EXPOSURE MODELS FOR THE DISPOSAL OF WASTE RESULTING FROM HANDLING OF RADIOACTIVE SUBSTANCES AT DUMP SITES *

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Introduction

In the classification of radioactive waste, the question arises as to whether a limiting value can be proposed, such that material with less activity than this limit does not necessitate radiation protection measures. This would imply that such material may be disposed at public dumps sites together with conventional waste without any further requirements.

For determining appropriate limits it is necessary to estimate the radiation exposure resulting from the disposal of substances contaminated by low level radioactivity. Therefore the possible exposure pathways from dump sites must be analysed and their respective contribution to the exposure of man must be determined.

This study is concerned with the above topics and limiting values for 7 different radionuclides are estimated.

Model of a Dump Site

A typical dump site is proposed schematically by fig. 1.

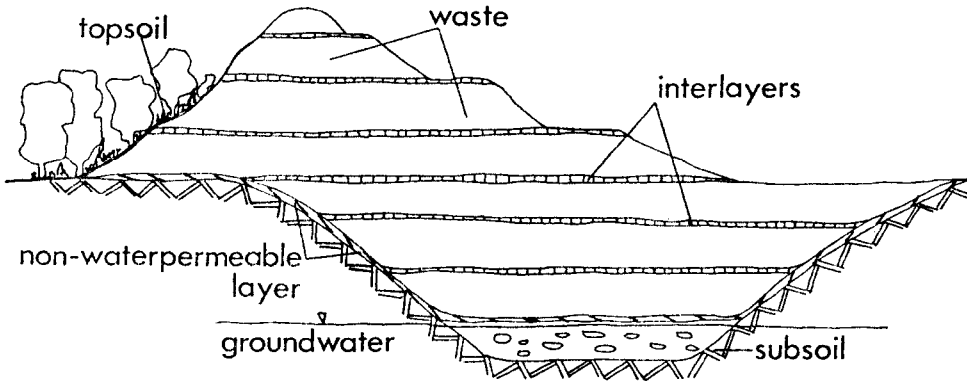

Fig. 1: A schematic representation of a reference dump site, according to (1).

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The area, capacity and height of a dump site may be different (2). The first analysis has shown that for large dump sites with a considerable volume of waste disposal per year, more restrictive limits are calculated than for smaller sites. In the following calculations the reference dump site used was consequently taken as being 33 ha, and is filled to capacity within 20 years. 500 000 t waste are disposed per year, which corresponds to an annual disposal height of 2.5 m. Public dump sites must be insulated against ground water by non water permeable layers.

Exposure Pathways

While the facility is in operation, dump site workers are exposed to direct radiation and inhalation of suspended particles. Another exposure pathway is over the water drained from the dump and piped to a sewage. The assumption made for other models can also be made here in so far that the resultant purified and diluted water is consumed as drinking water by man and animals, used for irrigating agricultural land and in fish hatcheries. A fourth exposure pathway results from the German guideline (3), which specifies that abandoned dump sites must be recultivated and may be used for agricultural purposes. It must be assumed that the roots penetrate through a 30 cm layer of natural top soil and reach the waste where radionuclides can be uptaken.

The above exposure pathways, inhalation, direct radiation drainage-water and use of dump sites as agricultural land have been mathematically formulated. In the first calculations the critical exposure pathways were determined and possible limiting values calculated. Model parameters were chosen corresponding to the German regulatory guide (4) and recent references. Steady state conditions were assumed for all models.

The following conditions are assumed for the individual exposure pathways:

- The radionuclides are in a water soluable from and homogenously distributed in the waste material.
- For inhalation it is assumed that the concentration of a radionuclide in dust particles in the air is equal to that in waste material. One cubic meter of air contains 0.15 mg dust particles of a diameter less than 10 μm.
- For direct radiation, the shielding provided by waste according to Blatz (5) was taken into consideration.
- For the drainage water model an annual precipitation of 600 mm is assumed, 40 % of which is removed as drainage water. The migration rates of the radionuclides are determined in relation to their chemical characteristics. In the sewage the drainage water is diluted at a proportion of 1:100.
- When calculating activity limiting values for the exposure pathway resulting from the agricultural use of a dump site after its closure, the transfer factors soil/plant are reduced by a factor 2 or 10, according to root depth.

Results and Discussion

Using these models activity limiting values were calculated for 7 radionuclides. For this, an annual exposure of 1 mrem ≙ 0.01 mSv was assumed for a reference man. Table 1 shows the limits calculated for each exposure pathway together with the limits for all four pathways; Table 2 reflects the relative significance of each individual pathway.

	All Pathways	Inhalation	Direct Radiation	Drainage Water	Agricultural Use of the Dump
P 32	9.2E-5	3.6E-1	-	9.2E-5	-
Co 60	5.0E-8	3.6E-1	5.0E-8	9.1E-4	1.8E-4
Sr 90	2.1E-8	2.5E-3	-	3.2E-8	6.1E-8
Tc 99	7.0E-7	3.6E-1	5.9E-1	7.8E-7	7.0E-6
J 131	1.0E-6	1.1E-0	1.2E-6	6.2E-6	-
Cs 137	6.2E-7	7.1E-2	6.9E-7	7.4E-5	6.6E-6
Ce 144	1.5E.5	3.6E-2	1.5E-5	4.4E-1	5.3E-1

Table 1: Limiting values for waste in Ci/t according to models for inhalation soil radiation, seep-water and agricultural use together with the limit for all pathways, assuming an annual exposure of 1 mrem per year to man.

	Inhalation (%)	Direct Radiation (%)	Drainage Water (%)	Agricultural Use of the Dump (%)
P 32	<1	0	>99	0
Co 60	0	>99	< 1	< 1
Sr 90	0	0	65	35
Tc 99	0	0	90	10
J 131	0	84	16	0
Cs 137	0	90	1	9
Ce 144	<1	>99	0	0

Table 2: Proportions of the individual exposure pathways to total exposure.

These calculations show that the pathways direct radiation and drainage water are of particular significance for the considered nuclides. In assessing these results, it must be realised that only direct radiation was calculated under sufficiently realistic conditions. For drainage water, inhalation and for agricultural use of the closed dump site, some conservative assumptions were made to correspond with the German Regulatory Guide (4). It is remarkable that even making these assumptions the most restrictive activity limits are calculated for Sr-90 and Co-60. The limiting values for the remaining five radionuclides are greater by at least one order of magnitude. It is of particular interest

to see how these activity limits change when it is assumed that radionuclides are not homogeneously distributed in all the waste material, but are disposed in discrete amounts.

Literature

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