Hydrogeological modelling for establishment the protection perimeters in Morocco

Jamal Chao[1], Ilyas Kacimi[2] & Bouâbid El Mansouri[1]

[1]Faculty of science, Ibn Tofail University, Laboratory of Environment-Natural Resources, BP.133, 14000 Kenitra, Morocco; E-mail: elmansourib@univ-ibntofail.ac.ma
[2]Faculty of science, Mohamed V University, Laboratory of Applied geology, Department of earth sciences Rabat, Morocco

Abstract: The protection perimeters protects public water-supply wells from several polluting agents. By using a hydrogeological modelling, we have calculated isochrone based on travel time in the Sidi Taibi and Ahmed Taleb sites (Morocco). The hydrogeological model uses flow and transport equations which are resolved by using a finite elements method.

Key words: Protection perimeters, Hydrogeological modelling, Morocco.

Introduction

Nowadays, the aquifers become more and more exposed to residuals infiltration and chemical toxic products, which are results of anthropic activities that are developed and stressed by socio-economic needs. We mainly note pollutions caused by agricultural proliferation activities, the decrepit network of urban areas sewers and industrial zones.

The protection perimeter notion was adopted by almost all countries[1]. It's defined as a surface surrounding a pumping well, in which arrangements must be taken to prevent pollutants to migrate and contaminate groundwater near and in this well[2]. There are three different kinds of protection perimeters, which are adopted. Around pumping well, an inner mandatory perimeter and a second close protection perimeter, compulsory, inside which risky activities like quarries exploitation, wells, products dropping of dangerous pollution are forbidden or regulated. Finally, an optional perimeter of remote protection. In this study, we have estimated close protection perimeter dimensions for both important sites of a public water-supply wells in Morocco.

The protection perimeters fixation was made at first in transitory regime based on Theis formula. Several authors have worked on this subject: Bear and Jacob[2,3] and Hofman and Lillich [4-8].

This study is based on hydrogeological modelling of catchment site, which allows us to determine the isochrone. This is considered as close protection perimeter. The equations, which describe the flow and transport, are given by[3]:

$$S\frac{\partial H}{\partial t} + div(b\omega_c V) = q \tag{1}$$

$$\omega_c V = -K\nabla H \tag{2}$$

$$\frac{\partial C}{\partial t} = -\frac{V}{R} gradC + div\left(\frac{D}{R} gradC\right) - \lambda \cdot C + \frac{q}{bR\omega_c}(C_{in} - C) + \frac{S_{sur}}{bR\omega_c} \tag{3}$$

Scientific paper

where S: storage coefficient (confined aquifer) or effective porosity (phreatic aquifer); H: piezometric head [L]; t : time [T]; b: thickness of saturated flow [L]; ω_c: cinematic porosity, V: average flow velocity [LT^{-1}]; q: source/sink term [LT^{-1}]; K: permeability tensor [LT^{-1}]; C: solute concentration [ML^3]; λ: degradation rate of pollutant (T^{-1}); D: dispersion coefficient [L^2T^{-1}]. In isotropic porous medium, the dispersion coefficient can be expressed by[9] $D_{xx} = \alpha_L \frac{V_x^2}{V} + \alpha_T \frac{V_y^2}{V} + D_m$; $D_{yy} = \alpha_T \frac{V_x^2}{V} + \alpha_L \frac{V_y^2}{V} + D_m$ where D_{xx}, D_{yy}: dispersions in main axes of the isotropy; a_L and a_T respectively longitudinal and transversal dispersivities ; V_x and V_y : velocity in main axes of flow and V: velocity module. The numerical model's resolution is based on finite elements method and uses the piezometric state of 1994 (Fig. B1, C1). The developed numerical code calculates the travel time in bidimensional case, and can take account the heterogeneity and the anisotropy.

The Sidi Tad'bi and Ahmed Taleb catchment sites are situated between Rabat and Kenitra (Fig. A). Sidi Tad'bi field wells produce about 245 l/s. The site is situated in Maamora aquifer; which belongs to Plio-villafranchien period. Its geological facies is principally sand and fractured calcarenite. The saturated thickness is about 40 m. The Tortonien blue marls constitute the bottom of the aquifer. Hydrogeologic studies principally that of [10] estimated permeability which about 15.10^{-3} ms^{-1}. This catchment site is placed in a very vulnerable environment. In fact, many quarries, which exploit the calcarenite are left and are often used as industrial or urban rubbish dump. The site is also taken between the principal road RP2 linking Rabat and Kenitra at the west and the railway at the east. These elements constitute high polluting risk factors the catching field.
As for Ahmed Taleb site (Fig. A), there are two groups of six wells: Three in the south zone of the site and three other wells in the north zone. All these wells produce about 210 l/s. For its hydrogeologic context, it is situated in the coastal zone of Rharb plain. The studies effected in this zone, showing that the soils are characterised by raised vertical hydraulic conductivity ≅ 20 m/d. The aquifer system to which the site belongs, consists of a principle aquifer, constituting the continuity in the coastal zone the Rharb deep aquifer. The Plio-quaternary formations mainly calcarenites sand, sandstone, constitute the principle aquifer. The aquifer presents a hight transmissivity, which is about of 5.10^{-2} m^2/s[1]. The bottom is made of Tortonien blue marls and is located between 60 and 90 m deep. The site environment is characterised by the presence of a powerful agricultural activity, of old left quarries, and a big scrap iron depot. Shanty towns agglomerations limit the site to the West.

RESULTS AND DISCUSSION

Numerical code has allowed us to establish the perimeter based on travel time with taking account a dispersion phenomenon. The isochrone is considered as close protection perimeter. Both sites have perimeters, which surfaces are respectively 90 ha for Sidi Tad'bi site (Fig. B2), 38 ha and 40 ha; respectively for north and southern site Ahmed Taleb zones (Fig. C2).
The attendance by ONEP (drinkable water national office) of these catchment sites qualities, and the analysis carried out on certain neighbouring wells; have showed a tendency to

the increase of chlorides tenor, sulphates and nitrates[11]. Placed in the site environmental context, the isochrone (protection perimeter) can explain the origin of this pollution. The sites are very near of some agro-industrials and chemical unites in the zones. Sometimes, these unites are found even inside the established isochrone.

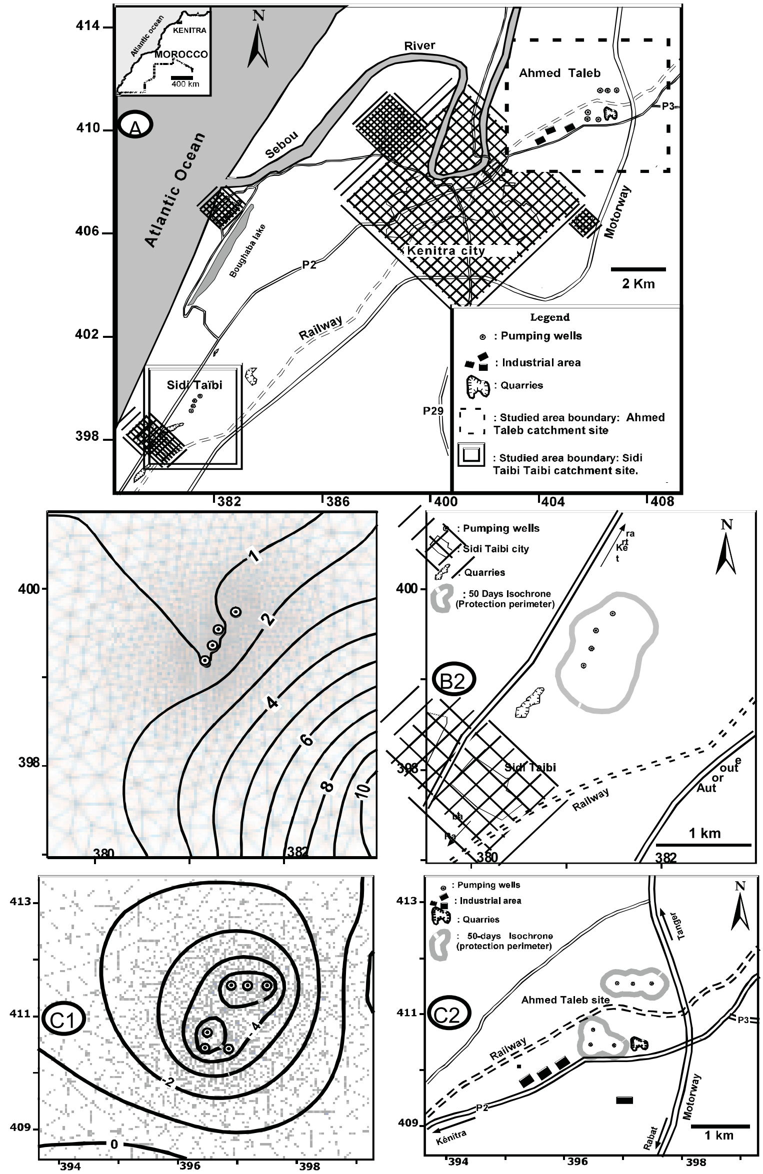

Figure A-Study areas, **B1**-finite elements mesh and piezometric state in sidi Taibi field, **B2-** Sidi Taibi Protection perimeter in its regional environment, **C1-**finite elements mesh and piezometric state in Ahmed Taleb field, **C2-**Ahmed Taleb Protection perimeters in its regional environment

CONCLUSION

The determinist modelling groundwater flows and transport constitute a modern and actual approach in protection perimeter estimation. This approach carried by a public use declaration of catchment site would contribute without doubt to attenuate the potential risk of public water supply wells from pollution. Close protection perimeters are based on estimated hydrodispersive parameters; which create a certain uncertainty on obtained results. This open field to researches in experimental determination of these parameters by the tracking way. This perspective constitute a research objective in collaboration with guardianship authorities which are called more than never to look for scientific means reinforced by legal tools to protect water resources in Morocco.

REFERENCES

[1]EL MANSOURI, B. (1999): *Développement d'outils et concepts pour la gestion des eaux souterraines.* Ph.D. Thesis. University of Ibn Tofail, 1999, 145 p. Morocco.

[2]BANTON, O. & BANGOY, M. (1999): *Hydrogéologie multisciences environnementale des eaux souterraines*. Presses de l'Université de Québec/ AUPELF, 459 p. Canada.

[3]Kinzelbach, W., (1986): *Groundwater Modeling - An Introduction with Sample Programs in Basic*, 333 p. Elsevier, Amstenlam.

[4]LALLEMAND-BARRES, A., ROUX, J. C. (1988): *Guide méthodologique d'établissement des périmčtres de protection des captages des eaux souterraines destinées ŕ la consommation humaine*, Ed. BRGM, Orléans

[5]SAUTY, J. P., & THIERRY, D. (1985) : Utilisation d'abaques pour la détermination des périmčtres de protection. *BRGM 75 SGN 430 AME,* Orléans, France.

[6]CRAMPON, N. (1983) : Abaques de détermination rapide des caractéristiques hydrodispersives lors de traçage par injection brčve. Hydrogéologie, *Géologie de l'Ingénieur*, 4. France.

[7]ROUX, J. C. (1988): Contrôle et protection de la qualité des eaux souterraines. Opérations récentes de services publics réalisés en France par le BRGM. *Hydrogéologie*, 1, pp. 1-33.

[8]EL MANSOURI, B. LOUKILI, Y. AND ESSELAOUI, D. (1999): Une approche numérique des périmčtres de protection des captages des eaux souterraines. *Comptes Rendues de l'Académie des Sciences de Paris*, pp. 695-700. Paris.

[9]BEAR, J. (1979): *Hydraulics of groundwater*. 569 p.Mc-Graw-Hill, New York.

[10] ONEP & GTZ (1996) : Protection des ressources en eau potable ONEP/maroc. Programme d'essai de traçage. Champ captant de Sidi Taibi. *CES Consulting Engineers Salzgitter GmbH Succursale Lingen*, Allemagne.

[11]ABOUZAĎD, H., OUTAIR, A. (1991): Les nitrates dans les eaux. VII^{čme}. *Congrčs mondial des ressources en eau*. 13-18 Mai 1991, Vol. 2. Rabat, Moroco.