Risk evaluation and management disaster

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Plan

I - Introduction
II- Risk evaluation
  • Modelisation: Vulnerability and risk
  • Application: Groundwater pollution risk
  • Topography impact
III- Conclusion
I. 1. Groundwater pollution: Vulnerability and risk

Fig. 1- Diagram of groundwater contamination

Risk?

Definition:
- A more or less possible predictable danger; the hazard to incur a harm
  Un danger éventuel plus ou moins prévisible ; le hasard d’encourir un mal (Linguistiquement)
- A mathematical esperance of possible damage
  Une espérance mathématique de dommage possible (Concept probabiliste des années 50)
- A probability of damage
  Une probabilité d’un dommage
- The crossing between vulnerability and unforeseen (probability)
  Le croisement entre vulnérabilité et aléa (Environnement)
- The interaction between contaminant load and aquifer vulnerability
  L’interaction entre la charge polluante et la vulnérabilité de l’aquifère (Hydrogeologie)

Foster, 1987 ; Brugnot, 1998 ; Arousseau, 1999
Fig. 2- Diagram of evaluation of groundwater pollution risk

**Evaluation of the pollution risk**

**Principle:**

- Interface soil
- Unsaturated Zone
- Saturated Zone

Sure Situation

Probable Situation

\[ C(t) \quad R \]

\[ C'(t + T) \quad R'(t + T) \]

**Sure situation:**

- \( C(t_0) \): Initial concentration
- \( C'(t_0 + T) \): Concentration in the arrival at the level of the tablecloth
- \( T \): Transit time

**Gravity**

\[ \text{Gravity } (t_0+T) = \alpha \times C'(t_0 + T) \quad (1) \]

\( \alpha \): Nature of the pollutant

**Remark:** Gravity depends on the nature and on the dose of pollutant in the waters of the aquifer

**It is the dose which makes the poison**

C’est la dose qui fait le poison (Paracelse, 1493 – 1541)
The concentration in the arrival at the tablecloth \( C'(t_0 + T) \) depends of the initial concentration \( C(t_0) \) and the power purifier \( Md \) of the coverage zone:

\[
C'(t_0 + T) / C(t_0) = \begin{cases} 
1 - Md & \text{if } Md < 1 \\
0 & \text{if } Md \geq 1
\end{cases}
\]

**case of partial purgation**

**case of complete purgation**

Gravity \((t_0 + T) = \alpha (1 - Md \ C(t_0)) \) if \( Md < 1 \) \( (2) \)

**Remark:**
- Gravity \((t_0 + T)\) depend of the initial concentration \( C(t_0) \) and caracrtistics of pollutant and of medium
- Implicit relation between gravity and vulnerability

\( Md \): purifying power \( (Reshe, 1977) \)

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**Evaluation of the pollution risk**

**Probable situation (aléatoire):**

\( Cp(t) \): Probable initial concentration
\( C'p(t + T) \): Probable concentration at arrival in the water of aquifer
\( T \): Transit Time (Certain)

Gravity \( p \ (t + T) = \alpha \ C'p \ (t + T) \) \( (3) \)

Gravity \( p \ (t + T) = \alpha \ (1 - Md \ Cp(t)) \) \( \text{if } Md < 1 \) \( (4) \)
Evaluation of the pollution risk

Or in the surface soil the evolution of use and/or rejection of pollutants \( C_p(t) \) follows a law of evolution form:

\[
\begin{align*}
\frac{d C_p(t)}{dt} &= f_a (C_p(t)) \quad \text{for} \quad t > t_0 \\
C_p(t_0) &= C(t_0)
\end{align*}
\]

Where \( f_a \) is a function aleatoire to be determined (law of aleatoire evolution)
Which gives \( C_p(t+T) \) and then the probable gravity

\[
\text{Gravity } p(t+T) = \alpha (1 - M_d) C_p(t) \quad (4)
\]

Remark: Probable gravity = Risk

Qualitative / Quantitative approach of the pollution risk

\[
\text{Gravity } p(t+T) = \alpha (1 - M_d) C_p(t) \quad \text{if } M_d<1 \quad (4)
\]

Risk = f (Gravity, Vulnerability, Probability)

- Gravity: depends on the nature and dose of pollutants
- Vulnerability: depends on the considered medium
- Probability: law of evolution of pollutants in the surface soil (evolution of use and/or rejections) of pollutant

The qualitative evaluation of the pollution risk requires the estimation of these three parameters
Vulnerability : TCR approach

**Principle**: A zone is vulnerable if the polluting product reached the groundwater at a short time and with a high concentration.

Vulnerability index $I_v = f(T, C, R)$

**Vulnerability index**:

$$I_v = \alpha \frac{1}{T} + \beta \frac{C'}{C_p} + \gamma \frac{R'}{R}$$

$\alpha$, $\beta$, and $\gamma$ are coefficients (ponderateurs).

**Remark**: The choose of $\alpha$, $\beta$ et $\gamma$ : sensibility tests

A. Bernonais ISS, 2007
Evaluation of vulnerability

- \( \frac{1}{T} = \frac{V}{h} \) where \( V \) the filtration speed and \( h \) thickness of the coverage zone

- \[ C'(t_0 + T) / C(t_0) = \begin{cases} 
 1 - Md & \text{if } Md < 1 \\
 0 & \text{if } Md \geq 1 
\end{cases} \]

- \( R'/R \) : water balance sheet (bilan hydrique)


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Pollution Risk

Vulnerability

Gravity

Probability (Alea)

Biodegradability

Bioaccumulation

Toxicity

污染风险

脆弱性

重力

概率 (Alea)

生物降解性

生物积累

毒性

FIG Working Week 2011
Bridging the Gap between Cultures
Marrakesh, Morocco, 18-22 May 2011
Gravity

Gravity of a pollutant can be characterized: biodegradability, bioaccumulation and toxicity.

Gravity of a situation depends on the nature of pollutant and on the concentration \( (C'p) \) with polluting water arrives in tablecloth.

\[
\text{Gravity} = \alpha \times C'(T)
\]

\( \alpha = \frac{1}{S_n} \): Proper gravity of each pollutant.

It’s deducted from standards norm \( (S_n) \) (potable water-quality Guidelines) defined by WHO (Worldwide Organization of Health), or from law water for considered country.
Probability (Alea)

Probability (groundwater pollution):

1- Evolution of use or rejected of pollutant (law of evolution for probable concentration $C_p(t)$)

2- Variation of probable recharge $R_p(t)$ (law of evolution of irrigation and of infiltration de la pluie efficace: Climatic change)
Application (Gharb's plain, Morocco)

Distribution of data points and irrigated areas

Piezometric Map
Degree of recharge map (R'/R)
(Topography, Soil nature and occupation, …)

Transit Time map
Purification degree map (C'p/Cp)

Intrinsic vulnerability map of the Gharb shallow aquifer
Potentiel sources of pollution in the Gharb plain

Pollution risk map of the Gharb shallow aquifer
**Flood Risk**

Risk = f (Gravity, Vulnerability, Probability)
- **Gravity**: depends on the nature and the intensity of flood damage
- **Vulnerability**: depends on the considered medium and topography
- **Probability**: law of evolution of precipitation (climatic change)

**Other risk**

- 1. Risk: error of modelisation;
- 2. Risk: error of measures

Applications (pollution; flood):
- Topography: R'/R (pollution), Speed flow (Flood)
Risk due to error on estimation measures / Model

- Small error on the estimation of topography parameter ..... Big error on the final results (Nonlinearity of the system).
- Risk must take into account such errors.

Conclusion/ Recomendation

Ideal managment risk is with some risk !!!): Pluridisciplinarity

I) 1. Try to prevent the unumprevisible (natural and techniques);
   2. Consider many sceneries for a same situation (evolutive) : Non linear systems; chaotics.

II) 1. For known (or predictible) situations : Low (perimeters of protection (pollution), Autorisation of built (flood).
   2. Umpprevisible situation : encouraged scientific research!

Prendre la responsabilité de gérer les risques… est très risqué… Mais il faut bien prendre le risque de le faire car si on ne fait rien… on est certain…qu'on va tout perdre un jour ou un autre !
Références


Références


Vulnerability

Gravity

Probability (Alea)

\[ T = \sum \frac{h}{V_i} \]

\[ C'/C = \begin{cases} \frac{1}{1 - M_d} & \text{if } M_d < 1 \\ 0 & \text{if } M_d \geq 1 \end{cases} \]

Interface soil

Topology

Couver végétal

Climat

Autres

Gravity

Probability (Alea)

Biodégradabilité

Bioaccumulation

Toxicité

Pollution Risk

Vulnerability

Gravity

Probability (Alea)
Qualitative evaluation of the gravity

<table>
<thead>
<tr>
<th>Situation</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toxicity (CL50 en mg/l)</td>
<td>not very toxic CL50 &gt; 100</td>
<td>moyennement toxin 10 &lt; CL50&lt; 100</td>
<td>toxin 1&lt;CL50&lt;10</td>
<td>very toxic CL50 &lt; 1</td>
</tr>
<tr>
<td>Bioaccumulation Facteur of accumulation</td>
<td>not much (très peu) F.ac &lt; 5. 10²</td>
<td>not much (peu) 5. 10² &lt; F.ac &lt; 10³</td>
<td>medium 10² &lt; F.ac &lt; 10⁴</td>
<td>high F. ac &gt;104</td>
</tr>
<tr>
<td>Biodegradation</td>
<td>very easy &gt; 80 %</td>
<td>easy de 60 à 80 %</td>
<td>medium de 40 à 60 %</td>
<td>weak &lt; 20 %</td>
</tr>
<tr>
<td>Gravity</td>
<td>weak</td>
<td>medium</td>
<td>strong</td>
<td>very strong</td>
</tr>
</tbody>
</table>

Tab 1. Parameters caracterising the gravity of a pollutant

Gravity / vulnerability

<table>
<thead>
<tr>
<th>Gravity</th>
<th>Weak</th>
<th>Medium</th>
<th>Strong</th>
<th>Very strong</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weak</td>
<td>weak</td>
<td>weak</td>
<td>medium</td>
<td>medium</td>
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<tr>
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<td>medium</td>
<td>strong</td>
<td>strong</td>
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<tr>
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<td>medium</td>
<td>strong</td>
<td>very strong</td>
<td>very strong</td>
</tr>
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<td>Very strong</td>
<td>strong</td>
<td>strong</td>
<td>very strong</td>
<td>very strong</td>
</tr>
</tbody>
</table>

Tab 2. Coupling effect of the gravity and vulnerability
Transit Time map (1/T)

Qualitative approach of the risk:
Risk = f(Probability, Vulnerability, Gravity)

<table>
<thead>
<tr>
<th>Probability</th>
<th>Very weak</th>
<th>Weak</th>
<th>Strong</th>
<th>Very strong</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravity/Vulnerability</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Very weak</td>
<td>weak</td>
<td>weak</td>
<td>medium</td>
<td>medium</td>
</tr>
<tr>
<td>Weak</td>
<td>weak</td>
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Tab 3. Qualitative estimation of risk