OPTIMIZATION OF MANAGEMENT OF LIQUID RADIOACTIVE WASTE GENERATED IN RESEARCH AND EDUCATION CENTRES

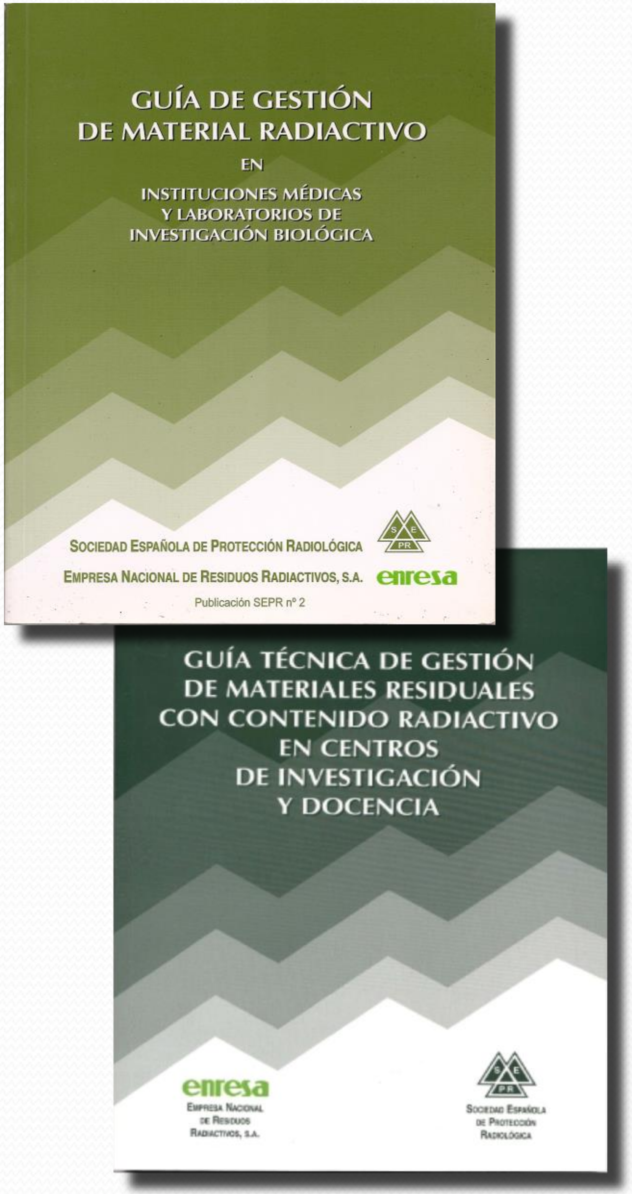
Macías M T[1], Pérez J[2], Pulido J[2], Sastre G[2], Sánchez A[3], Usera F[4]
[1]Instituto de Investigaciones Biomédicas "Alberto Sols" (CSIC-UAM), Spain
[2]Universidad de Alcalá de Henares, Spain
[3]Centro de Biología Molecular "Severo Ochoa" (CSIC-UAM), Spain
[4]Centro Nacional de Biotecnología (CSIC), Spain

INTRODUCTION

Improving the management of the radioactive waste generated in radioactive installations

One of the most important issues is to reduce the volume of the waste, carrying out adequate clearance procedures

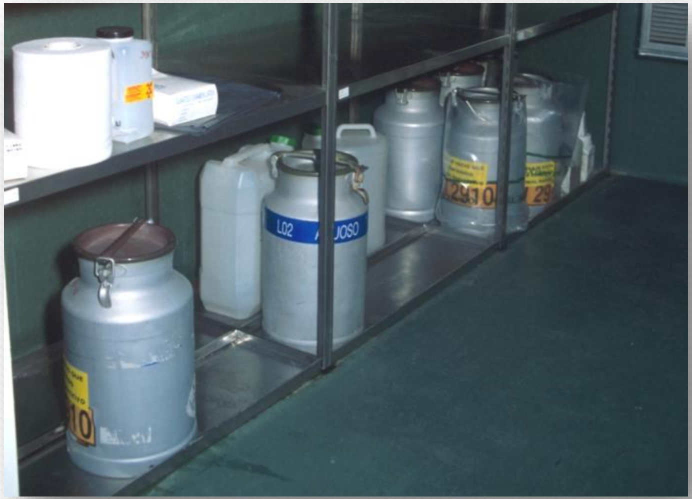
In Spain, some guides have been published for management of residual materials, but there are some issues that have not been solved yet



Objectives of the research project:

"Procedures to optimize the management of waste materials generated at research and teaching centres"

With the aim of trying to solve these issues, four large research and teaching centres have carried out a research project with a grant from ENRESA



Objectives:

1) Radiological and chemical characterization of radioactive waste

2) Propose a correct management of

- filled scintillation vials
- waste generated in electronic microscopic techniques
- **Aqueous and organic liquid waste**

This is the most important objective of the project. Here we present the results obtained

MATERIAL AND METHODS

Measurement of the Liquid Waste Activity Concentration

Scintillation counting was used. Absolute activity and radioactive concentration were determined applying the protocols indicated in the document[1]

Calculation of Reference Values of Activity for Organic Liquid Waste

- ✓The study focuses on the incineration of C-14 and H-3 waste
- ✓Effective dose limit established for individuals should be ≤ 10 μSv/year
- ✓Pathways of exposure: inhalation, ingestion and external irradiation
- ✓The individual can be exposed for 24 h, 365 days/year
- ✓The scenery contemplates the following conditions:
  - Atmospheric standard conditions.
  - Gaseous discharge reaches up to 1 m high on a building of 10 m
  - Wind speed is 1 m/s going towards where an individual lives 25 % of the time
  - The distance from the gaseous discharge to the individual is 100 m

The theoretical model was made by "Unidad de Protección Radiológica del Público y del Medio Ambiente" (CIEMAT).

[1] Macías, M.T., Pulido, J., Ruiz, A., Sánchez, M., Sánchez, A. y Usera, F. 2002.Guía técnica de gestión de materiales residuales con contenido radiactivo en centros de investigación y docencia. Sociedad Española de Protección Radiológica, publicación nº 7. (Senda. Madrid).

MATERIAL AND METHODS (2)

Calculation of Reference Values of Activity Concentration for Aqueous Liquid Waste

Final disposal: discharge to the normal sewerage system

CSN, Regulatory Body in Spain, limits the annual amount of discharge to a maximum of 10 GBq of ^{3}H, 1 GBq of ^{14}C and 1 GBq as the sum of the rest of radionuclides, ensuring that ALIing is not exceeded

Taking into account these parameters, we must make the following calculations:

- ✓ALIing: annual limits of intake by ingestion (fulfilling the annual effective dose limit of 1 mSv)
- ✓Cvmax: maximum limit of activity concentration in the final point of the sewerage system (annual ingestion rate of 600 l)
- ✓CvPI: maximum activity concentration of the waste to be discharged in the initial point of the sewerage system (knowing the daily volume of water evacuated from the building)

$$LIA_{ing} = \frac{1 \bullet 10^{-3}}{e(g)\,j} \; \frac{Sv}{Sv/Bq} = Bq$$

e(g)j: committed effective dose coefficient

$$CV_{\max} = \frac{LIA_{ing}}{600} \; \frac{Bq}{l}$$

$$Cv_{PI} = \frac{CV_{\max} \times (V_c + V_{ec})}{V_c}$$

Vc: liquid waste volume in the container

Vec: water volume released in the centre daily

RESULTS

Characterization of Liquid Waste

Most of the liquids had low activity concentration.

They are clear candidates for clearance, some of them may be directly and others should be stored for decay if they do not have long half-lives

Nº	Group of techniques	Technique	Radionuclide	Radioactive concentration (Bq/ml)	Total %
1	Enzymatic Assays	Leucine decarboxilation	^{14}C	0,338	0,006
		Methionine adenosyl transferase	^{3}H	244,3	51,50
		Deoxiglucose Intake	^{3}H	590	13,71
		Telomeric amplification	^{32}P	181,9	12,29
2	Cell culture assays	Ethanolamine kinase	^{14}C	2.989,6	33,7
		Ceramides quantification	^{32}P	76.487,8	87,18
		Intracellular calcium release	^{45}Ca	102.378,2	75,33
3	Nucleic Acid Hybridisation	Northern blot	^{32}P	186,3	5,08
4	Nucleic Acid Characterization	Electrophoretic mobility shift assay	^{32}P	27,3	1,19
5	Radioinmunoassay	Radioimmunoassay for GMPc	^{125}I	85,6	82,07
		Radioimmunoassay for methionine	^{125}I	324,7	18,84
6	Binding assays	Binding somatostatin-receptor	^{125}I	49.107,4	64,14
		Binding VIP-receptor	^{125}I	720,1	96,33
7	Radioiodination	Radioiodination of somatostatin	^{125}I	173,3	40,57

RESULTS (2)

Reference Clearance Levels Proposed for Organic Liquid Waste

To obtain the effective dose of 10 µSv/year with a continual emission is necessary of:

H-3	12,262 Bq/s	$3.9 \cdot 10^{11}$ Bq/year
C-14	171 Bq/s	$5.4 \cdot 10^{9}$ Bq/year

When both radionuclides are incinerated:

$$\sum \frac{A(H-3)(Bq/a)}{3.9 \cdot 10^{11}(Bq/a)} + \frac{A(C-14)(Bq/a)}{5.4 \cdot 10^{9}(Bq/a)} \leq 1$$

a: year

The calculation of the reference clearance values has been performed using the indicated data and the volume of liquid waste generated in Spain (495 liters for 2008)

H-3	$3.9 \cdot 10^{11}$ Bq /year of 3H / 495 l = 7,8 10^{8} Bq/ l
C-14	$5.4 \cdot 10^{9}$ Bq /year of 14C / 495 l = 1,09 10^{7} Bq/l

If it is necessary to incinerate both radionuclides simultaneously:

$$\sum \frac{A(H-3)(Bq/l)}{7.88 \cdot 10^{8}(Bq/l)} + \frac{A(C-14)(Bq/l)}{1.09 \cdot 10^{7}(Bq/l)} \leq 1$$

The liquid waste with a radioactive concentration that is lower than these values may be incinerated with the Spanish regulatory body approval

RESULTS (3)

Reference Clearance Levels Proposed for Aqueous Liquid Waste

Annual limits of intake by ingestion (ALI_{ing}) and maximum limit of activity concentration at the final point of the normal sewerage system (CV_{max}) obtained for several radionuclides

		ALI_{ing} (Bq)	CV_{max} (kBq/l)		ALI_{ing} (Bq)	CV_{max} (kBq/l)
^{3}H	H_2O tritiated	$5,56\cdot10^{7}$	92,593	^{55}Fe	$3,03\cdot10^{6}$	5,051
	OBT	$2,38\cdot10^{7}$	39,683	^{59}Fe	$5,56\cdot10^{5}$	0,926
^{14}C		$1,72\cdot10^{6}$	2,874	^{65}Zn	$2,56\cdot10^{5}$	0,427
^{22}Na		$3,13\cdot10^{5}$	0,521	^{75}Se	$3,85\cdot10^{5}$	0,641
^{32}P		$4,17\cdot10^{5}$	0,694	^{86}Rb	$3,57\cdot10^{5}$	0,595
^{33}P		$4,17\cdot10^{6}$	6,944	^{111}In	$3,45\cdot10^{6}$	5,747
^{35}S	inorganic	$7,69\cdot10^{6}$	12,821	^{125}I	$6,67\cdot10^{4}$	0,111
	organic	$1,30\cdot10^{6}$	2,165	^{131}I	$4,55\cdot10^{4}$	0,076
^{36}Cl		$1,08\cdot10^{6}$	1,792	^{133}Ba	$6,67\cdot10^{5}$	1,111
^{45}Ca		$1,41\cdot10^{6}$	2,347	^{153}Gd	$3,70\cdot10^{6}$	6,173

$$Cv_{PI} = \frac{CV_{max} \times (V_c + V_{ec})}{V_c}$$

Vc: liquid waste volume in the container

Vec: water volume released in the centre daily

Maximum limit of activity concentration to be discharged in the initial point of the normal sewerage system (*CvPI*) for ^{3}H and ^{14}C in a facility that releases 45,000 liters daily

		ALI (Bq)	*CVmax* (kBq/l)	Cv_{PI} (kBq/l)
^{3}H	$^{3}H_2O$	$5,56\cdot10^{7}$	92,593	138.981,48
	OBT	$2,38\cdot10^{7}$	39,683	59.563,49
^{14}C		$1,72\cdot10^{6}$	2,874	4.313,22

OBT: Organically Bound Tritium

CONCLUSIONS

✓If the incineration is the last part of the organic liquids management, it would reach the clearance levels if the radioactive concentration is lower than $7.8 \cdot 10^8$ Bq/l of ^3H or $1.09 \cdot 10^7$ Bq/l of ^{14}C, taking into account a general production of 495 liters (Spain, 2008)

✓The ^3H and ^{14}C radioactive concentrations obtained in the characterized techniques are lower than the values indicated, which makes it possible to transfer the liquids to a hazardous waste company for its incineration

✓As regards the aqueous liquids, the Cv_{pi} have been determined for several radionuclides assuming that a water volume of 45,000 l/day is released. The radioactive concentrations for ^3H and ^{14}C obtained in the characterized techniques were lower than the values indicated. Therefore these liquids could be discharged directly into the normal sewerage system

✓All radioactive installations need to perform their own calculations in order to obtain reference values to make the adequate clearance of their aqueous liquids. We are currently preparing a technical guide based on this study. This guide will contain the most suitable protocols to determine the management for all types of radioactive waste

✓Nowadays the organic liquid waste management is an unsolved problem. This work emphasizes the necessity to establish reference clearance values for organic liquid waste, suggesting the use of the obtained results to determine the indicated values. These values should be approved by the regulatory body and published in a technical document