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Organic And Bacteriological Pollution Of Groundwater In The Department Of Collines (Benin, West Africa)

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Abstract – Water contamination not only threatens human life but also disrupts continuous access to quality drinking water supply. In the present study, we carried out an investigation on the quality and pollution assessment of groundwater in the department of Collines, in the republic of Benin. Organic pollution which characterizes the organic pollution from the content of ammonium, nitrites and orthophosphates, was assessed using the organic pollution index. Results highlighted Zero to low organic pollution in various studied site. Furthermore, the presence of *Escherichia coli* as well as the detection of *enterococci* in the sampled groundwater bodies pointed out a serious suspicion of faecal contamination and the presence of enteropathogenic microorganisms.

Keywords – bacteriological pollution, department of Collines, groundwater, water contamination, Organic pollution

I. INTRODUCTION

The objectives of sustainable development in water sector include guaranteeing access to water and sanitation for all and ensuring sustainable management of water resources". It aims for universal and equitable access to drinking water, hygiene and sanitation by 2030, in particular for vulnerable populations (SDG 6.2). This envisages an improvement in water quality in order to contribute significantly to the reduction of pollution and, among other things, to ensure adequate use of water use (Thomas, 2020). Faced with this challenge of achieving the objectives of sustainable development for the water sector in general and for DWS in particular, strong pressures are exerted on water resources, in this case groundwater, which is under heavy demand due to their technically favorable and financially less costly operating conditions.

In the Department of Collines in Benin, groundwater is the main source of drinking water supply for populations (MacDonald et al, 2012). As a result, the availability and good quality of these groundwaters would make the resource relatively conducive to drinking water for the populations. But the strong demographic pressure observed in the area and the unceasing and poorly controlled development of human activities around water points can affect the availability in quantity and quality in the medium and long term of water resources. The objective of this study is to assess the state of organic and bacteriological pollution of groundwater in the department of Collines.

II. Area Of Study

The Figure 1 presents the geographical location of the study area and the climatic regime in the department of Collines.

The Department of Collines is located between 7°27' and 8°46' North latitude and between 1°39' and 2°44' East longitude. Composed of six municipalities including Bantè, Dassa-Zoumè, Glazoué, Ouèssè, Savalou and Savè, it covers an area of 13,931 km^2 with a population of 717,477 inhabitants for a density of 52 inhabitants/km^2 (RGPH4, 2013).

The Department of Collines is spread over two climatic domains with a rainfall nuance. This is the bimodal subequatorial climate which extends from the coast towards the interior of the country and the subequatorial climate which is the transitional climate which prevails mainly in the center of the country. The subequatorial climate is characterized by a bimodal rainfall regime. Two rainy seasons, the largest of which extends from April to July with a maximum of 170 mm in June and 145 mm in September for the short rainy season which extends from mid-September to mid-November. They are alternated by two dry seasons from December to March on the one hand and from mid-July to August on the other hand. The nuance observed in this domain relating to the transitional climate is the intermediary between the subequatorial climate with two rainy seasons and that of the tropical of the Sudanian type with one rainy season (Boko, 1988; Afouda, 1990; Atchadé, 2014). The specificity of the rainfall regime of this frame is almost unimodal, displaying a tendency to erase or even disappear the short subequatorial dry season (Houndénou, 1999; Amoussou, 2010). It is therefore the result of the influence of the South Sudanese tropical climate and the Beninese climate reinforced by the impact of the relief in place and human activities on the rainfall regime (Yabi, 2008).

Monthly minimum temperatures vary between 21.1°C in December and 23.7°C in March, while maximum temperatures vary on average between 29°C in August and 36.7°C in February. The annual rhythm of the minimum temperature is practically unimodal. The first peak is observed in March, followed by a slight dip from May to July due to low insolation and high soil humidity. The second peak is visible in the month of November. The maximum temperature follows an annual bimodal rhythm with two peaks; that of February (36.7°C) and that of November (34.4°C). This climatic rhythm is explained by the strong direct radiation and the low cloudiness observed during these months.

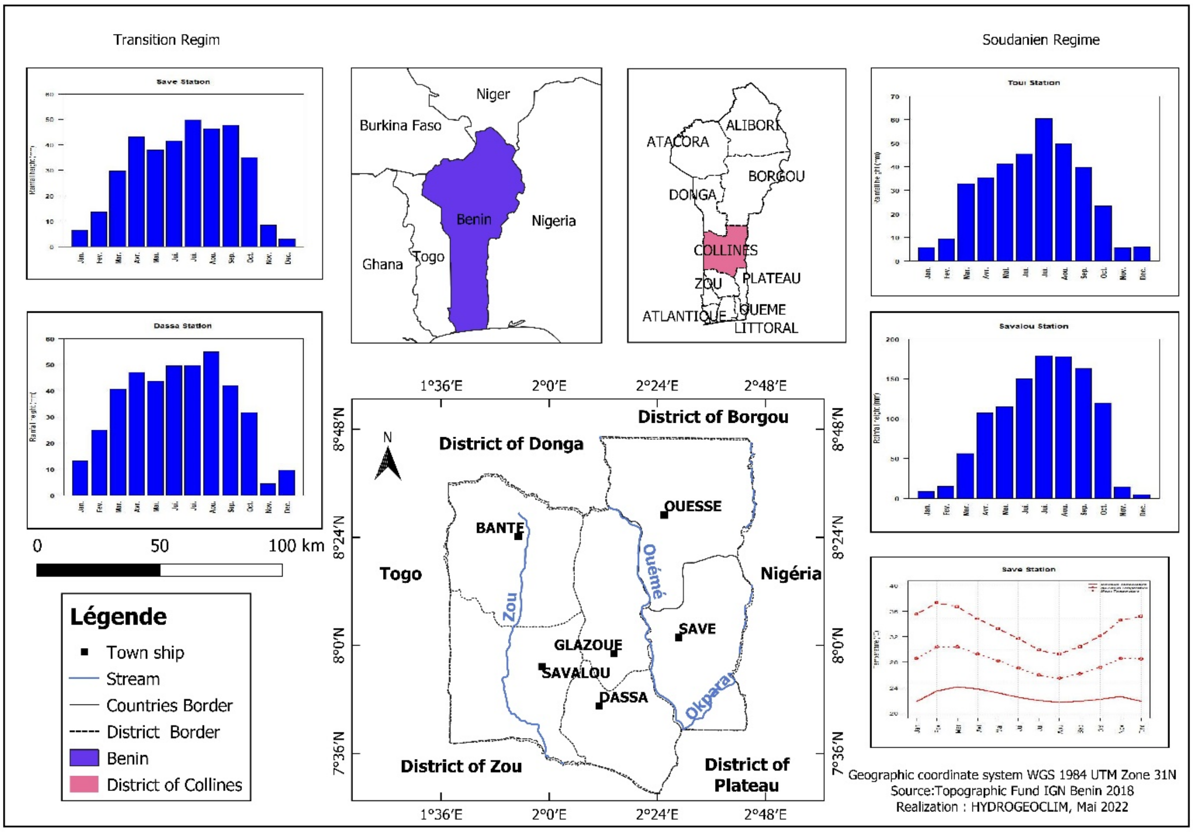

Figure 1: Geographical location of the Department of Collines and associated climatic regime

III. Materials and methods

Water samples from 15 wells and boreholes were taken during a sampling campaign in the study area (Figure 2). At each station, a raw water sample was taken in a 1.5 mL plastic or glass bottle previously rinsed with water from the station. After collection, these samples are stored in a clean, well-ventilated area before being sent to the laboratory in a cooled container to keep them in good condition. In the laboratory, the physicochemical parameters were assayed and the bacteria levels (*E. coli*, total coliforms, faecals coliforms and faecals streptococci) were determined according to the recommended protocols.

Organic pollution was assessed using the organic pollution index (Leclercq and Vandevenne, 1987). This characterizes the organic pollution from the content of ammonium, nitrites and orthophosphates which are divided into five classes (Table 1) of which the average of the class numbers of the three (03) parameters is the organic pollution index of the sample made. A numbers of pathogenic germs were evaluated and the origins of the forms of contamination were then identified.

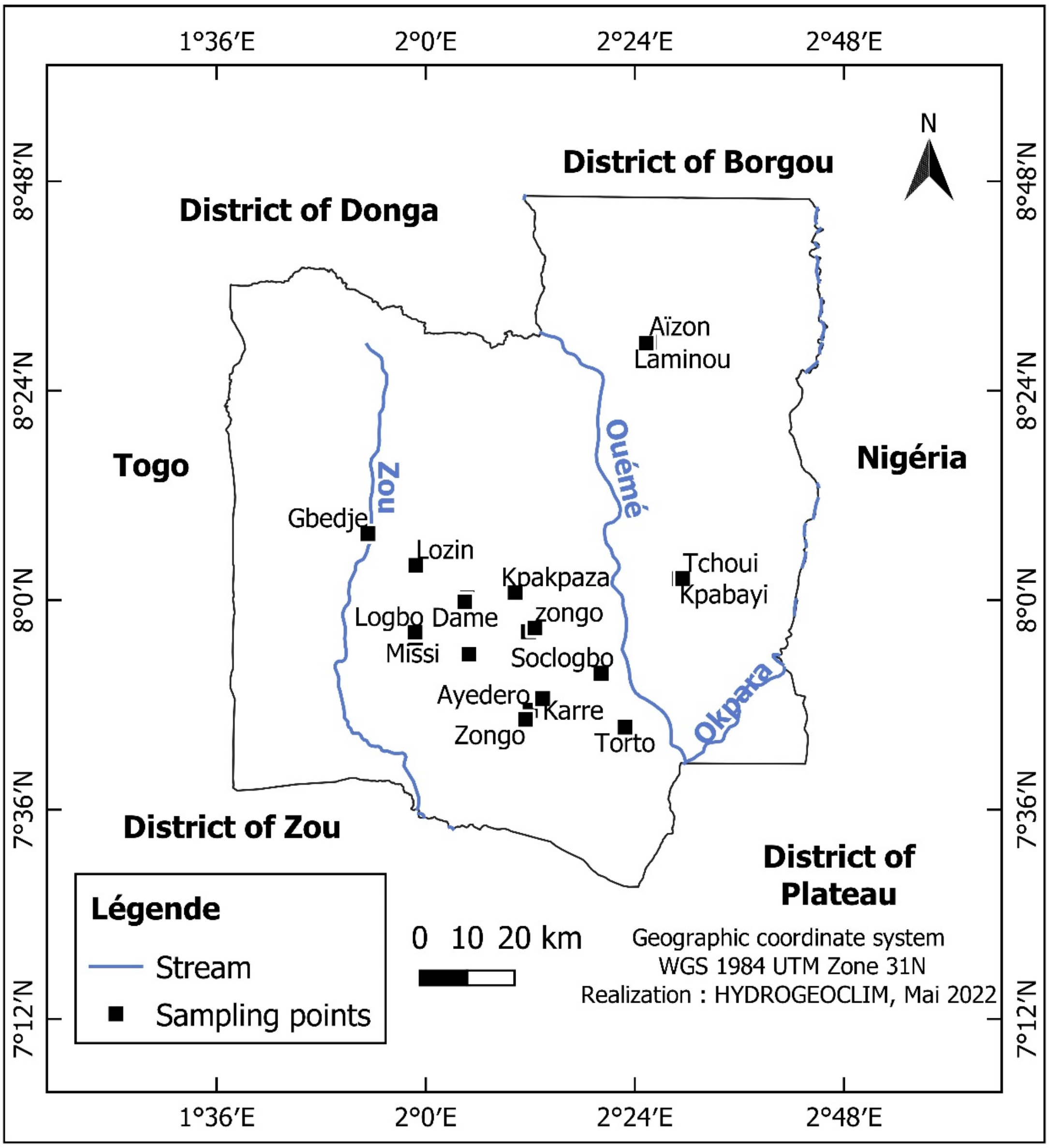

Figure 2: Spatial distribution of sampling points in the Collines

IV. RESULTS AND DISCUSSION

The nitrite, ammonium and phosphate contents were used to assess the degree of organic pollution of groundwater. The Figure 3 shows the nitrate, ammonium and nitrite levels in the groundwater from Collines.

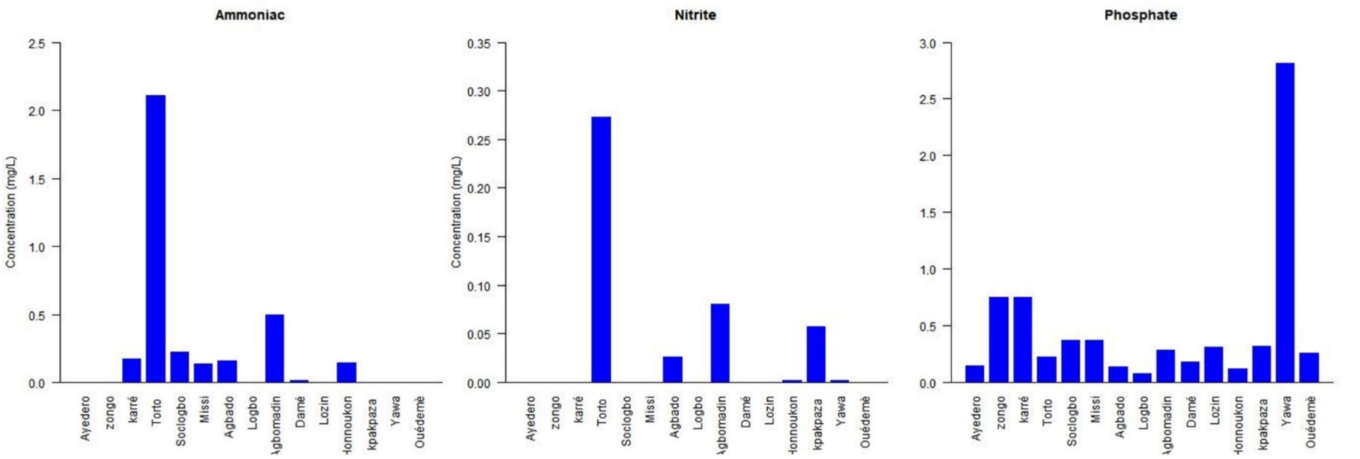

Figure 3: Nitrite, ammonium and phosphate content of groundwater sampled

The nitrite levels in the waters from the department of Collines are low and between 0 and 0.27 mg/L with an average of 0.03 mg/L. The ammonium contents are comprised between 0 and 2.12 mg/L for an average value of 0.24 mg/L. These are high in the areas of Soclogbo and Torto in the South-East and almost zero in the localities of Gbedje, Lozin, Yawa, Kpakpaza, Karre, Ayedero, Zongo and Ouedeme. Phosphates are homogeneous and low throughout the department with slightly higher values in Ouedeme. The values are comprised between 0.09 and 2.82 mg/L for an average value of 0.40 mg/L. Table 1 shows that groundwater in the Collines is of zero to low organic pollution (Zongo, Karré, Torto, Missi, Agbado, Logbo, and Lozin).

Table 1: Organic pollution index (IPO) of sampling sites

Sites	Ammoniac	Nitrite	Phosphate	IPO	Degree of pollution
Ayedero	5	5	4	4.7	Zero organic pollution
Zongo	5	5	3	4.3	Low pollution
Karré	4	5	3	4.0	Low pollution
Torto	3	5	5	4.3	Low pollution
Soclogbo	4	5	5	4.7	Zero organic pollution
Missi	4	5	3	4.0	Low pollution
Agbado	4	5	4	4.3	Low pollution
Logbo	5	5	3	4.3	Low pollution
Agbomadin	4	5	5	4.7	Zero organic pollution
Damé	5	5	4	4.7	Zero organic pollution
Lozin	5	5	3	4.3	Low pollution
Honnoukon	4	5	5	4.7	Zero organic pollution
Kpakpaza	5	5	5	5.0	Zero organic pollution

Yawa	5	5	5	5.0	Zero organic pollution
Ouédemè	5	5	4	4.7	Zero pollution

The microbial loads recorded at the different sampling sites are presented in Table 2.

Table 2: Average Bacterial Loads in the water studied

Sampling sites	Total coliforms per 100mL	Faecal coliforms per 100mL	E.coli per 100mL	Faecal strep throat per 100mL
Dassa Kavé1	10	6	2	0
Ayédéro	8	3	4	0
Glazoué Kpaoza1	12	4	4	1
Glazoué Ouédémé	16	4	7	1
Glazoué Yawa1	13	10	1	0
Savè	6	2	2	0
Atchakpa	5	4	1	0
Savè Dépôt	12	5	6	0
Savalou Missé	4	2	1	0
Savalou Lozin	4	2	2	0
Savalou Logbo	1	0	0	0
Savalou Honoukon	6	2	4	0
Savalou Agbado	12	4	6	C

The density of total coliforms varies from 1 to 20 per 100 mL. At Glazoué Ouédémé, Glazoué Yawa, at Savè Dépôt and at Savalou the rates are higher than 10 per 100 mL. The faecal coliforms measured are around 10 per 100 mL in Glazoué Yawa1, Savè Dépôt, Dassa Kavé1 and almost non-existent in the other water points. High concentrations of E.Coli are found in the waters from Glazoué Ouédémé, Savè Dépôt, Savalou Agbado. Faecal strep are present in the waters of Glazoué Kpaoza1, Glazoué Ouédémé.

V. Discussion

The study of the water quality in the department of Collines through the organic and bacteriological characteristics determined, made it possible to assess the level of water pollution in this department. The state of organic pollution of the waters in the department of Collines, calculated from the organic pollution index (IPO), indicates that 53.33% of the sampling stations, i.e. 08 out of 15 sampling stations, do not present any organic pollution ($4.5 \leq IPO \leq 5.0$). On the other hand, in the areas of Totro, Zongo, Agbado, etc., the organic pollution index presents values varying between 4.0 and 4.3, which reflects low organic pollution of the waters of these localities (Tab.3). This pollution is due to the anthropogenic activities carried out by the inhabitants and the discharge of domestic waste (wastewater, household waste) into the living environment (Serge and Ernest, 2020). These results are in line with those reported by Bekri and al. (2020) who found values of 4 to 5 reflecting zero and weak organic pollution and an exception of 2.5 (strong organic pollution). Zinsou and al. (2016) meanwhile, also obtained a value of 4 (low organic pollution) in the locality of Gangban in the Ouémé River delta.

The rate of organic pollution of the waters of the Department of Collines, determined by the concentration of ammonium ions, nitrites and phosphates, shows that the waters of the study area are highly phosphated. The waters of the studied area have a low concentration of ammonium and nitrite ions, i.e. 2.5 mg/l, unlike their phosphate ion content, which is 120 mg/L. This high value in phosphate ions is due to the use of chemical fertilizers in agriculture and domestic discharges (Zinsou and al. 2016). The same results were obtained by Zinsou and al. 2016 which found average phosphate values. According to Jen (2002) domestic wastewater contains a lot of detergents which are sources of phosphorus.

The presence of total coliforms is explained by pollution of faecal origin and in particular its degree of association with faeces. For example, they can also come from the environment: from the soil or degrading vegetation (WHO 2000). The group of total coliforms includes bacterial species and strains that colonize the intestine of warm-blooded animals, but also others that grow in the soil and on vegetation (CEAEQ, 2015a). In this context, their presence in treated water does not necessarily imply an imminent risk to public health since most of these bacteria do not have a faecal origin (Edberg and al., 2000; Health Canada, 2012).

Although the presence of faecal coliforms usually indicates contamination of faecal origin, several faecal coliforms are not of faecal origin, coming rather from water enriched in organic matter, such as industrial effluents from the pulp and paper sector or food processing (Barthe and al., 1998; WHO, 2000). The presence of these microorganisms in the water indicates that it has been contaminated by feces. Water contaminated in this way may contain microbes (bacteria, viruses or parasites) that can cause health problems. Water contaminated with microorganisms can in particular cause gastroenteritis.

E. coli is present in large quantities in the feces of humans and almost all warm-blooded animals; this is why it constitutes a reliable index of recent faecal contamination of the water. *Escherichia coli* (*E. coli*) is a bacteria commonly found in the digestive tract. Most strains are harmless but some can cause food poisoning. Most patients recover within 10 days, but in some cases the disease can be life-threatening, especially for children.

The detection of *enterococci* in a groundwater body should lead to serious suspicion of faecal contamination and the presence of enteropathogenic microorganisms. More conclusively, Charrière and al. (1994) clearly demonstrated that the detection of *enterococci* was strongly associated with the presence of *E. coli* in distribution networks supplied by groundwater. As for Zmirou and al. (1987), they demonstrated an increased risk of developing *gastroenteritis* with a relatively small number of faecal *streptococci*. Edberg and al. (1997) also suggest not consuming groundwater in which enterococci have been identified. Total coliforms and *E. coli*, like most bacteria, are very sensitive to chlorine disinfection compared to viruses and protozoa (Health Canada, 2012).

VI. Conclusion

The assessment of the state of organic and bacteriological pollution of groundwater in the department of Collines was the objective of this study. For this purpose, 21 water samples (wells and boreholes) were taken in the study area. Physico-chemical parameters (ammoniac, nitrites and phosphates) and bacteriological parameters (E. coli, total coliforms, faecals coliforms and faecals streptococci) were analyzed. The determination of the organic pollution index showed that there is not organic pollution in most of this samples, so in the study area. All the germs sought are present in all the waters studied except faecal streptococci which are just preset in the waters of Glazoué (Kpaoza and Ouèdèmé). Of all the waters studied, only the water from Savalou Logbo is potable from a bacteriological point of view. However, in order to avoid the appearance or increase of pollution in places in our study area, regular monitoring of water quality is necessary.

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