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Groundwater pollution and sustainable development of the Collo plain; Northeastern Algéria

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Abstract

This study constitutes the diagnosis of groundwater pollution of the Collo aquifer, as well as the mapping of areas vulnerable to pollution. It has been carried out to identify the areas at high risk of contamination either by wastewater or by pesticides. and fungicides and also the intrusion of saline waters, for this we used the method of GOD to draw a map of vulnerability, interpretation of this map revealed that the vulnerability represented by three classes: The most polluted area (GOD index between 0.7 and 1) which represents about 30% of the plain; the index of GOD is high-to-high (0.5 and 0.7) represents 50% of the plain is one of the largest and smallest countries in the world (0.3 and 0.5) which represents about 20% of the plain and finally we will see the effect of underground pollution on sustainable development in the region (tourism and agriculture).

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Introduction

The Collo region has experienced in recent years some economic expansion (sustainable development) particularly agricultural and tourism, and Despite the abundance of rainfall (nearly 1500mm/year), and the presence of a very dense hydrographic network formed by the Oued el Guebli and its tributaries which feeds the groundwater.

The Collo region shows an increased drinking water deficit in both the agricultural and domestic sectors. The 2017 estimate indicates a need for irrigation water of 41 Hm3/year. At the base of a daily allowance of 150l/inhabitant and a growth rate of 3.15%. The needs for drinking water by 2025 would be of the order of 2.37Hm³/year for the Collo agglomerations. These needs would double in the long term (horizons 2050: 4.75Hm³/year) according to (DHW)

Groundwater resource protection requires knowledge of groundwater to pollution vulnerability and any vulnerability information is essential to facilitate groundwater planning and management. The concept of ground waters vulnerability to contamination was first introduced by Albinet and Margat in 1970 (Boulabeiz Mahrez *et al.*, 2017)

Prevention against pollution the prevention of groundwater pollution is a delicate step in the management of aquifers. Scientists are devoting more and more effort to this, particularly to the study of the vulnerability of groundwater to pollution. (Hamza *et al.*, 2007) this study was undertaken with the aim of identifying areas of high risk of contamination, regardless of the type of pollutant by the GOD (vulnerability) method and to know the effect of pollution on sustainable development (agricultural and tourism) in the region and finally we will propose some solicitations for this problem.

Materials and methods

Study area

The plain of Collo has an area of around 15Km² (Fig. 1.). It is located on the coastal strip on the eastern side of the town of Skikda (Algeria).

It is surrounded by the Mediterranean Sea from the north, the town of Kerkera from the east, the city of Beni Zid from the south and the city of Collo from the west.

The plain of Collo known by a multiple pollution: Industrial petroleum discharges (petrol station); the intensive use of chemical fertilizers in agriculture (pesticides and fungicides), the cement factory, the rise of sewage, the invasion of salt water. Geologically, Coll's geological formations are part of the peri-Mediterranean Alpine orogeny.

This is a recent mountain chain "chain of the Maghreb" (Durant Delga. 1969 *et al.*,) (Fig. 2.) The geological history of which extends from the Triassic to the Pliocene. North-eastern Algeria consists of a stack of units with a complex structure: Internal zones: Kabyle plinth, limestone chain, flyschs; The outer zones: Tellian nappe; Post-nappe formations.

The different formations of the alluvial plain (Fig. 3.) (Russian mission), to better understand the aquifer system of the Collo plain, two hydrogeological sections were made in 1965 by (C.C.G., 1996).

It can be seen that the thickness of the alluvium (sand, gravel, and a thin layer of silt) reaches 23 meters in the South-East and decreases towards Cherka Oued in the North-West where the piezometric level is very close. Sea level (zero coast); to identify the hydrogeological interest of each soil type and from the geological sections we have summarized them in the (Table 1)

Fig.1. Location map of the study area.

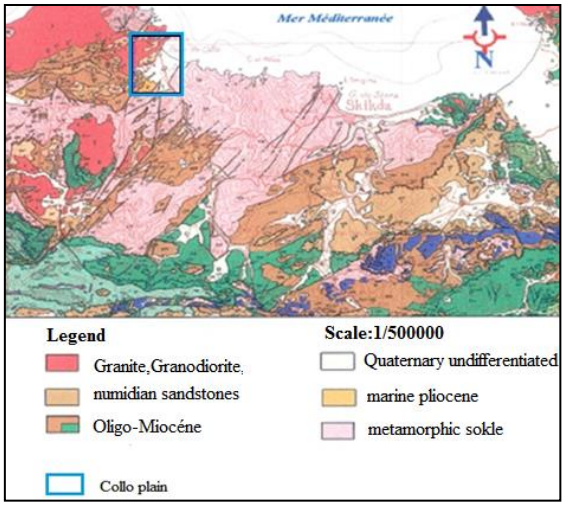

Fig.2. Geological map of the Collo plain according to J. M. Vila (1980).

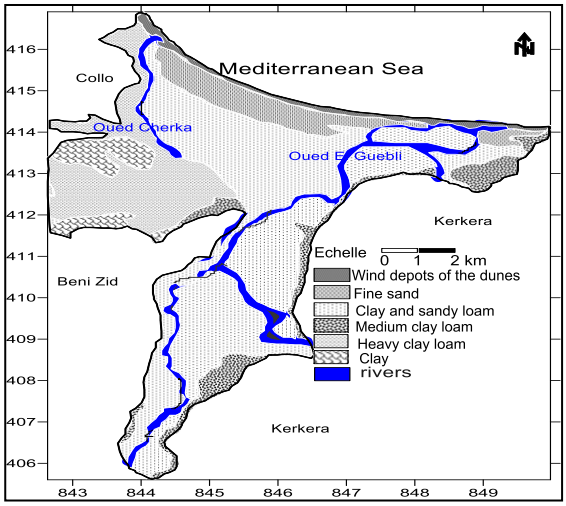

Fig. 3. Lithological map of the plain of Collo (Russian mission 1967).

Table 1. Hydrogeological interest of geological formations.

Leasing	Formation	Thickness	Hydrogeology interest
Midfielder	Clay loams and sand	10m	Large underground water reservoir
West of Kerkera, East of Beni Zid	Medium clay loams	15m	low hydrogeological interest
between Oued Cherka and Collo	Heavy Clay loams	15-23m	Large underground water reservoir
between Oued Cherka and Collo	Clay	25m	Waterproof substrate of aquifer formations
the northern part	Wind depots of the dunes	5m	low hydrogeological interest
the northern part	Fine sand	10-15m	Large underground water reservoir

The Tablcloth receives, in addition, a lateral feeding from the aquifer in the inferior flow of the wadi Guebli and its tributary the Oued Aflassen. In times of flood, these two wadis participate, moreover, fully, in the supply of the aquifer of the Collo plain (N. Chabour *et al.*, 2004). In general, the piezometric map observes two directions of flow, the first directed from South to North and a second reverse directed from North to South at the level of the littoral zone (Fig.4.), in detail there are four areas of convergence of flows, the latter are related to the exploitation of the tablecloth. At the level of the littoral zone it has a contribution of marine water; the variation in the spacing of the piezometric curves is due mainly to the heterogeneity of the aquifer lithology. (Layachi Gouaidia *et al.*, 2011).

Applied methods

In this work, the GOD method was chosen to assess the vulnerability of groundwater to pollution (foster ss., 1987).

It's an empirical approach that assesses the vulnerability using three parameters (Ake G.E *et al.*, 2009). The first: Groundwater occurrence (G), lies in the identification of the degree of confinement of the aquifer. The second:

Overall lithology of aquifer (O) corresponds to the overall lithology of the aquifer and the third is the Depth to groundwater (D), it's defined by depth to the water table (Najat knouz *et al.*, 2017) the determination of the GOD index is obtained by multiplication of these three parameters, according to the equation IG = Ca × Cl × Cd (foster ss., 1987), after the determination of these indices we can classify the vulnerability (Table 2) of after (Foster SS., 1987).

Table 2. Classes of GOD vulnerability index.

Vulnerability Index	Class of vulnerability
0	No vulnerability
0-0.1	Negligible
0.1-0.3	Low
0.3-0.5	Medium
0.5-0.7	High
0.7-1	Very High

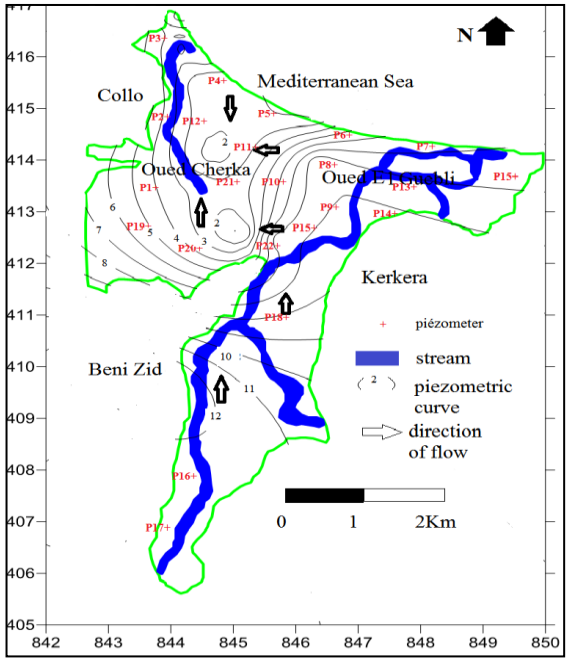

Fig. 4. piezometric map of the collo plain(April 2017).

To create the vulnerability map, information on materials covering the aquifer, unsaturated zone lithology and depth of groundwater was collected and interpreted from 23 wells are scattered on the plain (Fig. 4.) and the geological map (Russian Mussion, 1967) (Fig. 3.) of the study area. For the piezometric levels, measurements were made in April 2017 (high water).

Results and discussion

Groundwater occurrence:

In the natural context, groundwater generally takes place within geological formations that give rise to confined, Unconfined aquifer and Semi-Confined aquifers. The geological context of coastal aquifers (geometry, organization of permeable and impermeable formations) has an undeniable influence on the presence of underground pollution. The aquifer type of the Collo Plain is a Unconfined aquifer and Semi-Confined Aquifer (Fig. 5.), thus exposed more underground pollution because of the lack of waterproof roof.

Overall lithology of aquifer:

It is a very important parameter and from it one can know if there is a protective layer or not and the thickness of the aquifer or of the saturated zone and also, the plain of collo (Fig. 5.) it is formed by clay and sandy loam and fine sand and clay (Russian Mussion 1967). Depth to water table: (Fig. 5.) shows the map of the depth, In the study area the water level is weak, it does not exceed 10 meters, because of the measured depth in a very rainy period, which implies that the tablecloth more exposed to pollution generally the depth of the water between 0 and 2 meters to the north and 2 to 5 meters in the center and 5 to 10 meters to the south.

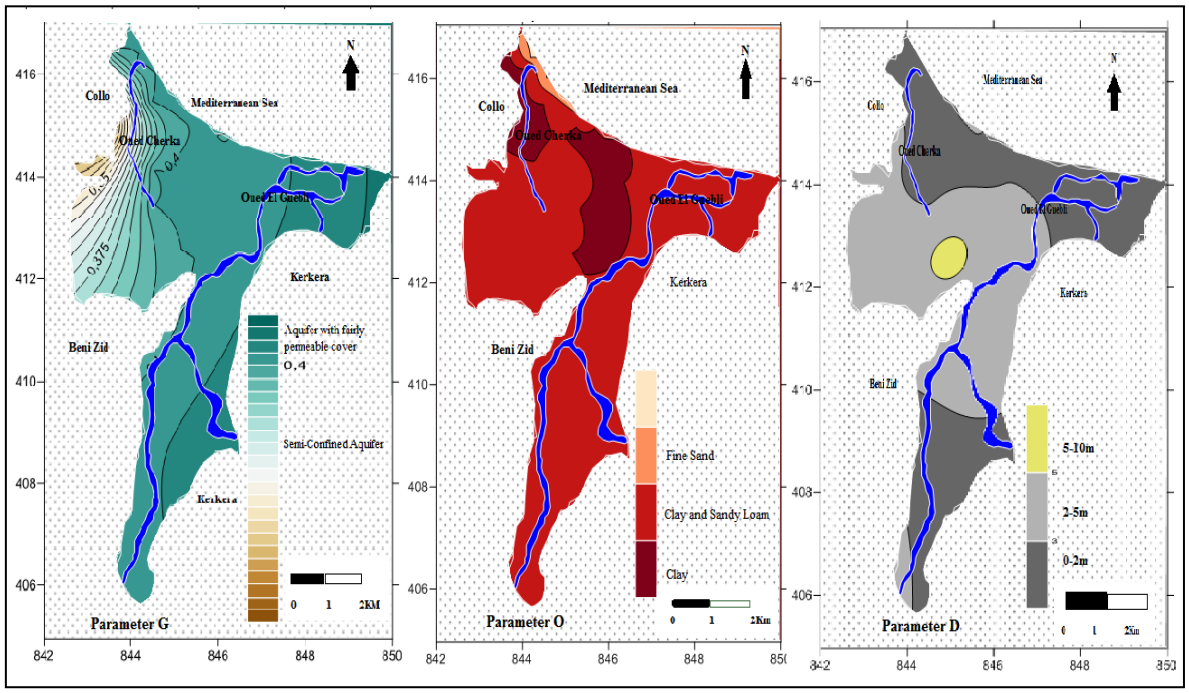

Fig. 5. GOD Parameters reclassified.

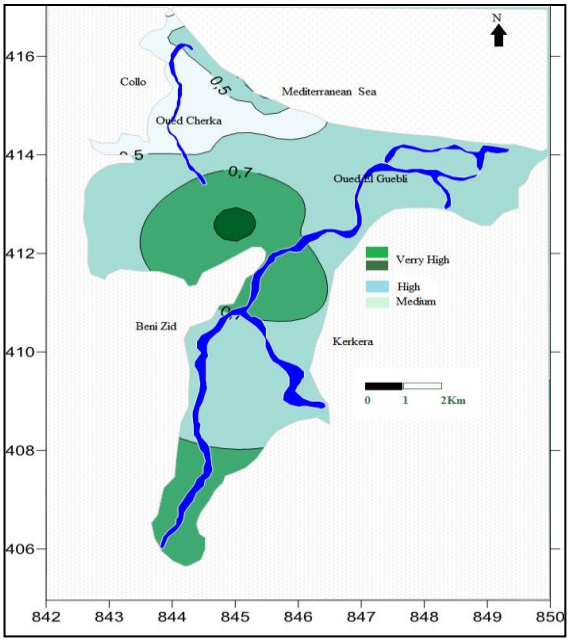

Fig. 6. Groundwater vulnerability maps of the Collo aquifer according to the GOD model.

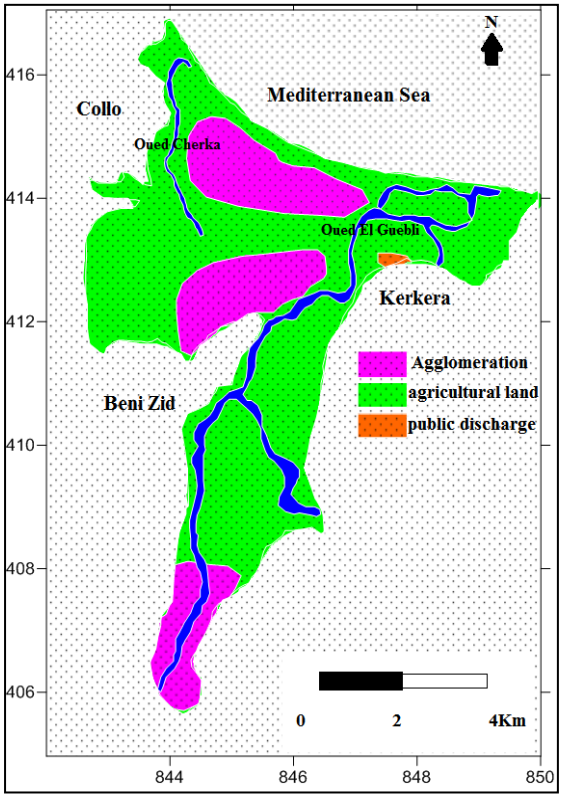

Fig. 7. Land use map of the Collo Plain.

Sustainable development:

The authors argue that sustainable development cannot be achieved without consideration of risk and vulnerability (Juha I *et al.*). of the aquifer, Among the risks Urbanization (increase in the number of inhabitants) (Fig. 8) and intensive use of pesticides and fungicides, the last two factors have a direct effect on the tourism and agricultural development of the region, the problems of urbanization are: disturbance of flow systems by foundations; pollution problems caused by point or non-point sources in urban areas (especially in the absence of a sanitation network).

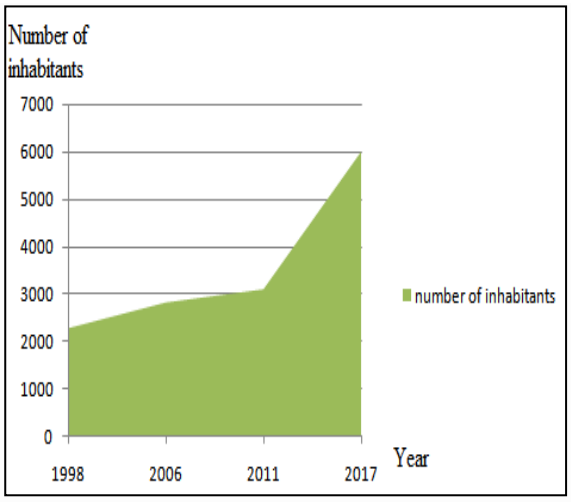

Fig. 8. Estimated population in the Collo Plain.

Discussion:

Fig 6 and 7 shows the vulnerability map of the Collo Plain established by the GOD method, which shows the existence of three areas of vulnerability: medium, high, very high .the most polluted zone is located in the center and south of the plain (GOD index between 0.7 and 1) which represents about 30% of the plain, because of the existence of the inhabitants and also several sources of pollution which caused dangers.

Hazards are potential sources of groundwater contamination, comprising point (e.g. septic tank), linear (roads) and diffuse hazards (spreading of fertilizer and pesticides)(Nico goldscheider *et al.*, 2005). The index of GOD is high between which (0.5 and 0.7) represents 50% of the plain is located to the south and to the north (agricultural terrine, Fig. 7), generally the source of the pollution is the intensive use of pesticides and fungicides; on the other hand the West side the GOD index is average between (0.3 and 0.5) which represents about 20% of the plain, this area protected naturally by its altitude. According to (Fig. 7), urbanization significantly affects the natural cycle of water, both quantitatively and qualitatively.

It usually results in a regression of wetlands, the waterproofing of soils not to allow water to dilute against pollution (decrease in the index of infiltration), disturbance of flow systems by foundations, pollution problems caused by point or diffuse sources in urban areas (especially in the absence of a sanitation network) and a strong increase in salinity, flooding problems. The first building nucleus set up was the agglomeration on the north side of the plain (Fig. 7), (direct effect on tourist life as the reserved area for tourism infrastructure). Subsequently, these two areas (central and southern) were intensively urbanized and in the absence of a sanitation network for a long time, these constructions were prohibited, but the geographical constraints (strong hilly reliefs) and the lack plots of land pushed more and more people into farming land (direct effect on agricultural development)

Conclusion

The assessment of the vulnerability of the Collo aquifer by the method of GOD it allow to conclude that the statistics of the GOD index was evaluated of 30% compared the area of the plain under very high vulnerability, the pollution are mainly in the southern and central parts due to urbanization and the northern part represents about 50% of the plain area under high vulnerability (agricultural land) and about 20% under medium vulnerability this study also allow to put a plan for sustainable development in the plain especially in the agricultural and tourist field and to reduce pollution of groundwater must be organized urbanization in a way consistent with the concept of sustainable development.

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