The impact of urbanization on groundwater quantity and quality – model predictions for urban planning of the city of Lille

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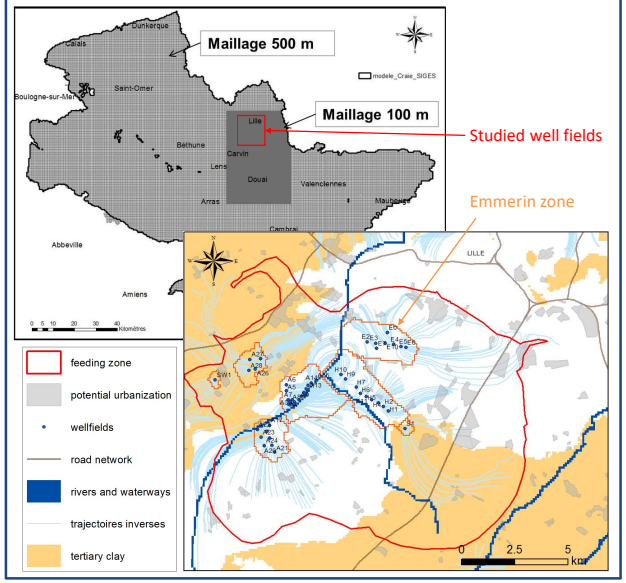
At less than 10km south of the urban core of the city of Lille (North of France), the chalk aquifer is a shallow and productive groundwater resource. Around 40% of the water supply of the city of Lille comes from well fields located in this area. Due to its location, this area is becoming more attractive for economic and residential development. Urbanization inevitably causes soil sealing and runoff collecting, leading to the decrease of groundwater recharge, and then to the risk of a non-sustainable drinking water resource.

2 Hydrogeological model

This study used a previously developed hydrogeological model [1] constructed on the 1982-2012 period and taking into account:

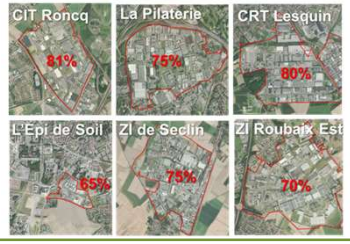
- 10-layer with geometry based on a previously constructed geological model
- Hydrogeologic knowledge (pumping tests, role of the faults, etc.)
- pluviometry data measured at 16 regional stations
- Hydrographic network and aquifer-river exchange
- Well pumping and piezometric data



3 Knowledge on potential future urbanization

In the scope of urban planning, zones of potential future (until 2035) urbanization were inventoried in a database. A preliminary version of the database (i.e. with larger total area than in the final version) were used, representing 441 pieces of land with a total area S_{urban} = **4090 ha**, including around 1000 ha in the feeding area of well fields.

Using aerial photography of existing urbanized area, the rate of surface sealing are evaluated around 80%.

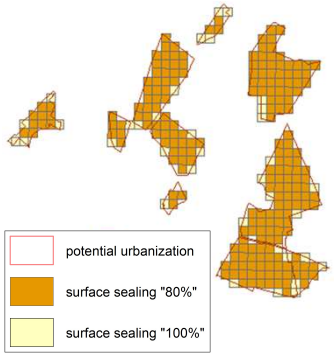


4 Methodology – Predictive simulation

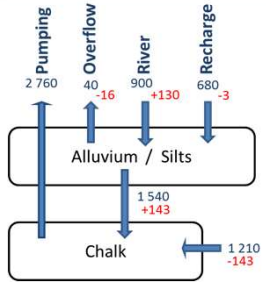
To evaluate the consequences of surface sealing due to future urban development project, predictive simulations are built. Previously developed model [1] are used to simulate the next 31yr using constant well pumping fixed to those assumed representative of future pumping.

3 scenarii are constructed :

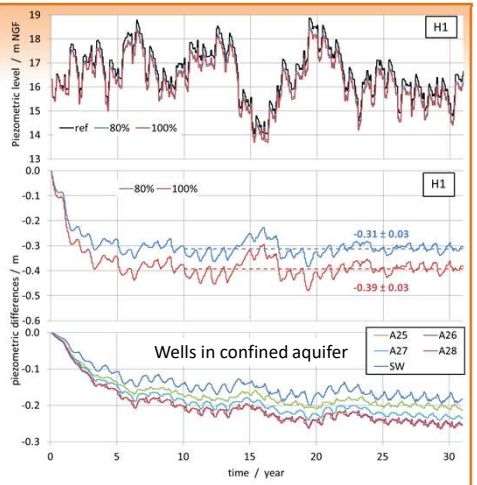
- 1 "reference" scenario assumed to be representative of the state of urbanization of 2012;
- 2 "urbanization" scenarii with surface sealing (no rain) on pieces of land adapted from urban planning database. Total area of modeled surface sealing S_{model} is fixed as:
  - $S_{model} = S_{urban}$ in "100%" scenario
  - $S_{model} = 0.8\ S_{urban}$ in "80%" scenario



5 Modelling results



Average flow (in 10^3 m^3/yr) in Emmerin zone for "reference" scenario (blue) and change with "100%" scenario (red)



After surface sealing, time of response of piezometric level are around 5-10 years, even more for the part of aquifer confined under tertiary clay.

Results suggest that urbanization should:

- ↗ the supply by rivers and waterways (until +14% at Emmerin);
- ↘ the groundwater level in the chalk aquifer (-10cm at Emmerin to -2m below the large-area sealing zone);
- No modification of the feeding area could have been identified.

These changes should likely impact the water resource quality because:

- the water and sediments of rivers and waterways are of poor quality;
- the ↘ of groundwater levels can alter the wetland purification system;
- the ↘ of groundwater levels near a Chalk-Clay interface can modify the geochemical behavior of undesirable substances [2].

6 Conclusions

In the area around the city of Lille, soil sealing may impact the quantity and quality of water resource. Urbanization also leads to a more intense anthropic activity that increases the risk of accidental pollution. With the aim of defining a territorial development consistent with the sustainability of water resource, hydrogeological study should be associated with economic and/or social studies.

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[1] Bessiere *et al.*, 2015 BRGM/RP-63689-FR ; [2] Cary *et al.*, 2014 Applied Geochemistry 48:70-82.