Vulnerability and risk assessement for groundwater pollution: Application to Oualad Ogbane aquifer (Morocco)

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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

Evaluation of the pollution risk

Principle :

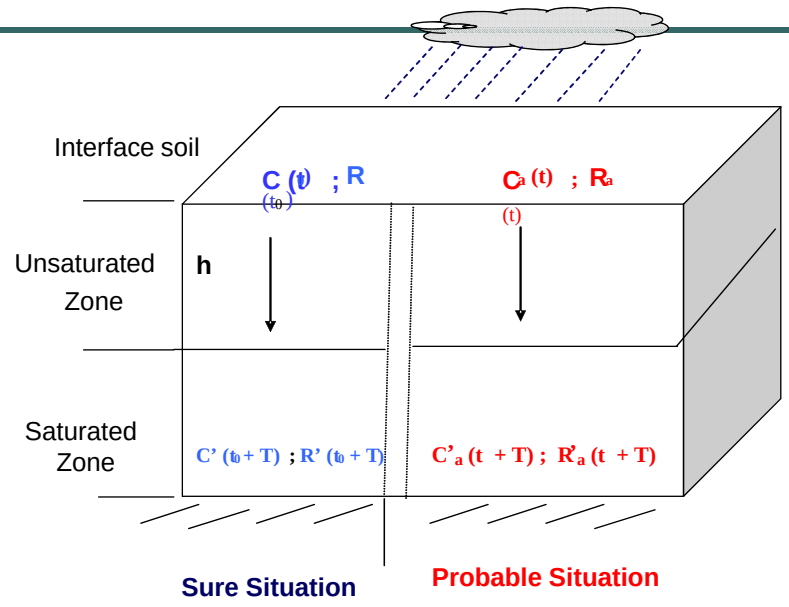


Fig. 2- Diagram of evalution of groundwater pollution risk

Evaluation of the pollution risk

Sure situation :

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

$$\text{Gravity } (t_0+T) = \alpha * C'(t_0 + T) \quad (1)$$

α : Nature of the pollutant

Remark : 1. Gravity depends on the **nature** and on the **dose** of pollutant in the waters of the aquifer
2. Gravity is linked to vulnerability

It is the dose which makes the poison (Paracelse, 1493 – 1541)

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**)

$$\text{Gravity p } (t + T) = \alpha * C'p\ (t + T) \quad (3)$$

Remark : **Probable gravity = Risk**

Groundwater pollution risk

Risk = f (Vulnerability, Gravity, Probability)

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

Vulnerability assessement : DRASTIC approach

Principle :

DRASTIC: one of the weighted classes methods, developed in USA (Aller et al, 1987)

It reflects the vulnérabilty by considering the sum of weighted seven factors

Vulnerability index :

$$Iv = \sum (Wj * rj)$$

- *D, R, A, S, T, I, C: The parameters used by the DRASTIC method (*Depth, Recharge, Aquifer media, Soil, Topography, Impact usz, Conductivity);
- *r, w: note weight assigned to each "j".*

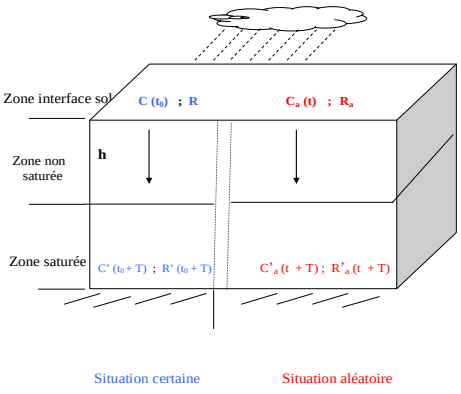


Fig. 2- Schéma d'évaluation du risque de pollution des eaux souterraines

Vulnerability assessement : GOD approach

Principle :

GOD: one of the class system methods developed in England by Foster in 1987

It considers the following three parameters:

- **G**: nature of the aquifer (free, semi captive, captive)
- **O**: lithology and degree of consolidation of the unsaturated zone
- **D**: depth (thickness of the unsaturated zone).

Vulnerability index :

Iv = IG = CG * CO * CD

C: note assigned to the three parameters

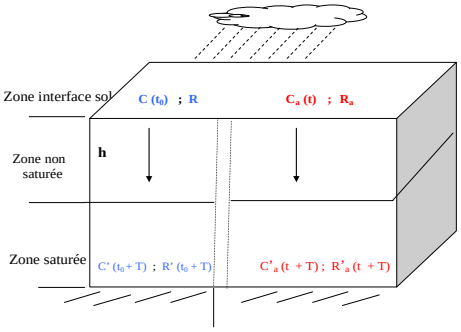


Fig. 2- Schéma d'évaluation du risque de pollution des eaux souterraines

Gravity

Garvity of a pollutant can be characterized : Biodegradability, bioaccumulation and toxicity

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

Gravity = α * C'(T)

α = 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

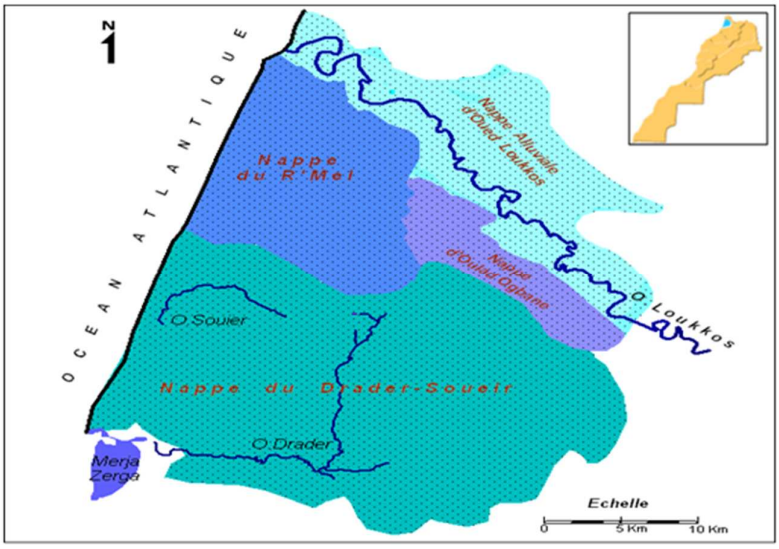
Probability (Alea)

Probability (of groundwater pollution):

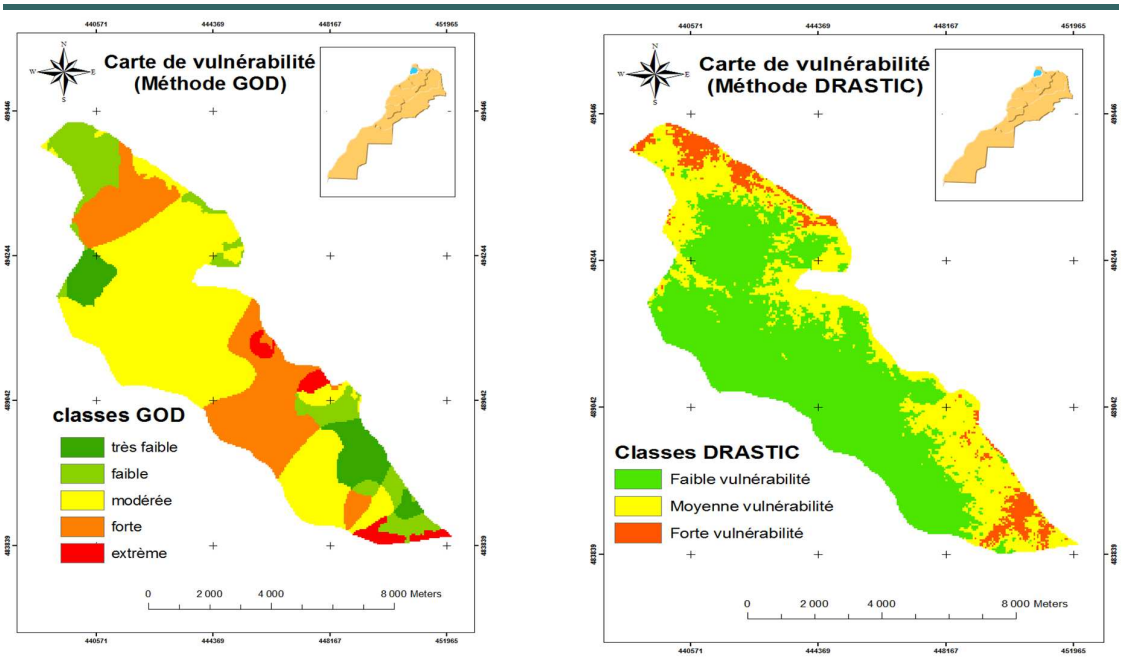
1- Evolution of use or rejected of pollutant (law of evolution for probable concentration **Cp (t) ?**)

2- Variation of probable recharge Rp (t) (law of evolution of irrigation and of rainfull: **Climatic change ?**)

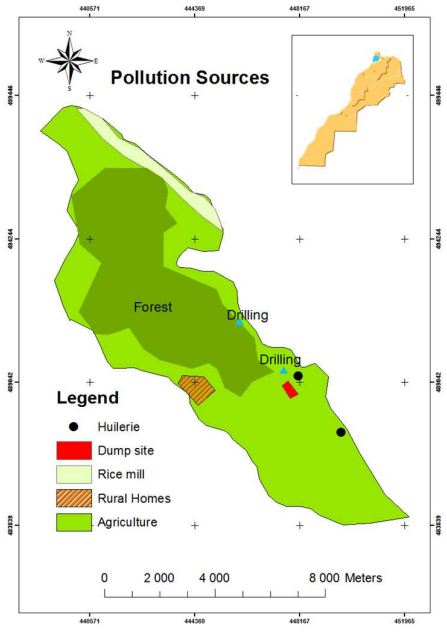
Application : Loukkos aquifers (Geographical Localisation)



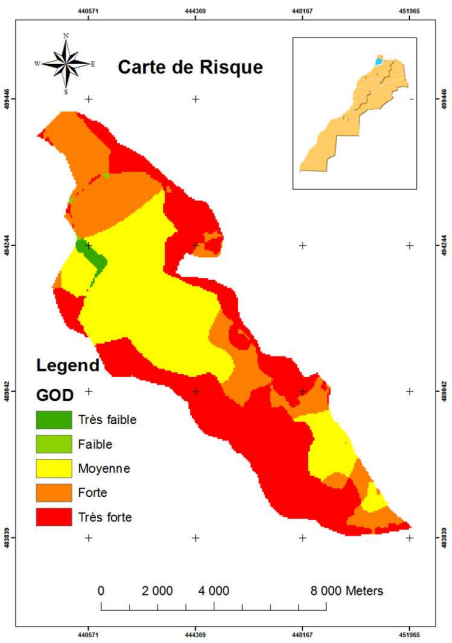
Vulnerability maps of Oulad Ogbane aquifer: GOD and DRASTIC approaches

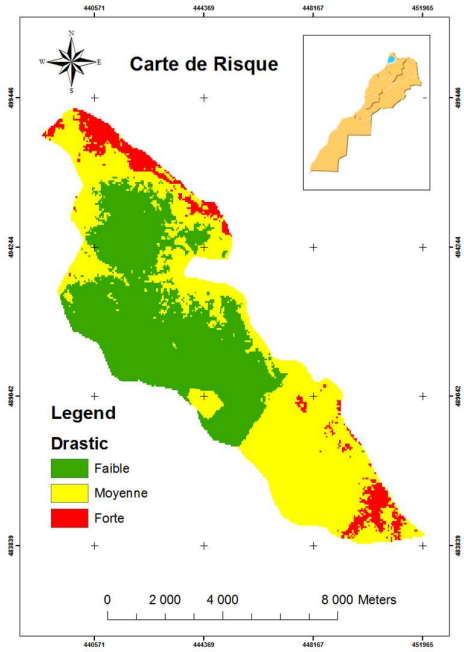


Pollution sources



Pollution Risk maps





Conclusion and perspectives

- Tool's help to decision;
- Risk evaluation depends on the choose of vulnerability method;
- Others comparatives studies.

And to finish …

Thank you for your attention