American Journal of Materials Science and Engineering, 2022, Vol. 10, No. 1, 1-7
Available online at http://pubs.sciepub.com/ajmse/10/1/1
Published by Science and Education Publishing
DOI:10.12691/ajmse-10-1-1

Bacteriological Study and Monitoring of the Evolution of the Concentration of Lead in Water Intended for the Drinking Water Supply of Keur Momar SARR in Thiès (SENEGAL)

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Received April 05, 2022; Revised May 09, 2022; Accepted May 18, 2022

Abstract Water provides all living beings with good health and the well-being of their organism. It allows him to meet his basic needs and especially his food. But, for a beneficial use, the optimal quality of the water is essential. In Senegal, most regions are fed by Lake Guiers and the latter is threatened by industrial discharges, hydro-agricultural activities which cause a gradual deterioration in its quality. In this study, we carried out bacteriological studies and a follow-up of the evolution of the lead content on the Keur Momar SARR-Thiès axis in order to see the degree of potability of the water intended for human consumption of Keur Momar Sarr to the storage reservoir of the Polytechnic School of Thiès. The microbiological parameters were determined by the colony-forming unit (CFU) method on selective agar media. The results of the physico-chemical parameters show that the concentration of lead is not significant with a maximum value of 0.11 mg/L. This value does not exceed the limits of the World Health Organization (WHO). The results of the bacteriological parameters show that the Kelle 1 and Beud forage boreholes contain the highest levels of total coliforms (110 and 115 CFU/100 mL) and faecal coliforms (34 and 85 CFU/100 mL). Faecal streptococci predominate in the borehole area (50 CFU/100 mL). A comparison with the WHO standards, these bacteriological parameters belong to the tolerance interval for water intended for consumption.

Keywords: *potability, bacteriological, content, lead, microorganisms*

Cite This Article: Famara Seydi Ba, Diadioly Gassama, Alioune Ly, Baba Ngom, and Séni Tamba, "Bacteriological Study and Monitoring of the Evolution of the Concentration of Lead in Water Intended for the Drinking Water Supply of Keur Momar SARR in Thiès (SENEGAL)." *American Journal of Materials Science and Engineering*, vol. 10, no. 1 (2022): 1-7. doi: 10.12691/ajmse-10-1-1.

1. Introduction

Water is of paramount biological and economic importance, it presents both a food, a medicine, an industrial, energy and agricultural raw material, and a tool for movement [1].

Water supply is currently a major need in the various areas of life, due to the increase in population and the constant development of living standards over time [2].

The aging of facilities and a galloping increase in the population are all causes of new infectious diseases [3]. Currently, the problem of drinking water quality remains a public health priority [4,5,6].

In an era of unprecedented urbanization, population growth and industrialization are now serious threats to water management in Senegal and human health is facing serious problems due to the degradation of drinking water quality [7].

Although Senegal has developed many water laws and policies, their application remains difficult in the face of the high pollution noted. However, the strict enforcement of regulations for the environment and water in Senegal is fundamental, it is important to create a reliable risk assessment system for water quality, human health and ecological safety [8,9].

All activities related to the water of Lake Guiers, which is our main source of food in Senegal, has significant consequences on its ecological status [10].

Water-related diseases are due to lack of water, precisely the lack of drinking water.

In its report of 26 June 2008, WHO estimates that dirty water is responsible for 9.1% of diseases and 6% of deaths recorded each year worldwide. Children are the first victims, since water is involved in 22% of diseases in children under 14 years of age [11,12].

2. Materials and Methods

2.1. Location of the Project Area and Identification of Measurement Points

The Keur Momar Sarr treatment plant is located south of Lake Guiers, along the departmental road D302, in the Louga region, 3 km north of the town of Keur Momar Sarr [13].

For this present work, we have chosen eight sampling points, namely:

- Point 1: Ndiang FALL in the Keur Momar SARR area
- Point 2: North Santhiaba, a neighborhood in the city of Louga
- Point 3: Gueoul
- Point 4: Kelle 1 borehole
- Point 5: Beud forage
- Point 6: Kelle 5 drilling
- Point 7: Takhy kao Thies
- Point 8: Polytechnic School of Thiès

Figure 1 shows the different measurement points from Keur Momar SARR to Thiès.

2.1.1. Sampling - Sampling Methods

The waters were sampled at the taps for bacteriological and chemical analyzes to monitor the evolution of the lead content. The sampling bottles were rinsed several times with the water to be sampled. Sampling took place between 10 a.m. and 3 p.m. in January 2022 continuously.

The role of the preservation process is to preserve the integrity of the samples taken between the time of sampling and that of laboratory analysis. This step is necessary so as not to alter the original quality of the sample [14].

These water samples were stored at 4°C in polyethylene bottles to be sent to the laboratories of the polytechnic school of Thiès and ONAS (National Office of Sanitation of Senegal) for analysis.

3. Results and Discussion

Table 1 provides information on the results of the analyzes obtained after measurement at the level of the eight points.

We first made a study on the characterization of the physico-chemical parameters of the waters of Keur Momar SARR to have visibility on the evolution of ions, temperature, pH, conductivity etc. A comparative study between certain measured chemical elements and the standards of discharge or potability was then made.

Table 1 shows the results obtained after analysis of water samples taken at lake level and at the exit of the drinking water treatment plant.

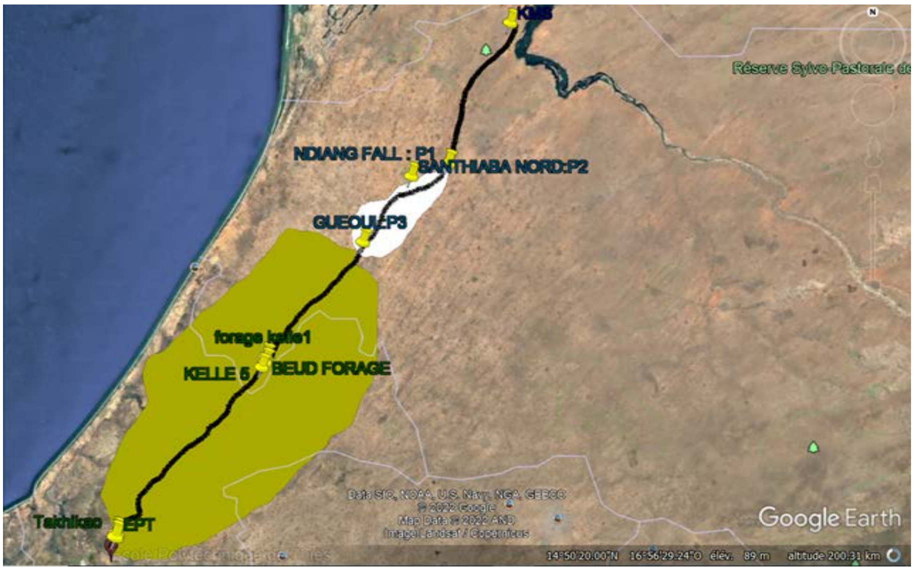

Figure 1. Location of the study area in Google Earth

Table 1. Results of chemical and physicochemical parameters obtained from the analyses

Parameters	Measuring points				
	Point 1 (left bank)	Point 2 (Middle of the lake)	Point 3 (Right bank)	Point 4 (Hydrant)	Point 5 (factory)
Temperature (°C)	26,4	26,9	26,6	26,4	28
Turbidity (uTN)	28	23	26,7	25,2	26,8
Conductivity (µS/Cm)	257	260	256	251	271
pH (25°C)	7,64	7,69	7,83	7,87	7,26
pH saturation (Langelier's formula)	8,04	8,07	8,17	8,21	8,35
Langelier index	0,4	0,38	0,34	0,34	1,09
Total alkalinity (mg/L)	82	76	78	64	46
Calcium hardness (mg/L)	44,9	44,89	34,69	38,76	38,77
Total Hardness (mg/L)	104,08	138,78	102,04	97,96	100

Parameters	Measuring points				
	Point 1 (left bank)	Point 2 (Middle of the lake)	Point 3 (Right bank)	Point 4 (Hydrant)	Point 5 (factory)
CO_2 (Tillman's formula) (mg/L)	3,81	3,14	2,34	1,75	5,13
Total Cations meq/L	1,64	1,52	1,56	1,28	0,92
OH^- (mg/L)	0,01	0,01	0,01	0,01	0,003
HCO_3^- (mg/L)	99,46	92,11	94,3	77,3	55,98
HCO_3^{2-} (mg/L)	0,26	0,28	0,39	0,36	0,06
SO_4^{2-} (mg/L)	16,2	16,1	16,6	16,6	31
Cl^- (mg/L)	39,99	39,53	33,45	36,35	44,53
Sum of anions (meq/L)	3,1	2,97	2,85	2,65	2,82
H^+ (µg/L)	0,0254	0,0226	0,0164	0,0150	0,0609
Ca^{2+} (mg/L)	17,96	17,96	13,88	15,51	15,51
Mg^{2+} (mg/L)	14,38	22,81	16,35	14,38	14,87
Na^+ (mg/L)	25,99	25,7	21,74	23,63	28,95
K^+ (mg/L)	3	2,8	3,1	2,8	3,8
Sum of cations (meq/L)	3,3	3,98	3,08	3,07	3,37
DCO (mg/L)	17	19,2	15,9	19,9	17,9
Zn^{2+} (mg/L)	0,03	0,03	0,03	0,03	0,03
Pb^{2+} (mg/L)	0,82	0,87	0,91	1,09	0,6
PO_4^{3-} (mg/L)	0,39	0,39	0,32	0,18	0,13
Fe^{2+} (mg/L)	0,24	too low	0,13	0,12	too low
NO_3^- (mg/L) de N	too low	0,01	Not available	Not available	too low
NO_2^- (mg/L) de N	0,01	0,01	0,01	15	too low
Total Nitrogen (mg/L) de N	25	17	Too low	15	too low

Lead is a dangerous cumulative toxic element with widespread effects, the effects are mainly neurological, nephrological, hepatic, cardiovascular and hematological [15]. The results of these analyses showed the presence of a significant concentration of lead in the treated water. This high content shows that the WHO standard has not been met [16]. Faced with this situation, we plan in this work to monitor the evolution of the lead content and the bacteriological study of Keur momar SARR in Thiès which is the place of storage of treated water.

Table 2 provides information on the results of the analyses obtained after measurement at the eight water withdrawal points on the Keur Momar SARR-Thiès axis.

Table 2. Summary table of laboratory test results

Water samples	Parameters measured			
	Lead Concentration (mg/L)	Faecal streptococci (CFU/100mL)	Total coliforms (CFU/100mL)	Coliforms Faeces (CFU/100mL)
Ndiang FALL	0,11	Not available	Not available	Not available
Santhiaba Nord	0,1	Not available	Not available	Not available
Gueoul	0,1	Not available	05	Not available
Drilling Kelle 1	< 0,1	Not available	110	34
Beud Forage	< 0,1	50	115	85
Drilling Kelle 5	< 0,1	50	20	Nd
Takhy kao Thiès	< 0,1	Not available	Not available	20
Thies polytechnic school	< 0,1	Not available	05	04

Table 3 shows the standards set by the World Health Organization (WHO) on water quality.

Table 3. Summary table of standards established by WHO

Parameters measured	World Health Organization standards
Lead Concentration	[0.01- 0.1] mg/L
Faecal coliforms	[0-1] CFU/100mL
Total coliforms	[50-150] CFU/100mL
Streptococci	0 CFU/100mL

3.1. Evolution of the Lead Content

Figure 2 shows the evolution of the lead content in water from Keur Momar SARR to the polytechnic school of Thiès.

Lead is toxic and is ubiquitous in the environment, the main sources of human exposure to lead are diffuse (air contaminated with automobile exhaust, contaminated food at the source or during processing or conditioning, water contaminated by the pipeline) [17].

The results of the analyses show that the evolution of the lead content is low and belongs to the WHO tolerance range [0.01- 0.1 mg/L]. The maximum value is obtained at Ndiang FALL which is an area close to the processing plant. The presence of this value may be caused by the high lead content at the water intake in the lake (see Table 1).

Figure 3 shows the evolution of the lead content from the raw water intake through the treatment plant to the distribution.

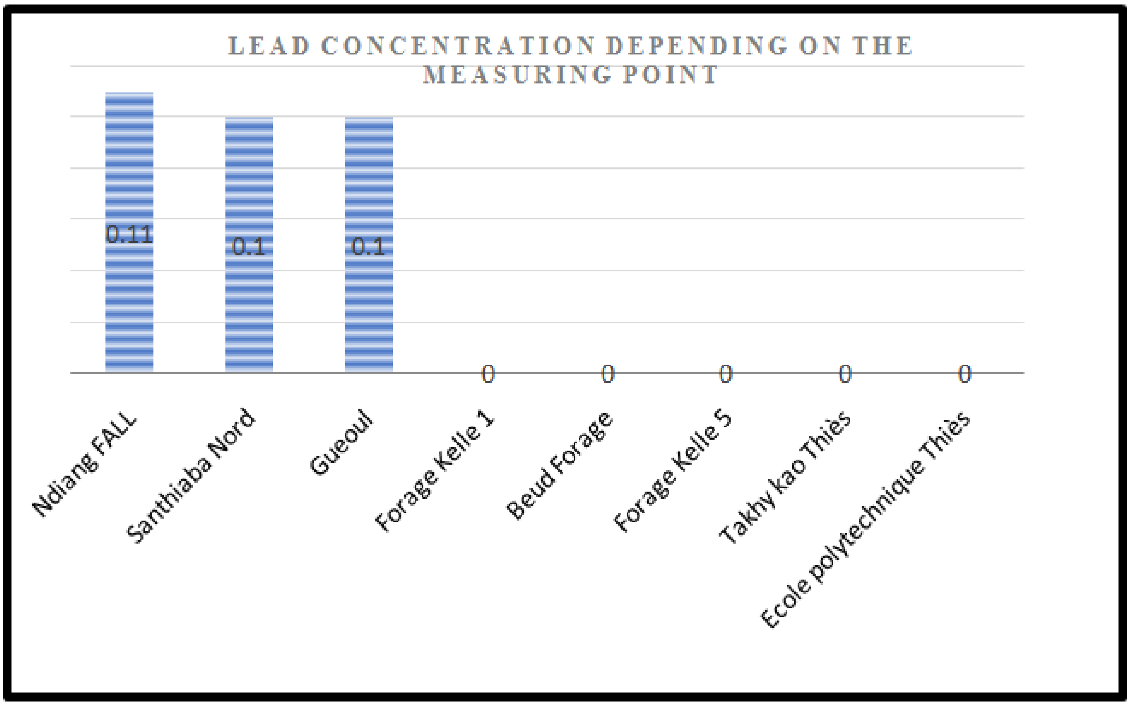

Figure 2. Evolution of the lead content of the eight collection points

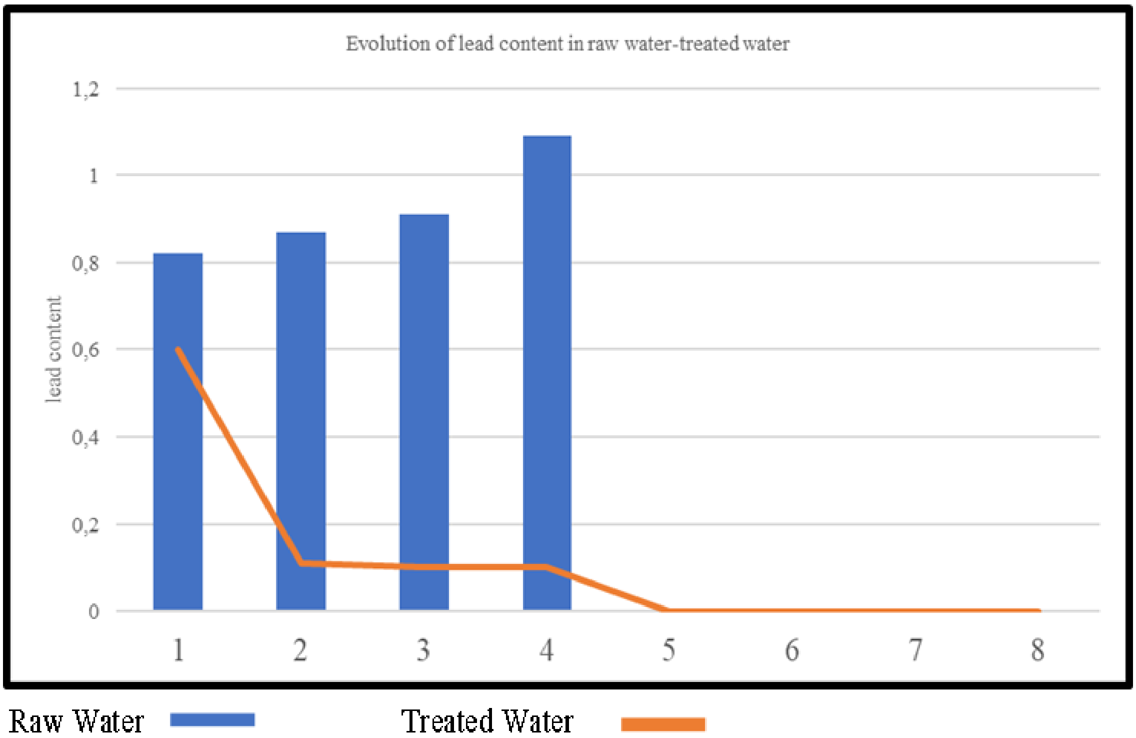

Figure 3. Evolution of lead content before and after water treatment

We note a total disappearance of lead at the entrance to the drilling area. Thus, we can say that the water inputs from the boreholes have led to a dilution leading to the disappearance of lead in the water. In drinking water systems, an increase in the concentration of lead in consumers has also been shown to be caused by the use of lead valves or a lack of an effective lead removal mechanism in the treatment plant [18,19,20].

In this figure frame we see that the treatment is acceptable based on lead before and after treatment.

3.2. Evolution of the Presence of Faecal Coliforms and Totals

Figure 4 and Figure 5 show the evolution of the presence of fecal and total coliforms in the water from Keur Momar SARR to the Polytechnic School of Thiès.

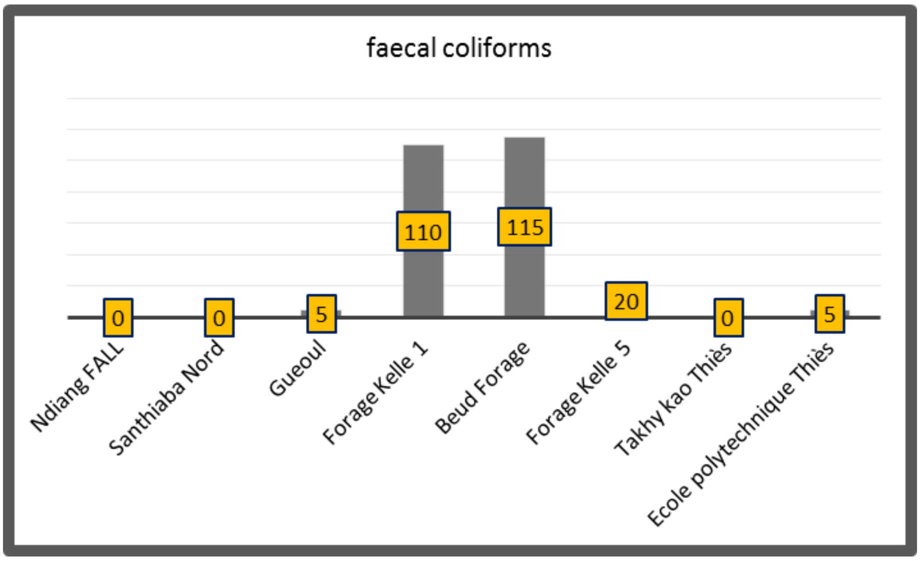

Figure 4. Presence of faecal coliforms at water withdrawal points

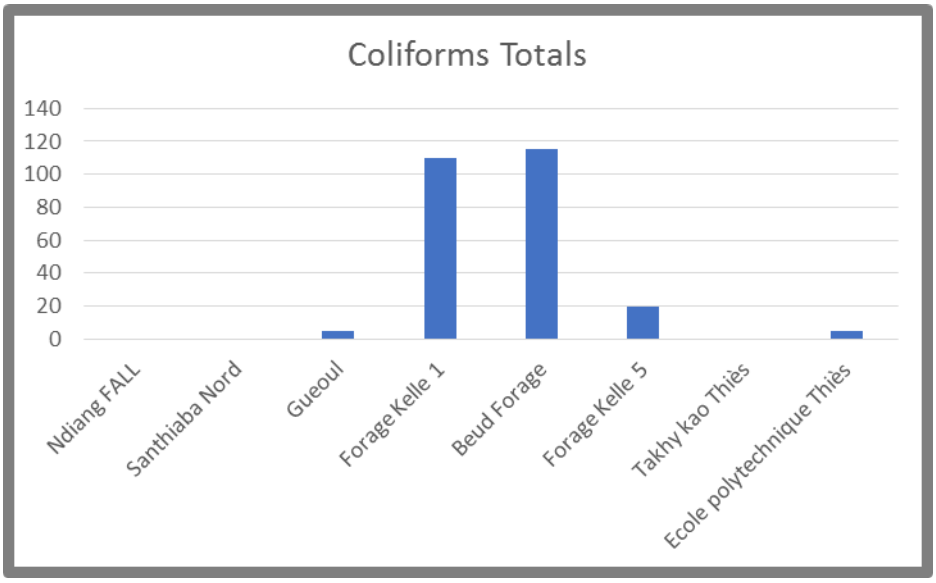

Figure 5. Presence of Coliforms Totals at sampling points

Fecal coliforms are the majority in the water taken from the Kelle 1 (34 CFU / 100 mL) and Beud Drilling (84 CFU / 100 mL) boreholes, in Gueoul (05 CFU / 100 mL) and the Thiessoise part, namely Takhy Kao and the Thiès Polytechnic School which have respective values of 20 and 04 CFU / 100 mL. The presence of total coliforms in water is not significant based on WHO standards. However, based on the results of analyses, only the boreholes have the highest levels and do not exceed the WHO limit value. We find that chlorine is much more effective in areas close to the plant (Ndiangue FALL and Santhiaba) with a total absence of coliforms.

The presence of faecal and total coliforms may indicate a deterioration in water quality, due to the distribution system and the residence time of the water in the network. Since total coliforms are not resistant to chlorine, their presence in water samples may indicate the existence of a biofilm or a lack of treatment efficacy [21,22,23,24].

The results of our analyses showed that only boreholes have high contamination.

During the field visit we noticed an absence of chlorination station at the level of the boreholes, and this can be a major factor of contamination.

Other researchers have shown that pumping the aquifer has an impact on water quality. Pumping changes, the organization of flows in the aquifer by converging the water of its environment towards the well. The increase, following the emptying of wells, in bacterial contamination and conductivity therefore probably reflects the presence of nearby sources of contamination: effluents from latrines, leachate from garbage deposits [25].

Total coliforms are enterobacteriaceae that include bacterial species that live in the intestines of homeothermic animals, but also in the environment in general (soil, vegetation and water). They are considered an indicator of the microbial quality of water because it contains bacteria of fecal origin, such as Escherichia coli [26,27,28].

The presence of E. coli in drinking water is considered an extreme danger to human health. Common symptoms of these diseases caused by E. coli are fever, abdominal cramps, and diarrhea [29,30,31].

3.3. Evolution of the Presence of Streptococci

Figure 6 shows the evolution of the presence of streptococci in the water from Keur Momar SARR to the Polytechnic School of Thiès.

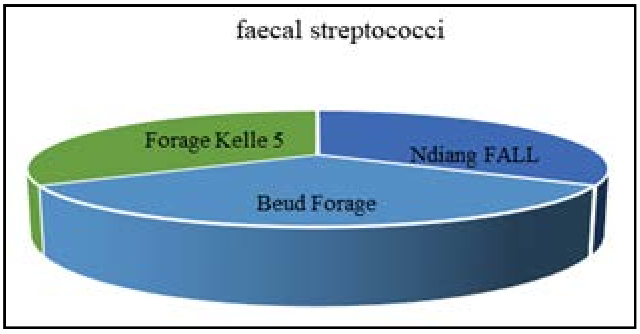

Figure 6. Presence of streptococci in drilling areas

The results of the analyses showed that only three of the eight sampling points have a high presence of streptococci. These streptococci are often noted at the point of taking the boreholes of Beud drilling, Kelle 5 and the Ndiang FALL area. The presence of streptococci is linked by the free movement of animals in these rural areas. Faced with this situation, better management of borehole water (protection, collection, transport) must take place to reduce the degree of contamination [32].

Streptococci are microorganisms that can cause many disorders or certain lung or skin infections. Symptoms vary depending on the organ concerned [33,34].

Most infections caused by streptococci can be easily eliminated and do not endanger the patient's life prognosis. These are usually throat infections, skin and ear infections [35].

The consequences of certain contaminations, in particular bacteriological contaminations, are such that preventive measures and corrective treatments are of paramount importance and must not be the subject of any compromise [36].

Some researchers have set up effective water treatment mechanisms namely slow sand filtration has been identified as an effective mechanism of the same and disinfection for the search for indicator germs [37,38].

The waters of Lac de Guiers are surface waters. They are therefore subject to environmental pollution.

Chemical pollution is probably the most frequent, very felt and very diverse. These are first of all contaminations by inorganic compounds, for example sodium, nitrates and heavy metals etc. [39]. With the discharge of household and industrial garbage into rivers often noted in developing countries, constitute for this purpose sources of contamination of water by human fecal matter [40]. Making water drinkable, i.e. containing no dangerous quantities of toxic chemical substances or germs harmful to health, will require complex metrology and techniques for the design of raw water treatment works. To do this, effective physico-chemical and bacteriological analyses must take place [41].

Lake Guiers is Senegal's main freshwater reserve, along with agricultural and industrial activities, Lake Guiers is threatened [42].

4. Conclusion

The results of the chemical analysis of the waters of Keur Momar SARR in Thiès can be considered eligible. These waters do not present any danger to consumption. The results obtained showed that the source is of excellent quality with the dominance of a chlorinated and calcium sulphate facies. We noted a dominance of chloride ion for anions on the one hand and on the other hand a dominance of magnesium ion for cations.

Laboratory analyses have shown that the lead content is low by WHO standards.

From a bacteriological point of view, the results also showed high concentrations of total coliforms, faecal coliforms, and streptococci at the borehole level, but which do not exceed the standards established by the WHO. The presence of these bacteria remains a threat to users. However, with effective treatment, these germs can be eliminated.

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