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Bacterial and Physicochemical Specification of Wells Water in Vulnerable Areas in the District of Maroua II

(Far North Cameroon)

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Abstract:-In some areas of the district of Maroua II, water from wells built by the Ministry of Agriculture and Rural Development is not suitable for human consumption. On the edge of each of these wells it is written: "The water of this well is not drinkable." Despite the ban, populations continue to use it for cooking and / or drinking. Consumption of this poor quality of water exposes the population to water-related diseases. The indication of the water quality of these wells appears important to highlight the health risks and propose a solution to provide quality water to the population. The main objective of this study is to identify the wells and find out the quality of the water produced by prohibited wells and compare the results with those of other wells whose use is not prohibited in the same area. The results show that water from wells in the targeted areas do not contain suspended solids, average nitrate concentrations (0.164 ± 0.265 mg / L), phosphates (1.00 ± 0.472 mg / L) and ammonium (0.2 ± 0.05 mg / L) are below WHO standards. The electrical conductivity (1045.9 ± 359,3µS / cm) is much higher than the WHO standard in 60% of the wells. The presence of high levels of faecal coliforms (1.37 x 106 ± 1.01 x 106 CFU / 100 mL) and faecal streptococci (19.2 x 106 ± 16.3 x106 CFU / 100 mL) assumes in severe contamination by faecal streptococci, which would be of animal origin. This investigation shows that all samples contain high amounts of bacteria and exhibit an electrical conductivity significantly higher than the standard. Therefore, this water requires a pre-treatment before usage.

Keywords: Well, vulnerable, bacterial, physico chemical, Cameroon.

I. INTRODUCTION

Because of the lack of permanent rivers, the main source of quality water in the far north region of Cameroon is the exploitation of the underground resource. This situation is explained by the low level of rainfall over the years from an average of 700 mm before 1970 to less than 500 mm in recent years [19]. This region is characterized by a long dry season of eight (08) months for four (04) months of rain in a year. The seasonal rivers called "MAYOS" flow through Maroua. These rivers are revived after rain or a few hours after a precipitation. Access to drinking water in quantity and quality in the district of Maroua II is an ordeal for the population. The main water provider company, the Cameroonian Water Company (CWC) fails to cover the city. Like other cities, Maroua requires an increase in water supply. To satisfy this demand, Non-Governmental Organizations (NGOs), associations and councils support the CWC by building wells and boreholes. The low availability of secured water boreholes and CWC supply pushes people to use water from wells in their daily needs. Meanwhile the bacteriological and / or physico-chemical composition of well water is not good for human consumption. Their water has a very high concentration of faecal bacteria [3]. This water thus constitutes a health risk for the population [18].The main cause of faecal pollution is of animal origin. This contamination is due to the littering of animals around wells, and failure to comply with hygiene and sanitation rules [13]. Consumption of these waters would be responsible for waterborne diseases suffered by people [12] and [9]. Among the diseases related to water, cholera is a major concern for public health in the Far North region of Cameroon. The "DOUALARE" neighbourhood located in the district of Maroua II is the area most affected by this epidemic. It is thus the bastion of cholera in the city of Maroua [6]. This study aims at determining the physicochemical and bacterial .determinants of well water whose consumption is forbidden to populations in DOUALARE area and those not prohibited in parts of the district of Maroua II bastion who are neighbours of the area. More specifically, this study seeks to highlight the major faecal contamination of germs and the main physicochemical parameters responsible for the variation of the water quality. This investigation is carried out from the assumption that: the quality of well water depends on its location relative to a potential source of pollution from human activities.

II. MATERIALS & METHODS

2.1. Sampling and study site

Located at 10 ° 35 'north latitude and 14 ° 19' east longitude [11], the city of Maroua has a climate of Sudano-Sahelian characterized by a dry season as twice as long as the rainy season [19]. Ten water wells rated P1; P2; P3; P4; P5; P6; P7; P8; P9 and P10 were sampled in the neighbourhoods of the district of Maroua II (fig.1), following the permanence of the productivity of the well, usage by the public, nearness to latrines, agricultural projects, prohibition of use or other sources of wastewater production (Table 1). These wells were sampled in April 2014 (dry season) and August 2014 (rainy season). Samples of 310 mL of water to each sample per well were carried to the laboratory in sterile glass vials kept cold with ice in a refrigerated cooler and analysed the same day.

2.2. Analysis of physicochemical elements

The dosage of the physicochemical parameters was done following the guidelines of Rodier (2009). These analyses were performed using a spectrophotometer UV-VIS spectrophotometer brand RS spectrophotometer UV-2500 for assaying nitrate ions (500 nm), phosphate ions (890 nm), ammonium ions (425 nm) and suspended solids (810 nm) in accordance with techniques described by APHA (1995); a liquid column thermometer graduated in 10^{th} degree and reading made after ten minutes immersion for temperature; a multi brand parameters "EXTECH" to measure the electrical conductivity, salinity and total dissolved solids (TDS); a pH meter WAGTECH International mark for measuring the pH of water. The electrical conductivity, temperature and pH were measured in situ at the sampling time and the other on the same day in the laboratory.

Table 1: Location and environment of wells

Wells	GPS Location (altitude)	Quarters	potential sources of pollution	protection of the well	water use	Number of users	Wells' Hygiene
P1	N10.61799 E014.32818 407m	MBALGARE	Latrines located less than 30m and a tree within 3 m	covered against weather	Drinking, household stains	Public	Neither drained or cleaned
P2	N10.61941 E014.32709 411m	MBALGARE	Latrines located less than 30m, consumption prohibited by MINADER	Not covered against rain and sun	Water used for drinking and household tasks	Public	Disinfected with bleach once a year
P3	N10.62219 E014.32623 416m	DOUALARÉ II	Latrine around 30m,	No protection against the weather	Drinking, meal preparation	Public	Never drained or disinfected
P4	N10.62166 E014.32382 416m	DOUALARÉ I	Latrine between 30m, 5m month for trash	Not covered to protect water against weather	Water used for drinking and household tasks	Public	Not drained or disinfected
P5	N10.61876 E014.32059 418m	DOUALARÉ I	Latrines around 3 m, consumption prohibited by MINADER	Not covered against rain and sun	Water used for drinking and household tasks	Public	Not drained or disinfected
P6	N10.61913 E014.32182 423m	DOUALARÉ II	Latrines around 3 m,	Not covered against rain and sun	Water used for drinking and household tasks	Public	Not drained or disinfected
P7	N10. 62580 E014.32842 411m	DOUALARÉ II	Latrine within 30m, consumption prohibited by MINADER	Not covered against rain and sun	Meal preparation and consumption	Public	Disinfected with bleach twice a year
P8	N10.62678 E014.33116 409m	MAYELIBBE	Latrines located less than 10 m, farms all around.	Not covered against rain and sun	Water used for consumption and cooking meals	Public	Not drained or disinfected
P9	N10.63354 E014.32858 410m	LAINDE II	Between latrine within 20m	partly covered	Water used for drinking and household tasks	Public	Disinfected with bleach every two months
P10	N10.64081 E014.32836 440m	LAWOL-DIGA	Latrines located less than 25 m, practice of agriculture around	Not covered	Water used for consumption	Public	never disinfected

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2.3. Bacteriological analyses

The different analyses were carried on the detection of total coliform (TC), faecal coliform (FC), faecal streptococci (FS) and Aerobic Mesophilic Heterotrophic Bacteria (AMHB) using a combination of methods of Rodier and those of American Public Health Association (APHA). Counting was performed by seeding AMHB Agar nutrient agar surface with yeast extract on tryptone glucose in a single layer after incubation at 37 ° C for 24 hours. Counting FC is effected by seeding agar Tryptone agar surface the lactose in a single layer after incubation at 44 ° C for 24 hours.

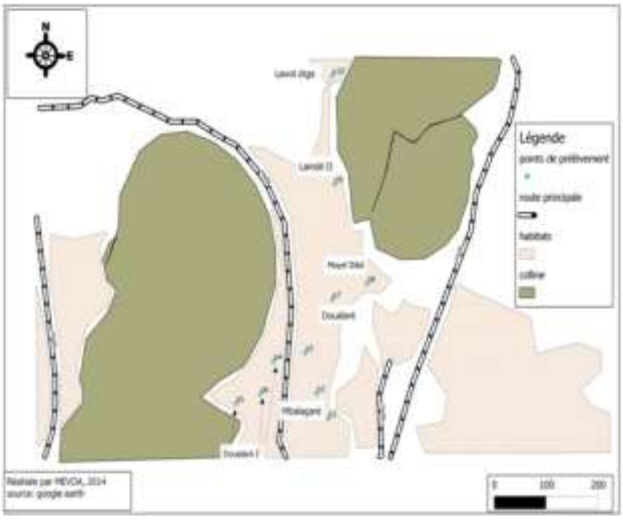

Figure 1 Location map of wells

The TC enumeration is done by seeding the surface of the agar Tryptone Lactose single layer after incubation at 37 ° C for 24 hours. FS of the counting is done on the beef broth peptone agar incubated at 37 ° C for 48 hours.

Table 2 Classification of faecal pollution according Borrego and Romero

N°	FC/FS	Source of Pollution	Observations
1	>4	essentially human pollution	Wastewater discharge
2	2< FC/FS<4	Mixed pollution predominantly human	/
3	1< FC/FS<2	Uncertain pollution	/
4	0,7< FC/FS<1	Mixed pollution to predominantly animal	/
5	<0,7	Animal pollution, including livestock	Particularly sheep

Dilutions were performed with a sodium chloride solution (8.5g NaCl in 1000 ml of distilled water) sterilized at 121ºC for 15 minutes. A Petri dish containing the culture medium for each dilution (10^{-2} to 10^{-3}) is inoculated and incubated at a temperature compatible with the multiplication of each type of bacteria. The results are expressed in colony forming units per 100 mL (CFU / 100 mL).

3.2. Statistical analyses

Statistical analyses were performed using SPSS Version 2.0 and lnk XLSTAT 2007 software for the analysis of the main component. The origin of faecal pollution was determined using the method of Borrego and Romero (1982) which allows us to say whether faecal pollution is of animal, human or mixed.

III. RESULTS & DISCUSSION

Table 3 Concentrations of bacteria

Wells	AMHB	TC	FC	FS
P1	$2,32.10^6 \pm 1,80$	$12,17.10^6 \pm 1,45$	$1,45.10^6 \pm 0,04$	$6,29.10^6 \pm 0,48$
P2	$45,12.10^6 \pm 22,69$	$9,58.10^6 \pm 0,22$	$0,25.10^6 \pm 0,01$	$0,70.10^6 \pm 0,03$
P3	$4,50.10^6 \pm 0,12$	$18,47.10^6 \pm 0,43$	$0,50.10^6 \pm 0,03$	$3,39.10^6 \pm 0,02$
P4	$4.10^6 \pm 0,7$	$48,52.10^6 \pm 0,42$	$0,50.10^6 \pm 0,03$	$0,50.10^6 \pm 0,08$
P5	$7,29.10^6 \pm 0,12$	$25,50.10^6 \pm 0,18$	$0,51.10^6 \pm 0,02$	$44,62.10^6 \pm 0,21$
P6	$2,51.10^6 \pm 0,15$	$39,47.10^6 \pm 0,43$	$0,54.10^6 \pm 0,04$	$26,37.10^6 \pm 0,21$
P7	$1,60.10^6 \pm 0,12$	$6,34.10^6 \pm 0,91$	$0,25.10^6 \pm 0,01$	$34,05.10^6 \pm 0,86$
P8	$7,75.10^6 \pm 0,70$	$9,74.10^6 \pm 0,13$	$1,94.10^6 \pm 0,91$	$37,97.10^6 \pm 0,43$
P9	$20,50.10^6 \pm 1,2$	$19,95.10^6 \pm 0,87$	$3,02.10^6 \pm 0,42$	$3,53.10^6 \pm 0,02$
P10	$57,05.10^6 \pm 1,12$	$51,50.10^6 \pm 0,86$	$1,99.10^6 \pm 0,48$	$8,02.10^6 \pm 0,04$

Table 5 Descriptive statistics of the parameters studied

Parameters	Observations	Minimum	Maximum	Mean	Standard déviation
AMHB	10	$16,05.10^6$	$57,05.10^6$	$18,21.10^6$	$20,67.10^6$
TC	10	$6,34.10^6$	$51,50.10^6$	$26,58.10^6$	$17,02.10^6$
FC	10	$0,25.10^6$	$3,02.10^6$	$1,37.10^6$	$1,01.10^6$
FS	10	$0,50.10^6$	$44,62.10^6$	$19,19.10^6$	$16,30.10^6$
TEMP	10	25,300	28,650	26,965	0,971
PH	10	7,360	7,840	7,669	0,109
TDS	10	446,500	1204,250	752,032	240,783
EC	10	638,000	1800,250	1045,905	359,274
SAL	10	323,500	890,250	534,305	176,729
NITRA	10	0,029	0,961	0,164	0,265
PHOSPH	10	0,258	1,919	1,008	0,472
AMMON	10	0,142	0,345	0,194	0,050
TURB	10	0,346	1,468	0,556	0,407

The temperatures obtained vary between 25.30 ° C (P4) to 28.650 ° C (P1) for an average of 26.965 ± 0.971 ° C. These values are relatively greater than the indicative value of 25 ° C proposed by RODIER. High temperatures could be favourable for growth or destruction of bacteria. In our case, the high bacterial loads show that these temperatures have contributed to the proliferation of bacteria in the wells. The pH values show a minimum of 7.36 ± 0.19 well P1 and a maximum of 7.84 ± 0.2 at well P2 for an average of 7.67 ± 0.11. Thus, all values of pH are contained in the range of 6.5 to 8.5. WHO recommendations are therefore respected as these waters respect the standards in terms of pH. The differences in pH observed among the various wells could be explained by the nature of the soil. The chemical properties of underground water are not significantly different from those of the soil which protects the cash [7]. The values of electrical conductivity ranged from 638 ± 1.87 S / cm in P1 to 1800 ± 2.05 S / cm in P2, an average of 1045.9 ± 359,23µs / cm. 60% of the analysed wells have conductivity greater than the reference limit value 1000µs / cm [16]. While not having effects Health [5]. The fact remains that it shows strong mineralization.

Table 6 Sources of Pollution according to the report on faecal coliform / faecal streptococci (FC/FS).

Wells	FC	FS	FC/FS
P1	1,45	6,29	0,23
P2	0,25	0,7	0,36
P3	0,5	3,39	0,15
P4	0,5	0,5	1,00
P5	0,51	44,62	0,011
P6	0,54	26,37	0,02
P7	0,25	34,05	0,007
P8	1,94	37,97	0,05
P9	3,02	3,53	0,85
P10	1,99	8,02	0,25

This is because the Far North Region of Cameroon undergoes a long period of drought, which increases evaporation that would raise the salt concentration of the water and therefore their electrical conductivity [3]. Nitrate concentrations (0.164 ± 0.265 mg / L) are much lower than the recommended value of the WHO (50 mg / L). These values are lower than those obtained by Ndongo (2015) in the district of Maroua III. Although respecting the standards, these nitrates can promote the development of nitrifying bacteria [9]. The ammonium content ranges from 0.142 ± 0.02 mg / L to the minimum pit P10 to a maximum of 0.345 ± 0.018 mg / L to the wells P1 for an average of 0.05 ± 0.194 mg / L. ammonium concentrations are below WHO standards which sets the pollution threshold of 0.5 mg / L. Given the practices observed around the wells (living animals, use of dirty containers to collect water in the well, etc.), if urgent measures are not taken to limit the actions contributing to the long-term contamination we will witness an increase of the health risk that may be attributable to the increase in the amount of ammonia nitrogen from animal excreta (sheep, goat, etc.). Concentrations of Ortho phosphates rotate at an average of about 1.008 ± 0.472 mg / L. This value is less than the minimum recommended concentration which is 5 mg / L in drinkable water [14]. So the phosphate concentration would not constitute a limit to the consumption of these waters. The analysed waters are less turbid. The evolution of turbidity ranges from 0.346 ± 0.019 NTU at P4 to 1.468 ± 0.021 wells NTU at P7. The average is 0.556 ± 0.407 NTU. This result demonstrates the absence suspended matter in these waters such as the analysing content of solids suspensions has demonstrated in this study. Related parameters, salinity and total dissolved solids evolve simultaneously. When salinity increases, the TDS concentration increases. The values of these parameters are minimum (446.5 ± 2.3 ppm for TDS and 323.5 ± 2.3 mg / L for salinity) P8 to the maximum (1204.25 ± 2.5 ppm for TDS and 890.25 ± 2 mg / L of salinity) at P2. These high values of TDS do not constitute instant danger to consumer health [14]. These high concentrations find an explanation in the soil composition of the region that is salty clay type and the fact that the continuous dissolution of the mineral plagioclase and carbon tends to increase the salinity through the increase of the concentration of Na^+, $Ca2^+$ and $HCOO^-$ in water [19]. These waters contain high quantities of microbial germs. Aerobic Mesophiles Heterotrophic Bacteria (AMHB) are of the order of $20,67.10^6 \pm 18,21.10^6$ CFU / 100 mL, the Total Coliforms (CT) average $26,58.10^6 \pm 17,02.10^6$ CFU / 100 mL Faecal Coliforms (FC) is a proportion of $1,37.10^6 \pm 1,01.10^6$ CFU / 100 mL and Faecal Streptococci (FS) average $19,19.10^6 \pm 16,30.10^6$ CFU / 100 ml This abundance of bacteria in water could be explained by the poor protection of wells, the non-respect of well construction rules, and the lack of respect of hygiene rules applied to containers used to collect water in the well. These containers are sometimes placed on the floor or in the livestock pens and plunged back into the well. The neighbourhoods of this district are surrounded by Trickling waters and leaching from the hills that reach the wells would be fraught with animal faeces and are used as fertilizer in agriculture on hills and humans through confusion of lavatories and take them back to the wells that are located downstream. This migration of polluted water may lead to contamination of underground water by infiltration of faeces [10]. Furthermore, most of the wells are located within walking distance of latrines or higher than the lavatories. This geographical location accentuates the contamination of these wells. The study of FC / FS reports for each well (Table 6) allows us to confirm a mixed or uncertain pollution animal predominance (animal or human). There was a significant correlation between the TDS and the electrical conductivity (r = 0.710) with p = 5%, the TDS and salinity (r = 0.998) with p = 1%. This means that the increase of TDS in water causes the increase in electrical conductivity and salinity and vice versa. The relationship between TDS and the salinity is higher than that between the TDS to the electrical conductivity.

Table 4 Concentration of physicochemical parameters

Wells	Temperature	PH	TDS	CE	Salinity	Nitrates	Phosphates	Ammonium ions	Turbidity
P1	28,65 ± 0,19	7,36 ± 0,187	1147 ±1,9	638 ± 1,87	832 ± 1,87	0,084 ± 0,018	1,076 ± 0,015	0,345 ± 0,018	0,36 ± 0,019
P2	26,2 ± 0,18	7,84 ±0,2	1204,25 ±2,5	1800,25 ± 2,05	890,25 ± 2,04	0,793 ± 0,018	1,116 ± 0,017	0,256 ± 0,018	0,353 ± 0,017
P3	28,25 ± 0,23	7,64 ±0,178	1122,75 ±2,6	1620,75 ± 2,6	784,75 ± 2,58	0,161 ± 0,018	0,832 ± 0,014	0,249 ± 0,02	0,354 ± 0,018
P4	25,3 ± 0,3	7,54 ±0,18	1158,25 ±2	1628,25 ± 1,9	822,25 ± 1,92	0,960 ± 0,019	1,9185 ± 0,026	0,1995 ± 0,019	0,3455 ± 0,019
P5	25,35 ± 0,18	7,51 ±0,182	921,25 ±2,05	1333,25 ± 2,05	664,25 ± 2,04	0,028 ± 0,025	1,1285 ± 0,028	0,1625 ± 0,025	0,4035 ± 0,026
P6	26,15 ± 0,18	7,74 ±0,18	734,5 ±1,8	1049,5 ± 1,80	525,5 ± 1,80	0,130 ± 0,021	1,306 ± 0,02	0,265 ± 0,021	0,355 ± 0,022
P7	28,25 ± 0,19	7,54 ±0,178	704,25 ± 2	962,25 ± 2,04	491,25 ± 2,04	0,099 ± 0,029	1,388 ± 0,031	0,172 ± 0,029	0,385 ± 0,03
P8	27 ±0,2	7,71 ± 0,18	446,5 ± 2,3	645,5 ± 2,29	323,5 ± 2,29	0,048 ± 0,023	0,2575 ± 0,022	0,1475 ± 0,024	0,3925 ± 0,023
P9	27,3 ± 0,18	7,78 ±0,18	795 ± 1,87	1157 ± 1,87	575 ± 1,87	0,035 ± 0,020	0,5235 ± 0,019	0,2275 ± 0,020	1,4675 ± 0,021
P10	27,3 ± 0,2	7,71 ±0,178	513,5 ± 2,3	663,5 ± 2,29	345,5 ± 2,29	0,071 ± 0,018	1,2 ± 0,017	0,142 ± 0,018	0,386 ± 0,016

This close relationship between TDS and the two other parameters could be explained by the phenomenon of evaporation that would promote elevation of the salt concentration and consequently the electrical conductivity [3]. There was a significant correlation between the electric conductivity and salinity (r = 0.705), electrical conductivity and nitrate (r=0.693) to 5%. The increase of electrical conductivity causes the others parameters increasing and vice versa. The ammonium content and the salinity are significantly correlated (r = 0.667), ammonium and TDS (0.654) to 5%. The increase in ammonium brings about that of the salinity and TDS and vice versa. Well P9 presents a CF / SF ratio equal to 0.85 and more than 0.7. Faecal pollution would be mixed with animal predominance. P1 shaft has a ratio equal to 1. In this case, the pollution would be uncertain or mixed animal-dominated. The wells have a ratio less than 0.7; the pollution in these other works in this case would be animal sheep, goats and bulls staying around the wells. To group the wells on the basis of physicochemical and bacteriological analyses performed, the choice of different axes called principal components (PC) which constitute the fundamental tool of the principal component analysis was done according to the criteria of Kaiser [8]. Among the nine main components generated and each having an "Eigen value" greater than 1, four were retained and can explain 59.18% of the variation between the wells.

Tables 7 and 8 show the contribution of each variable on the four main axes.

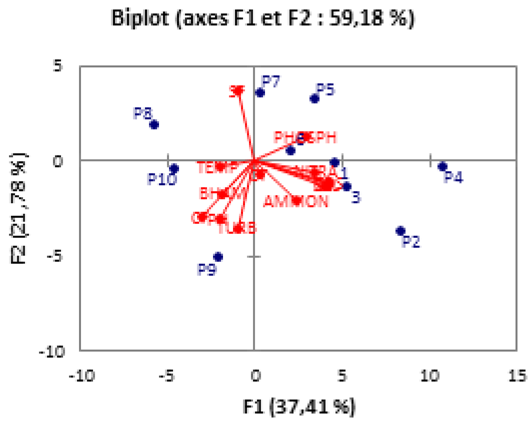

Figure 2 Mapping correlations between variables of different wells

Each analysed parameter having a value greater than or equal to 7.69% is considered representative for this axis. The principal component 1 (PC1) that expresses 37.41% of the variation shown by the physicochemical and bacteriological present TDS (17.83%), EC (15.81%), salinity (17.53%), nitrates (11.87%) and phosphate (8.32%). On this axis, these parameters, with positive contributions tend to be the most important, as they count for 71.36% of the variation on this axis. The PC2 axis meanwhile expresses 21.78% and is made up of the following parameters and ranked in descending order

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following representation: FS (24.11%), Turbidity (21%), pH (15.3%) and FC (14.9%) and ammonium chloride (7.6%). The principal component analysis also generates the data for specifying the location of each well in the axis systems of the main components. This mapping allows the observation of similar wells that are characterized by their merger in the figure and those that are different are characterized by their remoteness (Lawless and Heymann, 1998). Figures 2, 3 and 4 show the position of the shaft on the axis planes PC1 and PC2. Table 8 shows the contribution of wells on each axis.

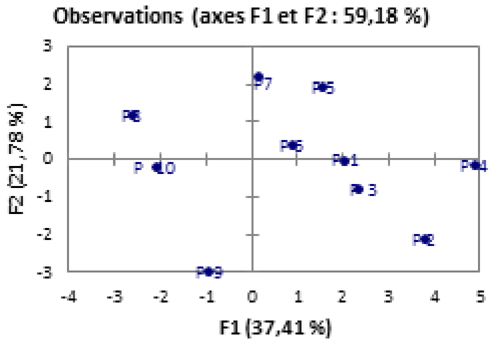

Figure 3 Mapping of different wells

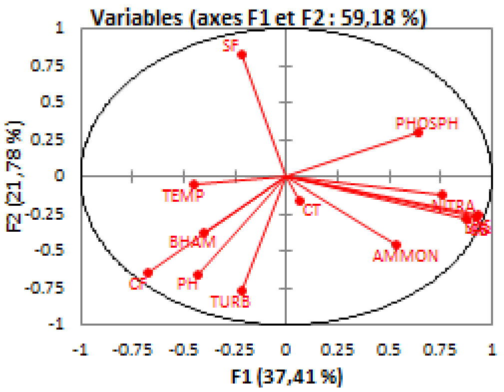

Figure 4 Circle of correlation variables

One having a higher contribution to 7 in each axis plane is considered to have a strong representation. This allows seeing that the well P2, P4, P5, P7, P8, P9 and P10 are well represented on the PC1 x PC2 axis plane. In general, it is noted that this projection plane, the P9 is well isolated from the others and strongly contributes negatively (51.94%) to the construction of the PC2 axis. Moreover P5 wells (12%) and P7 (21.3%) in turn contribute to the development of the PC2 axis positively. The wells P2 (10.7%), P 4 (35.5%) and P8 (20.4%) are characterized by a positive contribution on the main component PC1. The well P10 (16.35%) is characterized by a negative contribution to the results PC1.These results may allow P9 suggest that the well has a high pH, rich in AMHB, CF and its turbidity is very high.

Table7 Contributions of variables (%) for the four axes

	F1	F2	F3	F4
AMHB	3.334	4.937	21.486	2.567
TC	0.098	0.859	34.659	0.579
FC	9.436	14.932	0.022	1.174
FS	0.940	24.089	5.647	10.704
TEMP	4.161	0.122	3.813	64.121
p^H	3.902	15.272	0.256	8.355
TDS	17.827	2.313	1.119	0.586
EC	15.810	2.793	1.028	1.810
SAL	17.529	2.538	1.660	0.129
NITRA	11.866	0.506	4.934	1.007
PHOSPH	8.316	3.044	13.417	6.419
AMMON	5.816	7.617	5.899	1.711
TURB	0.965	20.979	6.059	0.838

Table 8 Contributions of wells (%) on the four axes

	F1	F2	F3	F4
P1	1.584	0.000	3.395	18.573
P2	10.672	5.844	0.140	0.473
P3	6.216	1.153	4.777	12.320
P4	35.498	0.054	11.770	2.207
P5	4.497	11.972	0.685	16.505
P6	1.807	0.488	0.170	5.360
P7	0.045	21.344	6.333	24.209
P8	20.376	6.909	6.872	13.305
P9	2.955	51.940	11.483	0.639
P10	16.349	0.296	54.374	6.410

Well P10 has a high temperature. Well P7 is very rich in SF. P3 has a high electrical conductivity, salinity, a high TDS and a high concentration of nitrates. Well P7 is rich in SF and P6 is rich in phosphates.

IV. CONCLUSION

It appears from this study that the P^H of the water is around 7.7 ± 0.1 for an average temperature of 27.8 ± 0.2 ° C. Phosphates and the electrical conductivity are high in 30% of the wells. The other measured parameters (TDS, ammonium ions and nitrates) are at relatively lower levels of pollution in the indicator values. Search for bacteriological contamination indicators (Total Coliforms, Faecal Streptococci, Faecal Coliforms and Aerobic Heterotrophic Mesophilic Bacteria) is positive in all wells. Their presence in the water used by people in the consumption cycle is evidence of pollution, particularly animal pollution caused by excrements of cows and sheep that litter around the wells, the closeness to the latrines, and the waters of trickling from the hills or other activities that generate wastewater. The evolution of certain parameters above average values for pollution in some wells would make an objective orientation of the treatment to be given to each well at the end to obtain clean water for human consumption.

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