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Temporal evolution of the qualitative parameters relating to groundwater of well fields of Ahmed Taleb, Aïn Sebaä and Sidi Taïbi, Morocco

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Abstract
Water resources exploited by the Moroccan National Office of Drinking Water (MNODW), in the fields of Ahmed Taleb, Ain Sebaä and SidiTaïbi are threatened by several pollution caused by urban, agricultural and industrial development, in particular, waste water from neighboring agglomerations which do not have a sanitation system, household refuse, quarries used as dumps for various discharges, roads and agricultural activities.In order to highlight the temporal evolution of groundwater quality in these three localities, the variation of the different parameters characterizing the groundwater quality from 1995 to 2015 has been plotted. It is generally shown that organoleptic, physico-chemical parameters, sulphate, chloride and trace element contents comply with Moroccan standards for the groundwater quality intended for human consumption. It is also shown that the nitrate, nitrite and ammonium levels occasionally exceed the Moroccan standards which may be due to the importance of anthropogenic influence in the vicinity of the studied wells. These findings were confirmed by the bacteriological analysis results.

1. Introduction

Water resources exploited by the National Office of Drinking Water (NODW) of Morocco, at the level of water catchment areas: Ahmed Taleb, AïnSebaä and SidiTaïbi, located in the Gharb plain, are increasingly threatened by the pollution caused by urban, agricultural, industrial and craft development. Indeed, the focus points of pollution have multiplied over the past two decades in the region, where no protection measures of the environment in general and water resources in particular are in place [1], exposing these two latter potential risks of continuous or episodic alterations. Voluntary or involuntary ignorance and non-compliance with urban planning regulations, classified establishments, quarries, the transport of hazardous materials, etc., has only engraved the risks which weigh on water resources in the three localities.

The purpose of the present work is to exploit the analyzes of water operated by the National Office of Drinking Water at the level of the water catchment areas: Ahmed Taleb, Aïn Sebaä and Sidi Taïbi and which cover 20 years (1995-2015) in order to highlight the evolution in time of the nitrates, nitrites and ammonia which are elements characteristic of the quality of groundwater, at the three localities mentioned above.

2. Material and Methods

2.1. Localization of catchments and the various sources of pollution

2.1.1. Ahmed Taleb

The catchments of Ahmed Taleb were made in 1951. They are located in close proximity to the national road 1 linking the city of Kenitra to Larache to approximately 4 km NE of Kenitra. The water catchment area of Ahmed Taleb is composed of six wells divided into two areas: Area (A) and Area (B) (Figure 1).The main sources of pollution which prevail there are: Tow quarries, their vulnerability against the pollution is due to the decreased distance between the ground and the water table level. The problem arises especially for the quarry located just upstream of the area (B) and where the water table is flush by location. This quarry is currently used as a dump of solid household or industrial waste, then, there is also the seaweed processing plant SETEXAM which uses the seaweed such as raw material to produce the Agar-agar [2].

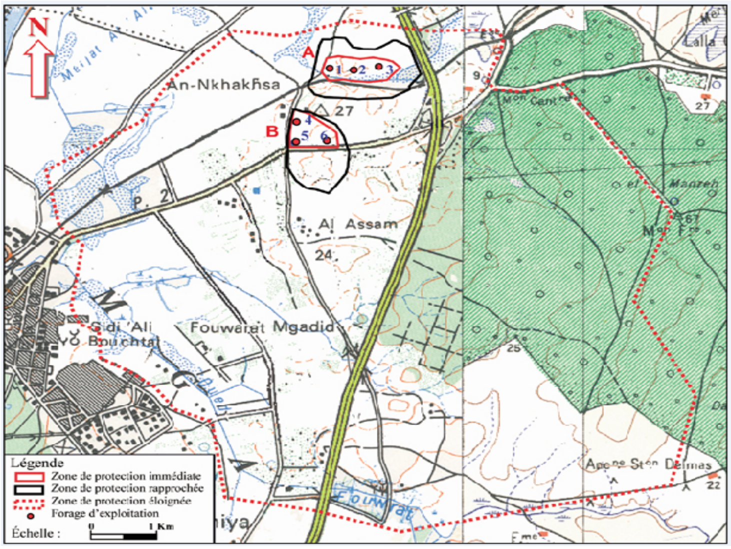


Figure 1: *Location area of the catchments of Ahmed Taleb(Area A and Area B)*

2.1.2. Ain Shebaa Gallery

It is located about 4 km SE of Kenitra and has a length of 1200 m (Figure 2). It is linked to the surface of the ground with at least 9 wells for the maintenance (Grit Removal), two of them are equipped with a pump for drawing water, these are the top and bottom wells. Two canned olive factories, with respective production capacities of 70 and 100 L/s, represent the main source of pollution of waste water olive. This adds up to the pollution caused by the slums which represent 60 % of scattered rural settlements [2].

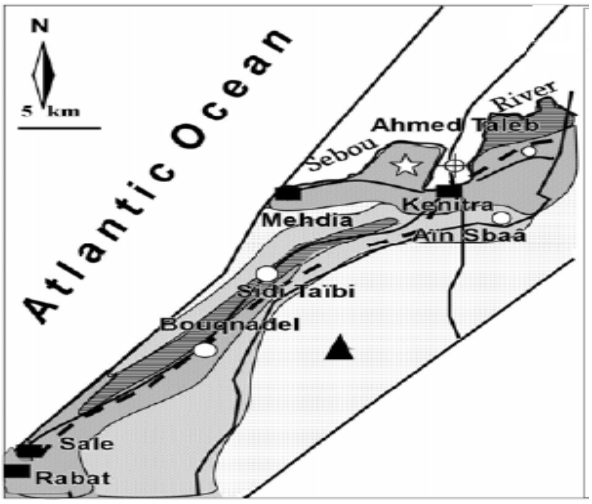


Figure 2: *Location area of AînSebaä*

2.1.3. *SidiTaïbi*

The four catchments of SidiTaïbi are located near the National Road 1 connecting the city of Rabat to Kenitra about 13 km south of Kenitra (Figure 3).

Among the main sources of pollution, there are four quarries used as a dump of solid household or industrial waste, on top of that there is the pollution generated by the weekly Souk located in the feeding area of SidiTaïbi's watershed, this souk is equipped with slaughterhouses that can receive 5 to 10 cattle and 50 sheep a week. Its discharges are transported to a large lost well and infiltrate in the ground water [3, 4]. On the other hand, at the level of these three localities, groundwater is permanently threatened by the pollution caused by wastewater, garbage, the wells of individuals operated with the help of pump motors for irrigation. Here the risk of pollution arises from the spillage of hydrocarbons during the exploitation and maintenance operations, and then there are phytosanitary products, given that in these three localities the most pesticide consumer crops are vegetable farming and fruit cultivation and in these regions the use of fertilizers is very dominant [5-8] that the infiltrated water can contain up to 282 mg NO_3^-/L [3]. These Nitrates are easily leachable pollutants and reach the aquifer without modification [9]. According to the literature,the groundwater contamination by nitrates in areas of intensive agriculture has been largely discussed [10].

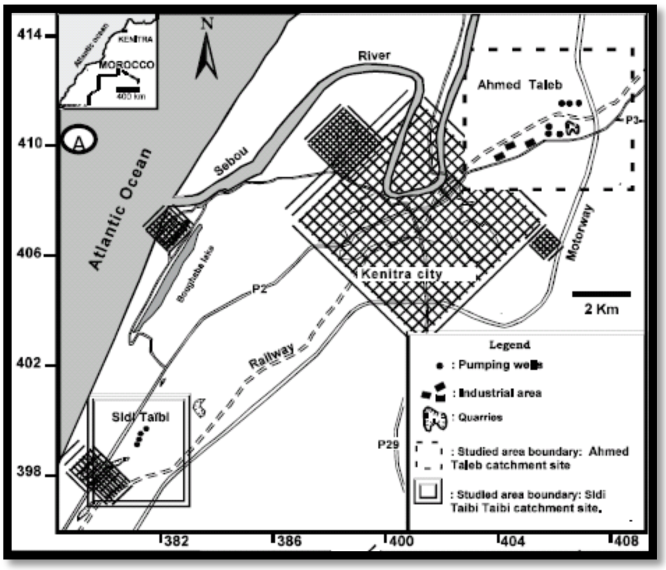


Figure 3: *Location area of SidiTaïbi's catchments*

2.2. Groundwater Pollution Control Parameters

In order to appreciate the impact of pollution sources in the National Office of Drinking catchments, several pollution indicators are used, their list cannot be exhaustive, given the evolutionary nature of analytical methods and the appearance of new polluting substances.

These determinants are: Organoleptic parameters (Temperature and turbidity), physicochemical parameters (pH and conductivity), chemical composition (Nitrate, Nitrite, Ammonium, Sulphate, Chloride and trace element content), and microbiological parameters (microorganisms indicating fecal contamination, in other words, a contact with wastewater (fecalcoliforms, fecal streptococci and total coliforms) [11].

Furthermore, the groundwater vulnerability mapping is a methodology that has become imperative in order to ensure the quality management of water resources and the protection of the catchments of drinking water [12,13]. Hence,it appears necessary and unavoidable, because it allows identifying areas sensitive to potential pollution. It also allows guiding the development of the territory [14,15].

In order to highlight the temporal evolution of groundwater quality at the three localities: Ahmed Taleb, SidiTaïbi and AïnSebaä, curves reflecting the variation in the various parameters characterizing the quality of groundwater in function of the different sampling dates covering 20 years have been established.

In addition, in order to fully appreciate the impact of the sources of pollution on the catchments, and to confirm that some chemical contaminants exceptionally exceeded the standards, microbiological analyses are conducted at a rate of two samples per month during the period January 2015/ June 2015 at the three communities and which have concerned the search of germs pollution indicators (Flora Aerobic Mesophilic Total (FAMT); Total Coliforms (TC); Fecal Coliforms (FC); Fecal Streptococci Aerobic(FSA); Sulfito-Reducing Organisms (SRO)) and *Pseudomonas aeruginosa* (PA).

The bacteriological parameters of groundwater in the three localities have been determined according to the protocol for the analysis of Rodier [16] reported by Belghiti [17].

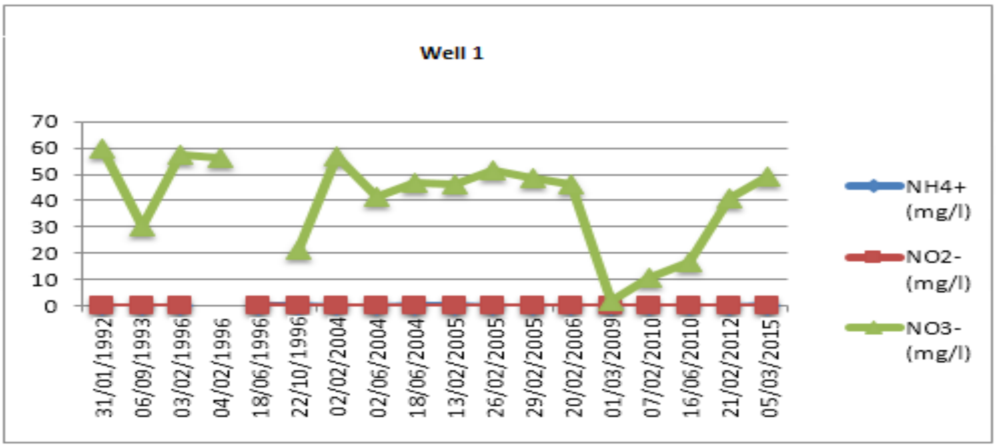
A Millipore membrane of 0.45 µm was used to sterilely filter, 100 mL of water to be analyzed or diluted with a filtration device. The enumeration of the FAMT, TC, FC, FS, ASR and PA, has been carried out respectively on appropriate culture medium (Agar Plate Count Agar (PCA), agar medium Tergitol at TTC 7, Agar Agar medium Tergitol at TTC 7, Agar medium Slanetz and Bartly, agar medium SPS and mid cetrimide).

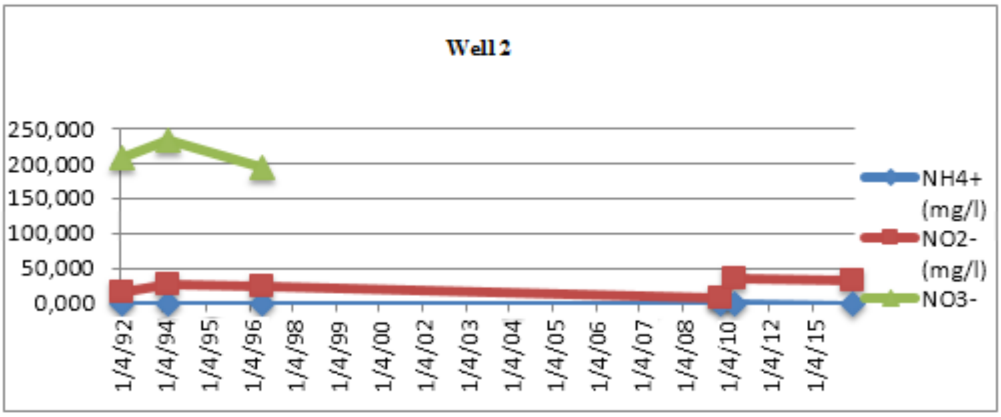
3.1. Chemical contaminants

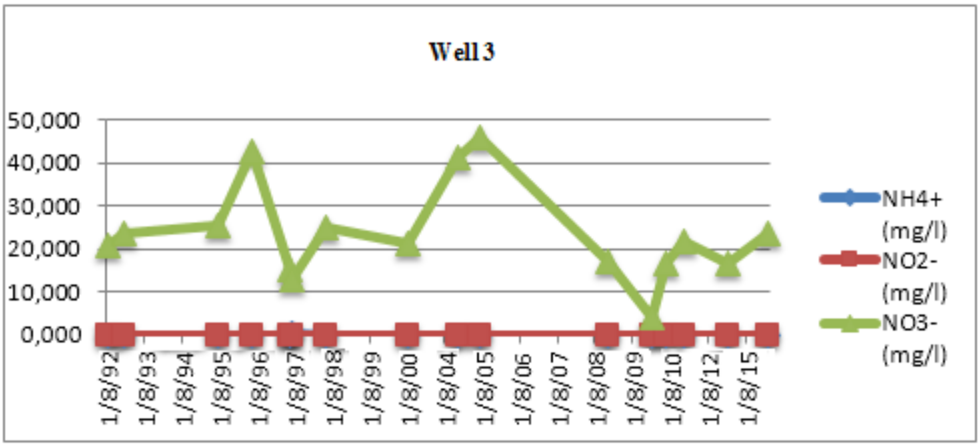
3.1.1. Ahmed Taleb:

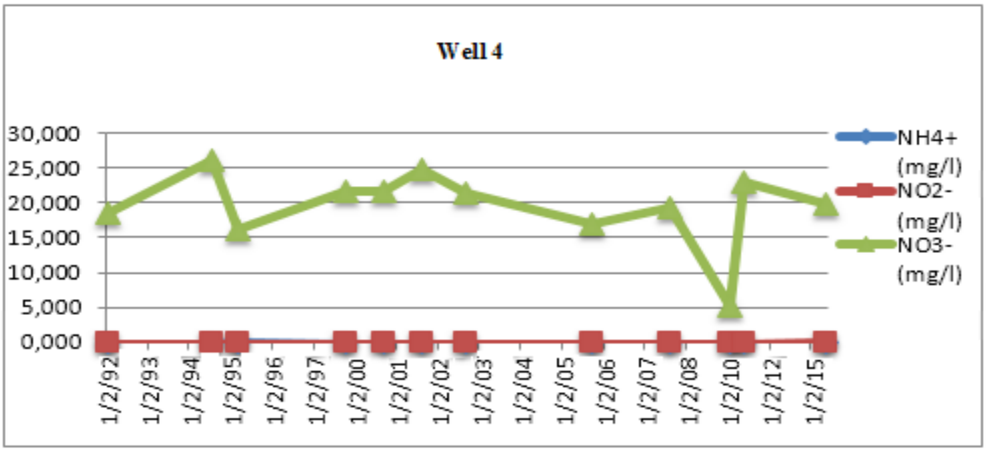
Figure 4 represents the time variation in levels of nitrates - nitrites and ammonium (water catchment area: Ahmed Taleb). No exceedance of the ammonium values at the six Ahmed Taleb wells has been recorded; they comply with the standard drinking water value (0.5 mg /L) [18]. Same observation for nitrites whose standard drinkingvalue is 0.5 mg /L [18]. It is also noted that the norms of the drinking watervalue for nitrate (50 mg/L) [19] has been exceeded according to the following frequencies:

↪ 5 times for the well (1) and 3 times for the well (2), this can be explained by the importance of the anthropogenic influence in the vicinity of these wells.
↪ 1 times for the well (5)









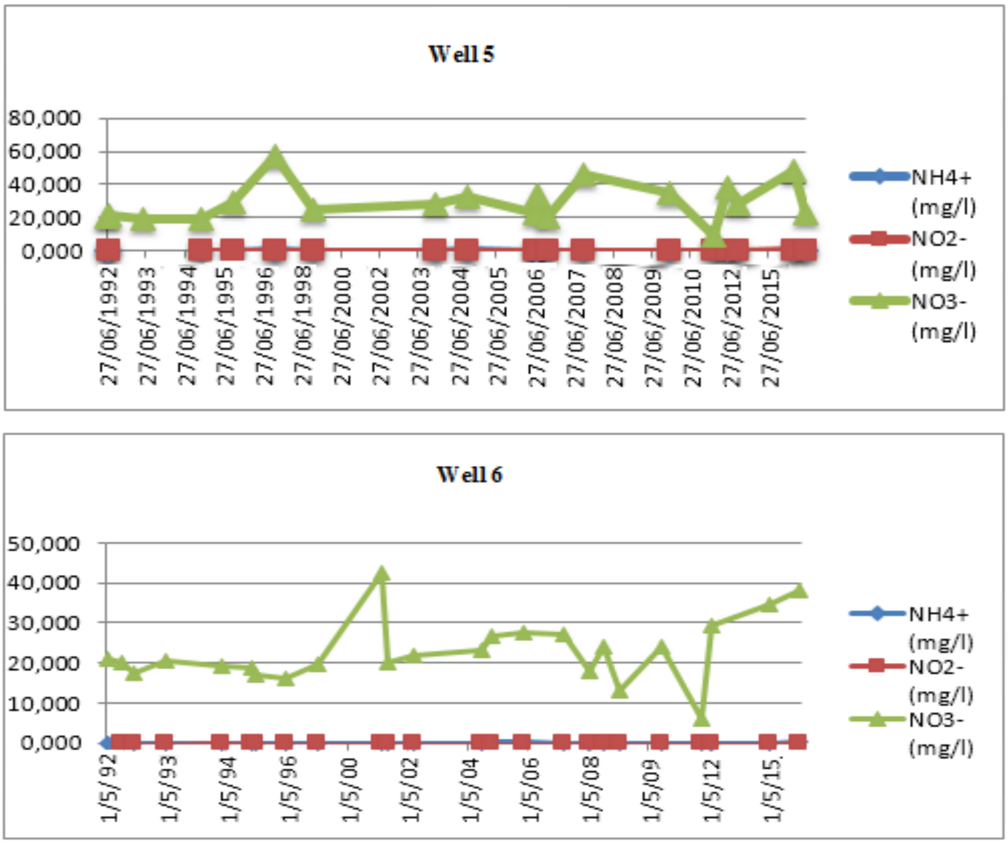


Figure 4: *Time variation in levels of nitrates - nitrites and ammonium (water catchment area: Ahmed Taleb)*

3.1.2. AinSebaä gallery

Top and bottom wells: The analyses of groundwater to be operated during the observation period are represented in the figure 5.

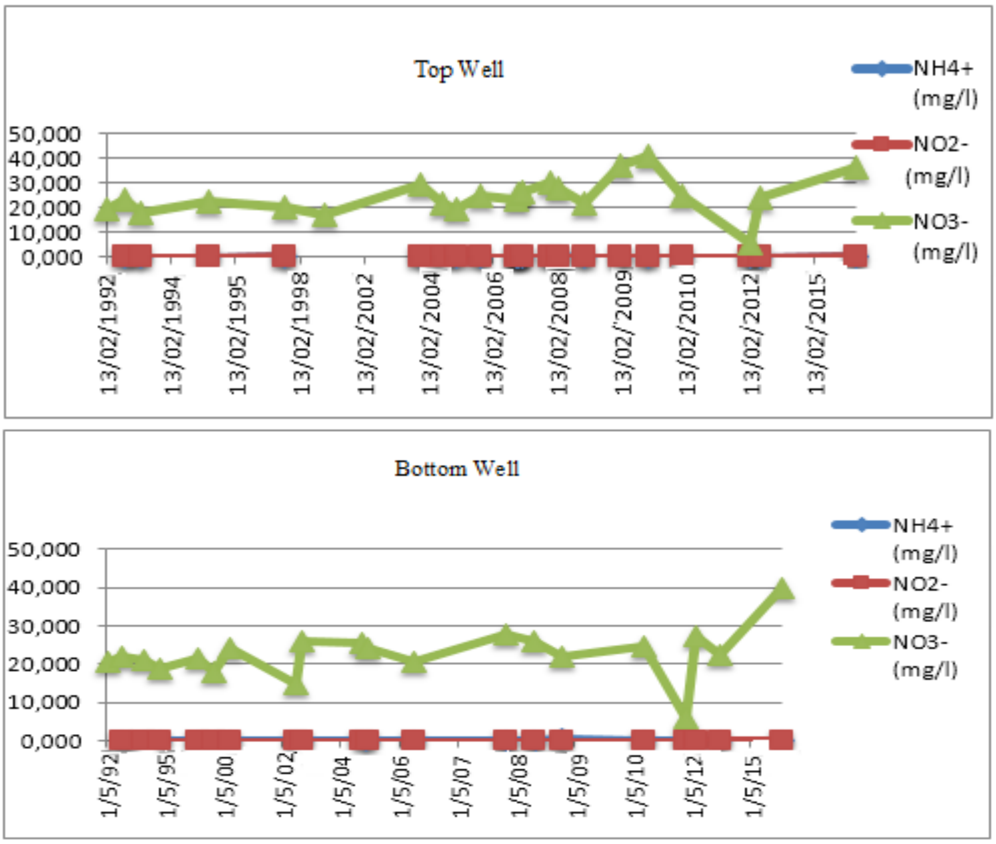


Figure 5: *Time variation in levels of nitrates-nitrites and ammonium(water catchment area: AïnSebaä gallery))*

it is shown that no overrun of the standard norms of the drinking water for the ammonium (0.5 mg/L) [18], has been recorded. Nitrate has shown the same result. Concerning nitrates the obtained maximum value was about 40 mg/L and corresponds to the sampling dates 13/02/09 and 01/5/15 but these values are below the drinking water maximum value (50 mg/L) [19].

3.1.3. SidiTaïbi

As Figure (6) shows, for the ammonium content, there is no exceedanceof the standards norms of the drinking watervalue which is about 0.5 mg/L[18]. Concerning the nitrite, all the stored values are null. In addition, the Nitrates values show a single maximum value which has been registered at the level of the wells (1), the value maximal registered (VMR) = 42.5 mg/L and corresponds to the sampling date (18/07/15), the maximum permissible value is about 50 mg/L[19].

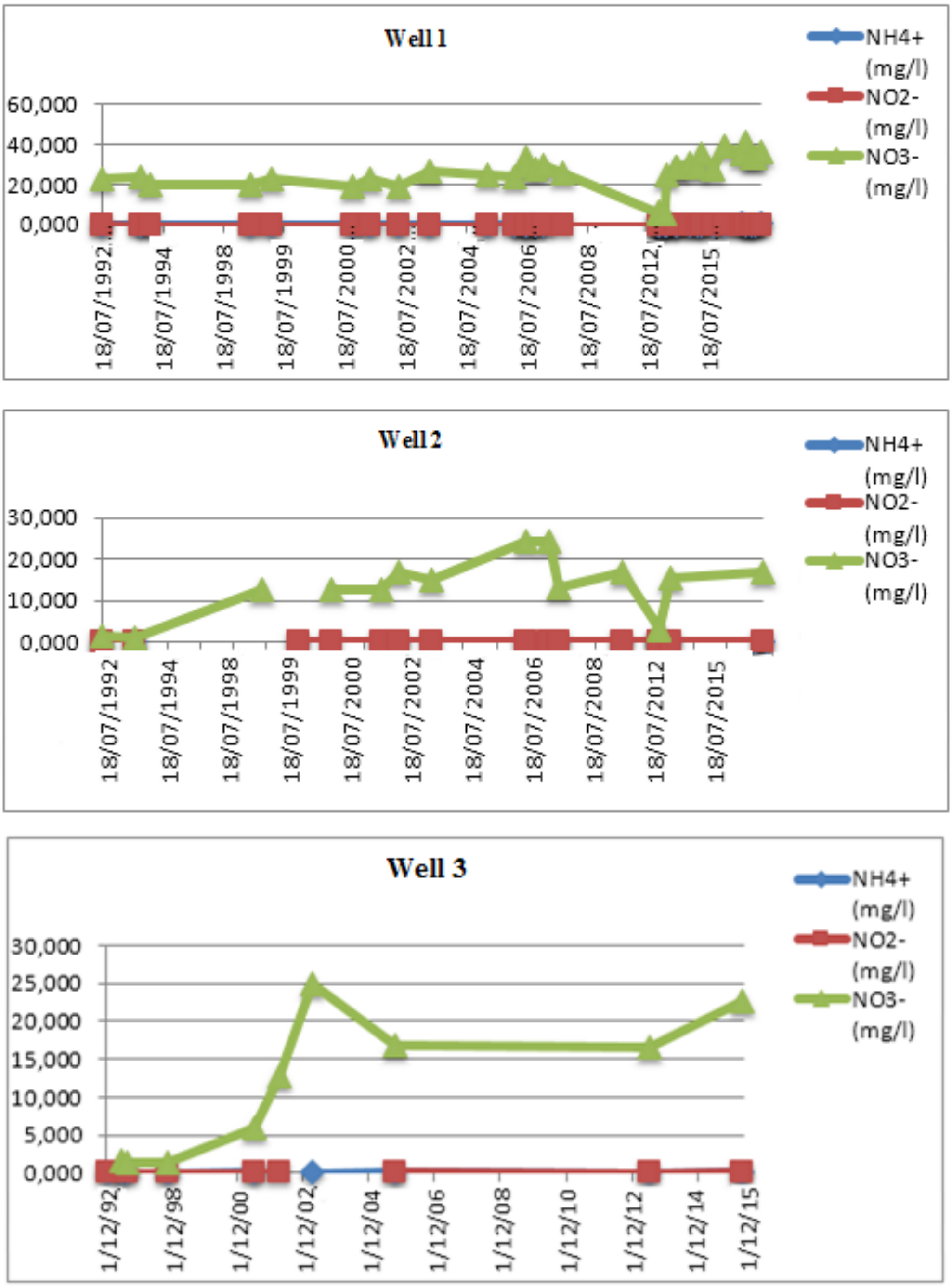


Figure 6: *Time variationof nitrates - nitrites and ammonium in 3 catchments of SidiTaïbi*

3.2. Microbiological Contaminants

The results of the microbiological examination of groundwater at the level of the three localities, during the study period from January 2015 to June 2015, are represented in the table 1.

The average concentration of the mesophilic flora total aerobic (FMAT) is 1.97 log_{10}/100 mL for the wells of the locality Ahmed Taleb and 1.81 log_{10}/100 mL for SidiTaïbi.
However, the total coliforms (TC), fecalcoliforms (FC) and fecal streptococci (FS) are ubiquitous in average concentrations of 2.4 log_{10}/100 mL, 2.35 log_{10}/100 mL and 1.5 log_{10}/100 mL in the wells of the locality Ahmed Taleband 2.1 log_{10}/100 mL, 1.9 log_{10}/100 mL, 1.4 log_{10}/100 mL for SidiTaîbi. The bacteriological analysis of the waters of the latter has shown an average concentration of the order 1.7 and 1.2 log_{10}/100 mL for *Pseudomonas aeruginosa*.
The number of anaerobic sulfato-reducing organisms varies from 3 to 1 CFU/20 mL in the wells of Ahmed Taleb's locality and it saves a minimum concentration at the level of the well (1) of SidiTaïbi, while at the level of Ain Sebaä'sgallery we note a total absence of anaerobic sulfito-reducing organisms.

Table 1: Average concentration of microbial germs during the period January 2015/ June 2015 in the different wells.FAMT (Flora aerobic mesophilic total), TC (total Coliforms), FC(fecalColiforms), FS (fecalStreptococci), PA (*Pseudomonas aeruginosa*) and ASR (Anaerobic Sulfito-reducing organisms).

	FAMT	***TC***	***FC***	***FS***	***PA***	***ASR***
Ahmed Taleb						
Well 1	3.01	3.66	2.92	2.85	2.54	3
Well 2	2.46	2.28	2.76	1,65	2.08	1
Well 3	1.41	2.15	2.57	1.15	1.82	0
Well4	1.61	2.06	1.95	1.47	1.35	0
Well 5	1.81	2.12	2.00	1.12	1.44	1
Well 6	1.54	2.04	1.89	1.06	1.02	0
Aïn Sebaä galery						
Top well	1.24	0	1.15	1.14	0	0
Bottomwell	1.14	0	1.25	1.18	1.72	0
SidiTaïbi						
Well1	3.11	2.45	2.58	1.61	1.35	1
Well2	1.52	2.10	1.12	1.08	1.06	0
Well3	1.13	1.98	2.18	1.23	1.21	0
Well4	1.48	2.04	1.85	1.68	1.08	0

The presence of fecalcoliforms and fecal streptococci indicates contamination of fecal origin, which confirms the presence of a significant source of pollution which could be of anthropogenic origin.
The bacteriological examinations have revealed the presence, in the water of these catchments, of micro-organisms indicators of fecal contamination, responsible for infections transmitted by the water and constituting, undoubtedly, a threat to the inhabitants who draw water of these wells that is necessary to the major part of their needs [19-22]. Bacteriological study makes it possible to highlight the nonconformity of the analyzed waters with the standards of the portability of the water[23]. These require the complete absence of indicator germs for fecal contamination in water intended for human consumption[24].These results confirm those shown in the analysis of chemical contaminants (nitrates, nitrites and ammonium).

Conclusion

For the three localities, the quality of the well's water operated by the Moroccan National Office of Drinking Water, apart from a few exceptions, is consistent with the Moroccan standards regarding the quality of the waters for human consumption. At the level of the 4 wells of SidiTaïbi's water catchment areas, the occasional exceedances of the maximum allowable values in the amount of nitrate and the overall tendency to increase indicate, however, that in the vicinity of the wells, the anthropogenic influence on the quality of the water has increased.This note is confirmed by the results of the bacteriological analysis.
Given these interesting findings on water resources in this region of Gharb and to solve the problem as a whole, it is imperative to:
-Incite the industrialists to equip themselves with a system of clean purification with waterrecycling, which will allow both a saving of the water and a very distinct reduction of the polluting loads.
-Eliminate all landfills at the quarry level by creating new controlled landfills.
-Require moderate and controlled use of pesticides due to their health and environmental risks

-Sensitize the public about the responsibility of every citizen in the success of any pollution control program, using information media together.

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