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Hydrogeological and hydro-geochemical study of the water wellfields of Loubet, Nice Region – France

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Abstract

Growing population in the krast area of the Alpes Maritimes (Loubet and Breil sur Roya) associated with urban sprawl and development of recreational activities in the adjacent mountain areas has led to increased use of the krast ground water and surface water. In this study, we use a set of hydrological, statistical and hydro-geochemical analyses to characterize the water capturing of Loubet, Nice area – France. The results from the geochemical analysis show that freshwater drawn from the wellfield of Loubet is characterized by a dominant mixed bicarbonate facies (other ions are minor) and a higher amount of sodium chloride. Therefore, the concentration and conductivity of these waters represent a significant evolution in recent years. This demonstrates that the change of minerals is not associated to the increase of residence time or to the spin mixing with salted water. However, it is related to the lithology and crossed rock dissolution in contact with these waters.

1. Introduction

The Maritime Alps take their name from the existence of a strong relief, with mountains exceeding 3000 meters in the Massif du Mercantour and plunging to the south directly into the sea offering only a small coastal strip where the cities of Nice and Monaco are located .

Nice area experience increasing demographic pressure, particularly along the coastal zone, which lead to widespread coastal urbanization and increasing recreational activities in coastal areas and in the surrounding mountains. In this chapter, it attaches to Loubet wellfield that undergoes the same pressure. This has consistence to stem the demand in water and his accessibility.

Water is much more than just a human need; it is the most vital element for life [1]. It has become a strategic global issue, the management of which must imperatively integrate itself into a political perspective of sustainable development. Some say it will be, in the third millennium, an issue of wars as oil has been and still is today [2-3-4].

The aquifer Jurassic of Before-Country Provençal by intermediary of deep boreholes on site of the Loubet is exploit by the SILRDV and other collectivity [5-6].

Following the mineralogical and chemical composition of those waters for the year 2000 until now, runs databases permits to study and interpret variations of their mineralogical compositions.

2. Geographic location and geological characteristics of the aquifer

The wellfield of Loubet is located in Nice, France in the Alpes Maritimes department, between Cagnes and Antibes at the mouth of the Loup. It is delimited by the commune of Saint Laurent of Var at the West, and by villefranche at the East.

The wellfield of Loubet, placed on commune Villeneuve Loubet currently used by Syndicate Intercommunal Coastal the right bank of the Var, for alimentation waters for human consumptive townships of Antibe, Biot, and Villeneuve de Loubet. According to the public inquiry carried out by the Alpes maritime department, the

Loubet wellfield include four working boreholes and a piezometer deep, realized between 1989 and 1992. Stopped of declaration the public utility in 22 march 1994 there authorizes the deduction in advance of 10 000 ms3/years.

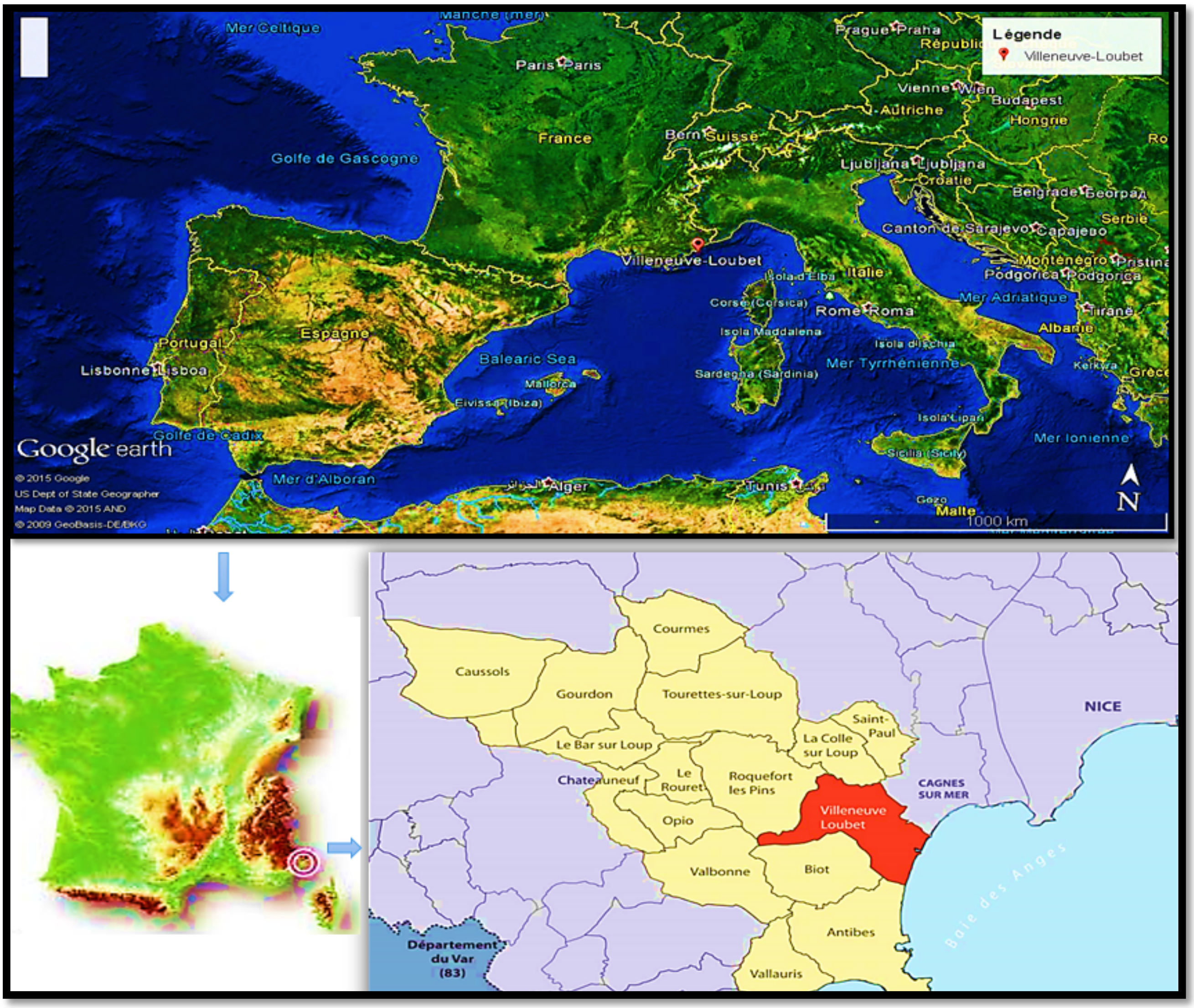

Figure 1 : Geographical locality of the study area.

The alimentation of human consumption of water from the town of Villeneuve-Loubet (about 14,500 permanent inhabitants and 42,000 in summer is provided by sampling in the surface alluvial aquifer of Loup through four drilling (P1, P2, P3, P4) forming the field captivating Farrayones (Figure 1).
The aquifers of Jurassic of before Provençal country have been used for drinking water supply by drilling in the following sites: the Lauron (Véolia) in the valley average of the Loup, Louve and Sambuque (Antibe) in the valley bass of the span, Ferrayones (Villeneuve Loubet) and the Loubet (SILRDV) in the valley bass of the Loup [6].

3. Hydrogeological characterization:

The wellfield of Loubet is located along the coast; indeed and coastal aquifers are often vulnerable to seawater intrusion because of the increased use of boreholes for water supply. The water level of the layer decrease, so the balance between freshwater and brackish water (saltwater wedge) is made to be changed.
Figure 2 shows that the lithology of the study area composed essentially of limestone and Jurassic dolomite, which characterized by a carbonate group of about 500 m thick, consisting generally tint shade of limestone and dolomite [6-7].
The training has been divided into two units, separated into southern part of the outcrop by a continuous clay horizon and a limestone-marl cap: the Lower Jurassic (Hettangian and Bajocian) and the Upper Jurassic (Bathonian to Portlandian).

The Jurassic limestone was found at a depth of 320m to 360m, where drilling was stopped in a karst cavity filling unstable blocks. The water inflows came forward with limited productivity in the Eocene and upper Jurassic (50 m3/h) and significantly to the right of the terminal karst cavity (500 m3/h).

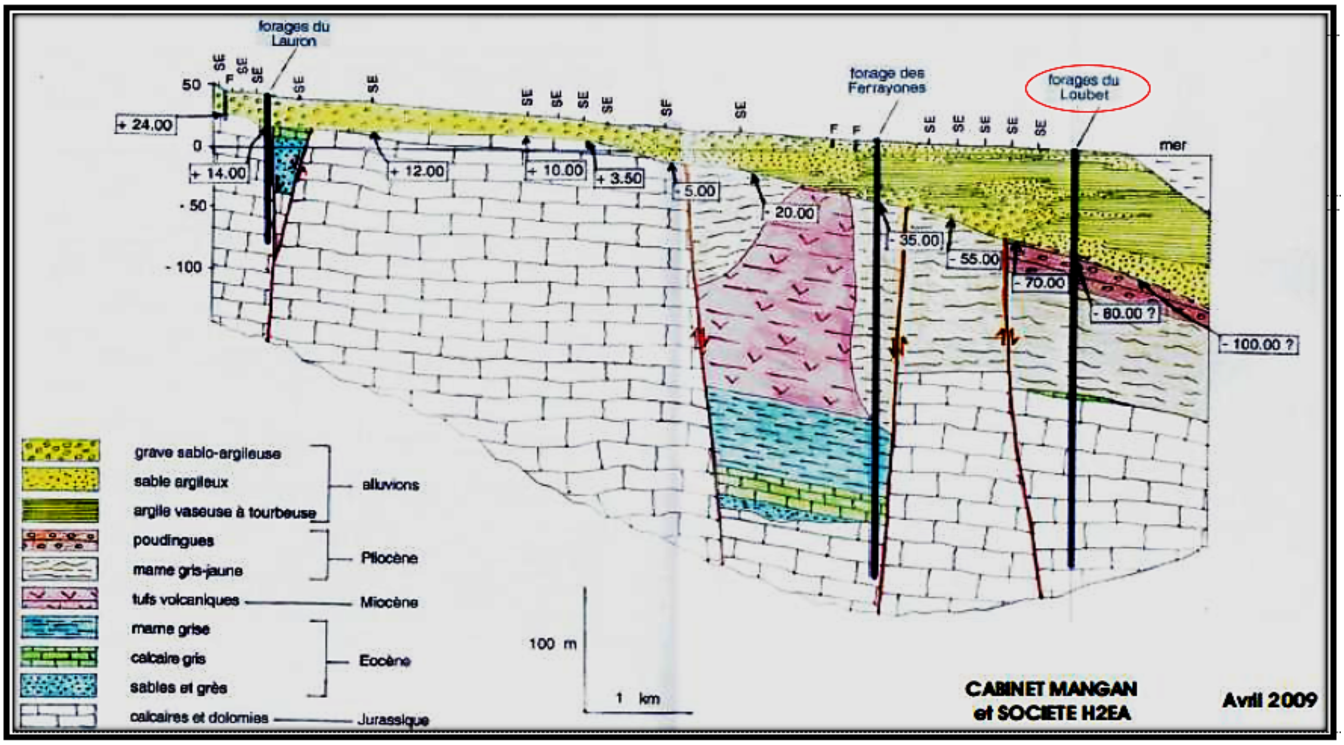

Figure 2: Wellfield Lithology of Loubet [6].

The karst layer of Jurassic power is ensuring by infiltration across its catchment area, with an area of 100 km2 [7]. The specific module infiltration holding of 10 l/s/ km2 (30% of infiltration pluviometry, an annual water blade 300mm), the average flow of the nappe is measured at 1000 l/s, but it is possible that the feed rate is undervalued [8-9-10].

4. Geomorphology :

Drainage basin of Loup is a mountainous area made up mostly of limestone, dolomite Jurassic. These limestones are certified and form an aquifer system completely drain by Loup. It is part of the territory of the Agglomeration Community of Sophia Antipolis (CASA), which consists of three principal geographic areas:

The plateau corresponded to a mountainous area, especially characterized by large karst plateaus that extend south through several rock bars "Baous". The set has several peaks where the altitude exceeds 1200 meters. To the north, slopes reduced behind the Baous. The trays locally incised by rivers.

The littoral consists of a narrow strip of land and relatively plane, is nestled between hilly areas and sea.

Generally, the report of the urban community Sophia Antipolis is morphologically interdependent units well superseded its perimeter, with several watersheds constituting its territory, among them, drainage basin of Loup where operates wellfield studied.

The Principal physic-chemical parameters and the composition of major elements show no obvious similarity between each sample point. Those underground waters of Loubet have generally a pH almost neuter (varying between 7.0 and 7.6), [11-12-13-14].

5. Materials and Methods

The main objective of this section is to study the evolution of the chemical compositions of groundwater of Wellfield of Loubet, which supply the major agglomerations of Maritimes Alpes of drinking water located near the Mediterranean Sea.

In 2006, the study of design office H2EA, showed that the mineralization of the aquifer increased significantly since 1998 and that it related to marine contamination. For these reasons and following the physicochemical updating of data from this aquifer, we try to study the different chemical and mineralogical compositions and monitor their concentrations from 2000 until the current.

Following mineralogical and chemical composition of those waters from 2000 until2015, we use the data from the aquifer database to study and interpret variations of their mineralogical composition.
To achieve this goal, we started by geological context, morphological and hydrological characteristics. Then, chemical treatment of groundwater, beginning with chemical facies according to Piper diagrams, we calculate chemical conductivity, persistent of mineralogy evolution during last years, utilization of saturation index, and so on (principal component analysis PCA).

6. Results and discussion

The interpretation of the major elements in chemical facies proves valuable when it comes to distinguish groups of water chemistry and mineralization (salinity) different within an aquifer or aquifer system. One can also identify relationships between these families especially in case of mixing between freshwater and saline waters [15-16-17].

Facies highlighted by groundwater Loubet is globally homogeneous and mixed bicarbonate type as we have on the chart (Figure 3). However, two samples show enrichment of chlorine and calcium: the C11 sample taken October 17, 2006 and C12 taken February 22, 2007 .

Moreover, other samples rich in potassium and sodium formed facies sodium and potassium bicarbonate: C1 (30 May 2001), C3 (04 June 2002), C6 (22 July 2003), C4, C5, C2.

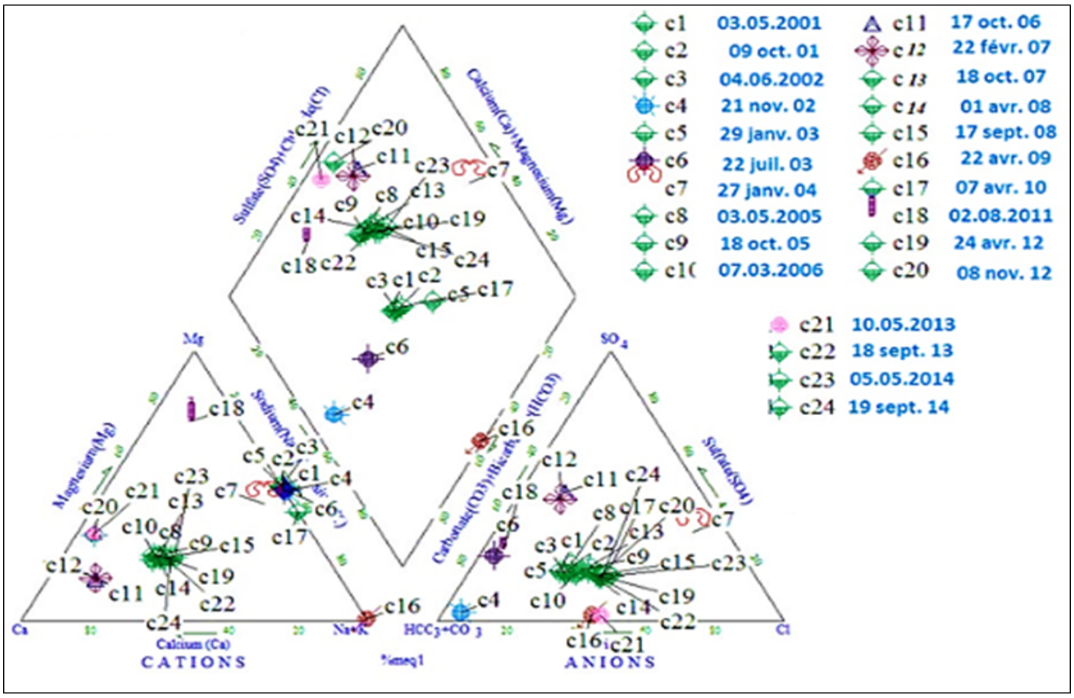

Figure 3: Piper Diagram of groundwater.

Following the analysis of the collected data, we found that the waters of this aquifer has essentially three facies (figure 3):

- ✓ Calcium bicarbonate facies.
- ✓ Sodium and potassium bicarbonate Facies.
- ✓ Mixed bicarbonate Facies: include majority of samples analyzed, none dominance marked of major elements (the cations).

The figure below (Figure 4) marked a most important evolution of chlorides since 1998, which means an evolutionary trend over time, in parallel with that of sodium, which shows less evolution.

It is interesting to note the inverse correlations between temperature and soluble components (EC, Na, Mg, and SO4) or NO3. A negative correlation between Ca and F, Ca and K and HCO3 and SO4 is also present.
Figure 3 shows the profile of factor axis 1, which indicates an increase from 2001 until 2008-2009, and then values of FA1 decrease slowly.

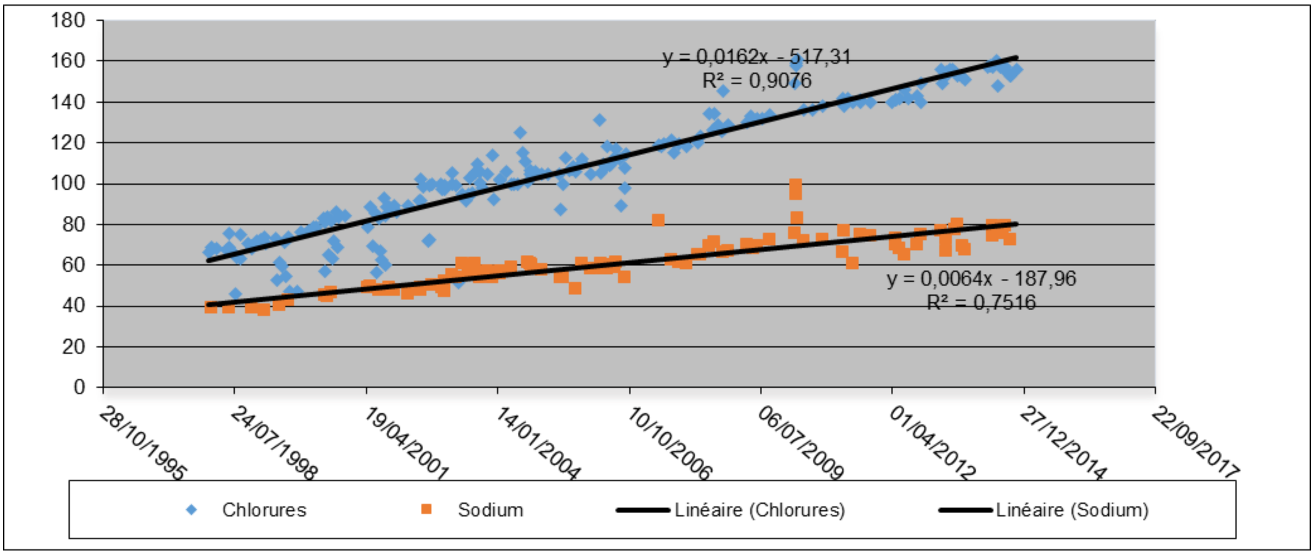

Figure 4: Correlation between Chloride and Sodium.

This change is likely related to a drier climate context over the first part of this chronicle.
The gap to linear regression (residue) appears to be related to seasonal variations (then to climate character), but the total data does not allow to advance this hypothesis. However, there is a disparity between the elements. Thus, Na and Cl have comparable variations in total. The Na/Cl ratio decreases steadily as shown by the profile below (Figure 5).

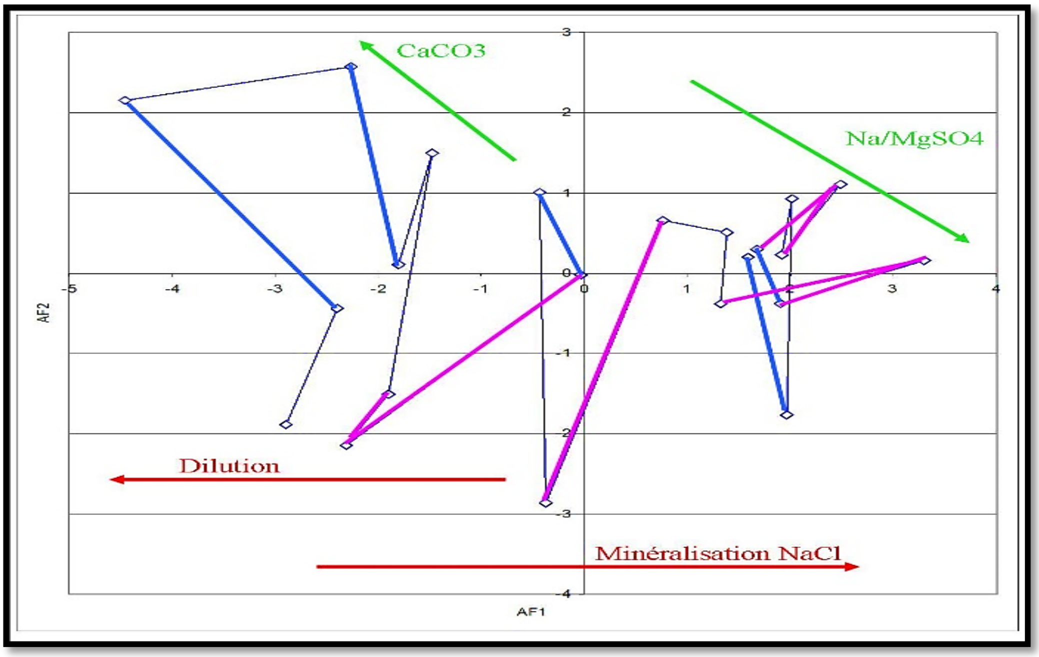

Figure 5: Evolution of the water quality according to AF1 and AF2.

This phenomenon is usual for little saltywaters (levels of Na / Cl less than 10mg/l) and explained by the ionic exchange phenomena. For the high mineralisation, exchanges can significantly affect the sodium mass balance and Na and Cl developments then become parallel. The temporal evolution in the first factorial plane (Figure 6) shows a disturbing evolution towards salinization (global displacement from right to left) with backtracking translating dilutions by continental waters, This phenomenon being limited in scale compared the overall trend of mineralization. The temporal evolution in the first factorial plane (Figure 6) shows a disturbing evolution towards salinization (global displacement from right to left) with backtracking translating dilutions by continental waters, This phenomenon being limited in scale compared the overall trend of mineralization.

The concentration units are different and therefore should pay attention to changes in each parameter, not their position in the graphic (Figure 7). The concentration diagram of different mineral shows that concentration of Calcium (Ca) and bicarbonate (HCO3) is almost constant during this period.

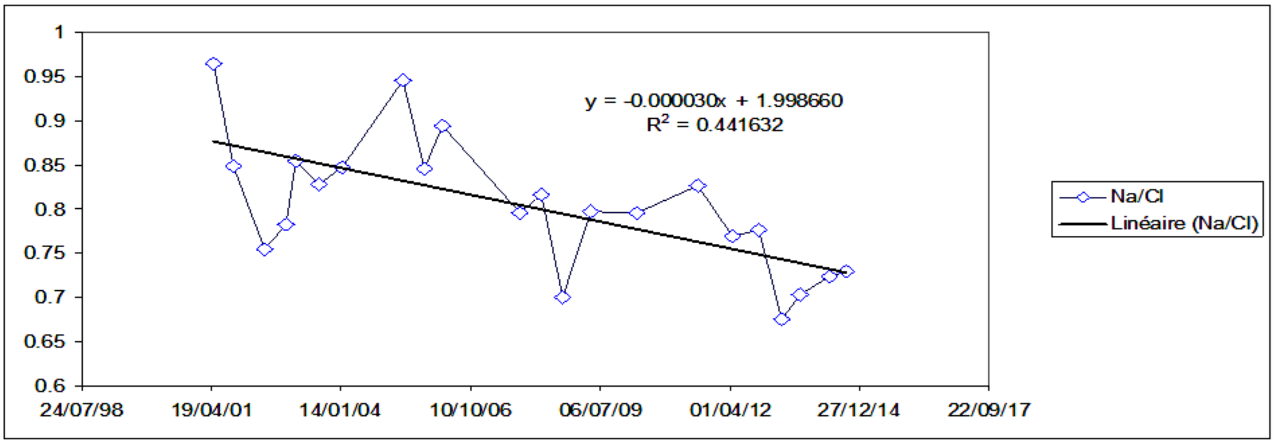

Figure 6: Sodium and chloride ratio (Na / Cl).

The concentration of chloride (Cl) and Sodium (Na) increases with a very steep slope greater than 1. The last two concentrations in the lowest diagram, magnesium and sulphate, vary with low slope and a crossing trend.

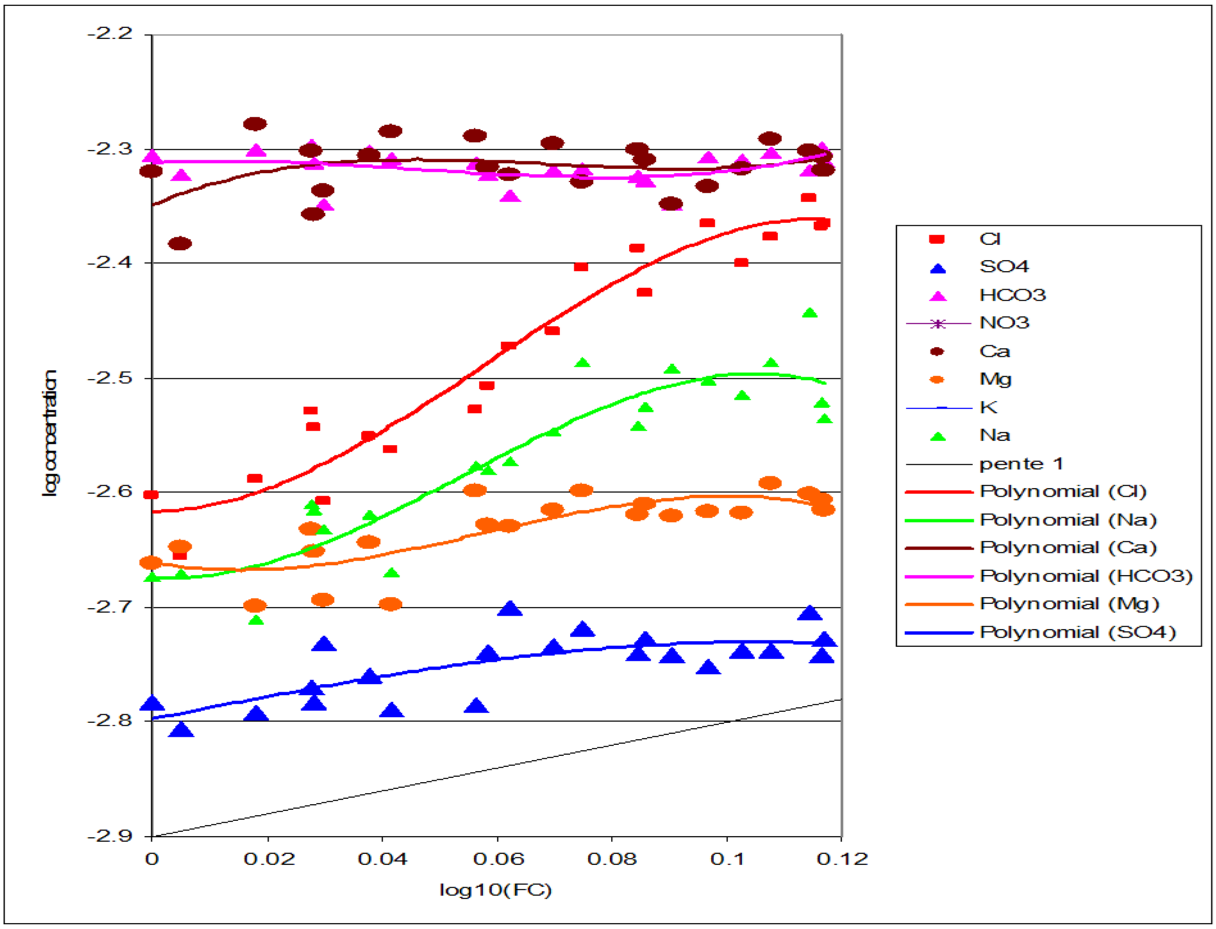

Figure 7: Concentration diagram.

Freshwater taken at wellfield Loubet are mix bicarbonate, the other ions being minor. Sodium and chloride increases with a slope much greater than 1. That of sodium is lower than the slope of the chloride. Thus, the concentration and conductivity of water Loubet mark a significant development since 2000 until now.

This shows that change of mineral is notrelate to a residence time increase, and notto the spin-mixture with salt water. We can say it is relate to lithology crossed and dissolution of rock in contact with these waters.

In 2006, the study of design office H2EA showed that the mineralization of the aquifer increased significantly since 1998 and that it related to marine contamination [18].

At this level of concentration, showed in our study, the precipitation of sodium minerals is not possible and the gap between chloride and sodium is link to ion exchange type Na/Ca and incidentally Na/Mg with clays, the solid matrix.

For the most mineralized waters, the facies becomes mixed carbonated and chlorinated, if the trend continues, it is feared a chlorinated Calco-Sodic and chlorinated sodic facies.
However, for water that is not of marine origin, there is an increase level of magnesium and sulfate. Thus, the contents of calcium carbonate remain stable.
In this study, it is indeed increasing residence time, calcium carbonate waters linked to low residence time, more Mg and more sulphate waters are characteristics of a longer residence time.

Conclusion

The present study focused on the hydrogeochemical characterization of coastal groundwater of the area of Loubet (Nice, France). The aquifer plays a substantial role in supplying several cities with drinking water.
The study of the aquifer of Loup Basin ply is done at wellfield Loubet, in strata essentially formed by clay sand alluvium, yellow-gray marl of Pliocene age, limestone, and dolomites of Jurassic.
Our results show that the waters of the aquifer are moderately to strongly mineralized. The Piper diagram indicates three chemical facies: calcium bicarbonate, sodium and potassium bicarbonate, mixed bicarbonate.
The conductivity of the water is generally high and varies between 1000 µs/cm and 1500µs/cm indicating the high amount of dissolved salt and the increasing degree of mineralization of the water. The analysis show that chlorides and sodium are the main drivers of this salinity. The saturation index and the analysis of water samples allowed us to understand the water mineralization process that is related to the dissolution of the rock aquifer and commodity exchanges, and not intake-mixture with salt water.

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