Study of the Water Quality of Natural Water Sources in the Alkalaa Municipal Community Area – South Lebanon

M. Khatib[1], J. Hleihel[2], W. Arairo[3], H. Skeineh[4], and H. Mortada[5]

[1]Department of Civil Engineering, ISSEA-Cnam, Zkak Blat Maurice Barres, Beirut, Lebanon.

[2]Enviroment Laboratory, Science and Technology Department, Doctoral School, PRASE, Hadath, Lebanon.

[3]Civil Engineering and Construction Technology Department, University of Balamand, Kalhat, Al-Kurah, Lebanon.

[4]Departrment of Prosthodontics, Faculty of dental Medicine, Al Ayen University, Nasiriyah, Iraq.

[5]College of Health and Medical Technology, Faculty of Agronomy, Al Ayen University, Nasiriyah, Iraq.

Corresponding author: Milad Khatib (milad.khatib@isae.edu.lb)

Key Points:

- Highlight on one of the major problems that affect the health of people.
- Clarify how to analyze this catastrophic problem and prevent the losses in different levels (Humans life and economic way).
- Encourage the researches to take into consideration such catastrophic situations and ensure the water purification around word.

Abstract

Around the world, water is considered a fundamental factor, and plays a role in public health and economic growth. Both the water development rates and the proportion of the population are directly related to water needs. Water quality regarding physiochemistry and microbiology is important in dietary needs. Drinking water is considered one of the most important food products. Therefore, the water should meet the recommended quality standards. So, it should be free of bacteria, parasites, all kinds of microorganisms, and chemical substances which are dangerous to human health. This research focused on five cities of the Alkalaa Municipal Community, which forms 43% of the inhabitants of this community, in the Bint Jbeil district south of Lebanon. The goal of this study is to determine the fundamental physicochemical and microbiological water properties of eight distinct sites, as well as the amount of pollution. These tests were carried out in accordance with World Health Organization criteria (WHO). The collected data were utilized to assess the level of pollution in the examined zone.

Plain Language Summary

Water is considered an essential element of life. In this work, several water public sources in the Alkalaa Municipal Community, in the south of Lebanon were tested to ensure that the water is good for drink and irrigation.

1 Introduction

The blue planet, the third planet in the solar system, is covered by a 71% water. The latter is a unique natural source, in the sense that it can be renewed but not replaced. the majority of this water is salty and therefore cannot be consumed (97%). About 3% of the water present on the earth is freshwater, only part of which is available for various human uses, most of which is locked up in the polar glacier caps. In general, water is distributed in a very uneven way. More than 40% of the world's population faces some form of water scarcity (WHO, 2022). There are many substitutes for the various sources of energy, and for the majority of raw materials, but there is no substitute for water. It is an essential resource for all living beings on earth. It has different uses, from the most basic, such as consumption or agriculture, to the most advanced, such as the chemical industry. Water that can be consumed without risk of harm in the short or long term is a fundamental element of human life. Under the effect of population growth, the water requirements gradually increase, this becomes more and more serious by the decrease in the amount of water available due to the reduction and lowering of the amount of precipitation on the one hand in parallel with climate change which disrupts the water cycle, and water pollution on the other hand. (Postel et al. 1996). Water permanently receives pollutants of different types such as organic matter, industrial, and domestic discharges which affect its quality and reduce its availability. When the water becomes enriched with dangerous substances (ions, heavy metals, and bacteria), its normal characteristics will be altered (Daou et al. 2018). Such water becomes synonymous with health disasters, also environmental and aesthetic problems. Therefore, the treatment will become very necessary for the polluted water to continue the normal life.

Lebanon, with a land size of 10,452 km^2 and a coastline stretching 210 kilometers from north to south, is located on the Mediterranean Sea's eastern shore. However, it is like a water tower in a region plagued by aridity. This country receives a large volume of precipitation which is found in surface waters and groundwater. But this country could run out of water in the coming decade due to drought. Indeed, out of a total of 9.6 billion m^3 of annual precipitation, only 1.3 billion is used, the rest evaporates, pours in the sea, or reaches other countries (Blanc, 2006).

Moreover, it has 40 rivers, including 17 perennials and 23 seasonal. The quantity of surface and underground water is around 2.6 billion m^3, while 2 billion are actually exploitable. The annual rainfall volume over Lebanon is almost 8,600 million mm^3. This precipitation feeds the water sources in Lebanon, which are concentrated in six months of the year (from November to April) while the rest of the year is dry throughout the territory. Most of this water is lost by evaporation (almost 50% of the total volume of precipitation) while another significant proportion is lost via the flow of surface water to neighboring countries (Zaremba, 2000, Kassem, 2020).
Water quality in Lebanon is a problem. Groundwater suffers from the infiltration of pollutants, which can be, for example, wastewater, industrial waste, decomposing solid waste, etc.. Population growth, proliferation of uncontrolled drilling, and lack of sanitation in vulnerable areas of the resources are considered also problems faced the freshwater. As a result, surface waters and rivers are in danger due to pollutants coming mainly from human activities. (Nassif, 2019).
Our study will focus on water from natural springs and more specifically groundwater where the objective of our work is to determine the quality for drinking and irrigation of these springs which are located in the region of the municipal union Alkalaa in southern Lebanon. The characterization of the water quality for these sources in certain cities will be discussed referring to the obtained results of physical, chemical, and microbiological analyses. Recently, several districts and cities of the Alkalaa community have been faced with a major disruption in the drinking water supply. This is due to fairly large population growth. In order to meet the needs of the population and solve this lack of water, another source of drinking water has been put into service. The collected water in this well is derived from artesian well and various natural sources which have been there for decades.
The community of municipalities Alkalaa (12 villages) rises above the sea between 550m and 750m. The studied area does not exceed 20 km^2, it is located in the valleys between the five villages (Tibnine, Safad El Batikh, Soultaniyeh, Aita El Jabal, and Haris). The water management of the community of Alkalaa municipality is followed by the establishment of the water in the South of Lebanon. Due to the lack in the water quantity and the reduced amount of precipitations, the inhabitants of the studied cities (estimated around 100,000 inhabitants as distributed in Fig.1) are obligated to buy water for fulfil their needs. The following table (Table 1) shows the inhabitants of studied cities.

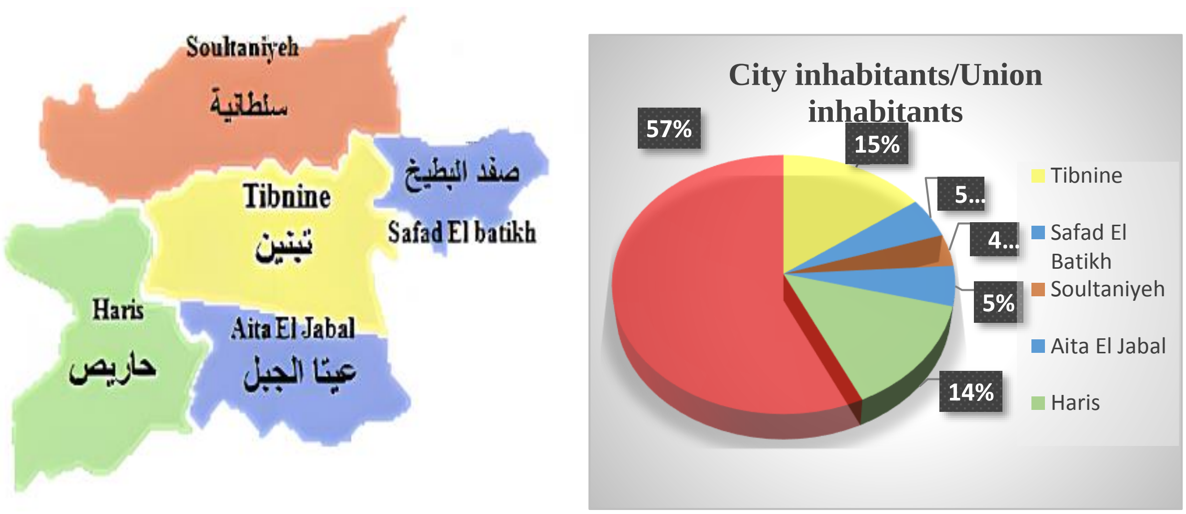


Fig.1. Population distribution map for the selected cities.

Table 1. Inhabitations of studied cities.

City	Residentials	Expacts (in Summer)	Total inhabitants	% city inhabitants to total union inhabitants
Tibnine	10,000	5,000	15,000	17%
Safad El Batikh	4,500	5,00	5,000	6%
Soultaniyeh	3,000	1,000	4,000	5%
Aita El Jabal	2,000	3,000	5,000	6%
Haris	10,000	4,000	14,000	16%
Total	29,500	13,500	43,000	50%

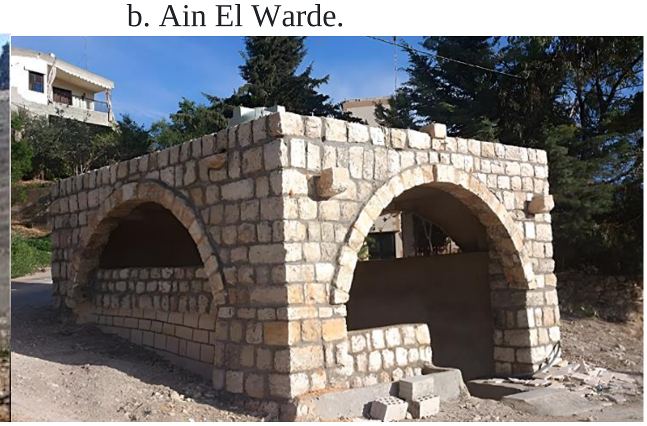
Different sources remained almost dry or dried up early, which is not the case for Ain El Mezrab (Fig.2.a) and Ain El Warde (Fig. 2.b) sources in Tibnine city, in addition to the Ain El Hamam (Fig. 2.c), and Ain El Bakar (Fig. 2.d) sources in Safad el Batikh city. The Ain El Warde and Ain El Mezrab springs are springs flowing from the "Siddiq" mountain in the city of Tibnine, as well as the Ain El Hamam springs, its filter (Fig. 2.c) and Ain El Bakar (Fig. 2.d) which depend on water flowing from the mountain of Safad el Batikh village and adjacent mountains, whose water accumulates in an underground reservoir. Today, these springs are the refuge of most of the inhabitants of the Bent Jbeil region.

In Aita el Jabal village, towards the south side, there are natural and permanent water sources such as Ain El Tayta (Fig. 2.e) and Ain El Jawze (Fig. 2.f). There are also temporary springs that will only appear during the rainy season. The sources of Ain El Tayta and Ain El Jawze are located in the valley separating the villages of Aita el Jabal and Beit Yahoun. The artesian well (Fig. 2.g) has been built since 1989, in addition to the existence of a plastic greenhouse 500 m faraway. The water from this well was used for domestic and agricultural purposes.

a. Ain El Mezrab.

b. Ain El Warde.

c. Ain El Hamam.



d. Ain El Bakar.

e. Ain El Tayta.

f. Ain El Jawze.

g. Artesian well.

Fig.2. Specimen Locations.

2 Materials and Methods

On the 30th March of three consecutive years (2020, 2021, and 2022), the water samples were choosen from eight different resources in Alkalaa region. For each site, almost 800 ml of raw water was taken and putted in plastic bottles tightly closed. These water samples were stored in coolers during transport, and still cooled until the testing days. All the tests were achieved within few days to quantify their pollution degrees by carrying out both of physicochemical and microbiological characteristics. The site elevations, and the types of activities around the springs studied in the region are presented in Table.1.

Table. 1. *Site locations and types of activities.*

Sites		Latitudes (North)	Longitudes (East)	Altitudes (m)	Types of activities / uses
S1	Ain El Mezrab	33,2027	35,4237	526	Agricultural area, irrigation, domestic, and drinking water.
S2	Ain El Hamam	33,2006	35,4283	555	Agricultural area, irrigation, domestic, and drinking water.
S3	Hamam filtre	33,2006	35,4283	555	Agricultural area, irrigation, domestic, and drinking water.
S4	Ain El Warde	33,2030	35,4220	535	Agricultural area, irrigation, domestic, and drinking water.
S5	Ain El Bakar	33,2015	35,4284	560	Agricultural area, irrigation, and domestic.

S6	Ain El Tayta	33,1738	35,4111	593	Agricultural area, irrigation, and domestic.
S7	Ain El Jawze	33,1680	35,4061	615	Agricultural area, irrigation, and domestic.
S8	Artisian Well	33,1795	35,3997	603	Agricultural area, irrigation, and domestic.

Addition precaution was taken into consideration concerning the samples intended for microbiological analysis, they were reserved in sterile containers. The microbiology tests were achieved firstly to avoid any bacterial multiplication and then the physicochemical parameters. In addition, an air space had left off at least 2.5 cm in the plastic bottles, which facilitates the homogenization of the sample at the analysis time in the laboratory. All the selected locations are shown on 3D map using GIS system (Fig.3).

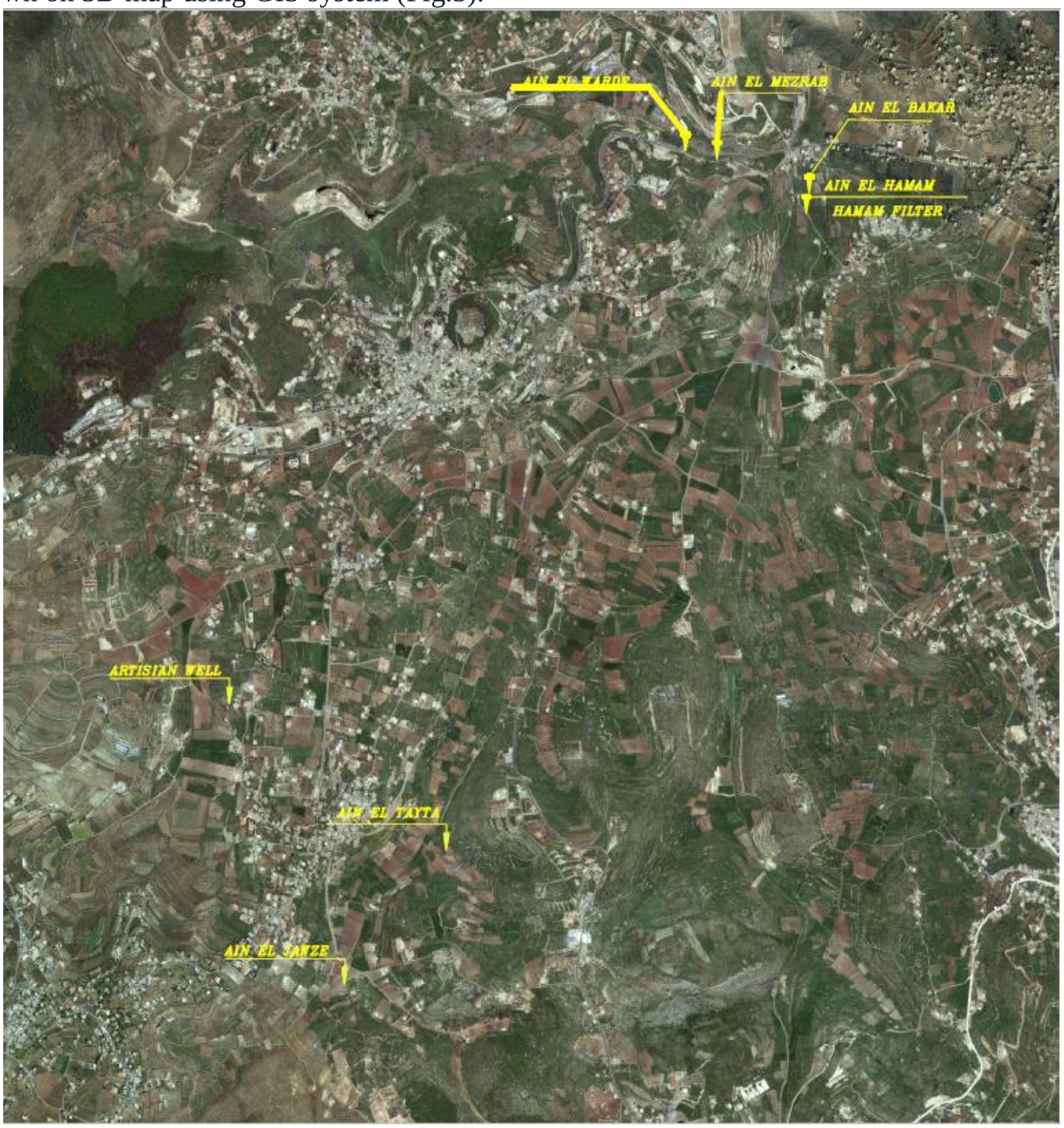


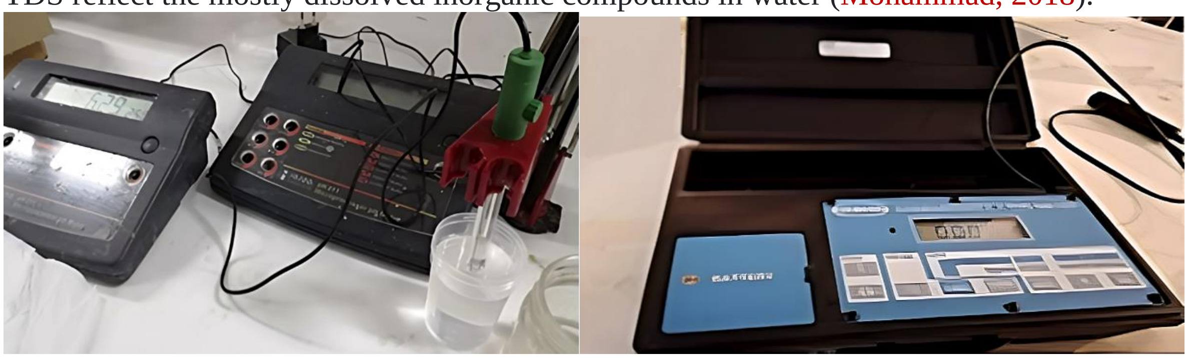
Fig.3. GIS studied locations.

2.1 Microbiological analyses

The microbiological analyses were carried out at the laboratory of the Faculty of Agronomy, Dekwaneh. The microbiological analysis of the samples requires the preparation of suitable culture media. In this study, three types of bacteria were studied: Total Coliforms, Escherichia Coli (E.Coli), and Salmonella. In each case, a specific culture medium was prepared. By using a graduated pipette, 1 ml was taken from the tested water, then it was distributed on the entire surface of the culture medium using a sterile spreader. The solutions (water + culture medium) were left next to the flame (so that the medium remains sterile) until they gelled. The reading is made after 48 hours of incubation in Macconkey Agar as a culture medium at 37 ^oC and 45 ^oC after 24hrs and 48 hrs respectively (for **Total Coliforms** & **Escherichia Coli)**. However, the culture medium for **Salmonella** bacteria was Shigella Agar at 37 ^oC after 24hrs. The bacteria, on the surface, give rise to colonies isolated from each other which can be directly counted. It is assumed that each colony corresponds to a bacteria.

2.2 Physical analysis of water

The water physical properties were measured using different apparatus. The pH (potential of hydrogen) meter is a parameter that indicates the degree of acidity of the water (Fig.4.a). The "Pocket Tester" (Fig.4.b) was used to evaluate both of the electrical conductivity (EC), and the total dissolved solids (TDS). EC is an excellent indicator of the mineralization of water, while, TDS reflect the mostly dissolved inorganic compounds in water (Mohammad, 2018).

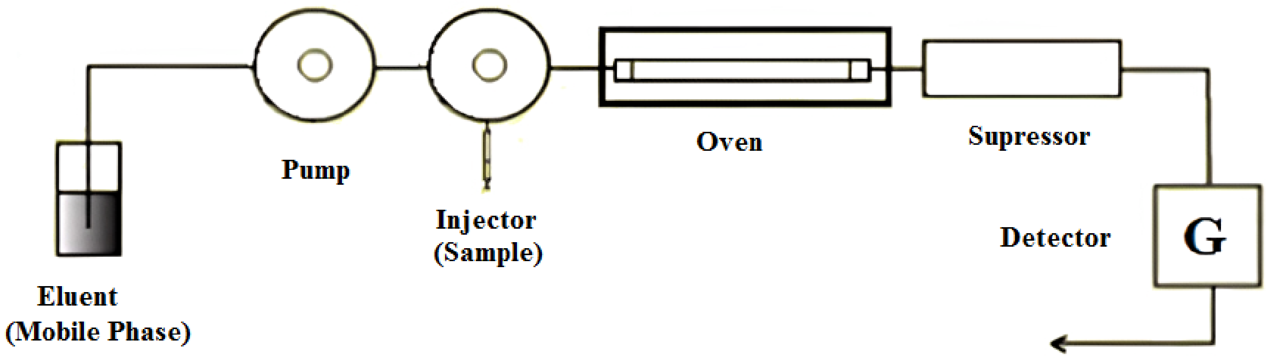


a. pH meter. b. Pocket tester.

Fig.4. Physical appartus tests

2.3 Analysis of anions

The analysed anions were F^-, Cl^-, SO_4^{2-}, NO_2^-, PO_4^{2-}, and Br^-. The analysis of anions (fluoride, sulfates, nitrites, and bromide) was made at the doctoral school of science and technology (DSST) at the Lebanese University, and their concentrations were measured by the method of ion chromatography (IC). The principle of this method (Fig.5) is based on the properties of ion exchange resins, which allows selective fixation of the anions or cations presented in the solution. On the resin packaged, in the form of a chromatography column, an eluent constantly circulates. The analyzed solution is injected and the ions are fixed selectively on the column. Then, the ions are released according to their size, their charge, and their degree of hydration. Each ionic species is separated and detected at the outlet of the column (Haddad, 2004).



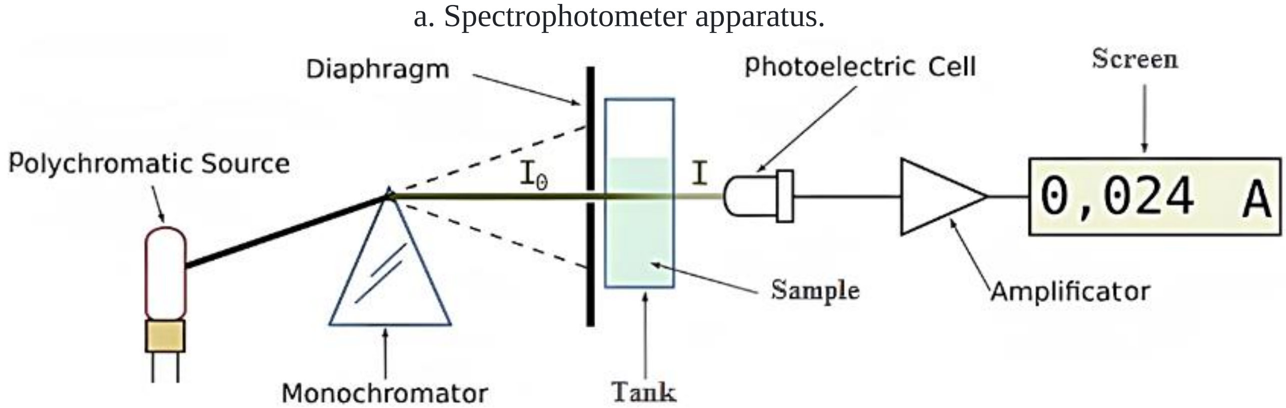
a. IC chromatography process.

b. IC chromatography apparatus.

Fig.5. IC chromatography

While chloride (Cl^-) and phosphate (PO_4^{2-}) ions were analyzed at the Dekweneh University of Agronomy. The concentrations of chloride anions were measured by the titrimetric method. This method is one of the analytical methods based on the determination of a reagent of known concentration which is required to react completely with a volume solution containing the analyte. However, the concentration of phosphates was obtained using the spectrophotometer (Fig.6.a). The spectrophotometer measures the absorbance of a solution at a given wavelength. In practice, the device measures the intensity of light after it has passed through a tank containing the solution to be studied. The intensity of the emitted monochromatic light (I0) is known. From the intensity of the transmitted light (I), the device gives the absorbance (A) as follows: A = log(I0/I) (Fig.6.b) (L'vov, 2005).

a. Spectrophotometer apparatus.



b. Spectrophotometer process.

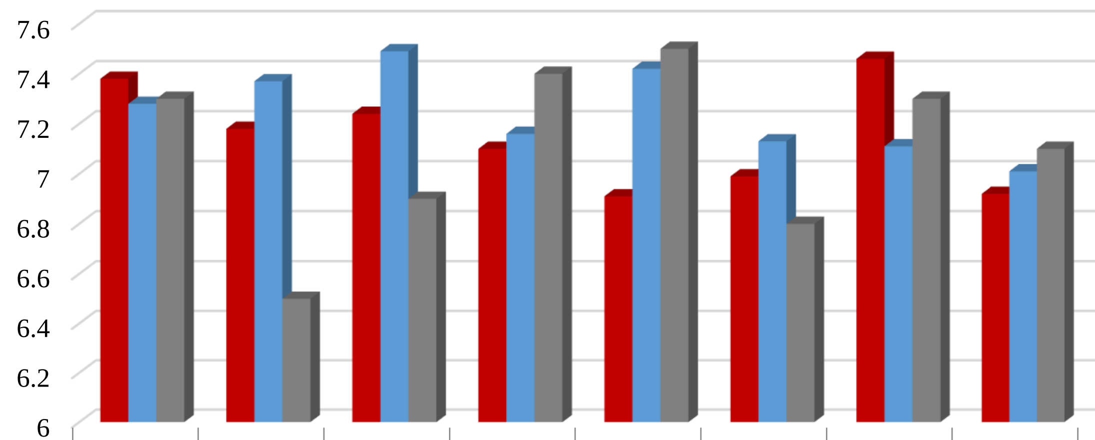
Fig. 6. Spectrophotometer

4 Results

The experimental study was carried out on 8 water locations taken from the municipal community Alkalaa, in particular from the villages Tibnine, Safad el Batikh, Aita el Jabal and Haris, to determine the physicochemical and bacteriological parameters of 8 natural water sources. For three consecutive years 2020, 2021, and 2022, all the samples were taken in 30 April. The latter is for microbiological analysis, where the samples are analyzed the following day directly. The results obtained are processed and discussed in the form of histograms and tables.

4.1 The physical analysis

This research will enable the interrelationship and assessment of the reservoir's numerous naturogenic and anthropogenic elements. The pH levels ranged between 6.91 and 7.46 for 2020, 7.01 and 7.49 for 2021, and 6.5 and 7.5 for 2022. (Fig. 7). All these values were within the allowed range between 6.5 and 8.5 (LIBNOR, 2010).

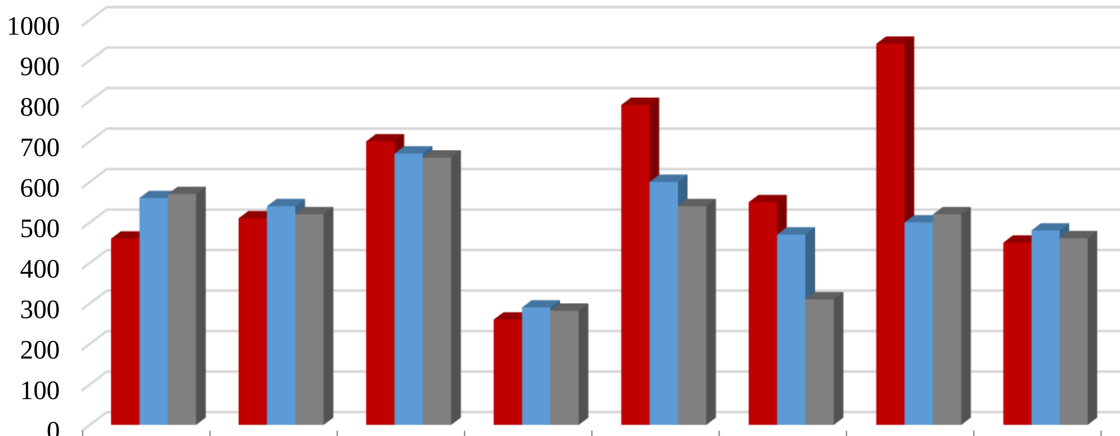


	Mezrab	Warde	Hamam	F Hamam	Bakar	Tayta	Jawze	Well
2020	7.38	7.18	7.24	7.1	6.91	6.99	7.46	6.92
2021	7.28	7.37	7.49	7.16	7.42	7.13	7.11	7.01
2022	7.3	6.5	6.9	7.4	7.5	6.8	7.3	7.1

Fig. 7. pH values for the eight locations.

Water having an electrical conductivity of more than 1000 s/cm norm for drinking water (WHO, 2022) is highly mineralized and unsafe for human consumption. The FAO recommended that EC values should be less than 3000 s/cm standards for irrigation water (FAO, 2003). The high conductivity alters the availability of free metals to plants and wildlife. Pipes can be corroded by water with a concentration less than 180 s/cm (Konan, 2018).

The EC values for the chosen sites ranged from 260 s/cm to 941 s/cm in 2020, 290 s/cm to 670 s/cm in 2021, and 282 s/cm to 660 s/cm in 2022 (Fig.8). These values do not exceed the international recommendations neither for drinking nor for irrigations.

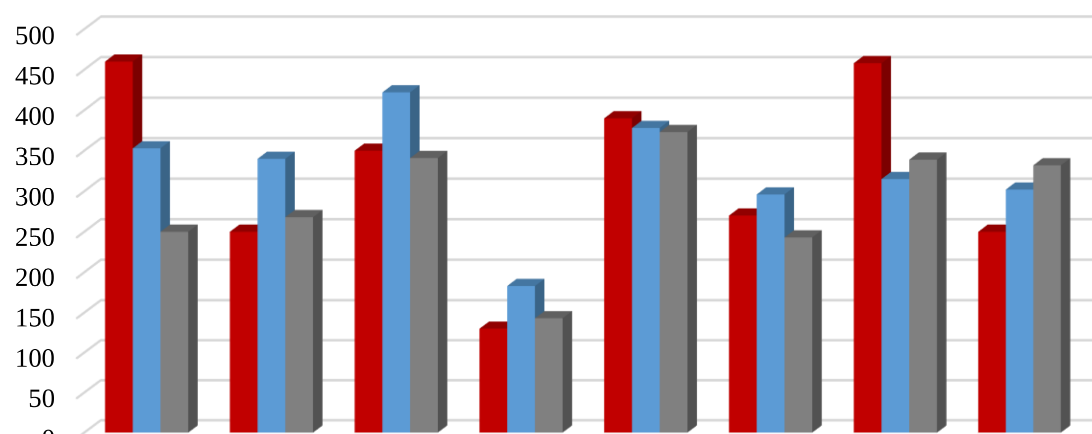


	Mezrab	Warde	Hamam	F Hamam	Bakar	Tayta	Jawze	Well
2020	460	510	700	260	790	550	941	450
2021	560	540	670	290	600	470	500	480
2022	570	520	660	282	540	310	520	461

Fig. 8. Electrical Conductivity EC values.

The dissolved solids are mostly composed of chlorides, sulfates, bicarbonates, calcium, magnesium, and sodium. These solids come from natural sources, municipal and industrial effluents, runoff from agricultural land, and the fallout of atmospheric particulate matter. The most significant impact of total dissolved solids on the quality of water is flavor modification. They sometimes cause scaling of the pipes.

A very high or very low concentration of TDS limits growth and can cause the death of several aquatic organisms. The values from different sources varied between 130 mg/l and 460 mg/l in 2020, 183 mg/l and 422 mg/l in 2021, and 143 mg/l until 373 mg/l in 2022 (Fig. 9). None of these values was exceed the specified limits 600 mg/l standards for drinking water (WHO, 2022) and 2000 mg/l standard for irrigation water(FAO, 2022).



	Mezrab	Warde	Hamam	F Hamam	Bakar	Tayta	Jawze	Well
2020	460	250	350	130	390	270	458	250
2021	353	340	422	183	378	296	315	302
2022	250	268	341	143	373	243	339	332

Fig. 9. TDS results.

4.2 The chemical analysis

Phosphorus is an important component of living materials that ranges from 0.1 to 1%. Because it is one of the three necessary nutrients for plants, it has become vital as a chemical fertilizer. Teeth and bones contain around 85% of the phosphorus in the human body. Phosphate ions are utilized in water treatment, as well as in cleaning products and metal treatment . Phosphate pollution of water is connected to industrial and household wastes, as well as phosphate fertilizer seeping from cultivated land (Konan, 2018, Belmehdi, 2004). The phosphate concentration in the various sources investigated is zero (0 mg/l) in 2021 and 2022, eventhoug in 2020 two sources (Ain El Warde and Ain El Bakar) had 0.1 mg/l, and Ain El Jawze had 0.2 mg/l. There is no measurement surpasses the LIBNOR drinking water guideline of 1 mg/l or the FAO irrigation water standard of 2 mg/l.

Fluor is a natural element found in low concentrations in nature, it is located in the environment because of industrial activities such as in the manufacture of phosphate fertilizers, cement, aluminum, steels, etc., and found in geological environments. Note that an excessive intake of this ion (7.7 mg/day) causes the disease of fluorosis, a pathology affecting tooth enamel.

The mass concentration of fluor presented in all the sites within the range of 0.019 mg/l until 0.067 mg/l in 2020, 0.0 mg/l until 0.037 mg/l in 2021, and 0.172 mg/l until 0.291 mg/l in 2022. These values are acceptable because they are below 1.5 mg/l stated for drinking water (WHO, 2022), and 1 mg/l for irrigation water (FAO, 2022). This result can be attributed to the absence of industrial activities such as the synthesis of phosphate fertilizers, and a very small quantity of fluorine in the geological cover. (Fig. 10).

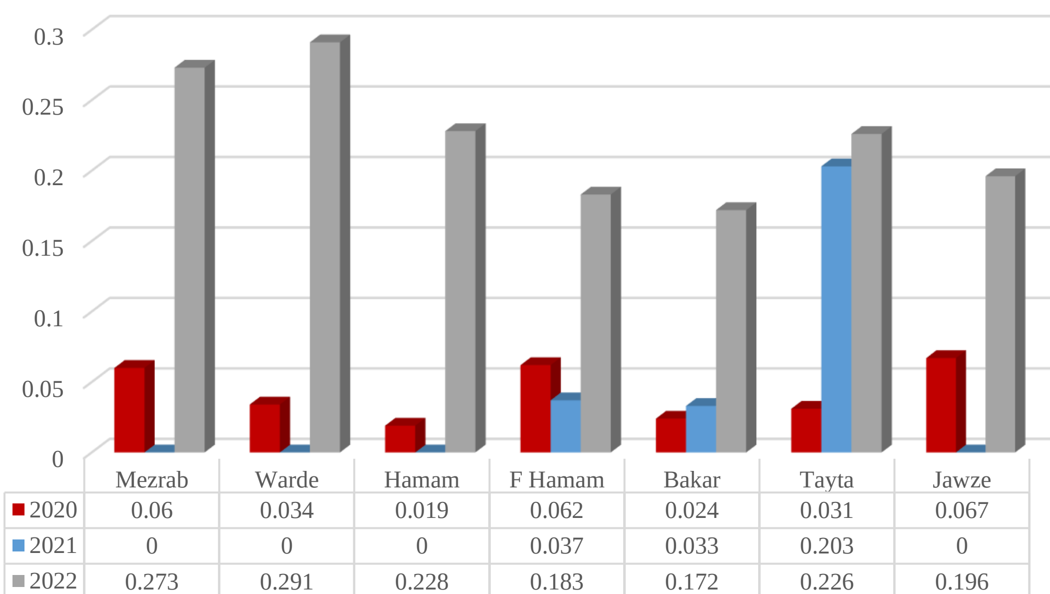
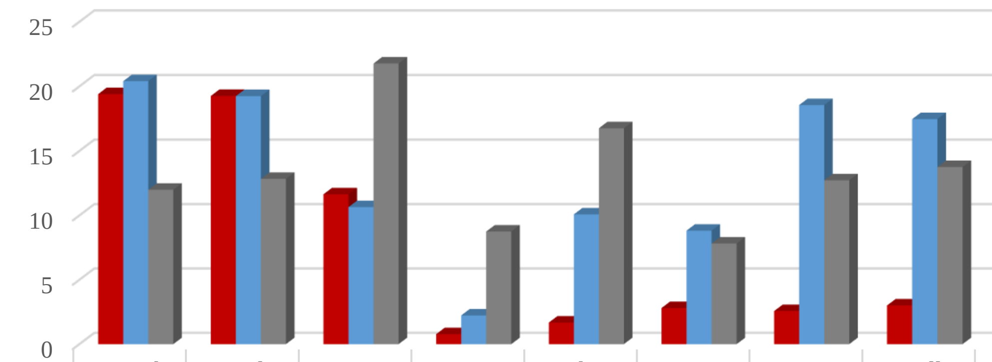


Fig. 10. Fluor concentration results.

Chlorides are abundant in nature, and commonly found in the form of sodium and potassium salts. They constitute for around 0.05% of the continental crust. The oceans have the greatest concentration of chlorides in the ecosystem. When chloride concentrations surpass 200 mg/l, water has an unpleasant and harsh taste, and there is a risk of oxidation of distribution networks. These ions are derived by the erosion of rocks and sedimentary soils, i.e. water disinfection and industrial operations that employ chlorine as a cleaning agent (Papin, 2016).

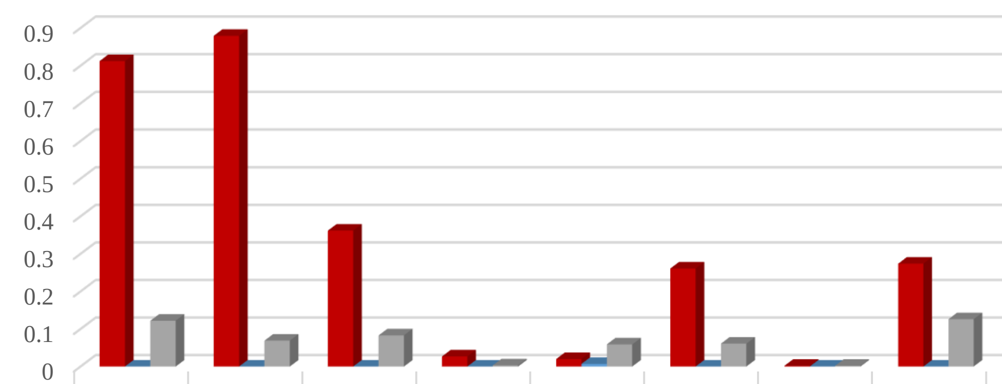
The obtained results (Fig. 11) show that the chloride ion concentration varies between 0.78 mg/l to 19.404 mg/l in 2020, 2.231 mg/l to 20.404 mg/l in 2021, and 7.82 mg/l to 21.773 mg/l in 2022. It should be noted that all of the sites have acceptable chloride concentrations in terms of drinking water standards specified by LIBNOR (200 mg/l) and irrigation water (1050 mg/l) specified by FAO.



	Mezrab	Warde	Hamam	F Hamam	Bakar	Tayta	Jawze	Well
2020	19.404	19.263	11.645	0.78	1.676	2.809	2.574	3.011
2021	20.404	19.25	10.645	2.231	10.082	8.814	18.552	17.468
2022	11.992	12.841	21.773	8.751	16.757	7.82	12.733	13.757

Fig. 11. Chlore concentration results.

Nitrites are formed as a result of the partial oxidation of organic compounds. Nitrites are present in the most food items, the atmosphere, and the majority of water. Nitrites are formed as a result of the nitrification of nitrates. Once in the body, nitrites can react with iron inside the red blood cell “hemoglobin”, resulting in the formation of "methemoglobin", and they are suspected of interacting with specific amino compounds. This is the case for amides and amines that combined to generate N-nitrosated chemicals, knowing that some of it may be carcinogenic (Konan, 2018). In 2020, the values of nitrates were between 0.002 mg/l and 0.879 mg/l, while in 2021 only site 5 showed a minimal amount of nitrites (0.007 mg/l). However, in 2022 the range becames between 0.002 mg/l and 0.126 mg/l (Fig. 12). All the obtained results are lower than the WHO drinking water guideline (3mg/l) and the FAO irrigation water standard (0.05mg/l).



	Mezrab	Warde	Hamam	F Hamam	Bakar	Tayta	Jawze	Well
2020	0.812	0.879	0.362	0.027	0.02	0.261	0.002	0.274
2021	0	0	0	0	0.007	0	0	0
2022	0.122	0.069	0.083	0.003	0.059	0.061	0.002	0.126

Fig. 12. Nitrite concentration in mg/l.

The bromine is a natural existed element in the environment. It makes up 0.001% of the earth's crust and is most abundant in granitic rocks and pegmatites. It is found combined with oxygen or other elements in compounds known as borates. They are found in the natural world, and can be found in the oceans, sedimentary rocks, charbon, argilous schiste, and certain soils. This is an essential oligo-element for plants. The bore is involved in the formation of the os, the production of red blood cells, and the immune system's cells. The symptoms of bore intoxication include nausea, vomiting, diarrhea, cutaneous irritations, and epidermal desquamation, as well as indicators of central nervous system excitation followed by depression (Johnston, 2019).

The results of bore concentrations in all tested sites show values within the recommendations of the WHO limit for potable water (0.5mg/l) and the FAO limit for irrigation water (2 mg/l). They varied between 0 mg/l and 0.293 mg/l (2020), 0 mg/l and 0.056 mg/l (2021), 0 mg/l and 0.08 mg/l (Fig.13).

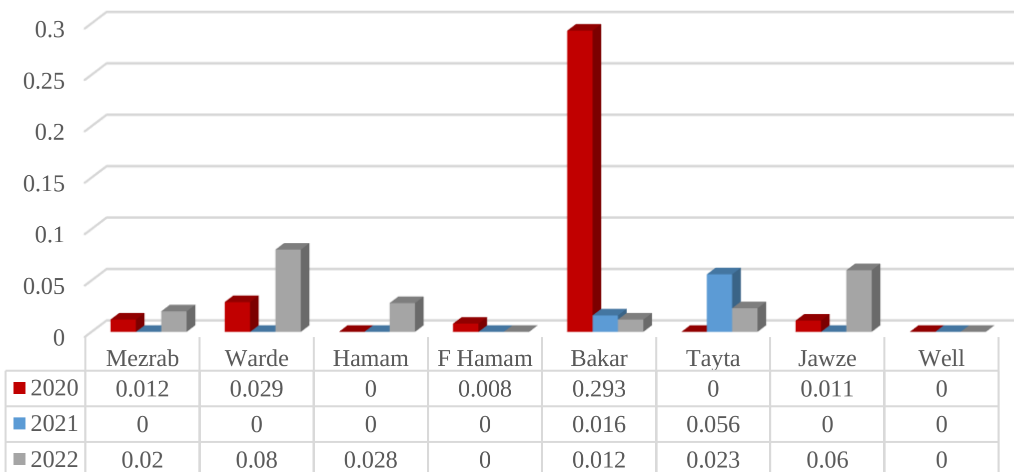


Fig. 13. Bore concentration in mg/l.

4.3 The microbiological analysis

Microbiological parameters are the first to be taken into account when it comes to the drinking water supply because they can have effects on consumer health. The microbiological analysis makes it possible to highlight the faecal pollution of the water. For this reason, it is important to look for germs that are always present in large numbers in the faeces of humans and animals, which are more easily maintained in the external environment, which are: Total Coliforms, Faecal Coliforms, and Salmonella Shigella.

Table.2. *Microbiology Test Results.*

		Bacteria types – Culture media								
		Total Coliforms Maccokney 37^o			Faecal Coliforms Maccokney (E.Coli) 44^o			Salmonella Shigella agar (SS) 44^o		
		2020	2021	2022	2020	2021	2022	2020	2021	2022
Site 1	Ain El Mezrab	7	200	100	-	-	-	-	-	-
Site 2	Ain El Warde	20	200	100	-	-	-	-	300	600
Site 3	Ain El Hamam	-	-	-	-	-	-	-	-	-

Site 4	F Hamam	-	-	-	-	-	-	-	-	-
Site 5	Ain El Bakar	-	-	-	-	-	-	-	-	-
Site 6	Ain El Tayta	-	-	-	-	-	-	-	-	-
Site 7	Ain El Jawze	18	600	-	-	-	600	-	-	-
Site 8	Artisian Well	2	300	-	-	250	-	-	-	-

The term "coliform" corresponds to organisms has the abaility of growing in the presence of bile salts and capable of fermenting lactose with the production of acid and aldehyde within 48 hours, at temperatures of 35 ^{o}C to 37^{o}C. These bacteria has intestinal origin (animal or human). They are frequently found in the environment, soil, vegetation, and water. These bacteria cause nausea, vomiting, and diarrhea and infect the lungs, skin, and eyes. The sources of this bacteria can be wastewater discharges, the presence of urban areas, or significant industrial activities (Hussain, 2019).

The number of total coliforms in our sites oscillates between the values of 0 and 20 CFU/100 ml (2020), 300 CFU/100 ml and 600 CFU/100 ml (2021), 0 and 100 CFU/ml. (Table. 2). The four sites: Ain El Hamam, Hamam filter, Ain El Bakar and Ain El Tayta show no pollution by CT. For the other sites (Ain El Mezrab, Ain El Warde, Ain El Jawze, and Artisian well present contamination by CTs where the highest concentration corresponds to site 7 (Ain El Jawze) which is equal to 600 CFU/100 ml. All these concentrations exceed the WHO standards for drinking water (0 CFU/100 ml) and that of the FAO for irrigation water (100 CFU/100 ml). This pollution is manifested by the discharge of wastewater without treatment.

Faecal coliforms are a subgroup of total coliforms and show the same properties and characteristics after incubation at 44^{O}C. An important species in this group is Escherichia coli (E. Coli). The presence of E. Coli in the water is considered a positive indicator of contamination by human or warm-blooded animal faecal material. The E. Coli is an inhabitant of the intestines and stools of warm-blooded animals and folds. This bacteria cause bloody diarrhea, vomiting, and fevers and produce a powerful toxin that causes hemolytic uremic syndrome.

With regard to study sources, all the sites does not show the existance of contamination by this type of bacteria (0 CFU/250 ml), except that the site of Artisian well in 2021 show high concentrations with this type of bacteria (250 CFU/250 ml), and the site of Ain El Jawze in 2022 (600 CFU/250 ml). These values exceed drinking and irrigation water limits (0 CFU/250 ml by WHO and 100 CFU/250 ml by FAO respectively). This contamination is due to the flow of untreated domestic wastewater.

Salmonella is a very resistant bacteria of which there are two species but more than 2,500 serotypes. They can survive several weeks in a dry environment, and several months in water. They lodge in the intestines of infected people and animals, particularly poultry and reptiles. These bacteria are found in soil, food, and water (Liu, 2018).

Bacteria are transmitted through human-to-human or animal-to-human contact, or through the consumption of contaminated water and food. Most cases of bacteria spreadings are associated with mishandling raw meats or eggs, or undercooking meats or eggs. Contact between cooked food and raw poultry on a cutting board or through the use of an unwashed knife can further contribute to the spread of Salmonella infection. Typically, symptoms appear one or two days after infection. Most people who get sick have diarrhea, abdominal cramps, headaches, nausea, vomiting, and fever. Symptoms usually last less than a week. However, some people can become seriously ill.

Regarding the obtained results, all the sites were not contaminated by salmonella, while the Warde site show the existence of this bacteria in 2021 (300 CFU/100 ml) and in 2022 (600 CFU/100 ml), which exceed the drinking water limit set by the WHO (0 CFU/100 ml) as well as for irrigation water (0 CFU/100 ml) by FAO which are respectively (Table.2). Water pollution by salmonella is explained by the flow of domestic wastewater in most sites. Besides that for the Warde site, there are a few chicken farms not far from the source.

5 Conclusions

The study was carried out in the years 2020, 2021, and 2022. It was found that the results are not too far off (the concentrations of parameters analyzed).

(1)-The concentrations of ions (cations and anions) in the last year are a little higher (but all respect the standards for drinking water and for irrigation) because there was also precipitation (early April) so there will be more leaching from the rocks and the ions will sink further into the groundwater.

(2)-Regarding the bacteriological study, the concentrations of different bacteria are also close knowing that the samples were taken during the same period last year.

(3)-We also notice in the analysis of the samples (2022) in all the studied sites, the presence of high concentrations of iron mainly coming from the corrosion of soil and rocks.

(4)-In addition, lead exists only in site 6 (Warde filter), this is due to corrosion in the present filter.

Water sources are continually exposed to pollution problems, sometimes on the physicochemical side, sometimes on the microbiological side, or to mixed problems that affect both sets. Water contamination can always be of natural or anthropogenic origin.

The main objective this work is to determine the physicochemical characteristics of the eight water resources in the Bint-Jbeil district. So we can conclude:

(1)-AGU does not normally allow dedications The monitoring of the Physico-chemical parameters has shown that the physicochemical characteristics of the water (pH, TDS, and EC) are always within the ranges respecting the standards specified at the national and international level adopted for water.

(2)- The analysis of anions (PO_4^{3-}, F^-, Cl^-, NO_2^-, and Br^-) shows that the values were acceptable for all the tested sites, except for the Artisian well in 2020.

(3)- The results of microbiological analyzes carried out the show:

*The total coliform in 2020 was unremarkable in all the sites, but in 2021 it becames active in the Ain El Mezrab, and the Ain El Warde sites, while the Ain El Jawze and the Artizian Well depassed the limits. In 2022, it disappeared from all the sites, except the Mezrab and the Warde.

*Regarding faecal coliforms (E. Coli) all the sites show an absence of contamination by this bacteria except the Artisian Well in 2021 and the Ain El Jawze in 2022.

* Regarding Salmonella, all the sites show an absence of contamination by this bacteria except the Ain El Warde in 2021 and 2022.

Based on the obtained results, it can be concluded that the water distributed by these different sources in the Alkalaa community is devoid of certain consumption safety measures. Water analysis is necessary to protect the consumer. Improving health cannot be achieved without a better living environment, a healthy environment.

The local authorities should participate in :

- Development of the policy on the fight against pollution,

- Encouraging community participation and establishment of the infrastructures necessary to reduce pollution, especially waterborne
- Make the effort to install several treatment plants.
- Pollution protection measures should be applied at all times.

The inhabitants should be involved in the protection and conservation of water reserves (be careful when using fertilizers). In addition, it is necessary to encourage the inhabitants into installing treatment filters for purify the water to get rid of pollutants.

Data Availability Statement

The authors declare that all the used data was cited in this paper and references.

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