Probabilistic exposure risk assessment with advective-dispersive well vulnerability criteria

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Motivation
According to current Water Safety Plans, water managers and stakeholders should ensure safe drinking water supply by controlling the risk from catchment to tap through a preventive risk management concept: (1) What kind of hazards exist within the water catchment, (2) how these hazards can be controlled and (3) knowing that they are controlled.

We aim to develop a concept, providing the fundamental basis for probabilistic risk assessment (PRA) in actively managed well catchments. Thus we can provide stakeholders with the necessary information and tools to develop complete risk management schemes.

Approach
Our probabilistic intrinsic transport-based well vulnerability criteria are:
(a) The probability distribution of peak arrival time from source to well;
(b) Possible levels of peak concentration arriving at the well;
(c) Probability distribution of reaction time until a threshold level is exceeded (e.g., drinking water standard); and
(d) The probability distribution of well down time (exposure time).

Illustrative Example
Figure 1: Illustrative sketch showing the four intrinsic well vulnerability criteria and temporal moments characterizing the concentration BTC c(t)

Figure 2: Methodology to determine probabilistic intrinsic well vulnerability criteria

Table 1: Uncertain model parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>(v_p)</td>
<td>1.7 (, m/s)</td>
<td></td>
</tr>
<tr>
<td>(a)</td>
<td>1.0 (, m/s)</td>
<td></td>
</tr>
<tr>
<td>(q_{in})</td>
<td>1.0 (, m^2/s)</td>
<td></td>
</tr>
<tr>
<td>(h_{in})</td>
<td>0.0 (, m)</td>
<td></td>
</tr>
<tr>
<td>(h_{ex})</td>
<td>0.0 (, m)</td>
<td></td>
</tr>
</tbody>
</table>

Conditional Results

Figure 4: Probabilistic isopercentiles [0.1, 0.5, 0.9] for the four intrinsic well vulnerability criteria (a)-(d) from n=500 simulations. Grey-scale maps show the ensemble mean of the respective well vulnerability criteria.

Table 2: Showing the fractional area [%] of delineated catchments according to the four VIP maps that is sacrificed to uncertainty for the conditioned and the unconditioned case.

<table>
<thead>
<tr>
<th>VIP</th>
<th>Unconditional uncertainty (U_{uc})</th>
<th>Conditional uncertainty (U_c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(50% peak)</td>
<td>57%% 1.25 (\times 10^{-7}) (\tau_{peak, uncond})</td>
<td>37.8% 2d (\tau_{peak, uncond})</td>
</tr>
<tr>
<td>(90% peak)</td>
<td>50%% 44% (\tau_{react})</td>
<td>50%% 14.6% (\tau_{peak, uncond})</td>
</tr>
<tr>
<td>(exp)</td>
<td>37.7% (\tau_{peak, uncond})</td>
<td>25.2% 10.4% (\tau_{peak, uncond})</td>
</tr>
</tbody>
</table>

Outlook

- Optimal site exploration for minimal uncertainty in probabilistic well vulnerability criteria.
- Risk concept for long-term sources and transients (e.g., varying pumping schedule in cooperation with DTU).
- Risk Analysis (FTA, ...).

Literature


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