Endogenous and exogenous pollution of groundwater and interactions between heavy metals and nitrogen compounds (Burkina Faso)

Sauret E[1], Ouédraogo I[2], Kam A[3]

[1] Centre National de Recherche Scientifique et Technologique (CNRST) - Institut de l'Environnement et de Recherches Agricoles (INERA), Station de Recherche de Farakôba - Bobo Dioulasso, 01. BP. 910 Bobo Dioulasso 01. Author email : saurelie517@yahoo.fr
[2] Institut International de l'Eau et de l'Environnement - 2iE, Rue de la science; 01 BP 594 Ouagadougou, Email : igor.ouedraogo@2ie-edu.org
[3] Water Aid et ADAE, Manager de projet, Expert GIRE. Email : kam_massa@yahoo.fr

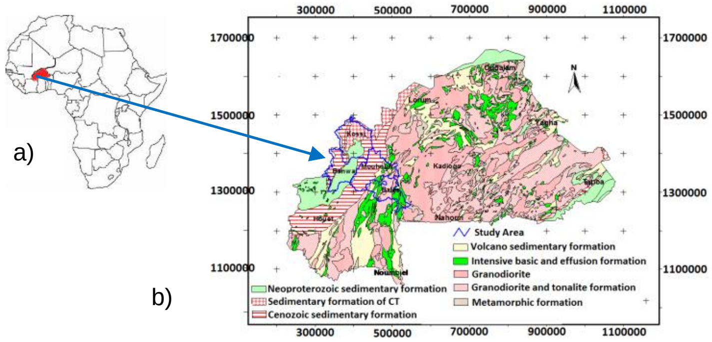
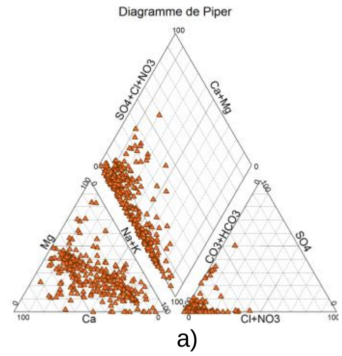


Fig. 1. a) Africa Map, b) Geology of BF (study area in blue)



Location and problematic

Rural localities of south-central Burkina Faso (Fig. 1) have a low density of drinking water drillings just about, 0.02 to 0.05 drillings per km²; this corresponds to a ratio of 1 drilling per 1794 inhabitants in some provinces (Nikiéma, 2002). In order to increase access to drinking water drillings in these localities, Burkina Faso has requested and obtained from the Arab Bank for Africa financing the realization of 310 drinking water drillings. This opportunity, although beneficial for rural communities, has revealed the presence of chemical elements in drillings at concentrations above the WHO drinking water standards.

Objective

The objective of this study is to understand the chemistry of water, the origin and reaction mechanisms of different types of pollution.

Methodology

Physico-chemical water and soil analyses data are collected (Fig 1c). The water analyses focused on: T°, pH, EC, total alkalinity, TDS, major and minors ions: Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, HCO_3^-, Cl^-, SO_4^{2-} ,…and pollution indicators: NO_3^-, NO_2^-, NH_4^- F_e^{3+}(Total iron), PO_4^{2-}, Mn^{2+}, Zn^{2+}. As for the soils, samples are taken every 20 cm from 0 to 1.20 m. The analyses carried out for the soils covers the contents of organic matter, NO_3^-, P, exchangeable bases, cation exchange capacity, saturation rate, pH of imbibition water. Water analyses for which the ionic balance is less than 15% have been interpreted as suggested by Mathess (1994).

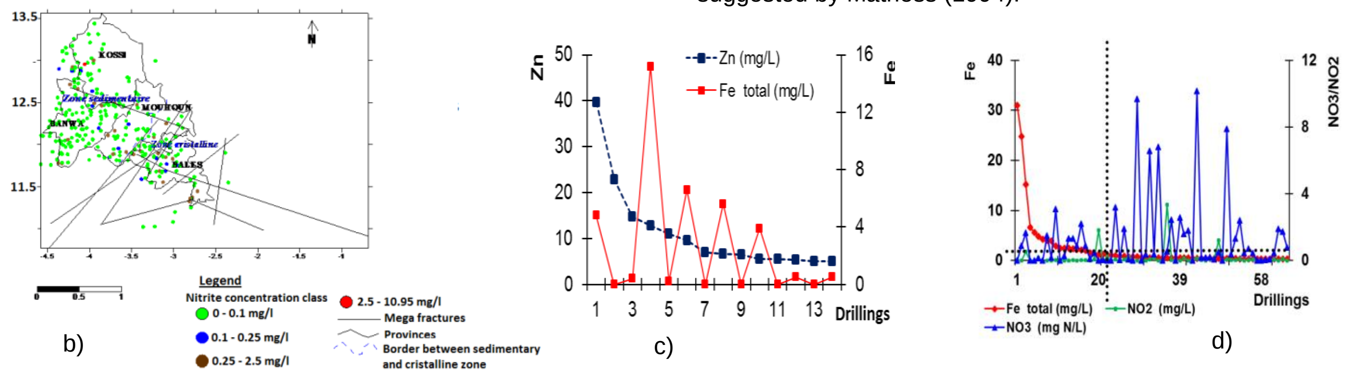


Fig.2. a) hydrochemical facies of water, b) Map of nitrite concentrations, c) Comparison of iron and zinc levels in waters with anomalous zinc concentration (> 5 mg/l), d) Comparison of iron, nitrate and nitrite contents in drillings with anomalous iron concentration (> 0.3 mg/l)

Results and discussion

194 of the 305 water analysis were plotted on Piper diagram (Fig 2a). The dominant anion is HCO_3^- ion; for cations, in 90.% of cases there are no dominant ions (mixed facies), Ca^{2+} is dominant in 2% of cases, Mg^{2+} in 0.5% and [Na^+, K^+] in 7.5%. The water can be attributed to calco-magnesian and sodi-potassium bicarbonate facies. In total, 63 drillings have iron concentrations > 0.3mg/l, 14 have zinc concentrations > 5 mg/l and 49 have nitrite concentrations higher than 0.1 mg/l (Fig.2b and 2c). Iron and zinc showed the same accumulation dynamics in drillings inversely correlated with the occurrence of nitrites (Fig. 2d). Indeed, drillings with iron-enriched concentrations close to 1 mg/l have simultaneously the lowest nitrite concentrations. Conversely, low iron concentrations (< 1mg/l) are associated with high nitrite concentrations. The presence of iron and zinc seems endogenous linked to materials of groundwater aquifers constituted of granodiorite, granite to amphibole, mica, pegmatite, clayey - limestone and sandstone with clay cement. There would be processes of iron oxides and hydroxides reduction in the aquifers and conversely of nitrogen oxidations. As for nitrates/nitrites, their origin is exogenous linked to (i) drainage, infiltration and oxidation of nitrogen coming from (i) application of nitrogenous fertilizers on cotton fields (nitrogen, phosphorus, potassium), burning of cotton residues, manure pits, and (ii) discharge waters from industrial cotton processing units on, ferralitic, ferruginous, eutrophic, hydromorphic and vertisol soils at favourable texture: clayey silt (50%), sandy silt (33%) and, sandy clayey silt (17%), fairly porous and normally drained.

Conclusion

In absence of any corrective treatment (de-ironing, zinc precipitation by soda or lime milk, reverse osmosis, etc.), the consumption of these "polluted" waters exposes these rural populations to diseases.

Bibliography

Nikièma, J. (2002). Caractérisation des forages à haut rendement en zones de socles cristallins du Burkina Faso. DEA de Géologie appliquée. Université Cheikh Anta Diop de Dakar, 77p.

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