Environmental impact of a Very Low Level Waste specific landfill

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I - INTRODUCTION

Operating enrichment plants, nuclear power plants and reprocessing plants and the decommissioning of nuclear facilities will give rise to large volumes of waste material (concrete, steel and others metals, technological wastes heat insulators...) and most of them, in term of quantities, will be categorized as Very Low Level Wastes.

This paper deals with the environmental impact of a specific landfill as a final destination for the Very Low Level Radioactive Waste (VLLW) with the aim of providing technical elements for safer workers practices during the operational and the monitoring phases and for a public occupation after closure of the site. This study has been made on the basis of inventories in terms of estimated quantities and spectra of the French VLLW for a set of scenarios which are representative of practices in a landfill.

II - POSITION OF THE FRENCH AUTHORITIES

For very low level wastes, it will be necessary in a near future to define practical rules to achieve a coherent and standardized management of VLLW.

The nuclear regulatory agency DSIN proposes to establish controled disposal channels with a total treacability of all waste produced. In particular, this process will lead to the elaboration of studies on VLLW, the definition of "zoning" in nuclear installations to identify areas having a potentiality to generate radioactive wastes, the definition of adapted channels based on impact studies,. for each kind of radioactive waste and the creation of VLLW specific landfills with accurate regulatory controls.

A concrete and approved solution is not finalized, but a specific landfill, concept between an industrial landfill and a low-and-medium level waste repository, seems to be a realistic solution.

III - ORIGIN AND POTENTIAL QUANTITIES OF VLLW

Low specific activity materials can arise during most maintenance activities carried out in nuclear fuel cycle facilities, however the largest potential source of such materials is from the decommissioning of nuclear facilities, especially the commercial power reactors.

Origins of the Very Low level wastes are multiple and theirs specification also. They result especially from :

- operating of the nuclear facilities, enrichment plants, nuclear power plants and reprocessing plants,
- the dismantling of the same nuclear facilities from 1970 to 2090,
- the radioactive wastes from the "small producers" , hospitals and universities,
- the uranium mine and mill tailings wastes,
- the wastes issued from fabrication processes in the classical industry but using radioactive materials.

The three last categories have not been taken into account in this study for the following reasons :

- the radioactive wastes from the "small producers" are incinerated,
- the uranium mine and mill tailings wastes are disposed of at the extraction site because of very large volume and specific nature of the radionuclides,
- the wastes originated from fabrication processes in the classical industry but using radioactive materials are submitted to special treatment case by case.

We consider that in 2050, all French gas-graphite reactors will be dismantled, as well as uranium enrichment and reprocessing plants operating at present time. We consider also that the stage 2 of PWR dismantling will be over. Depending on the delay of 40 years taken into account between the stage 2 of decommissioning and the stage 3 (final phase) for PWR power plants, the VLLW production will drop down for 25 years between 2050 and 2075.

IV - DATA AND PARAMETERS OF THE IMPACT STUDY

IV 1 Source term

The estimated VLLW volumes are 60 000 m^3 for 1994-2015, 128 000 m^3 for 2016-2030 and about 60 000 m^3 for the last period, 2031-2049. The total volume of waste would be about of 250 000 m^3 for a total weight of 866 000 tons.

The drums are put in trenches dug below the original ground level and covered with the concrete and rubble wastes. The dimensions of the landfill are 350 m length, 100 m width and 7 m depth without the ground cover.The mean activity will be of 10 Bq/g with a mean spectrum depending of the origin of the waste.

The main radionuclides likely to be found in VLLW are H3, Mn54, Co58, Co60, Ni63, Sr90, Cs137, U234, U238 and α-total. The spectra are mean spectra, weighted by the potential quantities of the four main materials: concrete and rubbles, metals (steel, copper, aluminium...), technological wastes and heat insulators.

The release of activity from the source to the geosphere is modelled by the Annual Leaching Fraction (A.L.F) for each radionuclide.

IV.2 Description of the geosphere

Calculations have been made for a generic site, the hydrogeological characteristics being quite representative of a surface site disposal [1]. The main outlet is a river with a flow rate of 1.10 m^3/y located at 250m of the nearest landfill boundary. The medium is clayey-argileous, equivalent to a porous medium. The radionuclide transport is slowed up by the sorption of species in the medium and modelled with a distribution coefficient Kd [1].

IV.3 Description of the biosphere

The river water is used for irrigation and for drinking (man and cattle). A conservative diet [1] is defined with meat, fish, vegetables and drinking water comsumption; all these products are coming from the site (autosuffisance). The biosphere data, transfer factors in the differents boxes of the biosphere are taken from litterature and International exercices [2] [3].

IV.4 Exposure pathways

The workers involved in the operating processes will inhale and ingest dust or soil deposited on their hands and face, and will be submit to external exposure from the waste scraps. We considered a driver of handling truck and a chemist who makes measures on small samples of wastes.

We considered that thirty years after closure of the landfill, an individual would live on the site in a house with a garden around (residence scenario). This individual could be an adult, a 10 years old child or an 1 year old baby. The scenario takes into account all the possible pathway exposures.

We have also considered the use of contaminated water, during the operating and post-closure phases, for the irrigation of crops, for fishing areas, by consumption of contaminated drinking water and by consumption of meat from cattle eating pastures and drinking water at the discharge point.

V - IMPACT RESULTS

V.1 Methodology of dose calculations.

The methodology for estimating the individual dose resulting from the exposure pathways described above, is to calculate the impact of a set of scenarios representative of practices using the best-estimate values for related parameters (time of exposure in the practice, inhalation rate, concentration of particles, ingested quantity of dust, human diets,...).

Calculations of the doses during the operational phase of the landfill and for the residence building after closure, are made with the computer code CERISE [4] which determines for various individual exposure situations, the relationship between the effective dose and the radioactivity of a material handled by or located near the person considered, or his radioactivity intake.

Calculations of the radiological consequences from the landfill activity flow rate to the river outlet uses the geosphere GEOS code [5] which estimates the activity flow to an outlet, river or well, coupled to the biosphere ABRICOT code [6].

V.2 Results of dose calculations.

The maximum annual dose occurs in the landfill aera during thethird operational phase where the annual flux of waste is maximum. The total massic dose is of $3.7.10^{-1}$mSv/y for the manual worker, for all radionuclides and all practices taken into account. 65% of this dose is due to Co60 (2.4 10^{-1} mSv/y).

For the public scenarios, the maximum dose due to the residence scenario is 2.4 10^{-2} mSv/y for the adult and 3.10^{-2} mSv/y for the ten year old child. This dose is due for 30% to Pu239 and for 20% to Cs137. The residence has been considered to be built 30 years after the closure of the landfill and the short-lived radionuclides have strongly decreased.

For the river scenario, between 1994 to 2094, the maximum dose of 6.5 10^{-4} mSv/y is due to Tritium and the maximum occurs very early (about 2040) because of the absence of sorption in the geosphere for this radionuclide. This dose is essentially due to the consumption of vegetable products (~100%), especially cereals (62%) and fruits (21%).

The absolute maximum dose of 5.10^{-3} mSv/y occurs about 6500 years after closure of the landfill and is due in equal proportion to the uranium isotopes U234 and U238. The main pathway is vegetables consumption for 90%, water drinking for 5% and 1.5% for external exposure.

VI - CONCLUSIONS

The deterministic calculations of individual dose were performed for a low isolation capacity. It should be mentioned that it is possible to add engineered barriers to improve the safety of these disposal facilities :

- barriers to make the intrusion of humans, animals or plants more difficult. These include : greater thicknesses of earth cover and reinforced concrete ;
- barriers to prevent the ingress of grounwater, surface water or precipitation. These include : clay covers, synthetic impermable barriers, draining layers and hydraulic bypasses around the facility ;
- barriers to prevent the release of radionuclides from the disposal. This include : impermeable clay or man-made barriers and buffers which let water out but retard radionuclide migration.

Besides the possibility to improve the landfill safety by the implementation of such technical solutions, the generic impact assessment performed shows that the effective doses undergone by persons of the public are well below 1mSv whatever operational or post-closure phase is considered. The highest calculated exposure concerns mainly engine drivers submitted to external irradiation. It should however be stressed that in this case, the range of doses undergone by workers are again low (about one order of magnitude below 1mSv, and mainly due to Co60). Since exposures are only relevent to ponctual operations, they can easily be reduced if necessary by additional temporary protection (such as radiation protected engins or temporary shields above wastes).

According to former results, it is therefore foreseeable that VLLW are likely to be disposed of safety in specific landfills of very simple conceptual design (such as for example the back filling of quarries). Some favorable site characteristics should be looked for but since the radiological impact of the landfill is low, the site selection criteria may not be stringent.

VII - REFERENCES

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