is chosen for this aspect because of its simple, inexpensive and adequate safe and very well know process.

2. WASTE CHARACTERISTICS AND MANAGEMENT

Currently, there are about 100 licensed radioactive users. These licensees are a heterogeneous mixture of individual and governmental institutions which possess the radionuclides of activity ranging from a few kilo becquerel up to some giga- becquerel. Table 1 reveals the type of nuclear and radionuclides utilizing facilities in Thailand. Apart from net benefits of nuclear utilization, such development is inevitably accompanied by the increasing production of radioactive wastes in quantities and forms. Table 2 and 3 follow, disclose the inventory of waste stream arising from their usage.

To facilitate subsequent treatment, conditioning, storage, transport and disposal, the waste categories are as follow :-

A. Solid waste containing short-lived radionuclides which can be stored for decay and subsequently be disposed of as exempted waste within 2 years after collection.

B. Aqueous liquid waste containing short-lived radionuclides which can be stored for decay and subsequently be disposed of as exempted waste within 2 years after collection.

C. Organic liquid waste containing short-lived radionuclides which can be stored for decay and subsequently be disposed of as exempted waste within 2 years after collection.

D. Solid waste which after proper treatment and conditioning can be disposed of in near surface repositories in accordance with the conditions laid down in this regulation. This waste category shall, in addition, be separated in burnable and non-burnable waste. The non-burnable waste can be separated in compactable and non-compactable waste.

E. Aqueous liquid waste which after proper treatment and conditioning can be disposed of in near surface repositories in accordance with the conditions laid down in this regulation.

F. Organic liquid waste which after proper treatment and conditioning can be disposed of in near surface repositories in accordance with the conditions laid down in this regulation.

G. Sealed radiation sources which after proper treatment and conditioning can be disposed of in near surface repositories in accordance with the conditions laid down in this regulation.

H. Sealed radiation sources with activities exceeding those acceptable for disposal in near surface repositories in accordance with the conditions laid down in this regulation.

I. Gaseous waste which require encapsulation and dispose as radioactive waste.

J. Biological waste, such as animal carcasses, which can undergo decomposition if not properly treated and stored.

K. Special waste not meeting any of the above criteria.

Since the main radioisotope users are those in the medical sector, thus, most of the wastes originated from the hospitals in Bangkok. The waste from this quarter can be estimated at 60 percent of the total volume of waste production annually, while the wastes from agriculture and industrial sectors are less than 5 percent. The remainder figure ascribes to the R&D work and OAEP waste. All the waste emanated is accumulated at the place of the waste producer, and later on, transported by means of truck to OAEP.

The liquid wastes are predominantly aqueous solutions with low content of salts, and small amount of organic liquids. The quantities of untreated waste is about 200 cubic meter per year. The raw solid wastes constituted refuse or debris contaminated with radionuclides as well as biological waste are about 45 cubic meter per year. There are also a small volume of the spent radiation sources of Co-60, Kr-85, Sr-90, Cs-137 and Ra-226 sent to OAEP for further handling every year.

The waste produced in Thailand is categorized as low level wastes and spent radiation sources. The activities of the low level wastes are in the range of 3.7 - 37 Bq/l for liquid, and about background level to 0.2 mSv/hr for solid waste. While, the activities of the spent radiation sources can be considered as a high activity waste ranging from 20 kBq up to 50 TBq and some 10 MBq to 148 Gbq for Ra-226 sealed sources.

For liquid waste, the chemical co-precipitation process has been employed. For the solid waste, after segregation, the burnable waste was incinerated in a small incinerator, and non-burnable waste was packed in a compactor. The treated wastes such as the sludge residues, ash, compaction product and the used ion exchange resin, were then transferred to conditioning process, using cement as an

immobilization means. The end product, which is in the 200 litter steel-drum, is kept in temporary storage in site at OAEP.

The spent sealed radiation sources are not yet treated but allowed to decay in the shielding after collection. They can be divided into 2 levels of activity :- high activity is kept in high density concrete and low activity is in shielding, both are stored at the temporary storage facility. Some spent sealed source are reused in other industrial and educational applications.

3. INVENTORY OF RADIOACTIVE WASTES

The amount of solid and liquid wastes arising, lists of spent seal sources and its accumulation in each year, has been given in Table 4 and 5, respectively . In Table 6, the estimated waste volumes of treated and conditional waste for 10 years period is shown. It is apparent that the amount of waste will become immense and a repository for the treated waste will be required in the near future.

The inventory of radioactive waste and spent sealed sources are kept by OAEP and the records reflected both current and previous uses of radiation source. But, users intend to keep the spent sealed source at their own sites as a normal radiation material. However, these required inspection for safety control by the radiation safety officers.

After collection, at OAEP, the wastes are labeled for collection code, date, activity, dose rate at surface and 1 meter, type of waste, radionuclide, collector and producer on the container. In the log-book is referred to those in size, volume or weight, storage room, further treatment process, special requirement, etc. After treatment, the waste products are coded and recorded of surface dose rate, treatment process, type of waste, year-month and number of treatment.

At present, the record keeping has been done by computerized system (DOS with Windows, Microsoft Office (6.0a), Microsoft Project and Animator Pro plus Story Board). For the inventory of radioactive waste at OAEP, the Microsoft Excel and SRS-Registry(IAEA) are applied.

4. SELECTION OF A DISPOSAL SYSTEM

They are three disposal options exercised in worldwide practice, i.e. deep geological disposal which predestine predominantly for high level waste containing long live radionuclides, disposal into rock cavities which is suitable for low and intermediate level waste and near surface disposal or shallow ground disposal which appears to be the most amiable for low level waste disposal in Thailand. The main reason is that, this method is much less expensive than the other options. It is satisfactory safe and offers a prospect for an easy remedial actions in case of an extraordinary situation, if occurred.

Waste suitable for the shallow ground disposal is that classified as low and intermediate level waste containing predominantly short-lived nuclides (with half-lives approximately up to 30 years) and negligible amounts of long-lived and alpha-bearing nuclides. This requirements accomplish practically all radioactive waste resulting from applications of radionuclides in research, medicine and industry etc. , and also reactor waste originating from nuclear power plant operations.

Nevertheless, prior to disposal, waste which originates in liquid should be converted into stable solid from and should be packed in such a way as to comply with conditions for safe storage, transportation and disposal.

5. FEASIBILITY STUDY FOR SUITABLE DISPOSAL SITE IN THAILAND

Thailand occupies a territory of about 518,000 sq.Km. in the Southeast Asia Peninsula, extending from 5' to 21' North latitude and 97' to 106' East longitude. The area of the country can be topographical characterized into 4 groups :

1) folded mountains in the Northern part
2) flat alluvial plain in the Central part
3) the Khorat Plateau in the North Eastern part
4) the long coast line in the Southern part

To find out the candidate site for underground disposal, the rejection criteria has been established as follows:

(I) Geology-exclude all areas with the potential of soil liquefaction, subsidence, undermined areas, highly porous rocks, carbonaceous rocks, karstic formations and areas with occurrence of thermal and mineral water.

(II) Hydrogeology-exclude all sites with groundwater table levels higher than
8 - 10 m. from the surface.

(III) Hydrology -exclude all sites at a distance less than 1 km. from water streams or with the springs and other discharged points within the repository area including all sites with potential for flooding.

(IV) Meteorology -exclude all areas with potential for large local rains that can cause inundation.

(V) Seismology -exclude all areas with seismic activity higher than 8 degree of the MCS.

(VI) Radiation safety-exclude all sites where the exposure to the general public under unnatural conditions can be exceed prescribed limits of IDE values.

(VII) Other interests of higher priorities (i.e. valuable minerals and raw materials, protected zones, national parks and reservations, etc.) and exclude the site where is very far from Bangkok area.

In addition, the technical performance criteria and the economical criteria are also considered as follow :

(I) Topography-avoid hilly areas and areas with slopes higher than 5 degrees, avoid regions with terrain's difficult to construct access roads.

(II) Geology-avoid sites where earth materials are hardly excavation, avoid sites with hard rock basements higher than 8 - 10 meters below the surface, select preferably sites with occurrence of suitable backfilling and sealing materials.

(III) Justification of the cost of land, distance from the main stream of waste production, access of power and water utilities and the cost and plentiful of man-power for excavation work.

The feasibility study on the underground disposal site has been done since 1982. About 50 locations in the Central part and the Khorat Plateau have been picked up for consideration and 5 candidate sites have been selected and subsequently investigated. The potential sites under investigation are Ratchaburi site

A, and Ratchaburi site B located in the west Central Plain, at about 180 Kms. from Bangkok, and Kornburi, Lamplai Mat and Satuk in Khorat Plateau , at about 280, 370 and 430 Kms. from Bangkok, respectively.

All candidate sites are found to possess promising geology and hydrogeology. The site areas are not affected by inundation due to heavy rains since they are at elevated levels with respect to surroundings. But the land use, in general, is intensive and the site are at reasonable distance from the OAEP central waste management plant where the whole waste production is likely to be collected prior to disposal. The major problems for the selection of suitable disposal site in Thailand are those related to the meteorology and the hydrological aspects. Because, the average precipitation in all areas in Thailand is rather high, (>100 cms annually) and the surface water outlet is abundant. Therefore, the fully engineered facilities provided with a multi-barrier system will be designed to minimize any potential releases of radioactive nuclides into the biosphere.

After thoroughly investigation regarding the technical performance criteria and the economic criteria, a definite location in Ratchburi Province, about 180 Kms, southwest of Bangkok is considered as the most suitable place for the near surface disposal of radioactive waste in Thailand.

6. CONCLUSION

Even the candidate site is selected, many more phases of work need to be conducted. They are work on site confirmation including the safety assessment of the selected site, the primary mechanism for the potential movement of radionuclides from waste repositories, the physico - chemical properties of the soil and the environmental behaviors, etc. These information must be taken into account for the design and construction of the waste repository. In addition, tedious work on the procurement of pieces of land and on the acceptance of the local community must be tackled, too.

7. REFERENCE

1. The Atomic Energy for Peace Acts, B.E.2504 Thai Royal Gazette, April 26, 1961
2. IAEA Safety series No. 53 Shallow Ground Disposal of Radioactive Waste : A Guidebook (1981)
3. IAEA Safety series No. 54 Underground Disposal of Radioactive Waste : Basic Guidebook (1981)
4. Z. Dlouhy and P. YAMKATE; Development of a Radioactive waste Disposal System in Thailand : an internal paper submitted to OAEP, (1987).
5. Z. Dlouhy ; Disposal of Low - and Intermediate - Level Waste in Shallow Ground and Rock Cavities: paper distributed in IAEA Regional Training Course on Handling and Disposal of Nuclear Wastes, 2-27 May 1988, Beijing, China.
6. IAEA, ``International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Source'' Safety Series No.115-1 IAEA, Vienna, 1994.
7. Radioactive Waste- Product Coding, Radioactive Waste Management Division, Office of Atomic Energy for Peace, 1994
8. OAEP ``Radioactive Waste Management Guide Line'' Bangkok, January 1995.

Table 1. Types of Nuclear and Radionuclides Utilizing Facilities in Thailand

Facilities	*Number*
Research Reactor	1
Isotopes Production	1
Neutron Generator	1
Research Gamma Irradiator	3
Industrial Gamma Irradiator	2
Medical Radiation Therapy	10
Industrial Radiography	20
Manufacturing of products by nucleonic techniques	40
R & D Laboratories Using Radionuclides	30
Radioactive Waste Handling and Storage	1
Mineral extraction plant (monazite etc.)	2

Table 2 Distribution of Type of the Institution by Waste stream

Waste stream	Percentage	Major Radionuclide	Chemical Composition
Medical	60	Ga-67, Cr-51, Tc-99m, I-131, Tl-201, H-3, C-14	HCl, PO_4^{-3}, NO_3^-, NaCl, NaOH, Serum blood, Scintillants, Urine
Education & Research	35	P-32, S-35, Cr-51, Ca-45, Tc-99m, I-131, Co-60, Cs-137, Am-241, Be-7	PO_4^{-3}, Ca^{+2}, Cl^-, NO_3^{-2}, HNO_3, H_2SO_4, $HClO_4$
Industrial	5	Fe-55, Kr-85, Sr-90, Cd-109, Cs-137, Co-60, Ir-192, Am-241, H-3	Most of them are sealed sources.

Table 3 The Principal Type of Radioactive Waste Generated in Thailand

Waste Forms	Waste Compositions
Liquid: Aqueous	Laboratories, hot cells (isotope production), Fuel storage pool (research reactor), decontamination campaign, sump/rinsing water,
Organic	Oil from pump, etc. Scintillation liquids. Extraction solvent (TBP/kerosene, amine, etc.)
Solids: compactable/ combustible	Tissues, swabs, paper, cardboard, rubber, plastic (Polyvinylchloride, PVC; Polyethylene, PE), gloves, filters, protective cloths, glassware, carcasses .
non-compactable/ non-combustible	Ion exchange resins(research reactor), metallic, scrap, brickwork, sealed sources, contaminated chemical

Table 4 Radioactive Wastes Production during 1982 -1996

year	Liquid Waste (cu.m.)	Solid Waste (1000 Kg.)	Spent Radiation Source (piece)
1982	845	1.06	1
1983	600	1.12	0
1984	500	1.12	0
1985	780	1.62	0
1986	934	3.47	1
1987	400	2.62	118
1988	840	7.72	0
1989	480	1.88	41
1990	720	2.80	31
1991	485	2.78	15
1992	249	3.11	0
1993	277	3.18	0
1994	134	3.11	12
1995	140	1.73	20
1996	130	3.20	0
			413 pieces

Table 5 . Type and Quantity of Spent Radiation Source Accumulated in OAEP

Radionuclide	number (pcs)	Total activity (mCi)
Co-60	44	3,250
Kr-85	5	500
Sr-90	6	230
Cd-109	3	8
Cs-137	27	3,100
Ir-192	2	100
Po-210	2	12
Ra-226	239	4,200
U-238(depleted)	59	800 Kg
Am-241	25	25
Am/Be-source	1	unknown
Total	413	11,500 mCi (+ 800 Kg.of U)

Table 6 Estimated Waste Volume for 10 years Period (1995-2005)

Waste Type	Volume (m^3/y)	Activity (Bq/m^3 or Dose Rate)	Treatment and Conditioning	VRF after Conditioning	Conditioned Waste Volume (m^3/y)
Liquid:					
-aqueous liquid	200- 300	$4x10^4$ -$4x10^9$	precipitation cementation	-10	20-30
	6				
-organic liquid	2	$4x10^4$	incineration	-	-
			cementation	+2	4
Solid :					
-compactable	10	<10 mSv/hr	compaction	-5	2
-cumbustible	90	<10 mSv/hr	incineration	-20	4
-non-compactable	12	<10 mSv/hr	cementation	+2	24
-sealed source	<1	<10 Sv/hr	cementation or special treatment	+5	5
Wet Solid :		$4x10^9$	cementation	+5	10
-ion exchange resin	2				
				Total	69-79