PROBABILISTIC DOSE ASSESSMENTS FOR AQUATIC EXPOSURE PATHWAYS

by Marcus Grzechnik and Carol Smedley

Introduction

It is important that uncertainties in calculation of dose estimates are addressed. In this study the Monte Carlo Method has been applied to aquatic deterministic models with input parameters represented as distributions. The distributions are propagated through the model to produce a distribution of dose that encompasses uncertainty and variability.

Dose Assessment Models

WAT - *radionuclide concentration calculation (Round, 1998a)*

Depending on the situation, an advection-diffusion or compartment model is used to calculate steady-state concentrations of radionuclides in seawater (Figure 1).

ADO - *dosimetry calculation (Round, 1998b)*

Doses are calculated using appropriate combinations of consumption and occupancy pathways. Rates of exposure (external occupancy) or consumption (of aquatic foods) are determined by 'habits surveys'. The habits data are combined with the output from the WAT model and dose coefficients to determine dose.

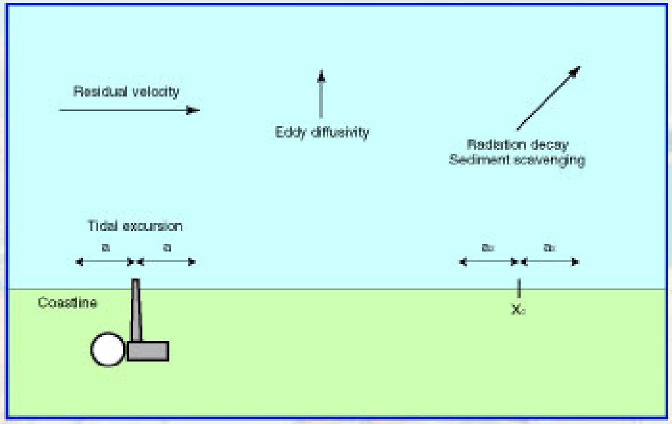

Figure 1: WAT advection-diffusion schematic.

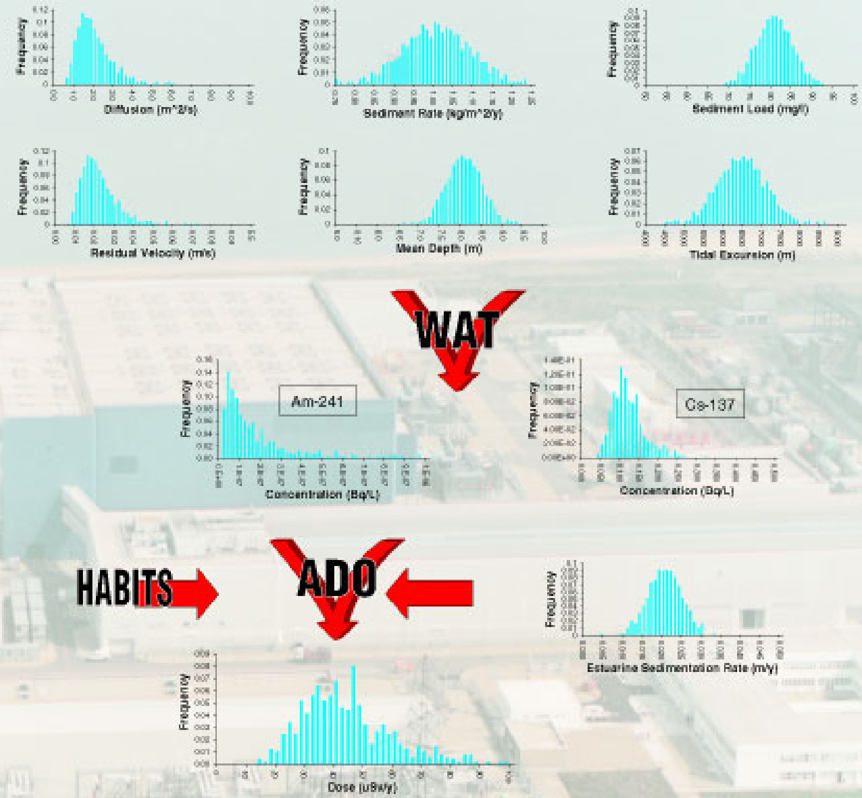

Figure 2: Conceptual comparison of probabilistic model statistics with deterministic outputs.

Results

The probabilistic model was tested by undertaking a dose assessment for Sizewell, a nuclear power station on England's eastern coast.

Deterministic Assessment

The verified 'best estimate' (or deterministic) model can be used as a benchmark example for the running of the probabilistic model.

Probabilistic Assessment

The probabilistic dose assessment was conducted using the Monte Carlo method to perform multiple runs of the deterministic models. The probabilistic assessment is illustrated conceptually in Figure 2, with results also given in Table 1.

Table 1: Comparison of probabilistic model statistics with deterministic outputs. The columns include percentiles, uncertainty (95th/5th) and deterministic results.

Output Value	5th Percentile	50th Percentile	95th Percentile	Uncertainty	Deterministic model
^{137}Cs Conc. (Bq/l)	5.91E-2	1.07E-1	2.01E-1	3.4	9.01E-2
^{241}Am Conc. (Bq/l)	1.47E-8	9.80E-8	6.38E-7	43.5	5.57E-8
^{137}Cs Dose (µSv/y)	17.4	31.6	60.3	3.4	27.2
^{241}Am Dose (µSv/y)	5.22E-4	3.49E-3	2.27E-2	43.5	1.98E-3
Total Dose (µSv/y)	22.0	40.1	73.6	3.4	31.5

Conclusion

The relationship between deterministic and probabilistic outputs varies depending upon the particular radionuclide (mainly due to the large variations caused by the distributions of sediment parameters), but generally it has been noticed that deterministic predictions are between the 5th and 50th percentiles. It is desirable to use an upper percentile in dose calculation for conservatism.

Uncertainties (95th to 5th percentile ratio) are increased if the predicted dose is relatively small, however the effect on overall dose is then less significant. It has been found that the use of distributions to represent uncertainty and variability in habits surveys can significantly alter the predicted probabilistic dose. Future work will focus on quantifying and reducing uncertainties in data collection, as well as optimising the incorporation of habits data into probabilistic assessments.

Acknowledgement

Financial support and scientific discussions regarding this project have been provided by the Food Standards Agency (FSA), London. Probabilistic versions of dose assessment models for terrestrial pathways are also being considered by the FSA.

References

Grzechnik, M.P. A probabilistic modelling suite for the marine environment. Environment Report RL 3/02, CEFAS, Lowestoft (2002)

Round, G.D., Individual doses from discharges of liquid effluents to the marine environment: Water concentration model - WAT. CEFAS Env. Tech. Note RL 2/98, CEFAS Lowestoft (1998)

Round, G.D., Individual doses from discharges of liquid effluents to the marine environment: Dosimetric model - ADO. CEFAS Env. Tech. Note RL 8/98, CEFAS Lowestoft (1998)

The Centre for Environment, Fisheries and Aquaculture Science (CEFAS), Lowestoft Laboratory, Pakefield Road, Lowestoft, Suffolk NR33 0HT, UK.

E-mail: M.Grzechnik@cefas.co.uk

http://www.cefas.co.uk