POSEIDON: A Dispersion Computer Code for Assessing Radiological Impacts in a Marine Environment

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MAIN PURPOSE

At the request of the French Nuclear Protection and Safety Institute, the CEPN has developed a dispersion computer code to assess at medium and long time scales the evolution of the radiological consequences associated with a radioactive release in European sea waters. The general methodology and the physical parameters have been derived from the EC 'Marina' project and EC RP 72 report. The specificity of the modeling is that it integrates the daughter products and operates under a Windows environment on PC computers.

GENERAL DESCRIPTION

Due to the large scale of dispersion, a box modeling method has been retained. It assumes homogeneity of all parameters (suspended sediment load, sedimentation rate, depth) within a given compartment, and an equal distribution of activity within the considered volume. Exchange between compartments are expressed in term of annual volume of water transferred. This kinetic spreads the radioactive material simultaneously weakened by sedimentation and disintegration processes. With respect to the radiological impact of some radionuclides generated by disintegration, calculations have been extended to daughter products. To ensure the simultaneity of behaviours, all nuclides of the decay chain are evaluated at the same time by replication of the physical system (Figure 1). For each element, the concentration is evaluated and associated with specific radionuclide parameters and marine products consumption to determine collective ingestion and doses.

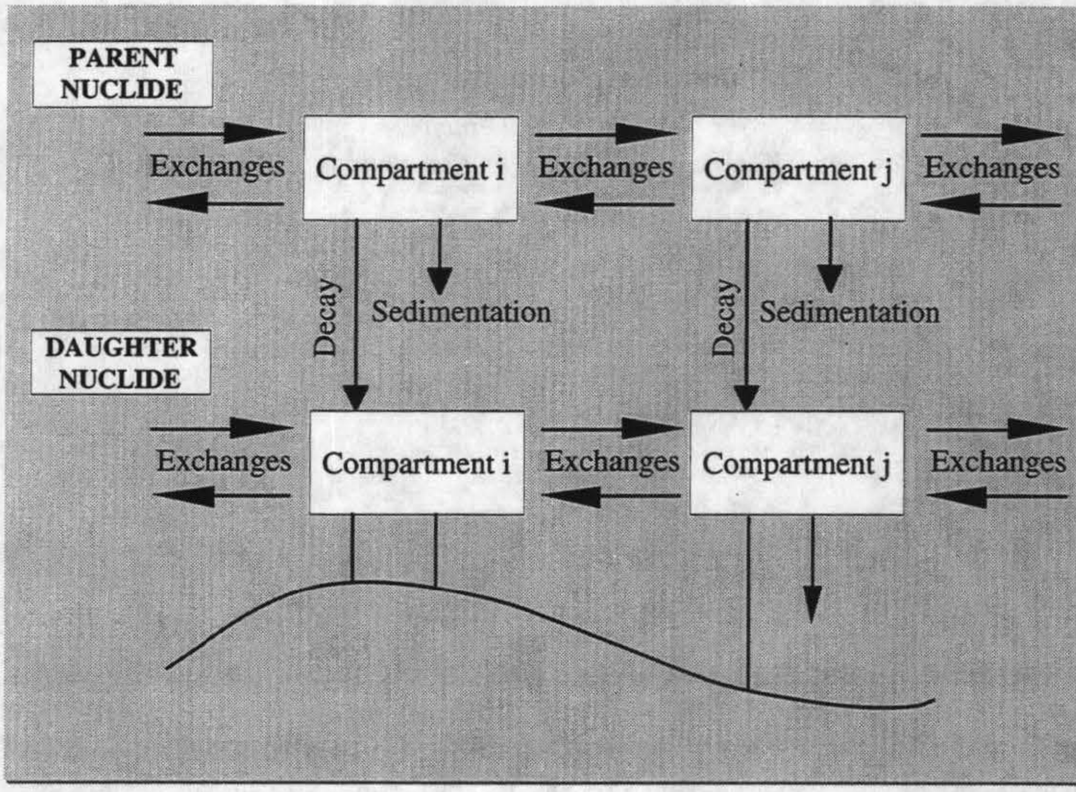

Figure 1. Modeling of the decay process.

METHODOLOGY AND OUTPUT

Once the release has been identified (determination of the location and the source term), the code simulates the dispersion of the radionuclides in the marine modeling. For each selected time, concentrations are calculated in each compartment. The next step consists in evaluating the quantities of radionuclides ingested collectively, based on the edible fraction of the quantities fished (fin-fish, shellfish, molluscs, and algae) in the different compartments and on the coefficients for the migration of the radionuclides into the seafood. The last stage concerns the calculation of the collective dose and its evolution over time, using the ingested quantities formerly calculated. For each adopted observation time, the code provides the collective doses associated with each selected radionuclide from the decay chain. Thereby, the relative influence of the decay products in the total collective dose can be appreciated. The results in terms of collective dose can also be obtained for the different countries in the European Union according to the origin and the quantity of seafood consumed by each country. These steps took place within the general structure of the code presented in Figure 2.

The impact in terms of individual doses can be estimated by dividing the collective doses by the population of the country in question. Dividing the data up into the type of seafood fished by each country allows more accurate calculations of the mean individual doses and thereby indicates any differences depending on the types of release considered.

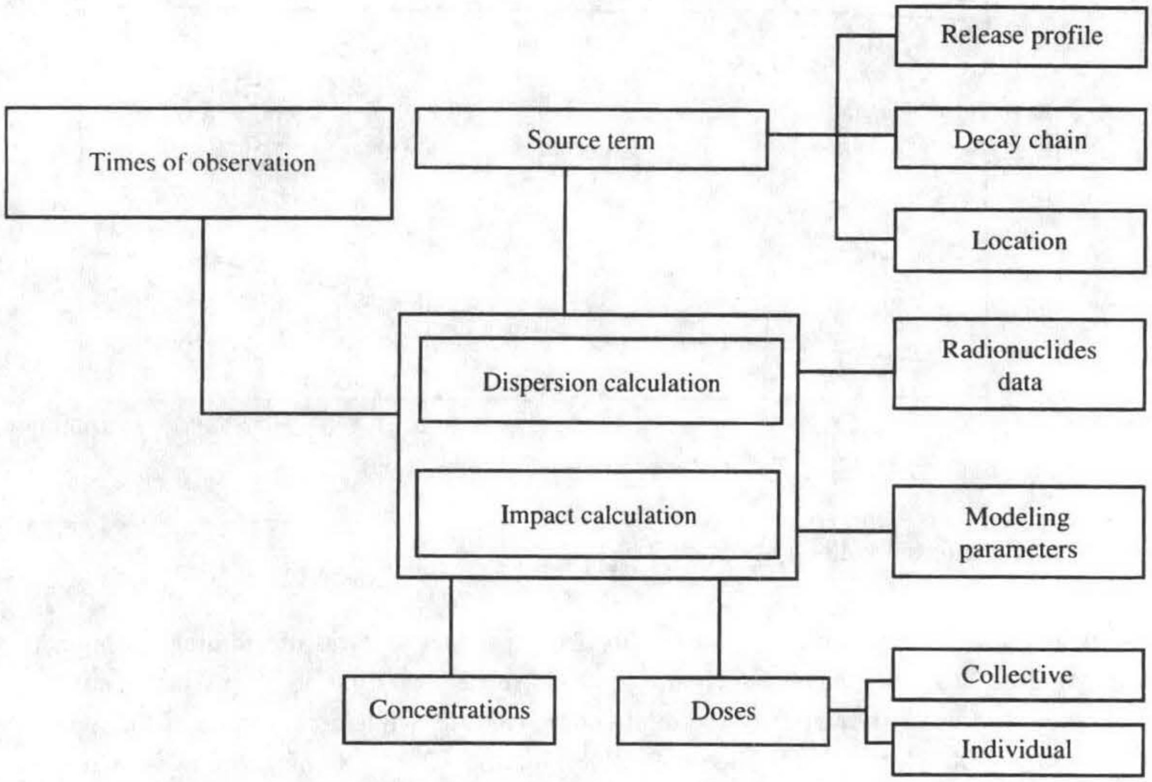

Figure 2. General structure of the code.

On the basis of concentration measurements of Cs-137 in the Irish Sea, as provided in the Marina report, a validation was carried out, using as a source term the 1952-1985 releases of La Hague and Sellafield reprocessing plants. Predicted concentrations are usually within the measured range, and up to a 10% maximum difference is observed between the two modelings.

IMPLEMENTATION

In order to describe the type of calculation and results provided by the code, an application of the model has been performed for a hypothetical release of 1E+15 Bq of Pu-241 in the English Channel West compartment. A duration of some minute was considered to be representative of an immediate release. With respect to the decay chain, the first two decay products were considered (Am-241, Np-237). For the observation duration selected, Figure 3 was obtained:

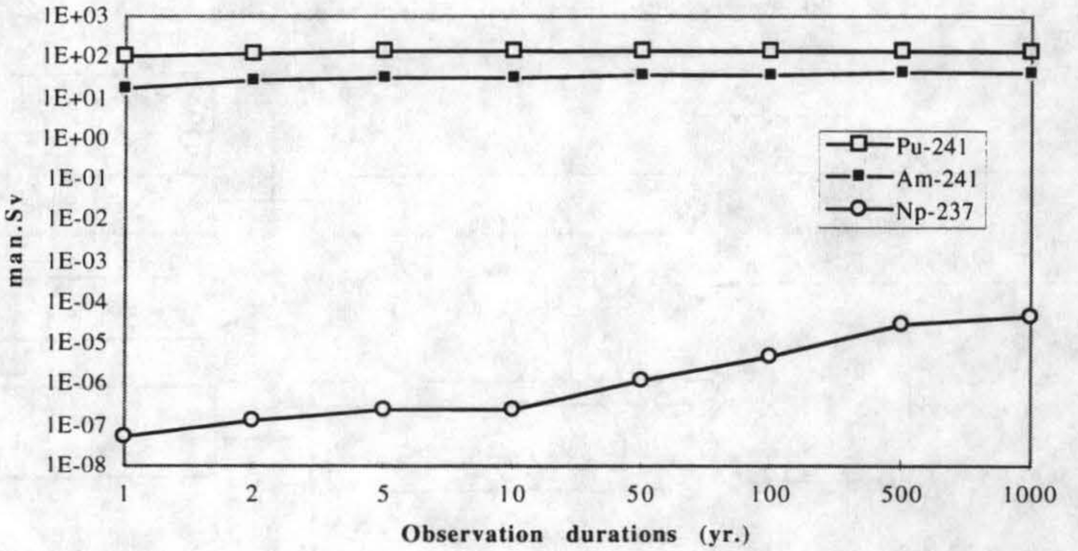

Figure 3. Cumulated collective doses.

The estimation of the relative influence of its decay product in terms of radiological impact demonstrates the significance of such an approach. Indeed, the first decay product seems responsible for almost a quarter of the total collective dose, while contribution of the Np-237 appears negligible. A total cumulated collective dose of 172 man.Sv has been estimated broadly generated during the first 50 years. The stabilisation of the slopes is mainly due to the dispersion of the element out of the European sea waters, combined with sedimentation and decay processes.

The distinction of the doses per country reveals that for this specific release, Belgium, France and Netherlands receive about 80 % of the total European collective dose (Figure 4), with average individual doses 3 or 4 times higher than the European average. Assuming a 50-year consumption of marine products after the release, the European average individual dose values about 0.5 μSv, with a maximum annual individual dose increment of 0.3 μSv for the first year (Figure 5). Despite a significant activity release, these radiological impacts can be considered as negligible compared to the background radiation levels in European countries.

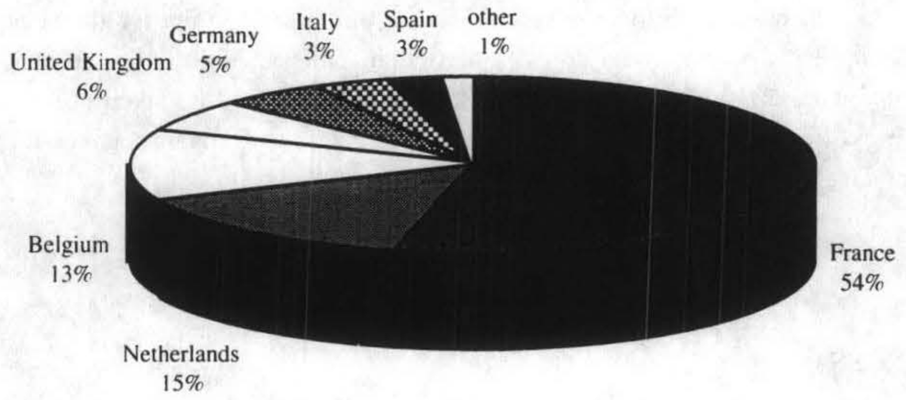

Figure 4. Distribution of the collective dose.

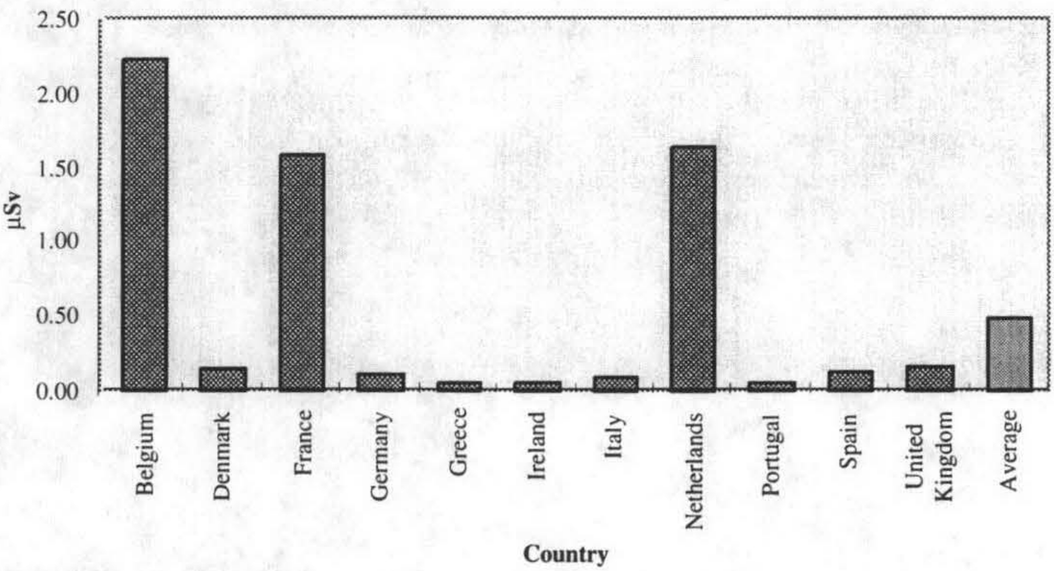

Figure 5. Average individual doses cumulated over 50 years.

CONCLUSIONS

The system of modeling each separate compartment in European seas, although not as accurate as a hydrodynamic approach which would give a better description of the dispersal of elements at local level and in the short term, nonetheless does seem adequate to evaluate the medium and long-term effects over a large geographical scale with a view to evaluating the potential exposure associated with continuous or accidental marine releases.

There are plans to make additional developments in the future to improve the accuracy of the calculations in terms of individual dose. In particular, more accurate information concerning the eating habits and fishing zones for the different regions could be taken into account in the modeling. Similarly, on the basis of the available data, the compartments could be divided up more precisely.

REFERENCES

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