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Impact of industrial waste on the quality of ground water in the M'Zab valley. And Evaluation of the salinity of the ground water used for irrigation in the region of El Atteuf, South Algerian

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ABSTRACT

The wastewater discharged by industries without any pretreatment pollute not only the fauna and aquatic flora but often carry diseases germs that are responsible for certain diseases such as cholera, typhoid, and dysentery**. Objective:** the study evaluating the impact of pollution from industrial discharges and the quality of the ground water of valleée El Atteuf and highlight the problems of pollution and nuisances recorded in the valley. **Results:** The data allowed the establishment of water ability cards irrigation, a high concentration of suspended solids was recorded 575 mg \ l, the COD 408.64, while on all stations sampled, mineralization is generally high, poses a risk of salinization of soils, this excess salts (cond 6.47ms \ cm) is due to infiltration of industrial water and stagnant water through the geological layers. Chemical facies types of waters are sodium sulfate, calcium sulfate, magnesium sulfate, sodium chloride chlorinated magnesium. Most waters are loaded with salts and present a danger of salinity going from high (C3) to excessive (C5). Represent on the diagram of Riverside classes (C3) (C4) and (C5). In assessing the danger of alkalinity, the waters are distinguished by the level of danger from low (S1) to high (S3). Haut du formulaireBas du formulaire **Conclusion:** The results of this study show that the waters of the wells studied are considered unacceptable for human consumption; this could due to the high mineralization during the recharging of the groundwater and its occurrence and movement.

KEYWORDS: Water; salinity; COD; physicochemical parameters

INTRODUCTION

Groundwater reserves in Algeria are estimated at 6.8 billion m 3. However, these groundwater "the Albian table" are at great depths between 300-500 m so far from all pollution and are characterized by a more strong mineralization [1] by against the water table is exposed to any type of contamination because of its depth which is close to the surface or is infiltration of wastewater.

In arid and semi arid, irrigation water is one of the determinants of the expansion of agricultural production. However, the success of any agricultural development will depend on the rational use and periodic inspection of available water resources.

Agriculture has problems such as the risk of salinization that can be enjoyed by the electrical conductivity and of alkalization of soils. The latter due to ion exchange concerns especially sodium, calcium and magnesium. In south of Algeria and especially in the M'Zab valley, the water deficit climate is such that the use of irrigation is vital for agricultural production. Groundwater is the only resources to meet the needs of irrigation and domestic uses different hence the need to study the quality of the water and protect against the risk of contamination.

The valley of wadi m'zab:

The M'Zab Valley is located in the central part of northern Sahara to the desert with altitudes ranging from 330-450 m to the south and south - east and 550-650 m in the north and north - west [2]. The M'Zab Valley covers an area of 37,105 km 2. It is bounded to the north by Daïas region to the east by Ouargla (inserted in the valley of the Oued Mya), the South by El Golea and west by the Grand Erg Occidental. This valley is enhanced by Mozabites; seven oases (heptapole) were created including five (pentapole) on the route of the river Zab, and close to each other: Ghardaia, Melika Ben Isguen, Bounoura and El-Atteuf, Beriane and Guerrara (Figure 1).

In the hollow of the valley, sandy beds, originally unfit for cultivation, he had to arrange special prices and renewed efforts indefinitely. These alluvial contain groundwater which was until recently the only resource hydraulic operated by thousands of traditional wells.

The position of the oasis of El-Atteuf downstream of the M'Zab Valley, which gives it a natural outlet function is the reception area for all industrial and domestic discharges of the wilaya, location provoked aggression waste and industrial water. Irrigation palm trees and crops had long from the water table through traditional wells.

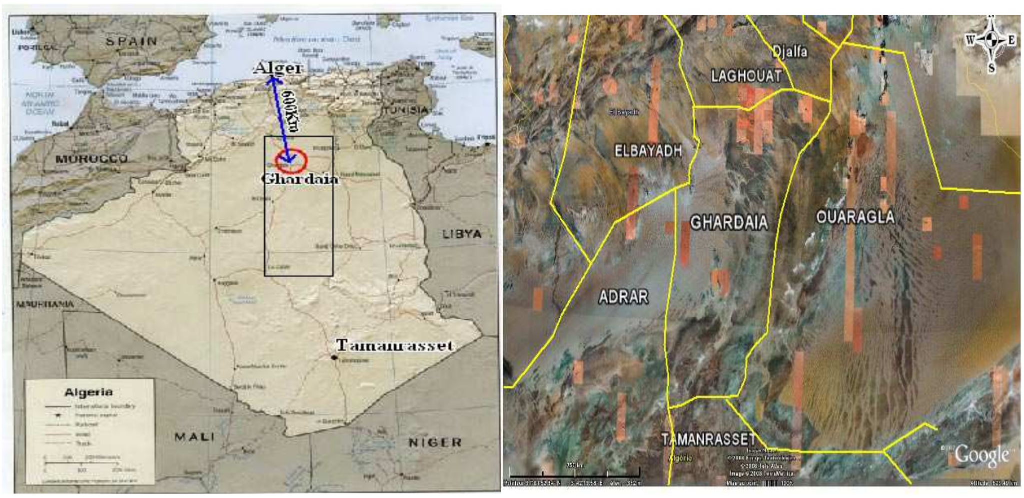

Fig. 1: Geographical location of the M'Zab Valley

Hydrogeological Aspect:

In the Algerian Sahara, the water has a vital, because climate and hydrological contexts are extremely fragile. The spatial and temporal irregularity of the availability of water, the impact of droughts and floods, and the pressure of water demand are continually increasing in the face of limited resources [1]. The potential water resources in Algeria is 17 billion m ^{3} (10 billion m^3 of surface water to groundwater of 6.8 billion m ^{3} mainly in the Sahara [3].

The tablecloth Albian: corresponds to the formation of the intermediate continental with a depth of 200-700 m. Water production is entirely from groundwater, from holes drilled in deep aquifers geological layers of the Albian. Various traditional and modern means are used to access these pits, including pulleys and motor pumps [4,5]

Surface water is scarce, the rainfall is very low (about 60 mm / year) and poorly distributed in the year in all the Saharan regions [6] Water (Oued and rain) to the surface of the earth seeps into the soil, through permeable geological layers. Filtrations contribute to the formation and food staple groundwater forming stagnated waters and also affects the chemical composition of the retained water and allows water to regenerate and purify, eliminating impurities which it loads in surface (dust, debris ... etc.)

Wadi M'zab arises from the confluence of two tributaries of Wadi el Haimeur northwest and Wadi Wadi Labiad West, Wadi Touzouz low impotence, joins the river upstream of Mzab Ghardaia palm grove at an altitude of 745 meters upstream, the river runs about 270 km from west to east to reach the depression Sabkhet safioune its natural binding, at an altitude of 107 meters (figure 2).

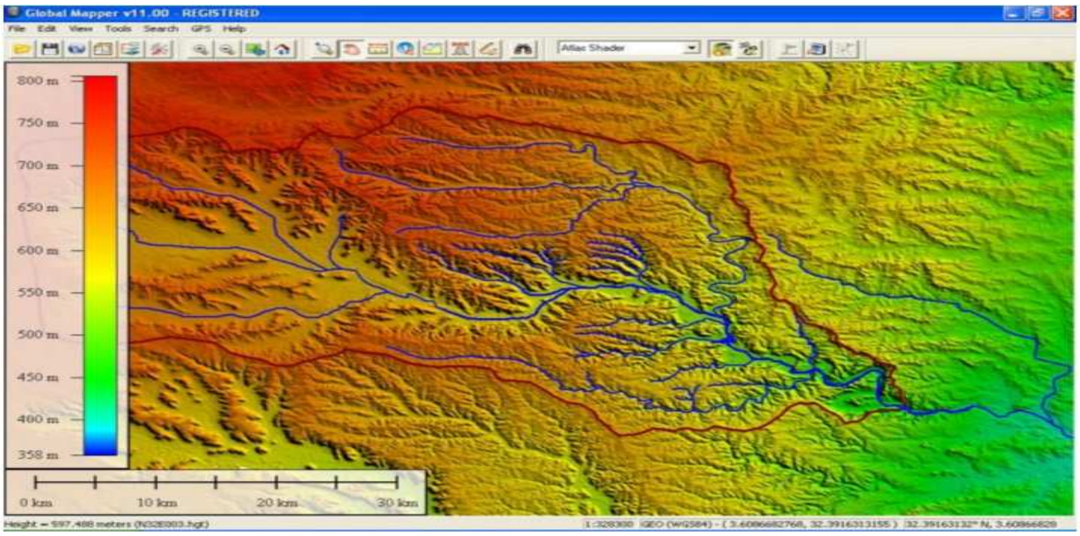

Fig. 2: Basin pouring and network orographique of the M' zab sampling strategy

In order to assess the physico-chemical characteristics of ground waters and to assess the effects of pollutants discharges, a hydrochemical study was conducted; it focused on the major elements of industrial waste water and the water table seven industrial units and 6 wells located at the bottom of the industrial area and 35 wells of the oasis of El Atteuf of pronfondeur varies between 6-40 m, were selected according to their importance to use, and according to the direction flow Oued and wastewater these wells are spread over a distance of 50 km.

Industrial waste, liquids, solids and air discharging untreated their domestic and industrial wastewater in the receiving environment and a danger to the groundwater and the environment downstream.

The results of analyzes carried out in laboratories officially authorized for the implementation of the Water characterization of operation and in accordance with the regulations in force [7.8] These laboratories are those of the ADE Ghardaia

Resultats Analyzes And Interpretations:

Pollution from industrial wastewater: industrial enterprises in Algeria delivered each year over 220 million m^3 of water used and leads to the formation of about 55 000 tonnes of BOD_5 and pour 135 tons of suspended solids and discard 8 thousand tons of nitrogenous material and as domestic sewage also reject nitrogen contents which leads to pollution[9].

The results of discharges from the analysis are presented in Table 01. The results are given in the dry season (August). This is particularly useful to determine the influence of high temperatures which promotes the growth of microorganisms,

The suspended Mater (SM), nitrates and dissolved oxygen providing interesting indications of pollution and helping to found the quality of wastewater.

The results presented show a wide gap between the minimum and maximum recorded values of MES and salinity, however a recorded increase in the unit 2 SM reached a value of 1365 mg \ l with a conductivity of 3290 µs / cm. This increase is more evident due to plastic drops.

The results of industrial waste also suggest that the parameters pollution NO_3 nitrate, ortho-phosphate PO_4, Ammonium and SM do not comply with standards specified by the Algerian regulatory standards (40 mg \ l for SM[10]. Infiltration of these parameters in the random water sources may be the cause of various problems of pollution

The high chloride concentration was recorded at all discarded industrial units exceed the thresholds set by the standards with values between 852 and 10783.12 mg / l. This excess salts gives help to the presence of toxic products The very low concentrations of dissolved oxygen in these discharges due to the presence of microorganisms (0.13- 7.54 mg \ l). In fact the lack of oxygen in the medium promotes the growth of anaerobic bacteria.

The high levels of , ammonium fluctuate between 0.17 and 0.37 mg \ l , with a small object at Increase in Unit 4 (1.66 mg / l), and the contents are acceptable for Orthophosphates (0-0.24 mg \ l). Nitrates show the spatial variation Sami as the ammonium ion. By contre nitrate levels fluctuate entre 1.46 and 7.69 mg / l, Ortho phosphates Meanwhile, show averages around 0 and 2.40 mg / l. However thesis gains are low Compared to the extent of pollution in the region.

Nitrate show the same spatial variation as the ammonium ion. For against nitrate levels are between 1.46 and 7.69 mg / l, but these values are low compared to the extent of pollution in the region If the mineralization clues reflect the influences Mentioned Above, Those of organic pollution (BOD_5, COD and O_2) give an idea of the organic load discharged. Indeed, the spatial patterns of BOD and COD are inversely proportional to the dissolved oxygen of that. In terms of BOD_5 and COD, their variation indicates that concentrations associated are significantly superior to the thresholds established by the norms WHO, these values vary between 47 and 50 mg / l for BOD_5 mg \ l O_2 and between 143 and 408.64 mg / l O_2 for COD. The test results indicate that biodegradability coefficient is in the range of 2.86 <COD \ BOD <8.17 in the sampled points, so the natural purification process does not efficient for some points.

Physico- chemical characterization and classification of ground water:

Several studies have highlighted the deterioration in the quality of surface waters in Algeria [6, 11]. For analyzes carried out in 1991-1992 [12] has revealed signs of nitrate contamination for the Mazafran Cheliff, Hamiz and Ghrib waterways. He reported nitrate levels in excess of 50 mg / l.

Overall, this finding is consistent with findings of other traveaux [13]. In the hollow of the valley, sandy beds, originally unfit for cultivation, he had to arrange special prices and renewed efforts indefinitely. These alluvial contain groundwater which was until recently the only resource hydraulic operated by thousands of traditional wells.

The position of the oasis of El-Atteuf downstream of the M'Zab Valley, which gives it a natural outlet function, is the reception area for all industrial and domestic discharges of the wilaya, location provoked aggression waste and industrial water.

Irrigation palm trees and crops had long from the water table through traditional wells. Groundwater: is presented in the region due to the nature of the rocks and erosion which created a network of deep valleys with a flat bottom. The groundwater recharge is done primarily by the waters of torrential rains and the waters of the deep aquifer (Albian) of some drilling intended for irrigation and drinking water supply. The number of operators groundwater wells is not exactly known, it is estimated at about 1,100 wells, with an average unit rate of 5 l/s. The pump usually lasts 6 pm The pump usually lasts 6 hours per day, which gives us a volume of water extracted daily 108.5 m3 is a sampling 39 582.5 m3 potential surface water resources in the north of Algeria, estimated at 13,500 hm^3 per year in 1979, was revalued to 12,410 hm^3 per year in 1986 and is currently at more than 9,700 hm^3 per year.

Water from rainfall or those made by the floods of the wad is seep into the limestone fissures; arrested by the Cenomanian marls they come together and form a water table that feeds the wells M'zab

Assessment Of The Quality Of Ground Water:

To assess the quality of ground water in the oasis of El Atteuf for agricultural use, we used diagrams Schoeller- Berkaloff and PIPER for the determination of chemical facies, and the diagram of L. A. RICHARDS (1954 - diagram "Riverside"), [14] for understanding the risk of salinization and soil sodisation. The results of the major elements (Table 1) show a wide gap between the minimum and maximum values registered, this is due to the depth of wells, distance themselves contributed to the flow of the Oued and the nature of the geological layers of the well.

The physico-chemical analyzes of the waters of the sheet of Ben Isguen (bottom of the zone and the oasis of El Atteuf (Tab. I) has been obtained of a number of commonly used parameters for estimating the quality salinity water consumption (translated by electrical conductivity) and the concentration of chloride, sodium, sulfate and pollution elements.

Annual changes in concentrations of Na (50-935 mg /l) in CI (144-1725 mg /l) and Potassium (0.65-65 mg/l), are in the same direction. Indicating that these three chemical é1éments have the same origin lithological The highest conductivities are around 8340 µs/ cm, which reflects a high salinity due to the lithology of course, but also to very arid climate. In recent induce high evapotranspiration which concentrates the soil solution.

The physico-chemical quality of the water in some points are more often poor, the salinity of the water, part of which is of geological origin and partly by poor management of industrial and domestic waste, is growing continually with the significant demographic expansion Indeed, the quality of this water is of poor quality and content can exceed SM (33 mg \ l). This high salt content, combined with the presence of a water table near the surface of the soil is one of the main causes of soil sterilization of several agricultural areas more often undrinkable and even dice once for irrigation

Table 1: Physico-chemical characteristics of industrial waste and Major elements (in mg/l) in the ground waters in Ghardaia region.

	Physico-chemical characteristics of industrial waste		Major elements of the ground water	
	min	max	min	max
Cond µs/cm	1122	7410	1129	8650
T°(C°)	16.5	32.20	28	29
Sal	1.20	29.80	0.8	2.6
PH	7.31	11.54	6.95	7.29
P_{redox}Mv	152	513		
dissolved oxygen mg/l d'O_2	0.10	7.54	0.07	0.08
Degrés de saturation %	1.2	105.7	0.9	1.2
Sulfates mg/l			339.53	3076.34
SM at 105 °C mg/l	3.7	1365	0	33
Cl^- mg/l	852	10783.12	144	1725
O.PO_4^{-3} mg/l	0	2.40	0	0
NO_3^- mg/l	1.46	7.69	0	23
NO_2^- mg/l	0.017	0.43	0	0.15
NH_4^+ mg/l	0.17	1.66	0	0.03
DCO mg/l d'O_2	143	408.64	1	19
DBO5 mg/l d'O_2	47	50	30	180
K^+ mg/l	-	-	0.56	65
Na^+ mg/l	-	-	50	935

Determination Of The Facies Hydrochimiques Of Waters:

The representation of waters on the diagram of Schoeller-Berkaloff makes itself according to a diagram semi logarithmic. This diagram permits the graphic representation of the chemical analyses of the samples and the fast reading of the chemical features.

The chemical facies of water analyzed is given by the higher concentrations association, quoted anions and cations side, between anion of a share of the other cation.

The figures (3) show the results of such a representation of the compositions of major elements of water points on this diagram The representation of samples on the Schoeller-Berkaloff diagram shows the existence, throughout the observation period, the dominant chemical fives facies, which are respectively:

• Water facies sulfated sodium (Na SO4) (P2, P7, P30, P31, P33) which has 14.28% of the analyzed water points;
• Water facies sulfated calcium (Ca-SO4) (P15, P10, P13, P17, P18, P19, P21, P25, P28, P32, P3) with 34.42%;
• facies Water sulfated magnesium (Mg SO4) (P3, P4, P5, P8, P9, P11, P14, P16, P22, P23, P27, P36, P37, P38, P39) is 42.85% of water withdrawn ;
• sodium chloride-water facies (Cl-Na) (P6) is 2.85%.

The Stabler classifications, Schoeller-Berkaloff and Piper (Figure 4) show the existence of a single chemical facies in the oasis of El-Atteuf (Figure 5) which is chlorinated and calcic facies and magnesium sulphate. There is no cation dominant in the majority of the water analyzed with the presence of a sample where the calcium dominates.

However among the anions, sulfates dominate in most water points, then we have another group containing no dominant anion.

All waters appear highly mineralized and rich in sulphate ions, calcium and magnesium, the most concentrated water facies corresponding to sulfated and sulfated magnesium and calcium, so the dissolution of halite or gypsum

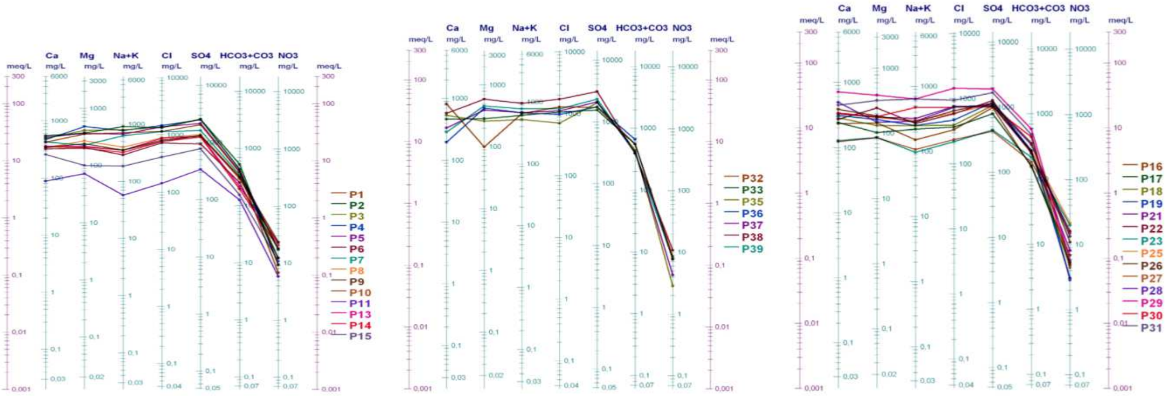

Fig. 3: representation of water analysis by Schoeller-Berkaloff diagram

Assessment Of The Quality Of The Waters Of Irrigation Of The Oasis Of El Atteuf:

Most problems that develop in irrigated agriculture derived from the chemical composition of the irrigation water, the use of such varieties of water in irrigation, as well as the need to predict the problems that can develop when different irrigation waters are used, have created the need for a water quality classification system that is completely different systems used to industry, aquatic life and health, etc [15]. Several schemes have been proposed for classifying the water with respect to their quality for irrigation [16, 17] Water has no inherent quality in itself except for the context in which it is used. In theory, the water quality is measured by the features that make it more or less suitable for a given use, that is to say, to meet the needs of use. It is defined by certain physical, chemical and biological. In irrigation the focus is on the chemical and physical properties of water and other factors are rarely considered important.

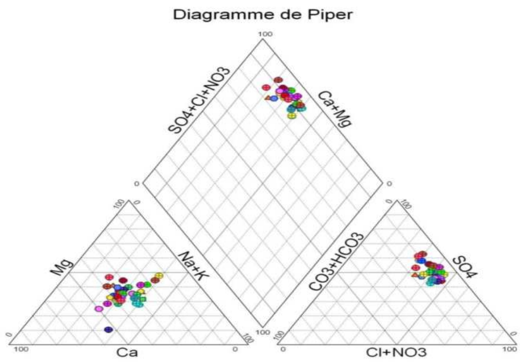

Fig. 4: Representation of the analyses of waters according to the diagram of PIPER

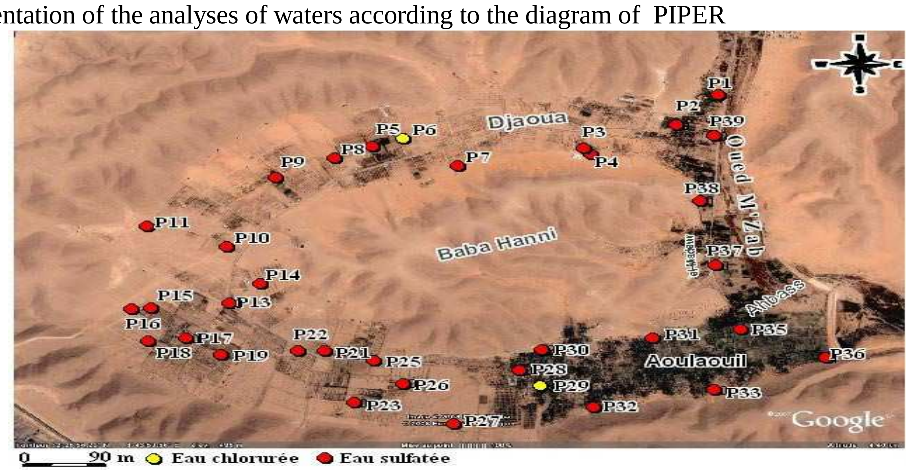

Fig. 5: Distribution of the sulphated waters and chlorinated in the oasis of El-Atteuf according to the classification Schoeller-Berkaloff.et Piper

Salinisation Risk (SAR):

When the concentration of Na^+ ions soluble in soil is important, these ions replace the more frequently the Ca^{2+} cations in the absorbent complex. Water loaded with salts can cause this action. The risk is determined from the value of adsorbable sodium (Sodium Adsorption Ratio, SAR). For the same conductivity, the risk is even greater than the coefficient is higher[18]. We have three classes are distinguished (Table 2). The SAR value based on the electric conductivity at 25 ° C (Figure 6). We deduce the class to which the water. According to the sodium adsorption ratio (SAR) was the following classification:

SAR = $[Ca^{2+} + K^{+}] / [\sqrt{(Ca^{2+} + Mg^{2+}) / 2}]$, the concentrations being expressed in meq / l.

We pay for each water removal, the SAR value based on the electric conductivity at 25 ° C (Fig.-). We deduce the class to which the water.

According to the sodium adsorption ratio (SAR) was the following classification (Table 2):

S1 Class: low water hazard to soil alkalinization;

S2 class: Water hazard fairly significant alkalinization;

Class S3: Water hazard important alkalizing.

Table 2: sodicity class of water [16]

Classes	SAR
S1	<13
S2	13-23
S3	>23

To classify groundwater from the oasis of El-Atteuf we use the classification of the American laboratory Riverside (Riverside USSL, 1954). This classification is based on two main characters [19]. Salinity identifies four classes of water:

• Class C1 (EC <250 µS/cm) : It is represented by 0% of sample analyzed, usable water for most crops in most terrain with little chance of occurrence of salinity in the soil;

• Class C2 (250 <CE <750 µS/cm) : It is represented by 0% of the total number of samples taken. Water is used with a slight leaching. Moderately salt-tolerant plants can grow in most cases without special practical salinity control;

• Class C3 (750 <CE <2250 µS/cm): It is represented by 8.57% of total collected sample. Water unusable for restricted drainage soils. Even with good drainage, special practices for salinity control may be necessary and plants with good salt tolerance can only be grown;

• Class C4 (EC> 2250 µS/cm) :It is represented by the majority of samples with a percentage of 91.43% of the total collected sample. These waters are normally unusable for irrigation. Exceptionally, they can be used on very permeable soils with good drainage and irrigation water applied in excess to provide strong leaching. Cultivated plants should be very salt tolerant.

All samples having the EC> 2250 µS/cm) :are distributed over the entire surface area except the study three water points (P11, P27 P23et) which have an electrical conductivity of between 750 and 2250 µS/cm. These 3 points are located at the western end of the study area for the P11 point and south of the oasis of El-Atteuf for P23 and P27 points.

The hydrochemical groundwater assessment of the oasis of El Atteuf revealed that most waters are loaded with salts and pose a threat salinity ranging from high (C3) to excessive (C5). The electrical conductivity values are between 1129 and 8650 µS/cm / cm and represent on the diagram of Riverside classes (C3) (C4) and (C5).

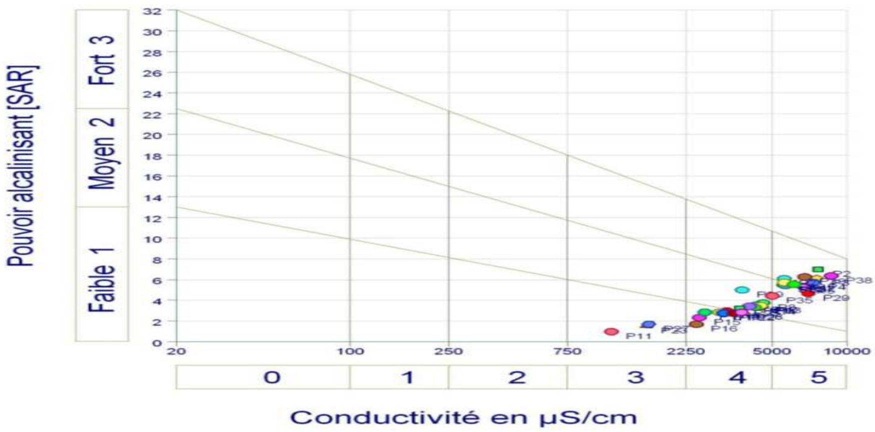

Fig. 6: Diagram of classification of the waters of irrigation of the oasis of El-Atteuf

Danger Alkalizing Of Soil:

The danger of soil alkalization is estimated based on the sodium adsorbable by the ground; the result is to impart poor physical properties. He was awarded three classes ranging from a low hazard at high risk. In assessing the danger of alkalinity, the waters are distinguished by the level of danger from low (S1) to high (S3). Although soil texture El-Atteuf predominantly sandy, natural or artificial drainage is mandatory. The ground water are virtually the only resource used in crop irrigation and livestock watering. The chemical results of those waters justify the choice of crops to grow in this case salt tolerant ones. According to Figure 7, we note that 31.42% of the total collected sample have a low danger of soil alkalization, 34.14% of the total collected sample with a risk of significant enough alkalizing, and the danger alkalizing is important for 31.42% of the total collected sample.

From drinking, the majority waters of the surface water of El-Atteuf's oasis are of bad quality and unfit for human consumption, except some water points like points (P11) (P23) and (P27) which are relatively less loaded salts

Conclusion:

The wastewater discharged by industries without any pretreatment pollute the ground water, waste analysis results indicate very high levels of dissolved salts, this means that the infiltration of industrial water from geological cause problems pollution agrave this situation with significant population growth and the lack of organizational control distribution of industrial discharges.

The hydrochemical evaluation of ground water to the oasis of El Atteuf which is downstream of the valley revealed that most of the water is loaded and salts pose a threat of salinity, this excess salts is due to the infiltration of industrial water and stagnant water through the geological layers and the absence of organic material has high salinity of the plateau.

The salinity of the water resource is compounded in some cases by anthropogenic pollution, mostly domestic, and industrial is one of the main causes of soil sterilization of several agricultural areas. Indeed, the quality of this water is bad usually appropriate quality to the consummation and sometimes even for irrigation

The use of different methods of classifications of ground waters of the oasis El-Atteuf such as classifications Stabler, Schoeller-Berkaloff and Piper show the existence of a chemical facies dominating that is the chlorinated facies and sulphated calcic and magnésien.

There is no cation dominant in the majority of the water analyzed with the presence of a sample where the calcium dominates. However among the anions, sulfates dominate in most of the observed water points, followed by another group containing no dominant anion.

Most waters are loaded with salts and present a danger of salinity going from high (C3) to excessive (C5).

1129 and 8650µS / cm and represent on the diagram of Riverside classes (C3) (C4) and (C5). In assessing the danger of alkalinity, the waters are distinguished by the level of danger from low (S1) to high (S3).

From drinking, the majority waters of the surface water of El-Atteuf's oasis are of bad quality and unfit for human consumption with a few water points like points (P11) (P23) and (P27) that are relatively less loaded salts.

REFERENCES

[1] Sekkoum, K., Mohamed Fouzi Talhi, Abdelkrim Cheriti, Younes Bourmita, Nasser Belboukhari, 2012. Nouredine Boulenouar and Safia Taleb Water in Algerian Sahara: Environmental and Health impact , Advancing Desalination
[2] BRL ingénierie, 1998. Etude du plan directeur général de développement des regions sahariennes-connaissances d'ensemble ; Rapport ANRH, Alger, Algeria.
[3] Baba amer Z., 2001. Analyse d'une famille d'herbicides triazines par FT/IR et GC/MS Application à la recherche des polluants organiques dans un puits d'El Atteuf " Ghardaia"Thèse magister univ. Ouargla
[4] Meddi, M., 2006 Evolution des régimes pluviométriques dans les différentes stations du nord du Sahara septentrional. Avenir des zones sèches, Tunis: UNESCO, 10.
[5] Mutin, G., 2000 L'eau dans le monde arabe. Enjeux et conflits. Paris, Ellipses Edition.
[6] Kadi, A., 1997. La gestion de l'eau en Algérie, Journal des sciences hydrologiques, 42: 191-197.
[7] Bernard, J., 1989. 'Memonto Technique de l'eau' Edition Paris-France
[8] Rodie, J., 2005. L'analyse de l'eau edition Dunod Belgique
[9] The Ministry of Environment and Sustainable Development in Algiers in December 2001.
[10] Décret exécutif n◦ 06-141 du 19 avril 2006 qui définissant les valeurs limites des rejets d'effluent liquides industrielles, Journal officiel de la république Algérienne.
[11] Hazzab Abdelkrim, 2011. « Eaux minérales naturelles et eaux de sources en Algérie » C .R Géoscience, 343: 20-31.
[12] Kettab, A., 2001. Les ressources en eau Algérie : Stratégie, enjeux et visions. Désalination, 136: 25-33.
[13] Boudjadja, A.M., Messahel., H. Pauc, 2003. Ressources hydriques en Algérie du Nord. Rev. Sci. Eau., 16 : 285-304.
[14]RICHARDS, L. A., 1954. Diagnosis and improvement of saline and alkali soils. Agric.Handbook 60, USDA, Washington D.C. 160 p.
[14] Gouaidia, L., O. Guefaifia, A. Boudoukha, M. Laid Hemila, et Claude Martin 2012 « Évaluation de la des eaux souterraines utilisées en irrigation et risques de dégradation des sols : exemple de la plaine de Meskiana (Nord-Est Algérien)" Physio-Géo., 6: 141-160.
[15] USSL,1954. Diagnostic and improvement of saline and alkali soil, Washington, Richards LA, p: 160.
[16] Ayers, R.S., D.W. Westcot, 1976. La qualité de l'eau en agriculture. Bulletin F.A.O. Irrigation Drainage, 29: 97.
[17] Fadel, D., Kh. Nacer, R. Michèle, C. Raoul, 2004. Aptitude des eaux de la vallée de la Seybouse à l'irrigation (Nord-Est algérien). Sécheresse, 15(4): 353-360.
[18] Durand, J.H., 1983. Les sols irrigables : Étude pédologique. Paris, Presse Universitaire de France, p: 339.