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Sustainable management of springs in a crystalline basement context using a coupled hydrogeophysical and hydrodynamic modelling approach (Daloa, Central-Western Côte d'Ivoire)

KOUASSI Kouassi Jean-Michel[1,2*], KONAN Yao Emile Desmond[1], KOUADIO Kouamé Jean Olivier[1], MANGOUA Oi Mangoua Jules[1], LACHASSAGNE Patrick[2], ROSSIER Yvan[3], DIBI Brou[1]

[1] Laboratory of Environmental Sciences and Technologies, Univ. Jean Lorougnon GUEDE, Daloa, Côte d'Ivoire
[2] HSM, Univ. Montpellier, CNRS, IRD, IMT Mines Alès, Montpellier, France
[3] Univ. Grenoble Alpes, CNRS, INRAE, IRD, Grenoble INP, IGE, 38000 Grenoble, France
[*] Corresponding author: kouassimichel48@gmail.com, Tel: +225 0748365414

INTRODUCTION & AIM

The management of groundwater resources in crystalline basement regions in West Africa, particularly that of springs, is crucial, especially with the increase in their use due to difficulties in supplying drinking water. In contexts such as urban and agricultural zones, the issue of contamination of these springs and the aquifers from which their groundwater originates is becoming particularly worrying. It is therefore essential to understand the hydrogeological functioning of the aquifer system that feeds the springs, in order to delineate their capture areas and define appropriate protection zones.

Based on the hydrogeological conceptual model of the springs, developed from a vast set of geological, hydrogeological and geophysical data, this study presents an innovative approach to numerical modelling of groundwater flows, which has made it possible to delineate capture areas consistent with the groundwater flow system.

The research is being conducted on the aquifers of the Tétégbeu River watershed, a tributary of the Lobo River located in central-western Côte d'Ivoire.

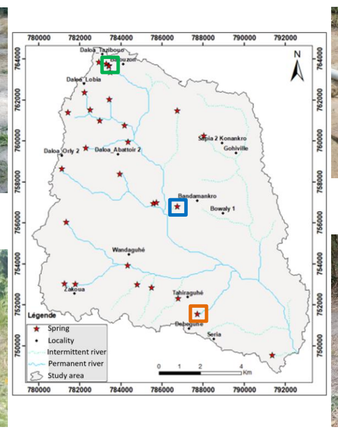
Numerous springs in various parts of Daloa city (0.1 L/s < Q < 2 L/s)

Undeveloped spring

Developed spring

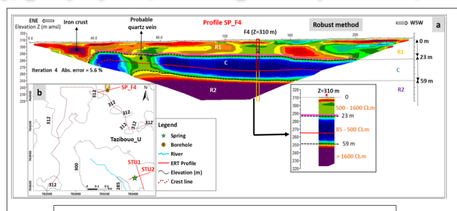
Undeveloped spring

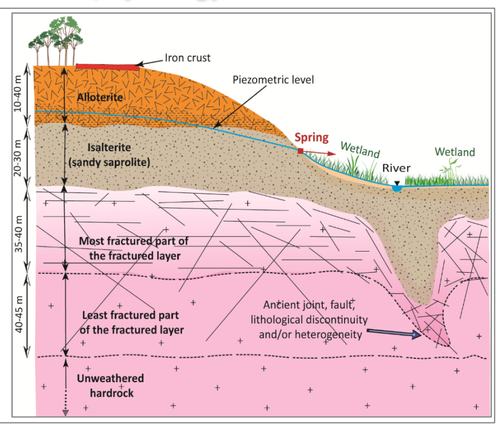
Undeveloped spring

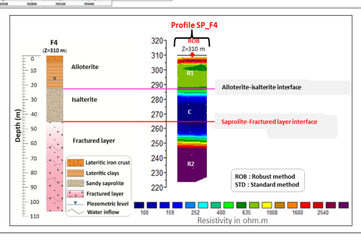


METHOD

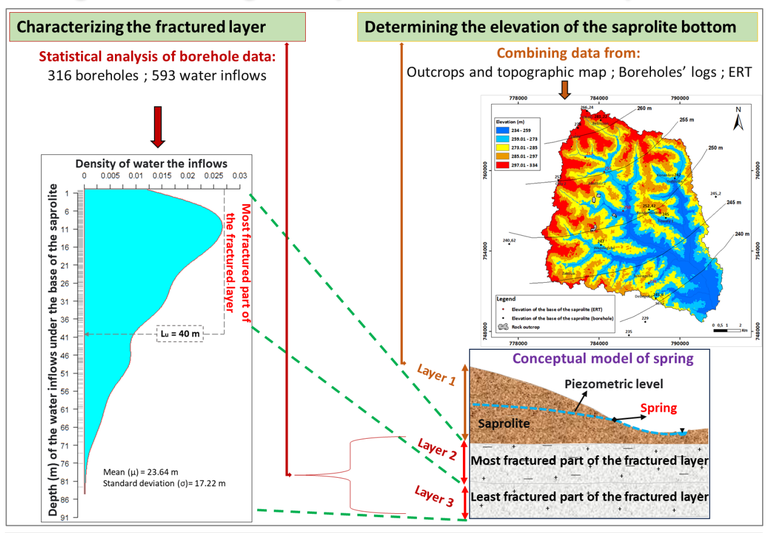
Hydrogeological conceptual model from a multidisciplinary approach (Kouassi et al,. 2024): geology, geophysics, recharge computation, data bases, hydrology…

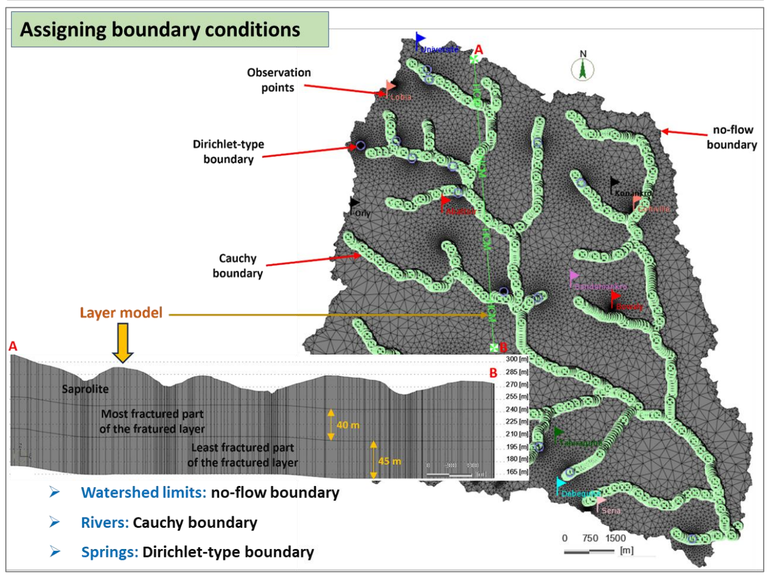






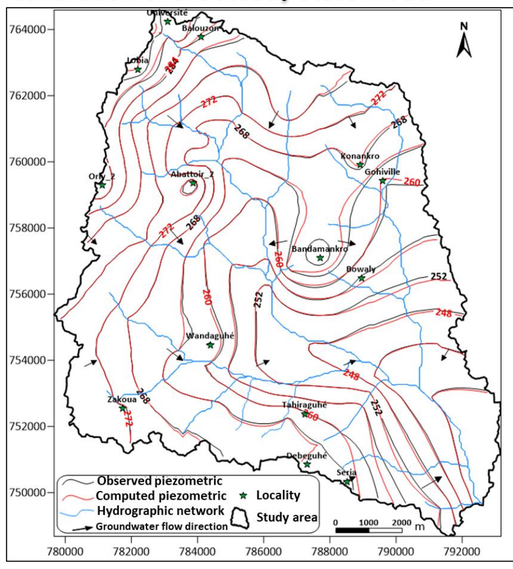
Implementation of a groundwater age transport model to determine probabilistic capture areas





RESULTS

Calibration of the steady-state model

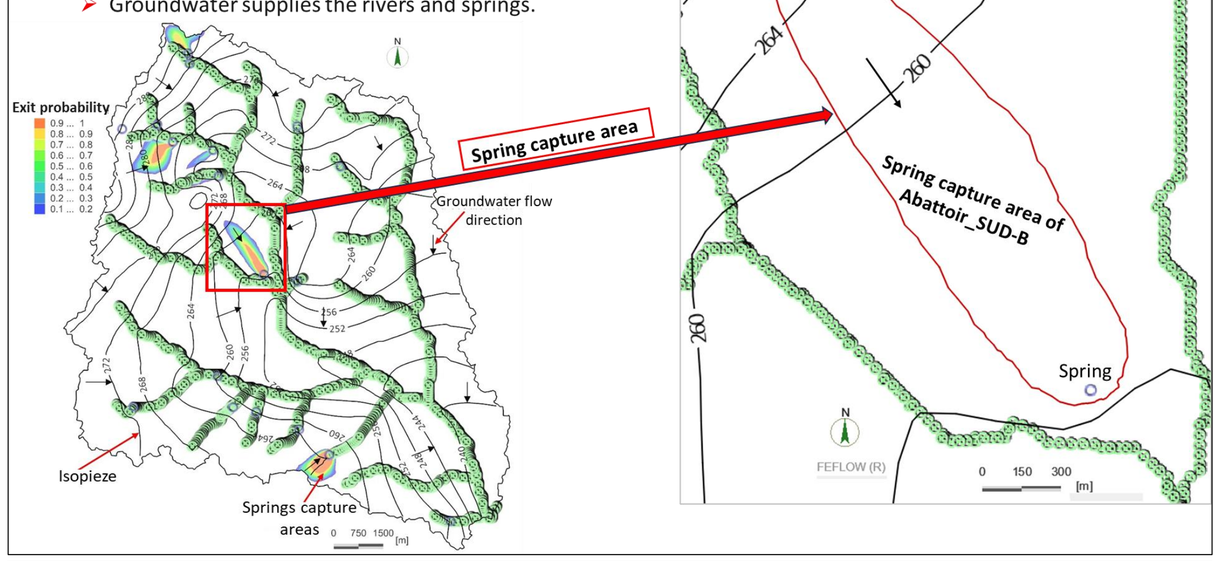


- The model was able to simulate hydraulic head values close to the observed values.
- The flow lines point towards the river, indicating that the river is the main outlet for groundwater in this zone.
- GW Budget
  - Recharge: 221 L/s (or 50 mm/year)
  - Discharge
    - Rivers: 211 L/s
    - Springs: 6 L/s
    - Wells: 4 L/s
  - :

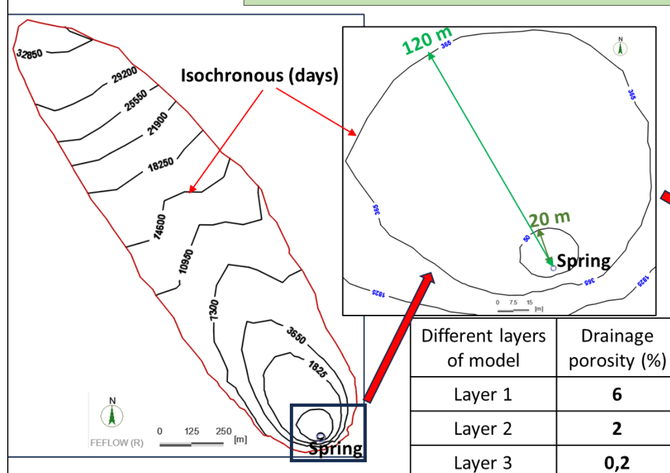
Capture and protection areas of springs obtained using a groundwater age transport numerical model

Springs capture areas

- Computed springs capture areas are coherent with the observed piezometric map.
- Groundwater supplies the rivers and springs.



Influence of drainage porosity on groundwater velocity



Different layers of model	Drainage porosity (%)
Layer 1	**3**
Layer 2	**1**
Layer 3	**0,2**

Different layers of model	Drainage porosity (%)
Layer 1	**6**
Layer 2	**2**
Layer 3	**0,2**

Isochronous 50 days: 30 meters → Immediate protection perimeter

Isochronous 1 year: 180 meters → Close protection perimeter

Spring capture area → Distant protection perimeter

CONCLUSION AND OUTLOOKS

- **Groundwaters feeds the river** either directly or through springs;
- **The spring capture areas** vary between 0.17 and 1 km²;
- **The springs' protection perimeter** is 30 m for the immediate perimeter (50-day Isochronous), 130 m for the close perimeter (1-year Isochronous) and the entire capture area for the distant perimeter.

For effective springs protection, we propose using artificial or natural tracing test techniques to improve the extent of springs capture areas.

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