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Impact of the Berka Zerga urban discharge on the Environment and Lake Fetzara (Annaba, Algeria)

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Abstract

Urban discharge of Annaba is one from landfills where buried garbage by backfill generates High concentration leachate. The objective of this work is the assessment of the physico-chemical water quality in the study area and whether these waters are apt for irrigation. For this, chemical analyzes were carried out on nearly 30 points. These analyzes have concerned the temperature (T°C), conductivity (EC), TDS, pH, BOD_5, TH, Mg^{2+}, Ca^{2+}, Na^+, Cl^- and HCO_3^- and heavy metals (lead, Manganese, Iron, Copper). The results show that the elements iron, lead, Copper and Manganese, EC, TDS and BOD_5 have high concentrations likely related to the proximity of the landfill. The study of the ability of groundwater for irrigation revealed three types of water: Eligible quality of water (24.13% of the Wells of the plain), Mediocre quality of water (representing 62.06% of the wells of the plain) and Poor quality water (13.80% of the Wells of the plain). These waters are generally used only for irrigation of crops tolerant to salt on well-drained soils, but require prior monitoring changes in salinity. As for sodium absorption (SAR), the report indicates that almost all of the water Wells are bad for irrigation.

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Introduction

The contamination of natural waters with toxic pollutants poses a potential threat to the future of human activities (Andreasen *et al.*, 2001). Poorly controlled landfill can contaminate soil and groundwater; leachate infiltrating the subsoil results in a significant deterioration of groundwater in landfills (Aoun and Hayek, 1998; Mehdi-Mekakia, 2007; Tahiri *et al.* 2014).

In Algeria, the danger of pollution and environmental degradation is a reality that concerns all cities and in particular Annaba which has a large urban and industrial fabric.

The various studies that have concerned several regions in eastern Algeria and which focus on water resources and different forms of pollution (Chaffai *et al.*, 2005, Chaffai and Mourdi, 2011), surface and underground by heavy metals (Khelfaoui *et al.*, 2013; Bougherira *et al.*, 2014; 2016; Chaffai *et al.*, 2016) and various methods of analysis and modeling (Khelfaoui *et al.*, 2012; Hani *et al.*, 2016; Sedrati *et al*, 2016), show that these areas are very vulnerable and require effective protection that is currently lacking.

This contribution will make it possible to monitor and demonstrate the negative influences of domestic and industrial waste on the environment. The latter, by its geomorphology and favorable location has become a very important pole of industry and agriculture in addition to an ever-expanding planning. This development has largely contributed to permanent and dangerous pollution of water supplies (Djorfi *et al.*, 2007; Sayad *et al.*, 2017). In this context, our work aims to provide a detailed overview of this liquid pollution by measuring the contamination of the Ziad plain water with toxic metals such as manganese, nickel, lead, zinc and iron. The impact of these on the environment is also presented.

The characterization of the water quality in the Ziad wadi plain and the evaluation of the impact of the Berka Zerga urban landfill on groundwater showed a high electrical conductivity due to the presence of certain chemicals in water with high concentration (Cl^-, Na^+, Ca^{2+}, HCO_3^- ... etc.). Chlorides, sodium and calcium are the cause of the high mineralization of water. This is due to natural contamination by dissolving minerals to cross. The geology of the study area allows the predominance of calcium and magnesium over sodium. Indeed, calcium is the altered crystalline rock and the hydrolysis of silicate minerals.

The high proportion of anorthite in plagioclase, the most easily modifiable variety (Faillat and Drogue, 1993), justifies the high concentrations of Ca^{2+}. Mg^{2+} ions are derived from the decomposition of mafic minerals such as biotite and amphibole present in the rocks of the region. However, especially sodium-sensitive plants, such as some stone fruit species, trees, avocados, can dangerously accumulate sodium in their leaves. Heavy metals (Pb, Cu, Fe, Ni and Mn) are present at high concentrations exceeding the FAO standards for irrigation water around the landfill and spreading into groundwater away from the landfill in the direction of the flow. This study is carried out by means of an analytical monitoring of the groundwater taken from the wells around the outlet to Lake Fetzara.

Materiel and methods

Industry studied

The study area, located 15km southwest of the city of Annaba, includes watershed Berka Zerga an elongated shape, the plain of Oued Zied and an expanse of water corresponding to the lake Fetzara. It is surrounded by mountains of Edough and massive metamorphic Beliliéta North by Highway 44 and finally the plain of the Zied river and lake Fetzara West. The plain is crossed by Oued El Goullia and Wadi Zied (Fig. 1).

The geological study of the catchment basin of the landfill allows the identification of several geological formations; metamorphic formations (gneiss, mica schists and crystalline limestones) and sedimentary formations (calcareous marn sandstone, the numidiennes clays, sandstone Numidian, scree slopes and alluvium). The subsoil of the region has an aquifer of alluvial formations composed mainly of 70% sand and 30% clay (Zenati, 1999). Mean permeability ranges from 10^{-3} to 10^{-4} $m.s^{-1}$ (Debièche *et al*, 2003).

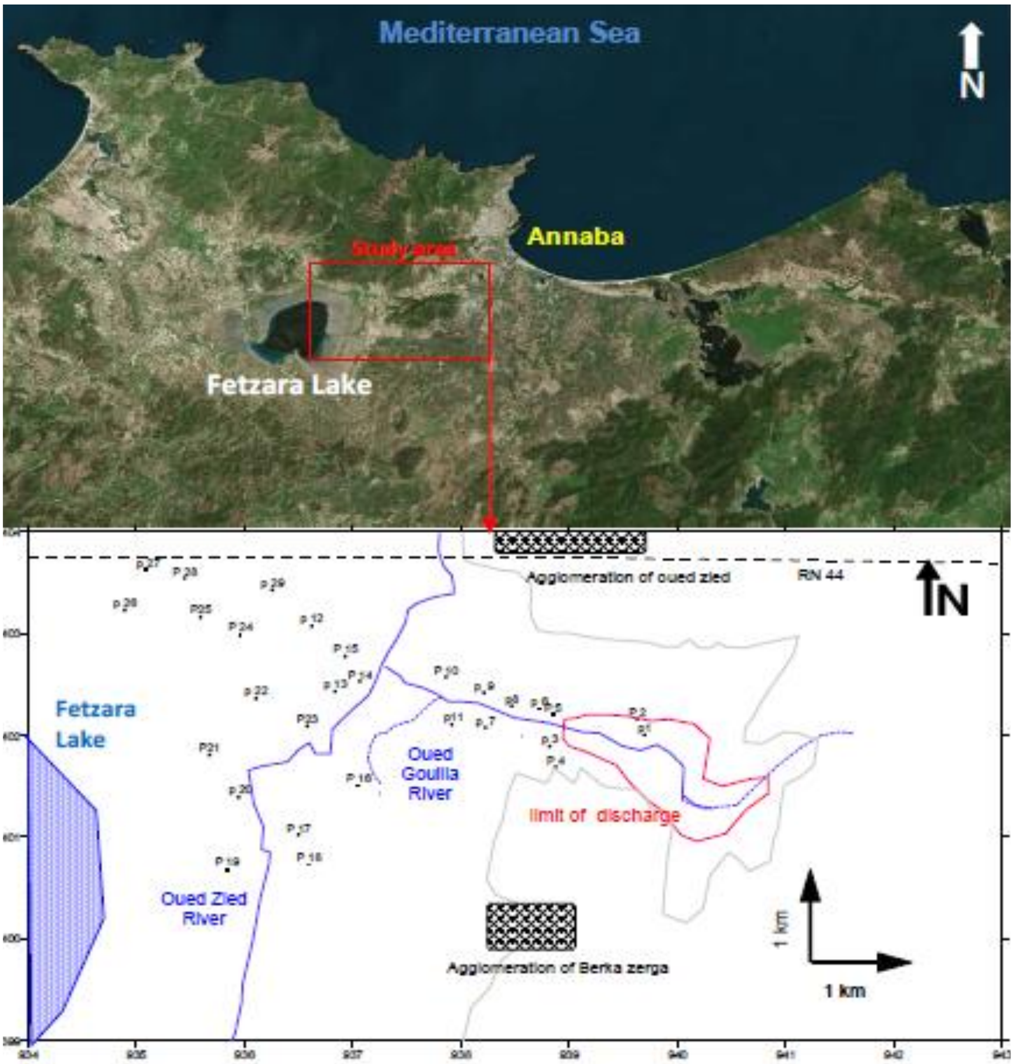

Fig. 1. Maps of the study area and sampling points.

Wadi Goullia is characterized by a steady flow in winter and dry in summer. The climate is Mediterranean with annual rainfall of 650mm, an average Temperature of 18°C and a value of the high humidity. The prevailing Wind direction is North-South that is to say towards the region of El-Hadjar. The effective infiltration is about 15% of precipitation, almost 100 mm per year seeping into the water table (Hani, 2003).

Country analysis

A sampling was conducted in the month of April 2015 and reached 29 wells capturing the gneissic formations and sedimentary formations (calcareous marn sandstone, the numidiennes clays. Sensing the water table of the plain Ziad and river. Variables physicochemical affected by this campaign are:

Physical parameters: Temperature, Electrical Conductivity, total dissolved solid (TDS) were measured using a multi brand parameters COND apparatus (179I WTW), the pH is measured using a pH-meter HANNA (HI9811-5)

Chemical parameters

BOD_5 is measured at Sonatrach in the environmental laboratory of Skikda by a flow meter (WTW OxiTop BOX) and Bain-Marie (Memmert).

Samples of specific samples for metal analysis are performed according to the sampling standard (Norm ISO 5667-1, 1980; Norm ISO 5667-6, 2005). They are assayed by atomic absorption spectrophotometer with flame (PYE UNICAM, Philips) Hydrogeology Laboratory of the University of Constantine.

Samples are taken in bottles made of polyethylene low density, capacity 1l. In the laboratory, they were filtered, deoiled, acidified with a few drops of HNO_3 and optionally stored at 4°C (Norm AFNOR T 90-112, 1986).

Results and discussion

Physical characteristics

The Temperature

Values varied between 14°C and 18°C, the maximum is observed at points P1 and P2 and P26 is minimum (Fig. 2).

pH:

The pH values varied between 5.8 and 7.9 for the waters of the plain Ziad river. The minimum value is recorded in the P7 and P19 Wells and the maximum level of P16 and P29 Well (Fig. 3). The pH standard is 6.5 (FAO/Unesco, 1973). For pH values below 6.5, the water use for irrigation risk is zero. These are water wells P5, P7, P11, P15, P17, P18, P19 and P28. For pH values between 6.5 and 8.4, Wells are :(P1, P2, P3, P4, P6, P8, P9, P10, P11, P12, P13, P14, P16, P20, P21, P23, P24, P25, P26 , P27) and P29, the risk of use of this water for irrigation is significant.

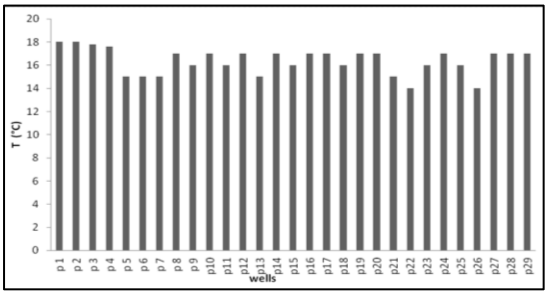

Fig. 2. Temperature of the water in the points of samples.

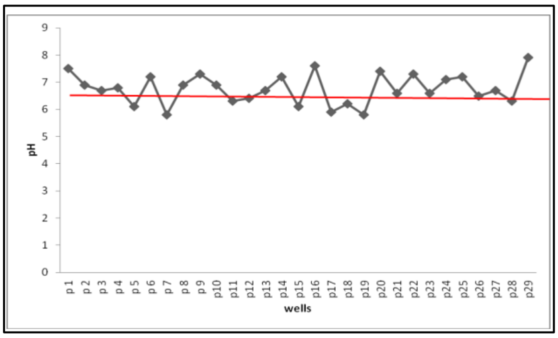

Fig. 3. Water pH variation collected compared to the irrigation norm (FAO, 1976).

The Electrical Conductivity (EC)

The maximum value is recognized in well P2 with 2871 µS/cm, and the minimum value is recorded in P19 Wells with 512µS/cm. The conductivity is high in neighboring wells in the landfill but it gradually decreases away towards the plain (Fig. 4).

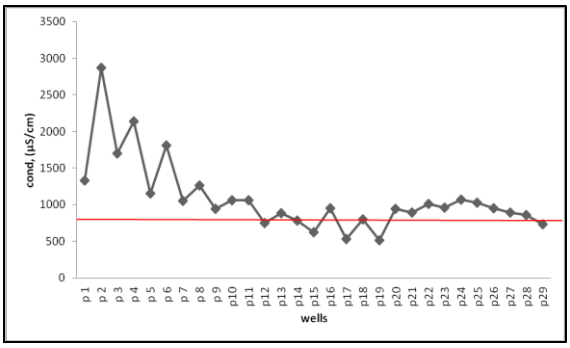

Fig. 4. Variation of Electric Conductivity measured relative to the Norm irrigation.

If we consider that the standard of the electrical conductivity for irrigation water is 750 µS/cm (FAO, 1976), we can establish the following geographical distribution: water Wells in P15, P17, P19 have values below 750µS/cm and the risk is zero. Points (P1, P2, P3, P4, P5, P6, P7, P8, P9, P10, P11, P12, P13, P14, P16, P18, P20, P21, P22, P23, P24, P25, P6, P27, P28 and P29 are characterized by values between 750 and 3000 µS/cm. These waters therefore present a significant risk (Table 1).

Total Dissolved Solid (TDS)

The Norm is 450mg/l. The results show that water P15 Wells P17, P19 have values close to the standard, against concentrations in the waters of the points P1, P2, P4, P5, P6, P7, P8, P9, P10, P11, P12, P13, P14, P16, P18, P20, P21, P22, P23, P24, P25, P26, P27 and P28 exceed the normative value, which may pose a risk to use this water for irrigation (Fig. 5).

TH (Water Hardness or Hydrometric Title)

TH values vary between P2 and P17 Wells. The High value is raised near Oued Gouilla (P2) with 288.08mg/l and the minimum observed at point P17 is 46.4 mg/l (Fig. 6). Note that the values decrease in the direction of the flow of Wadi Ziad and it sinks to the center of the plain (P12, P15, P17, P19 and P21).

Table 1. Representation of the Risk (FAO, 1976)

Risk	Parameters						
	pH	CE (µs/cm)	TDS (mg/l)	Cl^- (mg/l)	HCO_3^- (mg/l)	Fe (mg/l)	Mn (mg/l)
No	< 6.5	< 750	< 450	< 150	< 90	< 0.2	< 0.1
Mild to moderate	6.5-8.4	750-3000	450-2000	150-350	90-250	0.2-0.5	0.1-1.5
Severe	>8.4	>3000	> 2000	> 350	> 250	> 1.5	> 1.5

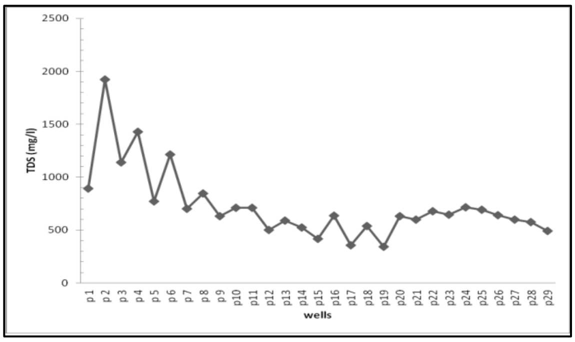

Fig. 5. Variation of the TDS compared to the norm irrigation (FAO.1976).

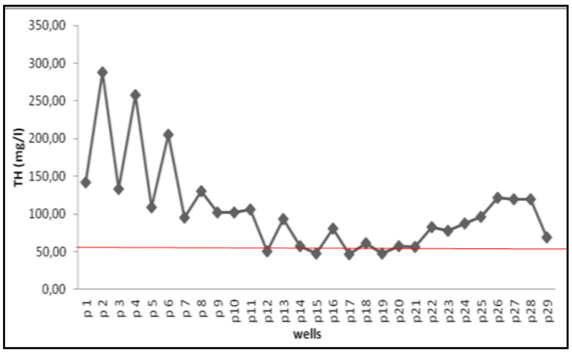

Fig. 6. Variation of Hydrometric Title of the points samples.

Chemical Characteristics

Biochemical oxygen demand in five days: The values of BOD_5 (Biological Oxygen Demand in five days) vary between 1.32 mg/l and 25mg/l. The maximum value recorded at fair P1 near the landfill and the minimum value is recorded in P26 (Fig. 7).

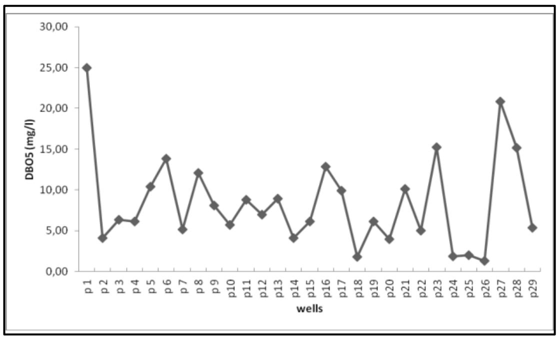

Fig. 7. Variation of BOD_5 of the points samples.

Chloride

The standard for chloride is 150mg/l. The results obtained show that the water Wells P15, P17 and P19 show levels below the so standard does not pose a risk. However, concentrations in the waters of the points P1, P2, P4, P5, P6, P7, P8, P9, P10, P11, P12, P13, P14, P16, P18, P20, P21, P22, P23, P24, P25, P26, P27 and P28 exceed the normative value, which may pose a risk to use this water for irrigation (Fig. 8).

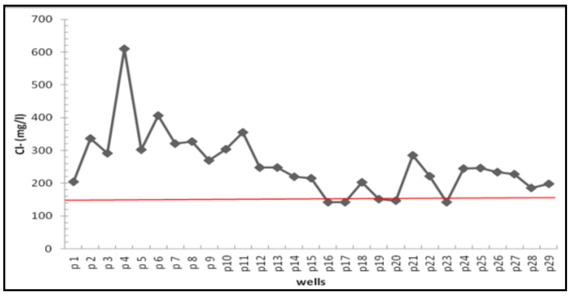

Fig. 8. Variation chloride taken in relation to irrigation standard (FAO, 1973).

Bicarbonate

For Bicarbonates the standard is 90mg/l (FAO, 1984). The results obtained show that the water shaft P3, P5, P8, P9, P11, P12, P15, P17, P19 and P21 have values below the standard in contrast to the concentrations in the water Wells (P2, P4, P7, P11, P13, P16, P18, P20, P22, P23, P24, P25, P26, P27, P28 and P29) That exceed the value of the standard, which Can pose a risk to use this water in 'irrigation. But the recorded value at well P1 is significantly greater than 250mg/l, which represents a significant risk (Fig. 9).

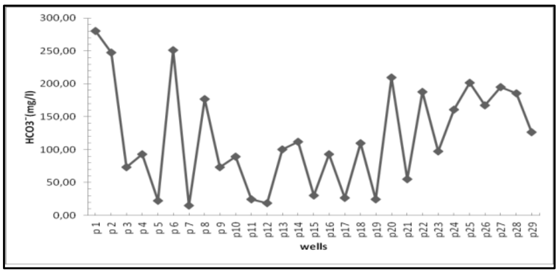

Fig. 9. Variation of bicarbonate collected in relation to irrigation standard.

Water Contamination metal

Pb, Cu, Fe, Ni and Mn are metallic elements characteristic of urban-type pollution (Bennacer *et al.*, 2000). This type of pollution is characterized by the presence of heavy metals whose impact is as serious analytically quantify.

Lead (Pb): Lead, one of the most harmful elements comes from corrosion debris of old pipes, smelting of ores, stripping stations and fuel combustion (Ma *et al.*, 1995). His analytical monitoring revealed a more or less important presence that can harm humans and the environment (Fig. 10). The measured values show an irregular and sometimes large water contamination of the aquifer. The minimum value of lead 0.035mg/l is registered at the Wells P25 and a maximum value of 1.1mg/l is recorded at the point P8.

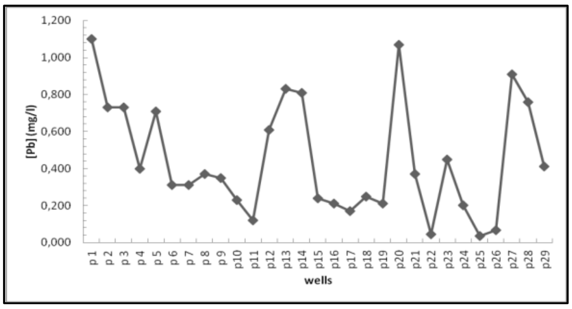

Fig. 10. Variation of Lead (Pb) of sampling points.

Copper

The maximum value of copper registered in Wells (P3) with 1.98 mg/l and the minimum value recorded in P17 Wells with 0.07 mg/l (Fig. 11). *The Iron:* The standard for iron is 0.2 mg/l (FAO, 1984). The results obtained show that almost all water from the wells values greater than the standard (Fig. 12). *Nickel:* The majority of the values observed in the Wells of the plain of Wadi Ziad are high. The high value is stored at the P17 with 0.209 mg/l and the minimum at P21 Wells with 0.018 mg/l (Fig. 13). Nickel released back into surface water is absorbed by sediments and suspended solids become immobile. However, in acid soils, nickel becomes mobile and can polluting the groundwater (Nordmyr *et al.*, 2008). *Manganese:* the standard is 0.1mg/l (FAO, 1984). The results show that water wells P17 and P23 have values below the standard which means there is no risk in the use of water from these Wells. However, concentrations in the waters of P3 and P7 well far exceed the value of the standard, which constitutes a serious risk to use this water for irrigation (Fig. 14). The existence of such contents has very serious consequences on the environment. It contributes to the pollution of groundwater, contamination of plants (Abe *et al.*, 2006) and can harm animals (Bikashvili *et al.*, 2001).

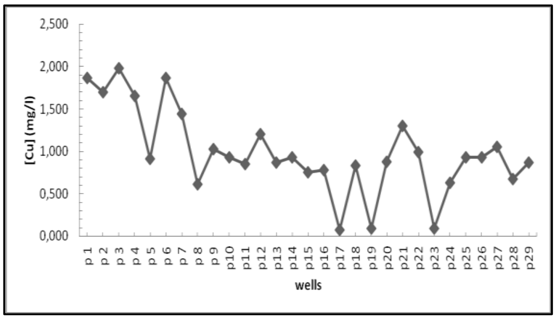

Fig. 11. Variation of Copper of sampling points.

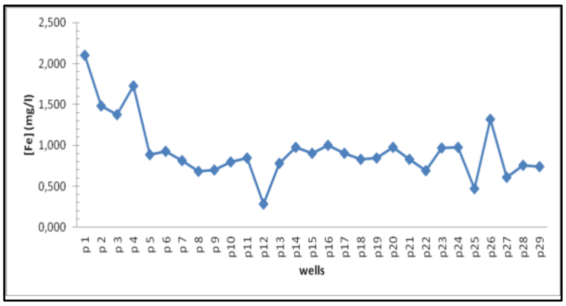

Fig. 12. Variation of Iron of the points levies.

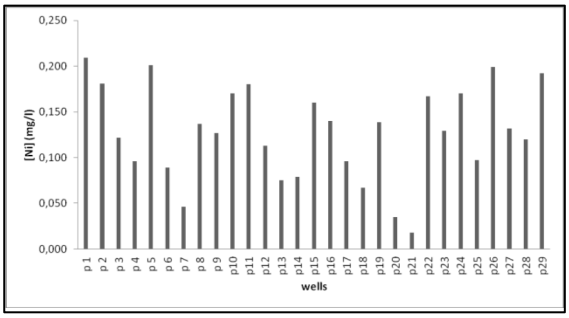

Fig. 13. Variation of Ni of the points levies.

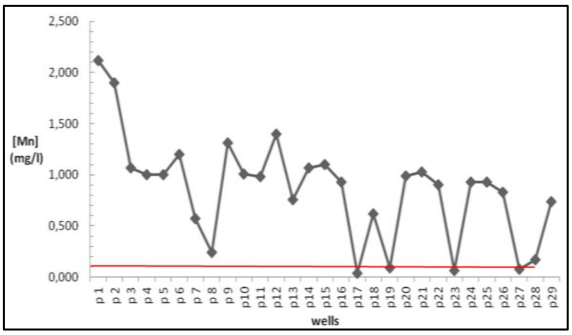

Fig. 14. Variation of Manganese collected in relation to irrigation Norm.

Criterion quality of irrigation water

There are several criteria for quality control of water intended for agricultural activity (Fig. 15). In the case of our study, we used the sodium absorption ratio (SAR). Beside this test, we used the Wilcox diagram. This method describes the power of alkalizing water. It is used to assess the potential risk of salinization. To control the negative effects of irrigation water on soil and plants.

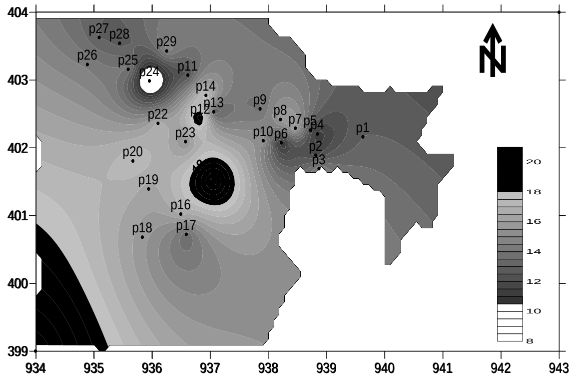

Fig. 15. Water Quality Map of the study area.

Sodium Percentage

In our study, boron has not been determined, we consider that the conductivity and Na%. When the Na^+ ions are very abundant in the dissolved state in the soil, they can replace Ca^{2+} ions in the absorbing complex (Base Exchange). The combination of electrical conductivity and SAR (Sodium Absorption Ratio) is used to discern the type of risk. The risk is even greater than the conductivity and SAR are high.

After postponing all water points in the Wilcox diagram (Fig 16), the following classes are highlighted:

- The class C2S3, C2S4, C3S2 characterizes eligible quality water. This category is present for 24.13% of the analyzed Wells. These are well P17, P19, P29, P12, P15, P18 and P23. Generally these waters are suitable for crop irrigation salt tolerant, on well-drained soils. Changes in salinity should however be controlled.
- The C3S3 class indicates water of poor quality, highly mineralized. The Wells belonging to this class are P5, P6, P7, P8, P9, P10, P11, P12, P13, P16, P20, P21, P22, P24, P25, P26, P27 and P28 (Fig15). 62.06% of water Wells tested are only suitable species much salt tolerant and well-drained soils.
- The C3S4 and C4S4 classes indicate poor quality water. They represent 13.80% of the analyzed Wells are as follows for the two classes: P1, P3, P4 and P2 that are just at the exit of the discharge. These waters are generally not suitable for irrigation, but can be used under certain conditions: very permeable soil, well washed, salt tolerant plants.

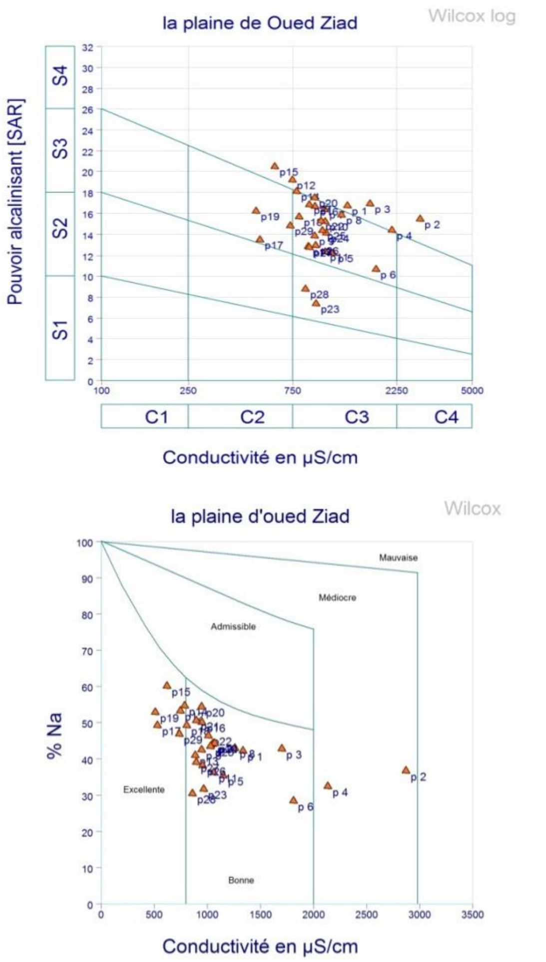

Fig. 16. Classification of groundwater in the plain of Wadi Ziad.

Conclusion

Our objective in this study was determining the impact of human activity through leachate. These percolas contain significant metal charge with high concentrations of metals, which by flow cause groundwater pollution confirmed by the levels observed in the 29 Wells. Discharge based on gneissic formations fractured with high permeability ($k \approx 10^{-5}$ $m.s^{-1}$), inducing deep groundwater pollution.

The physico-chemical analysis of water Wells in the area shows a sharp deterioration.

This is a pollution both physical, high conductivity, chemical and high salinity. The study of the spatial distribution of various contaminants showed the existence of a plume of pollution from neighboring Wells in the landfill and that tends to spread in the direction of flow of the water table. Which may cause toxicity to the consumer by the use of this water.

After this research, it appears that measures should be taken urgently:

- The immediate closure of the landfill.
- The establishment of a leachate drainage system and a Rainwater drainage system outside the site to minimize the production of these Leachate.
- Ensure that a good drainage underground. If a restricted indurated layer the movement of water through the root zone, water with a RAS (sodium adsorption ratio) greater than 6 or a salinity of 1.5 mmho/cm should not be used.
- Do not allow the soil to dry out unduly because given salinity, the plant can not take as much water than normal.
- Sample the soil regularly to monitor sodium.
- Restricted use: Use only in times of drought or when other water sources are lacking. Sometimes the cost and the risk is too great for us to use water.

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