Available online at www.derpharmachemica.com

ISSN 0975-413X
CODEN (USA): PCHHAX

Der Pharma Chemica, 2016, 8(20):97-103
(http://derpharmachemica.com/archive.html)

Study of the classification of spring water with regard to the opinion of users: Case of the Tangier-Tetouan region, Western Morocco

Ali Laghzal[1*], F. Salmoun[1], R. Taourati[1], N. Nouayti[2], M. Fihri[3] and Z. Mammad[4]

[1]*Laboratory of Physical Chemistry of Materials, Natural Substances and Environment, Faculty of Science and technology, Tangier, Morocco*
[2]*Laboratory of Applied Geosciences and Centre of Oriental Sciences and Water Technologies (COST), Mohamed I University, Oujda, Morocco*
[3]*Laboratory of Mathematics and Application, Faculty of Science and technology, Tangier, Morocco*
[4]*English Department, Ibn Tofail University, Kenitra, Morocco*

ABSTRACT

In order to identify a classification according to the Hierarchical Ascending Classification (HAC) method, based on the physico-chemical and bacteriological parameters of the source waters of the Tangier-Tetouan region so as to determines the degree of the impact of certain anthropogenic activities upon the quality of spring water and to draw up a spatial typology analysis for possible proceedings that may protect these water resources, a multidisciplinary study has been realized. The latter is based on: an evaluation of the physico-chemical quality and, also, a study of the bacteriological quality of the source waters of the study area which has been carried out in accordance with the potability standard required by the World Health Organization. The overall results showed that almost all of the physico-chemical parameters correspond to Moroccan standards. The chemistry of the source waters of the Tangier-Tetouan region indicated two different facies: bicarbonate-calcium facies and chloride-calcium ones. All the results suggest an absence of input of heavy metals by the agricultural activity and a low contribution by the geological formation of the aquifers crossed by the groundwater. Bacteriological results showed microbial contamination that was observed for the majority of sources from runoff and domestic and industrial wastewater.

Keywords: physico-chemical, HAC, survey, quality, pollution, source waters.

INTRODUCTION

In Morocco, groundwater constitutes an important part of the country's hydraulic heritage [1], due to its relatively easy exploitation. Groundwater is traditionally the preferred water resource for drinking water because it is more pollutant-free than surface water [2]. However, the nutrition quality of water is an increasing worry. The challenge facing the regions of Morocco, particularly the rural areas, is the protection of the quality of groundwater resources. Groundwater pollution is one of the most worrying aspects and the use of these waters for drinking represents a threat for the health [3].

The degradation of water quality caused by pollution began to emerge in some areas a long ago. However, the problem began to become more critical during the latest years of the century, particularly with the industrial development, rapid population growth, and the increasing use of coastal land and urbanization [4].

During the recent decades, the ecology of groundwater was developed rapidly, forming a fertile discipline of aquatic ecology [5]. While the underground domain has long been regarded as an environment that is poor of species, global syntheses revealed an unexpected and high diversity of living forms in groundwater [6-8].

While the environmental determinants of groundwater biodiversity was, also, addressed in some synthesis papers, these relationships were addressed generally at the continental level rather than at the regional one [9].

The spring waters of the groundwater in the Tangier-Tetouan region are known for their low piezometry and, consequently, for their easy uncontrolled exploitation. Indeed, the absence of drinking water supplies, in some rural areas or in some fragile categories of the population, pushes them to utilize spring water in all usages, including drinking, because these waters are for free. Besides, and with the dominance of traditions and customs related to the culture of the users, they are using spring waters even when treated drinking water is available.

The aim of this article is to present the classification of the 25 sources studied according to the physico-chemical and microbiological criteria, this gives us similar groups, in order to compare the results obtained with the results of the survey that was fulfilled at the level of users.

MATERIALS AND METHODS

2.1. Study area and sampling sources:

The region of Tangier-Tetouan (Figure 1), the capital city of Tangier covers an area of 11,570 km ², representing 1.6% of the total area of the Moroccan Kingdom. It is bordered by the Mediterranean Sea to the north, the Atlantic Ocean to the west, the region of Taza-Al Hoceima-Taounate to the east and the Gharb-Chrarda-Beni Hssen South.

From the geographical point of view, the Tingitane Peninsula is characterized by a structural entity that is the Rif area according to figure [10].

Indeed, and outside the coastal plains areas geomorphology steep or heavily corrugated cover more than 80% of the region.

✓ Tangiers, located in the Strait of Gibraltar between the Mediterranean and the Atlantic Ocean, approximately coincides with the basin of the river M'harhar and presents an alternation of valleys, covered mainly Quaternary alluvium, marl and sandstone hills.
✓ Lower Basin Loukkos constituting the countryside the most developed in the region, thanks to good soils and abundant water and covering the clay alluvial plains and the sandy plateau of Larache. Tangiers Peninsula is characterized by a dense hydrographic network in the form of Oueds with low and unsteady flow [11].

Given the general objective of the study, the choice of sampling stations was made on the basis of the implantation of human and industrial activities. Twenty-five sources were selected (Figure 1).

Table 1 shows the coordinates (latitude and longitude) of the prospected sources, with the names of each source and the associated code

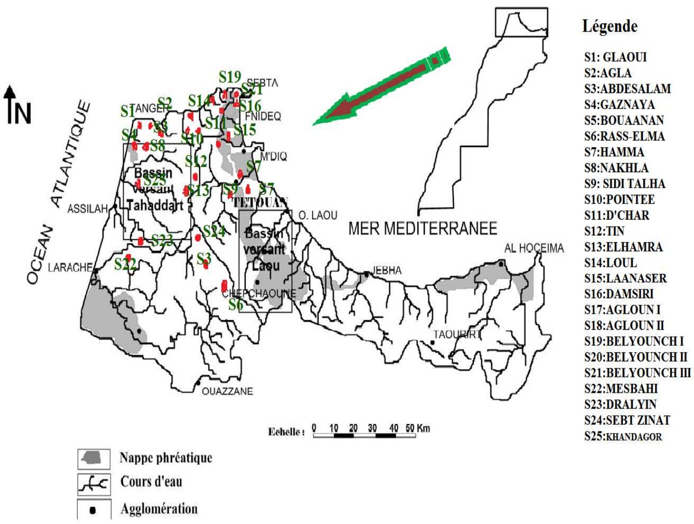

Figure 1. Localization map of the study area and location of sampling stations area

Table 1. Description of prospected sources by their coordinate

Source code	*Position*	*Description*
S1	35°.7868N // 005°.8638W	**GLAOUI**
S2	35°.7939N // 005°.8707W	**AGLA**
S3	35°.3157N // 005°.5169W	**ABDESSALAM**
S4	35°.7020N //005°.8807W	**GAZNAYA**
S5	35°.5529N // 005°.3715W	**BOUAANAN**
S6	35°.1711N // 005°.2563W	**RASS-ELMA**
S7	35°.5486N // 005°.3851W	**HAMMA**
S8	35°.7860N // 005°8653W	**NAKHLA**
S9	35°.5758N // 005°.3817W	**SIDI TALHA**
S10	35°.8471N // 005°.5306W	**POINTEE**
S11	35°.8460N // 005°.5290W	**D'CHAR**
S12	35°.5875N // 005°.6669W	**TIN**
S13	35°.6964N // 005°.6279W	**ELHAMRA**
S14	35°.5829N // 005°.3380W	**LOUL**
S15	35°.8490N // 005°.4419W	**LAANASER**
S16	35°.8514N // 005°.4431W	**DAMSIRI**
S17	35°.8539N // 005°.4313 W	**AGLOUN I**
S18	35°.8539N // 005°4313W	**AGLOUN II**
S19	35°.9094N // 005°.3848W	**BELYNCH I**
S20	35°.9045N // 005°.3914W	**BELYCHB II**
S21	35°9106N // 005°.4019W	**BELYCH III**
S22	35°.4266N // 006°.0355W	**MESBAHI**
S23	35°.4699N // 006°.0355W	**DRALYIN**
S24	35°.6595N // 005°.7235W	**SEBT ZINAT**
S25	35°.0097N // 004°.8594W	**KHANDAGOR**

2.2. Analytical methods:

In our region, sources have been selected to have a representation on the spaced Tingitane peninsula. We conducted a total of 150 samples during the year 2014 for physico-chemical and bacteriological analysis:

- ***Physico-chemical analysis***

The physicochemicala nalysis of the water is assessed using several parameters of varying importance. Temperature, pH, electric conductivity, dissolved oxygen, turbidity, hardness, chlorides, nitrates, and ammonium sulfate [12].

Temperature (T), the potential of hydrogen (pH) and conductivity (Cs) were measured by immersing a thermometer, a pH meter, turbidity and conductivity of all types EUTECH in 50 ml of water taken from each sample. After 4 minutes of immersion, each of these devices has been removed for reading the results. Ares sample bottles are kept in a cooler at 4°C and transported to the laboratory for physical and chemical analysis within the following 24 hours. For other physicochemical parameters: volume is the method used for the determination of chlorides, dissolved oxygen, calcium and magnesium, total hardness; the molecular absorption spectrophotometry for sulfates, nitrates, ammonium [13].

- ***Microbiological analysis***

For microbiological analysis, samples were collected using sterile Pyrex glass bottles (120°/20) fitted with screw caps: the submerged bottle filled and then closed before being returned. The samples were immediately placed in an insulated cooler where the temperature is kept between 2°C and 8°C; they are sent to the laboratory to be analyzed immediately on selective media according to FAS_NF T 90-414.2000.

Germs test of fecal contamination (GTFC) chosen according to Normalizes Moroccan 03.7.001 are:
- o Escherichia coli (E. coli) is the most significant species of faecal contamination.
- o Coliform bacteria (CB).
- o Intestinal enterococci (IE).
- o Viable microorganisms at 22°C and 37°C: Sprouts Totals (GT) at 22°C and 37°C.

2.3. Statistical analysis:

The application of this method of statistical analysis in the field of environmental study was the subject of many studies [14]; [15]. This method of statistical processing allows regrouping of heterogeneous data (different units) in a simple graphical representation.

Multivariate statistical analysis is an essential tool to study the data of many observations made on several variables. It aims to summarize the data information. In order to obtain a grouping of the sources in class (homogeneous class), a Hierarchical Ascending Classification (HAC) has been realized [16].

On the other hand, this statistical method is compared with the results of a questionnaire carried out on the sources reputation used by the users. After the analysis of the questionnaire, more than 200 witnesses participated in the survey. In this article we are interested in the opinion of users who has fed on these sources.

RESULTS AND DISCUSSION

3.1. Field study (survey):

The majority of witnesses confirm that the flow of these sources is permanent, of which half of the consumers reside in the region; these sources are more frequented in summer and weekends.

On the other hand, the majority of witnesses use these source waters as they are good for health, not exposed to any chemical treatment; they represent a natural heritage that keeps a good reputation for the population of the area.

Table 2, summarizes the results obtained on the reputation of the sources.

Table 2. Results of Opinions of the users of the prospected sources

Opinion	*Sources*	*Frequency*
Acceptable	*S1, S2, S8, S9, S14, S16, S17, S18* and *S23.*	36%
Good	*S11 and S15.*	08%
Very Good	*S3, S4, S5, S6, S7, S10, S12, S13, S19, S20, S21, S22, S24* and *S25.*	56%

The respondents confirm that 56% of the sources are of very good quality, 36% are acceptable and S11 and S15 which represent 8% are of good quality.

These results will be compared with the classes according to the HAC method obtained (Figure 2, Table 3).

3.2. Classification using HAC method:

The Hierarchical Ascending Classification is obtained for 25 sources using 13 physico-chemical and 5 bacteriological parameters, figure 2 illustrates the dendrogram of this classification (obtained for Ward's method with Euclidean distances).

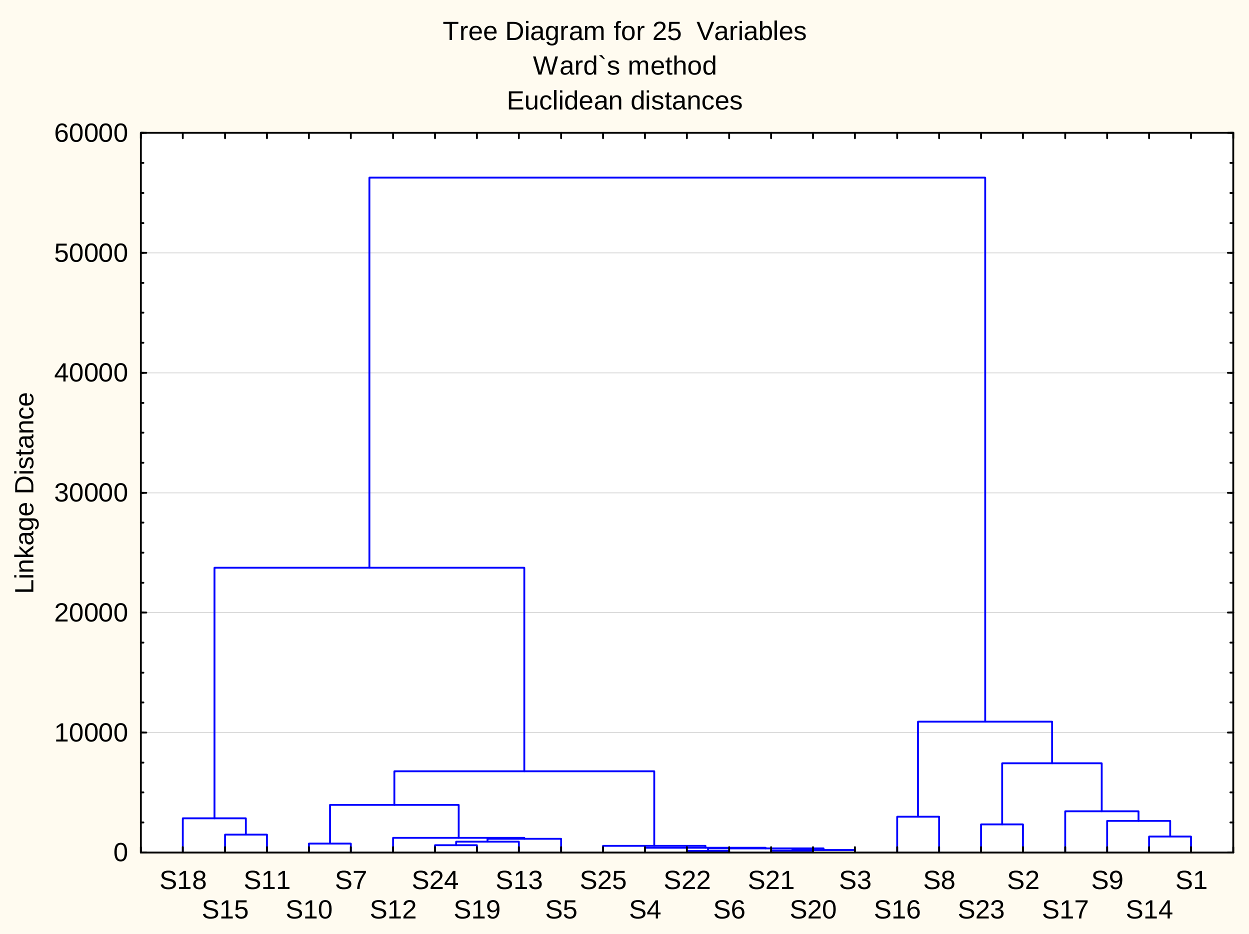

Figure 2. Hierarchical tree obtained by the HAC

The main objective of this analysis is to present homogeneous classes that represent similar values in all the variables analyzed. Several cutting possibilities make it possible to give homogeneous classes. In this analysis, three possible homogeneous classes are presented. The results are shown in Table 3.

Table 3. Source classification results

Class	***Sources***	***Frequency***
Class 1	*S3, S4, S5, S6, S7, S10, S12, S13, S19, S20, S21, S22, S24* and *S25.*	56%
Class 2	*S1, S2, S8, S9, S14, S16, S17* and *S23.*	32%
Class 3	*S11, S15* and *S18.*	12%

Class 1: More than half (56%) of the sources are homogeneous from a physico-chemical and a bacteriological point of view. The same class was declared of very good quality according to Table 2.

By analyzing the sources individually (see Appendix, Table **A**), as an example, it has been found the sources S3, S6, S20 and S21 are of course very good quality.

Class 2: Represents 32% of the homogeneous sources, comparing with the results of Table 2 are the same sources of the acceptable group except the source S18 which took place in the class 3.

Class 3: Contains the sources of the group good quality with source S18.

Indeed, the bacteriological water quality of the sources surveyed reveals contamination of the water table in some most sources of pollution S1, S2, S8, S9, S14, S16, S17, S11, S15, S18 and S23. The latters could be due to domestic human activities and agriculture, to the existence of any kind of waste and uncontrolled public landfills. Moreover, the springs of our study area experiencing heavy pollution in indicators of faecal contamination [17] , in agreement with those found by [18, 19] for the sheet of Fez. The results [20] have also shown that the water from a groundwater is more vulnerable when the top of the water table is close to the ground surface, knowing that the lands which overcome the aquifer are permeable and that the superficial pollution sources are important.

CONCLUSION

In this study, the application of the Hierarchical Ascending Classification (HAC) method allowed us to identify three classes divided into sampling stations as well as sampling periods.

These classes were compared with the results of a questionnaire on the water sources reputation. The combinations of these two methods results have almost the same homogenization on the sources.

This study also confirms that the sources **S3**, **S6**, **S20** and **S21** have very good quality from the point of view of: classification, reputation and, also, physico-chemical and bacteriological criteria.

REFERENCES

[1] Ministry of Territorial Development, Water and Environment, National Observatory of the Environment of Morocco, **2001**, 2, 296-297.
[2] S.GUERGAZI, S. Achour, *LARHYSS Journal*, **2005**, 04, 119-127.
[3] M. Laferriere, J. J. Minville, J. Lavoie, P. Payment, *Health Information environment*, **1996**,7 (2), 1-4.
[4] P. Sumok, Sabah Inter-Agency *Tropical Ecosystem Research Seminar*, **2001**, 4.
[5] J. Gibert Mathieu, F. Fournier, International Hydrology Series, **1997**.
[6] L. Botosaneanu, M. Stygofauna, A. Faunistic, E.J. Brill, W. Backhuys, **1986**.
[7] C. Juberthie, V. Decu, Speleology SocietyIII, **2001**, 215–216.
[8] C. Juberthie, V. Decu, Speleology Society II, **1998**, 230–234.
[9] JR. Holsinger, Journal of Natural History, **1993**, 27, 821–835.
[10] Agency for the Promotion and Development of the North, Presentation of the intervention agency North perimeter, **2007**, 124–125.
[11] M. Dakki, Coastal Area Management Programme in Moroccan Mediterranean, **2004**, 3, 112-113.
[12] French agency for standardization, **1997**, 1(3), 439.
[13] J. Rodier, *The analysis of the water*, **2009**, 1293-1487.
[14] N. Zerki, A. Bouhaouss, R.Bchitou, *Australian Journal of Basic and Applied Sciences*, **2012**, 6, 396-402.
[15]A. Brahimi, A. Chafi, N. Nouayti, H. Elmsellem and B. Hammouti., *Der Pharma Chemica*, **2015**, 7(9), 346-353.
[16] J.P. Benzécri, *Linguistique & Lexicologie*, **1981**, 3, 234**.**
[17] A. Laghzal, F. Salmoun, B. Boudinar, M. Khaddor, S. Cherroud, M. Fihri, C. Mammad, J. Mater. Environ. Sci., **2016**, 7 (2), 456-462.
[18] A. Lalami., F. EL-Akhal., S. Berrada., L. Bennani., N. Raiss., S. Maniar., *J.Mater. Environ. Sci.*, **2014**, 5, 2333-2344.
[19] W. Hamzaoui, N. Bougherira, A. Rezeg, A. Drouiche, W. Chaib, L. Djabri, *J. Mater. Environ. Sci*., **2011**, 2, 459-462.
[20] C. Boutin, *Water Sciences*, **1987**, 6(3) 357-365.

APPENDIX

Table A. Results of the physicochemical and bacteriological analyzes of the prospected sources in the Tangier-Tétouan region

S	*T*	*PH*	*CE*	*O_2*	*TR*	*NO_3^-*	*NH_4^+*	*Ca^{2+}*	*Mg^{2+}*	*TH*	*TAC*	*Cl^-*	*SO_4^{2-}*	*GT à 25°C*	*GT à 37°C*	*B.C*	*C.F*	*E.I*
S1	17,50	7,25	4,32	6,70	2,63	9,90	0,00	0,32	0,47	0,94	0,12	118,00	17,00	7890,00	3567,00	518,00	378,00	231,00
S2	17,20	6,60	331,00	7,33	3,74	0,79	0,23	0,38	0,35	0,73	0,13	165,00	80,00	3567,00	4389,00	1780,00	431,00	349,00
S3	16,00	7,42	49,66	7,83	0,71	0,44	0,08	0,10	0,07	0,17	0,05	7,30	133,30	0,00	0,00	0,00	0,00	0,00
S4	15,50	6,72	271,30	7,60	3,78	1,34	0,00	0,73	0,52	1,25	0,50	4,35	28,67	150,00	89,50	231,00	139,00	29,50
S5	17,00	7,59	555,00	8,30	4,32	2,65	0,03	3,42	2,83	3,25	4,40	36,67	138,30	1219,00	1012,00	789,50	30,00	0,00
S6	16,00	7,75	356,60	8,43	0,38	2,94	0,06	2,72	1,74	4,46	4,08	24,43	12,23	0,00	0,00	0,00	0,00	0,00
S7	16,40	7,67	501,60	6,63	1,06	2,73	0,00	3,27	1,78	5,30	4,20	43,20	22,44	2718,00	1348,00	780,00	389,00	123,00
S8	17,00	6,52	439,30	4,43	2,75	7,77	0,02	0,58	0,75	1,33	0,53	75,00	120,60	12678,00	890,00	289,00	98,00	70,00
S9	17,20	7,40	985,00	6,81	3,73	16,80	0,02	6,80	3,65	10,36	4,36	91,70	128,80	9889,00	3789,00	450,00	241,00	71,00
S10	16,30	6,58	105,60	4,13	1,30	6,72	0,00	0,38	0,51	1,20	0,31	29,13	58,33	2348,00	890,00	934,00	312,50	7,00
S11	16,00	6,69	256,60	6,68	3,60	3,76	0,01	0,35	0,86	0,32	0,20	78,00	41,67	1078,00	7890,00	780,00	230,00	0,00
S12	15,00	6,98	270,00	5,60	1,10	0,56	0,15	2,40	0,15	2,70	2,14	160,00	67,00	458,00	762,00	0,00	0,00	9,00
S13	14,50	6,99	250,00	6,70	1,20	5,23	0,23	4,60	0,67	1,60	2,67	98,00	89,00	780,00	560,00	1045,00	780,00	67,00
S14	17,00	6,52	130,00	5,60	2,90	1,20	0,01	2,80	0,78	1,09	3,89	67,00	123,00	8230,00	2389,00	980,00	200,00	120,00
S15	16,30	6,52	340,00	5,90	1,50	0,27	0,08	1,40	0,60	0,89	3,78	5,98	78,00	679,00	6579,00	245,00	50,00	0,00
S16	15,80	6,25	190,00	4,80	1,60	0,96	0,06	0,22	1,90	1,89	2,34	9,87	145,00	9802,00	150,00	150,00	80,00	120,00
S17	16,40	7,50	256,00	6,70	1,10	3,81	0,67	0,88	2,90	3,01	2,78	220,00	96,00	7890,00	5789,00	560,00	971,00	67,00
S18	16,50	6,88	109,00	6,30	2,70	3,23	0,55	1,89	3,00	2,23	1,89	100,00	45,90	15761,00	6789,00	2789,00	719,00	3,00
S19	17,00	7,71	230,00	4,20	1,80	2,35	0,31	2,77	2,90	2,89	1,34	156,00	230,00	762,00	60,00	780,00	78,00	230,00
S20	16,00	7,41	170,00	5,80	1,50	1,67	0,08	3,80	1,69	0,89	0,45	123,00	76,00	98,00	20,50	89,00	34,00	12,50
S21	17,00	8,10	200,00	7,20	0,90	1,23	0,37	1,80	1,80	0,45	0,67	90,00	189,00	54,00	9,00	0,00	0,00	0,00
S22	16,00	6,37	300,00	7,80	2,90	1,83	0,04	0,90	1,90	0,23	0,89	67,00	77,00	79,00	0,00	0,00	0,00	9,00
S23	17,00	6,30	340,00	7,60	1,80	1,67	0,02	2,80	2,87	1,90	1,93	98,00	287,00	5657,00	4678,00	1021,00	870,00	789,00
S24	17,50	6,25	300,00	6,50	1,60	13,67	0,09	1,50	1,90	1,20	2,13	129,00	31,00	679,00	541,00	580,00	234,00	67,00
S25	16,00	7,23	570,00	5,30	1,50	2,23	0,02	0,89	0,22	0,98	1,34	222,00	98,60	10,00	9,00	89,00	34,00	101,00

S=** Source**; T(C°)=** Temperature **; EC(**µS/cm**)=** Electrical Conductivity **; O_2(**mgO2/l)**=** Dissolved Oxygen **; TR**(NTU)**=** Turbidity **; NO_3^-=** Nitrates (mg/l) **; NH_4^+(**mg/l)**=** Ammonium **; TH(**meq/l)**=** Total Hardness **; Mg^{2+}**(meq/l)= Magnesium **; Ca^{2+}(**meq/l)= Calcium **; SO_4^{2-}**(mg/l)= Sulfates **; TAC**(meq/l)= Complete Alkalimetric Titre **; Cl^-**(mg/l)= Chloride **; G.T=** Sprouts Totals**(**UFC/100mL) **; F.C** (UFC/100mL)= Fecal Coliforms **; B.C**(UFC/100mL)= Coliform Bacteria **; I.E**(UFC/100mL)= Intestinal Enterococci**.