WASTEWATER URBAN REJECTIONS IMPACT ON GROUNDWATER QUALITY IN BÉCHAR CITY (ALGERIAN SW), IN URBAN ENVIRONMENT UNDER AN ARID CLIMATE

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ABSTRACT

This work treats the problem of the urban wastewater (sewage) influence identification on the groundwater chemistry, in particular the quality parameter in an urban environment, under an arid climate in Béchar city, located at the Algerian Western south. The ability of this groundwater for consumption is treated by comparing its chemical composition to Algerian standards, according to which half of the wells is not potable, whereas those of the World Health Organization (WHO) qualify the majority of samples by drinkable ones. The irrigation suitability is also examined, where the distribution of the samples is variable among different classes, were the projection of some points is except Wilcox diagram (very bad quality). The determination of the chemical facies allows the different groups identification and their changes over time, and factors influencing this mineralogical mobility. The main identified facies are chlorinated calcium, and chlorinated sodium. Microbiological analysis (total germs, Total Coliforms, Streptococcus, Clostridium Sulfito-reducer) including research organisms indicator of sewage pollution (fecal coliforms) is also carried out, confirmed and interpreted by microbial load sizeable presence, the largest is located south of the city. Studying the spatiotemporal variation of the chemical and microbiological composition of groundwater in Béchar city identifies the intensity of this impact that influx directly on its quality.

Key-words: *Quality, groundwater, hydrochemistry, microbiology, urban wastewater, Béchar.*

1. INTRODUCTION

The chemical composition of water plays an important role in determining its quality, so the possibility of its use for drinking and other uses (irrigation, industry ... etc.). In Béchar city, the groundwater chemistry is influenced by the geological formations dissolution and wadi water (water discharges or precipitation) (Kabour et al, 2011). And, because of the multiple uses of these waters (irrigation, Turkish bath, etc...), this study was conducted to check this groundwater chemistry current status, its evolution over time and space.

Sampling is conducted to identify Béchar city groundwater quality, this characterization is performed by a graphical treatment of physical, chemical and microbiological parameters (Subbarao, 2002; Debieche, 2002; Mondal, 2005; Petelet-

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Guiraud, 2005; BRGM, 2006; Comte, 2006; Srivastava & Ramanathan, 2008; Fehdi et al, 2009).

The city of Béchar is located in the south west Algeria (**Fig. 1**), in an arid climate with Saharan tendency, where precipitation is irregular during the year, with an average of 71.48 mm for the 1988-2008 series. The lowest temperature is recorded in January (4 °C) and the highest in July (40 °C), with an average of 27.16 °C. Evaporation (average 305.29 mm) and evapotranspiration exceeds precipitation, consequently all the year is dry (Kabour et al, 2011).

The Béchar wadi through the town of Béchar along its entire length, where untreated wastewater is discharged into several discharge points, waste flow of the city is estimated at 248, 28 l/s (Kabour et al, 2011), these wastewater in running out in the bed of the wadi through several aquifers, the hydrogeological conditions make a very favorable contact, sometimes, direct, facilitating chemical elements reciprocal transfers, the water levels (depth) measured vary from 3 m (P18) to 6 m (P8) with an average of 5 m, which promotes rapid infiltration of Béchar wadi water (Kabour et al, 2012).

The waters of these layers are stretched, despite the low rate for daily needs; this situation requires an objective study to reach a diagnosis impact of these water discharges on the environment, including the pollution degree of the groundwater quality in Béchar city.

Sampling was carried out during April 2008 and 2010, 18 wells and six discharge points were selected (**Fig. 1**).

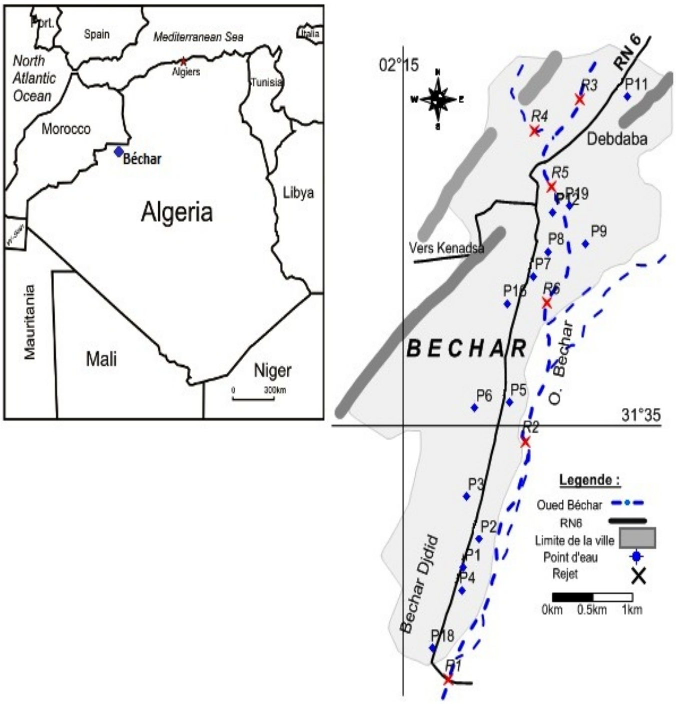

Fig.1 Location map of Béchar city (SW Algeria) and sampling network.

2. RESULTS AND INTERPRETATION

2.1. Potability ability (compared to standards Algerian (ADE) and WHO)

Comparison of physicochemical elements with standards usual (6362-1995) of the ADE (Algerian Des Eaux : Algerian Of Water) and the Official Journal Algerian republic (JORA) directives No. 35 and 51, on the water quality drinks (www.joradp.dz), as well as those of the World Health Organization (Elmore, Miller & Parker, 2005; WHO, 2006) shows that (**Fig. 2**):

for the parameters EC (electrical conductivity), Ca^{2+}, Mg^{2+}, Na^{+}, SO_4^{2-}, PO_4^{-}, NO_3^{-}, NO_2^{-}, respectively, 63%, 64%, 100%, 56%, 64%, 100%, 35%, 35% of the wells tested exceed the ADE potability standard, also for the ions Mg^{2+}, Na^{+}, K^{+}, Cl^{-}, SO_4^{2-}, NO_3^{-}, NO_2^{-}, were respectively, 77%, 88%, 6 %, 71%, 75%, 35%, 35%, wells with values above the WHO drinking water standards.

The total percentage (**Fig. 2**) wells with non- potable water are 50.45% compared to the standards of ADE, and 40.68% compared to those of WHO.

Determining the potability of water depends not only on global parameters compared to different standards, but also on the comparison of individual elements of the water wells sampled chemical composition, where it is noted that this composition presents at least one parameter which exceeds either one or the other standard of potability, which allows us to deduce that almost all wells are non drinkable, this is confirmed by microbiological analysis, where the simple presence of germs gives these waters a undrinkable qualifier.

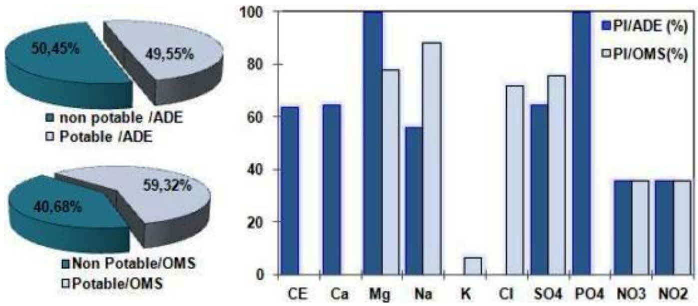

Fig. 2 Percentage of the non drinkable wells compared to the Algerian standards (ADE) and WHO (PI: infected well).

2.2. Irrigation ability (Wilcox diagram)

Wilcox diagram is used to determine the water suitability for irrigation, according to the percentage of sodium (meq / L) on the abscissa and the electrical conductivity (µS/cm at 25 °C) axis. The % Na^{+} is defined by the relation:

$$\%Na^{+} = [(Na^{+} + K^{+}) / (Ca^{2+} + Mg^{2+} + Na^{+} + K^{+})] \times 100$$ (All ions are expressed in meq/l.)

The application of this method on the Béchar city groundwater (**Fig. 3 and Table 1**), shows that: 2008 samples are spread over the classes: good (28%), poor (14%), unsuitable (14%) and more than 42% are except diagram; whereas, for 2010 samples, the distribution is: 23% in the fair class, 23% classified poor, and over 52% are except diagram.

Table 1. Wilcox diagram Results

	2008	*2010*	
Excellent	-	-	
Good	28,57 %	-	
Fair	-	23,53 %	
Poor	14,29 %	23,53 %	
Unsuitable	14,29 %	-	
Except diagram	42,86 %	52,94 %	

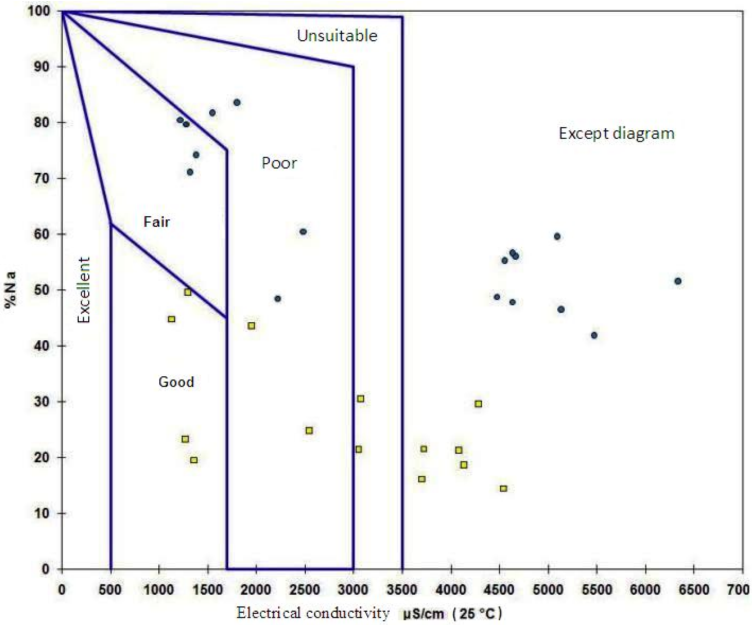

Fig. 3 Wilcox Diagram of Béchar city groundwater (2008, 2010).

2.3. Chemical facies

Classification based on the ionic formulas consists in arranging from left to right in descending order quantities of chemical elements in reaction starting with the anions then the cations (Schoeller, 1959; Al shaibani, 2008).

The percentage for each chemical facies is as shows in **Figure 4**, where, for 2008 samples, chlorinated calcium water represents 50% of the total analyzed samples, 22% are sulfated calcium, 14% are chlorinated magnesian, and 14% is calcium bicarbonate water. And 2010 samples, there are significant variations: the chlorinated sodium facies dominates with 50%, after sodium sulphate and sodium bicabonate with 22% , and ending the calcium chloride facies with only 6%.

We can say that the dominant chemical facies in Béchar groundwater are chlorinated calcium (2008) and the chlorinated sodium (2010).

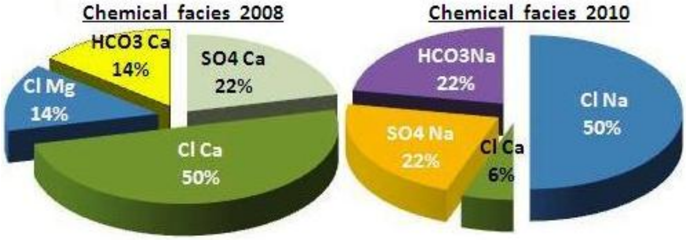

Fig. 4 Chemical Facies of Béchar city groundwater (2008, 2010).

2.4. Microbiological analyses

The microbiological analysis of water used for consumption allows assessing the risk due to pathogens micro-organisms; these organisms have as a normal habitat the intestines of humans or certain warm-blooded animals (Elmore, Miller & Parker, 2005; Rabiet, 2006; Alhou, 2007; Lamrani, Oufdou & Mezrioui, 2008).

Biologically, wastewater contains various microorganisms, which, in an aquifer contributes significantly changed their biological properties and damage the water medical state (Belousova & Proskuriva, 2008). Among them, there are many pathogenic organisms, usually from human origin. As their identification is complex and tedious, coliforms and fecal *Streptococci* organisms, more and therefore easier to assess, are used as indicators of pathogens presence and thus wastewater presence (Rabiet, 2006). High concentrations can cause health-risk (Bontoux, 1993; Bonnard, 2001; Venugopal et al, 2009).

Groundwater microbiological quality assessment Béchar city was performed on 18 water points distributed on both sides of the wadi (**Fig. 1**), sampling in the month of April 2010. The results are shown on graphs, whose x-axis is oriented north - south from the city to better visualizing the spatial distribution of different parameters.

Groundwater microbiological analysis in Béchar city show significant microbial load and reveal that there are signs of contamination by urban waste water (Wadi) in the majority of samples where the number of germs exceeds the standard.

Total germs are flora including all natural germs or contamination ones which lives in the presence of oxygen (Rodier, 2005; Rabiet, 2006; Alhou, 2007).

The results show that the rate of bacteria (colony forming units (Cfu/ml) at 20 °C and 37 °C) is very high (**Fig. 5**). It exceeds the Algerian standard (NA 6360-1992), the concentrations are limited between 8 to 1110 Cfu/ml, and from 28.67 to 1308 Cfu/ml (at 20 °C), with an average of 292.22 Cfu/ml (at 37 °C), and 382.09 Cfu/ml (at 20 °C).

The spatial distribution (**Fig. 5**) shows relatively low values in the north and center (< 200 Cfu/ml) (P22-20), except the P12, and strong values (> 500 Cfu/ml) in South from P3 to P18.

Total Coliforms (TC), as qualitative indicators, provides information on the character of water potability and the environmental condition of the water resource in question (Belousova & Proskuriva, 2008; Shashikanth et al, 2008).

The results (**Fig. 6**) show that the majority of samples, by the mere presence of CT are not drinking. Values are between 0 and 210 MPN/100 ml (Most Probable Number), while the average is 30.38 MPN/100 ml, high concentrations are located south of the city (P3, P4, P18) only P9 and P11 have a total absence of coliforms.

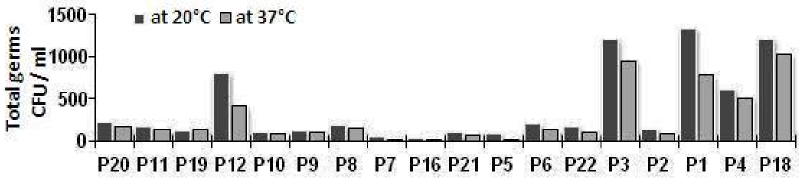

Fig. 5 Total germs in Béchar city groundwater (2010).

The detection and enumeration of fecal coliforms (FC) is a proposed review due to statistical concordance between their presence and an almost certain recent fecal contamination existence (Gaujous, 1995; Rodier, 1996; Rodier, 2005) and provides water, which contains them the non-potability character.

Fecal coliforms or Escherichia coli is a bacterial species belonging to the total coliforms group. This bacterium is always found in the feces of warm-blooded animals, but the difference of total coliforms, it is not present in a natural way in the environment (Jestin, 2005; Alhou, 2007).

Figure 6 presents the results of analyzes, where values are limited between 0 and 210 MPN/100 ml, and an average of 33.83 MPN/100 ml, the highest values are located south of the city (P3, P4); the wells P11and P9 present a total absence of fecal coliforms.

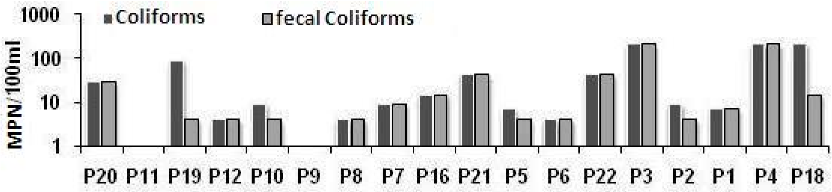

Fig. 6 Fecal coliforms and coliforms in Béchar city groundwater (2010).

Streptococci are serological group D streptococci of Lance Field, facultative anaerobic, associated with fecal coliforms, they are good indicators of recent pollution, they are indicative of fecal contamination rather resistant, even in saline environments (Gaujous, 1995). They can also multiply in environments with pH up to 9.6 and can therefore be used as indicators of pathogenic organisms that are resistant to high pH (WHO, 1979).

In all analyzed samples (**Fig. 7**) the number of germ is between 2 and 240 streptococci per 100 ml, with an average of 80.30 MPN/100 ml, this represents a majority samples contamination, the highest concentrations are located south of the city (P5, P6, P3, P18); at North only P20 has a value of 190 MPN/100ml, the others present low values (P19, P12 , P10, P8, P7, P16, P21), and Null (P11, P9).

The water potability, in this case, is simply function of these germs existence confirmation in the water.

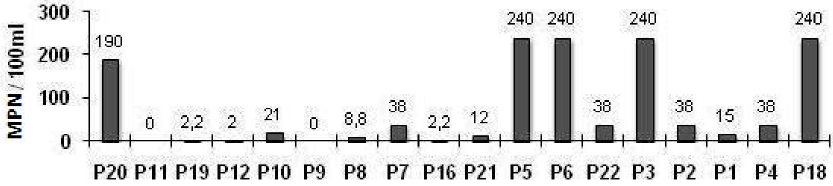

Fig. 7 *Streptococci* in Béchar city groundwater (2010).

Clostridium Sulfito-reducers (CSR) are forms of resistance anaerobic organisms. They are normally found in feces but in smaller quantities than *Escherichia Coli*, Clostridium Sulfito-reducing presence is an indicator of an old contamination, they come in two forms vegetative and spore (Gaujous,1995; Jestin, 2005; Alhou, 2007).

In the search of Clostridium sulfite-reducers, with a number of tubes giving a positive reaction on 4 tests (**Fig. 8**), the organism absence in some samples (P11, 19, P12, P9, P16, P5, P2, P1) is noted, while others present the vegetative form (P20, P10, P8, P7, P21, P6, P22, P4), only P18 contains both spore and vegetative forms, probably due to its situation at the extreme south of the city and its direct contact with water rejections.

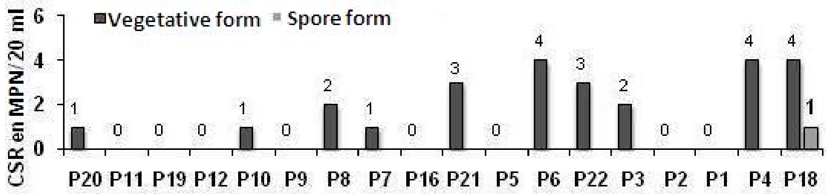

Fig. 8 ClostrodiumSulfitoReducer (CSR) in Béchar city groundwater (2010).

3. DISTANCE WELL / REJECTIONS

It was observed that 89% of wells have been contaminated by bacteriological fecal coliforms. The absence of coliforms in other wells does not guarantee that water is free of bacteriological pollution (Tandia, Diop & Gaye, 1999; Belousova & Proskuriva, 2008).

The correlation between fecal coliforms and distances wells / rejections (**Fig. 9**) shows no clear relationship between proximity to sewage discharges and wells bacteriological pollution, which expresses that the wells bacterial contamination mechanisms seem more complex (Tandia, Diop & Gaye, 1999; Belousova & Proskuriva, 2008).

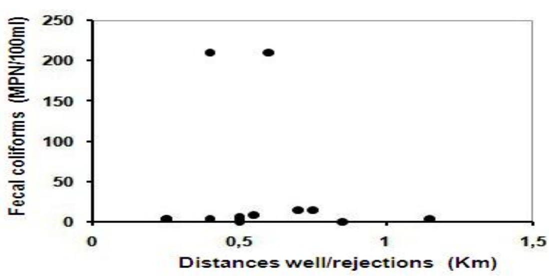

Fig. 9 Correlation between fecal coliforms and the distances well/wastewater discharges.

4. CONCLUSION

The results of the physicochemical and microbiological analysis of groundwater in Béchar city used to make some observations:

Comparison with physicochemical levels ADE standards water drinks quality, as well as the WHO, showed that the total percentage of wells with non-potable water is 50.45% compared to standards ADE, and 40.68% with respect to those of WHO.

To determine groundwater Béchar city suitability for irrigation, diagram Wilcox was applied, and where only 28% (2008) of the point are in the right class and the majority (42 % for 2008, 52% in 2010) is except diagram, so very bad quality.

Microbiological analysis shows that almost all the wells are not drinkable; this is confirmed by the simple germs presence in the water samples, which constitutes a real threat to the environment, including a real risk to the health of this water consumers.

In addition, the correlation between fecal coliforms and distance wells / wastewater discharges, describes a fairly complex contamination mechanism, which opens an opportunity for research.

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