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Physico-chemical and Bacteriological Characteristics of the Drinking Water of the Aguégués Lake District in the Lower Ouémé Valley - Benin

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Authors' contributions

This work was carried out in collaboration among all authors. Author TCD collected the data and designed the study. Author RCL performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author BD, TA and BNB managed the analyses of the study. All authors read and approved the final manuscript.

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ABSTRACT

Water is an essential resource for life on earth and is the source of several microbiological and toxicological diseases. The Aguégués one of the communes of the lower valley of Ouémé-Benin are very exposed to these type of diseases. Pathogens swarm in a highly polluted environment because of the peculiarity of this predominantly aquatic area. This is what justifies this research, which aims to assess the quality of drinking water for the populations of the Commune des Aguégués. The research technique focused on the field survey which made it possible to identify the different sources of water supply used by the population. Likewise, the physico-chemical and bacteriological quality of these water sources has been determined. These research techniques

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have made it possible to discover that the population of Aguégués uses several sources of water. Apart from the recommended sources (National Water Company of Benin and Village Water Supply) the populations use other sources of water. These are rainwater consumed in the rainy season by 97% of the households surveyed, surface water used by 78.26% of the population, especially during flood periods for various uses. Physico-chemical and bacteriological analyzes have shown that apart from SONEB waters only available in the districts of Zoungamey and Houédomey, the other sources of water have parameters which do not comply with WHO standards. This justifies the prevalence of diarrheal diseases in the study environment, which represents the second cause of consultation in health centers.

Keywords: Water; highly polluted environment; source of several microbiological and toxicological diseases; Commune des Aguégués.

1. INTRODUCTION

Water and sanitation, like education and health, are fundamental elements in the fight against poverty in the world. The sanitation needs in developing countries are enormous. In these countries, faecal and unhealthy diseases account for a significant proportion in the morbidity and mortality tables [1]. Water is considered a good, like air, as essential to human life. It is one of the driving forces behind the organization and development of territories. Unevenly distributed over the earth and present in sometimes limited quantities, it constitutes a major environmental issue [2]. Because of its vital nature, water must be made available to populations in potable form and therefore of good quality. But the quality of global freshwater supply is increasingly threatened by contamination. Although water contains natural contaminants, it is increasingly polluted by human activities such as open defecation, improper treatment of wastewater, illegal dumping, poor agricultural practices and chemical spills in industrial sites (CAWST, 2013). Water is an essential resource for life on earth and is the source of several microbiological and toxicological diseases [3]. These diseases constitute a major public health problem in Benin. The prevalence of diarrhea was 9% in 2016 and is the 3rd cause of morbidity in children under 5 years old (Demographic Health Survey V).

Les Aguégués, one of the Communes in the lower Ouémé-Benin valley, is no exception to this phenomenon. Pathogens swarm in a highly polluted environment because of the peculiarity of this predominantly aquatic area. There is a link between certain affections from which the populations of this locality suffer and the conditions of access to drinking water. This is evidenced by unsanitary conditions, the absence of latrines in homes, coexistence with garbage and the absence of drinking water. This portrait is sad and distressing, especially since the health impacts are considerable. Special attention must therefore be paid to it. Certainly, efforts have been made to fight waterborne diseases at the international and local levels through hygiene and sanitation programs at the base. However, a better knowledge of the peculiarities of this environment will undoubtedly contribute to reducing the prevalence of these conditions. It is in this perspective that this work on: Physico-chemical and bacteriological characteristics of drinking water from the Lake Municipality of Aguégués in the lower valley of Ouémé-Benin are inscribed.

2. MATERIAL FRAMEWORK AND STUDY METHODS

2.1 Study Framework

The commune of Aguégués is located between 6° 24'04 '' and 6° 33'24 '' north latitude and 2° 27'12'' and 2° 35'56'' east longitude. Covering an area of 103 km² or 8.04% of the area of the Department of Ouémé (1,281 km²), it is limited to the north by the Communes of Dangbo and AkproMissérété, to the south by Lake Nokoué and the Municipality of SèmèKpodji, to the east by the Municipality of Porto- Novo and to the west by the Municipality of So-Ava. It is divided into 21 villages distributed in 3 districts, namely: Avagbodji, Houédomè and Zoungamè (Fig. 1). Its population is estimated at 50,998 inhabitants in 2013.

The commune of Aguégués has hydromorphic soils with black clay suitable for agriculture. These soils receive alluvial deposits during the flood which maintain its fertility. The Municipality enjoys a humid tropical climate characterized by the alternation of two rainy seasons and two dry seasons. The entire Municipality is flooded from July to October except the village of Agbodjèdo

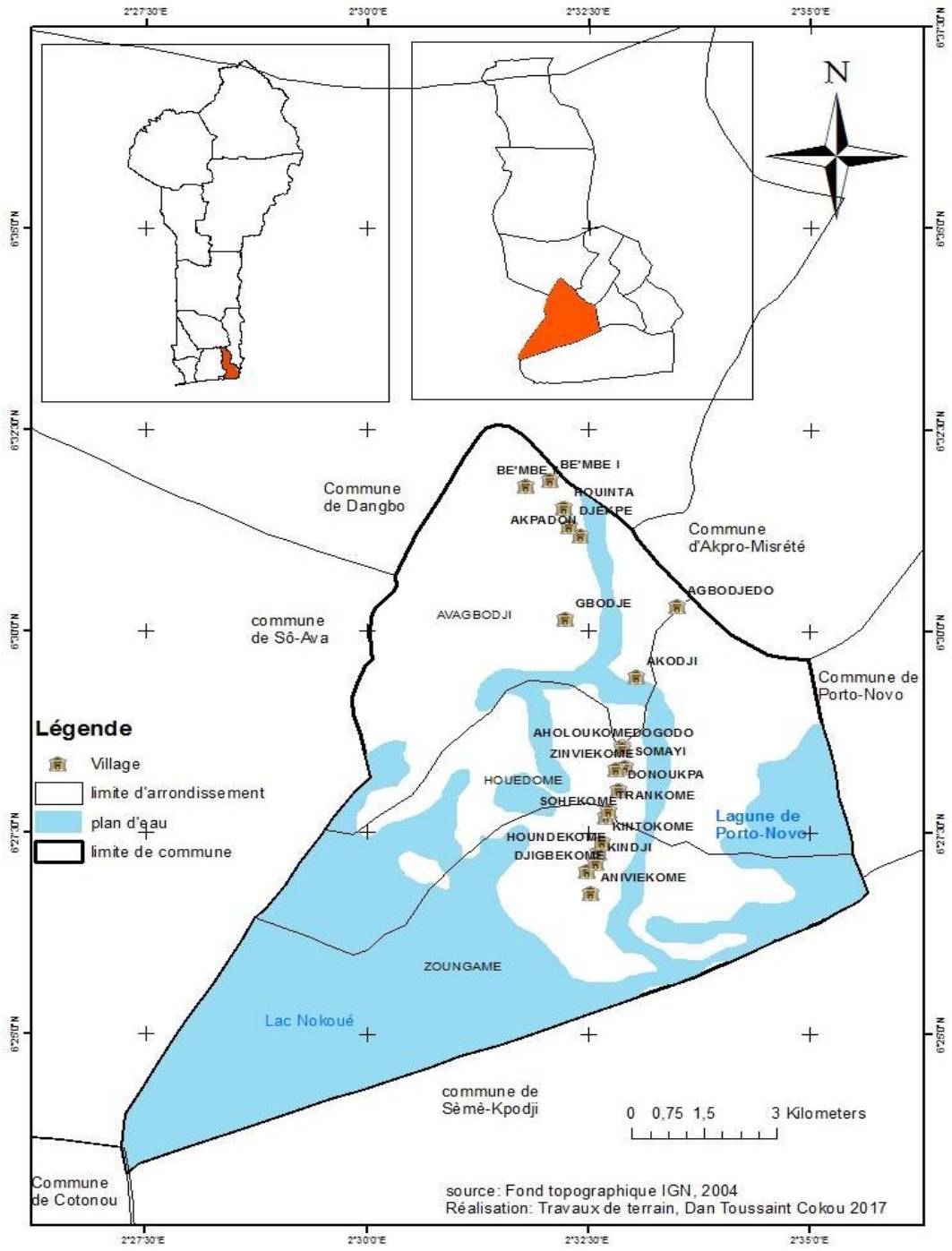


Fig. 1. Geographic location of the Aguégués municipality

in the Zoungamè district. The relief is characterized by two levels of altitude gradually going from south to north. In the Commune of Aguégués, we meet plains composed of floodplain shallows crossed by the Ouémériver and its tributaries, the edges of which constitute strips of land where the populations live.

2.2 Study Materials and Methods

2.2.1 Type of study

This is a cross-sectional, descriptive and analytical study which took place in the Commune of Aguégués from October to December 2018. To achieve this, water samples

from consumption followed by laboratory analysis were carried out. These analyzes made it possible to assess the quality of drinking water and the risk of disease to which the populations in the study environment are exposed.

2.2.2 Study population

In the context of this research, the target population consists of households in the Aguégués Commune, with whom it is a question of analyzing the consequences of poor management of household solid waste and excreta on the health of their families. In addition to households, this study has taken into account the actors involved in the management of drinking water, from whom information concerning the methods of treatment of drinking water at source has been collected. These are the services of the SONEB of Porto-Novo, the Departmental Directorate of Water Ouémé, the private suppliers.

2.2.3 Typologies of data

The data used in this study relate to epidemiological data, physico-chemical and bacteriological parameters of drinking water.

2.2.4 Data collection equipment

The equipment used for data collection as part of this study varies depending on the type of data collected.

2.2.5 Epidemiological data

For the collection of health information from households, questionnaires were used. In addition, interviews were held with the heads of health centers in the Commune des Aguégués on the prevalence of diseases related to hygiene and sanitation.

2.2.6 Laboratory equipment

These are devices such as: pH meter, turbidimeter, conductivity meter, molecular absorption spectrophotometer, water bath, oven, autoclave, bacteriological hood, filtration manifold. The dosage of the chemical elements was done using the specific kits for each element.

2.3 Measuring Parameters of Water Withdrawals

2.3.1 Data processing methods

The data collected were entered in Excel 2010 and then entered into the SPSS 21 software for descriptive analyzes and the creation of graphs. GIS and spatial analysis software were used to apply spatial processing to the data: geometric transformation, projection and estimation.

2.3.2 Techniques for analyzing results

The results were analyzed using the PEIR (Pressure-State-Impact-Responses) model. This model made it possible to describe the causal relationships which exist between the population of the Commune of Aguégués and the components of the environment (water, air and soil). Poor management of household solid waste, excreta and wastewater is indeed the driving force behind the pressure on and affecting the sources of drinking water. They cause subsequent impacts on ecosystems, human well-being and human health. The population provides responses aimed at preventing, repairing or compensating for the damage caused to the environment in general and to drinking water sources in particular by the mismanagement of excreta and wastewater.

3. RESULTS AND DISCUSSION

Drinking water is water which should be fit for consumption. It must not contain chemicals or germs harmful to health. The World Health Organization and Benin have therefore defined standards for assessing the quality of drinking water. For WHO, these are directives on the quality of drinking water, while for Benin, the Beninese authorities have published decree 2001-094 of 20 February 2001 which sets the standards for the quality of drinking water in the Republic of Benin. The populations of the Commune of Aguégués use water from various sources. These apparently healthy waters may contain germs and substances harmful to the health of populations due to the poor management of household solid waste and excreta in this environment. To better assess the quality of the water and the health risks of the water consumed by these populations, physical, chemical and bacteriological analyzes are carried out at the General Directorate of Water of the Ministry of Water and Mines in Cotonou.

3.1 Sources of Drinking Water Supply

To meet their water needs, the populations of the Commune of Aguégués have a variety of water resources. These are classified into two categories: Natural or unapproved sources and approved artificial sources.

3.1.1 Natural or unapproved sources

Precipitation and surface water are natural sources. - Precipitation They consist of rains with an average height of around 1364.77 mm over the period 1988-2018. Appreciated by the whole population, this source is mainly used during the rainy season. Almost all (97%) of the households surveyed use rainwater which they store for days to make drinking water. However, the consumption of rainwater is linked to risks of disease because of its quality. According to Landéou R, et al. [4], rainwater does not contain all the minerals necessary for man, in particular iodine, the absence of which in the body causes goiter. This potability is also linked to the collection surface (most often the roofs) which is still not absolutely clean. If it is true that rainwater eventually poses health problems, what about bodies of water? - Surface water they consist of bodies of water and streams. The research area's water bodies essentially include Lake Nokoué, swamps and many floodplains. Regarding the rivers, the research area is drained by the ramifications of the Ouémériver. According to field surveys, this source is used by 78.26% of the population, especially during flood periods for various uses, as shown in Fig. 2.

The most frequent uses of surface water by households in the Commune des Aguégués are laundry (38%) and dishes (32%). During the flood period, the surface water is clear and limpid and according to the populations it is drinking water that can be consumed. This brings 21% of the population to consume surface water during the flood season.

3.1.2 Artificial or approved sources

The Commune of Aguégués is in a difficult hydrogeological zone with a saline intrusion which makes it almost impossible to carry out drilling for the supply of drinking water. The supply of drinking water in the Aguégués Commune is partially ensured by SONEB in the districts of Houédomè and Zoungamey, by the Directorate General for Water through hydraulic infrastructures (AEV, FPM) and by the promoters of Private PEAs in the Avagbodji district.

3.2 SONEB Distribution Network

Two of the three arrondissements of the Commune des Aguégués are supplied with drinking water from the city of Porto-Novo by SONEB. These are Houédomè and Zoungamey. One of the conditions necessary before setting up a water point is the quality of the water to be collected. Thus, the saline intrusion did not allow the establishment of hydraulic infrastructures in these two districts. Since 1995, SONEB has installed its water distribution network and started supplying water to the populations of these districts.

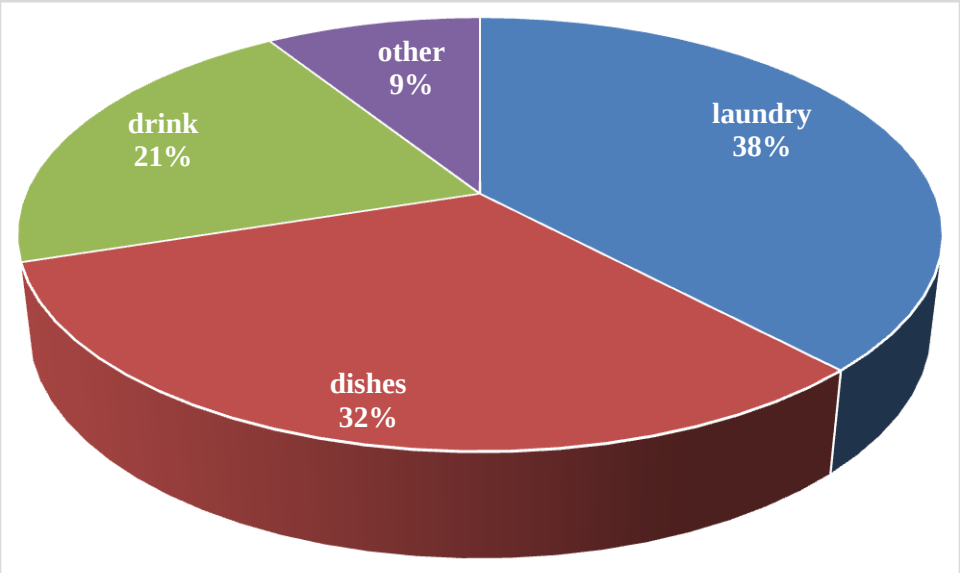


Fig. 2. Different uses of surface water in the Commune of Aguégués
Source: Fieldwork, Aguégués 2018

3.2.1 Hydraulic infrastructure

In the Commune of Aguégués, there are various hydraulic works used by the populations for their water needs. These include Village Water Adductions (AEV), boreholes equipped with a human-powered pump (FPM), Autonomous Water Stations (PEA), modern and traditional wells. In the Municipality of Aguégués, there are three (03) AEV. These are the AEV of Akpadon, the AEV of Houinta and that of BèmbèAkpa.

3.2.2 Quality of drinking water

The water to be consumed must meet bacteriological and physico-chemical conditions. This is why the present research is interested in the physico-chemical and bacteriological parameters of water.

3.2.3 Analysis of physico-chemical parameters

This analysis measured parameters like pH, conductivity, water color, turbidity, ammonia, nitrate / nitrite, dissolved oxygen.

3.2.4 Hydrogen potential and conductivity of water

The hydrogen potential and the conductivity of water are parameters that allow the quality of drinking water to be measured. They can be influenced by environmental hygiene conditions. It is to assess the consequence of poor management of waste and excreta in the Municipality of Aguégués that this study looked at the pH value (Fig. 3) and the conductivity (Fig. 4) of consumption sources. of the Aguégués populations.

The pH of a water represents its acidity or alkalinity; at pH 7 a water is said to be neutral, at a pH less than 7 a water called acid and at a pH greater than 7, it is said to be basic [5]. Analysis of the graph shows that the average pH of all the sampled waters is below 6. The pH values vary from 4.69 to 5.77. This drop in pH marks an increase in the CO_2 content, the decrease of the O_2 content and the increase of the organic matter content in drinking water [6]. Thus, one can deduce a pollution of the drinking water of the Municipality of Aguégués by organic matter. Electronic conductivity refers to the ability of water to conduct an electric current [7]. According to Rodier [5], measuring the conductivity of water makes it possible to quickly assess the overall mineralization of water and to follow its evolution. Contrasts in conductivity make it possible to highlight pollution, areas of mixing or infiltration of polluted water. As shown in Fig. 4, the private drilling waters of Dessan, Tota 2, Dogbamè 2 and 3 and the water from the village water supplies of Dogbamey 1 sampled in the Commune of Aguégués have conductivity values greater than the standard which is 2000 µS / cm. These waters are then highly mineralized. This highlights the pollution of these water sources by seepage of wastewater, leachate from waste or excreta. Apart from these samples, the other samples have conductivity values below 2000 µS / cm. These water sources then have a low mineralization.

3.3 Color and Turbidity of Water

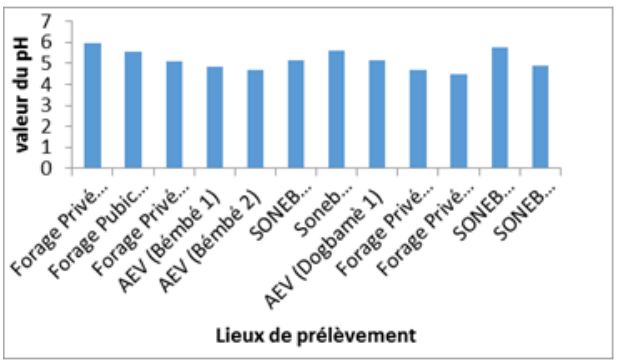
Color and turbidity are parameters that indicate the quality of the water. Color has no effect on health, but allows you to appreciate the appearance of water. The different values of the color of the sampled waters are illustrated in Fig. 5, while the turbidity of the water is a measure of its more or less cloudy appearance. It reflects the presence of particles in suspension in water (organic debris, clays, silts, silica grains, microscopic organisms, etc.) [5]. According to the WHO, turbidity greatly affects the potability of drinking water. Fig. 6 presents the results of the turbidity of the water sampled in the Commune of Aguégués.

Apart from the private drilling waters of Dessan, total 2 of Dogbamè and the AEV of Bembè 1 whose average color values (18.38 to 24, 62 ptCo) are higher than the standard which is 15 ptCo, the color values of other water samples are within required standards.

Regarding the turbidity of the water, apart from SONEB waters whose turbidity (1.98 to 2.5 NTU) conforms to the standard which is 5 NTU, that of other water sources is well above the norm. This indicates the presence of suspended matter in water and the risk of exposure of populations to pathologies to the extent that high turbidity can allow microorganisms to attach to suspended particles. These particles can be nutrients for the microorganisms they could use to grow. This can consequently cause illnesses in populations [5].

3.3.1 Dissolved oxygen

Indispensable for the respiration of the organs, it facilitates the degradation of detrital organic matter and the accomplishment of biochemical cycles (Méguida et al. 2019). It is one of the most important indicators of the degree of water



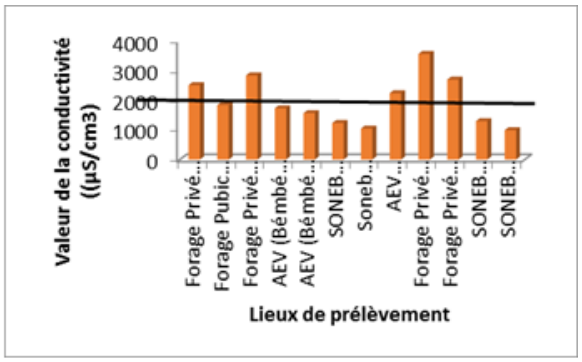
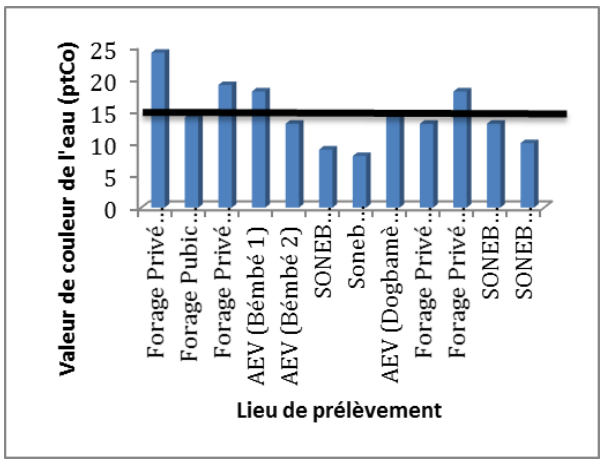


Fig. 3. pH of sampled water

Fig. 4. Conductivity of sampled water

Source: Fieldwork, Aguégués 2018



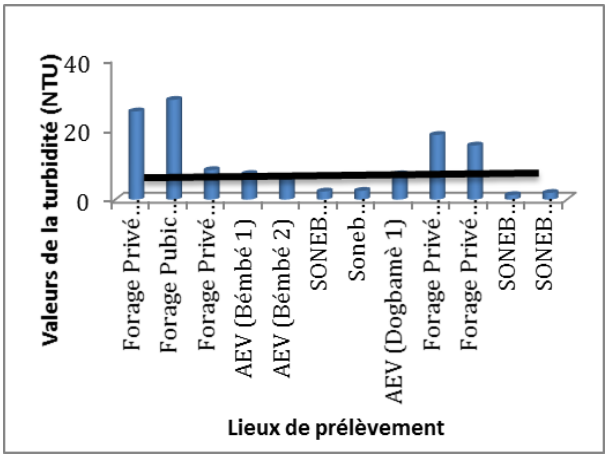


Fig. 5. Color of sampled water

Fig. 6. Turbidity of sampled water

Source: Fieldwork, Aguégués 2018

pollution [7]. Very aerated water is generally oversaturated with oxygen, while water loaded with organic matter degradable by microorganisms is undersaturated. Indeed, the strong presence of organic matter in a body of water for example, allows microorganisms to grow while consuming oxygen. Fig. 7 shows the dissolved oxygen in the sampled water.

Apart from SONEB waters where the quantity of dissolved oxygen is greater than 5, none of the other water samples has a dissolved oxygen value in accordance with normal (greater than or equal to 5 mg / l). The low dissolved oxygen content in these waters could be explained by the presence of microorganisms which use them for their biological activities and ensure their multiplication.

3.3.2 Ammonium

Ammonium is the product of the final reaction of nitrogenous organic substances and inorganic matter in water and soil. It also comes from the excretion of living organisms and the biodegradation of waste, without neglecting the contributions of domestic industrial and agricultural origin [7]. It is used by the phytoplanton as a source of nitrogen and oxidized by nitrifying bacteria. Surface water ammonium can originate from plant matter in watercourses, animal or human organic matter [5]. Generally speaking, ammonia changes fairly quickly to nitrites and nitrates by oxidation. The ammonium content in the water samples taken is shown in Fig. 8.

Fig. 8 shows that apart from SONEB waters, the ammonium content of the other sampled water sources greatly exceeds the standard (0.5 mg / L), we can then conclude that the process of incomplete degradation of the organic matter is very strong in the water supply sources of the Municipality of Aguégués.

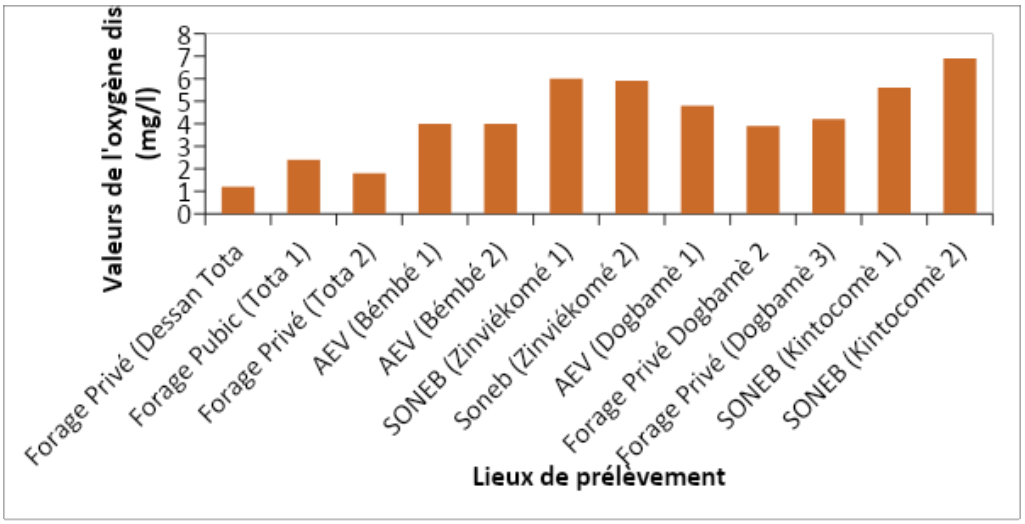


Fig. 7. Dissolved oxygen in sampled water
Source: Fieldwork, Aguégués 2018

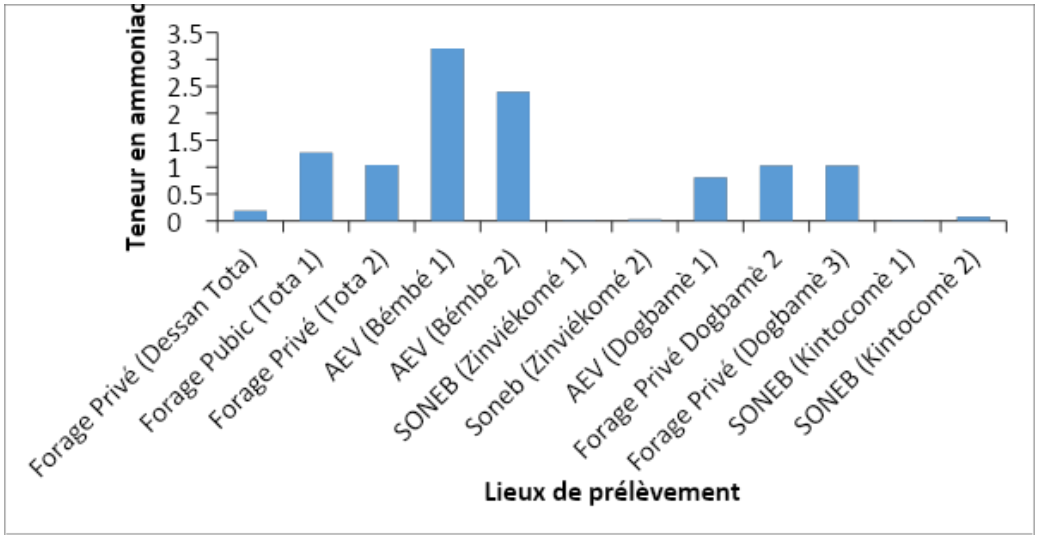


Fig. 8. Ammonium content of sampled water
Source: Fieldwork, Aguégués 2017-2019

3.3.3 Nitrate and nitrite

The presence of nitrate in drinking water is mainly attributable to human activities (Health Canada, cited by Groupe Scientifiquesurl'Eau, 2003).

Nitrates have an indirect toxicity by the fact that they turn into nitrites this intoxication, caused by the absorption of small doses of nitrates, is actually due to nitrites formed by reduction of nitrates under the influence of a bacterial action. The results of the analysis of the water samples on the nitrate content are shown in Fig. 9. In the nitrogen cycle, nitrites are considered to be intermediate ions between nitrates and ammonium. This explains the low concentrations encountered in the aquatic environment [4]. In the absence of pollution, there is very little nitrites in the waters. To assess the pollution of the sources of supply to populations of Aguégués by waste and excreta, the present study looked at the nitrite content of the sampled water (Fig. 9).

The water from private and public boreholes has a nitrate concentration which is considerably higher than normal (45 mg / l). You could say that there is a rapid transformation of ammonium into nitrate. This shows an incomplete degradation of organic matter in these waters.

SONEB water samples have a low nitrate content. This means that the degradation of organic matter is low in these waters.

With regard to nitrites, private well waters have a nitrite content far above the standard (less than 0.1). This indicates the pollution of these waters. According to Rôdier [5], water containing nitrite is considered suspicious because it is often associated with a deterioration in microbiological quality. The presence of nitrate and nitrite in the waters testifies to the poor management of household solid waste and excreta. It constitutes a threat to the health of the populations of the Commune of Aguégués.

3.4 Bacteriological Analysis

The germs responsible for water-related diseases are transported by waste and faeces. These sought-after germs are systematically indicators of pollution. These are coliform organisms (total coliforms), fecal coliforms (thermo-tolerant) and fecal streptococci. The results of the microbiological analysis of the water samples taken are presented by type of parameter.

3.4.1 Fecal coliforms

Typically, groundwater is free of pathogens. The presence of pathogens in well water can be the result of seepage of sewage. However, their presence in surface water is linked to animal droppings and human faeces which are released there. Fig. 11 shows the presence of fecal coliforms in drinking water in the Commune of Aguégués.

Analysis of Fig. 11 shows that all of the sampled waters contain large numbers of fecal coliforms. These numbers greatly exceed the Beninese

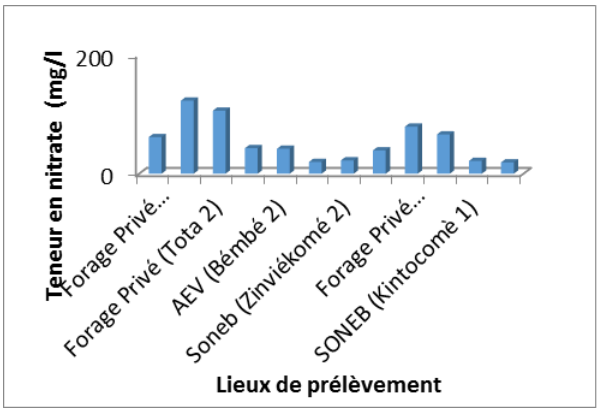


Fig. 9. Nitrate content of water

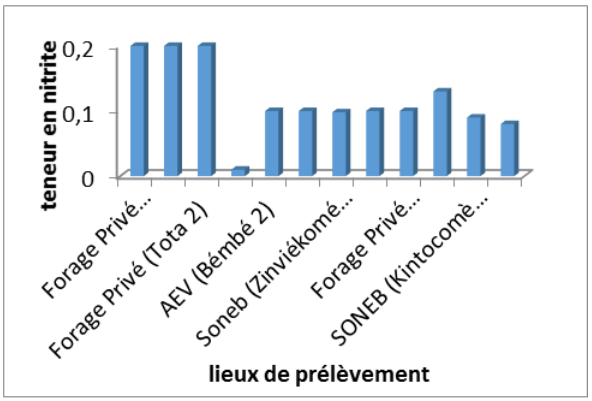


Fig. 10. Nitrite content of water

Source: Fieldwork, Aguégués 2018

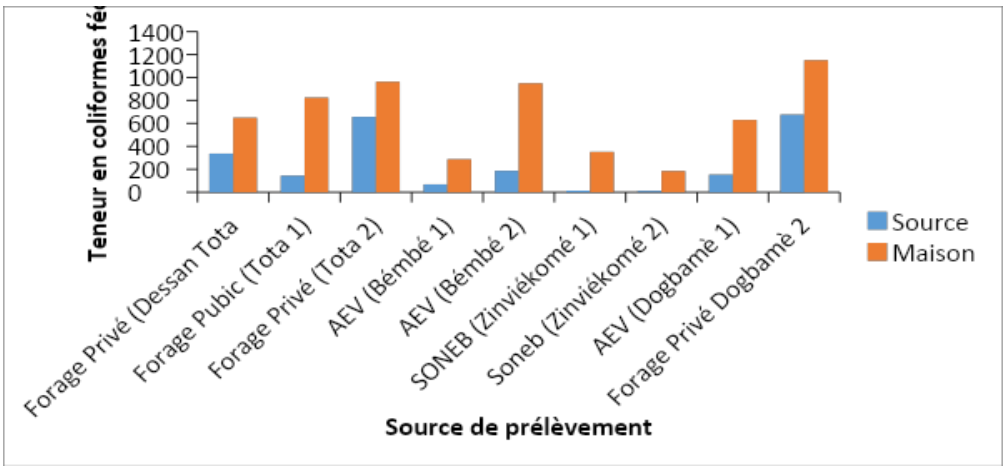


Fig. 11. Content of sampled fecal coliform water

Source: Fieldwork, Aguégués 2018

standard which is 0 fecal coliform per 1 ml of water. The presence of these coliforms in the sampled waters indicates heavy pollution of the environment of the Commune of Aguégués by waste and faeces, which constitute the main sources of faecal pollution [8].

The highest levels of fecal coliforms are in home waters. The increase in contamination of these waters is due to poor management of waste and excreta in households.

3.4.2 *Escherichia coli*

The presence of *E. coli* in water and food indicates not only recent contamination with faeces, but also the likely presence of pathogenic bacteria and protozoa (Health Canada, 2006). It is then the best indicator of faecal pollution. The E.Coli content in the sampled waters is presented in Fig. 12.

Taking into account the bacteriological criteria of the Beninese standard which fixes at 0/1 ml of water, all the sampled waters contain *E. coli* at various rates. The content of *E. coli* at the water sources is low varies from 2 to 77 / ml. The low levels are obtained in the waters of SONEB and the highest levels are observed in the waters of private boreholes and AEV. However, in the houses, there is a high water content in *Escherichia coli* in all the water samples. 2.2.3 Health consequences of poor management of household solid waste and excreta in the municipality of Aguégués In lake environments characterized by very large disparities concentrated in small spaces often densely populated, special conditions of exposure to health risks are created [4]. Similarly, in rural areas, the peculiarities of natural, societal and social conditions generally constitute remarkable factors of exposure to health risks. A certain number of pathologies resulting from these conditions or exposure factors then pose health problems with even greater acuity. The most endemic affections in the Commune of Aguégués are the subject of this research in order to assess the implications of the unhealthy condition of households and the quality of drinking water in the occurrence of these affections. - Epidemiological profile of the Municipality of Aguégués The analysis of the epidemiological profile is based exclusively on official epidemiological surveillance data. In this regard, data from 2014 to 2018 were used. The use of statistics relating to the various diseases led to the selection of a list of the diseases most frequently notified in consultations. Ten in number, these diseases represent 93.49% of the cases notified in the Commune of Aguégués. These ten conditions most frequently mentioned in consultation are presented in Fig. 13.

It appears from the analysis of Fig. 13 that malaria, diarrheal diseases and other ailments are the first three causes of consultation with the populations of the Commune of Aguégués. Malaria leads the way followed by diarrheal

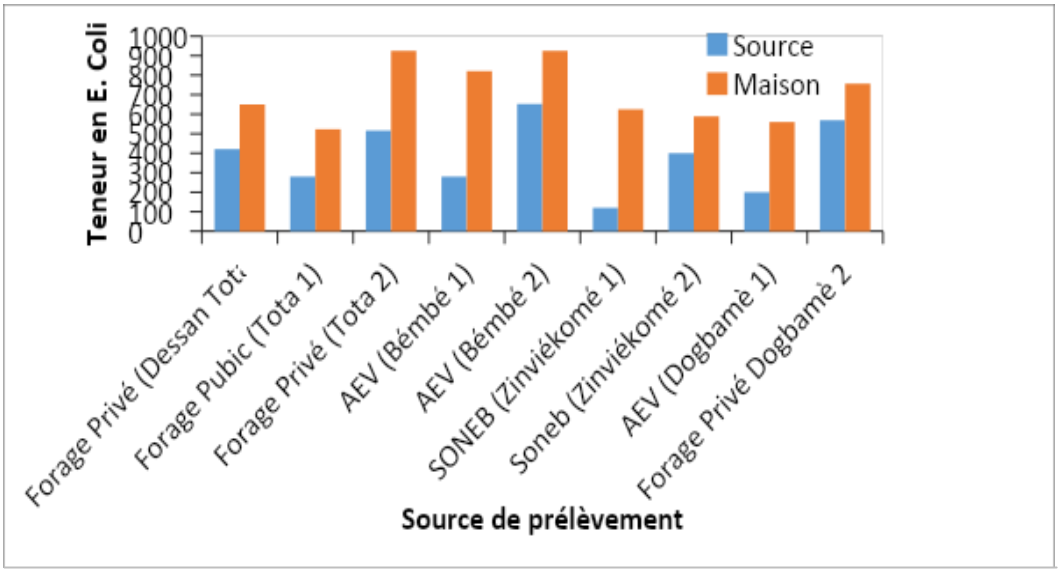


Fig. 12. Content of water sampled in *E. coli*
Source: Fieldwork, Aguégués 2017-2019

diseases. The gap between the proportions is very large between malaria and other conditions. However, this gap is relatively small between diarrheal diseases and other ailments. The spatial distribution of the profile of the three most frequent affections made it possible to determine the districts which offer more favorable conditions for the development of the pathogenic germs responsible for these affections.

3.5 Spatial Distribution of the Profile of Diarrheal Diseases in the Commune of Aguégués

Second cause of hospital consultation in the Commune of Aguégués, diarrheal diseases are due to the lack of hygiene in households. Fig. 14 shows the distribution of the epidemiological profile of diarrheal diseases in the Commune of Aguégués.

Fig. 14 shows that Avagbodji is the district in which diarrheal diseases are more frequent. Primarily due to the consumption of contaminated water and food, it is deduced from the analysis of the figure that the district of Avagbodji is very favorable to the proliferation of diarrheal diseases. It should be noted that this is the district in which the main sources of supply are private boreholes heavily loaded with microbiological germs as evidenced by the bacteriological analyzes carried out as part of this research. As for the districts of Houédomey and Zoungamey, the main source of drinking water supply is SONEB, whose microbiological germ content is low compared to private drilling.

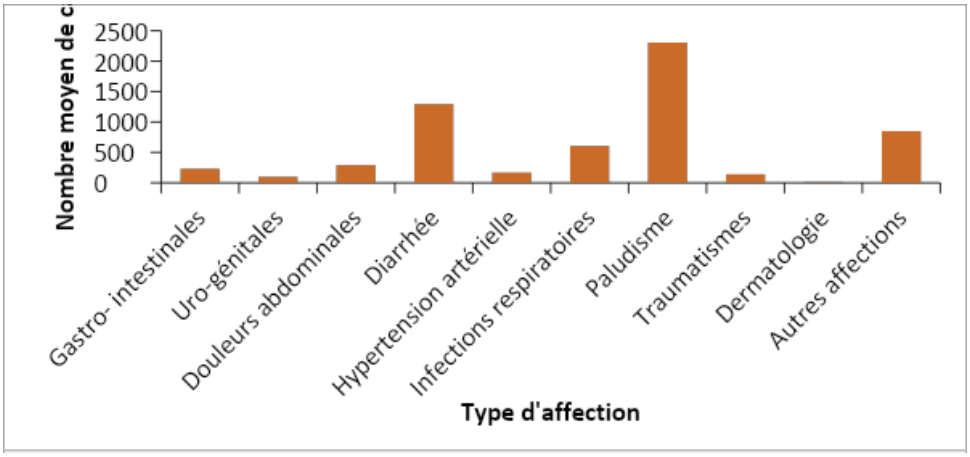


Fig. 13. Distribution of the ten most frequently mentioned clinical conditions in consultation
Source: SNIGS, 2014 to 2018

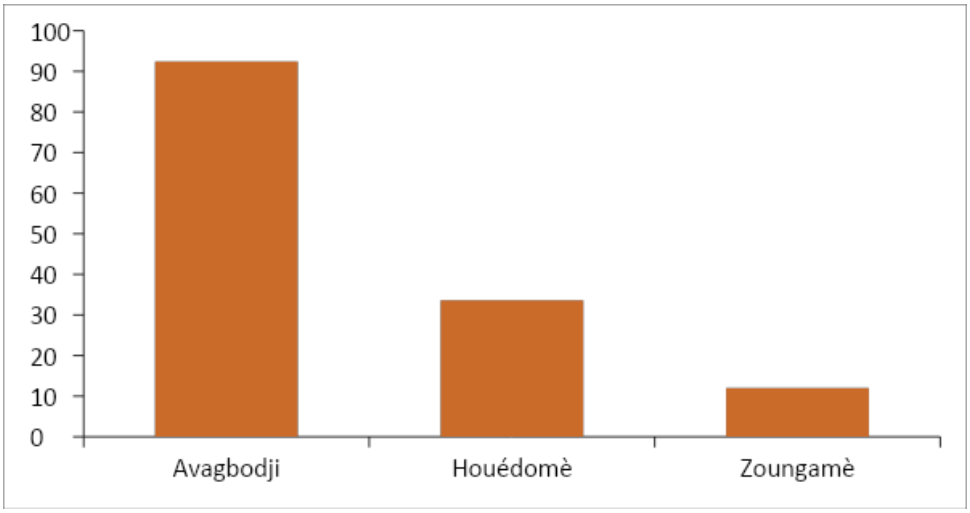


Fig. 14. Spatial distribution of the diarrheal profile in the Commune of Aguégués
Source: Field survey, February 2018 and statistical yearbook

4. DISCUSSION

The results of the fieldwork prove that the populations of the Commune of Aguégués travel an average of 400 m before having access to drinking water. The means of transport used are the canoes where the uncovered basins are installed. During transport, the movements of canoes cause the waters of contaminated streams to be poured into the waters of basins intended for consumption. These results are not in line with the prescriptions of the WHO which establishes the acceptable distance at 200 m. But this comparison made to the typology of Howard and Bartram [9] according to which a reasonable or acceptable geographical accessibility to drinking water is defined by the fact of having a drinking water point 100 meters from the house, it appears that less than 10% of households have easy access to drinking water in the Commune of Aguégués. These results are in line with those of Ayokpon [10] in his study on the environmental determinants of hydro-fecal peril in the Lake Municipality of Sô-Ava, discovered that only 22% of the population of his study environment has access to 'potable water.

In the context of poor countries, it has been shown that the water supplied by water systems can be of poor quality. The results of microbiological analysis confirmed this thesis. The bacterial load of the sampled water greatly exceeded the Beninese standard of 0 CFU / 100 ml. These waters have high concentrations of fecal coliforms, *Escherichia coli* and Enterococcus. This significant bacterial load in drinking water is identical to that found by Landéou et al. [40] in drinking water at the household level, in the Commune of Dassa-Zoumè where the number of fecal coliforms and *E. coli* is between 650 and 2000 germs per 100 ml of water. Similarly, these results are consistent with those of Totin [11] in shallow wells such as Gbècon (Grand-Popo), Tchikomè (Lokossa), and Ouando (Porto Novo) where the number of Escherichia coli exceeds the standard (0 CFU / 100 ml) and between (8 and 412 CFU / 100 ml) and (62 and 252 CFU / 100 ml). In the same vein, a study carried out by Dégbey et al. in [3] demonstrated that water from the water table in the town of Abomey-Calvi, another town in the Atlantic department is contaminated by *Escherichia coli*, *Klebsiella pneumoniae*, *Staphylococcus aureus*, *Salmonella*, *Clostridium perfringens* and faecal Streptococci. Also, microbiological studies by Odoulami [12], revealed that most of the Cotonou wells have a high load of fecal coliforms and Escherichia coli (more than 1500 CFU / 100 ml). The laboratory results are also close to those of Aissi [13], who found in Cotonou well water, Coliform levels far exceeding 103 colonies per 100 ml. It is therefore clear that the methods of managing household solid waste and excreta have an influence on the quality of drinking water sources.

These results show the sensitivity of water to microbial pollution. The geographical position of the boreholes, located not far from Lake Nokoué, which constitutes the places of defecation and final discharge of the majority of the populations located in the major bed of the said lake, could justify the density of the bacterial load. According to Rodier et al. (1975), water pollution is mainly due to the nature of the various rocks crossed, organic matter and chemicals which originate from the decomposition of plants, household waste and the discharge of polluted water to inappropriate places. For Chippaux et al. [14], the general pollution of groundwater is to varying degrees, depending on the location and depth of the aquifers. In fact, the surface waters loaded with microorganisms infiltrating the sandy soil, reach the water table without having benefited from effective filtration and cause a multitude of point pollutions, Dégbey et al. (2008).

In agreement with the same author, the prevalence of diseases of hydro-faecal danger recorded in the commune of Aguégués would be due to the quality of the water consumed, the methods of waste management and excreta. Lack of hygiene and sanitation in households makes water sources unsuitable. According to Goodman and Segreti [15], the majority of cases of diarrhea with an infectious etiology are caused by the consumption of food as well as the ingestion of contaminated water or drinks. Furthermore, Strauss et al. (2001) in Canada, in their studies, established the link between indicators of microbial contamination of water and the occurrence of episodes of gastroenteritis.

The results of laboratory analysis therefore justify the proliferation of germs related to hygiene and sanitation in the study area and confirm the work of Yéhouenou [16] who concludes that the raw water in Benin is all contaminated, however to varying degrees.

5. CONCLUSION

Poor waste management characterized by the unsanitary environment in which households live

has consequences for both the environment and human health. Physico-chemical and bacteriological analyzes carried out on drinking water reveal high loads of drinking water taken by densely high particles of fecal coliforms, *Escherichia coli* and Enterococcus which indicate that these waters are of poor quality for consumption outside SONEB waters which contain small particles. The detection of enterococci in a groundwater table should raise serious suspicions of contamination from faeces and the presence of enteropathogenic microorganisms. The consumption of these waters causes diarrheal diseases in the study environment. Avagbodji is the district in which diarrheal diseases are the most frequent mainly due to the consumption of contaminated water and food. Analysis of the data collected shows that households located in a very unsanitary environment have a very high diarrheal prevalence (69.85%) compared to households that are located in an unsanitary environment (58.56%) and those in a healthy environment (20.54%) throughout the Municipality of Aguégués. The lakeside town of Aguégués is particularly affected by hygiene and sanitation problems due in particular to its physical environment which does not favor the construction by the population of low-cost family sanitation works. It is an inhabited space that cannot be extended, under the permanent influence of the waters of the river, in particular the floods.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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