QUALITY MICROBIOLOGICAL OF GROUNDWATER IN THE EL HAJEB REGION (MOROCCO): ASSESSMENT OF THE FAECAL GERMS

A. Gamar [1,2], Z. Khiya 1,[2], T. Zair r[1,2], M. El kabriti [3] , F. El Hilali [1,2]

[1] Research team of Chemistry of the Bioactive Molecules and the Environment Department of Chemistry, Moulay Ismail University, Faculty of Sciences, Zitoune Meknes, Morocco
[2] Laboratory of Chemistry of Materials and Biotechnology of Natural Products (Chima-Bio) Department of Chemistry, Moulay Ismail University, Faculty of Sciences, Zitoune Meknes, Morocco
[3] National Laboratory of the Studies and the Surveillance of the Pollution (NLSSP) Rabat, Morocco

ABSTRACT

In the region of El Hajeb (Morocco), the inadequacy of the public network for the distribution of drinking water and the persistence of drought in recent years has forced the majority of the population to resort to water from wells, boreholes and sources. However, following the presence of a dump in the surrounding area, concerns have continued to increase due to the appearance of many water-borne diseases. The aim of this work is to microbiologically characterize the groundwater in the El Hajeb region (Morocco), in order to verify its state of salubrity and to sensitize the local population on water-borne diseases. To do this, a first sampling campaign was conducted for 29 months (from May 2016 to January 2017). A total of 43 stations (wells, boreholes and sources) were selected for monthly analyzes of total coliforms, fecal coliforms, fecal streptococci. The methods of microbiological analyzes referred to the techniques for assessing the quality of water described by Rodier (1978, 2009). The results of the count of the indicator germs of faecal contamination showed high concentrations (TC max = 1933.5 CFU/100mL; FC max = 1394 CFU / 100mL; FS max = 445 CFU/100mL) which exceeded national and international standards in the majority of stations especially those located near the dump.

Keyword : *Groundwater; Contamination; Faecal; Coliforms; Streptococci; Analyzes; Dump; Leachate*

1. INTRODUCTION

Waste from human activity is the source of groundwater pollution [1, 2]. In addition, the pollution of these waters represents a very worrying aspect, especially since their uses for food constitute health risks for consumers [3, 4]Some research work has revealed that the pollution of groundwater is linked to the presence of septic tanks, the absence of treatment, the lack of the sanitation network and the non-compliance with public hygiene conditions [5-7].

The most frequently detected indicators of faecal contamination are total coliforms (TC), faecal coliforms (FC) and group D faecal streptococci (FS). CTs have long been used as indicators of microbial water quality because they can be indirectly associated with pollution of faecal origin. The advantage of detecting these coliforms, as indicator organisms, lies in the fact that their survival in the environment is generally equivalent to that of pathogenic bacteria and that their density is generally proportional to the degree of pollution produced by them feces. It can be pathogenic and causative agent of toxi-infection (colibacillosis: infantile gastroenteritis) [8]. This bacteria does not multiply in the environment, but only in the digestive tract of humans and warm-blooded animals. As a result, a good correlation between its concentration and faecal pollution has been established [9]. In addition, faecal coliforms make it possible to detect faecal contamination resulting, for example, from the infiltration of polluted water into the pipes.

Group D FS are likely to contaminate supply water. They are rather typical of animal droppings, such as Streptococcus bovis, S. equinus, S. gallolyticus and S. alactolyticus. These species colonize cattle, horses and poultry although they can sometimes be present in humans, in particular S. bovis [10]. The origin of faecal pollution is linked to the quantitative ratio of faecal coliforms to faecal streptococci (CF/SF). When this CF/SF ratio is greater than four, pollution is essentially human (discharge of wastewater) [11]. When it is below 0.7, animal origin, especially cattle and in particular sheep, seems to play a predominant role in the contamination of water [12].

2. MATERIAL AND METHODS

2.1 Groundwater sampling Choice and method of sampling

During the first campaign (May-2015 to January-2017), a sampling network was chosen and consists of 43 stations, symbolized by W (well), B (drilling) and S (source) and distributed over the entire study area, with a higher density around the uncontrolled landfill and along the direction of flow of the groundwater . During these two hydrological cycles, samples were taken monthly according to the method of Rodier, 2009 in polyethylene bottles with a capacity of 5 liters. The samples were then immediately transported in cold boxes at a temperature below 5 °C to the laboratory where they were stored in the dark in a 4 °C refrigerator before analysis. The microbiological analysis was carried out within a maximum of 48 hours after the sample was taken.

2.2 Germs sought

During our work, we searched for pollution indicator germs, which are fecal coliforms (thermotolerant) (FC) and fecal streptococci (FS).
The TTC-Tergitol lactose agar medium was used for the enumeration of total coliforms and fecal coliforms, Slanetz and Bartley agar for fecal streptococci. Incubation takes place for 24 to 48 hours at a temperature of 37 °C for total coliforms and 44 °C for fecal coliforms. For fecal streptococci, incubation takes place for 24 hours at a temperature of 37 °C.

3. RESULTS AND DISCUSSION

The results of the microbiological analyzes of the water from the stations are given in Table 1. We found that the microbiological quality of the water was unsatisfactory for all the waters of the stations studied. This non-compliance is mainly due to the presence of pollution indicators.
This contamination has been attributed to the infiltration of leachate from the dump and to poor hygiene. Most of the stations were present before the landfill was set up; others were installed after it opened. These stations were undeveloped, some wells were fitted or not with concrete coping but all in the open air and devoid of a cover which constitutes a safety and resource protection device.
These conditions are not in accordance with Article 53 of Law n ° 10-95 on water published in 1995 by the Ministry Delegate to the Minister of Energy, forming Mines, Water and Environment [13], responsible for water, saying that any open water distribution system intended for human consumption is prohibited. The surroundings designed to avoid any stagnation of water, which favors the development of a flora dangerous for the aquifer, have not been fitted out. As a result, the water table has been easily invaded by surface runoff of rainwater, causing human wastewater discharged all around the soil surface. The contamination concerned the indicators of faecal contamination.
We have found a high degree of coliforms compared to streptococci. This is explained by the fact that coliforms are bacteria of faecal and environmental origin.
Although the concentrations of bacterial groups detected in the water of the stations greatly exceed the standard prescribed for drinking water, analyzes revealed relative differences between the different stations analyzed. This is probably due to their location in relation to various estimated sources of pollution (septic tanks, latrines and leachate from the dump and / or the season (wet or dry) during which analyzes were carried out.

Table -1: Microbiological quality of groundwater during the 1st camping (Shapiro-Wilk test)

Parameters	Groundwater samples (n=86)				
	Moy ± SE	*Min*	*Max*	*p-Value*	*F. Norm 2013*
FC/100mL	399,31±39,05	6,5	1394	< 0,0001	0
FS/100mL	184,47±13,78	0	445	0,0093	0
FC/FS	2,53±0,33	0,83	14	< 0,0001	-

Min. : minimum value; Max. : maximum value; Avg. :Average value ; SE. : Standard error; CFU: colony-forming units

The FC count in the different samples (Fig. 1) showed that the FC load fluctuated between 6.5 and 1394 CFU/100mL around an average of 399.31±39.05 CFU/100mL, the high concentrations were recorded at wells W28 (1394 CFU/100mL) and W29 (1316 CFU/100mL) and drilling B30 (995 UFC/100mL) during the study period.

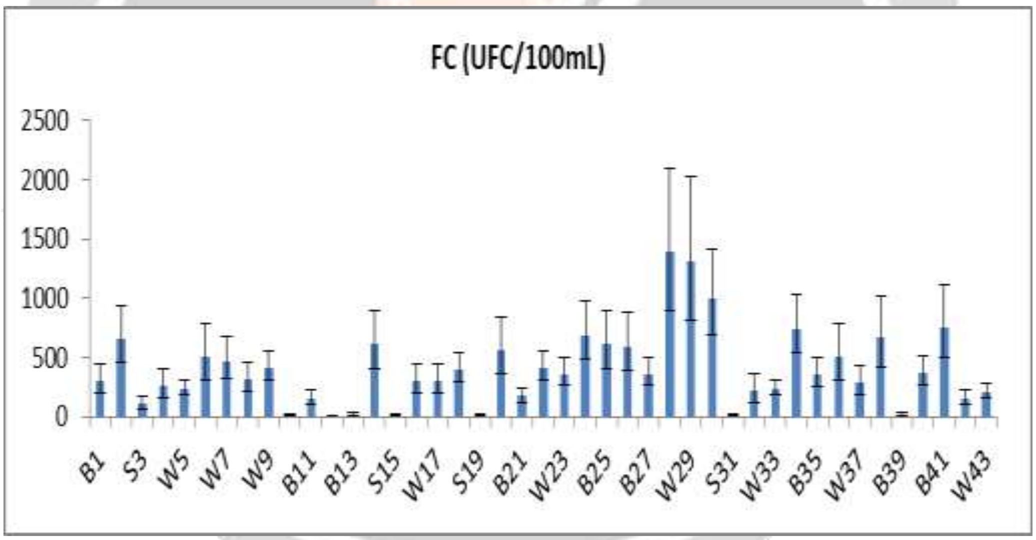

Fig -1 : Spatial evolution of faecal coliform contents in groundwater stations

These three stations are very far from the dumping site, which reinforces the hypothesis of the existence of septic tanks and latrines nearby. In addition, no FC analysis met the drinking water standard (Table 1). This proves that faecal coliforms are omnipresent in the 43 stations and can be explained by environmental contamination. As all the stations studied are used for irrigation and to supply the surrounding population with water, which may be in favor of presenting a risk of faecal contamination. This contamination can be caused by household discharges, proximity to the landfill and septic tanks, and infiltration of surface water.
The population of faecal streptococci fluctuated between a minimum of 0 identified in source S10 upstream of the wild dump thus meeting the standard and a maximum 445 CFU/100mL at the level of borehole B34 located downstream of this same discharge (Fig. 2) with an average of 184.47±13.78 CFU/100mL ($p<0.0001$). The presence of faecal coliforms and faecal streptococci is however explained by contamination of faecal origin. Among fecal streptococci, the fragile species S. bovis is dominant in cattle and dogs and rare in humans [14], which presents a significant and increasing risk of transmission of infectious diseases for the health of populations riverside. Source S10, containing a zero number in FS and

a minimum number in FC, complied with the standard of potability and therefore of good to excellent quality. The latter being located far from all anthropogenic discharges.

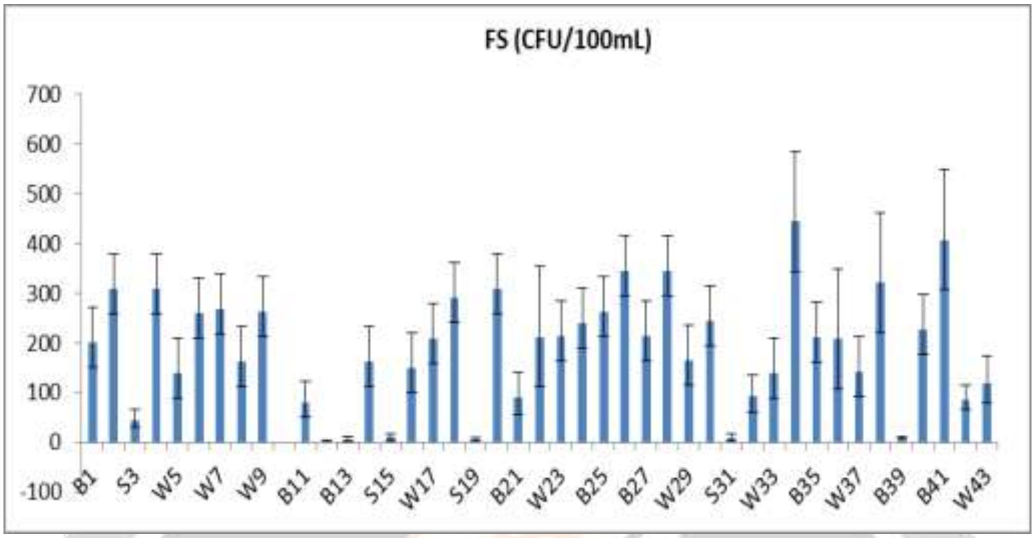

Fig -2 : Spatial evolution of faecal streptococcus levels in groundwater stations

The FC/FS ratio varied from 0.83 to atypical value 14 with an average of 2.53±0.33 ($p<0.0001$) less than 4 (Table 1). Figure 3 shows that 39 out of 43 stations surveyed presented a ratio lower than 4 according to Borrego and Romero, [11] the origin of faecal contamination was mainly human and animal (septic tanks, latrines and excrement of cattle and domestic animals which have free access to water stations). Figure 8 also shows that 4 stations have a ratio greater than 4 these are wells W12, W28 and W29 and borehole B30, according to these same authors their contamination is mainly human probably caused by the infiltration of leachate from household waste, hospital waste and slaughterhouse waste dumped in the dump.

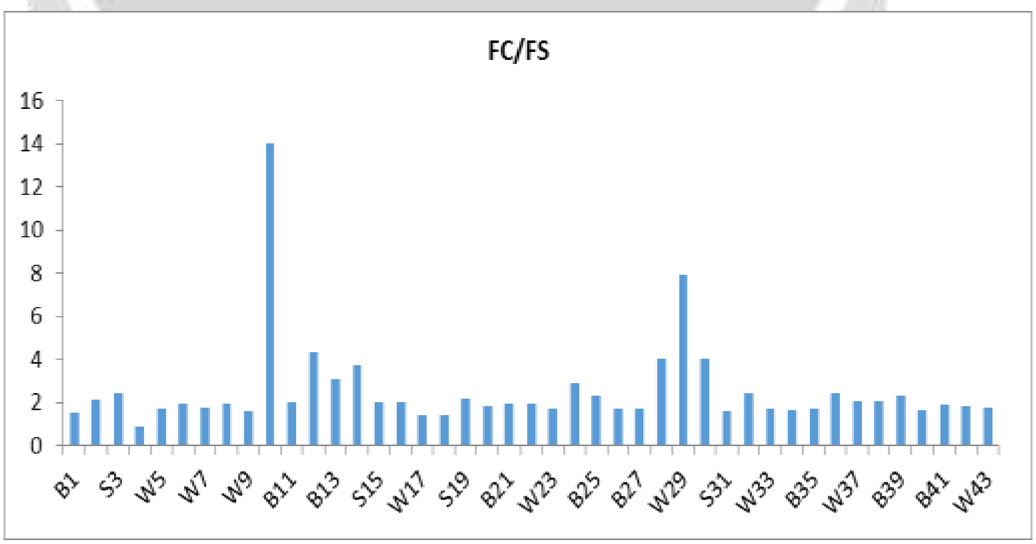

Fig -3 : Spatial evolution of the means of reporting faecal coliforms to faecal streptococci in groundwater stations

4. CONCLUSION

Drinking water should not contain any traces of FC and FS. The enumeration of bacteria indicative of faecal contamination (FC and FS) reflected intense faecal pollution in the vicinity and downstream of the wild dump. The abundance of fecal germs varies considerably from the wet season to the dry season due to dilution. The values recorded greatly exceeded the standards for water intended for consumption.

In conclusion, the groundwater in the El Hajeb region (Morocco) and cannot therefore be used raw for human consumption. Otherwise, treatment with chlorination is necessary or compulsory. However, these waters can be used for irrigation but not for market gardening in the region, these waters can, under certain climatic conditions, constitute risks of pollution transfer.

Finally, steps must be taken to rehabilitate the dump and better design of cesspools and sumps. This will reduce pollution of the surface water table; in order to protect populations from ailments linked to drinking water.

5. REFERENCES

[1]. D. C. W. Nkhuwa. Human activities and threats of chronics epidemics in a fragile geologic environment. Physics and Chemistry of the Earth, 28 : 1139-1145 (2003)

[2]. E.M. Hassoune, A. Bouzidi, Y. Koulali, D. Hadarbach. Effets des rejets liquides domestiques et industriels sur la qualité des eaux souterraines au nord de la ville de Settat (Maroc). Bulletin de l'Institut Scientifique, Rabat, section Sciences de la Vie, 28: 61-71 (2006).

[3]. M. Laferriere, J.J. Minville, J. Lavoie, P. Payment. L'industrie porcine et les risques reliés à la santé humaine. Bull. Information Santé Environnem., Québec, 7(2): 1-4 (1996)

[4]. El Kettani, E.M. Azzouzi. Prévalence des helminthes au sein d'une population rurale utilisant les eaux usées à des fins agricoles à Settat (Maroc). Environnement Risques et Santé, 2 : 99- 106 (2006).

[5]. A. Fakih lanjri, J. Brigui, A. El Cadi, Khaddor M., Salmoune F., Mater. Environ. Sci. 5 (S1) 2230- 2235(2014).

[6]. H. Guessoum, F. Benbrahim, M.T. Halilat, F. Laouar, M. Bensalama, S. Darem, Inter. Journ. Environ. Water. 3 35-43(2014).

[7]. C. Degbey, M. Makoutode, B. Fayomi, C. Brouwer, J. Int. Santé. Trav. 115-22. 9. (2010)

[8]. D. Gaujous. La pollution des milieux aquatiques, aide-mémoire, Paris, 40-183 (1995).

[9]. C. Gantzer, F. Lucena L. Schwartzbrod, J. Jofre Indicateurs de contamination virale du milieu hydrique: mythe ou réalité. Virologie 2, 117-125 (1998)

[10]. Groupe scientifique sur l'eau. Entérocoques et streptocoques fécaux, Dans Fiches synthèses sur l'eau potable et la santé humaine, Institut national de santé publique du Québec, 5p. 2002 [En ligne] Accès internet : http://www.inspq.qc.ca/pdf/publications /198CartableEau /198_FichesSynthesesEauPotable.pdf (consultée le 06 novembre 2012).

[11]. A. F. Borrego & P. Romero. Study of the microbiological pollution of a Malaga littoral area II. Relationschip between fecal coliforms and fecal streptococci. VIè journée étude pollutions, Cannes, France, 561-569 (1982)

[12]. E. Geldreich. Fecal coliform and fecal streptococcus density relationships in waste discharges and receiving 6 349-369 (1976)

[13]. Ministère délégué auprès du Ministre de l'Energie, des Mines, de l'Eau et de l'Environnement, chargé de l'Eau. Recueil des textes juridiques relatifs aux ressources en eau au Maroc. Royaume du Maroc (2015).

[14]. P. M. Rodier. Vulnerable periods and processes during central nervous system development. Environ. Health Perspect. 102, 121–124. (1994) doi: 10.1289/ehp.94102121