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Water pollution and degradation in the SEBOU watershed and their impact on human health (Region of GHARB-Morocco)

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Abstract

Today's water resources are menaced by pollution originating from industrial, agricultural and domestic sources drain without prior treatment. This pollution leads to a deterioration in water quality. The soil can be penetrated by surface pollutants to enter groundwater, which could cause major health problems for residents. The aim of this work is to assess the physicochemical quality of the waters of the lower Sebou watershed. Indeed, ten groundwater stations and ten surface water stations were involved and analyzed. The parameters analyzed are pH, EC, NO^{3-}, Cl^-, SO_4^{2-}, HCO^{3-}, CO_3^{2-}, Ca^{2+}, Mg^{2+}, Na^+, K^+, and NH^{4+}. However, in order to discover the water and sanitation situation and identify its impact on the health of the local population, a survey was carried out via a questionnaire in this study area. The physico-chemical results of the surface waters of the Sebou watershed revealed that the surface waters of this basin are very loaded with mineral matter. The values found do not always comply with Moroccan irrigation standards. These contents, whose mineralization succeeds the levels of dissolved salts, salinity, potassium, chlorides and sodium, are exposed to diverse types of natural pollution, particularly mineral and anthropogenic. Similarly, the groundwater results showed that the analyzed parameters do not always comply with the WHO guideline. It is noted that ammonium concentrations in 40% of the wells and nitrate concentrations in 100% of the wells are higher than WHO standards, indicating the presence of nitrogen pollution that may come from organic waste and fertilizers overused in agriculture and domestic or industrial discharges. As well as the electrical conductivity in 40% of the wells and the concentrations of chloride in 41% of the wells and of sodium in 41% of the wells of these are quite high, which corresponds to a strong mineralization resulting from the nature of the land crossed or industrial or in general domestic pollution. Regarding the survey that was carried out in the study area, it was found that the conditions of access to drinking water, sanitation are not satisfactory and the populations are vulnerable to waterborne diseases.

Keywords: Groundwater, physico-chemical, human health, Sebou watershed, Gharb-Morocco region.

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1. Introduction

Oued Sebou and its tributaries drain an area of 34,000 km^2. It sprawls for more than 600 km and has its origins in the Middle Atlas under the name of Oued Guigou. It ends at Mehdia in the Atlantic Ocean via its 35 km long river mounth [1]. The Sebou watershed is the first watershed in Morocco in terms of water inflows estimated at 6.6 billion m^3 per year. Indeed, this area is Highly important from a socioeconomic perspective and is among Morocco's most polluting sectors. its importance consists in the fact that it consists mainly of two very important agricultural plains in Morocco, that of Gharb and that of Maamoura as well as the multitude and diversity of industrial units in the major cities of the basin (Kenitra, Sidi Kacem, Meknes, Fez). This problem is aggravated by the scattering of uncontrolled landfills and household waste, which are the main causes of the deterioration of the quality of water in the basin [2]. In industry, the region is rich in tanneries, they are distributed in the cities of Fez, Meknes, Kenitra, and produce 60% of national production [3]. In addition, the use of fertilizers and pesticides in irrigated areas exceeds the needs of the plantations and also constitutes a source of pollution. For example, the volume of these products went from 689 Tons in 1986 to 1105 Tons in 1993 [4].

In this perspective, we started this study which focuses on studying the evaluation of physico-chemical parameters: pH, electrical conductivity CE, calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^{+}), carbonates (CO_3^{2-}), bicarbonates (HCO^{3-}), potassium (K+), chlorines (Cl^{-}), sulphate (SO_4^{2-}), ammonium (NH^{4+}), nitrates (NO^{3-}). Several research works have been carried out on the watershed waters of this region, among them we cite the work of [5], [6]. More specifically, we will control and monitor both the quality of groundwater and surface water by traditional chemical and physico-chemical methods, in order to enrich the database on this great Moroccan river. This study has a primary objective which serves to assess the physicochemical quality of well water from the lower Sebou sub-basin and the comparison of this quality with Moroccan standards and to examine the effect of their use in irrigation. To do this, several sampling and analysis stations are programmed using numerous physico-chemical techniques indicative of pollution. Each assay will be carried out according to a specific procedure and under well-defined conditions.

In the same section, we carried out a survey. A questionnaire was asked to different consumers of wells in the area of study. The aims of the survey are:

- ✓ Identification and assessment of water needs with the aim of collecting data on the water and sanitation situation in the region.
- ✓ Assess the level of knowledge and practices related to water, hygiene and sanitation of the population in the region.
- ✓ Identify cases of waterborne diseases among users in the study area

2. Study environment and study methods

2.1. Geographical location of the study area

Covering an area of approximately 40,000 km², the Sebou Basin is one of the most significant basins in the Kingdom and currently has a total population of about 6.2 million inhabitants (2004 census), of which 51% live in rural areas and 49% in urban areas. It has an agricultural and industrial economy that makes a significant contribution to the national economy. The prevailing climate throughout the basin is Mediterranean with oceanic influence and within the basin the climate becomes more continental.

The mean annual rainfall in the basin is 600 mm, with a minimum of 300 mm/year in the upper Sebou and Baht valleys and a maximum of 1000 mm/year on the Rif heights. The Sebou watershed is one of the most water-rich, best endowed with irrigated land and industries. The cultivation potential is 1,750,000 ha. The irrigable areas are estimated at 375,000 ha, of which 269,600 ha are currently irrigated. The Sebou Basin has a highly developed industrial activity. The important industries at the basin level are: paper mills, tanneries, cement factories, oil mills, textile industries, sugar mills [3].

2.2. Study instrument

Water sampling and analysis: The sampling campaign was carried out taking into account the lithological diversity of the Sebou basin as well as the distribution of anthropogenic activities. In August 2021, ten surface water samples and ten groundwater samples were taken along the lower Sebou (Magran region, Sidi Allal Tazi, Souk Tlet). The water samples were taken in 1.5 liter bottles and transported in a cooler and kept at a temperature of about 4°C according to the procedure of [7]. 12 physico-chemical and chemical parameters for the samples taken were measured. These parameters are: (pH), (Cl-), (EC), (Ca^{2+}), (K+), (Mg^{2+}), (Na^{+}), (SO_4^{2-}), (NO^{3-}), (NH4+), (CO_3^{2-}) and (HCO^{3-}). These analyses take place in the laboratory of the Faculty of Sciences at Ibn Tofail University, Kenitra, by chemicals, devices such as digital burettes, flame photometer, spectrophotometer, nitrogen distillation apparatus, pH meter, conductivity meter, and other materials.

Study survey

A survey to discover the culture of water use of the population of the study area for sustainable water management. A questionnaire was asked to different consumers of wells in the study area. In total, 100 households were interviewed individually. This questionnaire used has been validated by Action counter fain, which is based on the following areas: Water resources, Hygiene practices, Sanitation and Knowledge of waterborne diseases.

3. Results and discussions

The results of the physico-chemical data of the waters of the lower Sebou basin are presented in the following table (Table 1).

3.1. Hydrogen potential (pH)

The pH of water is a measure of hydrogen (H^{+}) ion concentration present in the water. The pH value is influenced by the water's origin and the geological composition of the soil and watershed it passes through [8]. It is sensitive to salinity, temperature and gases in the water below (CO_2, O_2, NO, SO_2, etc.). The pH is corrected, if necessary, by correcting the carbonate hardness or by removing excess dissolved carbon dioxide [9]. Regarding the research area, the recorded surface water pH values show no notable variations, with a minimum of 8.06, a maximum of 8.65 and an average of 8.40 (Fig.2). It is observed that all the stations comply with the irrigation standards. The pH of the recorded groundwater doesn't show any noticeable variations, with a minimum of 6.7, a maximum of 8.06 and an average of 8.34 (Fig.2). It is observed that all the wells respect the WHO standards which is between 6.5 and 9.5.

3.2. Electrical conductivity (EC)

The electrical conductivity of water is the measurement of water's ability to conduct electricity (ability of water to pass an electric current). The electrical conductivity of water is an indirect measurement of the level of ions in the water (Na+, Ca²+, Mg²+, K+, SO42-, HCO3-, NO3-, Cl-…) formed by the mineral salts in water.

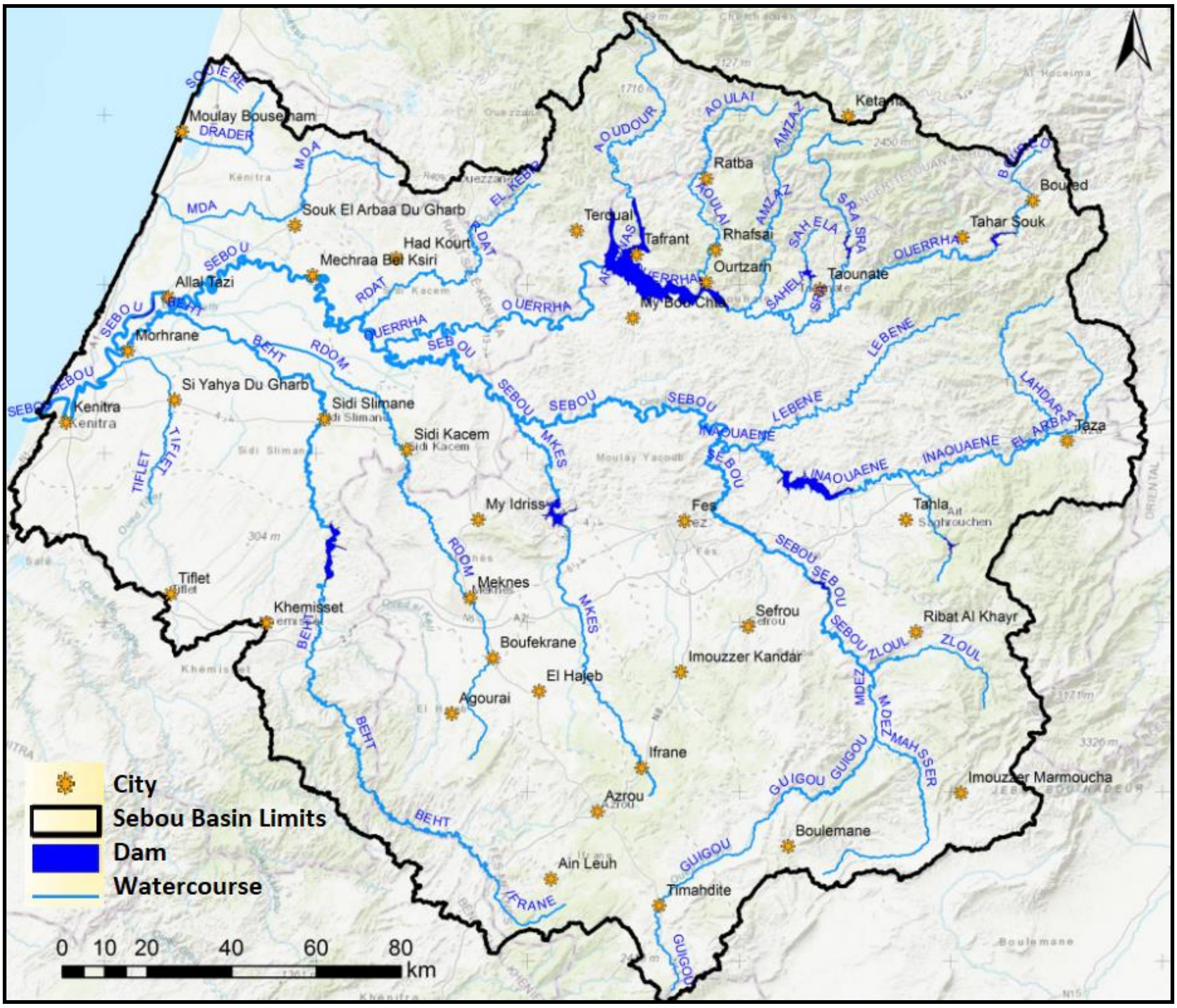

Figure 1. Map of the research area (ABHS)

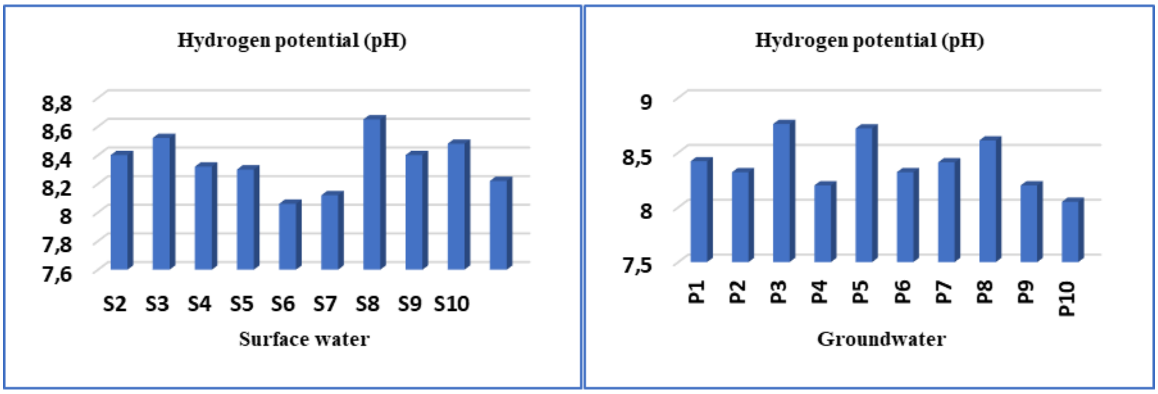

Figure 2. Spatial variation of pH values in surface and groundwater of the Sebou watershed

Table 1: Physico-chemical rates of cations and anions in surface and groundwater in the Sebou watershed

Stations	pH	NO3- mg/L	CL – mg/L	SO4-- mg/L	HCO3- mg/L	CO3- mg/L	Ca2+ mg/L	Mg2+ mg/L	K+ mg/L	Na+ mg/L	NH4+ mg/L	CE µs/cm
S1	8,40	9.30	215	312.65	230	13	97.8	88.70	7.15	1430	0.17	1160
S2	8,52	10,40	160	150.75	210	14	120	43.60	2.84	1220	0.48	1120
S3	8,32	0,47	200	142.27	211	5	127.7	54.40	5.64	1500	0.08	1225
S4	8,30	17,20	150	131.18	270	0	166.4	15.78	4.82	1350	0.24	1240
S5	8.06	63,44	240	172.15	240	0	152.3	41.50	9.58	1870	0.19	1410
S6	8,12	20,44	202	141.21	360	10	169.8	64.70	4.57	1330	0.67	1470
S7	8,65	86,93	275	175.14	240	21.12	147.6	50.40	4.57	1455	0.50	2334
S8	8.40	190.50	376	229.47	322	13	225.4	109.70	12.78	1855	0.67	624
S9	8.48	830.88	239	103.18	76	0	220.3	15.6	3.74	52	1.64	16320
S10	8.22	265.22	868	110.17	122	18	916.7	23.00	5.08	140	15.44	11750
P1	8.42	240.20	268	38.48	100	0	148.6	22.54	6.85	188	0.55	11770
P2	8.32	884.10	475	268.14	90	0	150.8	36.40	17.68	370	2.54	22210
P3	8.76	93.51	466	346.42	258	45	317.8	110.70	9.54	2553	1.26	2220
P4	8.20	164.21	396	435.25	178	43	170.6	65.80	15.85	130	1.28	16540
P5	8.72	58.85	303	238.5	242	13	145.7	92.60	8.12	400	1.54	1750
P6	8.32	686.85	147	55.42	105	15	174	400.00	2.73	107	1.50	730
P7	8,41	396.25	148	58.45	103	18	178	100.50	3.14	109	1.80	840
P8	8,61	62.47	138	298.4	148	13	180.4	120.50	6.54	430	0.87	250
P9	8.20	118.54	128	148.24	118	30	165.4	63.80	5.24	120	0.25	1030
P10	8.05	136.2	173	160.24	16	10	250.4	66.90	4.63	230	0.17	1230

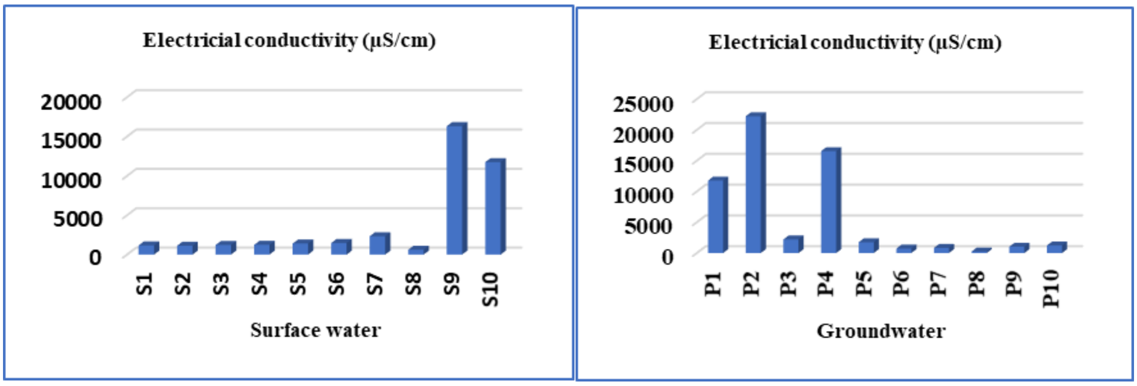

Figure 3. Spatial variation of EC values in surface and groundwater of the Sebou watershed

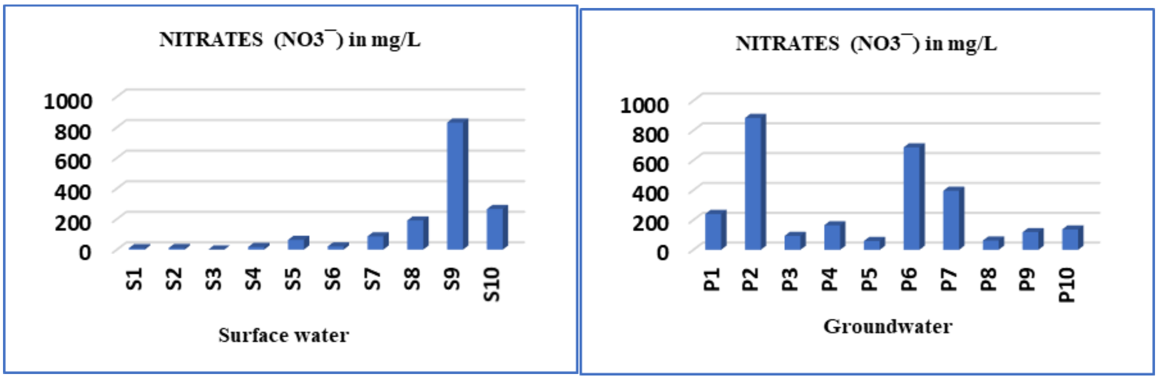

Figure 4. Spatial variation of nitrate values in surface and groundwater of the Sebou watershed

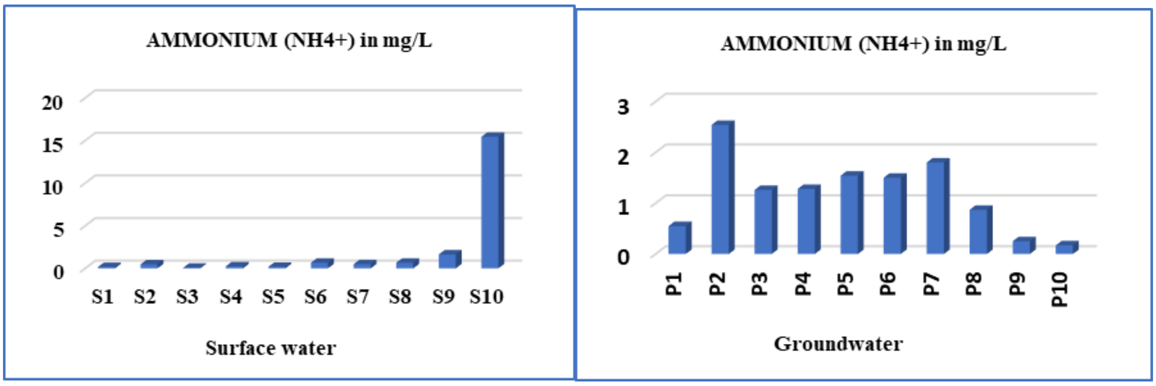

Figure 5. Spatial variation of ammonium values in surface and ground water of the Sebou watershed

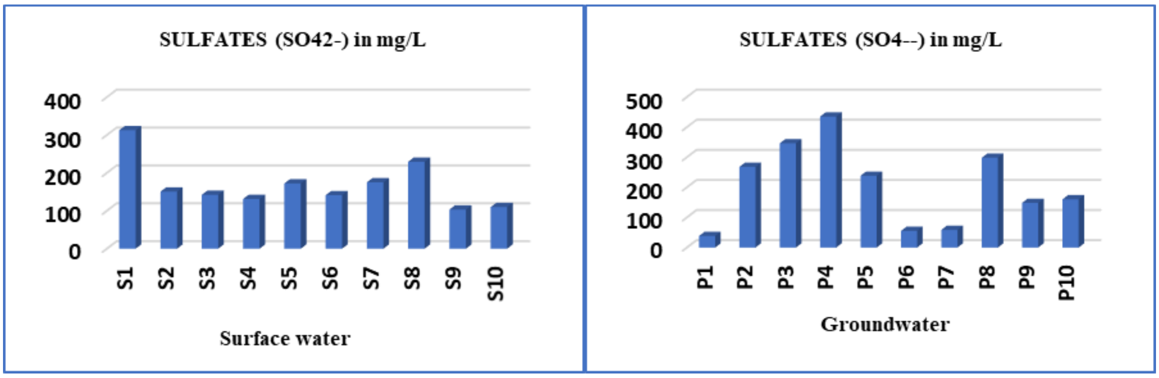

Figure 6. Spatial variation of sulphate values in surface and groundwater of the Sebou watershed

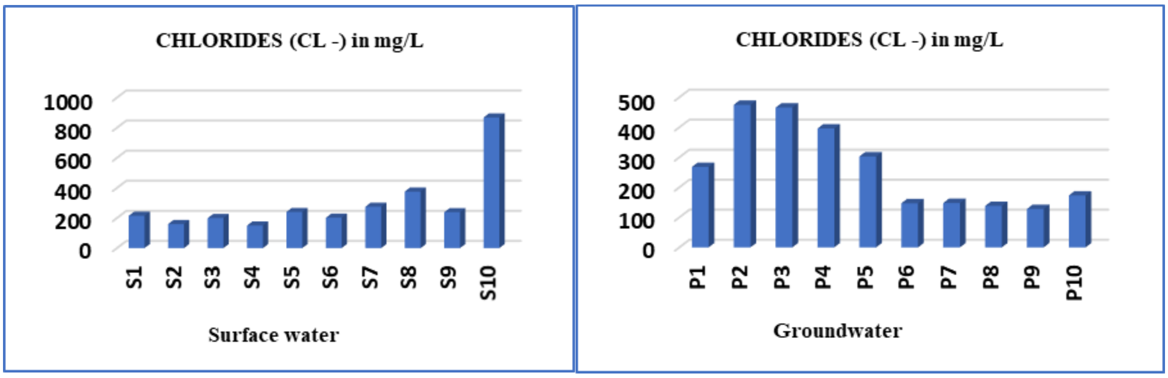

Figure 7. Spatial variation of chloride values in surface and ground water of the Sebou watershed

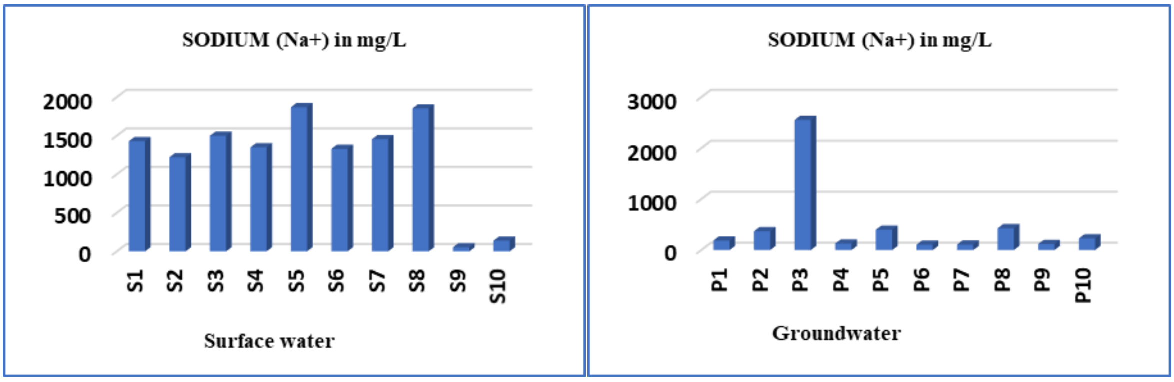

Figure 8. Spatial variation of sodium values in surface and groundwater of the Sebou watershed

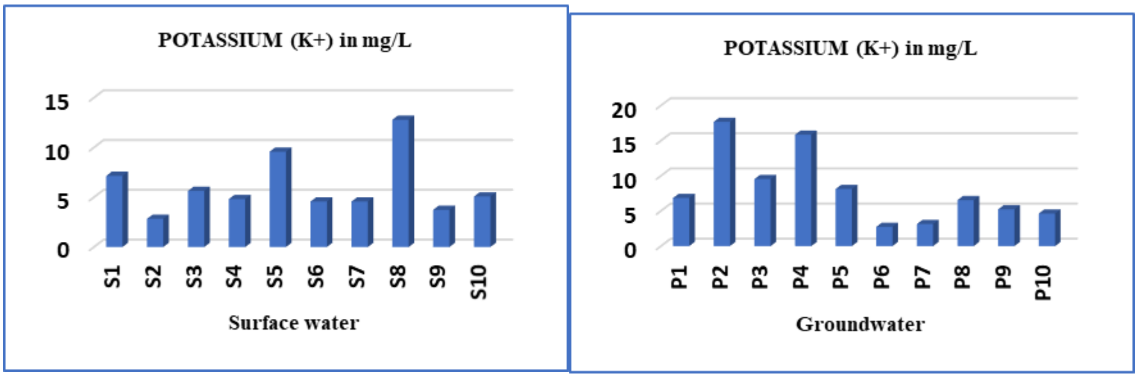

Figure 9. Spatial variation of sulphate values in surface and groundwater of the Sebou watershed

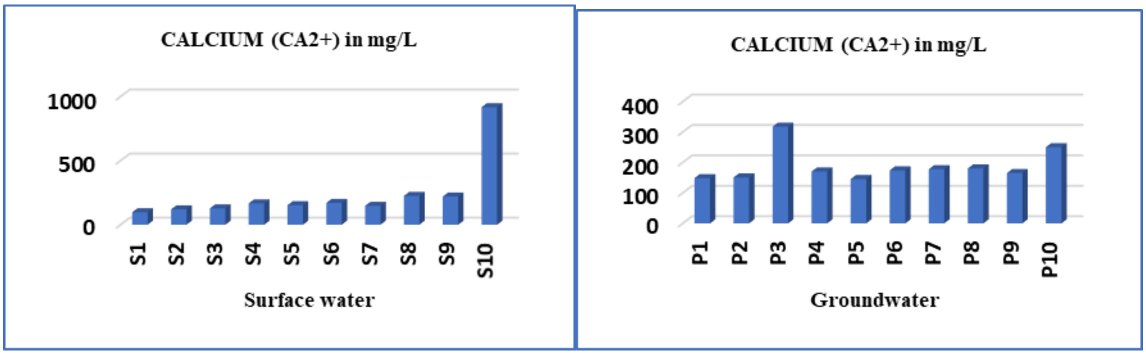

Figure 10. Spatial variation of calcium values in surface and groundwater of the Sebou watershed

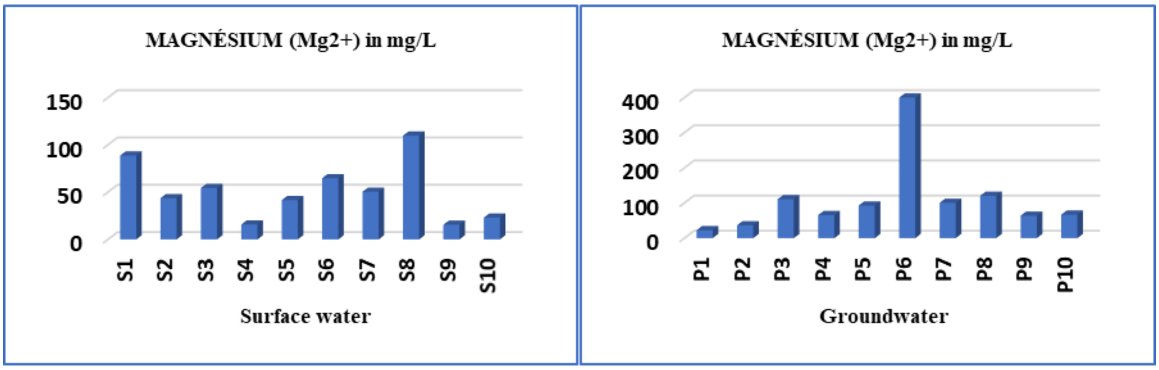

Figure 11. Spatial variation of magnesium values in surface and groundwater of the Sebou watershed

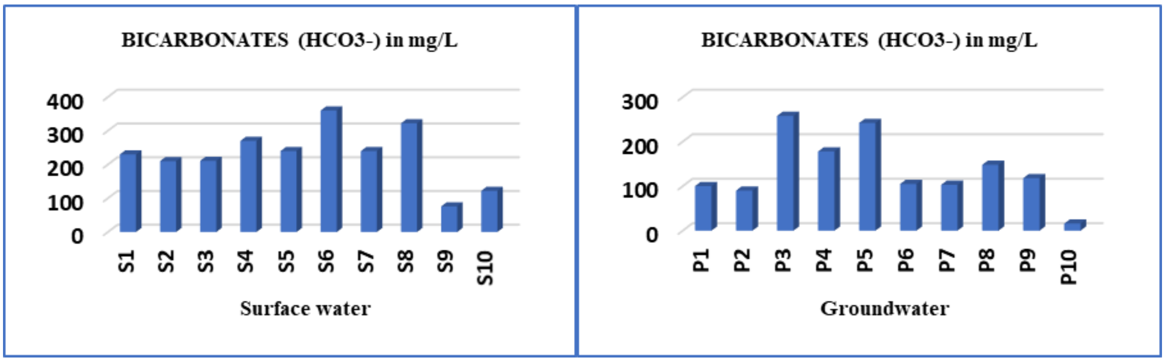

Figure 12. Spatial variation of the values of Bicarbonates in the surface and underground water of the Sebou watershed

Table 2. Results obtained at the end of the individual interviews carried out

VARIOUS	
Average number of people per household	6 people per household
WATER RESOURCE	
Drinking water resources used by the population during the rainy season	Well protected : 30 % :
	Unprotected well : 60 %
	Water drilling : 10%
Ressources en eau de boisson utilisée par la population pendant la saison sèche	well protected : 20 %
	Unprotected well : 60 % : 70 %
	Water drilling : 10%
What is the average amount of canister and basin of drinking water do you take per day	Average amount of drinking water per day: 1 container of 25 liters and 2 basins of 20 liters
SANITATION	
Use of individual latrine	Yes : 90 % No : 10%
KNOWLEDGE ON WATER-BORNE DISEASES	
Knowledge of the causes of water-related diseases	Yes : 82 %
	No : 10%
	I don't know: 8 %
What is drinking water	Clear water : 66 %
	Tasteless: 1 %
	Which does not cause disease : 24 %
	Odorless: 9 % Other : 1 %
Can standing water bring disease?	Yes : 87
	No: 1 %
	I don't know: 12 %
Can drinking water cause disease?	Yes : 87%
	No: 1 %
	I don't know: 12 %
Water-related diseases recorded in households over the past month	Diarrhea: 10 %
	Vomiting: 7 %
How many children under 5 have had diarrhea in the past 2 weeks	10 children had diarrhea out of 90 children Identified in households
Means used to make water drinkable	Boil : 4 %
	Traditional filter: 0 %
	Settling: 0 %
	Chlorination: 0 %
HYGIENE PRACTICE	
Do you clean the water transport container?	Yes : 90% No : 10
What means do you use to wash the container used to store water?	1- soap and water: 95% 2- sand and water 3- ash and water
When do you wash your hands	1. before eating : 100% 2. after the toilet : 100% 3. after the child's toilet : 100% 4. before cooking : 100% 5. after Work : 100%

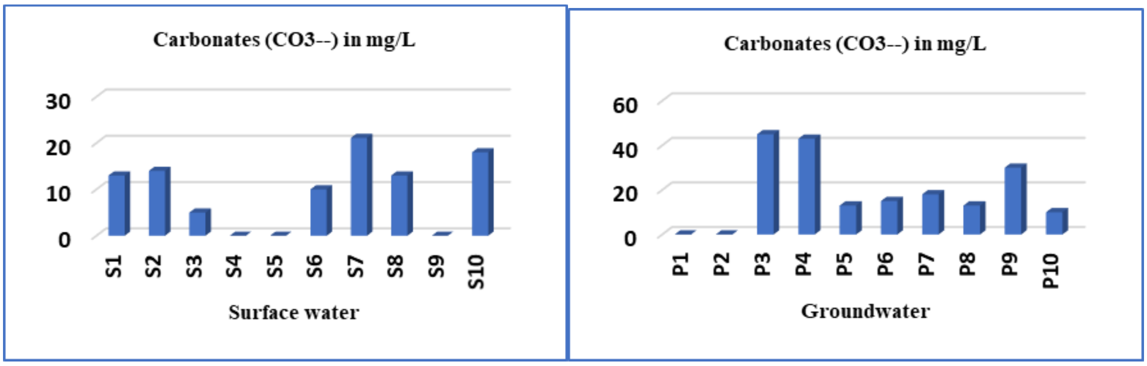

Figure 13. Spatial variation of carbonate values in surface and groundwater of the Sebou watershed

Conductivity is a useful indicator of the origin of water since it provides information on the mineralization of the water [10]. It is noted that the values of the electrical conductivity of the recorded surface waters vary from 624 µs/cm to 16320 µs/cm, with an average value of 3865.3 µs/cm (Fig.3). According to these analyzes only 30% of the stations comply with the irrigation standards (Ministry of the Environment of Morocco, 2007) which is set at 1200 µs/cm. 20% of stations are closer to irrigation standards, 50% of stations are further from Moroccan irrigation standards. These results could be explained, in part, by the discharge of waste water rich in artificial fertilizers from a fertilizer industry (NPK) and on the other hand, by the discharge of highly mineralized municipal slaughterhouse waste connected to these stations. At groundwater level, the results show that the electrical conductivity of recorded groundwater varies from 250 µs/cm to 22210 µs/cm with an average value of 5857 µs/cm (Fig.3). The maximum recommended value for electrical conductivity by the WHO is 2000 µs/cm. The results show that the recorded conductivities are quite strong, although 40% of the wells have an electrical conductivity higher than WHO standards. This corresponds to a strong mineralization of these waters.

The pollution in the wells which corresponds to a high electrical conductivity is done according to two mechanisms: direct contamination which is due to contact with industrial and domestic wastewater with the groundwater which rises to the bottom of the quarries. Contamination indirect on grounds of the penetration and seepage of agricultural products through the soil and the generally permeable unsaturated zone. This indirect pollution is favored by the shallow depth of the water table (4m) and spreads in the same direction as the water table flow to reach the wells near the wadi site. This explains the high conductivity values measured at the level of the wells closest to the wadis [11].

3.3. Nitrates (NO_3^-)

Nitrites are naturally occurring and soluble in soil, nitrates penetrate soil and groundwater and flow into waterways. However, they are also provided synthetically by fertilizers [12] and constitute one of the factors in the degradation of water quality. The ultimate product of nitrification, nitrates come from the decomposition of organic matter through bacterial oxidation of nitrites. They are very soluble salts which are easily driven deep by seepage water, their origin is mainly agricultural, the pollution generated is diffuse and is the result of an excess of decomposing vegetable organic matter on and in the soil after harvesting, after deforestation, spreading nitrogen fertilizers in quantities greater than the needs of cultivated plants: chemical fertilizers (potash nitrates, slag, etc.) and organic fertilizers (manure, slurry, sludge from treatment plants...). The domestic and industrial origin is secondary; the pollution generated is more occasional (faulty sanitation for example) [13]. Nitrates can come from an oxidation of nitrogenous organic matter; they can also be linked to the bacterial oxidation of ammonia. In surface water, nitrate concentrations vary from 0.47 mg/L to 830.88 mg/L with an average value of 149.47 mg/L (Fig.4). These results show that only 50% of the samples taken comply with the Moroccan irrigation standard. It should be noted that the other stations do not comply with Moroccan standards (Ministry of the Environment, 2007) and especially Moroccan drinking water standards (<50 mg/L). At groundwater level, nitrate concentrations vary from 58.85 mg/L to 884.1 mg/L with a mean value of 284.11 mg/L (Fig.4). The results obtained show that 100% of the wells have a nitrate content above WHO standards (50 mg/l), indicating the presence of nitrogen pollution coming from organic waste, fertilizers overused in agriculture and domestic or industrial effluents can originate. Therefore, the groundwater in this region is no longer drinkable and requires drinking water treatment.

3.4. Ammonium (NH_4^+)

In surface waters, ammonium comes from human or animal organic substance, plant substance, industrial waste, fertilizers, etc. Nitrogen is present in raw water; it can be organic or mineral in character. In groundwater, ammonium can be associated with nitrate reduction. It can also be of agricultural, urban or industrial origin. The presence of ammonium in groundwater stems from surface contamination from effluents or from a common nitrate reduction phenomenon in confined aquifers and gives us an indication of organic pollution. It may also give an indication of a possible microbiological load [13]. At surface water level It is observed in the results obtained that the ammonium ions record a maximum of 15.44 mg/L and a minimum of 0.08 mg/L with an average of 2 mg/L (Fig.5). The results of Ammonium ions are consistent with the values of the Minister of Water and the Environment in Morocco (<8 mg/l), used for irrigation 2007, except for the S10 station

(=15.44 mg/ L) which does not comply with Moroccan standards. In groundwater, ammonium concentrations vary from 0.17 mg/L to 2.54 mg/ with an average of 1.17 mg/L (Fig.5). These results show that 40% of the wells have levels above the WHO standards (0.5 mg/l), indicating the presence of nitrogen pollution coming from fertilizers overused in agriculture, organic waste and domestic or industrial waste water. Therefore, the groundwater in this region is no longer drinkable and requires drinking water treatment.

3.5. Sulfates (SO_4^{2-})

The natural origins of sulphates are rainwater and the dissolution of evaporitic sedimentary rocks, in particular gypsum ($CaSO_4$), but also pyrite (FeS) and more rarely igneous rocks (galena, blende, pyrite). The anthropogenic origins are the combustion of coal and oil which leads to a significant production of sulphides and the use of chemical fertilizers and washing powder [14]. The reversible transformation of sulphates into sulphides takes place thanks to the sulfur cycle [15]. According to the results obtained, the sulphate contents of surface waters vary from 103.18 mg/l to 312.65 mg/l with a mean value of 166.81 mg/L (Fig.6). According to this study, 90% of the samples analyzed in the study region comply with irrigation standards (< 250 mg/L). The sulphate contents of groundwater vary from 38.34 mg/l to 435.25 mg/l with a mean value of 112.58 mg/L (Fig.6). According to this study, 100% of the wells in the study region comply with WHO standards (< 500mg/L).

3.6. Chloride (Cl^-)

Chloride is a natural anion that is widespread, found on the surface and in groundwater sources. It is often associated with salts such as potassium chloride and sodium chloride. In addition to its natural tendency to be found in soil and groundwater, Chloride can enter the water from various sources, some of these chloride sources are rock salts, agricultural effluents and effluents from various industries. Chloride ions give an accurate indication of the watercourses' degree of mineralization; a high chloride content very often indicates human activity [16]. The concentration of chlorides in water is determined by the origin of the water, the terrain crossed and the chemical composition of the soils and rocks that are in contact with the water sources. Waters that are too enriched in chlorides are corrosive and laxative [17]. The concentration of chlorides in the surface waters of the Sebou vary from 170 mg/L to 868 mg/L with an average value of 292.5 mg/L (Fig.7). It is noted that there are approximately 25% of the stations (5 stations) which do not comply with the Moroccan standard, set at 350 mg/l for surface water used for irrigation (Minister of the environment, 2007). At groundwater level, analyzes show that chloride concentrations vary from 128 mg/L to 475 mg/L (Fig.7). According to the WHO standards relating to the potability of water, the recommended maximum chloride concentration is 250 mg/L According to this study, 41% of the wells have chloride contents higher than the WHO standards, which indicates the presence of strong mineralization of the groundwater in the study region.

3.7. Sodium (Na^+)

The presence of sodium in groundwater is a normal phenomenon. However, things like road salt, water softeners, natural underground salt deposits, pollution from septic tanks, leaching from geologic formations that contain sodium chloride, decomposition of mineral salts like silicates of sodium and aluminium, as well as the intrusion of salt water due to the proximity of the ocean and industrial and domestic discharges are often the cause of its high level in drinking water sources. The sodium content of the surface waters of Haut Sebou varies from 52 mg/L to 1870 mg/L with an average value of 1220.2 mg/L (Fig.8). It can be seen that about 25% of stations do not comply with the Moroccan standard, set at 350 mg/l for surface water used for irrigation (Minister of the Environment, 2007). At groundwater level, analyzes show that sodium levels vary from 107 mg/L to 2553 mg/L (Fig.8). According to the WHO standards relating to the potability of water, the recommended maximum sodium concentration is 200 mg//l. According to this study, 50% of the wells have sodium levels higher than the WHO standards, which indicates the presence of strong mineralization of the groundwater in the study region. This may be due to the high use of effluents in agriculture, which contain larger amounts of sodium. The SAR (Sodium Adsorption Rate) can evaluate the alkalinity of irrigation water. The higher the SAR value, the greater the risk of soil water sodicity. this can be explained by the equilibrium exchange between Na+ of the soil solution and Ca^{2+}/Mg^{2+} of the absorbing complex [11].

3.8. Potassium (K^+)

In water analysis, potassium is rarely analyzed as a separate component, it is very closely related to sodium. It mainly occurs in nature in the form of salts. It regulates the water content in the cells and thus plays an important role in the body's electrolyte balance. It's almost constant presence in natural waters does not usually exceed 5 to 10 mg/L [18]. Potassium levels in waters can come from erosion and Weathering of potassium minerals Like feldspar, leaching from soils containing fertilizers and seawater (In areas where saltwater infestation may occur). The potassium contents of surface waters of Haut Sebou vary from 2.84 mg/L to 12.78 mg/L with an average value of 6.07 mg/L (Fig.9). It is noted that except in the station there is a small increase in the concentrations of potassium, apart from that all the contents do not exceed the usual threshold in natural waters (10mg/L) [18]. At groundwater level, analyzes show that potassium levels vary from 2.73 mg/L to 17.68 mg/L with an average value of 8.03 mg/L (Fig.9). According to the WHO standards relating to the potability of water, the maximum recommended concentration is 12 mg/l for potassium. According to the WHO drinking water quality standards, it is recommended to take a maximum concentration of 12 mg/l potassium. According to this study, 50% of the wells have sodium levels higher than the WHO standards, which indicates the presence of strong mineralization of the groundwater in the study region.

3.9. Calcium (Ca^{2+})

Calcium exists in all natural waters alongside magnesium. Regarding groundwater, is the erosion of rocks the usual source of magnesium and calcium, such as limestone and dolomite, and minerals, such as calcite and magnesite, calcite (CaCO3), dolomite (CaMgCO3), magnesia (MgCO3), gypsum (CaSO4), apathite (Ca5(PO4)3) or fluorite (CaF). The variations in the concentrations of calcium and magnesium in water would result from the fact that calcium essentially comes from the dissolution deriving in addition to soil erosion and other weathering and remaining in solution in the water [18]. Calcium and magnesium are very present in hard water and can therefore have negative impacts on the quality of drinking water. The calcium contents of the surface waters of Haut Sebou vary from 97.8 mg/L to 916.7 mg/L with an average value of 234.4 mg/L (Fig.10). At groundwater level, analyzes show that calcium levels vary from 145.7 mg/L to 317.8 mg/L with an average value of 188.17 mg/L (Fig.10). According to WHO standards for water potability, optimal calcium concentrations are between 70 and 200 mg/L. The results obtained show the calcium content in 80% of the wells and the wells meet the WHO water potability standards.

3.10. MAGNESIUM (Mg2+)

3.11. Bicarbonates (HCO^{3-})

In groundwater, the bicarbonate content, which is not subject to anthropogenic influences, varies between 50 and 400 mg/l. The content of bicarbonate in water depends essentially on the existence of carbonate minerals in soil and aquifers and the CO2 content of air and soil in the catchment area [19]. In groundwater, the bicarbonate content, which is not subject to anthropogenic influences, varies between 50 and 400 mg/l. In unpolluted groundwater, the average bicarbonate content is about 302 mg/L [19]. At surface water level The bicarbonate contents of the stations sampled varied between 76 mg/L and 360 mg/L with an average value of 228.1 (Fig.12). It can be seen that around 100% of the stations comply with the Moroccan standard, set at 518 mg/l for surface water used for irrigation. The bicarbonate contents of the wells studied varied between 16 mg/L and 258 mg/L with an average value of 135.8 (Fig.12). The maximum concentration recommended by the WHO for bicarbonates in drinking water is 400 mg/l, according to this study. It is observed that 100% of the wells comply with the WHO guideline. So, in general, according to the results of this parameter, the water quality in the study region is acceptable for human consumption.

3.12. Carbonates CO_3^{2-}

We note that the concentration of carbonates (CO_3^{2-}) in water is linked to the content of CO2, because the latter is very soluble in water (200 times more than oxygen) and their solubility depends on the temperature and atmospheric pressure. As well as the concentration is very high of CaCO3 at the level of the samples analyzed. It could be attributed to wastewater discharges less loaded with fermentable organic matter likely to be oxidized and resulting in a high production of CO_2. As for $CaCO_3$, it is poorly soluble in water; nevertheless, the presence of CO_2 gives water a much greater power of dissolution by transforming calcium carbonate into calcium bicarbonate, which are more soluble in water. At surface water level The carbonate contents of the stations sampled varied between 0 mg/L and 21.12 mg/L with an average value of 9.41 mg/L (Fig.13). All the stations analyzed comply with the Moroccan standard for surface water used for irrigation. At groundwater level The carbonate contents of the wells studied varied between 0 mg/L and 45 mg/L with an average value of 12.38 mg/L (Fig.13). It is observed that 100% of the wells comply with the WHO guideline.

The physical and chemical properties of the rough surface waters of Upper Cebu indicated a high mineral

Magnesium exist in all natural waters alongside calsium. Magnesium is a fairly common element in nature, it is among the most soluble salts in water. It is a significant component of water hardness. Such as the soils or here gives strong fertility. A fertile soil has a very good yield in consumption. Whose irrigation water will be between good homogeneity. The magnesium contents of the surface waters of Haut Sebou vary from 15.6 mg/L to 109.7 mg/L with an average value of 50.73 mg/L (Fig.11). At groundwater level, analyzes show that magnesium levels vary from 22.54 mg/L to 400 mg/L with a mean value of 107.97 mg/L (Fig.11). According to WHO standards for water potability, optimal magnesium concentrations are between 50 and 150 mg/L. The results obtained show the calcium content in 80% of the wells and the wells meet the WHO water potability standards. loading of the oued. The average PH ist between 8.06 and 8.65. We can therefore see that it is basic but according to irrigation standards, it remains acceptable. Regarding the electrical conductivity (EC) There is a great difference in the chemical consistence of water, the latter varies between 624 µs/cm and 16320 µs/cm. Nitrates vary from 0.47 to 830.88 mg/L. Chlorides vary from 150 to 868mg/L, Sulphates also vary from 103.18 to 312.65 mg/L and Sodium varies from 52 to 1870 mg/L.It can be said that the upper sub-basin of Oued Sebou is vulnerable to several forms of natural pollution, mostly of two types: anthropogenic (from agriculture, industry, and urban areas) and mineral (from the dissolution of the natural substrate). These found values are not always consistent with irrigation standards. By way of conclusion, it seems that the surface waters of the upper Sebou have a heavy load of mineral but comply with Moroccan irrigation standards. At the groundwater level of the upper Sebou wells, the results obtained showed that the electrical conductivity varies from 250 to 22210 µs/cm as well as the pH varied from 8.05 to 8.76. The nitrate (NO3-) concentrations vary from 58.85 mg/l to 884.1 mg/l. The Sulfate (SO42-) concentrations vary from 38,48 mg/l to 435.25 mg/l. The calcium (Ca2+) contents vary between 145.7 and 317.8 mg/L. The kalium (K+) concentrations vary from 2.73 to 17.68 mg/L. It was also noted that the chloride (Cl-) concentration vary between 128 mg/l and 475 mg/L. The ammonium concentration varies between 0.17 and 2.54 mg/L. The bicarbonate concentrations vary from 16 mg/l to 258 mg/L and these concentrations are compatible with the irrigation standard. For magnesium (Mg2+) concentrations the maximum value is 400 mg/L and the minimum value is 22.54 mg/L. The natrium (Na+) concentrations in the waters vary from 107 mg/L to 2553 mg/L. After comparison with the WHO standard the resultat obtained showed that the concentrations of ammonium in 40% of the wells and of nitrates in 100% of the wells are higher than the WHO standards. These deviations indicate that nitrogen pollution is present. This pollution may come from fertilizers overused in agriculture, organic waste and domestic or industrial effluents. As well as the electrical conductivity in 40% of the wells and the concentrations of chloride concentration in 41% of the wells and of sodium concentrations in 41% of the wells of these are quite high, which corresponds to heavy mineralization generally resulting from the type of land traversed or industrial or domestic pollution. The results of the other analyzed parameters comply with the WHO guideline.

- ***Survey data***

Table 2 below presents the results obtained at the end of the individual interviews carried out in 100 households.Undrinkable water, poor sanitation and poor hygiene habits are the main routes of transmission of faecal-oral diseases including diarrhea considered among the most important public health problems in developing countries [20]. And like our case, the survey data showed that 10% of the population surveyed were affected by diarrhea and 7% by vomiting. In the study area and at the level of drinking water resources used by the population, the survey showed that the majority (70%) of the inhabitants use non-protected wells during the dry and rainy season. Most of the inhabitants have a good knowledge of waterborne diseases. Despite this good knowledge, the inhabitants do not condition their drinking water, they rely on the taste and smell of the water to know if the water is drinkable or not. Regarding hygiene practice almost all residents know how to manage the cleaning of water equipment and their hands during the day. At the sanitation level, the majority (90%) use individual latrines.

However, the conditions of access to drinking water and sanitation are not satisfactory in the study area and the populations are vulnerable to waterborne diseases. The lack of a sanitation network in the villages forces the inhabitants to build their own traditional latrines. Over time, feces in these boreholes enter the groundwater, as soon as locals notice that the well water tastes different from drinking water, the affected wells will be abandoned. Other deeper wells are then sought where the water is still spared from faces.

4. Conclusions

In general, in the study area the physical and chemical quality of groundwater was relatively average. Because pollution is present in the waters of the Sebou watershed, appropriate treatment of domestic and industrial effluents is recommended to realize a reduction in the load on this river and mitigate the loss of this important water resource. In light of this work, we can issue the following recommendations.

- ✓ Expand the study area and control a large number of surface and groundwater stations to inform us about the water quality of the Sebou watershed.
- ✓ Study other physicochemical, metallic and bacteriological parameters that may be the cause of contamination of the Sebou watershed.
- ✓ Monitor the levels of nitrate contamination especially in the intense agricultural region and study their impact on health.
- ✓ Monitor the levels of pesticide contamination especially in the region has activated intense agriculture and studied their impact on health.
- ✓ Looked for solutions to reduce the rate of contamination such as treatment plants to reduce the rate of pollution.
- ✓ Build sanitation networks in the affected villages.

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