



CONTRIBUTION TO THE CARTOGRAPHY OF THE GROUNDWATER QUALITY OF THE URBAN GROUP OF TLEMCCEN (ALGERIA)

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ABSTRACT

The existence of any kind of living is related to the presence of water. The qualitative degradation of this resource, and mainly the one underground, was observed in several cases.

The pollution represents a serious problem for the environment and groundwater. This is notably in the most vulnerable zones, which constitutes, in first, a public health problem and in a second degree, an alarming environmental problem. This pollution comes primarily from the rejections of unpurified domestic waters, industrial waste waters and irrational use of manure and pesticides in agriculture.

The north western part of Algeria contains a groundwater resource of a major importance for the social and economical developments of the area. This resource contributes largely to the satisfaction of the needs of drinking water, as well as agricultural and industrial waters. It represents in many districts and cities the only available source of water because of the scarcity or the inexistence of surface water resources.

However, the quality and the quantity of this inheritance are daily threatened. For this reason, this work enlightens a contribution for a better knowledge of the quality of the groundwater in the urban group of Tlemcen, by the application of the geographical information system.

Key words: Geographical Information System -Water quality - groundwater - Pollution - Database - Urban Group of Tlemcen.

RESUME

L'existence de toute sorte de vie est liée à la présence de l'eau. La dégradation qualitative de cette ressource surtout souterraine a été observée dans de nombreux cas. La pollution représente un sérieux problème pour l'environnement et les eaux souterraines, notamment dans les zones les plus vulnérables, qui constitue en premier lieu un problème de santé public et dans un second degré une problématique environnementale préoccupante. Cette pollution provient essentiellement du rejet des eaux domestiques non épurées, des rejets industriels et de l'utilisation irrationnelle d'engrais et de pesticides dans l'agriculture. Le nord ouest algérien renferme une ressource en eau souterraine d'une importance capitale pour le développement socio-économique de la région. Cette ressource contribue largement à la satisfaction des besoins en eau potable et en eau agricole et industrielle. Elle représente dans de nombreuses communes et villes la seule source en eau disponible à cause de la rareté ou de l'inexistence de ressources en eau superficielles. Cependant, ce patrimoine est quotidiennement menacé quant à sa qualité et sa quantité. Dans ce sens, ce travail constitue une contribution pour une meilleure connaissance de la qualité des eaux souterraines dans le Groupement Urbain de Tlemcen par l'application des systèmes d'information géographique.

Mots clés : Système d'information géographique- Qualité des eaux – Eau souterraine - Pollution – Base de données – Groupement urbain de Tlemcen

INTRODUCTION

Groundwater is available in small quantities almost everywhere (Chenini and al., 2010). It is the source of drinking water for many people around the world, especially in rural areas (Bilgehan and al., 2006), (Navin and al., 2006). The quality of groundwater is generally under a considerable potential of contamination especially in karstified areas (Bassam and al., 2010). It can become contaminated naturally or because of several types of human activities. Residential, municipal, commercial, industrial, and agricultural activities can all affect groundwater quality (Bilgehan and al., 2006).

Water quality is influenced by natural and anthropogenic effects including local climate, geology, and irrigation practices. The chemical character of any groundwater determines its quality and use. The quality is a function of the physical, chemical, and biological parameters (Thiyagara and al., 2011).

Groundwater plays a very important part in the water supply of the population of Tlemcen. It is a resource which tends to be increasingly exploited. From a qualitative point of view, the groundwater is deteriorated continuously in connection with the environment. The pollution degree varies from one point to another with amounts exceeding sometimes those recommended by the World Health Organization (WHO).

The Geographical Information System (GIS) is a powerful tool and has a great promise for use in environmental problem solving. Most environmental problems have an obvious spatial dimension and spatially distributed models can interact with GIS ((Goodchild, 1993 in (Bilgehan and al., 2006).

Troge, 1994 in (Bilgehan and al., 2006)) reported that this computer-based tool has allowed successful integration of water quality variables into a comprehensible format.

In this paper, we present the methodology of the groundwater quality mapping through the urban group of Tlemcen. This work is a contribution for a better knowledge of this water quality by using the geographical information system.

STUDY AREA

Tlemcen is located at the extreme North West of Algeria; it is limited geographically from the North by the Mediterranean Sea, by Morocco from the West, in the North-East and the East by the districts (wilayas) of Ain-Temouchent and Sidi Bel-Abbès, and from the South by the wilaya of Naâma (Zaoui and al., 2007). Tlemcen extends on an area of 9,061 km². The territory of the wilaya of Tlemcen is composed of a natural environment set which succeed in a coarsely parallel way. We distinguish from North to South: the mountainous chain of Traras, plains and plateaus limited from the South by the mounts of Tlemcen and finally the steppic zone which extends until the borders with the wilaya of Naâma (Bensaoula and al., 2012).

The urban group of Tlemcen occupy approximately 112.20 km² constituting the inner basin of Tlemcen. This basin is limited from the South by the cliff of Lalla Setti, from the North by the high hill of Ain El Houtz, from the East by Oum El Allou and from the West by the monticules of Beni Mester (Abdelbaki and al., 2012). The mounts of Tlemcen correspond to a vast area of 300 km² where level highly karstified carbonated rocks (80%). They are sprinkled enough (500 to 800 mm/yr) and infiltrating 200 to 400 mm/yr. This groundwater constitutes the principal underground reserve of the Algerian West (Bensaoula and al., 2007).

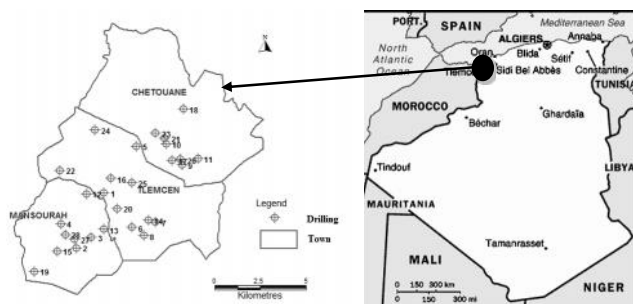


Figure 1 : Presentation of the studied area and situation of drillings through the urban group of Tlemcen

CLIMATOLOGY

The studied area is under complicated rainfalls mode, influenced by a Mediterranean climate with a dry and hot season in summer, also, rainy and cold in winter.

The distribution of the annual averages shows one rainy period spreading from October to April with a peak in January. The calculated rainfall average is 560 mm/year, the average temperatures oscillate between 5 °C in January and 34 °C in August (PDAU, 2009).

GEOLOGY AND HYDROGEOLOGY

The studied territory (Tlemcen-Mansourah-Chetouane Group) is located at the bottom of the Tlemcen mounts. It is characterized by a complex and diversified geology. Thus, we can observe that there is a succession of formations dated from the primary until the quaternary (Azzaz and al., 2012); (Bensaoula and al., 2012). It lies between the horsts of Ghar Rhoubane in the West and the mole of Tiffrit in the East. It consists of supra Jurassic age grounds and Eo-cretaceous. The Lias and the middle Jurassic leveled only in the Western part; whereas, the trias appears only in favor of diapiric structures.

In the North of the Tlemcen mounts, the Jurassic one hides very quickly under great thicknesses of primarily clayey Miocene. This was highlighted by various geophysical studies through electrical surveys carried out in the area (Algeo, 1979 in (Bensaoula and al., 2005)). In the South, the Jurassic one also disappears under the primarily conglomeratic Neocene deposits called conglomerates from high plateaus (Collignon, 1986 in (Bensaoula and al., 2005)). In the mounts of Tlemcen, deposits of Plio - Quaternary are present only in the collapsing fosses and depressions, such as the one of Sebdou and the plateau of Terni (Benest et al., 1999 in (Bensaoula and al., 2005)). In the

miocene basin, only the tortonian sandstones and plio-quaternary conglomerates are aquiferous and feed some sources with low flow (Bensaoula, 1992). The only interesting levels are the lime dolomite formations of Tlemcen and Terni (Benest et al., 1999 in (Bensaoula and al., 2007))

The Mounts of Tlemcen are often called the natural water tower of the Algerian West. They occupy the central part of the town with 28% from the total surface area.

These formations are largely karstified and constitute the most important aquifers of Tlemcen. The karstic water resources of Tlemcen Mounts are the most mobilized water resource and feeds for a great part the population of Tlemcen. Indeed, the best equipped communes in drinking water supply are those fed by the karstic resources in question. The communes of the central part of the town for example, the urban group of Tlemcen which includes more than 230.000 inhabitants of population, is fed by water resources which are nearly 65% of karstic origin (Bensaoula and al., 2012).

MATERIALS AND METHODS

Data collection and analysis

Analysis is divided into two steps: At first, data collection for database construction using a Geographic Information System for a graphical presentation, dated storage and retrieves (Al-Mahallawi and al., 2011).

Then, the collected data are used to build the database for groundwater drills in the urban Group of Tlemcen. The majority of the collected data for the study have physicochemical and bacteriological water quality. These data are taken from the drillings files available in various organizations of information namely: The Algerian for water and the national agency of water resources.

The follow-up of groundwater quality was done on the double shutter: physicochemical and bacteriological, the elements considered for the follow-up of groundwater quality for the urban group of Tlemcen are: PH, total Hardness and conductivity, Chlorides, Calcium, Magnesium, Sulfurs, Iron, Manganese, Nitrites, Nitrates, Ammonium and Phosphorus.

The follow-up of the quality is for the corresponding chronicle of the period 2000-2010. The maps are established basically on the drillings quality data feeding the urban group of Tlemcen. Table 1 shows the main features of these drillings.

Table 1 : Characteristics of the Tlemcen urban group principal drillings.

N°	Drilling	X (m)	Y (m)	Altitude (m)
1	Ksaar Chaara	652628.62	3861981.83	739.65
2	Blessed Boublène	651116.76	3858956.52	839.21
3	Minaret	651933.68	3859564.66	844.82
4	Imama	650269.74	3860281.44	767.28
5	Ain El Houtz	654386.02	3864531.40	580.00
6	Benzerdjeb	654144.88	3860099.59	844.68
7	Birouana	655428.90	3860379.31	824.62
8	Higher Kalaa (Djelissa)	654793.82	3859641.93	910.78
9	Saf Saf 3	656882.12	3863515.29	597.36
10	Chetouane	656017.59	3864676.78	593.44
11	Saf Saf 2	657750.93	3863861.42	590.65
12	GUT - Kiffane 2	651660.72	3861923.88	737.00
13	Hospital	652610.70	3859990.93	832.22
14	Seedbed	655054.75	3860476.56	825.00
15	Mansourah 1	650063.63	3858783.38	823.58
16	Olive-trees	652987.09	3862773.49	705.25
17	Ain Defla	656346.53	3863748.94	615.00
18	Ouzidane	656968.14	3866584.09	562.05
19	Mansourah 2	648812.67	3857682.85	820.00
20	Drilling APC	653355.85	3861121.07	747.00
21	Chetoune 1	655937.00	3864969.99	601.00
22	Koudia	650216.99	3863213.00	669.00
23	Chetouane 2	655432.00	3865248.99	600.00
24	Oudjlida	652123.99	3865432.99	584.00
25	Fedeen sbaa	654137.00	3862530.99	702.00
26	Saf-Saf 3	656802.99	3863812.00	589.00
27	BLESSED boublen 2	651005.00	3859455.00	837.00
28	SP3	650530.99	3859703.00	812.00

Installation of a GIS for groundwater quality

The Geographic Information Systems (GIS) has been developed for decades and commercial software packages have been successfully developed such as, for instance, ArcView and MapInfo. GIS has been widely used in developing countries to manage water resources (Luijten and al., 2003; Andreas, 2007; Yagoub and Engel, 2009) in (Daoyi and al., 2010))

The various functionalities available with GIS enable them to acquire the groundwater quality maps and their associated characteristics.

The question about the quality of this groundwater and their conformity to the drinking standards pushed us to establish a database. The constitution of the latter allowed to formulate several queries answering various interrogations. The constitution of the GIS for the groundwater quality of the urban group of Tlemcen depends on the facility of :

- Setting up a detailed digital mapping easier to update (Tena-Chollet and al., 2010).
- Possibility of spatial analyzes by interacting the information layers stored in database (Mario, 2010); (Sauvagnargues-Lesage S. and al., 2009).
- Elaboration of various maps by crossing the different information layers constituting the map of groundwater quality for the Tlemcen urban Group.

RESULTS AND DISCUSSIONS

Physicochemical analyzes

pH

The pH value of groundwater ranges from 7.0 to 8.2 with an average value of 7,5 , the tolerance interval for this parameter recommended by the World Health Organization is (6.5-9.5). The majority of water present bicarbonate character owing to the fact that the pH is often lower than 8.0, these waters are close to neutrality.

Conductivity

Electric conductivity varies between 569 μ s/cm and 1310 μ s/cm; all drillings have conductivity lower than the recommended value for the drinking standards which is 2800 μ s/cm.

Hardness

The complete title alcalimetric of Tlemcen urban group groundwater (TCA) varies between 24 mg/l and 52.5 mg/l.

The total hardness is attached mainly to the quantity of Calcium and Magnesium in water. The Hydrotimetric title of Groundwater of the considered zone (HT) varies between 23 mg/l and 49.5 mg/l.

For the majority of the wells presenting the subject of this study, HT is lower than the value of the drinking standard (50mg/l), except for Ain Defla in 2005 and 2006, currently this point is stopped, the Koudia in 2008 and Chetouane1 in 2005.

The water hardness results from its contact with the rocky formations during their passage in the underground. Thus, it varies according to the nature of this latter and the area from where water comes.

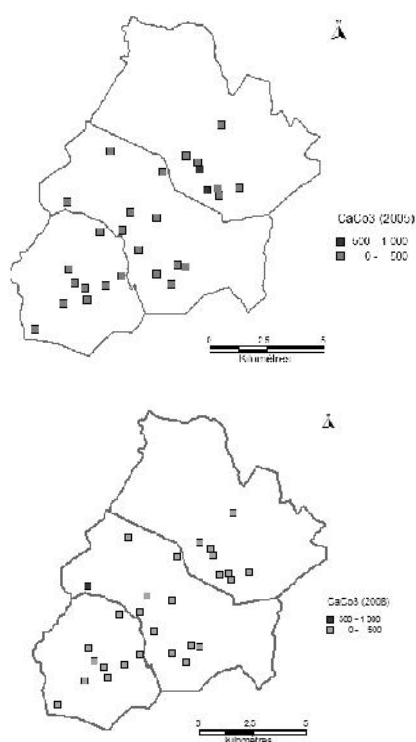


Figure 2: Repartition of water points according to calcium carbonates (2005 and 2008)

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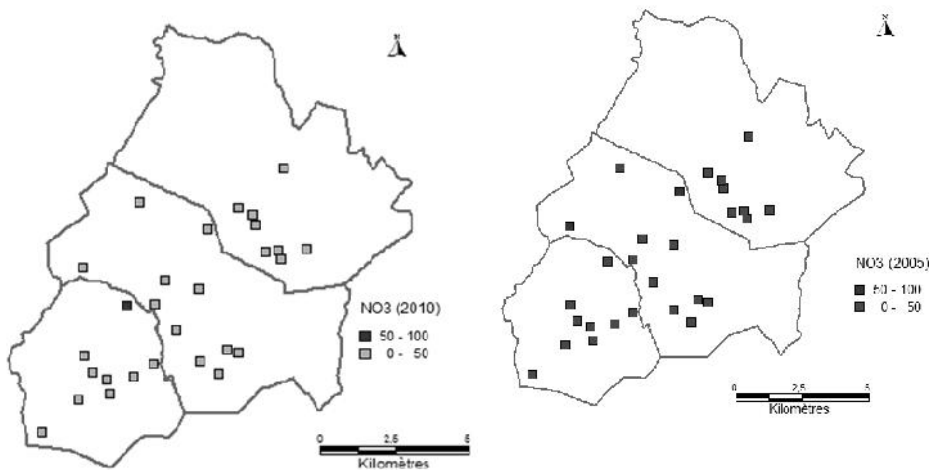
The concentrations of Ca and Mg on the level of these drillings vary respectively between (28 mg/l with 94 mg/l), and (32 mg/l with 86.6 mg/l). They are in conformity with the recommended standards of the World Health Organization.

Iron and Manganese

The results of the analyzes of Iron and Manganese in the drillings water show that the average concentration of Iron and Manganese in water of Tlemcen urban Group is 0,02 (mg/l), this water is in conformity with the drinking standards.

Nitrates and Nitrites

In the underground water of the Tlemcen urban Grouping, the Nitrates amounts exceed the standards per area. For example, the drilling of Djliissa in 2009 has an amount of 65 mg/l. For 2005, the nitrates amounts are respectively: well of Ain El Houtz 88 mg/l and the one of Koudia 70 mg/l. On the level of El Kiffane well for 2010, the NO₃ concentration reached 100 mg/l, twice higher level than the World Health Organization (WHO) drinking standard (50mg/l).



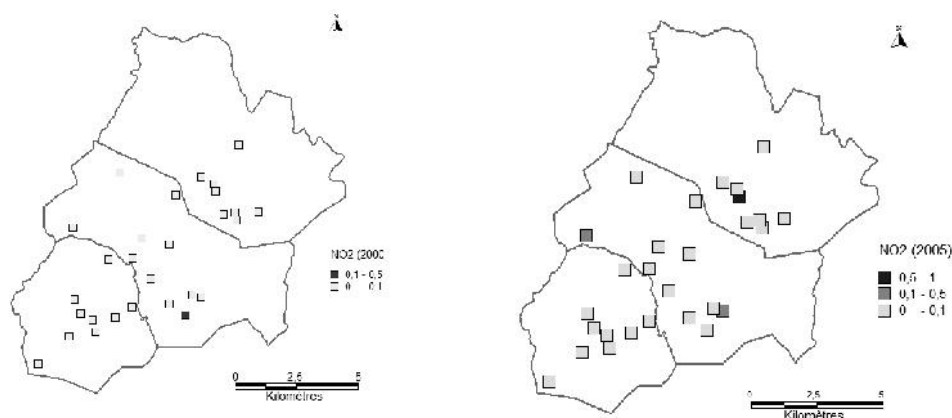


Figure 3 : Repartition of water points according to the nitrates (2005, 2010) and the nitrites (2000, 2005)

This strong concentration is due mainly to the excessive use of manures, and organic matter hidden in the ground (residues of preceding harvests, humus...), which provides nitrates after a bacterial transformation called “mineralization”. In addition to the artificial fertilizers and manures used for the development of the breeding and the fertilization of the agricultural zones, the domestic and industrial wastes take part in the significant enrichment by nitrates in the underground layers of the study area.

The results of the physicochemical analyzes of wells water in the Tlemcen urban grouping showed that the Chlorides, Calcium, Potassium, Magnesium Sulfurs, Ammonium and Phosphorus amounts, are in conformity with the allowed standards by the WHO in all the sampling points during the considered period.

Microbiological analyzes

The microbiological quality of water is evaluated by the search for indicating bacteria of fecal contamination (Maton and al., 2007).

With regard to the total coliforms, the average concentration is about (3 N/100 ml). The maximum average concentration is recorded on the level of Feddan Sbaa wells (2006 and 2009), Minaret 2010, Ouzidane 2010, El Koudia 2006 (4N/100 ml). While the minimal average concentration is recorded, in the Mansourah well 2005, Oudjlida 2009, Birouana 2005 and Ain Defla 2005 (2N/100 ml).

The numeration of the fecal coli forms shows that water of the Tlemcen Urban Grouping is good (0N /100 ml).

As for fecal streptococcus, the average concentration of the Tlemcen Urban Grouping wells water is 2N/100 ml for the Saf Saf 2 site.

As for the total germs, the maximum average concentration is recorded in Benzerdjeb drilling (23N/100 ml)... In this contrast, it appears that the water retained by Tlemcen Urban Grouping wells is bicarbonates water with good physicochemical quality also, in conformity with the drinking standards suitable for human consumption, except for drillings of Kiffane, Koudia and Ain El Houtz which exceed the WHO standards. This water is rather mineralized but in good according with the drinking limits for other wells.

CONCLUSION

The mounts of Tlemcen constitute one of the most important karstic carbonated basins in the north of Algeria. They have important aquifers contained in the limestone-dolomite formations of the upper Jurassic. These are largely karstified (Bensaoula and al., 2007). The ground waters are primarily mobilized by wells of average depth between 130 and 400 m. The physicochemical quality in this case is good.

After the mobilization of these waters and before their arrival to the consumers, they must be purified in order to have a good quality according the WHO standards.

The obtained maps within the framework of this study can be used for the determination of:

- the better wells intended for the human drinking water supply,
- further uses for territorial planning,
- suitable areas for wastes burying,
- Implantation of potentially polluting, industrial plant.

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