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RESEARCH PAPER

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Physico-Chemical and Bacteriological Impact on Well Water from the City of Sidi Slimane, Morocco

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ABSTRACT

In the current context of sustainable water resources management policy, the prediction of the risk of pollution and protection of these resources are of paramount importance. For this, the backup medium and long term, the quality of these resources is essential. Industrial development in Morocco has made this worrying situation for all socio-economic stakeholders. Indeed, this economic growth is marked in recent years by the establishment of factories and repair facilities that discharge liquid waste into rivers.

Medium, equipment and method of study

Milieu of study

The city of Sidi Slimane is located along the Gharb plain 70 km from Kenitra. It is the capital of the same name circle, depending on the province of Kenitra (**Figure 1**).

The region of Sidi Slimane is marked by the oceanic influence. The average rainfall is 445 mm. The average temperature ranges from 10 ° C in January to 26 ° C in July and August.

Sampling and analysis of water wells

The samples were taken on 6 wells, three wells (P1, P2, P3) are located in Wadi Beht Upstream, another two are adjacent downstream (P4, P5 and P16). These samples are filled into plastic bottles and transported to the laboratory of ORMVAG, Kenitra. To better exploit the data collected, we spread the wells into two groups depending on the distance that separates them from the source:

- Group1 where the wells are within the Oued compound wells 1; 2 and 3.
- Group 2 is composed of well in the downstream (4, 5 and 6).

The physical-chemical and bacteriological parameters studied are: pH, conductivity, calcium, chloride, Nitrats, Hardness, Total Coliform, Fecal. The dosage of the parameter studied according to NF EN ISO 11885.

RESULTS AND DISCUSSION

Study of the spatial variation of physicochemical parameters of well water

Potential of hydrogen

The pH is difficult to use as indicators of pollution as there is no relationship between pH and contaminants. The pH depends on the origin of water, the geological nature of the substrate and through the watershed. It is very sensitive to temperature, salinity, and the respiration of the organisms [Alexander and Wood, 2005].

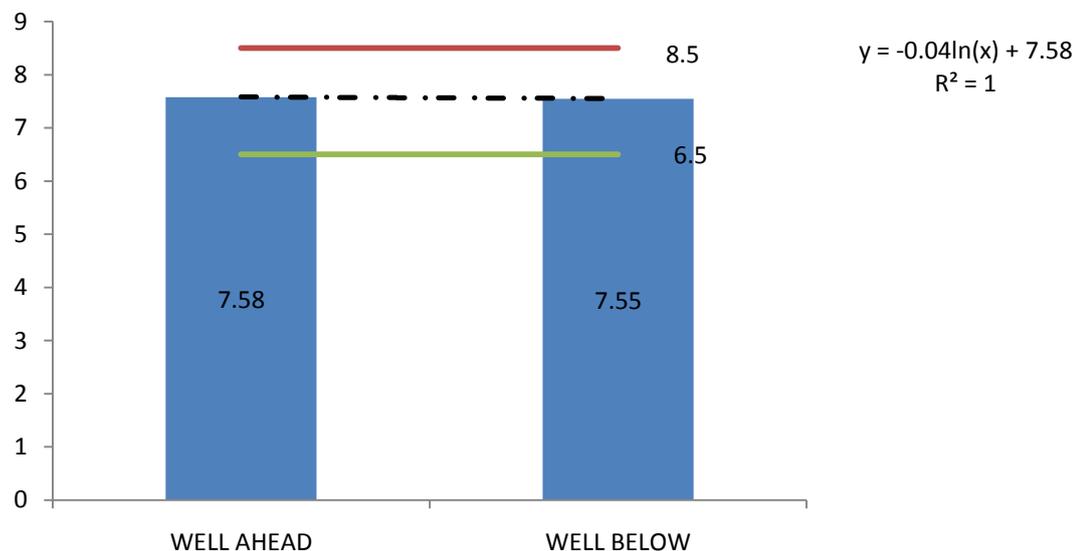


Figure 2. Evolution of the hydrogen potential of water wells depending on the distance.

For irrigation water, generally the recommended pH is between 6.5 and 8.5, for low pH promotes the growth of filamentous fungi and other responsible bodies floating sludge(**Figure 2**).

The measured pH values are acceptable according to the water quality standards of human alimentation NM 03.7.001 which are generally between 5.5 and 8.5. and for disinfecting water with chlorine to be effective, the pH must be smaller 8.

Electrical conductivity (EC)

The electrical conductivity is a good marker of the Origin of water, it reflects its total mineralization. Indeed, the conductivity measurement used to assess the amount of dissolved salts in water.

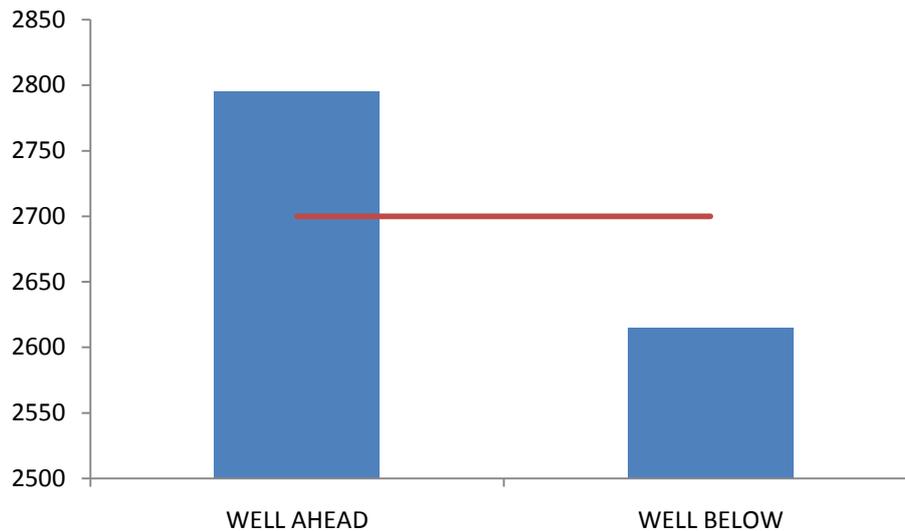


Figure 3. Evolution of the electrical conductivity of water wells in function of the distance (µs/cm).

However, groundwater wells along Oued Beht show high mineralization of around 2795µs / cm This pollution is two mechanisms: direct contamination that occurs career level Oued Beht and is due to contact with the water table dating back to the bottom of quarries; indirect contamination due to seepage through the ground and not saturated permeable general area (**Figure: 3**). It is favored by the shallowness of the water table (4 m). These results are consistent with those obtained by [Kharmouz et *al.*] and greater than those found by [5]. Many factors could locally influence the conductivity of a water such that the amount of matter inorganic or organic suspended the physicochemical quality of urban discharges, agricultural or industrial and evaporation phenomenon.

Therefore determined the average value is greater than 2.7 mS / cm, considered as limit value quality standards of human alimentation waters NM 03.7.001. Therefore, water wells group 1 is unacceptable for human consumption and those of group 2 are somehow to national standards.

Calcium (Ca²⁺) (mineral)

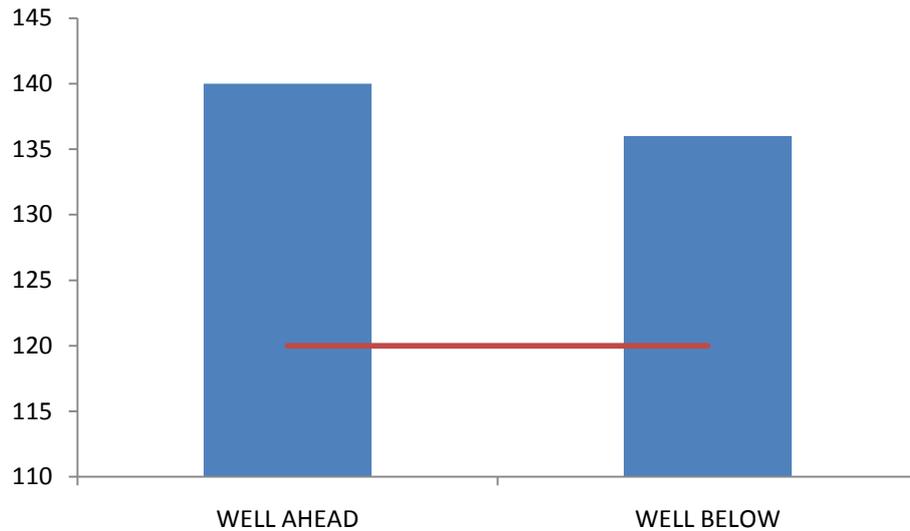


Figure 4. Evolution of the calcium water wells depending on the distance.

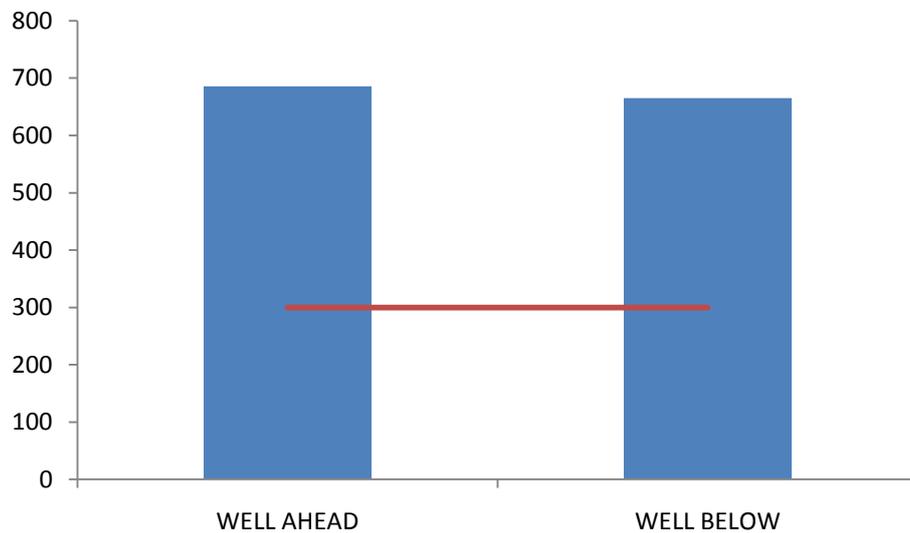


Figure 5. Evolution of chloride water wells depending on the distance.

A possible negative correlation was marked between the distance between the well source and also the Ca^{2+} content. From **Figure (4)**, these values often exceed accepted standards for drinking water for group 1 and 2. This indicates a pollution of groundwater by calcium probably from the pollution Wadi.

Chloride (Cl^-)

Too rich waters chlorides are corrosive and laxative, The concentration of chlorides in the water also depends on the terrain crossed.

The chloride ion is a very mobile element that easily migrates to the underlying layers, it is not affected by the phenomena of adsorption or ion exchange, it is not involved in acid-base balance or redox and it is not retained by the clay soil humic complex.

The values found in the wells do not respect Moroccan standard (750mg / l) (**Figure : 5**).

According to the grid this groundwater Classified bad qualities (750-1000 mg / l), by against the water quality at the City of Sidi Slimane. (According to Moroccan standards for the potability of water, the recommended maximum chloride concentration (CMR) is 300 mg / l).

Nitrate (NO₃)

Nitrates are present in the water leaching of nitrogen compounds in the soil, decaying organic matter or synthetic fertilizers or natural [Samake, 2002]. Nitrogen is an essential element in building the cell.

The evolution of the content of NO₃⁻ according to month shows that these two variables are highly correlated ($R^2 = 0.82$). This trend is growing for the season yesterday, for spring peaked in summer and fall after her fall. This difference between months one hand and between the other seasons was not significant ($F = 0.082$; $p = 1.000$). The nitrate concentration observed in the wells of the M'nasra area is a function of the depth of the well and cultivated crops. Furthermore, an overdose of nitrogen fertilizer and irrigation bad practice have an effect on pollution of shallow groundwater.

The use of synthetic fertilizers and manures, associated to crops and intensive livestock promotes the appearance of nitrate. The nitrate concentration is primarily due to kinds of waste.

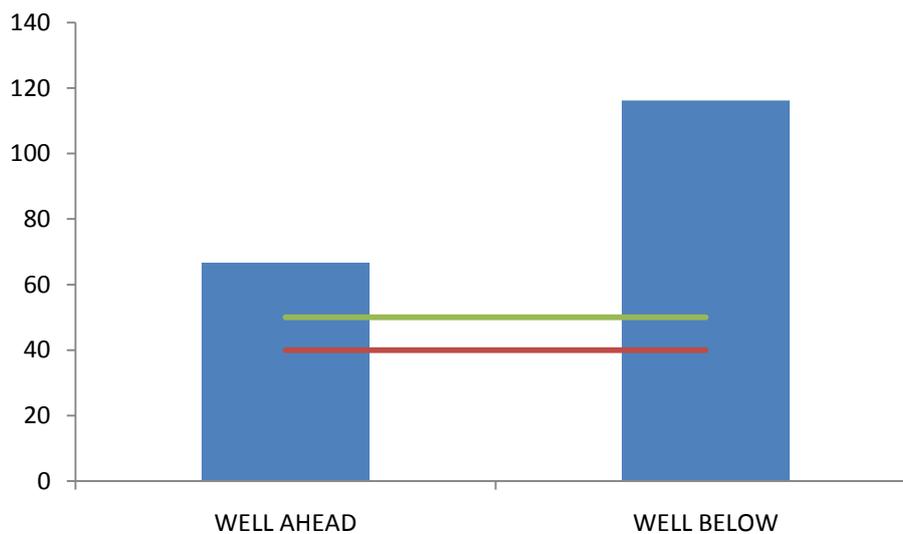


Figure 6. Evolution of nitrate water wells depending on the distance.

Many authors have conducted studies at the M'nasra zone [Moussaoui et al., 1994] have confirmed that 74% of 189 wells sampled show levels exceeding 50 mg / l (**Figure 6**).

Several factors, such as lithology of the exploited aquifer, irrigation and excessive pumping, rainfall and low depths of the water table from the ground, are responsible for the pollution of groundwater by nitrates and salts .

reported that one of the problems encountered in areas of intensive agricultural activities is the contamination of groundwater by nitrogen compounds from fertilizing crops and mismanagement of irrigation system that to effect a rapid increase in nitrate concentrations found in groundwater. Ingesting nitrates can cause methemoglobinemia in children, the

Environmental Protection Agency US has specified 10 mg/l NO_3^- or 44 mg/l NO_3^- like water potability threshold

Research efforts are then focused on farming practices that reduce the amount of chemicals such as nitrates and pesticides. Indeed, the results do not meet Moroccan standards (45 to 50 mg / l), and according to the grid groundwater, they are classified poor (50-100 mg / l) to very poor (> 100mg / l).

Hardness: calcium (Ca^{2+}) + (Mg^{2+}) (mineral matter)

The total hardness of a water is produced by calcium and magnesium salts contained therein.

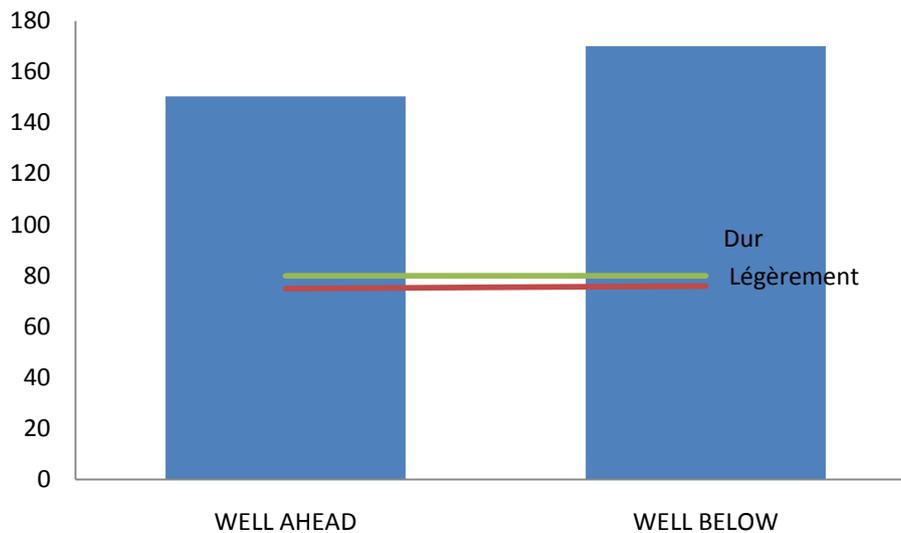


Figure 7. Evolution of the hardness of water wells depending on the distance.

Furthermore, concentrations of upstream wells recorded as far exceed those set appropriate limits, by the Moroccan authorities. These values indicate that the waters especially the first two groups are assumed to be very hard (**Figure 7**). The total hardness of a water is produced by calcium and magnesium salts contained therein.

This parameter has a great variation would be related to the lithology of the aquifer and in particular its composition magnesium and calcium. Rock formations containing divalent metals (Mg^{2+} , Ca^{2+} ) responsible for the hardness.

Study of the spatial variation of bacteriological parameters of well water

Coliform Totals

Total coliforms are used for a long time as indicators of microbial water quality because they can be indirectly associated with faecal pollution. Total coliforms are defined as rod-shaped bacteria, facultatively aerobic or anaerobic, having the β -galactosidase enzyme for the hydrolysis of lactose at 35°C. The main genera included in the group are: *Citrobacter*, *Enterobacter*, *Escherichia*, *Klebsiella* and *Serratia* [CEAEQ, 2000].

Almost all species are non-pathogenic and do not represent a direct risk to health [OMS, 1992], with the exception of certain strains of *Escherichia coli* and rare opportunistic pathogens. the fermentative power of lactose is the most important characteristic for distinguishing other Enterobacteriaceae [Rodier J. 1984, Sadek Sanae et al., 2014]

Table 1. Descriptive statistics of Coliform Totals (CFU / 100ml).

Variable	observations	Minimum	Maximum	Average	Standard deviation
CT	6	0,000	7×10^4	6×10^4	423.563

The group P4, P5 and P6 is characterized by levels of Total Coliforms (CT) élevées. Ces very well have a bad bacteriological quality of water (**Table : 1**).

Fecal Coliform

Fecal coliforms or thermotolerant coliforms are a subgroup of total coliforms able to ferment lactose at a temperature of 44.5 ° C. The species most commonly associated with this bacterial group is *Escherichia coli* and to a lesser extent, some species of the genera *Citrobacter*, *Enterobacter* and *Klebsiella* [Edberg et al., 2000, Khattabi 2001, Leclerc, 1982 and Goher et al., 2014]. Although the presence of fecal coliform generally a sign of fecal contamination, several coliforms are of fecal origin rather from waters enriched in organic matter, such as industrial tributaries of the pulp and paper industry or food processing [Goher et al., 2014, El-Bouraie et al., 2010, Aktar et al., 2010]. This is why it would be more appropriate to use the generic term "thermotolerant coliforms" rather than "fecal coliform". The fecal coliforms are weaker in water than fecal streptococci. Their presence indicates a contamination less remote in time or space that the presence of faecal streptococci. They are not necessarily dangerous in themselves, but their presence means that most other pathogens, but also more difficult to search, may also be present. The following table presents the results of analysis of germs of CF.

Table 2. Descriptive statistics of Fecal Coliform (CFU / 100ml).

Variable	observations	Minimum	Maximum	Average	Standard deviation
CF	6	0,000	11	5×10^4	4,980

Wells P5et P6 have a bad bacteriological quality of water, this group is characterized by levels of fecal coliform (*E. Coli*) high [Singare et al., 2012](**Table: 2**).

CONCLUSION

The study of parameters indicative of contamination of river waters Baht, allowed us to identify a mineral and organic water contamination of the aquifer. Indeed, it is the water collected from wells 1, 2 and 3 are located are located in Wadi Beht Upstream and in the flow direction of the web which are less vulnerable to contamination mineral, organic and inorganic and.

While the water collected just downstream of the wadi located well Baht show very high levels of contamination in some physicochemical parameters and also it has a high bacteriological contamination.

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