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Health monitoring of drinking water quality in the city of Jacqueville from 2012 to 2020

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Abstract

In order to better protect the health of consumers, drinking water must meet physico-chemical and bacteriological quality requirements. The objective of this study was therefore to evaluate the water quality of the city of Jacqueville. A retrospective survey was carried out on 162 samples from 2012 to 2020. The results of the analyses showed that the adduction water consumed in the city of Jacqueville had concerning qualities. This is due to the main physico-chemical and bacteriological parameters that caused numerous non-conformities, which are among others pH, temperature, residual chlorine. Bacteriologically, total coliforms and faecal streptococci show 5.26% and 50% non-compliance, respectively.

Keywords: Water Quality; Pollution; Health risk; Diarrhoeal Disease; Sanitation; Jacqueville

1. Introduction

According to WHO , drinking water must meet the requirements concerning microbiological, chemical, radiological and aesthetic aspects [1]. These aesthetic recommendations address parameters that may affect drinking water quality [1]. Thus, access to drinking water is a determining factor for the socio-economic development of a population. As a result, the United Nations, through one of the Sustainable Development Goals (SDGs) adopted in 2015, has committed to ensuring access to water for all. This very important issue for the international community is the subject of the sixth sustainable development goal [2]. This objective therefore constitutes a priority issue given the numerous difficulties encountered by households regarding water shortages and poor water quality [3]. In Côte d'Ivoire, In 2016, according to multiple indicator cluster surveys (MICS), nearly 4 households out of 5 (80.7%) used an improved source of drinking water [4]. According to the demographic and health survey, 81% of the Ivorian population has access to an improved drinking water source with a proportion ranging up to 98%, particularly in the district of Abidjan [5]. In the world, according to the United Nations [6], approximately 829,000 people die each year from diarrhea attributable to a lack of drinking water, sanitation, and hand hygiene. In Africa, according to Abubakar [7], there are approximately 2,670 deaths observed daily. In Côte d'Ivoire, according to the Ministry of Health, Public Hygiene and Universal Health Coverage [8], the incidence of diarrhea was 61.31 among children under 5 years old and 17.76 in the general population in 2020. The city of Jacqueville in the south of Côte d'Ivoire is not on the sidelines. It also faces problems with access to drinking water. In this city, given the many difficulties in providing drinking water, some households are struggling to afford good quality water. It is in this context that the present study aims to know the physico-chemical and bacteriological

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quality of the waters of the sewerage network. Specifically, it will involve analyzing the physico-chemical and bacteriological parameters in order to evaluate the potential health risks to which populations are exposed.

2. Materials and Methods

2.1. Materials

2.1.1. Présentation of the Study Area

Our research area, which is the city of Jacqueville, is located in the south of Ivory Coast. It is the capital of the department and located in the Lagunes District, in the Grands Ponts region (Figure 1). Jacqueville benefits from its strategic location between the Ebrié Lagoon and the Atlantic Ocean to the west of Abidjan, economic capital of Ivory Coast, on about sixty kilometers (figure 1)

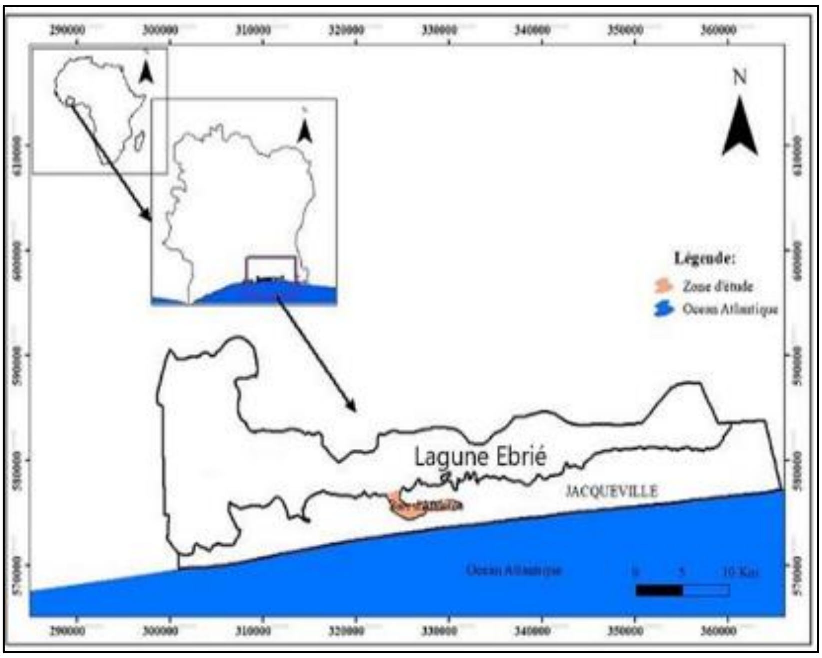

Figure 1 Mapping showing the city of Jacqueville

2.1.2. Equipment

Main measuring equipment consists of a Palintest photometer (Great Britain), a pH meter, a conductivity meter, a turbidity meter for physico-chemical parameters and amembrane filtration device for bacteriological parameters.

2.1.3. Sampling

The data were collected from 2012 to 2020. During this period, 169 water sample campaigns were analyzed. The samples intended for physicochemical analyses were collected in 1000 ml polyethylene bottles and those intended for microbiological analyses in 500 ml bottles filled approximately every 2/3. The samples were kept away from light and at a temperature between 4°C and 8°C in an ice house until the laboratory where the analyses were done within 8 hours.

2.1.4. Reagents

All reagents used were of analytical quality. Reagents used to measure chemical parameters were PALINTEST brand (Great Britain). Rapid' E. coli 2 Agar, BEA (Bile Esculin Azide) agar and TSN (Tryptone Sulfite Neomycin) agar from BIORAD were used for the enumeration of faecal markers.

2.2. Methods

2.2.1. Physico-Chemical Analyses

Physico-chemical parameters were determined by the following methods:

- pH is measured with a HACH type digital laboratory pH meter equipped with a combined electrode (Bioblock Scientific).
- Conductivity is measured using a HACH.
- Turbidity is determined using HACH nephelometry.
- Titrimetry was used for the determination of organicmaterials.
- Mineral salts and color were determined through colorimetry using a Palintest 7100 SE photometer with pre-programmed filters and calibration curves, using operational wavelengths between 410 nm and 640 nm and following manufacturer procedures. The mineral salts tested were nitrite, nitrate, fluoride, iron,

manganese, total alkalinity contents (TAC), total hydrotimetric degree (THD), ammonium, sodium, magnesium, calcium, sulphate, potassium, bicarbonate, zinc.

2.2.2. Microbiological Analysis

Microbiological analyses were used to identify and enumerate total coliforms (TC), thermotolerant coliforms (TTC), *Enterococcus faecalis (E. faecalis), Pseudomonas spp*. These microorganisms were identified and enumerated by filtering homogeneous aliquots of 100 ml and 50 cl (sulphite-reducing anaerobes) onto a membrane with 0.45µm pore diameter. Membranes were then placed on selective culture media for 24 hours at 37°C in a thermostatic oven.

2.2.3. Data Processing

Descriptive analysis (means, medians, minimum, maximum and standard deviation) were performed using the 300 samples, 15 physico-chemical variables and 6 microbiological variables. Percentages determination was carried out using EXCEL 2010 software.

3. Results

3.1. The water supplied to the populations of the city of Jacqueville has evolved over the years with a rate that varies from 1.23% to 24.69% depending on the year (figure 2)

3.2. Number of samples taken and their distribution

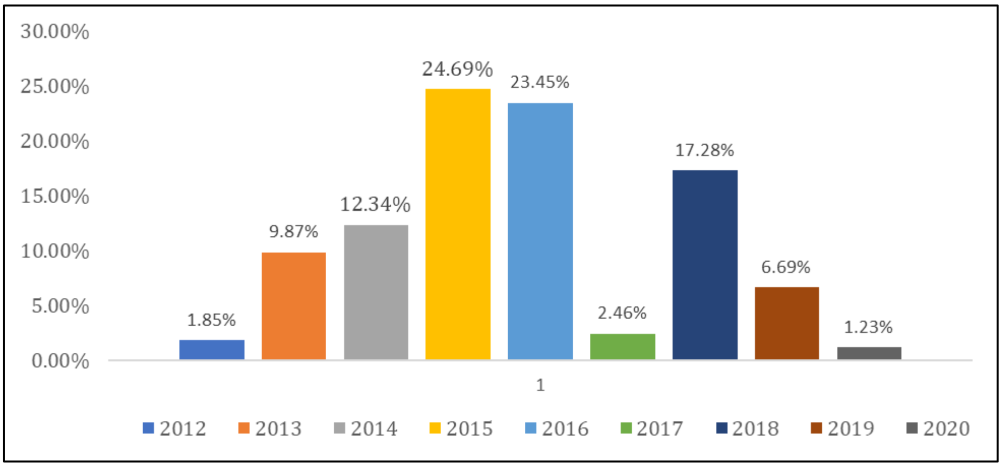

Figure 2 Evolution of water consumption according to the years in the city of jacqueville

A sampling campaign was carried out each year during the 9 years. The analysis of figure 2 shows that for a total of 162 samples over the 9 years, the years with the most sampling are 2015 (24.69%) and 2016 (23.45%) (figure 2).

3.3. Physico-chemical parameters of waters

The main physico-chemical parameters that caused many non-conformities are pH, temperature, and residual chlorine (table I).

Table 1 Physicochemical parameters

Settings	P1 (Input)				P2(Middle)				P3(End)				
	Min	**Max**	**AV**	**SD**	**Min**	**Max**	**AV**	**SD**	**Min**	**Max**	**AV**	**SD**	**WHO/Ivorian standards**
pH	4.1	5.5	4.7	0.6	3.8	6.5	4.5	0.72	3.8	6.3	4.6	0.9	6.5-8.5
color	5	10	8.33	2.5	5	10	8.7	2.2	5	10	8.3	2.5	≤ 15 UCV
Temperature	27.9	29.0	29.0	1.0	27.9	30.3	29.0	1.00	29	32.3	30.3	1.27	25°C
Turbidity	0.11	0.57	0.57	0.4	0,04	1.3	0.3	0.2	0.1	1.06	0.4	0.3	≤ 5 UNT
TDS	184.5	207.0	196.5	9.8	591.3	185	209	196	190.9	202.2	195.3	4.39	50-300 mg/L
Nitrites	0.01	0.03	0.02	0.008	857.8	0	0.07	0.01	0	0.04	0.01	0.015	≤ 0,1 mg/L
Nitrates	18	45	37.25	12.89	0	41	16.7	15.2	0	33	15	14.06	≤ 50 mg/L
Ammonium	0.01	0.45	0.17	0.19	0.01	0.23	0,07	0.07	0.07	0.22	0.09	0.07	≤ 1,5mg/L
Organic matter	0.4	1.36	0.75	0.41	0	0.96	0.4	0.3	0	0.66	0.38	0.27	≤ 5mg/L
Residual chlorine	32	36	33.5	1.91	19.5	36	23.2	14.5	23	36	24.5	13.01	0,2-0,5 mg/L

3.3.1. Physico-chemical parameters of waters

The main physico-chemical parameters that caused many non-conformities are pH, temperature, and residual chlorine (table 2).

Table 2 Bacteriological parameters of non-compliance

Parameters standards	P1 (Input)				P2(Middle)				P3(End) WHO/ Ivorian				
	Min	**Max**	**AV**	**SD**	**Min**	**Max**	**AV**	**SD**	**Min**	**Max**	**AV**	**SD**	**standards**
	bacteriological parameters												
Thermotolerant Coliforms	0	0	0	0	0	0	0	0	0	0	0	0	0 UFC/ml
Total Coliforms	0	0	0	0	0	0	0	0	0	0	0	0	0 UFC/ml
E coli	0	0	0	0	51	51	0	6	0	0	0	0	0 UFC/ml
Streptococcus faecalis	0	0	0	0	0	0	0	0	0	0	0	0	0 UFC/ml
Thermotolerant Coliforms	1	0	1	0	17,18	17,1	0	2,22	0	0	0	0	0UFC/ml

Min: minimum; Max: maximum; SD: Standard Deviation; AV: Average

3.3.2. Non-compliant bacteriological parameters

The main bacteriological parameters that caused many non-conformities are thermotolerant coliforms and faecal streptococci. The results of bacteriological analyses of these waters are listed in Table IV. The bacteriological analysis shows that out of 162 samples 5, 26% were found positive in 2016 for total coliforms. Regarding the streptococci feacalis, we have cases of non-compliance (5% in 2015), 18.4% in 2016 and 50% in 2020 (Table 3).

Table 3 Bacteriological parameters of non-compliance

	2012(n =5)	2013(n =5)	2014(n =5)	2015(n =5)	2016(n =5)	2017(n =5)	2018(n =5)	2019(n =5)	2020(n =5)
Total Coliforms	0%	0%	0%	0%	5,26%	0%	0%	0%	0%
Thermotolerant Coliforms	0%	0%	0%	0%	0%	0%	0%	0%	0%
E.coli	0%	0%	0%	0%	0%	0%	0%	0%	0%
Streptococcus faecalis	0%	0%	0%	5%	18,42%	0%	0%	0%	50%
Spores clostridia	0%	0%	0%	0%	0%	0%	0%	0%	0%

3.3.3. Non-compliant physicochemical parameters

From a physico-chemical point of view, the water supplies show rates of non-compliance with respect to certain parameters. These include pH, temperature and residual chlorine with a non-compliance rate of 100% (table 4).

Table 4 Physico-chemical parameters of non-compliance (NC)

	2012(n =5)	2013(n =5)	2014 (n=5)	2015(n=5)	2016(n =5)	2017(n =5)	2018(n =5)	2019(n =5)	2020(n =5)
Color	-	-	-	-	-	-	-	-	-
Turbidity	-	NC (12.5%)	-	-5%	NC (7.89%)	NC (25%)	-	-	-
Temperature	NC (100 %)	NC (100%)	NC(100%)	NC (100%)	NC (100%)	NC (100%)	NC (100%)	-	NC (100%)
pH	NC (33 %)	NC (100%)	NC(100%)	NC (100%)	NC (7.89%)	NC (75%)	NC (100%)	-	NC (100%)
$N0^{3-}$	-	-	-	-10%	-	NC (25%)	-	-	-
NO^{2-}	-	-	-	-	-	-	-	-	-
NH^{4+}	-	-	-	-	-	-	-	-	NC (50%)
Organic matter	-	-	-	-	-	-	-	-	-
TDS	-	-	-	-	-	-	-	-	-
residual chlorine	-	-	-	NC (5%)	-	-	-	-	-

4. Discussion

The pH has an influence on the physico-chemical components in the aquatic environment. As part of this study, the water from the city of Jacqueville has an acidic trend (pH<7). A low pH may indicate the presence of a pollutant in the water or even reflect a strong mineralizing activity of the bacteria near the groundwater [9]. According to WHO [10], these waters have acidic characteristics with regard to the acceptable range of pH for drinking water (6.5 and 8.5). These results are in agreement with those of the work of Amougou [11] who during their study had found a pH of 5.23. This acidity is all the more important as it concerns all the samples taken. The average concentration of TDS measured in waters varies on average from 195.3 to 209 mg/L. These average values of TDS do not comply with WHO standards [10] which require that the TDS of drinking water must be between 300 and 500 mg/l. Thus, these waters present a deficiency in mineral elements.

The turbidity of water refers to the material content of a fluid that disturbs it. As part of this study, the average turbidity content measured in the water supply varies on average between 0.3 and 0.57 NTU. These different values are lower than the threshold value recommended by WHO [10] (5 N.T.U). Thus, these waters are likely to cause microbial growth. These results are similar those of Coumare [12], where the turbidity is between 0.23 and 0.4 NTU.

As for ammonium, the concentrations obtained confirmed the good quality of the studied waters, respecting the WHO standards [10] which set a limit for ammonium 1.5 mg/L.

Moreover, the average nitrate concentration measured in water is lower than the threshold value recommended by WHO (50 mg/l) [10]. According to Redouane [13], nitrate ions can form methemoglobin which in high amounts reduces cell oxygenation, causing bluish coloration of the skin and mucous membranes, asphyxia and death in infants. During the chlorination of these waters, nitrogen compounds could react with chlorine to form monochloroamine compounds. They can also be responsible for the bad odor of waters, through the formation of amino acids [14,15].

For our study, the water supply network has a rate of 12% non-compliance compared to total coliforms and 50% compared to S. faecalis. Similar observations were reported in Grand-Popo by Makoutodé [16], in Niamey in Niger [17] where excessive contamination of the analyzed water by coliforms is noted. The presence of streptococci in the analyzed waters tells us about fecal contamination. It could emanate from infiltration or lateral diffusion [18].

Non-compliance rates for bacteriological parameters were related to indicator bacteria of fecal contamination (Total coliforms, Streptococci faecalis). Indeed, the poor quality of these waters could be explained not only by the lack of sanitation, an unsanitary environment due to the lack of hygiene around these water sources [19]. Hygiene measures around water sources could significantly reduce this contamination.

5. Conclusion

This study retrospectively evaluated the quality of drinking water distributed in the locality of Jacqueville in southern Ivory Coast from 2012 to 2020. The analysis allowed us to highlight the factors likely to impact water quality, namely the poor management of household waste, excreta and wastewater.

The results showed a predominance of non-conformities in water quality associated with physicochemical and bacteriological parameters

The health risks related to this non-compliance of physicochemical parameters were found to be more important with pH, temperature and residual chlorine. As for the bacteriological parameters, it concerned total coliforms and faecal streptococci. Thus, it seems essential to improve the health monitoring of these waters in order to make any necessary corrections. These measures could reduce the risks associated with drinking these waters.

Compliance with ethical standards

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Disclosure of Conflict of interest

The authors declare no conflict of interest.

Statement of ethical approval

All the analyses were carried out according to standards by the hygiene laboratory of the national institute of public hygiene.

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