Impact of hypothetical radioactive releases in the Belgian inland rivers-sea continuum

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Deleersnijder E., Lambrechts J., Sweeck L. Vives I Batlle J.
Problem description

- The Nuclear power plant in Scheldt Estuary (Belgium)
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The Scheldt Estuary is one of the largest European estuaries and internationally **Important nature area. Entrance to the port of Antwerp**
Objectives of the research

- Development of estuarine model for the simulation of the fate and transport of radioactive effluents as consequence of accidental releases
- Scenario definition based on the predictions of source term of NOODPLAN –Belgium
- Definition of possible release moments in order to include the influence of the tides in the transport
- Multiple partition coefficient scenario definition
- Estimation of the radiation dose rates to the aquatic biota
Model selection

- Boundary conditions problem
- Computation time problem
- Integration of the River-Estuary-Coastal systems (1D-2D) systems

Structured grid: Limits the extension of the model due to large number of cells (around 500 000 cells)
Model selection

- Boundary conditions problem
Model selection

- Boundary conditions problem
- Computation time problem
- Integration of the River-Estuary-Coastal systems (1D-2D) systems

Unstructured grid: Allows to extend model without loss of detail (around 30 000 cells)
Model selection

Integration of the River-Estuary-Coastal systems (1D-2D) systems
Model selection

- SLIM model

Second-generation Louvain-la-Neuve Ice-ocean Model (SLIM)
Institute of Mechanics, Materials and Civil Engineering (IMMC) & Earth and Life Institute (ELI) Université catholique de Louvain (Deleersnijders E., Lambrecchts J., Gourgue O., de Brye B.)
https://sites.uclouvain.be/slim/
General overview of the radioactive plume
Source term:

Based on the estimated total release inside the reactor building Doel 1 to 4

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Fraction</th>
<th>$^{131}$I MBq</th>
<th>$^{137}$Cs MBq</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scenario 1</td>
<td>2.0E-08</td>
<td>2.0E+03</td>
<td>2.0E+03</td>
</tr>
<tr>
<td>Scenario 2</td>
<td>2.0E-07</td>
<td>2.0E+04</td>
<td>2.0E+04</td>
</tr>
<tr>
<td>Scenario 3</td>
<td>2.0E-06</td>
<td>2.0E+05</td>
<td>2.0E+05</td>
</tr>
<tr>
<td>Scenario 4</td>
<td>2.0E-05</td>
<td>2.0E+06</td>
<td>2.0E+06</td>
</tr>
<tr>
<td>Scenario 5</td>
<td>2.0E-04</td>
<td>2.0E+07</td>
<td>2.0E+07</td>
</tr>
<tr>
<td>Scenario 6</td>
<td>2.0E-03</td>
<td>2.0E+08</td>
<td>2.0E+08</td>
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<tr>
<td>Scenario 7</td>
<td>2.0E-02</td>
<td>2.0E+09</td>
<td>2.0E+09</td>
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<tr>
<td>Scenario 8</td>
<td>2.0E-01</td>
<td>2.0E+10</td>
<td>2.0E+10</td>
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<td>Scenario 9</td>
<td>2.0E+00</td>
<td>2.0E+11</td>
<td>2.0E+11</td>
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</tbody>
</table>
Scenario description

- Partition Coefficient: Based on values of ERICA Tool

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Fraction</th>
<th>$^{131}$I L/kg</th>
<th>$^{137}$Cs L/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Kd</td>
<td>1.E-01</td>
<td>1.E+01</td>
<td>1.E+03</td>
</tr>
<tr>
<td>High Kd</td>
<td>1.E+01</td>
<td>1.E+03</td>
<td>1.E+05</td>
</tr>
</tbody>
</table>

- Discharge time: **24hr.**
Scenario description

[Image: Satellite map of the region with landmarks labeled, including Westkapelle, Vlissingen, Rijsehem, Breskens, Hansweert, Waarde, Paal, Bath, Zandvlietsluis, Deurganckdok, Doel, and Antwerpen.]
Scenario $^{137}\text{Cs}$

- Longitudinal profile

Release time
Scenario $^{137}$Cs

- Longitudinal profile

![Diagram showing longitudinal profile with two graphs, one for Low Kd scenario and one for High Kd scenario.](image-url)
Scenario $^{131}$I

- Longitudinal profile

Low Kd scenario

High Kd scenario
Time of arrival

![Graph showing arrival time vs. discharge delay with different locations marked on the map.](image)
Dose to biota-Doel Low Kd

Computed with D-DAT model


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Dose to biota-Doel High Kd

Computed with D-DAT model
Dose to biota-Vlissingen Low Kd

Computed with D-DAT model

Dose to biota

- The dose estimation was done based on the assumption of stationary biota. However it can be improved by coupling the model with a Particle tracking model.
Dose to biota

Computed with D-DAT model
Dose to biota-Particle tracking

Starting point
Dose to biota-Particle tracking
DSS tool Development
Conclusions

- SLIM-RN model has the required flexibility for fast impact assessments
- The Partition coefficient shows an important effect on the magnitude of the activity in the water column
- The influence of the tides on the RN distribution is stronger near the discharge point but it reduces at the mouth of the estuary
- The zone with the highest activity remains around ±10 km from the discharge point
- This studies tries to bridge the gap between research model and assessment tool
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