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Physico-chemical study of the water table in the region of Mnasra, Morocco

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Abstract--The considerable increase in the leachate infiltration rate through the Oulad Berja landfill as well as agricultural activities in the Mnasra region have a detrimental effect on the quality of groundwater. The percolation of leachate through the unsaturated zone of the soil, towards the water table, could have serious consequences on the quality of water and the environment in general. Groundwater is the only source of drinking water supply for the rural population of the Mnasra zone. As part of the assessment of the water quality of wells in the Mnasra region, we analyzed 30 water samples taken from different wells during the year 2019-2020. The analyzes were carried out in the "ONEP" laboratories The comparison of the results obtained with the WHO standards revealed a high level of pollution compared to the recommended standards. These results made it possible to classify these waters in the bad to very bad category.

Keywords--physico-chemical, leachate infiltration, groundwater.

Introduction

It is known that the deterioration of the quality of water resources due to human activities constitutes a threat as important as that linked to the quantitative imbalance caused by the overexploitation of water resources. Like other countries in the world, Morocco does not escape the scourge of all forms of pollution of water resources, but human activity remains the main cause of the deterioration of their

quality. Groundwater contamination is a pollution problem that goes back a very long way. For example, the problem posed by nitrates has aroused great interest in recent years and has become one of the current global concerns; like the case of Taiwan [1]; Shanghai in China [2]; in the United States [3]; Hong Kong [4], etc. Arsenic contamination has also been the subject of numerous studies (Bhattacharya [5]; Bhattacharya and Mukherjee[6]; Nickson [7]; Berg [8,9]; Chandrasekharam [10], McArthur [11]; Smedley and Kinniburgh[12]; Stueben [13]; van Geen [14,15]; Dittmar [16]; Roberts [17] and Farooq [18]. Our study area is experiencing a more significant danger to the quality of its waters due to the low depth of the water table, and the sandy texture with high hydraulic conductivity of most soils. This makes the water table particularly sensitive to contamination by leachate from the Oulad berjal landfill. The objective of this work is to make the physico-chemical characterizations of this aquifer and to evaluate the impact of the discharge

Environment, Study method

Study environment

The Mnasra region is part of the Gharb basin and covers an area of approximately 600 km². It is a coastal strip 7 to 15 km wide and 70 km long, bounded by the city of Kénitra to the south, the Merja Zerga to the north, the Oued Sebou to the east and the Atlantic Ocean to the west. The point values of the depth of the piezometric surface of the Mnasra aquifer recorded fluctuate between 0.15 and 41.5 m. The aquifer is located at a depth of 5 to 6 m in the central area of Mnasra and deepens in the southern part between 6 and 24 m from the ground. The piezometric characteristics of the Mnasra groundwater table reflect the natural conditions of groundwater recharge by precipitation and its destocking by direct evaporation, as well as by outflows to the Atlantic Ocean [19]. Rainfall is an essential component of the hydrological cycle. In hydrogeology, and more specifically for groundwater, it conditions the supply and represents the first recharge factor. The annual rainfall of the city of Kenitra is 555mm over the past 33 years.

Study method

In this study and during the collection, handling and storage of the samples, the WHO Rules (good practices applicable by water quality control laboratories) were respected. 30 water samples were taken after 30 minutes of pumping to avoid stagnation and water contamination. The white plastic containers were rinsed 3-4 times with the water sample to be collected, then filled to capacity and immediately sealed to prevent exposure to air. After collecting the samples, the containers were labeled for identification and brought to the laboratory. The water samples were analyzed in the "ONEP" laboratory. The results obtained are processed by SPSS statistical software and by multi-language hydrochemistry software available for free distribution.

Physico-chemical parameters hydrogen potential (pH)

The average pH values of well water during the study period are 7.01 and 7.35, revealing a neutral pH (Figure 1).

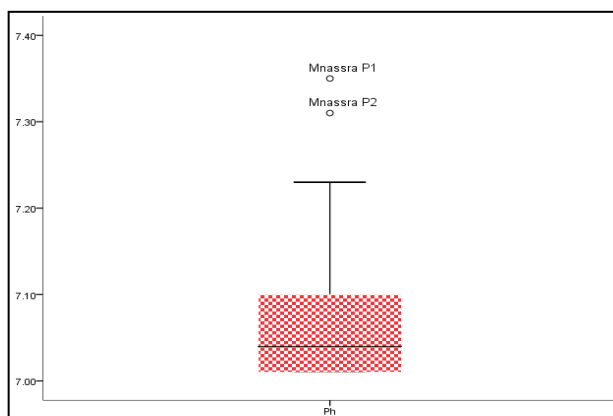


Figure 1. Annual variation in groundwater pH

These results are similar to those found by Belghiti [21] for the Meknes region. The analysis of these waters revealed that the pH is close to neutrality, for all the wells, the average pH values at the level of the study area were within the drinking water standards of groundwater.

Conductivity

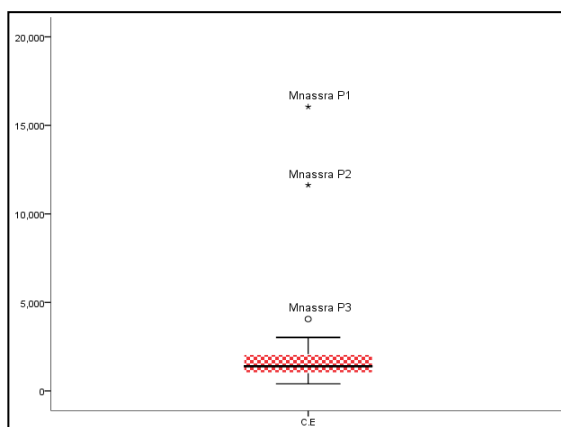


Figure 2. Annual variation in groundwater conductivity ($\mu\text{s}/\text{cm}$)

Mean groundwater conductivity values ranged from 16050400 $\mu\text{s}/\text{cm}$ to 16050400 $\mu\text{s}/\text{cm}$; The results obtained show a very significant variation in mineralization between the three wells close to the landfill and the rest of the wells. The average value of this conductivity in wells located far from the landfill is 1419 $\mu\text{s}/\text{cm}$. According to the simplified grid for the assessment of the overall quality of groundwater, this water is of average quality with an electrical conductivity between

1300-2700 $\mu\text{s}/\text{cm}$. On the other hand, the conductivity values of the three wells near the landfill exceed 3000 $\mu\text{s}/\text{cm}$ which classifies these waters of very poor quality.

Nitrates (NO_3^-)

Nitrates are listed among the main categories of chemical pollutants found in water [22]. They are chemical compounds made up of nitrogen and oxygen and are necessary for plant growth. However, their excessive presence in the soil can contaminate different water sources and raise health concerns. Indeed, nitrates are easily leachable pollutants and reach the aquifer without undergoing any significant modification. The problem posed by nitrates has aroused the maximum interest in recent years and has become one of the current global concerns, the case of Taiwan [2]; Shanghai in China [3]; in the United States [4]; Hong Kong [5], etc.

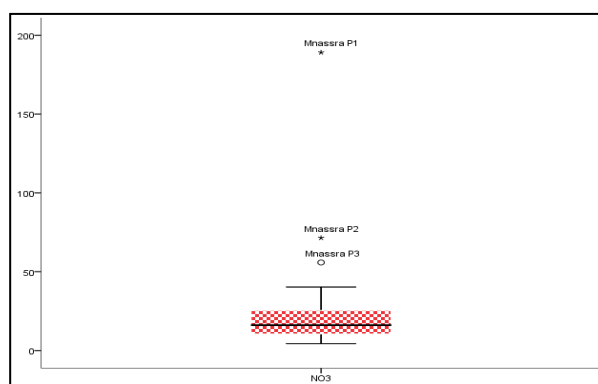


Figure 3. Annual variation of nitrates (mg/l) in groundwater

In the area studied and as shown in Figure 3, the nitrate levels varied between 34.96 mg/l and 489.1 mg/l. These values greatly exceed the standards of European Directive 98/83/EC, (Decree N° 2001-1220 of December 12, 2001), and European Directive 75/440/CEE of June 16, 1975 concerning the quality required for drinking water (50 mg/l in nitrates). Pollution by nitrates in groundwater waters originates from the excessive use of fertilizers and pesticides as well as the filtration of leachate from the Oued Berjal landfill, and the same result has been confirmed internationally by several studies [23-24]. Several articles have been published internationally to show the risk caused by the accumulation of nitrates in drinking water, whether in the short term on infants or in the long term on health [2,4,25,26]. This confirms the importance of the Moroccan state program aimed at limiting the anarchic use of nitrates and pesticides.

Ammonium (NH_4^+)

Ammonium in water usually reflects a process of incomplete degradation of organic matter. Ammonium comes from the reaction of iron-containing minerals with nitrates. It is therefore an excellent indicator of water pollution by organic discharges of agricultural, domestic or industrial origin.

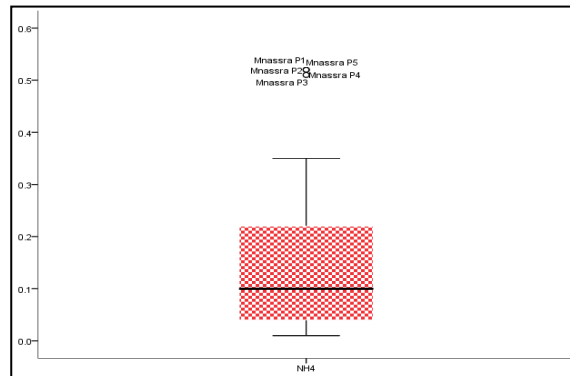


Figure 4. Annual variation of Ammonium (NH_4^+ mg/l) in groundwater

The ammonium (NH_4^+) level of groundwater is 0.55 mg/l. In comparison with the usual standards (WHO, 1986[27]), this rate is higher than the acceptable standards

Chlorures

The average chloride level per well is 415 mg/l with a minimum value of 72.32 mg/l and a maximum value of 3308 mg/l (Figure 5). These levels exceed the WHO standard of 100 mg/l.

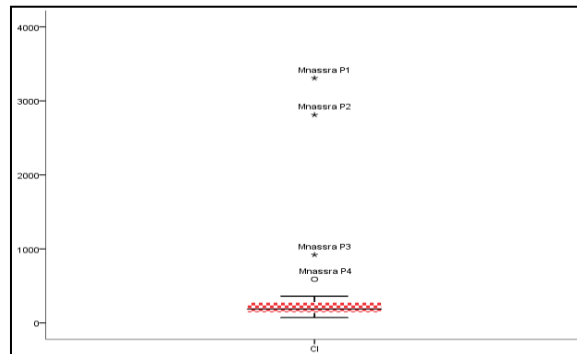


Figure 5. Annual variation in chloride levels (mg/l) in groundwater

Sulfates (SO_4)

The Mnasra aquifer has sulphate contents between 102.8 and 624 mg/l and which exceed 250 mg/l (limit value acceptable by WHO).

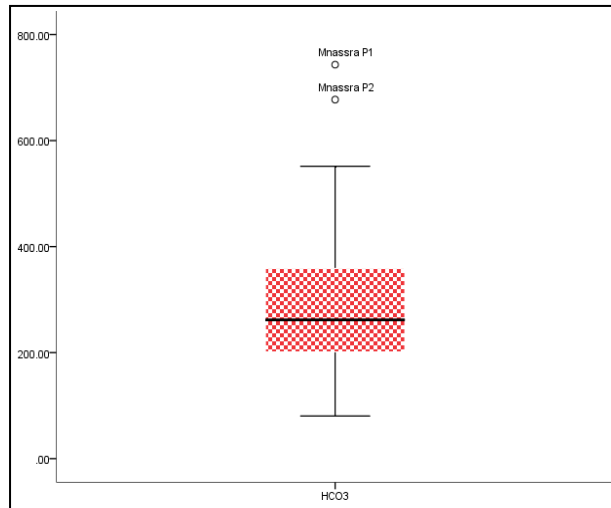


Figure 6. Annual change in sulphate (mg/l) levels of groundwater

This slick is therefore very sulfated especially at the level of the wells near the landfill and which show a strong contamination due to the infiltration of the leachate.

Piper diagram

The software used is the free multilingual hydrochemistry software from Roland SIMLER of the Hydrogeology Laboratory of Avignon Version 6.1 of 24-10-2014 for the preparation of the piper diagram.

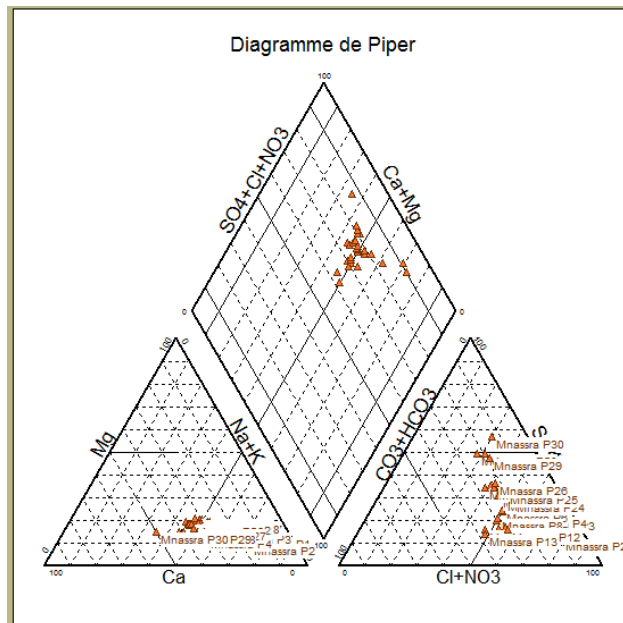


Figure 7. Piper Diagram of Groundwater Waters

The representation of the water analysis results of the wells of the Mnasra aquifer on the Piper diagram indicates that there is little diversity. The vast majority of waters are of the magnesium-calcic type, more or less bicarbonated. For the present study, the applied classification protocol refers to European standards [28]. The latter is systematically applied to drinking water classifications [29, 30, 31, 32, 33, 34] and seems to be more consensual [35].

Typology of wells according to physico-chemical parameters

Principal component analysis (PCA) was performed on a data matrix composed of 30 rows representing the analyzed wells prospected and 14 columns representing the physico-chemical variables measured or analyzed (Table 1 and 2). Examination of the numerical results of this PCA shows 90% of the variability captured. The first component F1 is composed of the following parameters: hydrogen potential, electrical conductivity, NO_3^- , Cl^- , SO_4^{2-} , HCO_3^- , Hardness, Ca^{2+} , Mg^{2+} , Na^+ , K^+ , TDS which are positively correlated. The second component, with 10% of the captured variability, it is formed by CO_3^{2-} and hardness which are negatively correlated with this axis.

Table 1
Component Matrix

	Component	
	1	2
PH	0.941	0.040
C.E	0.981	0.019
NH_4^+	0.219	-0.372
NO_3^-	0.940	0.021
Cl^-	0.981	-0.008
SO_4^{2-}	0.974	0.000
HCO_3^-	0.909	0.143
CO_3^{2-}	-0.114	0.790
TH	-0.105	0.859
Ca^{2+}	0.992	0.012
Mg^{2+}	0.993	0.044
Na^+	0.985	-0.009
K^+	0.990	0.015
TDS	0.995	0.001

Table 2
Component Transformation Matrix

Component	1	2
1	0.9	-0.1
2	0.1	0.9

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.

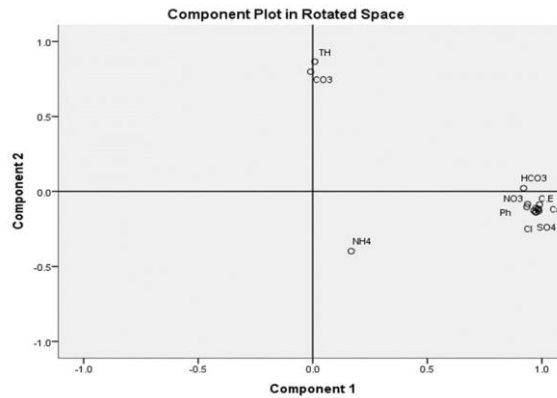


Figure 8. Projection of the 30 prospected wells on the PCA F1-F2 factorial plane

Conclusion

The diagnosis of the physico-chemical parameters indicators of pollution of the 30 wells of the Mnasra region of the city of Kenitra allowed us to conclude: the wells have a temperature and a pH lower than the standards of the standard committee of Morocco (CNS, 1994). All of the parameters studied show values that greatly exceed the concentration limit for direct discharge according to (CNS, 1994), and these parameters place these waters in the poor to very poor quality range. The physico-chemical parameters indicators of pollution allowed us to deduce that the wells close to the discharge (1 to 5 km) are heavily loaded compared to the other wells. This research shows that it is necessary for groundwater in the Mansra region to be monitored on a time and space scale in order to implement means of protection, particularly with regard to agricultural and industrial inputs and landfill leachate, which are the main presumed sources of pollution of these groundwaters.

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