

## **Groundwater physico-chemical characteristics of Bredeah area Plain (Oran area – Northwest Algeria)**

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### **Abstract**

A varied methodology on the field and laboratory was used for determining the physical and chemical characteristics of groundwater in Bredeah plain. The salinity values are high in the Quaternary aquifer, more than 7g/l whereas conductivity's reach 14440  $\mu\text{S}/\text{cm}$ . Chloride ions contribute significantly to anionic composition and increase up to 2392 mg/l. Conductivity and hardness values and some ions concentrations including chlorides, sulfates and nitrates exceed the WHO standards of drinking water. In Bredeah area, water is generally is of poor quality. For drinking water supply of Oran city, this water is demineralized by the reverse osmosis (RO) process.

**Keywords:** Miocene limestone, Quaternary alluvia, salinity, demineralization.

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### **Introduction**

Oran city (Algeria) has always known problems of drinking water. To satisfy its water needs, several searches were carried out in a perimeter of several radius km. They have been finally oriented to Bredeah area located about 26 km from Oran.

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The water pumped from Bredeah station were led to Aïn El Beïda basins (located to the East of the station), before being routed via the distribution networks of drinking water to Oran city.

However, these brackish waters with their salty taste (high salinity) do not appealed to users.

This problem of salinity of water sources Bredeah had attracted the attention of the departments responsible of water management, which have opted for a demineralization plant for these waters by the reverse osmosis. Water demineralized constitutes the 2/5 of the human consumption of Oran town. The neighbouring inhabitants continue to use this groundwater without prior treatment.

This work focuses on physical and chemical characteristics of groundwater of Bredeah aquifers and their quality.

## **Material and Method**

The study area is located southwest of Oran city. It is limited to North by the Murdjadjo Mount, to East by Es-Senia, to West by Bou-Tlelis and to South by the Mleta plain bordering the great Sebkhha (Fig. 1). This region comprises two distinct areas:

A Northern zone, characterized by whitish carbonate formations, with a surface flow is being done only during heavy rains (Benlekhail 1985); and a Southern zone, which corresponds to the plain of Bou-Yakor, is extended to Misserghin in East, and to Bou-Tlelis, in West. South of this plain lies the Great Sebkhha of Oran (Benziane 1984), in which accumulate rainwater and runoff during wet periods and evaporate in summer.

The aquifers of the Bredeah are mainly constituted by two formations:

\* Miocene Carbonate grounds resting on the Mesozoic substratum in North and dipping, downstream (in South) under the quaternary formation.



\* Quaternary formation represented by gray silt often salted and gypsum (plain of the M'leta and along the Sebkhia) (Benziane 1984, Dahmani and Bithorel 2001).

A system of faults presenting an identical orientation to that of the Sebkhia basin would be located under the uncemented formations edging this latter (Strojexport 1983 in Djebbari and Madani 1994).

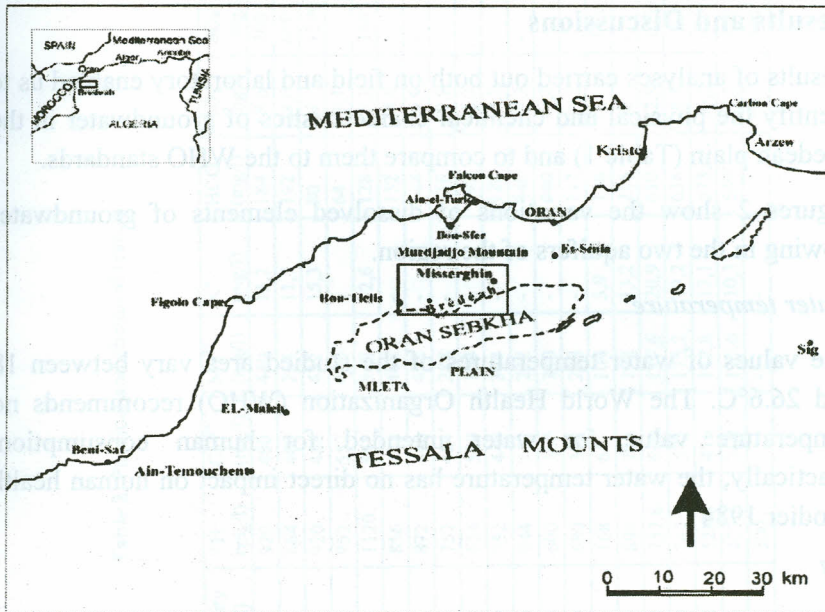


Figure 1. Situation of study area

19 water samples were taken: they relate to the 4 wells operated by the demineralization plant, 15 wells and boreholes across the plain (Figure 2a and 2b). The analyses in situ focused on temperature, pH, conductivity and salinity measures.

The measurements of these two last were made using a conductivity meter (Type Hanna HI 8033) and the pH with a pH meter type Sension 7 (HACH).

Other analyses were conducted in the demineralization plant laboratory of Bredeah. They concerned:

\* The total hardness (TH), Bicarbonates and chlorides. These parameters have been analyzed by volumetric methods.

\* Potassium, sodium, iron, nitrate, sulphate, fluoride and silica which have been analyzed by spectrometry.

The analysis of some elements (sulfate, potassium fluoride and silica) has concerned only wells P1, F1, P3, P5 and P14.

## **Results and Discussions**

Results of analyses carried out both on field and laboratory enabled us to identify the physical and chemical characteristics of groundwater in the Bredeah plain (Table 1) and to compare them to the WHO standards.

Figures 2 show the variations of dissolved elements of groundwater flowing in the two aquifers of the region.

### *Water temperature*

The values of water temperatures of the studied area vary between 18 and 26.6°C. The World Health Organization (WHO) recommends no temperature value for water intended for human consumption. Practically, the water temperature has no direct impact on human health (Rodier 1984).

### *pH*

Groundwater of plain Bredeah is prone acid: the values of their pH range between 5.5 and 7. They are not conform to the standards advocated by the WHO standard for water intended for human consumption and which pH values should be between 6.5 and 8.5.

### *Conductivity and salinity*

Values of water conductivity are very high in Quaternary formation: they vary between 3730 and 14400  $\mu\text{S}/\text{cm}$  (Maximum value recorded in wells P5) and salinity values are between 2820 and 7370 mg/l. In wells tapping the limestone formation, these salinity values are much lower and are respectively of 1910 and 730 mg/l in P14 and P12.



Table 2. Physical and chemical results

| Samples         | T (°C) | pH        | Conductivity (µS/cm) | Salinity (mg/l) | TH (mg/l) | Ca <sup>2+</sup> (mg/l) | Mg <sup>2+</sup> (mg/l) | K <sup>+</sup> (mg/l) | HCO <sub>3</sub> <sup>-</sup> (mg/l) | NO <sub>3</sub> <sup>-</sup> (mg/l) | SO <sub>4</sub> <sup>2-</sup> (mg/l) | Cl <sup>-</sup> (mg/l) | Fluorine (mg/l) | SiO <sub>2</sub> (mg/l) |
|-----------------|--------|-----------|----------------------|-----------------|-----------|-------------------------|-------------------------|-----------------------|--------------------------------------|-------------------------------------|--------------------------------------|------------------------|-----------------|-------------------------|
| P1              | 21     | 5,8       | 9550                 | 5720            | 920       | 480                     | 440                     | 13,2                  | 184                                  | 68,6                                | 760                                  | 1496                   | 0,3             | 25,4                    |
| F1              | 20     | 5,7       | 7770                 | 3900            | 664       | 400                     | 264                     | 11,7                  | 192                                  | 28,6                                | 650                                  | 1200                   | 0,05            | 24,3                    |
| P3              | 20     | 6,9       | 12650                | 6520            | 920       | 488                     | 432                     | 15,3                  | 80                                   | 14                                  | 1390                                 | 1920                   | 0,97            | 18,9                    |
| P4              | 18     | 7         | 13400                | 6760            | 952       | 552                     | 400                     | -                     | 64                                   | 18,1                                | -                                    | 2208                   | -               | -                       |
| P5              | 20     | 6,9       | 14440                | 7370            | 1120      | 552                     | 568                     | 12,6                  | 128                                  | 15,3                                | 1695                                 | 2392                   | 0,05            | 14,8                    |
| P6              | 22     | 5,8       | 7350                 | 3950            | 856       | 448                     | 408                     | -                     | 152                                  | 29,4                                | -                                    | 1144                   | -               | -                       |
| P7              | 26     | 6,1       | 9400                 | 5250            | 872       | 440                     | 432                     | -                     | 144                                  | 19,9                                | -                                    | 1264                   | -               | -                       |
| P8              | 18     | 5,6       | 8500                 | 4570            | 752       | 464                     | 288                     | -                     | 216                                  | 39,9                                | -                                    | 1192                   | -               | -                       |
| P9              | 20     | 5,5       | 8580                 | 5440            | 624       | 520                     | 104                     | -                     | 192                                  | 42,3                                | -                                    | 1216                   | -               | -                       |
| P10             | 21,6   | 5,9       | 6400                 | 3400            | 752       | 448                     | 304                     | -                     | 128                                  | 62,5                                | -                                    | 968                    | -               | -                       |
| P11             | 22     | 5,7       | 9300                 | 4800            | 944       | 712                     | 232                     | -                     | 440                                  | 79,2                                | -                                    | 1456                   | -               | -                       |
| P12             | 24     | 6,3       | 3730                 | 1910            | 600       | 360                     | 240                     | -                     | 440                                  | 19,2                                | -                                    | 504                    | -               | -                       |
| P13             | 24     | 6,2       | 5600                 | 2820            | 680       | 392                     | 288                     | -                     | 112                                  | 25,2                                | -                                    | 760                    | -               | -                       |
| P14             | 26     | 7         | 987                  | 530             | 168       | 64                      | 104                     | 3,9                   | 136                                  | 13                                  | 140                                  | 120                    | 0,32            | 11,6                    |
| P15             | 24     | 5,16      | 11390                | 6530            | 896       | 704                     | 192                     | 13,2                  | 216                                  | 32                                  | -                                    | 1464                   | -               | -                       |
| Pw <sub>1</sub> | 25,5   | 6,7       | 9460                 | 6673            | 757,6     | 640                     | 117,6                   | 20,9                  | 610                                  | 32,9                                | 1055                                 | 2662,5                 | 0,67            | 33,6                    |
| Pw <sub>2</sub> | 25,5   | 6,68      | 9600                 | 6788            | 747,2     | 572                     | 175,2                   | 19,2                  | 634                                  | 28,8                                | 1025                                 | 2769                   | 0,72            | 32,7                    |
| Pw <sub>3</sub> | 25,5   | 6,84      | 6060                 | 4348            | 528,8     | 416                     | 112,8                   | 13,1                  | 573,4                                | 20,2                                | 620                                  | 1668,5                 | 0,47            | 23,4                    |
| Pw <sub>4</sub> | 25     | 7,01      | 4950                 | 3195            | 477,6     | 360                     | 117,6                   | 10,3                  | 549                                  | 19,1                                | 420                                  | 1117,5                 | 0,36            | 17,8                    |
| WHO             | -      | 6,5 - 8,5 | 333 - 833            | -               | 500       | -                       | -                       | -                     | -                                    | 50                                  | 400                                  | 250                    | 1,5             | 20                      |

**Table 3.** Mn and Fe Concentrations in the wells feeding the Bredeah plain

| Sampling points | Iron (mg/l) | Mn (mg/l) |
|-----------------|-------------|-----------|
| Pw <sub>1</sub> | 0,09        | 0,14      |
| Pw <sub>2</sub> | 0,02        | 0,35      |
| Pw <sub>3</sub> | 0,18        | 0,03      |
| Pw <sub>3</sub> | 0,04        | 0,16      |
| WHO             | 0,3         | 0,1       |

### *Hardness*

All groundwater of the region are hard water: their total hardness exceeds 75 mg/l CaCO<sub>3</sub>. Furthermore, those taken from the Miocene limestone exceed, in general, the limit recommended by the W.H.O. standard (500mg/l expressed in CaCO<sub>3</sub>) for human consumption. Calcium content varies between 360 mg/l and 64 mg/l in water of Miocene formation and between 392 and 712 mg/l in water of the quaternary aquifer.

Regarding magnesium, ion concentrations vary between 240 and 104 mg/l in water of Miocene limestone and 104 to 568 mg/l in samples taken from the Quaternary aquifer. These concentrations are between 112.8 and 175.2 mg/l in water tapping the wells feeding the demineralization plant.

### *Potassium*

The potassium rate varies between 11.7 and 15.3 mg/l in groundwater of Quaternary aquifer and reach 20,9 mg/l in the well Pw1 feeding the plant. This concentration is much lower in the water collected from the wells P14 capturing the formation of Miocene limestone where a record value of 3.9 mg/l.

### *Bicarbonates*

Bicarbonate content in groundwater vary between 64 and 440 mg/l. They are more important in the waters of the wells supplying the Bredeah plant.



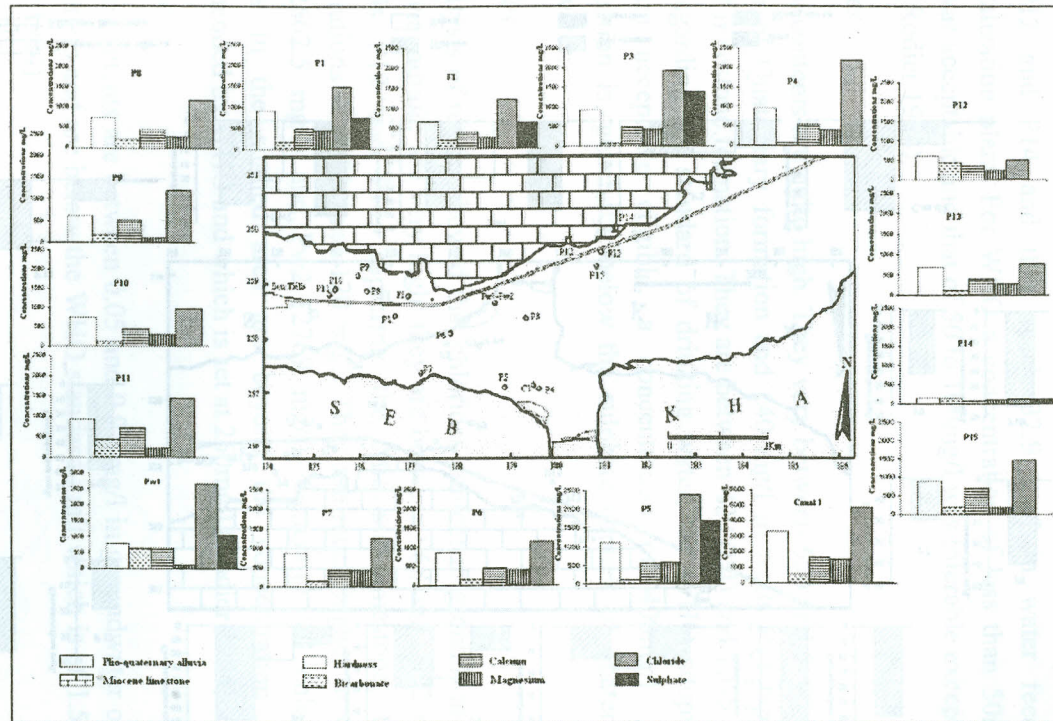


Figure 2a. Spatial evolution of chemical contents

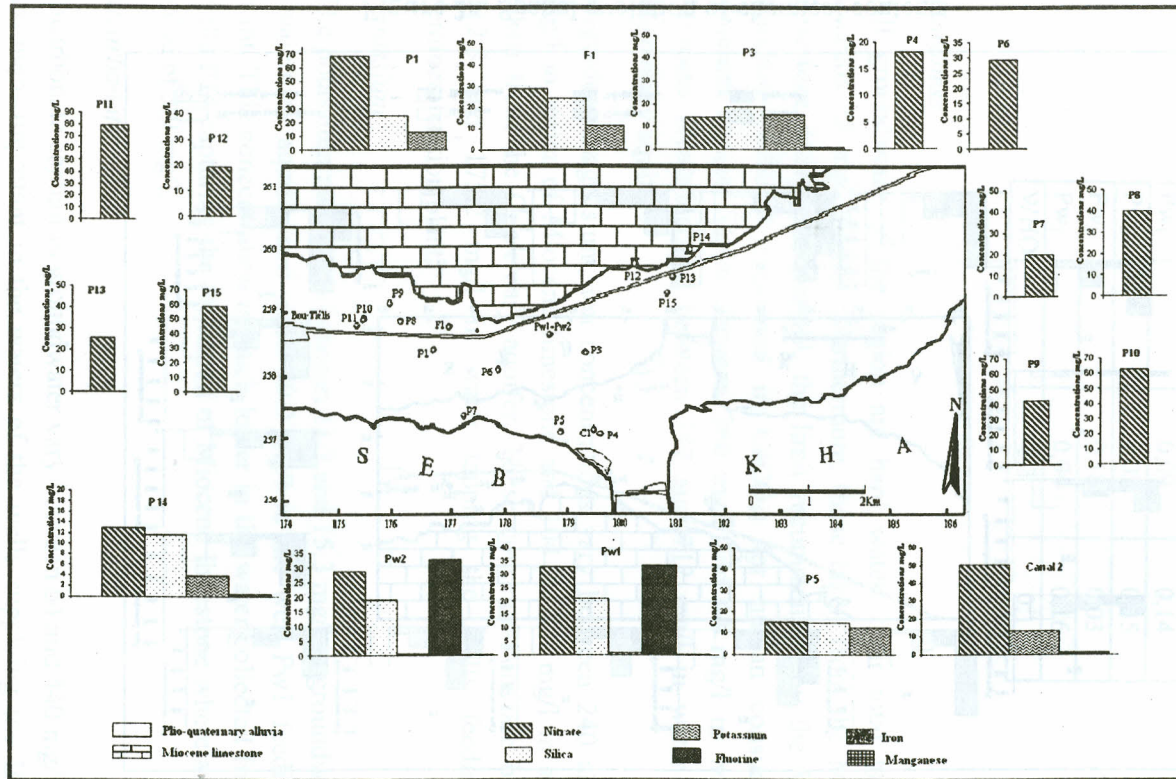


Figure 2b. Spatial evolution of chemical contents



### *Nitrates*

Nitrate contents are high in water samples: they are between 14 and 79.2 mg/l (content of well P11) and are respectively of 19.2 and 13mg/l in wells P12 and P14 and they reach 32.9 mg/l in water feeding demineralization plant. For WHO a concentration of less than 50mg/l nitrate was acceptable and that of 50 to 100mg/l was tolerable except for infants (Rodier 1984).

### *Sulphates*

Sulphate contents are quite high. They vary between 650 and 1695 mg/l in water of Quaternary formation and 140 mg/l in wells P14 tapping water of limestone formation. They are between 420 (P4) and 1055 mg/l (P1). Regarding the standard of drinking water, the WHO adopts as maximum acceptable eligible, a concentration of 400mg/l. This concentration is, generally, below the sulphate content of quaternary groundwater.

### *Chlorides*

The analysis of results showed that chlorides content in groundwater of the alluvial aquifer are very high: they are between 968 and 2392 mg/l. In wells P12 and P14, capturing the Miocene limestone, these concentrations vary 504 and 120 mg/l. They are much higher in wells Pw1 (2662.5 mg/l) and Pw2 (2769 mg/l). Generally, all chlorides contents in the studied area are beyond the concentration limit recommended by WHO and which is set at 250mg/l (Rodier 1984).

### *Fluorine*

Fluoride contents are between 0.05 and 0.97 mg/l in groundwater of the two aquifers and are below the WHO standard limit which is of 1.5mg/l (Rodier 1984).

### *Silica*

Silica content is of 11.6 mg/l (Minimum) at well P14 and reached the maximum value of 25.4 mg/l at well P1. In wells supplying the demineralization plant, silica concentrations are more important: they are between 17.8 and 33.6 mg/l (maximum value recorded at P1).

## *Iron and Manganese*

The both cations have been measured only for waters feeding the demineralization Plant. In these wells, iron contents are between 0.02 and 0.18 mg/l and are less than the standard adopted by the World Health Organization (0.3 mg/l). Those of manganese are between 0.03 and 0.35 mg/l and do not meet the standard limit required by WHO (0.1 mg/l).

## **Conclusion**

Following the results given above, we can conclude that groundwater salinity (which reaches 7370 mg/l) and conductivity of the Quaternary aquifer are very high unlike to those of waters flowing through the Miocene limestone. Groundwater is harsh, of poor quality and unacceptable taste. Contents of some ions, including chlorides, sulphates and nitrates and those of silica are generally higher and exceed the standards prescribed by the World Health for human consumption.

The existence of manganese in waters of wells feeding the demineralisation plant, where these rates are between 0.03 and 0.35 mg/l, suggests that his presence is probably due to the infiltration of water discharges dumped into the canal which evacuated rejection to the Sebkha.

## **References**

- Benlekhal, A. (1985). Contribution à l'étude hydrogéologique du bassin d'alimentation des captages de Bredeah (Oran), Thèse Ing., I.S.T., Univ. Oran.
- Benziane, A. (1984). Hydrogéologie du versant sud du Djebel Murdjadja (Problème d'exploitation et de gestion des eaux), Rapport Inédit, I. N. R.H.
- Dahmani, B., Bithorel, C. (2001). Déminéralisation des eaux saumâtres de Bredeah dans la région du bassin hydrographique Oranie-Chott-Chergui - Partie 1 : Hydrogéologie de la nappe de Bredeah, Desalination 137, Elsevier.
- Djebbari, F., Madani, H. (1994). Valorisation des ressources en eau de la région de Bredeah (Boutlelis- Misserghin)- Mem. Ing., I.S.T, Univ., Oran, 63 fig, 122 p.
- Rodier, J. (1984). L'analyse de l'eau (eaux naturelles, eaux résiduaires, eau de mer), Ed. Dunod, Paris.

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