Original Research Article

Assessment of the Bacteriological Quality of an Aquatic Ecosystem in South of Benin: Case of Ahémé Lake

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A B S T R A C T

The study aims to assess the bacteriological quality of water of the Ahémé lake, the second most productive lake of Benin, after Nokoué lake. For this, 21 points were sampled on the lake during two campaign periods during the year 2016: the low water period (March) and the flood period (September). A total of 42 water samples were taken and their charges in total flora, thermotolerant and total coliforms, *Staphylococcus* and *Salmonella* were determined. Despite the absence of salmonella in all those withdrawn waters, average charges recorded in both periods (low water period as flood period) for these counted germs were not consistent with standards. Mean charges expressed in CFU/mL of the total flora, total and thermotolerant coliforms and staphylococci recorded at low water were respectively of $19.69.10^8$, $17.49.10^5$, $12.07.10^5$ and $12.40.10^3$. These values increased and reached respectively $29.56.10^8$, $22.41.10^5$, $15.84.10^5$ and $27.53.10^3$ during the flood. Waters of Ahémé lake are considerably loaded with germs of fecal contamination. This lake pollution affects the quality of fishery products in it and perhaps also a potential source of disease.

Introduction

Water is the basis of all the life. It is at same time the habitat, food, means of production in the agricultural sector as in industry, transport route for people and goods, therefore indirectly it is a commercial product (Dovonou *et al.*, 2011). Such is the case of the waters of Lake Ahémé, the second largest lake in Benin which serves as dwelling place for lake people whose

principal income generating activity is fishing) (Dègnon *et al.*, 2012; Adigun, 2013).

In consideration of the socio-economic importance of Lake Ahémé, a high concentration of the population is noted in and around this lake. These people reject daily, the solid and liquid wastes which

come from their various activities in the lake or on the banks. The throwing out of the urban waters which come from the waterside agglomerations and the contributions of Couffo river, are also sources of contamination of the ecosystem (Dimon *et al.*, 2014).

In addition, within the context of their fishing activities, large quantities of branches for the fish traps construction commonly called "acadjas" are routinely abandoned or dumped by fishermen in the water (Dovonou *et al.*, 2011; Sachi *et al.*, 2016).

The lake is facing serious environmental problems including pollution (Agonkpahoun, 2006; Dimon *et al.*, 2014). What may be the cause of the disappearance of certain animal aquatic species and/or plant and therefore carry away the malfunctions of the food chain (Dimon *et al.*, 2014).

The objective of the study is to assess the bacteriological quality of the lake water Ahémé by determining of their mean loads in total flora, thermotolerant and total coliforms, staphylococcus and salmonella.

Materials and Methods

Frames of the study

The geographic cadre of this study is Lake Ahémé (Figure). It is located in southwestern of Benin. Between the parallel 6 ° 20 'and 6 ° 40' North and meridians 1 ° 55' and 2° East and with approximately an area of 80 km2 at low water, it stretches between Topka-Domé and Guézin according to the North-East-South-West direction and between Topka-Domé and Bopa following the North-South direction. It serves as a natural boundary between the departments

of Mono and Atlantic. Ahémé the lake is a valley that receives Couffo river waters in the northern part and is connected to the coastal lagoon of Grand-Popo by the channel called "Aho" (Niyonkuru and Lalèyê, 2012; Dèdjiho, 2014).

Microbiological analyzes were done in the Laboratory of Microbiology and Food Technology (LA.MI.TA.) based in Cotonou (Benin).

Materials

Several materials were used in this study as: the field materials which include a GPS (to identify sampling points), 1L bottles of sterilized water ballasted (for sample collection), an icebox with icicles (for storing samples), a water analysis suitcase including a digital peak thermometer (-50 ° C to 150 ° C to measure the temperature of the water) and an electronic pH meter (Hanna Instruments HI 96107) previously calibrated with buffer solutions of pH 4.1 and 7.1 for measuring the pH of water; mineral material consisting essentially of the drawn water samples; and standard laboratory equipment used for various microbiological analyzes.

Sampling

The data for this study come from 21 sampling points on the lake Ahémé symbolized P1 to P21 (Figure) whose geographical coordinates are presented in Table 1. These sampling points are obtained after the Lake mesh. The size of a mesh is 4 km^2 and vertex of each mesh constituted our water sampling sites. Two sampling campaigns were conducted. A first campaign unrolled during the low water period in March 2016 and a second during the flood period in September 2016. A total of 42 water samples were taken. Bottles of

1L of ballasted water sterilized and provided of a rope have been used in order to draw water in depth. The samples have been named carefully with all necessary information and have immediately been routed to the laboratory in an icebox with ice.

Assessment of microbiological quality

Microbiological analysis consisted in counting the total mesophilic flora on PCA (Oxoid CM 0325) incubated at 30°C during 48 to 72 h (NFV 08-051); total coliforms (NFV 08-060) and thermotolerant coliforms (NFV 08-050) on VRBA-Oxoid CM 0107 (Violet Red Bile Agar) incubated respectivelly at 37°C and at 44°C during 24 h; Staphylococcus on Baird Parker Agar (BP-Oxoid CM 0275) at egg yolk and potassium tellurite incubated at 37°C during 24 h (NFV 08-057-1) and Salmonella (NF EN ISO 6579) on SS Agar according to the following stages: pre enrichment (incubation solutions mothers at 37°C for 20 h); on enrichment broths Muller Koffman incubated at 37°C for 24 h and Rappaport Vassiliadis incubated at 37°C for 24 hours; isolation on Hektoen agar and incubated at 37°C for 24 h and Xylose Lysine Deoxycholate Agar (XLD) incubated at 41°C for 24 h; identifying on the urea-indole medium at 37°C for 2 h. The counting was done by counting the colonies (Guiraud and Galzy, 1980). Microbiological analyzes were performed in triplicate on each sample.

Statistical analyzes of data

The Excel software was used to perform the calculations. Analysis results were processed using Minitab 16.0 software that permitted to make analysis of variance (ANOVA) and Tukey's test for comparison of means. The significance level of 5% is selected (p <0.05).

Results and Discussion

Physicochemical parameters

The mean values of the temperature and pH of the water obtained on the lake were shown in Table 2.

The mean values of pH recorded were between 7.80 and 8.45 during the low water and between 6.55 and 7.25 during floods. For all sampling sites, the average pH of the water obtained during low water was higher than that recorded during the flood period and the difference was 1.23 (Table 2). Similarly, the mean values of the recorded temperature ranged between 28.50 and 29.15°C at low water and between 27.0 and 27.75°C during floods. For all sampling sites on the lake, its average temperature during the low water period was higher than that recorded during the flood period and the difference between these two averages was 1.50°C (Table 2).

Microbiological parameters

Tables 3 and 4 presented the results of bacteriological analyzes of water taken at different points of the lake respectively during low water and flood.

In low water as in flood, a major significant difference (p> 0.05) was observed between the mean charges obtained at different sampling sites for the total flora, staphylococcus and total coliforms and thermotolerant except for salmonella which noted the total absence in 25mL of all water samples.

The mean charges of the total flora obtained ranged $14.92.10^8$ and $24.74.10^8$ CFU/mL during low water and between $24.22.10^8$ and $35.29.10^8$ CFU/mL during the flood. For all sampling points, the mean concentration of

total flora resulting flood was 1.5 times higher than that obtained at low water.

The mean concentrations of total coliforms were obtained between $11.88.10^5$ and $23.36.10^5$ CFU/mL during low water and between $14.37.10^5$ and $28.61.10^5$ CFU/mL during the flood. The mean charge for all sampling points obtained during the flood was greater than that recorded during the low water and the difference between these two means was $4.92.10^5$ CFU/mL.

Mean charges thermotolerant coliform obtained ranged $7.16.10^5$ and $16.65.10^5$ CFU / mL during low water and between $9.27.10^5$ and $22.61.10^5$ CFU/mL during the flood. For all sampling points, the mean concentration of total flora resulting flood was higher than that obtained by low water and the difference between these two averages was $3.77.10^5$ CFU/mL.

The mean concentrations of staphylococcus obtained ranged $9.85.10^3$ and $15.23.10^3$ CFU / mL at low water and between $22.50.10^3$ and $31.61.10^3$ CFU/mL during the flood. For all sampling points, the mean concentration of staphylococcus obtained by flood was 2.22 times higher than that obtained at low water.

The mean values of water temperatures recorded on the lake showed that in times of low water as in the flood period (Table 2) are consistent with those of Abu (2001) and Dèdjiho (2014) which found that temperatures between 24 and 35 °C are favorable for good growth of commonly bred fish species. These temperatures are above 15 °C, also favor the development of microorganisms (Rodier *et al.*, 1996 cited by Adjahouinou *et al.*, 2014).

Similarly, the mean values of water pH obtained on the lake showed that in times of

low water as in the flood period (Table 2) are favorable for aquaculture because they are between 6.5 and 9 (Kanagire 2001; Dèdjiho, 2014) and also support the growth of microorganisms (Mara, 1980 quoted by Adjahouinou *et al.*, 2014).

Comparison with standards (Directive of the Council of European Communities of 16 June 1975 cited by Servais *et al.*, 2010) different means charges obtained after counting microbial germs shows that all these means charges are much higher than the standards required excepted salmonella (Table 3). These obtained mean charges are much higher than those obtained by Dovonou *et al.,* (2011) and Mégnon *et al.,* (2012) on Lake Nokoué, by Adigun (2013) on Nokoué and Ahémé lakes and the lagoon of Porto-Novo.

High loads of the total flora in the lake are due to the many activities of the local communities and around the lake; discharges of household rubbish and waste in the lake and the banks which are drained later in the lake by runoff and finally to the contributions of its tributaries (Couffo river, coastal lagoon of Grand-Popo) and collectors waste water surrounding communities especially in the rainy season (flood period).

The presence of total coliforms and thermotolerant in waters confirms the non-compliance with hygiene rules by the local population because coliforms are the work of fecal contamination of both men and animals. This is due to the low use of latrines by these populations and unhealthy breeding practices as highlighted the work of Sachi *et al.,* (2016) on Lake Nokoué.

These observations show that the lake Ahémé is extremely polluted by microbial germs.

Fig.1 Card of Ahémé lake with the points of withdrawal of the water samples (Sachi, 2015)
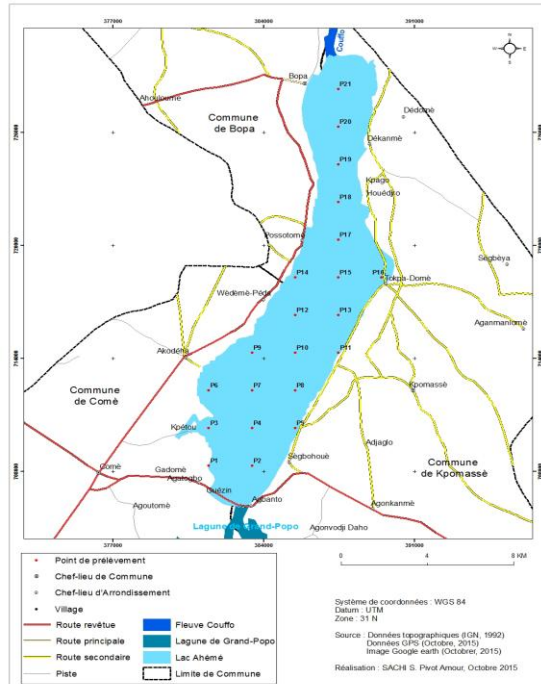
Table.1 Geographical coordinates of the different points of sampling

Points	Longitudes (m)	Latitudes (m)
P1	381475.4964	708309.156
P2	383475.4964	708309.156
P3	381475.4964	710309.156
P4	383475.4964	710309.156
P5	385475.4964	710309.156
P6	381475.4964	712309.156
P7	383475.4964	712309.156
P8	385475.4964	712309.156
P9	383475.4964	714309.156
P10	385475.4964	714309.156
P11	387475.4964	714309.156
P12	385475.4964	716309.156
P13	387475.4964	716309.156
P14	385475.4964	718309.156
P15	387475.4964	718309.156
P16	389475.4964	718309.156
P17	387475.4964	720309.156
P18	387475.4964	722309.156
P19	387475.4964	724309.156
P20	387475.4964	726309.156
P21	387475.4964	728309.156

Table.2 Mean values of temperature and pH of the drawn water samples

Points	Temperature (°C)		pH	
	Low water period	Flood period	Low water period	Flood period
P1	28.65±0.070[a]	27.00±0.000[a]	7.85±0.070[a]	6.60±0.000[a]
P2	28.80±0.000[a]	27.35±0.070[b]	8.05±0.070[a]	6.75±0.070[a]
P3	28.70±0.000[a]	27.10±0.000[a]	7.90±0.000[a]	6.65±0.070[a]
P4	29.05±0.070[b]	27.45±0.070[b]	8.10±0.000[b]	6.80±0.000[a]
P5	28.55±0.070[a]	27.05±0.070[a]	7.80±0.000[a]	6.55±0.070[a]
P6	28.65±0.070[a]	27.15±0.070[a]	7.95±0.070[a]	6.80±0.000[a]
P7	29.10±0.000[b]	27.50±0.000[b]	8.25±0.070[b]	6.95±0.070[b]
P8	29.05±0.070[b]	27.40±0.000[b]	8.15±0.070[b]	6.85±0.070[b]
P9	28.70±0.000[a]	27.25±0.070[b]	8.05±0.070[a]	6.75±0.070[a]
P10	29.15±0.070[b]	27.75±0.070[c]	8.40±0.000[c]	7.25±0.070[c]
P11	28.50±0.000[a]	27.05±0.070[a]	8.15±0.070[b]	6.85±0.070[b]
P12	29.00±0.000[b]	27.60±0.000[c]	8.30±0.000[c]	7.15±0.070[c]
P13	28.95±0.070[a]	27.55±0.070[b]	8.15±0.070[b]	6.95±0.070[b]
P14	28.85±0.070[a]	27.20±0.000[b]	8.05±0.070[a]	6.75±0.070[a]
P15	29.00±0.000[b]	27.65±0.070[c]	8.45±0.070[d]	7.25±0.070[c]
P16	28.85±0.070[a]	27.25±0.070[b]	7.95±0.070[a]	6.75±0.070[a]
P17	28.95±0.070[a]	27.50±0.000[b]	8.35±0.070[c]	7.20±0.000[c]
P18	28.95±0.070[a]	27.45±0.070[b]	8.30±0.000[c]	7.05±0.070[b]
P19	28.85±0.070[a]	27.40±0.000[b]	8.15±0.070[b]	6.95±0.070[b]
P20	28.80±0.000[a]	27.35±0.070[b]	8.05±0.070[a]	6.85±0.070[b]
P21	28.75±0.070[a]	27.20±0.000[b]	7.90±0.000[a]	6.80±0.000[a]
Means	29.64 ±0.210	27.85 ±0.180	8.10±0.180	6.87 ±0.200

Mean values with the same letter on the same line and in the same column are not significantly different at the 5% level. Data represents in table is mean of three replications. ± Standard deviation.

Table.3 Mean values in CFU/mL of the germs counted in the samples of water during the period of low water

Points	Total mesophilic flora (10^8)	Total coliforms (10^5)	Thermotolerant coliforms (10^5)	Staphylococcus (10^3)	Salmonella/25mL
P1	24.740±0.170[a]	23.360±0.113[a]	16.350±0.156[a]	15.230±0.042[a]	Absent
P2	21.340±0.170[b]	18.300±0.042[b]	13.360±0.127[b]	14.110±0.099[b]	Absent
P3	22.120±0.042[c]	21.650±0.127[c]	15.790±0.113[a]	14.900±0.056[c]	Absent
P4	17.565±0.177[d]	11.880±0.056[d]	9.630±0.127[c]	10.290±0.084[d]	Absent
P5	22.140±0.127[c]	20.720±0.042[e]	15.950±0.099[a]	15.020±0.056[ce]	Absent
P6	19.695±0.035[e]	22.440±0.170[f]	14.750±0.127[d]	13.800±0.028[b]	Absent
P7	14.920±0.085[f]	12.550±0.099[g]	7.160±0.113[e]	9.850±0.113[f]	Absent
P8	18.440±0.042[g]	14.240±0.099[h]	8.840±0.099[f]	10.500±0.056[dg]	Absent
P9	16.675±0.134[h]	15.810±0.085[i]	10.420±0.057[g]	11.080±0.070[h]	Absent
P10	15.670±0.057[i]	13.170±0.056[j]	7.900±0.113[h]	10.080±0.042[df]	Absent
P11	24.010±0.099[j]	19.260±0.170[k]	12.710±0.099[i]	12.390±0.028[i]	Absent
P12	16.250±0.099[h]	14.090±0.042[h]	9.260±0.113[cf]	11.340±0.099[hj]	Absent
P13	17.890±0.057[d]	15.840±0.127[i]	11.710±0.071[j]	12.540±0.084[i]	Absent

P14	22.515±0.064[c]	16.520±0.056[l]	12.370±0.113[i]	12.870±0.042[k]	Absent
P15	17.135±0.148[dh]	14.950±0.113[m]	9.660±0.099[c]	10.690±0.056[g]	Absent
P16	22.075±0.078[c]	22.760±0.099[f]	16.650±0.184[a]	15.270±0.099[e]	Absent
P17	18.440±0.099[g]	14.590±0.127[hm]	9.810±0.099[c]	11.230±0.084[hj]	Absent
P18	19.880±0.085[e]	16.820±0.085[l]	11.300±0.113[k]	11.580±0.113[j]	Absent
P19	21.550±0.127[b]	18.370±0.113[n]	12.550±0.127[i]	12.140±0.113[i]	Absent
P20	19.535±0.064[e]	19.680±0.156[k]	13.080±0.085[bi]	12.510±0.070[i]	Absent
P21	21.120±0.085[b]	20.220±0.056[o]	14.210±0.127[d]	13.100±0.028[l]	Absent
Means	19.690±2.781	17.489±3.531	12.073±2.862	12.398±1.769	Absent

Mean values with the same letter on the same line and in the same column are not significantly different at the 5% level. Data represents in table is mean of three replications. ± Standard deviation.

Table.4 Mean values in CFU/mL of the germs counted in the samples of water during the period of flood

Points	Total mesophilic flora (10^8)	Total coliforms (10^5)	Thermotolerant coliforms (10^5)	Staphylococcus (10^3)	Salmonella/25mL
P1	35.290 ± 0.099[a]	28.610±0.127[a]	22,610±0,156[a]	31.610±0.056[a]	Absent
P2	30.665 ± 0.148[b]	24.415±0.219[b]	17,615±0,078[b]	29.900±0.028[b]	Absent
P3	32.005 ± 0.219[c]	27.355±0.134[c]	20,255±0,134[c]	30.500±0.084[c]	Absent
P4	27.465 ± 0.106[d]	14.365±0.106[d]	11,315±0,106[d]	24.440±0.070[d]	Absent
P5	34.120 ± 0.099[e]	25.110±0.085[be]	22,080±0,042[e]	31.170±0.084[e]	Absent
P6	29.345 ± 0.177[f]	27.345±0.177[c]	20,245±0,035[c]	30.110±0.042[f]	Absent
P7	24.220 ± 0.198[g]	16.370±0.127[f]	9,270±0,127[f]	22.500±0.113[g]	Absent
P8	28.190 ± 0.113[h]	19.550±0.099[g]	12,340±0,099[g]	22.910±0.042[h]	Absent
P9	26.525 ± 0.063[i]	20.810±0.056[h]	13,510±0,085[h]	24.180±0.113[d]	Absent
P10	25.870 ± 0.056[j]	17.535±0.134[i]	10,885±0,078[i]	23.590±0.028[i]	Absent
P11	33.810 ± 0.099[e]	24.205±0.163[b]	17,130±0,127[j]	26.470±0.056[j]	Absent
P12	26.320 ± 0.127[i]	19.390±0.085[g]	12,320±0,127[g]	25.380±0.070[k]	Absent
P13	27.440 ± 0.127[d]	21.590±0.056[j]	14,390±0,057[k]	26.710±0.056[j]	Absent
P14	32.380 ± 0.156[c]	22.130±0.056[k]	15,430±0,085[l]	27.180±0.099[l]	Absent
P15	26.685 ± 0.063[i]	19.525±0.148[g]	12,475±0,078[g]	24.390±0.084[d]	Absent
P16	32.775 ± 0.063[k]	27.405±0.106[c]	20,425±0,134[c]	31.050±0.042[e]	Absent
P17	28.430 ± 0.127[h]	19.375±0.148[g]	12,780±0,085[g]	28.210±0.070[m]	Absent
P18	29.900 ± 0.170[f]	21.990±0.099[l]	14,970±0,127[l]	28.760±0.099[n]	Absent
P19	31.700 ± 0.156[c]	23.615±0.177[b]	16,665±0,106[j]	29.180±0.042[o]	Absent
P20	29.280 ± 0.127[f]	24.330±0.085[b]	24,330±0,085[b]	29.780±0.056[b]	Absent
P21	30.850 ± 0.184[b]	25.600±0.255[e]	18,700±0,113[m]	30.190±0.070[c, f]	Absent
Means	29.564 ± 3.073	22.413±3.911	15.844±3.892	27.533±2.991	Absent
Norms	10^4	5.10^2	2.10^2	10	Absent/25mL

Mean values with the same letter on the same line and in the same column are not significantly different at the 5% level. Data represents in table is mean of three replications. ± Standard deviation

The presence of staphylococcus (pathogen) at high concentrations in the lake water confirmed the high prevalence of diarrheal diseases and skin diseases reported by health workers lake communities as highlighted Dovonou *et al.,* (2011) on Lake Nokoué.

In conclusion, the study assesses the bacteriological water quality of the lake

Ahémé. It appears that the Ahémé lake is heavily polluted and its waters carry significant microbial charges especially bacteria, witness for fecal pollution and which are not consistent with standards. The main sources of pollution of the lake from waste are resulting from human activities of the local population (household waste discharges, biomedical waste, leaching, and discharges of domestic wastewater). This pollution of the lake can affect the microbiological quality of fish products they offer. It falls to the Beninese public authorities to undertake urgently a reorganization plan for the lake and this by:

- Purifying discharges from storm water drainage collectors from the surrounding areas of the lake;

- Organizing information campaigns, education and awareness of the local population with good attitudes and hygiene practices for better management of the lake;

- Building more latrines and public showers for these populations;

- The implementation of a wastewater treatment system, waste and domestic waste on the lake.

These actions will improve the quality of the lake water so that fish products and will also help prevent the epidemiological episodes due to recurrent water borne diseases especially in rainy seasons, periods of high unhealthy.

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