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Research Article

Factors Associated with the Quality of Drinking Water in the Commune of Adjarra in Benin, 2014

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Abstract

Water is a vital element to the life of living things, especially to that of human being. Its use for food and body hygiene purposes requires that it meets the norms of physicochemical and microbiological quality recommended by the World Health Organization. The aim of this work was to study the factors associated with the quality of drinking water in the commune of Adjarra in Benin in 2014. It was a descriptive and analytical cross-sectional study of the factors associated with the quality of drinking water in the commune of Adjarra in 2014. The population studied is made of two targets which are the primary targets (drinking water) and the secondary targets (the heads of households or their representative, hygiene and sanitation officials of the health center and the commune, the official of SONEB, the women's groups and the chiefs of villages). The non-probabilistic method and techniques of reasoned choice and comprehensiveness were used respectively for hygiene and sanitation officials of the health center, of the commune, the official of the National Water Company of Benin, the women's groups, the chiefs of villages and the six districts of the commune of Adjarra. The bacteriological analysis reveals that 9 out of 10 waters collected at the level of the supplying sources and 87.76% at the level of the storage containers are contaminated. The germs indicating pollution identified are fecal coliforms, *Escherichia coli* and ordinary germs. Autonomous and private wells and water points show a high degree of fecal coliforms and *Escherichia coli*. The study highlighted the link between the ownership status of the container used to fetch water and the quality of the drinking water (p = 0.045). The risk of contaminating the water is 7.32 times higher among households that use a dirty container to fetch water than among those who use a clean container. The factors associated with the quality of drinking water are the hygiene status of the water container and the type of water supplying source. Solving this problem requires a good communication to change the behavior of the community and a reinforcement of the drinking water supply infrastructure.

Keywords: Drinking Water; Bacteria; Contamination Index; Drinking Water Supply; Communication to Change Behavior; Benin

Introduction

Water is a vital element to the life of living things, especially to that of human being. Its use for food and body hygiene purposes requires that it meets the standards of physicochemical and microbiological quality recommended by the World Health Organization (WHO). Water, recognized as a source of life sometimes vehicles many microorganisms (bacteria, viruses, parasites and fungi) which can cause illnesses when they are ingested by human being. In developing countries close to 1.1 billion people do not have access to an improved water source. This situation remains the cause of death of 1.6 million people from diarrheal diseases every year of whom 90% are children under 5 [1]. In sub- Saharan Africa, in spite of efforts to ensure that disadvantaged groups have access to drinking water, 40% of the population still don't have access to good quality water. Thus, the most recurrent pathologies (malaria, cholera, fecal peril diseases...) are a heavy burden for vulnerable populations (children under 5, pregnant women and the elderly) [2]. In Benin, 78.4% of households use as drinking water the one that comes from an improved source of which 86.4% in urban areas and 72.1% in rural areas [3]. In 2012, waterborne diseases recorded represented 51% of all the diseases with 2,431 deaths [4]. National and regional offices in charge of energy and water in Benin are pursuing a series of capacity building actions designed to protect the health of the consumers. These include the implementation of the national water policy, of the national and regional strategies in terms of access to drinking water, the legislation, regulation and the norms regarding drinking water as well as the water code [5]. The government has also made efforts to meet the needs of the population by raising the coverage rate to 63.7% in rural areas against 67.3% for the millennium goal. Despite this achievement, a large part of this population doesn't still have access to drinking water. Diarrheal diseases (cholera, gastroenteritis, shigellosis, typhoid and giardiases) remain the leading causes of morbidity and mortality (178 deaths have been recorded for 360,006 cases in 2012), [6, 3]. In the commune of Adjarra, hygiene and sanitation conditions are precarious. Sewage and garbage are thrown in the yard, in the vicinity of the concessions and near water points. People defecate in the open air and animals roam in the concessions and around the water points. Underground and surface waters are exposed to agricultural and urban pollution. The hydro-geological nature show a high permeability of the soil, which favors quite rapid pollution of the water table. In this commune, drinking water coverage rate remains low (36%). In 2012, the incidence rate of gastrointestinal diseases was estimated at 35.4% [7]. The low coverage of drinking water, poor hygiene of the environment and the risky behaviors of the populations would be the cause of these disorders. The aim of this work was to study the factors associated with the quality of drinking water in the commune of Adjarra, in Benin.

Material and Method

The commune of Adjarra is located in the Department of Oueme, in south-east of the Republic of Benin. It is subdivided into six (06) districts and includes 48 villages and city neighborhoods districts with a population estimated at 88,687 inhabitants in 2014. The households of the commune of Adjarra are regularly supplied with water by five sources of supply. These are the traditional wells that exist everywhere, the network of the National Water Company of Benin (SONEB), water kiosks, rain water and undeveloped lakes [8].

- It was a descriptive and analytical cross-sectional study of the factors associated with the quality of drinking water in the commune of Adjarra in 2014.
- The population studied is made of two targets: the primary target which is drinking water; the secondary targets which are the heads of households or their representative, hygiene and sanitation officials of hygiene and sanitation of the health center and the commune, the official of the SONEB, women's groups and the chiefs of villages.

Are included in the sample, the traditional wells, the boreholes, the water of the SONEB, the autonomous and private water points, the public drinking fountains, the particular connections and drinking water stored at households level.

- The non-probabilistic method and the comprehensive selection of the six districts which form the commune of Adjarra have been used. Regarding the choice of households, we used the probabilistic method and the technique of three-degree random sampling.

First degree: in the six districts, we simply chose at random (without replacement) 1/10 of the 48 villages that form the commune, so 4.8 villages (rounded to 5 villages).

Second degree: at the level of each village, for the selection of the concessions, we went to the center and turned a pen that showed us the direction to follow. In this direction, we randomly selected (simple random selection) the first concession to investigate.

Third degree: in concessions where there were many households, numbers have been given to each household and one household was randomly selected.

Then one out of two concession has been investigated until the size calculated per village is reached.

The non-probabilistic method and the technique of reasoned selection have been used for the choice of hygiene and sanitation officials of the health center and the mayor office of the commune, the official of the SONEB, women's groups and the chiefs of villages.

The size of the sample has been calculated by using the SCHARWTZ formula: *$n = Z\alpha^2 p q / i^2$ for one risk of error $\alpha = 0.05$ (CI = 95%); a rate of drinking water supply of the commune of Adjarra of 36% according to the 2013 municipal water programming document, and a desired statistical precision of 10%. The size of the sample obtained is n = 89 households. In anticipation of non-respondents, the size is increased by 10% and the final size of our sample is 98 households.

We conducted a proportional allocation of the size of the sample on the five villages to investigate according to the number of households per village.

Moreover, the five chiefs of village, the five groups of women of the villages (for focus groups), the two hygiene and sanitation officials from the health center and the mayor office of the commune of Adjarra and the official of the SONEB of the said commune have been interviewed. Ten water supply sources (two per village) of the households have been selected, as well as 98 water stocks in the households have been collected for analysis.

- **The dependent variable** is the quality of the drinking water. It has two modalities: good or bad.
- **Independent variables** were demographic factors (gender, age, size of household, profession, level of education, monthly revenue, cost of water) ; environmental factors (distance between the water point and the household, hygiene around the water point) ; behavioral factors (type of drinking water supply source, treatment of drinking water, hand washing, knowledge of their link between water and disease, hygiene status of the container used to fetch drinking water, protection of water during transport, protection of drinking water during storage); factors related to health system (treatment of the wells, education of the population about water, hygiene and sanitation).
- **Operational aspects of the variables**

  The dependent variable which is the quality of drinking water has been operationalized as follows:

  - samples of drinking water have been collected at the level of storage containers and analyzed in laboratory;

  - any water which has presented nitrite, nitrates and fecal coliforms (*Escherichia coli*) contents which doesn't meet the norms recommended by the WHO is considered as of poor quality.

- **Techniques and data collection tools** have been the use of documents for consultation registers, the programming document for water supply; individual interview for the official of the SONEB, the hygiene and sanitation official of the health center, water, hygiene and sanitation officer of the mayor office and the chiefs of villages; the focus group for the women of the villages; observation of the environment of the households.

Table I. Operational aspects of a few independent variables which influence the quality of drinking water in the commune of Adjarra in 2014 and which deserve to be specified.

Variables	Modalities
Monthly income	<10 000 CFA francs ; 10 000-30000 CFA francs ; >30000 CFA francs
Cost of water (Daily expense for water)	Less than 100 CFA francs ; More than 100 CFA francs
Type of source of drinking water supply	Village water conveyance/ tape ; Traditional well; Autonomous and private point; SONEB ; Borehole; Public drinking fountain; River; Water tank; others
Treatment of drinking water	Boiling; Filtering; Bleach; Aquatab ; others
Characteristics of wells	Closed; Open; Edge <1.5m ; Edge >1.5m
Hygiene around the water point	Presence of garbage around water point; Presence of latrines/faeces around water point; Distance between latrines and water point; Presence of sewage around water point

▪

▪ Collection and conservation of drinking water samples;

The samples were collected with all the necessary aseptic conditions into sterile glass flasks with wide opening, of about 500 ml of capacity, by leaving an air space of at least 2.5 cm. At the level of wells and autonomous and private water points, collection was done in sterile flasks to which was attached a string allowing them to go down. The water was collected from about 50 cm from the free surface. Water from village water conveyance with a tap, cleaning with alcohol and cotton was first done, then a sterilization with a Bunsen burner. Before the takink of samples, we left water flow for 3 minutes.

The water samples collected were kept for on average 4 hours in a refrigerated cooler and were sent to the laboratory for Water and Food analysis of the Direction of Health of the Atlantic and Littoral in Cotonou.

- Operating method

✓ Analysis of physico chemical paramètres:

- physical parameters, namely temperature, hydrogen potential (pH), electrical conductivity (Cs) and the total of dissolved solids were measured in situ by using a WTW 350i-brand laptop with multiple parameters provided by VWR with a relative accuracy of ± 0.004 / ± 0.01pour pH and ± 0.5% for conductivity;

- nitrates (NO3-), nitrites (NO2 -), ammonia nitrogen (NH4 +) are determined by colorimetric dose using a spectrophotometer (DR/2800) with wavelength raging from 340-900 nm with an accuracy of ± 1.5 nm and a range of photometric measurement of ± 3 absorbance. The reagents used are HACH kits. The chemical reactions involved are the following: the diazotization method through Nitri Ver 3 for nitrites with a detection limit of 0.002 mg/L, the cadmium reduction method using the Nitra Ver 5 for nitrates of 0.1 mg/L as detection limit, the NESSLER method for ammonium with a limit below 0.002 mg/L [9, 10].

Bacteriological parameters analysis

It has been done in three stages:

1-Membrane filtration which consisted in passing 100 ml of water through a cellulosic membrane which has pores of uniform diameter equal to 0.45 micron. After filtration, this sterile membrane is put in a petri dish containing a culture medium. Two culture media were used to search the germs: the Rapid -E. coli (REC) medium for the coliforms and the Plate Count Agar (PCA) medium for the common germs.

2-Colony count with a binocular microscope after incubation of the Petri dishes for 24 to 48 hours. This count is done after laying on the stage the seeded Petri dish, and counted at a magnification of 45x using a hemoleucometer while identifying with a felt-tip pen the colonies in order to avoid forgetting or counting twice some colonies [11, 12].

3-Bacteria identification was done by the gallery API 20E (bio Mérieux sa 69280 Marcy-l'Etoile/France) made of 20 microtubes ready to be used and which help conduct 23 biochemical tests to identify Gram bacilli -, belonging to the family of the Enterobacteriaceae or not. This method consists in collecting a well isolated suspect colony to make it the inoculum from sterile distilled water. The inoculum is distributed in the microtubes containing dehydrated substrates of the API 20 E gallery. This gallery is incubated in an incubator at 37° C for 24 hours. The reactions occurred during the incubation period are translated by spontaneous or revealed changes in colors reagents (tryptophan deaminase: TDA, JAMES for indole, VP1 + VP2 for sodium pyruvate) are added. Reading is done using a reading table and identification is obtained by an analytical catalogue.

▪ **Data analyses and treatment**

Data have been analyzed using the software Stata 11. The quantitative variables were described by their frequency, their average, + or - standard deviation if the distribution is normal. The qualitative variables were described according to their frequency and proportion. We have conducted a uni-variate analysis to look for the existence of an association between the qualitative dichotomous dependent variable and the independent variables. The association was considered significant for the independent variables with a value of p value ≤ 0.05.

To assess the strength of this association, we used the Odds Ratio (OR). The variables that showed an association with a p-value ≤20% were included in the multivariate model. In the multivariate analysis, we used the modeling strategy "descending step by step" where we eliminated the independent variables with a p value higher that the significance threshold set at 5% in order to get the final model. The adequacy of the logistic model has been tested using the Hosmer-Lemeshow test.

▪ **Ethical aspect**

An authorization to conduct the survey has been obtained from the municipal authorities and those of the Departmental Direction of Health of Oueme/Plateau and from the institutional ethics committee.

Free and informed consent was required from all the people surveyed after they have been informed about the nature and objectives of the survey. Moreover, confidentiality and anonymity have been respected.

Results

Types of drinking water supply source of the households

Of the 98 households surveyed, 9.18% use water supply as drinking water; 21.43% use taps and autonomous water points and 69.39% use the traditional wells.

Education background of people surveyed in the households (n=98)

According to the distribution, 23.47% of the respondents are of primary education level, 36.73% of secondary level, 4.08% of higher level and 35.71% have not been to school.

Profession of people surveyed in the households (n=98)

Among the people surveyed in the households, 11.22% were civil servants, 5.10% were farmers, 23.47% were artisans, 38.78% were sellers, 16.33% were unemployed and 5.10% others.

Table II. Results of the physical analysis of the waters collected at the level of the supply sources of the respondents in the commune of Adjarra in Benin in 2014 (n=10).

Physical parameters	WHO norms	Modalities	n	Average +/- SD
Temperature (°C)	25	≤25 >25	0 10	30.00 +/-0.87
pH (pH Unit)	6.5-8.5	<6.5 6.5-8.5 >8.5	4 6 0	6.55 +/-1.71
Conductivity (μS/cm)	2000	≤2000 >2000	10 0	150.72 +/-31.73
Total of dissolved solids (mg/L)	<600	<600 ≥600	10 0	73.80 +/-18.79

Legends: SD= standard deviation n= size

Table III. Results of the physical analysis of the waters collected at the level of the respondents' storage containers in the commune of Adjarra in Benin in 2014 (n=98).

Physical parameters	WHO norms	Modalities	n	Average +/- SD	Median (Q1-Q3)
Temperature (°C)	25	≤25 >25	0 98	30.43 +/-0.76	
pH (pH unit)	6.5-8.5	<6.5 6.5-8.5 >8.5	33 65 0	6.23+/-0.55	
Conductivity (μS/cm)	2000	≤2000 >2000	98 0		54.40 (35.00-105.50)
Total of dissolved solids (mg/L)	<600	<600 ≥600	98 0		27.10 (17.20-48.80)

Legends : SD= Standard Deviation, Q1= quartile 1, Q3= quartile 3, n=size

Table IV: Results of the chemical analysis of the waters collected at the level of the supply sources of the respondents in the commune of Adjarra in Benin in 2014 (n=10).

Chemical parameters	WHO norms	Modalities	n	Average +/- SD
Nitrates (mg/L)	45	≤45 >45	10 0	7.07+/-3.23
Nitrites (mg/L)	0.1	≤0.1 >0.1	10 0	0.03 +/-0.03
Ammonium (mg/L)	0.5	≤0.5 >0.5	10 0	0.14 +/-0.06

Legends : SD= Standard Deviation, n= size

Table V: Results of the chemical analysis of the waters collected at the level of the respondents' storage containers in the commune of Adjarra in Benin in 2014 (n=98).

Chemical parameters	**WHO norms**	**Modalities**	**n**	**Average +/- SD**
Nitrates (mg/L)	45	≤45 >45	98 0	2.95 +/-2.31
Nitrites (mg/L)	0.1	≤0.1 >0.1	98 0	0.02 +/-0.01
Ammonium (mg/L)	0.5	≤0.5 >0.5	98 0	0.11 +/-0.042

Legends : SD= Standard Deviation, n=size

Table VI: Results of the bacteriological analysis of waters collected at the level of the supply sources of the respondents in the commune of Adjarra in Benin in 2014 (n=10).

Bacteriological parameters	WHO normes	Modalities	n	Median (Q1-Q3)
Common germs	50/ml	≤50 >50	10 0	336.00 (284-17680)
Fecal coliforms		≤0 >0	1 9	255.00 (192.50-120128.00)
Escherichia coli		≤0 >0	1 9	20.00 (8-390)

Legends: Q1= quartile 1, Q3= quartile 3, n= size

Table VII below summarizes the results of the bacteriological analysis of waters collected at the level of the respondents' storage containers.

All the water samples collected at the level of the households' storage containers showed a count of common germs higher than the one recommended by the WHO, which is 50 / ml.

Table VII: Results of the bacteriological analysis of waters collected at the level of the supply sources of the respondents in the commune of Adjarra in Benin in 2014 (n=98).

Bacteriological parameters	**WHO norms**	**Modalities**	**n**	**Median (Q1-Q3)**
Common germs	50/ml	≤50 >50	0 98	4587.10 (450-10001)
Fecal coliforms	0/100ml	≤0 >0	12 86	720.00 (480.00-1630.00)
Escherichia coli	0/100ml	≤0 >0	12 86	20.00 (8.00-390.00)

Legends: Q1= quartile 1, Q3= quartile 3, n =size

Of the 98 water samples, 86 showed a fecal coliforms count higher than the norm recommended by the WHO, which is 0/100ml.

Of the 98 water samples, 86 showed a count of *Escherichia coli* higher than the norm recommended by the WHO, which is 0/100ml.

- **Uni-variate analysis**

The factors associated with the quality of water in uni-variate analysis are presented in the table VIII below:

- **Multi-variate analysis**

At the end of the uni-variate analysis, variables that presented an association with one p-value ≤20% and which have been included in the multivariate model are: the level of education, the type of source of water supply, the hygienic status of the container used to fetch water, hand washing, monthly income, awareness raising.

The result of the multivariate analysis gives the following table.

Table VIII: Association between the quality of drinking water and the socio-demographic, environmental, behavioral factors, and those related to the health system in the commune of Adjarra in 2014.

Independent variables			Quality of drinking water		OR	CI 95%	p-value
	Bad (n=86)	%	**Good (n=12)**	**%**			
Sex							
Male	22	25.6	3	25	1		
Female	64	74.4	9	75	0.96	0.24-3.90	**0.965**
Ages							
18-25 years old	16	18.6	3	25	1		
26-60 years old	62	72.1	8	66.7	1.45	0.35-6.11	**0.610**
60 years old and above	8	9.3	1	8.3	1.5	0.13-16.81	**0.742**
Height							
≤ 6	66	76.7	9	75	1		
> 6	20	23.3	3	25	0.91	10.01-13.83	**0.894**
Occupation							
Farmer	1	1.2	4	33.4	1		
Civil servant	10	11.6	1	8.3	2.5	0.12-50.44	**0.550**
Artisan	20	23.3	3	25	1.67	0.14-20.40	**0.689**
Seller	33	38.4	2	16.7	1.65	0.15-17.91	**0.681**
Unemployed	15	17.4	1	8.3	3.75	0.19-74.064	**0.385**
Others	7	8.1	1	8.3	1	0.05-22.18	**1.000**
Level of education							
Primary	18	21	5	41.6	1		
Secondary	34	39.5	2	16.7	4.72	0.83-26.81	**0.080**
University	2	2.3	2	16.7	0.28	0.31-2.50	**0.253**
Illiterate	32	37.2	3	25	2.96	0.63-13.87	**0.168**
Type of drinking water supply source							

Village water supply	1	1.2	8	66.7	1		
Traditional wells	65	75.5	3	25	173.33	16.05- 1871.60	**0.000**
Autonomous and private water points	20	23.3	1	8.3	160	8.89-2280.46	**0.001**
Distance between water supply sources and households							
≤ 1km	72	83.7	10	83.3	1		
> 1km	14	16.3	2	16.7	0.97	0.19-4.93	**0.973**
Water container hygiene							
Clean	25	29.1	9	75	1		
Dirty	61	70.9	3	25	7.32	1.93-29.30	**0.005**
Knowledge of link between water and disease							
Yes	43	50	8	66.7	1		
No	43	50	4	33.3	2	0.56-7.13	**0.286**
Protection of container used for water conservation							
Closed	10	11.6	10	83.3	1		
Open	76	88.4	2	16.7	1.52	0.29-7.96	**0.62**
Water treatment							
Yes	8	9.3	1	8.3	1		
No	78	90.7	11	91.7	0.88	0.10-7.78	**0.913**
Hand washing							

Yes	21	24.4	8	66.7	1		
No	65	75.6	4	33.3	6.19	1.69-22.64	**0.006**
Water cost							
Low	6	7	1	8.3	1		
High	80	93	11	91.7	1.21	0.13-11.04	**0.864**
Monthly income							
<10 000	35	40.7	1	8.3	1		
10 000-30 000	24	27.9	3	25	0.23	0.22-2.33	**0.213**
>30 000	27	31.4	8	66.7	0.1	0.01-0.82	**0.032**
Awareness raising							
Yes	22	25.6	8	66.7	1		
No	64	74.4	4	33.3	5,81	1,59-21,23	**0.008**

Table IX: Factors associated with the quality of drinking water in Commune of Adjarra, (final model), Benin 2014

	Quality of drinking water				**OR**	**CI 95 %**	**p-value**
Independent variables	Bad **(n=86)**	%	Good **(n=12)**	%			
Hygienic status of drinking water handling vessel							
Clean	25	29	9	75	1		
Not clean	61	71	3	25	9.94	1.05- 94.22	**0.045**
Type of water supply source							
Village water supply (tap)	1	1.2	8	66.7	1		
Traditional wells	65	75.6	3	25	207.68	13.07- 3284.22	**0.000**
Autonomous water points	20	23.2	1	8.3	234.29	8.75-6274.95	**0.001**

Discussion

The techniques used for data collection tools, allowed us to determine:

- The types of source of water supply in Adjarra;

- The quality of drinking water in households and sources of supply;

- The factors associated with the quality of drinking water.

Probabilistic sampling technique was used for the selection of households, ensuring the representativeness for inference in the community. Data collection tools were in accordance with the study design.

To reduce the language barrier, we conducted training for enumerators and pre-tested tools in other town by checking the answerability and the appropriateness of questions. The result of the pre-test informed the investigator on the required adjustments in the questionnaire. Regular supervision of respondents, observation and control of the data collected helped ensure quality.

The lack of means of verification of certain information mentioned by householders like hand washing after defecation and treatment of drinking water, may result in limitation of the present study.

In our study, the temperatures of waters collected at the level of the 10 sources of water supply and the 98 households vary from 29.5 ° C to 31.6° C with an average of 30° C and are beyond the norm of 25° C recommended by the WHO. These results are close to those found by Degbey C et al. in 2008 in the commune of Abomey Calavi in Benin, where temperatures varied between 28.3 and 29.9° C with an average of 28.56° C [13]. These high temperatures could be explained by the influence of ambient heat on the water withdrawn and also by the geothermal gradient in the study area. It should be important to mention that water whose temperature is between 25 and 28° C is an adequate for microorganisms' multiplication, which means that the rise in temperature of water withdrawn creates favorable conditions for water pollution in the tropical. More than half of the waters collected (66.33%) have a pH consistent with the norm recommended by the WHO (6.5-8.5) with an average pH of 6.5. This result is close to that of a study conducted by Mek OC et al. in 2011 in Mauritania where the pH are close to neutrality [14]. Waters are poorly mineralized with an average electrical conductivity of 150.72µS/cm. The results are below the norm recommended by the WHO (2000µS/cm) and are consistent with those found by Ahoussi KE et al. in 2013 in the village of Mangouin-Yrongouin in Côte d'Ivoire where the average conductivity is 152.90µS/cm [15].

The results of the chemical analysis of the waters collected reveal the presence of chemical elements such as nitrites, nitrates and ammonium below the norms of the WHO (0.1 mg/L, 45mg/L and 0.5mg/L) with respectively average values of 0.02 mg/L, 2.95mg/L and 0.11 mg/L. Similar results were reported by Mek OC et al. during a study conducted in 2011 in Mauritania [14]. The presence of nitrates in drinking water could have an origin related to human activities (agriculture with the use of manure) or a natural origin resulting from the processing of nitrogen in waters and soils. The bacteriological analysis reveals that 9/10 of the waters collected at the sources of water supply and 87.76% of the storage containers are contaminated. The germs indicating pollution that have been identified are fecal coliforms, *Escherichia coli* and common germs. Wells and autonomous and private water points show a high degree of fecal coliforms and *Escherichia coli,* with an average of 255/100ml and 20/100ml, respectively. These results are similar to those found by Abdelrahman et al. in Sudan in 2011, Belghiti et al. in Morocco in 2013, Chouki WK in Benin in 2007 with 141/100ml for *Escherichia coli*, Degbey C et al. in Benin in 2011 and Ahoussi KE et al. in 2013 in Côte d'Ivoire with a degree of 500/100 ml for *Escherichia coli* [16, 17, 18, 19, 20].

Following factors could explain this bacteriological pollution of water withdrawn:

- Factors related to the environment and behavior of the population due to the absence of a system of collection, treatment and disposal of wastewater;

- Factors associated to the system of collection, evacuation ant treatment of houseware garbage. Water collected at the level of the village water supply (tap), source of supply for some households, did not show any germ but suffered from a contamination during storage in the households. The results are identical to those of Harris AR et al. in 2013 in Tanzania where water which is potable at source got contaminated when using the container to fetch water and after filling of the storage container. This contamination could be explained by the poor hygiene of the containers used to collect water. The common germs exist in all the samples of water collected. These results are identical to the one obtained in 2008 by Degbey C et al. in the commune of Abomey-Calavi in Benin [13]. The respondents (68.37%) use a dirty container to collect water and this is not without consequences on the quality of the water. So, water can be potable at source and get polluted during transportation or storage. Our study highlighted the link between the cleanness status of the container used to fetch water and the quality of the drinking water ($p = 0.045$). The likelihood of contaminating water is 7. 32 times higher in households that use a dirty container to fetch water than in those who use a clean container. Our results are consistent with a study conducted in 2011 by Abdelrahaman et al. in Tanzania which found that drinking water collected at source by the population is contaminated during its storage and its handling at home. Our study also showed a statistically significant relationship between the type of source of water supply used ($p = 0.000$), the monthly income ($p = 0.017$), the education of the population about water, hygiene and Sanitation (0.041) and the quality of drinking water consumed in the households. Similar results were obtained in a study conducted in 2011 in a rural commune of Senegal by Faye A et al. with a $p < 0.05$ [22]. The risk of water contamination is 173.33 times higher among households that use traditional wells than among those which use tap water. The risk of water contamination decreases by 10 times among people who have a high income compared to those with low income. The risk of water contamination is 5.81 times higher among people who are not sensitized compared to those who are sensitized. Hand washing after defecation is not practiced among 70.41% of the households. Our study highlighted a statistically associative link between the fact of not washing hand

and the quality of drinking water (p = 0.006). This result is consistent with that of a study in the Mekong Delta in southern Vietnam by Herbst S et al. in 2009, which showed that hygienic measures such as hand washing are not put into practice in an inopportune manner due to a misconception of risks and/or a lack of knowledge of the relationships between water and disease as well as anchored habits.

The risk of water contaminating among people who do not wash their hands after defecation is 6.19 times higher than among those who wash their hands. Many other factors could explain a water contamination. This includes among other things the lack of a system to collect, treat and dispose of garbage and sewage, defecation in the open air, the shallowness of the water table (6 to 15m according villages).

The presence of fecal coliforms (*Escherichia coli*) denotes fecal contamination and remedial actions must be taken immediately. The size of the household is not statistically associated with the quality of the drinking water. This result is contrary to a study conducted in the commune of Klouékanme in Benin by Agossou Y and Mc Garvey et al. in 2008 in Ghana [24, 25]. This difference could be explained by the size of our sample which is smaller than that of his study. The level of education is not statistically associated with the quality of the drinking water. This result is contrary to the one obtained by Faye A et al. during a study conducted in a rural community in Senegal in 2011. In our study, treatment of the drinking water is not statistically significant to the quality of the water. Its absence could be a favorable condition to maintain alive pathogenic germs that cause diseases.

Conclusion

our study revealed that in 2014, in the commune of Adjarra, 87.76% of the households have water of poor quality. Also, out of the households' 10 sources of water supply collected, 9 are contaminated. The factors associated with the quality of the drinking water are the hygienic status of the container used to handle water and the type of source of water supply. The solution to this problem requires a good communication in order to change the behavior of the community and a reinforcement of the drinking water supply infrastructure.

Recommendations

Based on our findings and according to the discussion we make the following recommendations:

-Improve the drinking water supply policy, waste management, agriculture and general sanitation (latrines);

-On the basis of a structural complementary study, develop a five year plan for water supply with the active participation of the population;

-Implement the five-year plan in collaboration with the population through operational plan.

The main lines of action are the following:

-Ensure drinking water through a systematic and periodic treatment of water collected using the required amount of chlorine dosing to provide effective residual chlorine;

-Organizing monitoring of water quality through sampling and chemical and bacteriological analysis;

-Avoid water contamination by adopting structural measures that eliminate factors of contamination.

References

1. Organisation Mondiale de la Santé. La santé et les services d'approvisionnement en eau. 2014.

2. Organisation Mondiale de la Santé, Fonds des Nations Unies pour l'Enfance. Rapport du programme commun: Principaux faits. 2012.

3. Institut National de la Statistique et de l'Analyse Economique Benin. Démo graphic and Heath Survey (EDSB-IV Cotonou INSAE. 2013.

4. Ministère de la Santé. Direction de la Programmation et de la Prospective. Service des Statistiques et de la Documentation. Annuaire des statistiques sanitaires. Cotonou MSP. 2012.

5. Ministère de l'Energie et de l'Eau. Politique Nationale de l'Eau. Cotonou. 2008.

6. Organisation Mondiale de la Santé. Faits et chiffres sur la qualité de l'eau et la santé. 2003.

7. Ministère de la Santé. Direction Départementale de la Santé de l'Ouémé et du Plateau. Zone Sanitaire Avrankou- Adjarra -Akpro- Missérété. Annuaire des statistiques sanitaires. Porto Novo ZS3A. 2012.

8. Commune d'Adjarra. Monographie de la Commune d'Adjarra. Bénin. PDAC. 2006.

9. HACH. Méthodes d'analyse : Colorimétrie. 1997-2009.

10. Organisation Mondiale de la Santé. Directives sur la qualité de l'eau de boisson. Genève. OMS. 2004.

11. Présidence de la République du Bénin. Décret n°2001-094 du 20 février 2001 fixant les normes de qualité de l'eau potable au Bénin.

12- Rodier J. L'analyse de l'Eau : eaux naturelles, eaux résiduaires, eaux de mer : physico-chimie, bactériologie et biologie.9ème éd. Paris : Dunod ; 2009.

13. Dégbey C, Makoutodé M, Ouendo EM, Fayomi B, De Brouwer C. La qualité de l'eau de puits dans la commune d'Abomey-Calavi au Bénin. Environnement Risques Santé. 2008, 7(4): 279-83.

14. Mek OC, El Kacemi K, Idrissi L. Caractérisation physico-chimique des eaux d'alimentation de la ville de Tijikja (Mauritanie). International Journal of Biological and Chemical Sciences. 2011, 5(5).

15. Ahoussi KE, Koffi YB, Kouassi AM, Soro G,Biemi J. Etude hydrochimique et microbiologique des eaux de source de l'ouest montagneux de la Côte d'Ivoire : Cas du village de Mangouin-Yrongouin (sous-préfecture de Biankouman). Journal of Applied Biosciences. 2013, 63: 4703–4719.

16. Abdelrahman AA, Eltahir YM. Bacteriological quality of drinking water in Nyala, South Darfur, Sudan. Env Mon. 2011, 175(1-4): 37-43.

17. Belghiti ML, Chahlaoui A, Bengoumi D, El Moustaine R. Etude de la qualité physico-chimique et bactériologique des eaux souterraines de la nappe plio-quaternaire dans la région de meknès (Maroc).

Larhyss Journal. 2013, 4: 21-36.

18. Chouti WK. Evaluation de la qualité des eaux des puits couverts munis de pompe dans la commune de Porto- Novo : Univ d'Abomey-Calavi. 2007.

19. Degbey C, Makoutodé M, Agueh V, Dramaix M, de Brouwer C. Les facteurs associés à la qualité de l'eau de puits et la prévalence des maladies d'origine hydrique dans la commune d'Abomey-Calavi au Bénin.

Santé. 2011, 21(1): 47-55.

20. Harris AR, Davs J, Boem AB. Mechanisms of post-supply contamination of drinking water in Bagamoyo, Tanzania. Water Health. 2013, 11(3): 543-554.

21. Faye A, Ndiaye NM, Faye D, Tal-Dia A. Water quality and personal hygiene in rural areas of Senegal. Med Trop. 2011, 71(1): 45-48.

22. Kassenga GR. The health-related microbiological quality of bottled drinking water sold in Dar es Salaam, Tanzania. Water Health. 2007, 5(1):179-185.

23. Herbst S, Benedikter S, Koester U, Phan N, Berger C et al. Perceptions of water, sanitation and health: a case study from the Mekong Delta, Vietnam. Water SCI Technol. 2009, 60(3): 699-707.

24 -Agossou Y. Facteurs associés à la qualité de l'eau de boisson dans les ménages de la commune de Klouèkanmé au Bénin. Ouidah: IRSP; 2009.

25. McGarvey ST, Buszin J, Reed H, Smith DC, Rahman Z et al. Community and household determinants of water quality in coastal Ghana. J Water Health. 2008, 6(3): 339-349.