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Quality of River Water and Impact on the Health of Populations in the Village of M'pody (Anyama, Ivory Coast)

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Abstract: The study focuses on the evaluation of the quality of domestic water and its effects on the health of the population. Indeed, in rural areas of Côte d'Ivoire where it is difficult to have access to public water networks. Water, the population is interested in drinking water of various origins. Thus water samples from the rivers of the village of M'pody were analyzed using standard methods. The results indicated that these waters were weakly acidic (pH between 6.26 and 7.61), weakly mineralized (electrical conductivity between 24 and 59.2 µS/cm) and strongly turbid (turbidity between 15.7 and 46.8 UNT). Almost all major ions met the standards. Nevertheless iron was highly concentrated in almost all samples (0.04 to 4.4 mg/l). From a bacteriological point of view, the waters were highly polluted because all the samples contained significant loads of total coliforms, E. coli, E. faecalis, ASR and Pseudomonas sp. A retrospective study of these health data recorded in the village health center from 2014 to 2020 gave us a predominance of cases of simple malaria among the different cases of pathology studied. Children under 5 years old are much exposed to these different pathologies with 36% of cases of simple pulpitis, 30% of cases of dermatosis, 40% of dermatosis cases and 28% of diarrhea cases. These waters are therefore unfit for human consumption. Thus, to minimize possible health risks, urgent attention must be given to the adequate treatment of water before consumption.

Keywords: Bacteriological Contamination, Physico-Chemical Quality, River Waters, Population Health, M'pody

1. Introduction

Water, hygiene and sanitation are major issues of the 21st century [1]. The WHO/UNICEF Joint Monitoring Program for Water Supply and Sanitation reports impressive gains made over the past two decades with 2.6 billion people gaining access to an improved source of drinking water and 2.1 billion to an improved hygiene service [2]. Water is therefore both a strategic resource and the fundamental basic element necessary for a healthy economy [3]. It plays a determining role in the life of humans, animals and plants [4]. Life on earth is possible thanks to the existence of certain vital resources including water, a commodity of great importance for living beings [5].

However, much remains to be done as 663 million people remain without an improved source of drinking water with 319 million in sub-Saharan Africa, and 2.4 billion without an improved sanitation facility and among those who still do not have access to of these water points, 8 out of 10 live in rural areas [2]. As a result, one of the elements that affects health is polluted water, of poor quality, which is one of the causes of diseases that affect human health [6]. Good quality water is not only clear, odorless and pleasant to drink, but it is also one that meets well-defined physicochemical and bacteriological criteria, which can be consumed without any significant risk to the health of a person who consumes it. Throughout its life, taking into account possible variations in sensitivity between the different stages of life [7]. Water, an essential and indispensable commodity for life, can also be a source of disease when it is contaminated by potentially pathogenic agents [8, 9]. The way of life of the local population (disposal of household waste, defecation in the open air, use of chemical fertilizers, etc.) could be on the one hand the cause of this pollution [10]. This work aims to assess the bacteriological quality, certain physico-chemical parameters and the health impact of water for domestic use in the locality of M'pody.

2. Materials and Methods

2.1. Presentation of the Study Area

The village of M'pody is located in the south of Côte d'Ivoire in the district of Anyama. This locality covers an area of 114 km2 and has an estimated population of 148,962 [11]. This village has UTM coordinates 30N03 north latitude and 0616 west longitude and is located 30 km from the Gulf of Guinea, northeast of Abidjan. The climate is of the equatorial type, characterized by the alternation of four seasons with the peak of the rainy seasons observed in June. The average annual precipitation varies between 1,600 and 2,500 mm. The humidity is always very high (above 75%) [12].

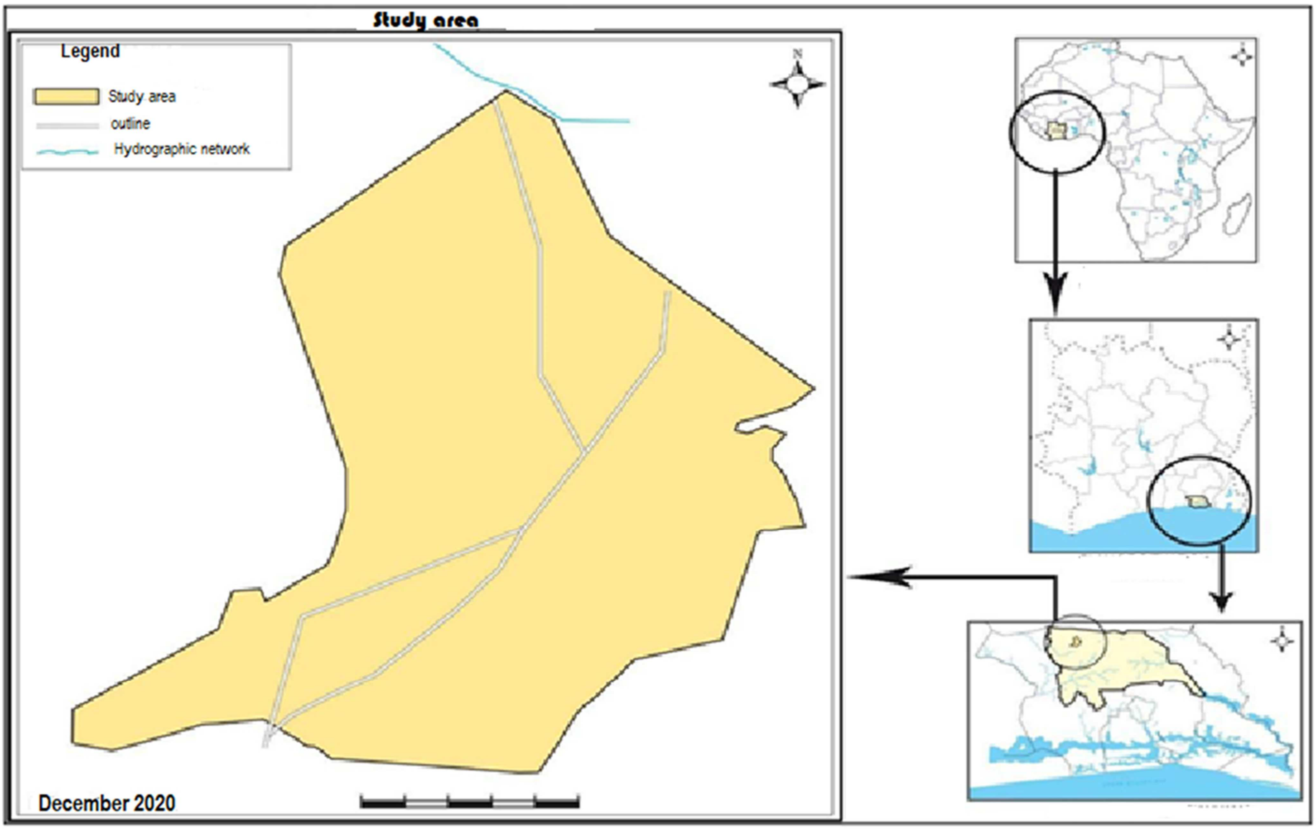

Figure 1. *Study Area presentation.*

2.2. Sampling and Analyzes

For this survey, water samples from the Chibi and Souman rivers were collected using polyethylene bottles of 1000 ml for physico-chemical parameters and 500 ml for microbiological parameters. 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. The physico-chemical parameters were determined with the following methods. The pH is measured with a HACH-type digital laboratory pH meter equipped with a combined electrode (Bioblock Scientific) [13]; the conductivity is measured using a HACH [14] type conductivity meter, 1990; turbidity is determined using HACH (1990 type nephelometry); titrimetry was used to determine organic matter [13]; 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 mineral salts sought were nitrites, nitrates, fluorides, iron, manganese, complete alkalimetric title (TAC), total hydrotimetric degree (DHT), ammonium, sodium, magnesium, calcium, sulphates, potassium, bicarbonate, zinc. With regard to microbiological parameters, microbiological analyzes made it possible to identify and enumerate total coliforms (CT), thermotolerant coliforms (CTh), Escherichia coli (E. coli), Enterococcus faecalis (E. faecalis), Pseudomonas sp and sulphite-reducing anaerobic germs (ASR). These microorganisms were identified and counted by filtering homogeneous aliquots of 100 ml and 50 cl (sulphite-reducing anaerobic germs) on a membrane whose pore diameter is 0.45 µm.

3. Results and Discussion

3.1. Physico-Chemical Parameters of River Water

The water is weakly mineralized with an average conductivity of 37.04 µS/cm. The average turbidity content of 24.23 UNT, iron content of 1.49 mg/L are higher than the WHO standard [15, 16]. The high concentration of residual chlorine in these waters is also a sign of non-compliance. The results in Table 1 show relatively high temperature values close to room temperature (25°C).

Table 1. *Physico-chemical parameters of river water.*

Parameter	Min	Med	AV	SD	Max	WHO Norms [15,16]
Turbidity (UNT)	15,7	18,9	24,23	11,66	46,8	≤ 5
Conductivity (µS/cm)	24	34,85	37,04	10,86	59,2	100-1000
Color (mg/L)	20	60	55	22,20	85	
pH	6,26	6,70	6,76	0,42	7,61	6,5-8,5
Temperature (mg/L)	25,1	27,95	27,78	1,77	29,9	25
Organic matter (mg/L)	3,65	17,27	15,09	7,47	27,96	
Nitrates (mg/L)	0,03	3,715	5,38	5,48	13,2	≤ 50
Nitrites (mg/L)	0,02	0,06	0,06	0,04	0,15	≤ 0,1
Ammonium (mg/L)	0,1	0,2	0,46	0,47	1,42	≤ 1,5
Total iron (mg/L)	0,04	1,34	1,57	1,49	4,4	≤ 0,3
TAC (mg/L)	50	65	114,38	79,71	220	
DHT (mg/L)	5	10	28,13	49,71	150	≤ 500
Magnesium (mg/L)	4	10	9,88	4,42	18	≤ 50
Manganese (mg/L)	0,001	0,02	0,02	0,01	0,025	
Phosphate (mg/L)	0,24	0,63	0,64	0,20	0,88	
Chloride (mg/L)	8,7	13	12,68	2,42	15,5	≤ 5
Sulfate (mg/L)	1	8	9,38	7,76	21	≤250
Sodium (mg/L)	1,5	3,6	4,48	2,50	8	
Potassium (mg/L)	0,1	5,15	6,69	5,96	17	
Sodium chloride (mg/L)	10,2	18	17,15	4,12	22	
Calcium (mg/L)	2	6	9,25	11,16	36	≤ 270
Carbonate (mg/L)	25	37,5	38,75	10,61	55	
Bicarbonate (mg/L)	45	65	66,25	13,30	85	

3.2. Bacteriological Parameters

At the bacteriological level, the analyzes of the water of the rivers indicated the presence of many germs. These microorganisms respectively reached maximum values of 7100 CFU/100 ml for total coliforms, 3900 CFU/100 ml for thermo-tolerant coliforms, 3900 CFU/100 ml for E. coli, 4500 CFU/100 ml for E. faecalis, 10 CFU/100 ml for ASR and 32 CFU/100 ml for Pseudomonas sp (Table 2).

Table 2. *Bacteriological parameters of river water.*

Paramètre	Min	Méd	AV	SD	Max	WHO Norms
TC (CFU/100ml)	528	2365	2534,5	2202,12	7100	0
C Th (CFU/100ml)	81	475	982,63	1280,13	3900	0
E. coli (CFU/100ml)	81	475	982,63	1280,13	3900	0
E. faecalis (CFU/100ml)	0	1700	1719	1539,02	4500	0
ASR (CFU/100ml)	0	0	2,125	3,64	10	0
Pseudomonas sp (CFU/100ml)	0	0	11	15,27	32	0

TC: Coliforme Total; C th: Coliforme Thermotolérant; ASR: Anaérobie Sulfito-Réducteur

3.3. Pathologies Contracted in the Village of M'pody

From the analysis of the different figures, it can be seen that many pathologies are most prevalent in the village. In the village of M'pody, several diseases are recorded such as malaria, dermatoses, diarrhea, and pneumonia. Malaria is the most contracted followed by other pathologies (Figures 2-8).

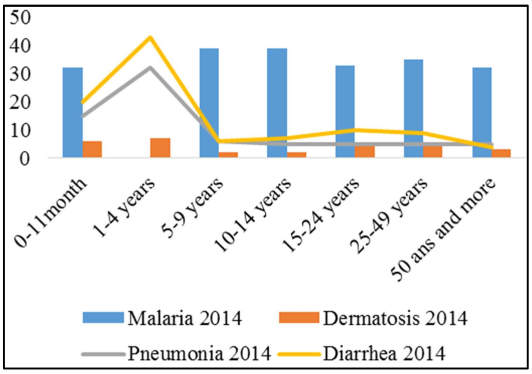

Figure 2. *State of pathologies in 2014.*

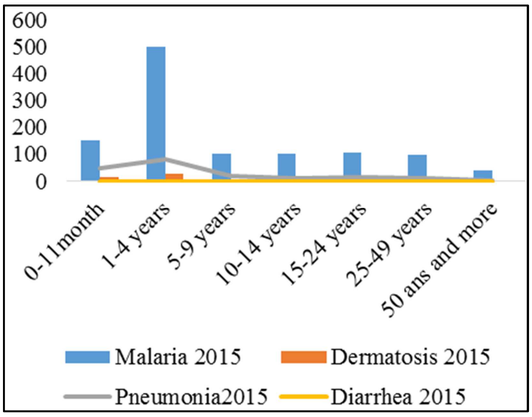

Figure 3. *State of pathologies in 2015.*

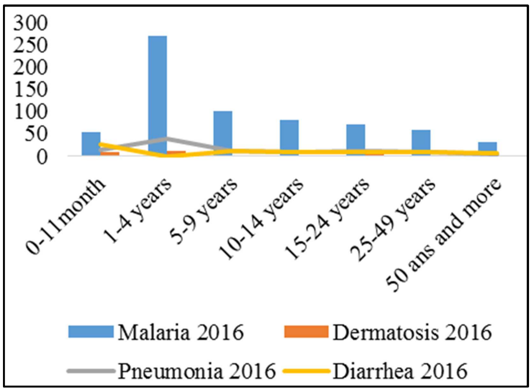

Figure 4. *State of pathologies in 2016.*

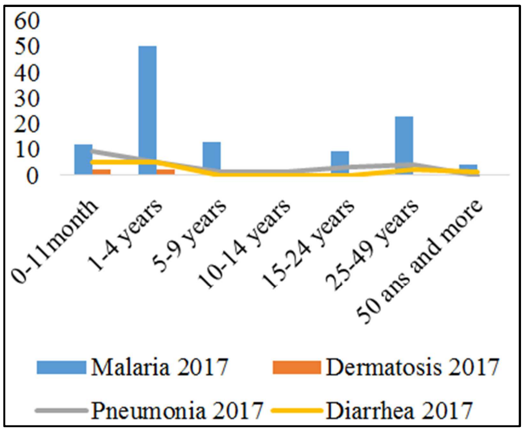

Figure 5. *State of pathologies in 2017.*

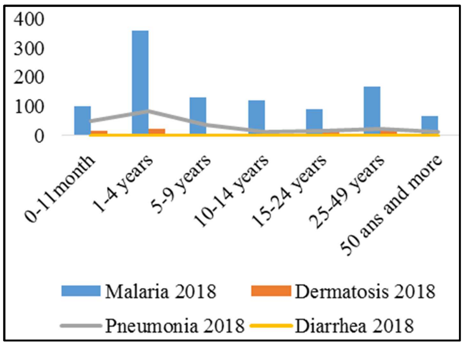

Figure 6. *State of pathologies in 2018.*

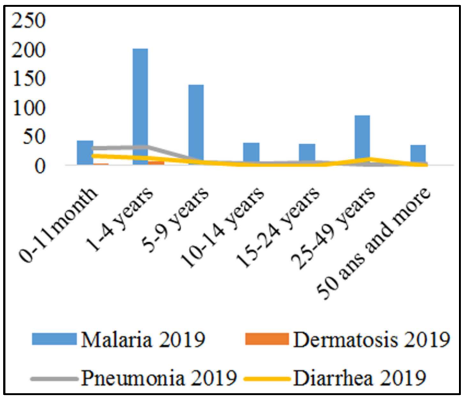

Figure 7. *State of pathologies in 2019.*

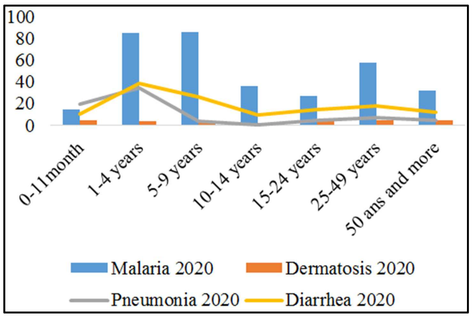

Figure 8. *State of pathologies in 2020.*

3.4. Pathologies Contracted by Children Under 5 Years Old

The exposure rate of children under 5 years old to different pathologies from 2004 to 2010 are respectively 36% for malaria, 30% for dermatoses, 40% for pneumonia, 28% for diarrhoea. (Figures 9-12).

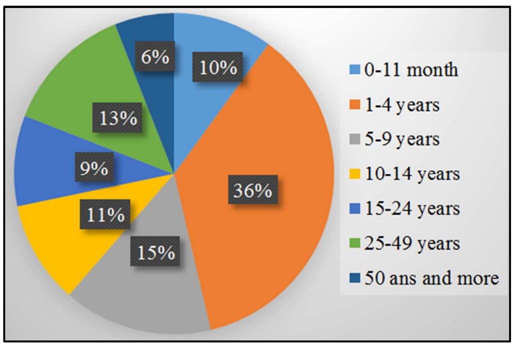

Figure 9. *Proportion of children under 5 (uncomplicated malaria cases).*

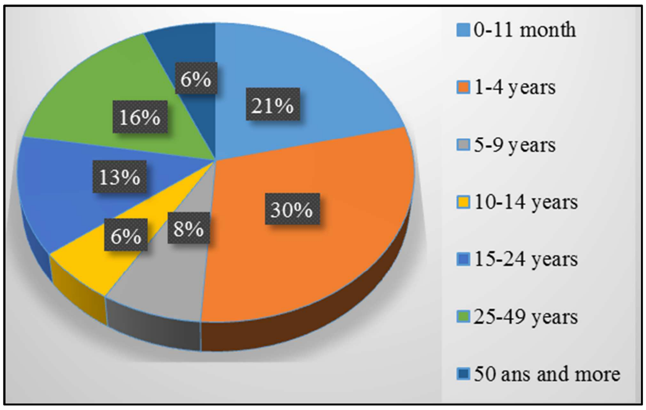

Figure 10. *Proportion of children under 5 (Case of dermatosis).*

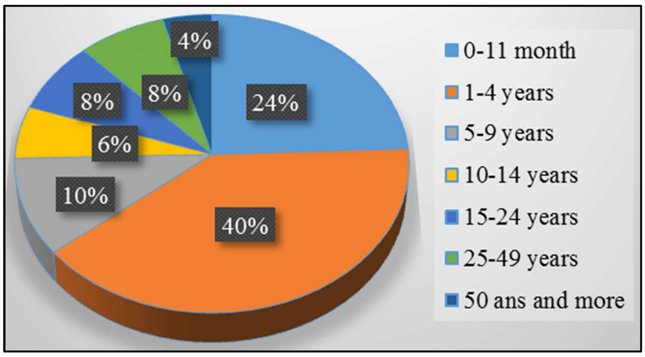

Figure 11. *Proportion of children under 5 (Case of pneumonia).*

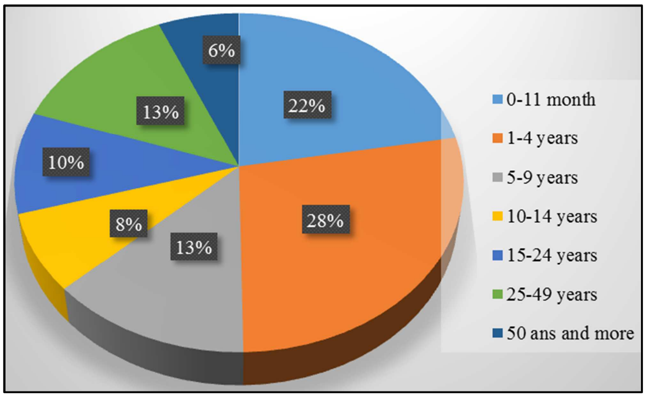

Figure 12. *Proportion of children under 5 (Case of diarrhea).*

4. Discussion

4.1. Physical-Chemical Parameters

pH is one of the most important operational parameters of water quality [17]. pH measures the concentration of ions in water. This parameter determines a large number of physico-chemical balances and depends on multiple factors including the origin of the water [18]. Although it has no direct effect on the health of consumers, its monitoring is necessary for drinking water. In the case of our study, for some samples we have pH values below the threshold recommended by the WHO [15, 16]. Low pH values indirectly affect human health since they promote the dissolution of heavy metals which can have adverse consequences on human health [19]. Electrical conductivity is one of the parameters that should, if possible, be regularly monitored for drinking water. It indicates the ability of water to conduct an electric current [20]. The electrical conductivity of the water of the souman and chibi rivers was very low compared to the standard of [16]. Indeed, it depends on the content of dissolved substances, the ionic charge, the ionization capacity, and the temperature of the water [21].

With regard to temperature, the results obtained show relatively high values close to room temperature (25°C). According to the WHO, high temperature increases the growth of microorganisms and can increase problems related to taste, odor, color and corrosion [22].

Also we have quantities of residual chlorine which are beyond the recommendations of the WHO [16] In the event of the presence of large quantities of organic matter, the action of chlorine on these matters can cause the formation of chlorinated derivatives such trihalomethanes which are carcinogenic [23]. Indeed, chlorine acts as an oxidant and can oxidize certain dissolved chemical species, such as manganese (II) to form insoluble products. It can also interact with the ammonia present to form chloramine derivatives (monochloramine, NH2Cl, dichloramine, NHCl2, and trichloramine, NCl3). This is directly and indirectly detrimental to the bacteriological quality [20]. It would be desirable to disinfect the water at home where the quantity of water and the dosage of chlorine will be known. It is possible to carry out filtration if necessary before disinfection in order to reduce the risk of waterborne diseases [23, 7]. For disinfection to be effective, there must remain in the water a residual concentration of free chlorine ≥ 0.5 $mg.L^{-1}$ after a contact time of at least 30 min at pH < 8.0 [17].

The turbidity of water is due to the presence of suspended particles, particularly colloidal ones such as clays, silts, silica grains, organic matter, etc. The appreciation of the abundance of these particles in the water measures its degree of turbidity [20]. In the case of this study, we have turbidities that reach 24.23 mg/L whereas the acceptable limit value for drinking water is 5 NTU (Nephelometric Turbidity Unit) [15]. As a result, high turbidity can promote the proliferation of microorganisms which can attach themselves to suspended particles, having a protective effect on these microorganisms against disinfection [24, 7]. Thus, the waters of these rivers were all cloudy and their bacteriological quality was therefore suspect. Indeed, certain dissolved substances such as iron (II) and manganese (II), oxidized into insoluble elements, remain in suspension, which would explain these high turbidity values. This high level of water turbidity is a source of concern because the particles forming the turbidity could protect the pathogenic micro-organisms which would thus escape disinfection. High turbidity can also stimulate bacterial growth and trigger high chlorine demand [20]. According to Rodier, water treatment will have been effective if we have low turbidity values. [21]

Ammonium is the product of the final reduction of nitrogenous organic substances and inorganic matter in water and soil. It also comes from the excretion of living organisms and the reduction and biodegradation of waste, without however neglecting the contributions of domestic, agricultural and industrial origin [18]. As far as our study is concerned, the NH4+ ion concentrations were very low compared to 35 mg/l established by the WHO [15]. Its presence in water is an indicator of possible bacterial pollution, sewage, and animal waste [24].

It should be noted that SO42- ions had a concentration between 1 mg/l and 21 mg/l in the waters of these rivers during this study. the presence of these sulphate ions can be due to rainwater (acid rain), the dissolution of evaporitic sedimentary rocks, the use of chemical fertilizers and laundry [18]. Due to the gastrointestinal effects that may result from ingesting water containing high concentrations, it is recommended to be careful with drinking water sources that contain sulphate concentrations above 500 mg/l [24].

NO^{3-} concentrations varied between 0.03 and 13.2 mg/l. These low concentrations could also be due to the growth of sewage algae [25]. In terms of health, the major risk associated with is methemoglobinemia, also called blue baby disease, resulting from the poor transfer of oxygen by the blood caused by nitrites from the transformation of nitrates by the body [28].

As for Iron, in the case of this study we obtained values between 0.04 and 4.4 mg/L. This gives an unpleasant flavor to the water because from 0.05 mg/l, it generates a reddish turbidity and promotes bacterial proliferation in the water [27, 24].

4.2. Bacteriological Parameters

From a bacteriological point of view, none of the water samples taken met the standards. The waters studied contained high levels of coliforms. The presence of faecal coliforms in these waters or of other pathogens linked to faecal pollution or from other sources is dangerous for health [7, 28]. Thus, the poor water quality of the chibou and souman rivers could be explained not only by the lack of hygiene but also by an unsanitary environment. This is in agreement with the work done by Davis and [29] and that of Nanfack [30]. Also, runoff water would be responsible for the presence of bacteria in this water [31].

4.3. Different Pathologies Contracted by the Populations

Cases of waterborne diseases are recorded in the M'pody village health center from 2014 to 2020. There are pathologies such as malaria, pneumonia, dermatoses and diarrhea. According to the WHO, studies on diarrheal diseases have shown that they cause 1.5 million deaths in developing countries [32].

Moreover, they account for 21% of infant mortality in developing countries [33]. The investigations carried out in the health centers gave an infant morbidity rate of 28% due to diarrheal diseases. This result is found in the work carried out by Wolfgang et al. (2017) [34] and sy et al. (2014) [35] who showed that the fringe of children under 5 years old is particularly affected by diarrheal diseases.

Moreover, the proportion relating to malaria recorded in the village health center is close to that found in the studies carried out in the municipality of Port-Bouët (46%) by [36]. This high rate of malaria confirms the fact that among the water peril diseases, the latter is the most frequent in marshy areas [37]. These results are similar to those recorded in developing countries where malaria is endemic [38]. This is explained by the ideal conditions for large-scale reproduction of the malaria vector during the rainy season and by the hatching of Anopheles eggs on stagnant water, sewage and sumps, when the temperature is greater than or equal to 16°C [39].

The infanto-juvenile population seems to be the most threatened because the figures obtained show that children are the most affected by these waterborne diseases and this confirms work carried out in Cameroon where children constitute the most vulnerable group [40]. The same observation was made in this study which showed that of all the pathologies studied, it is malaria which is contracted a lot by the populations, especially children under 5 years old with a proportion of 36%.

5. Conclusion

At the end of the analyzes carried out on the waters of the rivers of the village M'pody, it should be noted that on the physical aspect, the slightly acidic pH and the high turbidity were the main parameters which made the waters unacceptable for consumption. Regarding chemical parameters, all major ions were present at low concentrations and therefore posed no pollution risk. Regarding iron and residual chlorine, their presence in these waters is of great concern since they are responsible for the proliferation of bacteria in the water, an unpleasant taste and cancer. In addition, bacteriological analyzes revealed the presence of faecal coliforms, an index of faecal pollution, as well as other pathogenic bacteria (Escherichia coli) which are responsible for numerous pathologies. Overall, the water from the rivers that the population of M'pody uses for domestic needs does not meet the quality standards recommended by the WHO. The poor quality of this water was justified by the predominance of waterborne infections in this village, in particular diarrhea and malaria. To overcome this, the population should be made aware of the health risks associated with the consumption of this water and should also be educated on the methods of treatment of drinking water at home.

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