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Research Paper

Assessment of the quality of water for recreational use: Case of the waters of the Agneby River (Agboville, Ivory Coast).

Yapo, T. W [1]* Kpaibe S.A.P[1,2] Kouassi A. T. [1, 2] Meless D. F.[2] Gbagbo T.A.G.[1] Amin.N.C.[1, 2].

[1] *(Laboratory of Water and Food Analysis, National Institute of Public Hygiene, Abidjan, Cote d'Ivoire)*
[2] *(Department of Pharmaceutical and Biological Sciences, Félix Houphouët-Boigny University, Abidjan, Cote d'Ivoire)*
**Corresponding author*

ABSTRACT
The Agneby River, located in the department of the city of Agboville is subject to strong urban pressures. It is the receptacle of many forms of pollution with regard to the many activities that develop there. This has negative repercussions on the quality of this water resource. The objective of this study is to assess the impact of socio-economic activities on the quality of the waters of the river. To do this, physico-chemical parameters were determined and analyzes of bacteriological parameters were carried out. The methodology consisted of carrying out eight water sampling campaigns during the twelve consecutive months from December 2017 to November 2018. On these samples, the classic physico-chemical parameters were determined by electrochemical and colorimetric methods and microbiological analyses. was carried out using the membrane filtration technique. The results showed that the waters analyzed were weakly mineralized and all contained bacteria indicative of faecal pollution, including Escherichia coli, sulphite-reducing anaerobes. Thus, to minimize possible health risks, hygiene measures must be adopted for the well-being of populations.
key Words:Faecal contamination, Quality, Physico-chemistry, Bacteriology.

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I. INTRODUCTION

Bathing water is essentially surface water which includes all water flowing on the surface of the ground, from slopes to watercourses, passing through ponds, ponds and lakes (Dosso, 2017). According to Afri-Mehennaoui *et al*. (2009), these waters being the source most threatened by human activities.They are the most exposed to pollution, because these waters serve as dumping grounds for various wastes and are collectors of wastewater from agglomerations (Bagalwa et al., 2013). According to Saab *et al*. (2007), surface waters are the site of abusive discharges of domestic industrial effluents without prior treatment. Thus the activity of bathing, although associated with moments of relaxation or play, it presents physical risks but also chemical or biological risks due to a bad quality of the water of the bathing or the surrounding environment (Kouadio *et al*., 2019; Van Beek *et al*., 2005).Most people who engage in this bathing activity run the risk of waterborne illness if the water is of poor quality. Indeed, the city of Agboville located 79 km from the city of Agboville has been identified as one of the areas at high risk of waterborne diseases (Kouadio *et al*., 2019). It is served by the river "Agneby" called river "Agbo" which abounds in many bathing sites. However, few studies have focused on the quality of these bathing waters. And yet, Côte d'Ivoire has regulations on bathing water that have been in place since 1993, but which have not seen the start of application as for swimming pools (MH, 1993). In the meantime, the regulations in the countries have changed. Data was therefore needed to serve as a basis for a possible improvement of the Ivorian standard. To do this, our study consisted in characterizing the bathing waters of the Agneby River in order to know the risks incurred by the populations who frequent it.

II. MATERIALS AND METHOD

II.1 Matérials

Location of the study area

The Agnéby watershed with an area of 4693 km2 is located in a forest zone between longitudes 340,000 to 420,000 meters and latitudes 650,000 to 770,000 meters. It is drained by the Agnéby river (figure 1) which flows into the Ebrié lagoon near the Atlantic Ocean in the south of Côte d'Ivoire (van Beeck EF *et al.,* 2005).

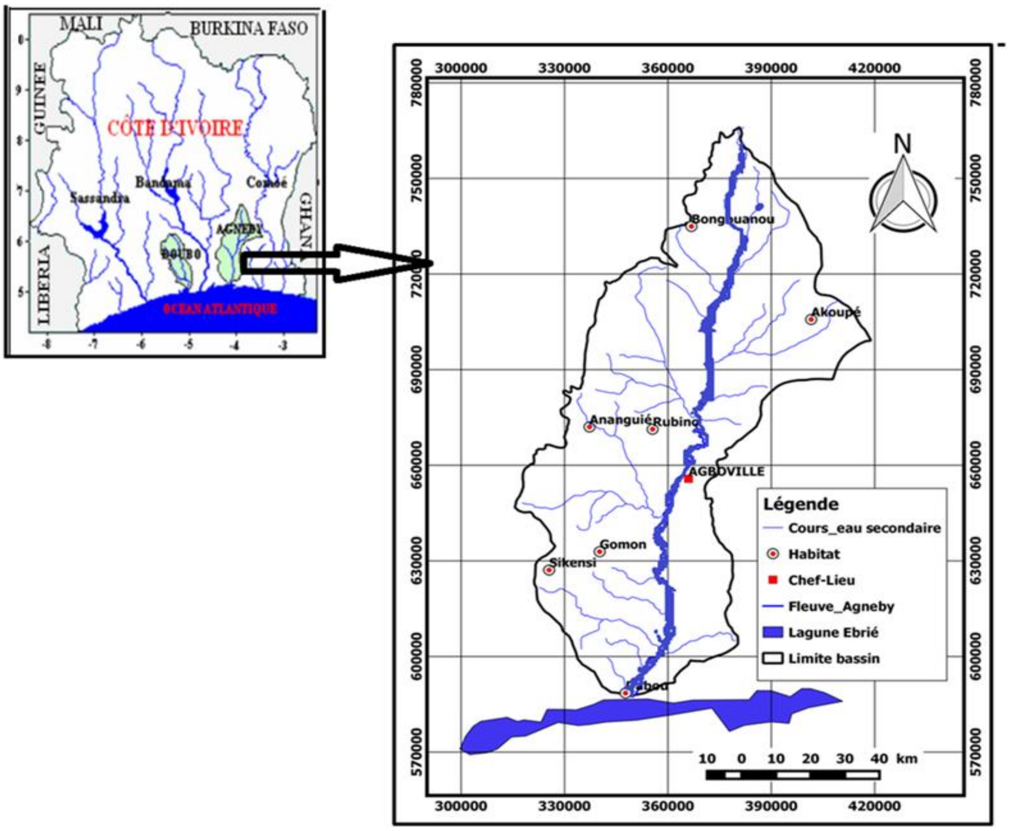

Figure 1: Map of the Agnéby watershed

Equipment

The main equipment consists of a Palintest photometer (Great Britain), a pH meter, a conductivity meter, a turbidity meter for the analysis of physicochemical parameters and a membrane filtration device for the parameters microbiological.

Sampling

Sampling was done during 13 (thirteen) distinct campaigns from November 2017 to December 2018. Samples were taken in polyethylene bottles of 1000 ml for physicochemical parameters, 500 ml for microbiological parameters and 1000 ml for vibrio research**.**

The reagents

The reagents used were of analytical quality. The reagents for measuring the chemical parameters were of the PALINTEST brand (Great Britain). Rapid'E culture media. coli 2® Agar, BEA agar (Bile Aesculin Azide) and TSN agar (Tryptone Sulfite Neomycin) from BIORAD brand were used for the enumeration of faecal contamination markers.

II.2 Method
Collection, transport and storage of samples
The samples were taken according to WHO/UNEP recommendations. The samples were stored in a cooler protected from light at a temperature between 4°C and 8°C and transported to the laboratory while respecting the cold chain by ice packs, with the exception of samples intended looking for vibrios. The latter were transported at room temperature taking into account the fragility of vibrios at low temperature.

Physico-chemical analyzes
- The physico-chemical parameters were determined by the following methods:
- - The pH is measured with a HACH-type digital laboratory pH meter equipped with a combined electrode (Bioblock Scientific).
- - The conductivity is measured using a HACH type conductivity meter.
- - Turbidity is determined using HACH-type nephelometry.
- - titrimetry was used for the determination of organic matter.
- Mineral salts and color were determined by colorimetry using a Palintest 7100 SE photometer equipped with filters and pre-programmed calibration curves. The operational wavelengths vary between 410 nm and 640 nm. The procedure followed is that of the manufacturer. The mineral salts sought were potassium, nitrites, nitrates, fluorides, orthophosphates, iron, manganese, complete alkalimetric title (TAC), total hydrotimetric degree (DHT), ammonium, aluminum , chlorides, sodium, magnesium, calcium, sulphates, potassium, bicarbonate, sulphur, zinc, phosphorus, silicates and silica.

Analyses microbiologiques
Microbiological analyzes made it possible to identify and count total coliforms, faecal coliforms, E. coli, E. faecalis, anaerobes sulfuto-reducer. These microorganisms were identified and counted by filtering homogeneous 100 ml aliquots on a membrane whose pore diameter is 0.45 µm. The membranes were then placed on selective culture media for 24 hours at 37°C in a thermostatic oven. The following media were used: KF agar (Selective medium used for the isolation and enumeration of enterococci by the classic method of enumeration in Petri dishes), Rapid'E. coli 2® Agar (culture medium for the identification of Escherichia coli), for total coliforms, TSN (Tryptone Sulfite Neomycin) agar.

Statistical analyzes
The values of the defined physical and bacteriological parameters have been the subject of a descriptive statistical analysis (average, minimum and maximum) making it possible to present the data in the form of a table or graph, thus facilitating reading and understanding and inductive analysis. . The analyzes were performed with R software version 3.6.1. The curves and graphs were made on Excell 2016, and the boxplots on R.
Moreover, according to Ossey *et al*. (2008), the Coefficient of Variation (CV) makes it possible to compare the variability between measurements of different dimensions. So when:
- CV < 2% the measurements of the parameters are very homogeneous
- 2% < CV < 30% the measurements of the parameters are very homogeneous;
- CV > 30% the measurements of the parameters are very heterogeneous.

III.Results

Analysis of organoleptic and physico-chemical parameters
The waters of the Agneby River are weakly mineralized with an average conductivity of 212.60 µS/cm. These waters have a high turbidity which exceeds WHO recommendations < (5 UNT). Compared to the standard, some parameters such as temperature, nitrite nitrogen derivatives, total iron, residual chlorine presented non-compliances (table 1). As a result, almost all parameters are heterogeneous except for pH, temperature and residual chlorine (Table 1).

Table 1: Results of the physico-chemical analyzes of the waters of the Agneby River

Parameter	Min	AV ± SD	Max	%CV	WHO Norms
Turbidity (UNT)	7,18	14,3±7,896	37,6	55,17	≤ 5
Color: Pink (UCV)	20	220±100,756	310	45,79	-
Conductivity (µS/cm)	6,04	212,6±85,115	294	40,03	100-1000
pH	6,37	7,13±0,395	7,62	5,46	6,5-8,5

Temperature (°C)	23,1	28,2±2,039	30,8	7,23	25
Organic matter (mg/L)	0,72	11±5,593	19,09	50	-
Nitrates (mg/L)	0,36	1±0,571	2,7	57	≤ 50
Nitrites (mg/L)	0,03	0,06±0,027	0,12	33,33	≤ 0,1
Al (mg/L)	0,01	0,1±0,059	0,23	590	-
Ammonium (mg/L)	0,01	0,21±0,131	0,44	61,90	≤ 1,5
Total iron (mg/L)	0,4	0,7±0,496	2,35	70	≤0,3
Cl (mg/L)	5,7	14±4,938	22	22	0
Phosphate (mg/L)	10	14,7±77,523	306	52,73	-
Sulfate (mg/L)	0	8±3,846	10	48	≤ 250

Bacteriological parameters

The results of the microbiology of the waters of the Agnéby River showed three groups of germs (Table 2). Analyzes of the waters of the Agneby River indicated the presence of coliform, enterococcus, and ASR type germs. These microorganisms reached maximum values of 1200 CFU/100 ml for total coliforms, 1000 CFU/100 ml for thermotolerant coliforms, 5400 CFU/100 ml for E. coli, 4 CFU/100 ml for E. faecalis , and 19 CFU/100 ml for ASRs.

Table 2: Results of physico-chemical and bacteriological analyzes of the waters of the Agneby River

Parameter	Min	Méd	Max	WHO Norms
CT	3	100	1200	0
CTh	3	100	1000	0
E *coli*	5	500	5400	0
E. *faecalis*	0	0	4	0
ASR	0	1	19	0

ASR: Anaerobic Sulfuto-Reducer

Correlation study between different parameters (Agneby)

A positive correlation was also found between coliforms and phosphates on the one hand and conductivity on the other. There was a negative correlation between coliforms and nitrates, turbidity, color (Figure 3).

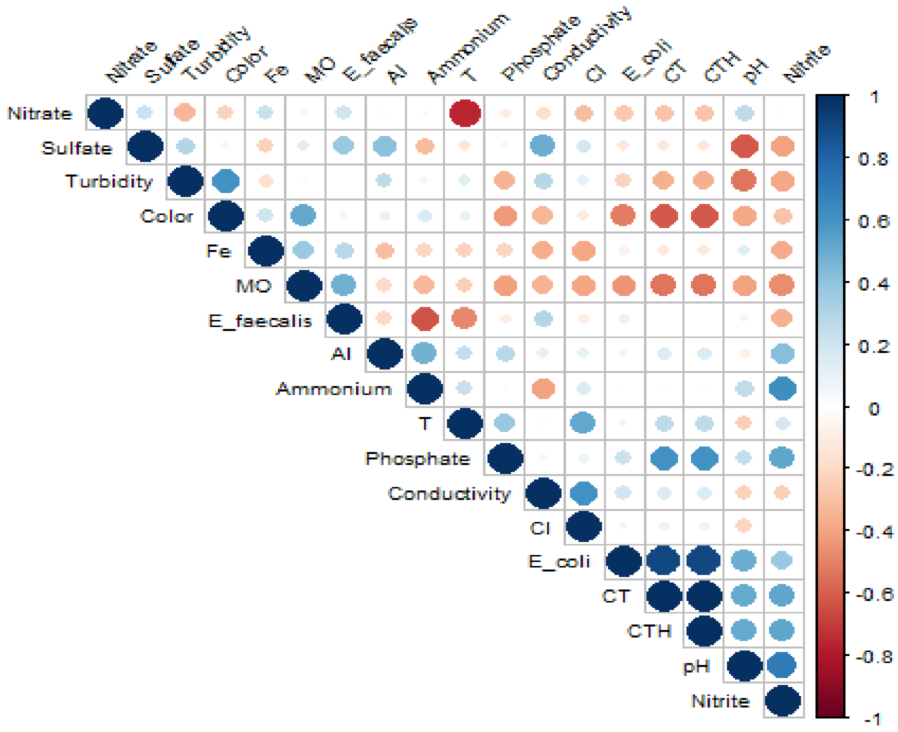

Figure 3: Correlation between the values of the different bathing water parameters agneby.

IV. Discussion

The pH of water represents its acidity or alkalinity. The waters of the Agneby River have a pH between 6.37 and 7.62 with an average of 7.13. This pH therefore complies with the normative criteria of the WHO (2011) ($6.5 \leq pH \leq 8.5$). According to Mayo (1995) and N'Diaye *et al.* (2011), basic pHs can lead to a marked decrease in the survival of faecal germs. On the other hand, the almost neutral nature of the pH can promote the development of good numbers of bacteria, in particular total coliforms, thermotolerant coliforms and faecal streptococci in river waters (Manizan *et al*., 2010).The turbidity of these waters varied from 7.18 NTU to 37.6 NTU with an average of 14.3 NTU. Turbidity reflects the presence of fine particles suspended in the water. The WHO has recommended that the turbidity of drinking water be less than 5 NTU. Where the average turbidity of the site waters is around 14.3 NTU.Therefore, this high content of turbidity can allow microorganisms to attach themselves to suspended particles, so the bacteriological quality of turbid water is therefore suspect (Ghazali and Zaid, 2013). Furthermore, the maximum values appear, which are 37.6 UNT, reflecting the influence of the various activities around the river. This is explained by the low content of water in colloidal matter, plankton and microscopic organisms (WHO, 2000). The measurement of the conductivity makes it possible to appreciate the quantity of salts dissolved in the water. It is a function of the water temperature and important when it is high. Ahadjitse (1991), indicated in the results of his work the following conductivity values:

- Conductivity > 500 µS/cm: highly mineralized waters;
- 200 < Conductivity < 500 µS/cm: moderately mineralized water;
- Conductivity < 200 µS/cm: weakly mineralized water.

The waters of the study site have conductivity values lower than 200 µS/cm. Consequently, these waters are very weakly mineralized because they contain very low levels of cations and anions (Ahadjitse, 1991).

Temperature is the degree of cold or heat of the water. According to the WHO (2006), drinking water should have a temperature of 25°C. The measurements of the study showed temperature values between 23.1 and 30.8°C with an average of 28.2°C. This rise in temperature can promote self-purification and the death of certain microorganisms (Ahonon *et al*., 2019).

From a bacteriological point of view, total coliforms and thermotolerant coliforms (44°C) are germs of faecal origin indicative of breaches of hygiene rules. As for thermotolerant coliforms, they are abundant in faeces and represent the predominant indicators of the environment. Their presence in these waters may be due to the discharge of domestic wastewater and its uses for bathing (Ahonon *et al*., 2019). The analysis results showed the presence of faecal contamination bacteria including Total Coliforms, Thermotolerant Coliforms, E.

coli, E. faecalis as well as pathogenic bacteria (sulfite-reducing sporulated anaerobes) in the waters of the Agneby River.According to Jacinta et al. (2007), the quality of surface water is subject to the presence of high levels of thermotolerant coliforms which constitute a good index of pollution, mainly attributed to faecal contamination (Ladjel, 2009). According to Manizan *et al*. (2010), the flow of domestic water without any prior treatment can contribute to the contamination of surface waterµ. Indeed, this high load may be due to the phenomenon of runoff which carries all the solid waste (human and animal waste) and liquid waste (wastewater) towards the water of the river. Similar observations have been made by Bahhou (1991) in certain areas of the northwestern Mediterranean coast of Morocco and by Dovonou *et al*. (2011) at Lake Nokoué in Benin. The abundance of faecal germs during the rainy season may be mainly due to an increase in anthropogenic inputs through the leaching of contaminated soils and the emptying of sewers and runoff water (Ouhmidou *et al*., 2015). The use of these waters exposes the population to many waterborne diseases caused by high levels of coliforms and E. faecalis (WHO, 2011). Wirmvem et al. 2013 also reported a high presence of coliforms in shallow groundwater in the Ndop Plain in Cameroon. Sulphite-reducing anaerobes occur as strict anaerobes in the intestine of humans and animals and in the soil or on dead leaves, very resistant and protected by spores (Ahonon *et al*., 2019). According to Guessoum *et al*. (2014), the presence of spores of sulphite-reducing anaerobes in natural water suggests faecal contamination and, in the absence of Coliform bacteria, old contamination. They are very persistent and their presence is a good indicator of the vulnerability of aquifers and sinks (Ayad *et al*., 2016). The presence of these bacteria could be due to the surrounding pollution and the absence of a sanitation network (Yapo *et al*., 2010). Therefore, these bacteria are suitable indicators of the most resistant waterborne pathogens such as enteric viruses, parasitic protozoa and helminth eggs (Payment and Franco, 1993). According to Payment (2003), Sulfito-Reducing Aerobes are responsible for gastroenteritis in children and the elderly.

V.Conclusion

The study of the physico-chemical and microbiological parameters made it possible to assess the quality of the waters of the Agneby River. It appears from this study that these waters are weakly mineralized and have high turbidity values. From a microbiological point of view, these waters show non-compliance with regard to the values of the bacteriological parameters. To do this, the sanitary monitoring of these waters is essential for the well-being of the populations.

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