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Contamination of Ain Djenane's water source of the city Tiaret (Algeria) by nitrates, nitrogen and phosphates

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Several levies have been made in the groundwater of Ain Djenane of the Tiaret region (Algeria) during the period of April to May 2016 at the level of several wells located in urban areas. These levies have been the subject of analysis according to the techniques of the quality of the water assessment and the recommendations of the World Health Organization. The physical characteristics show that the water is of good quality. Very high nitrate rate has revealed with the chemical analyzes. The physico-chemical analysis has shown that studied wells have toxic substances concentrations below the WHO and national standards. It was indicated a strong contamination with nitrates (98.19±2.46 mg/l), nitrogen (18.0±3.33mg/l), phosphates (0.487±0.06 mg/l), and the contents of suspensions (851.76±18.1 mg/l), respectively. These concentrations are bigger than the standards recommended by the WHO (2006) and the standards of Algeria. The presence very high nitrates content in these waters could constitute a significant health risk to human health.

Key words: groundwater; quality; wells; physico-chemical analysis; Tiaret; Algeria.

Introduction

The water is an indispensable element for life and for the socio-economic development real and sustainable from a country. It is therefore necessary to have a better knowledge on the existing water resources. First, it is connected with information concerning: the vulnerability of resources to any risk factor and measures connected with development of environment management and protection (Bermond and Vuichaard, 1973).

The groundwater constitutes a significant part of the Heritage hydraulic of the country caused with the fact of its operations relatively easy. The groundwaters are traditionally water resources preferred for drinking water because of the low content of the pollutants. The Tiaret region is an area to vocation of great culture and livestock. It plays the grate socio-economic role in Algeria. In the targeted area, groundwaters have always been an important source of drinking water supply for the local populations, the animals watering and irrigation (Chellali and Guendouz, 2015). However, the food quality of the water represents a growing concern. The challenge facing all regions of Algeria and particularly rural areas is the protection of the quality of groundwater resources. In effect, the pollution of groundwater represents one of the most worrying aspects and the use of these waters for food purposes represents a danger for health (Laferriere *et al,* 1999). The present study is concerned with the study of the physico-chemical quality of groundwater connected with the Miocene deposits (Ain El Djenane) in the region of Tiaret.

Matherials and Methods

Study area

The water source Ain El Djenane (Fig.1) is located in the city center of the Tiaret wilaya. This area is limited by the valley of the Cheliff in the North, by the mountains of Frenda to the West, by the basin of the chott Chergui in the South, and by the plateau of the Sersou to the East. The geographical Lambert coordinates are following: x = 375 092 m; y = 231 066 m (DRET, 2014). This source is a succession of sandstone benches (whose thickness varies from a few centimeters under the redoubt to some meters - 10m behind the finance) and benches intercales clay with the SRG, these formations belong to the Miocene. The source of Ain el-Djenane fate at the base of a bench of grés cobs. It is a massive sandstone end and powerful affected by fractures (usually

clogged) in all directions. The bench is extended following a shallow dipping north. The area of power is seeking more far to the north (syncline Guezzoul). This sandstone bench is surmounted by an alternation of sandstones and clays. The clays are often on the bench intercalated between the likings or in plates of colors generally greenish to bluish, at the level of the contacts emerges several sources.

Sampling

The water points have been selected to have an overall picture of the groundwater table of Ain el Djenane. We have conducted several levies for the physico-chemical analysis of these waters during the period of April to May 2016, on several sites that are presented in the croquet card (Figure 1). The study was conducted on samples of water from some wells in urban areas in the region of Tiaret. Several samples of water have been taken in each well. The taking of samples for the physico-chemical analysis have been put in glass bottles sterilized and store at 4°C (to avoid any activity of micro-organisms) before being forwarded to the laboratory for analysis. 56 samples of water were collected in total.

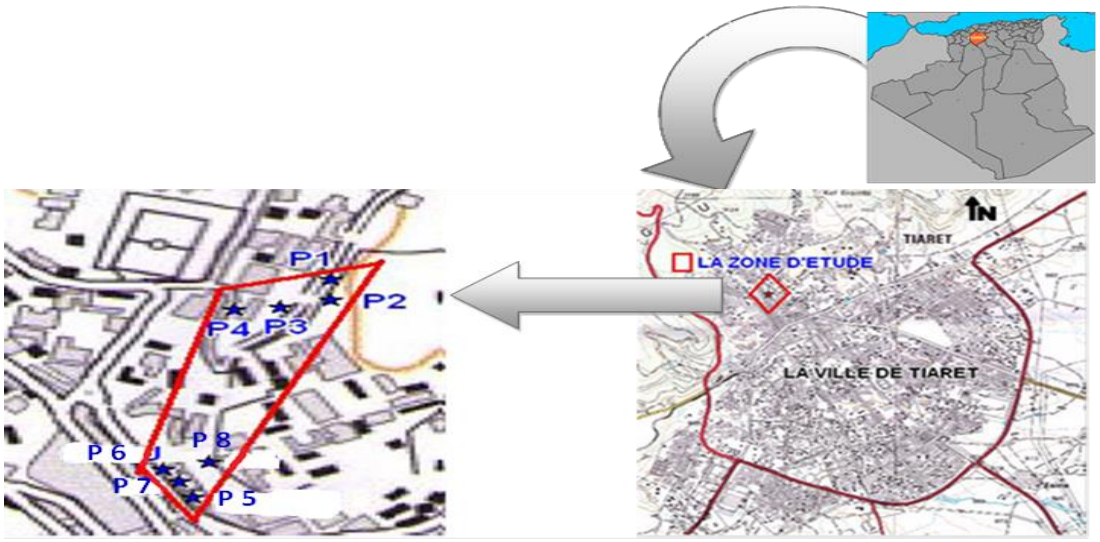

Fig. 1. Geographical situation of the various sampling points

The physico-chemical analysis has concerned the following parameters: t °C, pH, electrical conductivity, suspended solids, dissolved oxygen, DCO, nitrate, total nitrogen, nitrite, phosphate, total chlorine, chlorine free. To reduce the risk of errors which can be due to manipulation, to products reagents used, and to give a lot of reliability to the results obtained. The samples were analyzed both analytical methods (by preparation of standards in the laboratory) and instrumental method (direct reading on a qualified device using a prepared reagent). Outliers are eliminated. HPLC high performance liquid chromatography is sometimes used in some doubtful cases.

Results and Discussion

The results are shown in the tables 1 and 2.

Table 1. Results of the physical parameters of the water of Ain el Djenane (WHO, 2006; MREA, 2011)

Settings	N	Mean ± SD	Min	Max
pH	56	7.23 ± 0.25	6.99	7.84
T (°C)	56	16.57± 0.85	14.6	18.80
EC (µs/cm)	56	1371.66 ± 22.7	422.0	1758
SM (mg/l)	56	851.76 ± 18.1	267.0	1087

In the region of study, the results obtained show that the degree of this temperature does not present large variations of a well to another with a minimum of 14.60 °C and a maximum of 18.80 °C. The temperature of the water is an important factor in organic production. This comes from the fact that it affects the physical and chemical properties of the latter. It is density, viscosity, the gas solubility (including that of the oxygen) and the speed of chemical and biochemical reactions (Rodier 2005; HCEFLCD, 2006). The values of the waters pH of the ribbon cable from the Miocene do not show significant variations, with a minimum of 6.99 and a maximum of 7.84 (Table 1). This fact reflects a slight alkalinity of the environment. The pH depends on the origin of the waters, the geological nature of the substrate and the watershed crossed (Dussart, 1966; Bermond and Vuichard, 1973). In most natural waters, the pH is included usually between 6 and 8.5 while in the warm waters, the latter being between 5 and 9 (HCEFLCD, 2007).

The conductivity gives an idea of the mineralization of water and is in this respect a good marker of the water origin (HCEFLCD, 2006). Indeed, the measurement of the conductivity allows appreciating the quantity of dissolved salts in the water because of its mineralization. The minimum value recorded during the period of study is 422.0 µS/cm, whereas the maximum saves a value of 1758.0 µs/cm. The electrical conductivity depends on the charges of organic matter exogenous and endogenous, generator of salts after decomposition and mineralization together with the phenomenon of evaporation which concentrates these salts

in the water. It also varies depending on the geological substratum crossed (Belghiti, 2013). The results obtained during the course of our study show that the concentrations of contents of suspensions of samples largely exceeds the national standards defined (35 mg/l) with an average of 851.768±18.1 mg/l, these concentrations are caused mainly by variously of sewers and releases urban domestic which are rich in terms of colloidal origin the mineral or organic. The whole of the results of the chemical parameters of the water in this source are shown in the Table 2.

Table 2. Results of chemical parameters of the water of Ain el Djenane

Settings	N	Mean ± SD	Min	Max
O_2 Dissolved	56	3.26 ± 0.85	1.71	4.93
COD	56	15.96 ± 3.0	5.00	23.00
Cl Total (mg/l)	56	0.014 ± 0.01	0.001	0.080
Cl libre (mg/l)	56	0.085 ± 0.07	0.001	0.28
N Total (mg/l)	56	18.01 ± 3.33	13.90	25.00
PO_4 (mg/l)	56	0.487 ± 0.06	0.01	2.5
NO_3(mg/l)	56	98.19± 2.464	71.16	132.90

The request to chemical oxygen demand (COD) corresponds to the amount of the oxygen required to oxidize the oxidizable materials in certain conditions. They are in a very large majority of organic materials (Rodier, 1996). The analysis of the DCO performed on the samples of water collected shows that its concentration varies from one site to another where the average recorded 15,962±3.0 mg/ l. The minimum of 5 mg/l observed in several sites (S1, S2, S5). Maximum of 23 mg/l recorded at the level of S3 (3 th well). All these values are lower than the standard set for the drinking water which is 30 mg/l. These values indicate that all organic and mineral matter are oxidized (Rodier, 2005). For the whole of the levies, dissolved oxygen presented variations from one point to another, ranging from 1.71 to 4.93. These results show that the wells are slightly under oxygenates (Belghiti, 2014). The dissolved oxygen is an important parameter to take into consideration. It provides with information on the state of the waters. From the other hand, it promotes the growth of micro-organisms that destroy the organic matter. In general, the low values of the dissolved oxygen promote the development of pathogenic germs (Pedoya, 1993). The WHO (2006) noted that if the quantity of dissolved oxygen is less than 3 mg/l, the water quality is poor. Meantime, any decrease in the dissolved oxygen content detected in the water can then be interpreted as a sign of biological growth in the presence of a significant rate of organic matter. A consumption of organic matter (nutrient source essential for bacterial proliferation) is accompanied by an increase in the density of bacteria present in the water (Landreau, 1985). The total chlorine saves an average of 0.014±0.01 mg/l, while the free chlorine saves an average of 0.085±0.07mg/l. These values are always lower than the standard of drinking water set by WHO (2006) which is 0.5 mg/l. These results explain the increase in the concentration of nitrites estimated, knowing that the waters of Ain el Djenane do not undergo a treatment. The nitrites are from incomplete oxidation of organic matter (Belghiti, 2013).Their high levels correspond to the reduction of nitrate to nitrite by the anaerobic sulfite-reducing organisms. They may also be related to the bacterial oxidation of ammonia (Bengoumi et al*.,* 2004). The presence of nitrite in the water in large quantity degrades the quality of the water and could affect human health. The toxicity related to the nitrite is highly significant because of their oxidizing power (Belghiti, 2009). For the whole of the levies, the average total nitrogen is 18,01±3,33mg/l with a maximum concentration of 25 mg/l recorded at level S6 (Fig. 2) and a minimum value of 13.9 mg/l recorded at level S7. These values are much higher than the standard of drinking water set by WHO (1 mg/l). The nitrogen is going from one to the other by processes physico-chemical, and especially biochemical who are responsible for the formation of nitrate present in the water (Landreau, 1985). Nitrate concentrations in these waters are significantly higher than the national standards and those established by the WHO (50mg/ l). The highest value (125 mg/l) has registered in the S4 site and indicates a strong environment contamination from this source (Fig. 3). Nitrates are present in the water by leaching of nitrogen products in the soil, by decomposition of organic materials both synthetic fertilizers and (or) natural (Samak, 2002; Belghiti, 2014). The Nitrogen exists in the form molecular (N_2) or the ionized: nitrate (NO_3), nitrite (NO_2) and ammonium (NH+4) as well as in organic form Dissolved or particulate (protein, amino acids, urea, etc.). According Rodier (1978), nitrate can be at the origin of a complete oxidation of ammonium and a reduction of nitrite, even a water containing nitrites is considered suspicious. The phosphate content is almost stable for the whole of the sites. The average concentration is 0.487±0.06 mg/l. This value is slightly lower than the standard set by the WHO for drinking water which is 0.5 mg/l. The whole of the values obtained oscillates between 0.01mg/ l and 2.5 mg/ l registered at the level of S5 and S8, respectively. The amount of phosphate in the water comes from leaching of phosphate fertilizer and the degradation of the organic matter (Rodier, 1978).

Evolution of the rate of phosphate, nitrate, and the nitrogen in function of the sampling date

Total nitrogen (N)

According to the figure 2, it finds that the concentration of nitrogen varies as a function of the sampling date with a minimum of 17 mg/l recorded at the level of the 3 th Levy (01/05/2016) while the 4 th Levy (03/05/2016) stores a maximum of 24.2 mg/l. The nitrogen is an essential nutrient for the growth of algae and aquatic plants, which is found in various forms in the water (the form of ammoniac nitrogen (NH_3), nitrates and nitrites). The total nitrogen is the sum of the various forms of nitrogen present in the water (Belghiti, 2013).The present study has shown that the source Ain el Djenane is contaminated by a very substantial amount of nitrogen which leads to the degradation of its water quality.

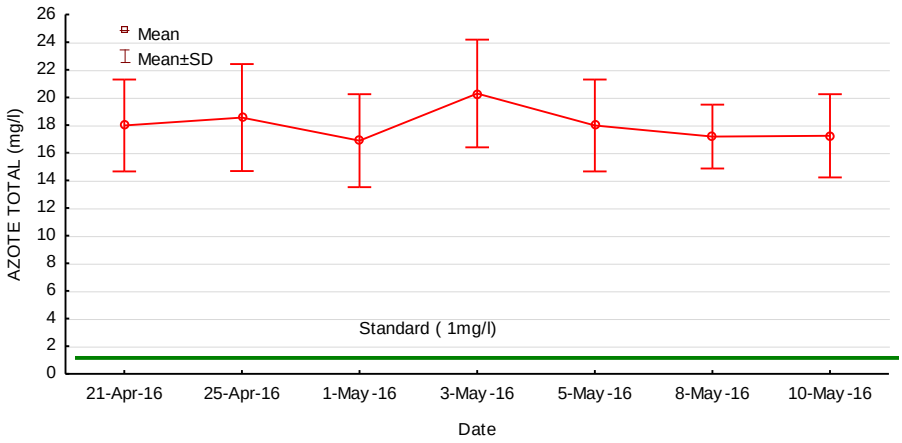

Fig. 2. Evolution of the rate of nitrogen as a function of the sampling date

Nitrate

The analyzes carried out on the waters collected show that the concentration of nitrate varies from a levy to another (Figure 3). The highest value is 132 mg/L recorded at the level of the 1ier Levy (21/04/2016), while the 3th Levy (01/05/2016) saves a minimum content of 71.32 mg/l. These high concentrations indicate the presence of a organic pollution (Samak, 2002). However, the pollution by nitrates can pose serious problems to the users of drinking water, which requires a regular monitoring of the quality of the waters of this natural source.

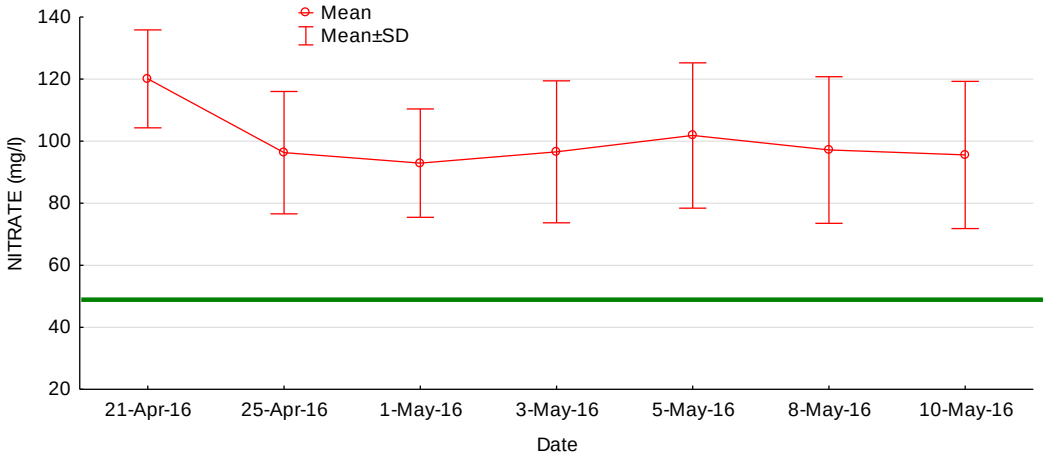

Fig. 3. Evolution of the rate of nitrate in function of the sampling date

Phosphate (PO_4)

In examining the figure 4 we find that the phosphate concentration varies as a function of the sampling date. It reaches its maximum of 2.1 mg/L in the 2 th Levy (25/04/2016). The effect of rainfall a few days before this levy is responsible, probably, of this increase. In effect, a fraction of phosphates is "washed out" by the infiltration of rain water, during this period, to the waters of this source.

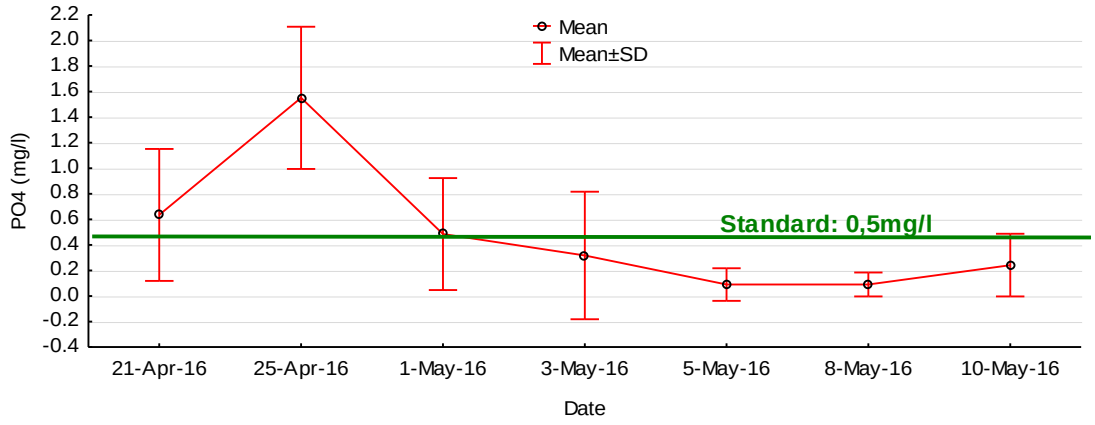

Fig. 4. Evolution of the rates of the phosphates in function of the sampling date

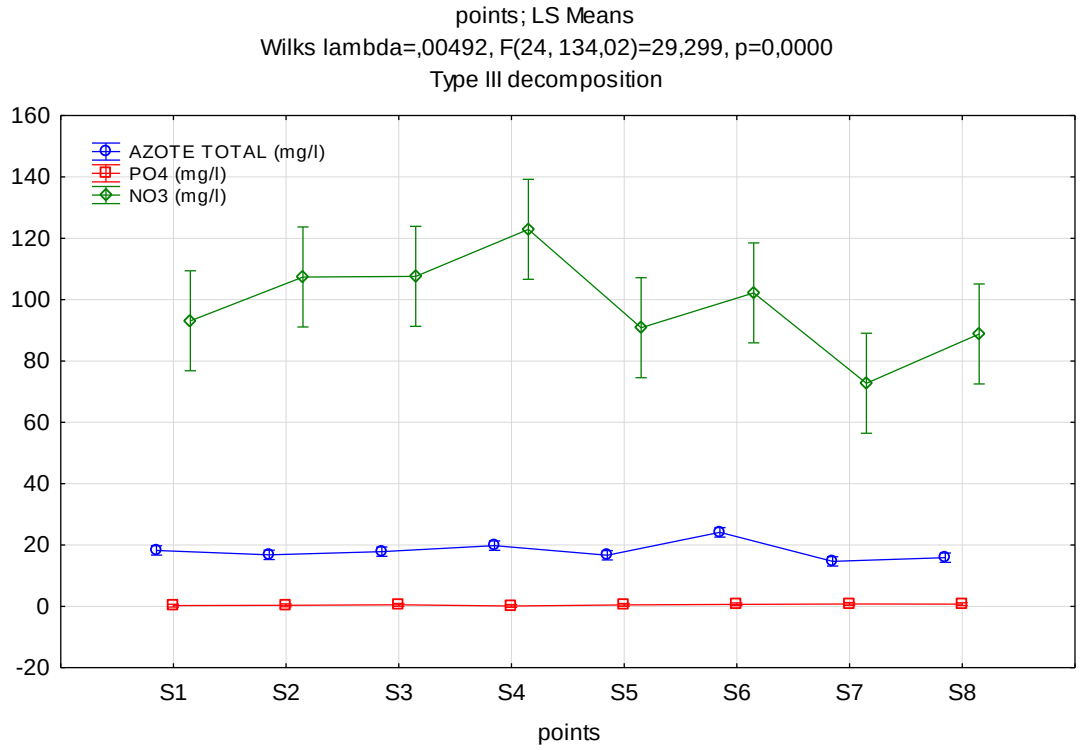

Fig. 5. Analysis of variance to measures deemed for the case of nitrogen, phosphates and nitrates

The review of figure 5 allows to see that there is a highly significant difference for the nitrogen, nitrate and phosphate (p=0.000). Indeed, the S4 site has registered the levels very high in No.3, whereas the site S6 mark the highest value of the nitrogen, by against phosphates exhibit concentrations slightly different. In the aquatic realm, nitrogen exists in the form molecular (N_4) or the ionized: nitrate (NO_3), nitrite (NO_2) and ammonium (NH^{4+}) as well as in organic form dissolved or particulate (protein, amino acids, urea, etc.). These different forms of nitrogen are in perpetual evolution. They pass from one to the other by processes physico-chemical and biochemical especially. Nitrates represent only one of the multiple forms of nitrogen present in the water, while constituting, in general, the most abundant form of mineral nitrogen (Belghiti, 2013).

Phosphates are, in general, originated of wastewater and sewage from landfills. Several authors report that it sometimes takes several years for a drop of water responsible of nitrate seeps into the soil and is found then in a tablecloth. One can say therefore that the pollution that can be observed today comes from 20 or 30 years of massive spraying on the land. According to the survey which was made during the sampling period, the high rate of nitrate in the site S2 (139 mg/l) in the vicinity of S2 (2^{th} wells). Nitrates come from the spreading of animal manure in the areas of livestock (Landreau, 1985).

Nitrates and nitrites are very widespread in a large part of the waters. The nitrites are from incomplete oxidation of organic materials. The high levels observed of nitrites estimated correspond to the reduction of nitrates by the anaerobic sulfite-reducing organisms. They may also be related to the bacterial oxidation of ammonia (Bengoumi et al, 2004). The levels estimated in nitrites vary from 15 to 30 mg/l during the study period; these values exceed the standard of potability fixed by the WHO (0.2 mg/l).

The presence of nitrite in the water in large quantity leads to degradation the quality of the water and could affect human health according to the WHO (2006). Nitrate infiltrates more quickly in light sandy soils than in the clayey soils. The rains and floods abundance may increase the concentrations of nitrate in the water of the wells (Belghiti, 2013). The possible correlations between the physico-chemical parameters of the Ain El-Djenane waters and the sampling sites were studied with a principal component analysis. Two factorial plans are likely to be interpreted. They represent approximately 56% of clouds of points. The result of this APC is shown in Fig. 6. On the factorial plan F1 32.26% of information can be interpreted.

We found the variables PO_4. Total chlorine and free chlorine are correlated to S7 and S8. However, a strong correlation is observed between the S8 and PO_4 (the two variable are located knew the same axis). The S8 is slightly contaminated by the PO_4 mainly due to the presence of algae in the site, knowing that this last has become a place of variously of urine. On the other hand, there is evidence of a strong correlation between nitrates, total nitrogen, the DCO and the two sites S1 and S3, on the factorial plan F2 (23.70% rate of inertia).

Nitrogen is the resulting from the degradation of organic material and comes mainly from urban discharges. The nitrates are the final stage of the oxidation of nitrogen. The DCO as important parameter for measuring the pollution of waters indicates the existence of the organic matter in the S1 and S3. The DCO is a comprehensive measure of organic material and of some salts oxidizable minerals (total organic pollution) present in the water. The oxidation of this contents generates the nitrate (Landreau, 1985).

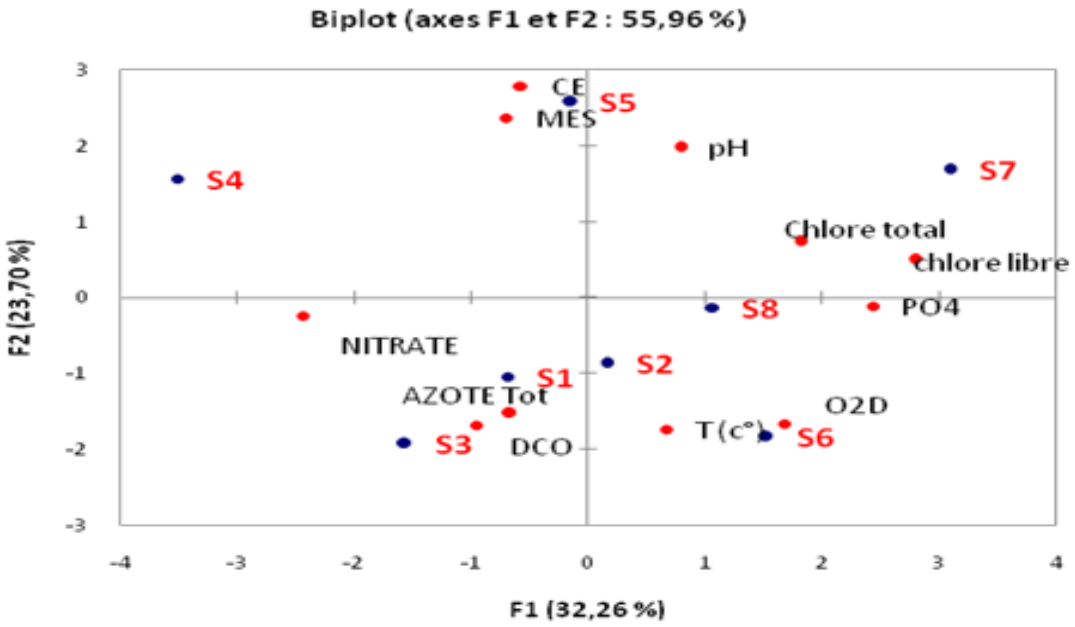

Fig. 6. APC linking the sites of levy for physico-chemical parameters studied

Conclusions

The non-protection of the environment, the defect of sanitation networks, the anarchic spills of wastewater have resulted in the pollution of the water in Tiaret. Most of all it relates to the source Ain el Djenane. The results obtained during this study have helped reveal a high level of contamination of the source by nitrate, nitrogen and phosphate exceeding the national standard of Algeria and that fixed by the WHO. The physical characteristics show that the water is of good quality. However, the chemical analyzes has revealed a rate of nitrates high. It seems inconceivable to leave to the competition a fountain-stele emblematic of any a wilaya, which in the only pronunciation of its name evokes a pan of the history of the city of Tiaret.
Several reflections have been engaged in a time spent to retrieve the enormous quantities of water, which is discharged all the days in the remediation network, but in vain to this day. The recovery of the source requires a control of the hydrographic network to correct the leaks due to sewers, so that to eliminate the sources of contamination of the waters of sanitation from homes and buildings. The evacuation pipes are clogged and dump their wastewater in the direction of the flow of the source Ain el Djenane. This study opens new horizons to proceed with the elimination pure and complete stables located near the wells supplying the hydrographic networks of Ain el Djenane on the one hand and the installation of technology to reduce nitrate content in the water on the other hand.

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