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DOSE IN A HOUSE BUILT WITH CONTAMINATED WOOD

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Introduction

This paper aims to assess the annual effective dose wich could be received by a person living in a house built in France with wood from Belarus and contaminated by ^{137}Cs from Chernobyl accident fallout. After the context be precised and the potential levels of radioactivity presented, an assessment of the annual effective dose is performed, based on an as realistic as possible scenario.

Context

In december 2004, an indvidual asked his local sanitary authorities about the radiological risk related to the potential use of Belarusian wood for building a house, taking into account the fact the wood could be contaminated by Chernobyl accident fallout. The question was then adressed to the national safety authority, wich in turn asks IRSN to assess the possible radiological consequences for an inhabitant, using realistic hypothesis.

Wood contamination

Among radionuclides measured and relevant for external exposure 20 years after the accident, only ^{137}Cs, ^{134}Cs, ^{125}Sb, ^{129}I and ^{90}Sr with their daughters have to be considered. As reported in literature [1], the composition of deposited radionuclides is generally incomplete and highly variable from one place to another. According to this variability and because it is the most penalizing radionuclide among those quoted for external exposure, only ^{137}Cs is considered.

Many measurements of soil deposits as well as wood contamination have been performed and are available in literature [2], [3]. In highly contaminated Belarus areas (deposit from 15 to 40 $Ci.km^{-2}$ of ^{137}Cs at the moment of the accident), wood contamination in ^{137}Cs could be up to 9,000 $Bq.kg^{-1}$ for pine wood and up to 25,000 $Bq.kg^{-1}$ for birch wood [4].

Since the geographical origin and nature of the wood intended to build the house are unknown on the one hand, and as deposition of Chernobyl accident fallout were very heterogeneous in the Belarus surface in the other hand, a standard wood contamination of 1,000 Bq.kg^{-1} of ^{137}Cs is adopted for calculations, for both wood natures - pine and birch.

Exposure scenario

The exposure of an inhabitant is assessed by the annual effective dose due to external exposure to γ rays from radionuclides in wood. Doses due to α or β rays by contact to the inner walls, or due to inhalation of particles from wood desorption are not assessed; such doses are likely to be very low.

An adult inhabitant is considered to live in this house 7000 hours a year.

All rooms can be represented by a parallelepiped, with 3 x 4 m for horizontal dimensions and 2.5 m for height.

Two scenarios are considered :

- *scenario A : the inhabitant is assumed to spend all his time inside the house at the center of the room (location of the calculation point : A),*
- *scenario AB : the inhabitant is assumed to spend 70% of his time inside the house at the center of the room (location of the calculation point : A) and 30% in a corner (location of the calculation point : B, at 30 cm from each inner wall) - simulation of sleeping for example.*

Calculation

The calculations are performed with the Microshield code [5].

Walls, ceiling and floor are represented as homogeneous parallepipeds of wood, with 20 cm thickness and no windows. The densities adopted are 0.5 for pine and 0.7 for birch [6].

The calculation points are at 1 m above the floor, as shown in figure 1.

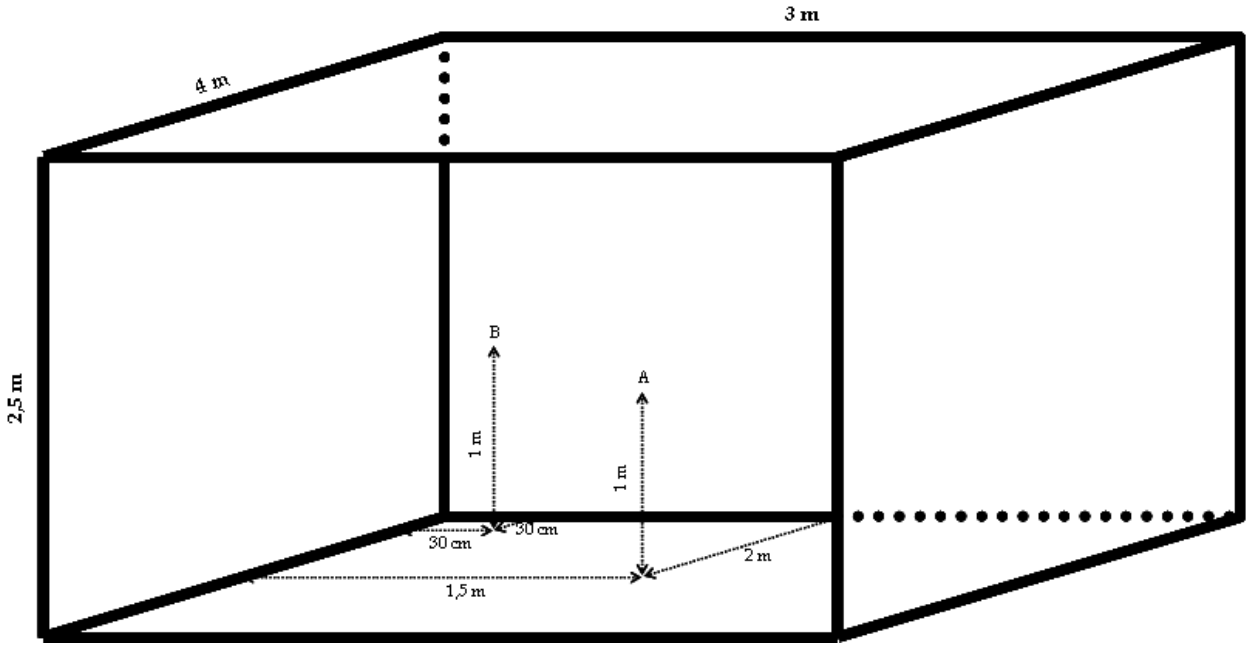

Figure 1 : Geometry

The Microshield code can consider different irradiation geometries [7]. The flux-to-dose conversion coefficients for a rotational geometry of irradiation are adopted in the present calculations, because they can represent quiet well the irradiation by the walls – at the opposite, the irradiation by floor and ceiling are less well represented.

Results

Dose equivalent rates calculated at points A and B are respectively :

- *85 and 103 nSv.h^{-1} for pine wood,*
- *113 and 132 nSv.h^{-1} for birch wood.*

Based on these results, the annual effective dose are :

- *scenario A : 0.60 mSv for pine wood and 0.79 for birch wood,*
- *scenario AB : 0.63 for pine wood and 0.83 mSv for birch wood.*

In order to assess the sensitivity of the results to the location of the individual in the house, calculations have been performed as a function of the distance of the calculation point from the largest wall[1]. The dose equivalent rate increases from 85 nSv.h^{-1} for point A to 112 nSv.h^{-1} at 10 cm of the inner largest wall. Then, the annual effective dose is not very dependent of the exact location of the individual in the house.

In order to assess the sensitivity of the results to the thickness of the walls, calculations have been performed considering 10 cm thickness instead of 20 cm. Results are found to be reduced by a factor about 1.8.

Considering that the Microshield code uses the flux-to-dose conversion coefficients of Publication 51 of ICRP [7], although the new flux-to-dose conversion coefficients of Publication 74 of ICRP [8] shoul be used, a brief comparison of the coefficients show that the dose coefficients of ICRP74 are about 10% higher than those of ICRP51; what is consistent with the global uncertainty.

Conclusion

The annual effective dose by external exposure potentially received by an inhabitant living in a house build with contaminated wood (pine or birch) at 1,000 Bq.kg^{-1} is of the order of 1 mSv, due to external exposure to walls. This dose is not negligible, and could even be much more higher if wood from highly contaminated Belarusian areas is used for building houses. Projects of such wooden buildings shoul be studied with a particular attention to the characterization of the contamination.

[1] *The height of the calculation points is 1 m.*

References

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[4] ***Circonstances et conséquences de la pollution radioactive dans l'ancienne Union Soviétique, Institut de Protection et de Sûreté Nucléaire, ISBN 2 – 11 - 089375 – 3, IPSN, 1995***

[5] ***MicroShield Version 5 User's Manual, Grove Engineering, Octobre 1996***

[6] ***Handbook of Chemistry and Physics, 82nd edition, 2001-2002, ISBN 0-8493-0482-2, CRC Press LCC***

[7] ***ICRP Publication 51 – Data for Use in Protection Against External Radiation, Annals of the ICRP, Volume 17 N° 2/3 1987, Pergamon***

[8] ***Conversion Coefficients for use in Radiological Protection against External Radiation, Annals of the ICRP, Volume 26 N°3/4, ICRP Publication 74, Pergamon, 1996***