Scientific Research Publishing

Journal of Water Resource and Protection, 2022, 14, 501-514
https://www.scirp.org/journal/jwarp
ISSN Online: 1945-3108
ISSN Print: 1945-3094

Evaluation of the Microbiological Quality of Drinking Water and Health Risks in the Commune of Sô-Ava, in Southern Benin (Evaluation De La Qualité Microbiologique Des Eaux De Boisson Et Risques Sanitaires Dans La Commune De Sô-Ava, Au Sud-Bénin)

Oswald F. Dan*, D. Mathieu Maurice Ahouansou, Luc O. Sintondji

Laboratory of Hydraulics and Water Control, National Institute of Water, University of Abomey-Calavi (LHME/INE/UAC), Cotonou, Benin
Email: *oswalddan01@gmail.com

How to cite this paper: Dan, O.F., Ahouansou, D.M.M. and Sintondji, L.O. (2022) Evaluation of the Microbiological Quality of Drinking Water and Health Risks in the Commune of Sô-Ava, in Southern Benin (Evaluation De La Qualité Microbiologique Des Eaux De Boisson Et Risques Sanitaires Dans La Commune De Sô-Ava, Au Sud-Bénin). *Journal of Water Resource and Protection*, **14**, 501-514.
https://doi.org/10.4236/jwarp.2022.147026

Received: April 12, 2022
Accepted: July 10, 2022
Published: July 13, 2022

Abstract

Access to drinking water in rural and semi-rural areas is a major concern for the populations because of the quality of the resources. This research work aims to analyze the bacteriological quality of the water consumed by households in the Commune of Sô-Ava in order to establish a relationship between this quality and the health problems observed within the communities. To succeed in this study, documentary research, surveys and observations in the field and analyzes of eighty-two (82) water samples were analyzed in the laboratory during two (2) seasons (rainy and dry). From the results obtained, it appears that the samples present concentrations of total germs, faecal coliforms, *Escherichia coli*, faecal enterococci, sulphite-reducing anaerobic bacteria (ASR), salmonella and Shiguela which do not comply with the water potability standards in respectively 78.05%, 60.98%, 50%, 64.63%, 80.49% and 70.73% of the samples taken. The statistics on the diseases recorded during this decade in the Commune showed that the populations of Sô-Ava are confronted with several ailments such as: malaria (75%), Acute Respiratory Infections IRA, (16%) and Gastrointestinal disorders (5%) especially during floods and during the rainy season. Education and sensitization of the population on good public hygiene practices around water must be highlighted in order to avoid waterborne diseases.

Keywords

Microbial Pollution, Drinking Water, Health Risks, Sô-Ava, Benin

1. Introduction

Water is an essential element for life and for the real and sustainable socio-economic development of a country. It is one of the driving forces behind the organization and development of territories [1]. Water, an essential resource for life and health, can also compromise them if conditions are not met [2]. Indeed, water can in many cases be a source of disease because of its contamination by household, industrial, agricultural waste, excreta and various organic wastes [3]. According to the World Health Organization (WHO), ten to twenty-five million deaths, including five million children, due to diarrhoea can be attributed to lack of water and poor sanitation. While drinking water poses virtually no problems in Western countries, it is a major problem that hampers the socio-economic development of African countries.

In Benin, only 70.6% of households have access to improved water sources with disparities in environments (78% in urban areas and 63.5% in rural areas) [3]. The provision of drinking water at the tap requires the collection, control and distribution of drinking water. All these operations require technical and financial resources that are now part of the development priorities of the Government of Benin. However, limited access to drinking water and spatial disparities in supply still characterize the water situation in Benin [4]. However, the water captured may contain elements that can have adverse health effects, such as pathogenic microorganisms, undesirable substances or even toxic substances [5].

The risks associated with the contamination of drinking water are multiple and can depend not only on the lack or insufficiency of hygiene measures at the source of supply but also during transport, storage of water at home [6].

In the Lake Commune of Sô-Ava, the rate of drinking water supply is around 49.43% and that of household access to family latrines is 14.57% [7] [8]. The same study indicated that 89.15 percent of households defecate in the bush and nearly 94.81 per cent of households do not have an adequate sewage disposal system. These statistics reveal the low level of hygiene and sanitation in the municipality. According to [9] the factors responsible for these pathologies are: the consumption of dirty water and unmaintained food and/or the lack of hygiene of the populations. In the same vein [10], report that in the lakeside commune of Sô-Ava in Benin, nearly 89.56% of drinking water is unfit for household consumption and would be the basis of the resurgence waterborne diseases that are prevalent in the study environment.

This work focuses on the evaluation of the bacteriological quality of water used as drinking water by households and likely to contain germs responsible for

waterborne diseases recorded in the study area.

2. Matérials and Methods

2.1. Description of the Study Area

The study was conducted in the lakeside town of Sô-Ava, located in the Atlantique department. The commune of Sô-Ava occupies the Lower Valley of the Ouémé River and the Sô River to which it owes its name (Figure 1). Covering an area of 218 km^2 [11], it has 118,547 inhabitants with a density of approximately 567 inhabitants per km^2 [12].

The municipality of Sô-Ava enjoys a humid tropical climate, characterized by the alternation of two rainy seasons and two dry seasons. The main rainy season extends from March to July and the short one from September to November. The average annual rainfall is 1200 mm. Temperatures vary between a minimum of 22˚C and a maximum of 33˚C.

Hydrologically, the commune of Sô-Ava is characterized by the richness of its bodies of water (65% of the commune), hence its name of lake commune. Its

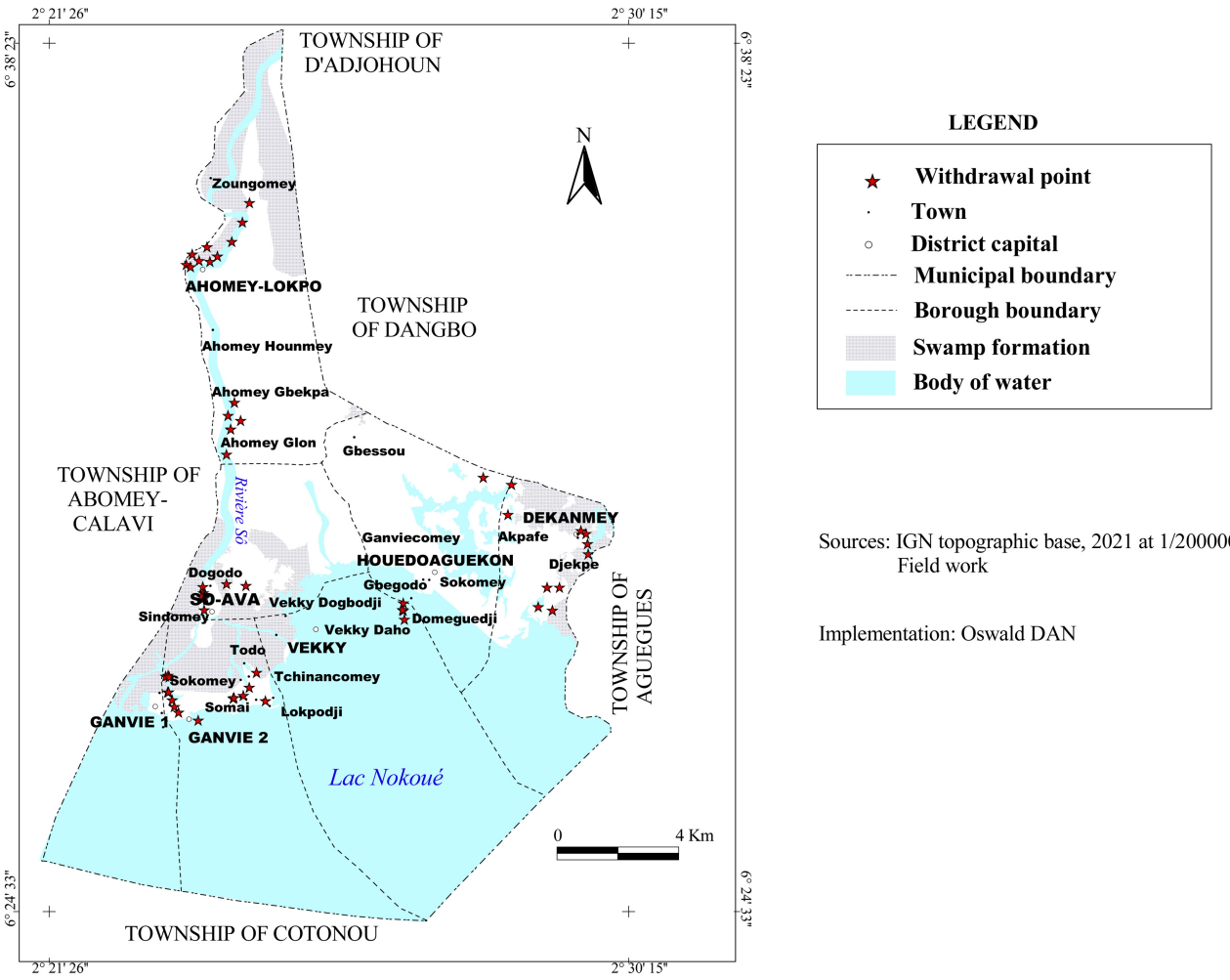

Figure 1. Water sampling points in Sô-Ava. Source: Field surveys, 2021.

main watercourse is the Sô River which flows into Lake Nokoué (a lagoon in fact) [13].

Administratively, the Municipality of Sô-Ava is subdivided into seven (07) districts, namely: Sô-Ava, Vekky, Houédo-Aguékon, Dékanmè, Ganvié 1, Ganvié 2 and Ahomey-lokpo [8].

Data: To properly conduct this study, data was collected. It's about:

- Demographic data (population numbers and number of households) (INSAE, 2013);
- Climatological data (rainfall and temperature) from the Air Navigation Safety Agency (ASECNA);
- Socio-anthropological data: quantitative and qualitative data collected in the field on hygiene and sanitation practices;
- Cartographic data (maps of geographical and hydrological location) from the National Geographic Institute (IGN);
- Data on microbiological parameters (*E. coli*, total coliforms, faecal streptococci, sulfite-reducing anaerobic bacteria, *salmonella-shigella*) to assess the quality of the water analyzed in comparison with the water potability standards set by the WHO and that in force in the Republic of Benin;
- Epidemiological data from 2011 to 2021 relating to the various pathologies taken from the register of the health center of the Commune.

2.2. Sampling and Analysis of Microbiological Parameters

In order to better assess the microbiological characteristics of drinking water, a total of 82 water samples spread over all 7 arrondissements were taken and analyzed during the rainy season (July 2020) then in the dry season (January 2021) according to the methods described by [14]. The sampling points are shown in red in **Figure 1**. The samples were taken taking care not to contaminate or modify the samples in hermetically sealed 210 ml Whirl-Pak sterilized pouches.

These water samples were labeled (labels bearing the name of the district, the name of the village, the type of structure, the date and time of sampling) and carefully stored in a cooler with cold accumulators before transporting them to the Water and Food Quality Control Laboratory (LCEQA) of the Benin Ministry of Health. Then, the samples were analyzed within 24 hours for analyzes of microbiological parameters.

For each sample taken, a household that uses the source sampled was interviewed. The investigations were carried out as follows:

- Administration of household questionnaires (socio-demographic data, drinking water supply, storage method, existence of latrines, waste and animal management, health problems related to water consumption);
- Direct observation of living conditions in households.

The microbiological analyzes made it possible to identify and count total germs, faecal coliforms, *Escherichia coli*, faecal enterococci, sulphite-reducing anaerobic bacteria (A.S.R), *salmonella and Shiguela*. Membrane filtration was used for

bacteriological analyses. The enumeration of revivable microorganisms was carried out by inoculating the Petri dishes containing yeast extract agar with a measured volume (1 ml) of the water sample to be analyzed or dilutions. A volume of 100 mL of the water sample is filtered and the membrane is incubated on a specific agar medium. Crystal violet-neutral red lactose bile agar medium was used to isolate thermotolerant coliforms. In contrast, tryptone bile glucuronide (TBX) agar for *E. coli*, Slanetz agar for the enumeration of faecal Streptococci, Hektoen enteric agar (BD Hektoen Enteric Agar) for the enumeration of *Salmonella* and *Shigella.* Tryptose-sulfite-agar (TSC) culture medium was used to estimate the spores of sulfite-reducing anaerobes. Incubation of these media at 37˚C for 24 to 48 hours allows enumeration of faecal streptococci, *Salmonella* and *Shigella* and at 44˚C ± 0.5˚C for thermotolerant coliforms and *E. coli.* The result is expressed in colony forming units (CFU) per unit volume.

2.3. Statistical Analysis

The data from the field surveys were analyzed manually, codified, entered in the Excel 2016 spreadsheet for analysis. This allowed the determination of numbers, frequencies, means, standard deviation (+ or −) and confidence interval. As for the results obtained after laboratory analysis, they are presented in tables produced using Microsoft Word software, and compared with the standards established by the World Health Organization and those in force in Benin.

3. Results and Discussion

3.1. Microbiological Characterization of Water

The purpose of the microbial analyzes is to look for germs that are likely to be pathogenic or indicative of faecal contamination in the water consumed by households in the Commune of Sô-Ava. To better appreciate the variation in the content of germs contained in the water consumed by households in the Commune of Sô-Ava, a summary of the results showing the minimum values, the averages and the extremes of each parameter sought during the two seasons is shown in Table 1.

Total germs: The results of the study indicate respectively that 71% and 85% of the samples taken in the rainy season and then in the dry season are contaminated by total germs, the maximum concentration of which reaches 12×10^3 CFU/mL. It should be noted that all of the water samples taken in households show bacterial pollution varying between 0 and 12×10^3 CFU/mL. The number of ordinary bacteria contained in 78.05% of the samples taken is higher than the standards in force in Benin, which is a maximum of 20 germs/ml for treated water and less than 50 germs/ml for untreated water. The work of [15] showed that 71.42% of the water samples analyzed from Foggaras d'Adar (Algeria) represent undrinkable water. The contamination of water by total germs could probably be due to: the lack of hygiene around water points, nearby pollution (presence of wild dumps, wandering animals, defecation in the open air, etc.).

Table 1. Comparison of microbiological results of water sampled during the two seasons.

	Statistic	Total Germs/1mL	Thermotolerant Coliforms/100mL	*Eschérichia coli*/100mL	Faecal enterococci/100mL	A.S.R	*Salmonella and Shiguela*
Rainy season	Minimum	0	0	0	0	0	0
	Maximum	12×10^3	27×10^3	7×10^3	8.5×10^3	2.5×10^3	6×10^2
	Moyenne	1.3×10^3	1.2×10^3	7.6×10^2	8.3×10^2	283	96
	Standard deviation (n − 1)	2.4×10^3	4.4×10^3	1.5×10^3	1.8×10^3	506	1.4×10^2
Dry season	Minimum	0	0	0	0	0	0
	Maximum	6.8×10^3	4×10^4	6.8×10^3	3.7 × 104	6.8×10^3	8×10^2
	Moyenne	2.9×10^3	7.5×10^3	4.1×10^2	2.2×10^3	754	89
	Standard deviation (n − 1)	2.2×10^3	1.2×10^3	1.2×10^3	6.7×10^3	1.4×10^3	1.4×10^3

Source: Results of statistical analyses, 2021.

Thermotolerant coliforms: the count of thermotolerant or faecal coliforms in water samples varies between 0 and 40×10^3 CFU/mL. Of the 82 water samples taken in the Municipality of Sô-Ava, 60.98% contained faecal coliforms, the rate of which was between 1.2×10^3 and 27×10^3 CFU/mL. Analysis of the data indicates that most of the waters in which faecal coliforms are absent were collected from sources of supply. In addition, there is a lack of water protection during transport in buckets and basins. Thermotolerant coliforms have been found as sources of contamination with a high rate of 97% contamination of non-compliant samples [16]. The preponderance of faecal bacteria in pastures is easily explained by the presence of cow droppings and their leaching by the rains along the watersheds [17].

Escherichia coli: microbiological analyzes have revealed that 50% of the water contains *E-coli* which are therefore not drinkable insofar as the WHO and Beninese standards require the total absence of these germs in water intended for consumption. Among this rate of polluted samples, it was found that 45.12% came from water taken from households, while 4.87% came from supply sources. The concentration of faecal coliforms (*E. coli*) present in the water sampled in the study environment is higher than that found in [1]. The latter indicated that the concentration of *Escherichia coli* is less abundant in the waters analyzed in Congo. Their concentration varies from 0 CFU/100mL to 8 CFU/100mL with an average value of 2 CFU/100mL. However, [3] found 100% contamination of samples for the two microorganisms in well water in the Commune of Abomey-Calavi (Benin), confirming our data.

Faecal enterococci: the search for faecal enterococci showed that 64.63% of the samples analyzed are contaminated with a concentration of these germs which fluctuates between 0 and 3.7×10^4 CFU/mL. This water containing faecal streptococci is therefore unfit for human consumption since it does not comply

with WHO standards and those in force in Benin which require a total absence of this flora in water intended for consumption. By studying the sanitary quality of drinking water in Switzerland, (Pruss, 1998 cited by [18]) confirmed a close correlation between the presence of Enteroccocus and *Escherichia coli* and the appearance of waterborne diseases. The presence of streptococci in the water sampled could be explained by the rejection of animal faeces which are left straying throughout the Commune of Sô-Ava, the proliferation of wild dumps strewing the alleys and streets.

Spores of sulphite-reducing anaerobic organisms (ASR): the average contamination of A.S.R varies from 0 to 2.5×10^3 CFU/mL with an average of 2.8×10^2 CFU/mL in the rainy season while it is between 0 and 6.8×10^3 with an average of 7.5×10^2 CFU/mL in the dry season. The overall content of A.S.R. obtained in our water samples is 80.49%, which is significantly higher than those indicated by [19]; [20] which are 16% and 6.41% in their respective studies. The high load of sulphite-reducing anaerobes in the waters studied would be justified by the low content of dissolved oxygen, which testifies to their quasi-anaerobic nature (IBGE, 2005 cited by [21]).

Salmonella*/*Shiguela: our results reveal an overall rate of 70.73% of non-compliant water samples with concentrations varying between 0 CFU/mL to 800 CFU/mL. These bacteria are agents causing gastrointestinal diseases, therefore present in the faeces of animals and humans [22]. The presence of one of these microorganisms in the water is usually the result of faecal contamination. Studies carried out by [1] on the microbiological quality of water sources in the city of Kikwit in Congo revealed contamination by *salmonella and Shigella* at concentrations varying from 2 CFU/100mL to 520 CFU/100mL with an average value of 105 CFU/100mL. In the case of our study, the presence of *Salmonella and Shigella* in the water examined can be explained by the hygienic and environmental conditions which favor the proliferation of pathogenic germs.

The risk of contamination by *Salmonella and Shigella* is very high and the use of this water can also cause health risks for consumers [23]. Most of the water withdrawn is unfit for consumption and this constitutes a potential risk for the spread of waterborne diseases. In addition, the study showed that only 14.63% do not present microbiological contamination. These results are in perfect agreement with the previous study carried out by [6] in the same study environment.

3.2. Water-Related Diseases in the Commune of Sô-Ava

Most of the water withdrawn (85.37%) is unfit for consumption and this constitutes a potential risk for the spread of waterborne diseases. The data collected at the level of the Communal health center indicate the typology and the frequency of the various affections in connection with water in the Commune of Sô-Ava. The diseases that are the subject of regular consultation in health centers are: malaria, acute respiratory infections (ARI), gastroenteritis, diarrheal diseases.

Figures 2-7 below show the evolution of the various conditions related to the lack of hygiene and sanitation recorded in health centers during this decade (2011-2021) in the Commune of Sô-Ava. A summary observation of the graphs makes it possible to affirm that all the pathologies present a peak during the years 2013 and 2014.

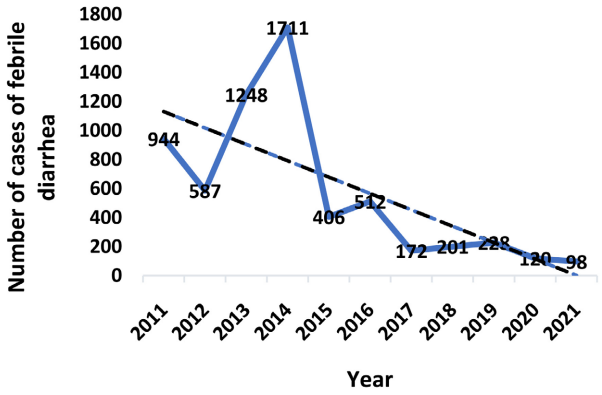

Figure 2. Annual evolution of cases of febrile diarrhea during 2011 to 2021 in the Municipality of Sô-Ava. Source: Area hospital statistical data.

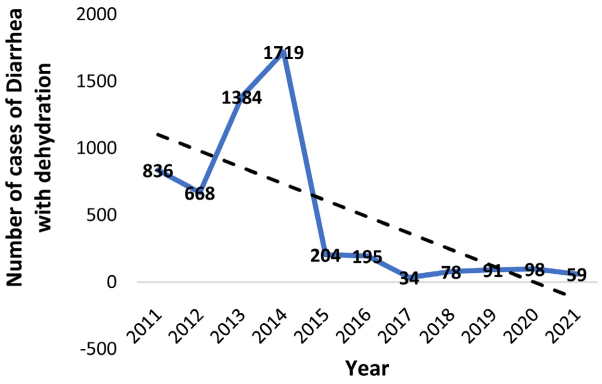

Figure 3. Annual evolution of cases of diarrhea with dehydration from 2011 to 2021 in the Municipality of Sô-Ava. Source: Area hospital statistical data.

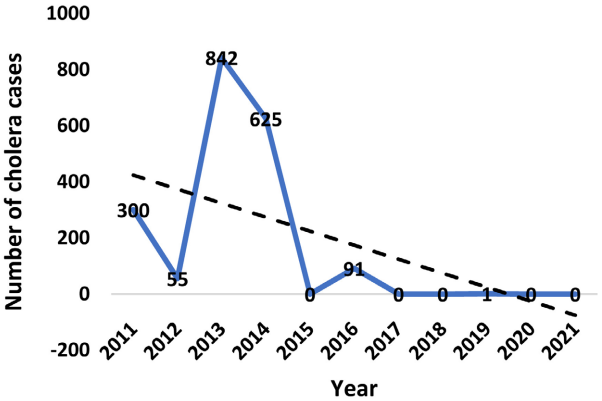

Figure 4. Annual evolution of cholera cases from 2011 to 2021 in the Municipality of Sô-Ava. Source: Area hospital statistical data.

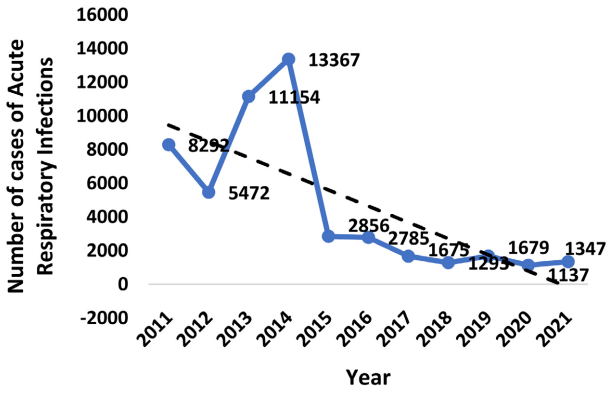

Figure 5. Annual evolution of cases of Acute Respiratory Infections from 2011 to 2021 in the Municipality of Sô-Ava. Source: Area hospital statistical data.

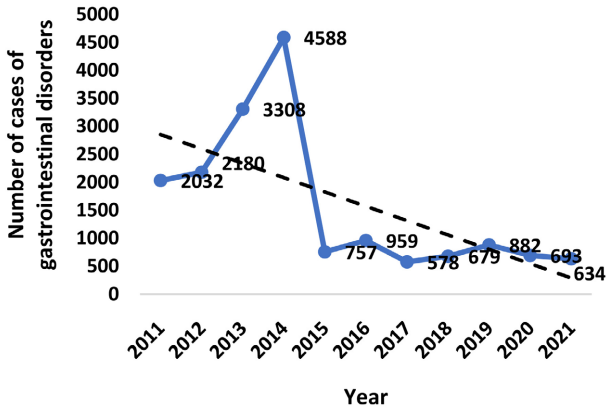

Figure 6. Annual evolution of cases of gastrointestinal diseases from 2011 to 2021 in the Municipality of Sô-Ava. Source: Area hospital statistical data.

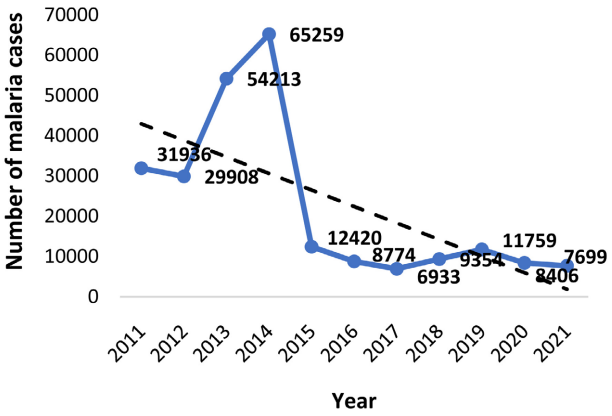

Figure 7. Annual evolution of malaria cases from 2011 to 2021 in the Municipality of Sô-Ava. Source: Area hospital statistical data.

Figures 2-7 trace the information on the pathologies relating to the ingestion of water and treated in the health centers of the Commune of Sô-Ava during the period 2011 to 2021. Analysis of Figure 2 and Figure 3 reveals that the years 2013 and 2014 were the most severe in terms of diarrheal diseases during this

period. The finding remains the same for cholera epidemics with 842 and 625 cases recorded respectively in 2013 and 2014 (**Figure 4**). With regard to **Figure 5**, the results mention that there were 11,154 and 13,367 cases of Acute Respiratory Infection which were detected in 2013 and 2014. With regard to gastrointestinal conditions, **Figure 6** also presents peaks in 2013 and 2014 with 3308 and 4588 patients identified. In view of the various data collected from the health authorities of the Health Zone/Abomey-Calavi, Sô-Ava (ZS/AS), we see that malaria remains the first cause of consultation and hospitalization in the health facilities of So-Ava. The statistics translated in **Figure 7** indicate respectively 54,213 and 65,259 cases of patients in 2013 and 2014.

The appreciation of the different figures makes it possible to realize that during this decade, the years 2013 and 2014 are those where the health facilities of the Commune of Sô-Ava recorded the greatest number of diseases due to the lack of hygiene and sanitation. This is explained by a relaxation of awareness-raising activities carried out by agents of the Basic Hygiene and Sanitation Service of the Abomey-Calavi/Sô-Ava health zone towards the population during these two years. This situation is due to a lack of human and financial resources and then to the absence of Technical and Financial Partners to support the various initiatives undertaken. Nevertheless, the increase in the rate of malaria must also be attributed to the poor management of household waste and waste water by households and then to the proliferation of uncontrolled dumps and stagnant water in the Commune. In addition, the mosquito nets distributed or used in households are sometimes not very resistant and poorly maintained. With regard to diarrhea, its increase would be due to the consumption of water contaminated by pathogenic germs. In short, the statistics on diseases due to lack of hygiene and sanitation collected in the health zone are in perfect harmony with the field survey data collected from households.

3.3. Spatial Distribution of Diseases

Apart from the temporal evolution of diseases, the study also looked at the spatial distribution of these conditions. The Municipality of Sô-Ava is part of the Abomey-Calavi/Sô-Ava health zone. The surveys carried out with the statistics department of the area hospital revealed that the populations suffer from several diseases linked to a lack of hygiene and sanitation, in particular malaria, cholera, its acute respiratory infections, diarrhea and gastrointestinal ailments. The spatial distribution by district of the main diseases linked to the lack of basic hygiene and sanitation in the Commune of Sô-Ava from 2011 to 2021 is presented in **Figure 8**.

Observation of **Figure 8** clearly shows that malaria is by far the most widespread disease in all the districts of the municipality. Analysis of health statistics data indicates that Malaria (75%), Acute Respiratory Infections ARI, (16%) and Gastrointestinal Disorders (5%) are the three main water-related diseases that have been the subject of consultation in the health facilities of the Municipality of Sô-Ava over the past twelve years. Malaria remains the first consultation and

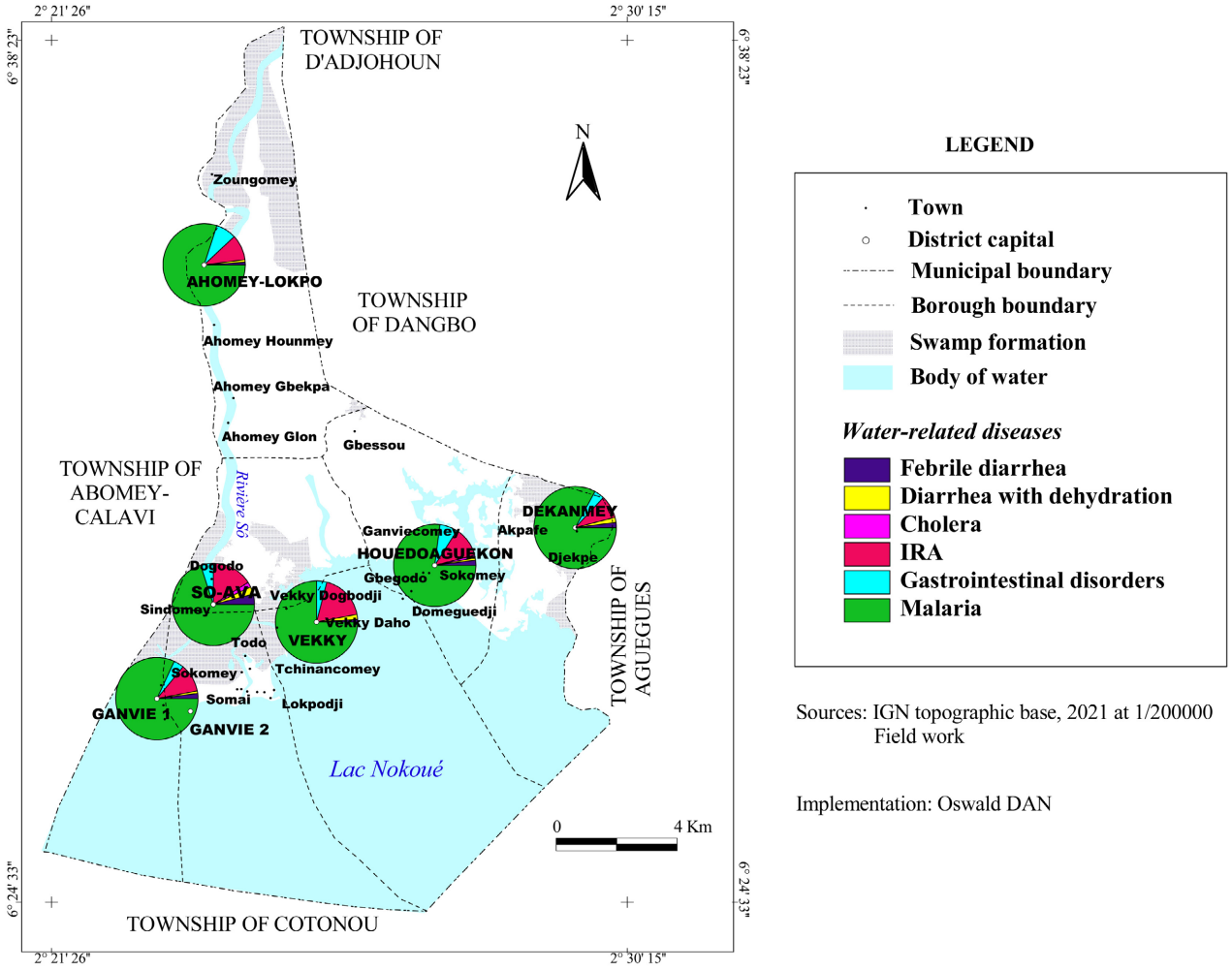

Figure 8. Distribution of the main diseases linked to the lack of hygiene and sanitation by district in the Commune of Sô-Ava from 2011 to 2021. Sources: IGN topographic Base, 2021 at 1/200,000.

hospitalization condition in the health centers of the Municipality of Sô-Ava. The high rate of malaria is explained by the fact that the environment is favorable to the development and multiplication of mosquitoes (Anopheles) which transmit plasmodium falciparum to the human body, the germ responsible for malaria which is moreover rife throughout the throughout the year by affecting vulnerable strata (women, children, the disabled, etc.). Ponds, holes, cesspools, stagnant water, tin cans containing water around houses are also breeding grounds for the hatching and proliferation of Anopheles eggs. The populations of Sô-Ava are exposed to diarrhea, cholera, gastroenteritis and acute respiratory infections. The sources of contamination of these pathologies are generally due to the ingestion of contaminated water, unmaintained food, the non-application of hygiene measures, the absence and/or poor design of latrines and septic tanks, the poor sewage disposal as well as the presence of sources of pollution, such as the proliferation of garbage dumps, defecation practices in the open air or in the water of straying humans and animals. All this constitutes a bundle of factors contributing to the deterioration of the quality of drinking water and, by exten-

sion, that of the health of populations. The information collected from respondents in the field is consistent with the statistics obtained on diseases from the DDS/Atlantique, Littoral. Even if local populations do not correctly understand all the contours of water-related diseases, they are aware of the consequences that can result from a lack of hygiene and/or the ingestion of water of questionable quality. Evidenced by the figures obtained in the field where 87.82% of respondents declared that the lack of hygiene is the factor responsible for illnesses in many households.

4. Conclusion

The data collected during this study made it possible to draw up a portrait of the microbiological quality of the water consumed by the households of Sô-Ava. Nearly 85.37% of the water samples analyzed are soiled by faecal contamination germs and should not be consumed without prior treatment. The factors that explain the bacteriological pollution of these waters are linked to the lack of hygiene (lack of a household waste and wastewater management system), but above all to the behavior of the populations (defecation in the wild, unhealthy cohabitation with animals, etc.). These poor quality waters undoubtedly constitute a threat to the health of the inhabitants of the Commune. The current level of water pollution then justifies taking measures to prevent any increase in the contamination of resources. Measures should be taken to better manage water resources.

Acknowledgements

Our sincere thanks to the International Foundation for Science (IFS) and COMSTECH for contributing to the realization of this work.

Conflicts of Interest

The authors declare that they have no conflicts of interest for this article.

References

[1] Disa-Disa, P., Ludemi, L., Nduku, F., Ekoko, G., Koy Kasongo, R. and Mulaji, C. (2020) Evaluation of the Physicochemical and Microbiological Quality of Spring Water in the City of Kikwit in the Democratic Republic of Congo. *Environmental and Water Sciences*, *Public Health and Territorial Intelligence Journal*, **4**, 451-459.

[2] Babadjidé, C.H. (2011) Pollution, Its Consequences, Its Causes and Its Impact on Human Health in the Mono River Basin in Benin. Université d'Abomey-Calavi, Godomey.

[3] Dégbey, C., Makoutode, M., Ouendo, E.M., Fayomi, B. and De Brouwer, C. (2008) The Quality of Well Water in the Municipality of Abomey-Calavi in Benin. *Environnement*, *Risques & Santé*, **7**, 279-283.

[4] Saïnou, J.E., Behanzin, P., Mariano, S. and Johnson, F.I. (2019) Study of the Physicochemical and Bacteriological Quality of Drinking Water in the Municipality of Toffo in Benin: Case of the District of Sèhouè. *Journal of Applied Sciences and Environmental Studies*, **2**, 126-138.

[5] Yapo, O., Mambo, V., Seka, A., *et al.* (2010) Evaluation of the Quality of Well Water for Domestic Use in Disadvantaged Neighborhoods in Four Municipalities of Abidjan (Ivory Coast): Koumassi, Marcory, Port-Bouet and Treichville. *International Journal of Biological and Chemical Sciences*, **4**, 289-307. https://doi.org/10.4314/ijbcs.v4i2.58111

[6] Dan, O.F., Aho, E., Ahouansou, M.M., *et al.* (2018) Study of the Physico-Chemical and Bacteriological Characteristics of Drinking Water in So-Ava, South Benin. *Journal of Water Resource and Protection*, **10**, 1031-1046. https://doi.org/10.4236/jwarp.2018.1011060

[7] Municipality of Sô-Ava (2013) Communal Hygiene and Sanitation Plan (PHAC).

[8] Municipality of Sô-Ava (2014) Communal Water Programming 2015-2017.

[9] Babadjidé, C.H., Vissin, E.W., Ouassa Kouaro, M. and Adékambi, A.C.K. (2008) Quality of Water Consumed by the Population and Waterborne Diseases in the Municipality of Kétou (Benin). *XXVIth Colloque de l'Association Internationale de Climatologie*, Benin, 81-86.

[10] Sintondji, L.O., Vissin, E., Dan, O.F., Dossou-Yovo, E.R. and Amouzouvi, D. (2017) Socio-Demographic Characteristics of Households as Determinants of Access to Water, Hygiene and Sanitation in So-Ava, Benin. *Journal of Environmental Science and Public Health*, **1**, 253-267. https://doi.org/10.26502/jesph.96120023

[11] Institut National de la Statistique Appliquée (INSAE) (2002) Second General Census of Population and Housing (Synthesis of the Results of Analysis).

[12] Institut National de la Statistique Appliquée (INSAE) (2013) Number of People in Villages and City Districts in Benin. Fourth General Population and Housing Census (RGPH, 4). http://www.insae-bj.org/recensement-population.html

[13] Municipality of Sô-Ava (2006) Communal Monograph of So-Ava.

[14] Rodier, J., Legube, B. and Merlet, N. (2009) Water Analysis. Dunod, Paris.

[15] Kihal, M., Boutiba, Z., Henri, D.E. and Al-Aboudi, A.K. (2002) Microbiological Quality of Drinking Water at Arid Zones in Adar South Algeria. *Journal Algérien des Régions Arides*, 26-30.

[16] Coumare, K., *et al.* (2017) The Bacteriological Quality of Drinking Water (Boreholes and Wells) in Three Circles of the Koulikoro Region, Mali. *Revue Malienne d'Infectiologie et de Microbiologie*, **11**, 25-32. https://revues.ml/index.php/remim/article/view/983

[17] Servais, P., Billen, G., Garcia-Armisen, T., Goncalvez, A. and Thibert, S. (2009) Microbial Contamination in the Seine Basin. Seine-Normandy Water Agency, France.

[18] Bengarnia, B., Henni, J.E., Al Aboudi, A.K. and Kahil, M. (2008) Evaluation of the Sanitary Quality of Raw Drinking Water: Case of the City of Béni-Abbès in Southwestern Algeria. Bulletin of the A.G.A.T N13. 67. LMA, University of Oran, Algeria.

[19] Sylla, K.S., Musabyemariya, B. and Sevdi, M. (2008) Comparative Study of the Bacteriological Quality of Water Used in the Fishing Industries in Senegal According to the Treatment Applied. Fisheries and Aquaculture Report, FAO, Sénégal.

[20] Traoré, E.H.B. (1996) Study of the Microbiological Quality of Water and Ice in the Fish Product Industries in Dakar. Médécine Vétérinaire, Dakar.

[21] Adjahouinou, D.C., Yehouenou, B., Liady, M.N.D. and Fiogbe, E.D. (2014) Bacteriological Characterization of Raw Wastewater from the City of Cotonou (Benin). *Journal of Applied Biosciences*, **78**, 6705-6713. https://doi.org/10.4314/jab.v78i1.13

[22] Bengarnia, B. (2016) Contribution to the Study and Evaluation of the Physico-

Chemical and Bacteriological Quality of Drinking Water in the Region of Oued Es-Saoura Case of Béni-Abbès, Ougarta and Zeghmra. Université d'Oran 1, Es Senia.

[23] El Ouali, L., Zanibou, A., Bekhti, K., Zerroug, F. and Merzouki, M. (2014) Microbiological Control Wastewater Domestic and Industrial City of Fes Morocco. *Journal of Materials and Environmental Science*, **5**, 2325-2332.