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Physico-chemical and bacteriological characterization of surface waters for domestic use: Case of river waters in M'pody village (Anyama, Ivory Coast)

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ABSTRACT

This study aimed at determining the physico-chemical and bacteriological quality of the waters of the rivers of the village M'pody in order to evaluate their impacts on the health of the populations. The methodology consisted of four water sampling campaigns in the Souman and Chibi rivers. Conventional physico-chemical parameters were determined by electrochemical and spectrophotometric methods. The microbiological analysis was carried out using the membrane filtration technique. The results showed that physico-chemical and bacteriological parameters are beyond the WHO recommendations. The noncompliance of this water is related to high levels of turbidity, conductivity, temperature and a high total iron content. For bacteriological parameters, this noncompliance is related to the presence of *Escherichia coli*, Tolerant Thermo Coliform, Total Coliform, Fecal Enterococci, *Pseudomonas* sp, Sulphite-Reducing Anaerobic) (SRA). Water of the rivers showed huge non-conformities related to physico-chemical and bacteriological parameters. This water was therefore unfit for human consumption. Thus, to minimize potential health risks, the adoption of hygiene measures in particular, a good purification of this water must be recommended to the populations in order to better preserve their health.

Keywords: River water quality; Bacteriological contamination; Physico-chemistry; Population health; M'pody.

INTRODUCTION

Access to drinking water is a determining factor for the socio-economic and environmental development of a population. This issue of great concern to the international community is the subject of the sixth sustainable development goal (UNRIC, 2020). Access to safe drinking water is therefore an essential condition for health, a basic human right and a key component of effective health protection policies (Moussima et al., 2020). Therby, water is not only an essential element for the functioning of any ecosystem, but also essential for human activities (agriculture, industry) and our everyday life (domestic use, leisure) (Mokeddeme et al., 2017). Water is an essential resource for the basic needs of man and his environment. According to the WHO-

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UNICEF Joint Monitoring Program for Water Supply and Sanitation, there are about 2.6 billion people who have access to an improved source of drinking water and about 2.1 billion having acces to an improved water service. However much remains to be done as 663 million people are without an improved source of drinking water with 319 million in sub-Saharan Africa, and 2.4 billion without improved sanitation facility. Among those who still do not have access to these water points, 8 out of 10 live in rural areas (WHO and UNICEF, 2015).Thus, due to the low availability of drinking water in urban, peri-urban and rural areas of some African countries, people are forced to obtain water whose potability is highly questionable. Surface water is open-air, often near farms and shared with cattle during transhumance activities in the dry season (Tamungang et al., 2016 ; Dovonou et al., 2022). Such water may contain elements that may have adverse health effects, such as pathogenic microorganisms, undesirable substances or even toxic substances (Yapo et al., 2010; Jang et al., 2012). According to the WHO (2004), water quality can be harmful to human health. Unsafe water is responsible for several water-related diseases, particularly in developing countries (Nanfack et al., 2014). Among the factors responsible for these infections, bacteria play an important role (Hounsou et al., 2010). In effect, Consumption of such water would expose the population to microbial diseases such as typhoid fever, bacillary dysentery, diarrhea and gastroenteritis, hepatitis A and E, and amoebian dysentery (WHO, 2011). As a result, poor water quality can be induced by anthropogenic activities, including pollution, and poor sanitation and hygiene (Torkil, 2004; Nanfack et al., 2014). The assessment of the quality of surface water is based on the measurement of physico-chemical parameters as well as on the presence or absence of aquatic microorganisms, indicators of water quality (Bli-Effert and Perraud, 2001). The objective of this study was therefore to show the vulnerability of surface water through the characterization of the quality of domestic river water in the locality of M'PODY.

MATERIALS AND METHODS

Study area presentation

The locality of M'pody belongs to the sub-prefecture of Anyama located in the south of Ivory Coast. It having coordinates UTM 30N03 latitude North and 06'16 longitude West and it is found in the forest zone. The village has 2,731 inhabitants (RGPH, 2014). The climate is equatorial, characterized by alternating four seasons. Average annual precipitation ranges from 1600 to 2500 mm with peaks in June.

Sampling

Water sampling was done at the Souman and Chibi rivers that are located near the village. Samples were taken in polyethylene bottles of 1000 ml for physico-chemical parameters and 500 ml for microbiological parameters. These samples once collected were stored in a cooler protedcted from light at a temperature that ranged between 4°C and 8°C.

Physico-chemical analysis

The physico-chemical parameters were determined by the using methods:

- The pH was measured using a AOAC-type digital laboratory pH meter equipped with a combined electrode (Bioblock Scientific) (FSA (French Standards Association) 1997).
- Conductivity was measured using a AOAC (Association of official analytical chemists, 1990) conductivity meter.
- Turbidity was determined by AOAC (Association of Official Analytical Chemists 1990).
- titrimetry was used for the determination of organic matter FSA (French Standards Association) 1997).
- Mineral salts and colour were determined by colorimetry using a Palintest 7100 SE photometer with pre-programmed filters and calibration curves. The operating wavelengths ranged from 410 nm to 640 nm following the manufacturer procedure. The mineral salts sought were nitrites, nitrates, fluorides, iron, manganese, complete alkalime title (TAC), total hydrometric degree (TDH), ammonium,

sodium, magnesium, calcium, sulphates, potassium, bicarbonate, zinc.

Bacterial analysis

Bacterial analysis identified and counted total coliforms (TCs), thermotolerated coliforms (ThCs), *Escherichia coli* (*E. coli*), *Enterococcus faecalis* (*E. faecalis*), *Pseudomonas* spp, and Sulphite-Reducing Anaerobic. These microorganisms were identified and counted by filtering homogeneous aliquots of 100 ml and 50 cl (anaerobic sulfito-reducing germs) on a membrane with a pore diameter of 0.45 µm. The membranes were then placed on selective culture media for 24 hours at 37°C in the thermal oven. The following culture media were used: BEA agar (Bile Esculine Azide) (Selective medium used for isolation and enumeration of enterococci by the classical method of Petri Dish counting) for fecal streptococci, Rapid *E. coli* 2 Agar (culture medium for the identification of *E. coli*) for total coliforms, TSN (Tryptone Sulfite Neomycin) agar for *Clostridium* spp and pseudosalt or kettrimide medium for *pseudomonas* spp.

Data processing

The data was processed using Excel 2007. The arithmetic mean (X), standard deviation (S), coefficient of variation (CV), which is the ratio of mean to standard deviation, was determined by Excel.
When CV < 2%, parameter measurements are homogeneous, when we have 2% < CV < 30%, parameter measurements are homogeneous, and when CV > 30%, parameter measurements are heterogeneous (Koné, 2008).

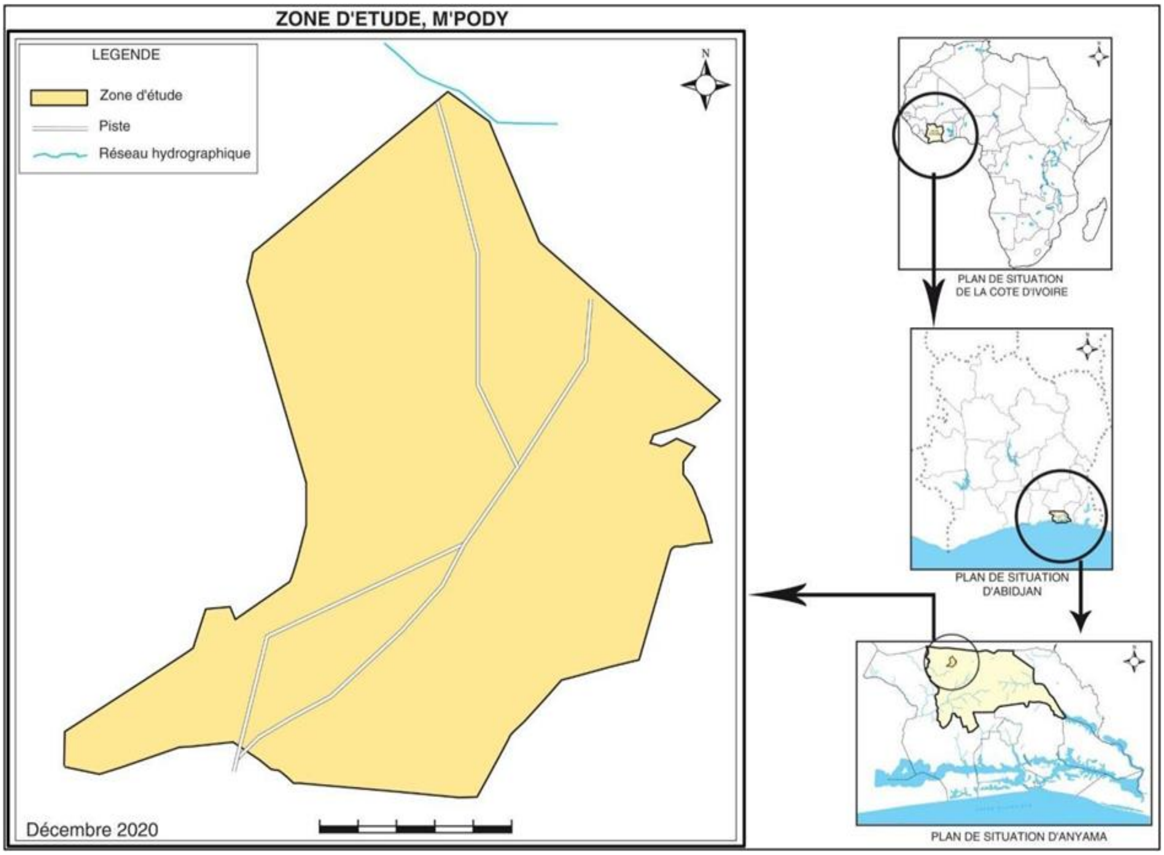

Figure 1: Study Area presentation.

RESULTS

Physico-chemical and bacteriological parameters of rivers water

Physico-chemical parameters of rivers water

The results of the physico-chemical and bacteriological analysis of rivers water is shown in Table 1. From the analysis of this table, it could be seen that the water was weakly mineralized with a conductivity < 100 µS/cm. The turbidity levels are less than 5 mg/L therefore below the WHO standard (WHO, 2008). Temperatures average 27,78°C, with total iron average above WHO guidelines. Most physico-chemical parameters were heterogeneous with the exception of conductivity, pH and temperature for which the coefficients of variation are less than 30%.

Bacteriological parameters of rivers water

Water analysis of these rivers indicated the presence of total coliforms, *E. coli*, SRA (Sulphite-Reducing Anaerobic) and *pseudomonas* spp. These microorganisms averaged 2534.5 CFU/100 ml for total coliforms, 982.63 CFU/100 ml for *E. coli*, 2.125 CFU/100 ml for SRA and 11 CFU/100 ml for *pseudomonas* spp. All these values were above the WHO (2008) recommended threshold. Most bacteriological parameters had coefficients of variation greater than 30%. These bacteriological parameters were therefore heterogeneous (Table 2).

Table 1: Results of physico-chemical parameters in Rivers water.

Parameter	Min	Med	AV ± SD	Max	%CV	WHO Norms
Turbidity (UNT)	15,7	18,9	24,23 ± 11,66	46,8	48,12	**≤ 5**
Conductivity (µS/cm)	24	34,85	37,04 ± 10,86	59,2	29,31	**100-1000**
pH	6,26	6,70	6,76 ± 0,42	7,61	6,21	**6,5-8,5**
Temperature (mg/L)	25,1	27,95	27,78 ± 1,77	29,9	6,37	**25**
Organic matter (mg/L)	3,65	17,27	15,09 ± 7,47	27,96	49,50	
Nitrates (mg/L)	0,03	3,715	5,38 ± 5,48	13,2	101,85	**≤ 50**
Nitrites (mg/L)	0,02	0,06	0,06 ± 0,04	0,15	66,66	**≤ 0,1**
Ammonium (mg/L)	0,1	0,2	0,46 ± 0,47	1,42	102,17	**≤ 1,5**
Total iron (mg/L)	0,04	1,34	1,57 ± 1,49	4,4	94,90	**≤ 0,3**
DHT (mg/L)	5	10	28,1 ± 49,71	150	176,71	**≤ 500**
Magnesium (mg/L)	4	10	9,88 ± 4,42	18	44,73	**≤ 50**
Chloride (mg/L)	8,7	13	12,68 ± 2,42	15,5	19,08	**0**
Sulfate (mg/L)	1	8	9,38 ±7,76	21	82,72	**≤ 250**
Calcium (mg/L)	2	6	9,25 ± 11,16	36	120	**≤ 270**
Carbonate (mg/L)	25	37,5	38,75 ±10,61	55	27,38	
Bicarbonate (mg/L)	45	65	66,25 ± 13,30	85	20,07	

Table 2: Results of bacteriological parameters in river waters.

Parameter	Min	Med	AV + SD	Max	%CV	WHO Norms
TC (CFU/100ml)	528	2365	2534,5± 2202,12	7100	86,88	**0**
E. coli (CFU/100ml)	81	475	982,63 ±1280,13	3900	130,27	**0**
SRA (CFU/100ml)	0	0	2,125 ±3,64	10	171,29	**0**
Pseudomonas spp (CFU/100ml)	0	0	11 ±15,27	32	138,81	**0**

DISCUSSION

The present work carried out on the water of the Chibou and Soumi rivers showed non-compliance at both chemical and bacteriological parameters. At the physico-chemical level, this non-conformity concerns turbidity, conductivity, temperature, chlorine, total iron. In addition, a chlorine non-compliance level in the water of M'pody rivers was found. This situation poses a real danger for the population in that if large quantities of organic matter are present, chlorine's action on organic matter can cause the formation of chlorinated derivatives such as trihalomethanes, which are carcinogens.

Moreover, the present study revealed that the water in the rivers of this village had pH values between 6.5 and 8.5 on average. This is consistent with WHO (2008) recommendations. However, for some samples values below 6.5were obtained. This gave the water an acidic character. Acidity is a problem for consumers in that acidic water can become rich in heavy metals as a result of material corrosion (Eblin et al., 2014) and therefore pose a threat to consumer health. It was also noted in this study a noncompliance for total iron in the waters of M'pody rivers. These elevated iron values would be related to anthropogenic activities in the study area. These results are similar to those obtained by Pambou et al. (2022).

In terms of bacteriological parameters, the results showed non-compliance with Total Coliforms, Faecal Coliforms, *Escherichia coli*, Faecal Enterococci, SRA and *Pseudomonas* spp. The advantage of detecting these coliforms lies in the fact that they are almost everywhere in nature. *Escherichia coli*, one of these coliforms is the best indicator of faecal contamination (Dovonou et al., 2020). In fact, contamination of these waters by these germs could be linked to the mismanagement of solid and liquid wastes from anthropogenic activities (Dovonou et al., 2022). This can be attributed to bacteria of fecal origin are often transported to aquatic environments by runoff (Servais, 2003). The high level of these germs indicates that they are above the WHO recommendations (2011). In addition, the large amount of M'pody coliform (2534.5 CFU/100 ml) is greater than those obtained by Hounsou et al. (2010) in the waters of the Okpara River.

Escherichia coli bacteria are recognized as better indicators of fecal contamination because of their specificity (Degbey 2011). Their presence in water indicates that the water is contaminated and consequently polluted (Hounsou et al. (2010). The maximum permissible concentration for *Escherichia coli* in drinking water must be 00 CFU/100 ml according to the WHO (2011). Thus, *Escherichia coli* must be totally absent in drinking water, which is not the case with the waters of M'pody rivers whose bacteriological parameters are beyond these recommendations. These results are similar to those of the work carried out by Maoudombaye et al. (2016) who found rather important values in the assessment of bacteriological quality of river waters consumed in the doba oil basin in Chad.

In addition, WHO (2011) recommends 1000 Germs/100 ml for faecal enterococci in domestic surface waters. The results in this study showed values beyond these recommendations and similar to those obtained by Maoudombaye et al. (2016) which exceed the standards in Benin (00 CFU/100 ml). The water of the M'pody rivers would therefore be contaminated by faecal enterococci and their presence could be considered to be indicative of fecal pollution (Dovonou et al., 2020). These fecal bacteria are dangerous to health (Temgoua et al., 2009). As a result, the consumption of these waters exposes the M'pody village population to many waterborne diseases as these waters contain high levels of *E. faecalis* (WHO, 2011). Similar observations have been reported by Chippaux et al. (2002) and Gbagbo et al. (2020), where excessive contamination of waters analyzed by coliforms was observed. It should also be noted that the water of the M'pody river showed non-compliance with *pseudomonas* spp and SRA. The assessment of the levels of Sulphite-Reducing Anaerobic is motivated by the fact that they are used to assess the sanitary quality of the water. According to some authors, sulphite-reducing aerobes are responsible for gastroenteritis in children and the elderly (Payment et al., 2003).

In addition, the study found non-compliance with *Pseudomonas* spp. This bacterium particularly infects young children, immunocompromised people and elderly people who may experience health impacts from bathing (Geldreich and Lechevallier, 1999).

Conclusion

At the end of this study, It was found that the physico-chemical parameters measured in the Chibi and Soumi rivers, including pH, turbidity and chlorine residual, were above the drinking water quality standard. In terms of bacteriological parameters, these waters were contaminated by bacteria indicative of fecal pollution. The heavy bacterial loads in these rivers show great health risks for consumers. It should also be noted that the loading of coliforms and Anaerobic sulfito-reductors in these waters could contribute to the diarrhea epidemic that took place in this village. Therefore, to minimise any health risks related to the consumption of water from the rivers, the promotion of hygiene through a good purification followed by disinfection is necessary. To limit the pollution of these rivers, it is imperative to protect the shores of these rivers and keep them away from waste and latrines.

COMPETING INTERESTS

The authors declare that there is no competing interests.

AUTHORS' CONTRIBUTIONS

YTW and ANC designed the study. MDF and GTAG conducted the study. MDF, GTA and KSAP analyzed and interpreted the data. YTW wrote the first draft. MDF, GTAG, KSAP, KAT and ANC reviewed the manuscript. All authors have read and approved the final version of the manuscript.

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