

Survey on Water Source Classification based on users' opinions: Case of the Al-Hoceima region, Northern Morocco

Fatiha Mchiouer^{1,*}, Asmae Charki¹, Hossain El Ouarghi¹

¹ Environmental Management and Civil Engineering Research Team GEGC, National School of Applied Sciences, Abdelmalek Essaadi University, 32 003 Al Hoceima, Morocco

Abstract. The purpose of the water sources study according to the opinion of the users in the region of Al-Hoceima, is to present a classification of investigated sources according to physico-chemical and microbiological quality, and to compare the obtained results with the sanitary survey taken from users. The region's groundwater is known for its low piezometry and, consequently, for its easy and uncontrolled exploitation. Indeed, the lack of drinking water supply in several rural areas or among some vulnerable categories of the population forces them to use water sources for all purposes, including drinking. Moreover, in urban areas and with the availability of treated drinking water, people resort to supplying water from a source as traditions and cultural customs of the users predominate. The public survey results in this study confirm, according to the majority of witnesses, that drinking from these sources is continual, as 50% of the consumers live in the area and they do not have any digestive or intestinal problems; these water sources are more frequented in summer and at weekends. Furthermore, the majority of respondents consider these waters to be healthy and not subject to chemical treatment, and they represent a natural heritage with a good reputation among the population of the region.

1 Introduction

Groundwater in Morocco is an important source of the country's natural hydraulic heritage [1,2]. Traditionally, groundwater is the preferred water resource for drinking water because it is more pollutants-free of than surface water [3,4,5]. The recurrent dry conditions in Morocco and in the Rif region of northern have led to an overexploitation of groundwater to meet human and socio-economic needs. The quality of groundwater is therefore strongly affected by this intensive exploitation and also by the low recharge following the decrease in rainfall in this region, probably partly due to the phenomenon of global warming. Groundwater pollution is one of the most worrying aspects and the use of groundwater for consumption represents a serious health risk [6,7]. The problem has started to become more critical in the last years of the century, especially with industrial development, rapid population growth, and urbanisation [8,9]. However, the quality of water for nutritional purposes is a growing concern.

The challenge facing the regions of Morocco, especially rural areas, is the protection of the quality of groundwater resources.

The water sources of the aquifer in the Al-Hoceima region are known for their low piezometric level and, consequently, for their easy and uncontrolled exploitation [10,11]. Indeed, the lack of drinking water supply in certain rural areas or among certain fragile categories of the population pushes them to use water sources for all purposes, including drinking. Furthermore, and with the predominance of traditions and customs linked to the culture of the users, they use water sources even when treated drinking water is available [12].

The aim of this article is to make a comparison of water sources according to physico-chemical and microbiological criteria, thus obtaining similar groups, in order to be able to compare the results obtained with the findings of the user survey.

2 Materials and methods

* Corresponding author: mchiouerfatiha1718@ump.ac.ma

The groundwater samples were selected on the basis of a health survey and the criteria of being used as collective water supply points by population.

The health survey is conducted among the population using very frequently the four water sources located on the map (Figure 1).

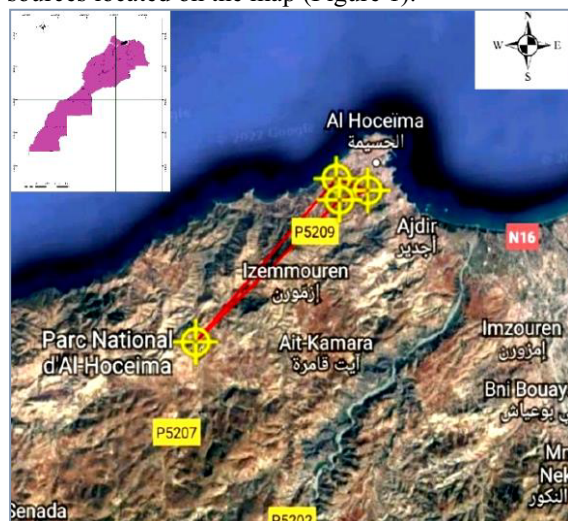


Fig. 1. Location of the study area.

The following physicochemical parameters: Turbidity, pH, temperature, dissolved oxygen, salinity and Total Dissolve Solids (TDS), as well as electrical conductivity (EC) have all been measured

on site immediately after sampling using a multi-parameter measuring device (HANNA HI 9829). In addition, chemical analysis methods for nitrate, nitrite and orthophosphate were used, as well as spectrophotometer determination.

BOD₅ measures the amount of oxygen consumed in 5 days at 20°C by the living micro-organisms present in the water. COD represents the resources that can consume oxygen in water, for example mineral salts and organic compounds. Measurements are made according to the analytical methods of Rodier et al, 2009.

For microbiological analysis, samples were collected using sterile glass bottles. The samples were immediately placed in a cooler where the temperature was maintained between 2°C and 8°C and sent to the laboratory for immediate analysis on selective medium according to the Rodier methods [13]. The chosen germ is *Escherichia coli* (*E. coli*), which is the most important fecal contamination bacterium [14,15,16].

3 Results and discussion

The results of the physicochemical parameters obtained show that almost all the water from the sources studied does not exceed the limit of the admissible value (Table 1, Table 2 and Figure 2).

Table 1. physico-chemical and bacteriological parameters of sampled water sources.

Collective water point	Turbidity FNU*	pH	dissolved O ₂ mg/L	conductivity µs/cm	TDS mg/L	T°C	E. coli CFU**/100mL
Sidimansor	1,06	8,71	4,78	1004	502	23,07	160
Tifart	1,94	8,2	5,59	2417	1208	21,23	0
Talabouda	1,68	7,83	4,34	913	456	25,3	0
Tidghine	0,5	7,76	3,9	57	30	22	80
Aghbal	0,58	7,7	5,94	472	237	21,2	1
VMA ***	<5	6,5-8,5	3-5	≤2700	500-1000	--	0

FNU* Formazin Nephelometric Unit, CFU** colony forming unit, VMA*** maximum permissible value

Table 2. Chemical parameters of sampled water sources.

Collective water point	NH ₄ ⁺ mg/L	NO ₂ ⁻ mg/L	NO ₃ ⁻ mg/L	PO ₄ ⁺ mg/L	DCO mgO ₂ /L	DBO ₅ mgO ₂ /L
Sidimansor	0,0214	0,01195	25,63	1,2591	24	--
Tifart	0,01460	0,01103	21,13	1,23608	48	10
Talabouda	0,01070	0,041375	48,78	1,6963	120	--
Tidghine**	0,008	0,0055	0,6865	0,9213	0	10
Aghbal	--	0,00735	40,34733	1,3896	96	--
VMA	<0,5	<0,1	<50	--	35-40	5-10

**Water from the Tidghine well is sold at the Mirador souk and is much appreciated by the urban population because of its physical and chemical quality.

The water sources surveyed are divided between rural and urban areas, and the persons in charge of water supply represent 83.33% of the adults, between women and men, and 16.66% are children. 50% of the respondents have an improved water source (connection to the ONEE water branch) and they get their water from the source on a daily or weekly basis depending on the wet or dry period. However, despite the presence of *E. coli* in this source water, the respondents state that there are no health problems or intestinal troubles associated with the use of this source water and they have been using it for years without any treatment (chlorination, boiling, etc.). Another study confirms the health risk of consuming untreated water, hence the need to treat water before consumption [17,18].

This is due to customs, to the fact that it does not have chemical treatment; it is good for cooking, especially for leguminous plants, and also for intestinal transit and the fight against gas, which is favoured by the presence of chlorine in ONEE water, as the interviewees affirm.

Eutrophication is favoured by the presence of nitrates and phosphates, but also by high water temperature (in summer). Temperature is therefore a double cause of COD increase in aquatic environments such as in the Talabouda spring.

COD is strongly correlated with BOD or biochemical oxygen demand, with the important difference that BOD is a measure of the organic matter that can be biologically oxidised whereas COD is a test of the amount of organic matter that can be chemically oxidised.

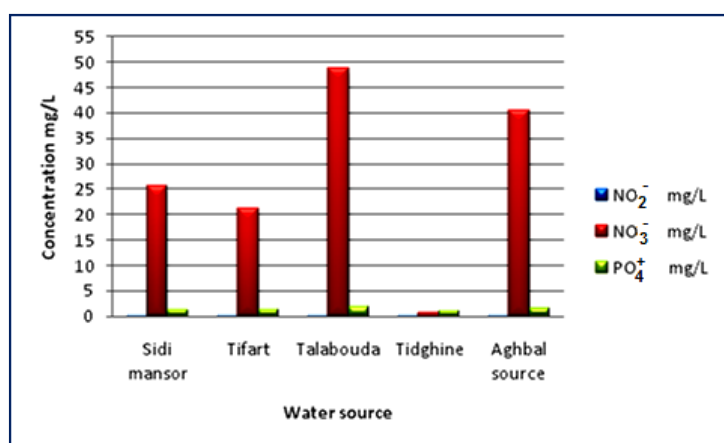


Fig. 2. Concentration of chemical parameters in sampled source waters.

A parallel survey was conducted in July 2022 at an urban health centre in Al-Hoceima on the prevalence of diarrhea among children under five.

However, most children with this problem come from families with an improved water source (drinking water connection) and improved sanitation facilities. The probable cause of diarrhea, according to the doctor, can be due to a viral intestinal infection, gastroenteritis, seasonal fruits, or even first teething. In this case, water is not the cause of diarrhea. Indeed, the bacteriological quality of the water in the sources studied reveals contamination of the water table. This could be due to human domestic and agricultural activities, the existence of all types of waste and uncontrolled public dumps [11,19].

4 Conclusion

Due to cultural factors in the province, natural water is perceived as having a better taste and is therefore widely consumed by the local population to the detriment of tap water. Some collective water points do not comply to Moroccan standard (NM 07.3.001)

[20] and with the standards established by the WHO due to their bacteriological or physico-chemical properties. Water is a blessing for which we must thank God. It is therefore necessary to adopt the right reflexes to protect the water in quantity and quality to avoid incorrect water management practices and the consumption of contaminated water, exposing the population to the risks of water-borne diseases and diarrhea, especially among children under five. The population needs to be made aware of hygiene and groundwater management in order to improve their living conditions and health.

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