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 Despite the absence of salmonella in all those withdrawn waters, average charges recorded in both periods (low water period as flood period) for these counted germs were not consistent with standards.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 19.69.10⁸, 17.49.10⁵, 12.07.10⁵ and 12.40.10³. These values increased and reached respectively 29.56.10⁸, 22.41.10⁵, 15.84.10⁵ and 27.53.10³ 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 km² 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 respectively 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.

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
The mean concentrations of total coliforms were obtained between $1.188 \times 10^5$ and $2.36 \times 10^5$ CFU/mL during low water and between $1.437 \times 10^5$ and $2.61 \times 10^5$ 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 $4.92 \times 10^5$ CFU/mL.

Mean charges thermotolerant coliform obtained ranged $7.16 \times 10^5$ and $1.65 \times 10^5$ CFU/mL during low water and between $9.27 \times 10^5$ and $2.26 \times 10^5$ 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 $3.77 \times 10^5$ CFU/mL.

The mean concentrations of staphylococcus obtained ranged $9.85 \times 10^5$ and $1.523 \times 10^5$ CFU/mL at low water and between $2.25 \times 10^5$ and $3.16 \times 10^5$ 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 favorable for aquaculture because they are between 6.5 and 9 (Kanagire 2001; Dédjiho, 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     | 27.00±0.000  | 7.85±0.070  | 6.60±0.000 |
| P2     | 28.80±0.000    | 27.35±0.070  | 8.05±0.070  | 6.75±0.070 |
| P3     | 28.70±0.000    | 27.10±0.000  | 7.90±0.000  | 6.65±0.070 |
| P4     | 29.05±0.070    | 27.45±0.070  | 8.10±0.000  | 6.80±0.000 |
| P5     | 28.55±0.070    | 27.05±0.070  | 7.80±0.000  | 6.55±0.070 |
| P6     | 28.65±0.070    | 27.15±0.070  | 7.95±0.070  | 6.80±0.000 |
| P7     | 29.10±0.000    | 27.50±0.000  | 8.25±0.070  | 6.95±0.070 |
| P8     | 29.05±0.070    | 27.40±0.000  | 8.15±0.070  | 6.85±0.070 |
| P9     | 28.70±0.000    | 27.25±0.070  | 8.05±0.070  | 6.75±0.070 |
| P10    | 29.15±0.070    | 27.75±0.070  | 8.40±0.000  | 7.25±0.070 |
| P11    | 28.50±0.000    | 27.05±0.070  | 8.15±0.070  | 6.85±0.070 |
| P12    | 29.00±0.000    | 27.60±0.000  | 8.30±0.000  | 7.15±0.070 |
| P13    | 28.95±0.070    | 27.55±0.070  | 8.15±0.070  | 6.95±0.070 |
| P14    | 28.85±0.070    | 27.20±0.000  | 8.05±0.070  | 6.75±0.070 |
| P15    | 29.00±0.000    | 27.65±0.070  | 8.45±0.070  | 7.25±0.070 |
| P16    | 28.85±0.070    | 27.25±0.070  | 7.95±0.070  | 6.75±0.070 |
| P17    | 28.95±0.070    | 27.50±0.000  | 8.35±0.070  | 7.20±0.000 |
| P18    | 28.95±0.070    | 27.45±0.070  | 8.30±0.000  | 7.05±0.070 |
| P19    | 28.85±0.070    | 27.40±0.000  | 8.15±0.070  | 6.95±0.070 |
| P20    | 28.80±0.000    | 27.35±0.070  | 8.05±0.070  | 6.85±0.070 |
| P21    | 28.75±0.070    | 27.20±0.000  | 7.90±0.000  | 6.80±0.000 |
| 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^c               | 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^e              | 20.720±0.042^e         | 15.950±0.099^a               | 15.020±0.056^c       | Absent          |
| P6     | 19.695±0.035^f              | 22.440±0.127^f         | 14.750±0.127^d               | 13.800±0.028^b       | Absent          |
| P7     | 14.920±0.085^g              | 12.550±0.099^g         | 7.160±0.113^e                | 9.850±0.113^f        | Absent          |
| P8     | 18.440±0.042^h              | 14.240±0.099^h         | 8.840±0.099^f                | 10.500±0.056^g       | Absent          |
| P9     | 16.675±0.134^i              | 15.810±0.085^i         | 10.420±0.057^g               | 11.080±0.070^h       | Absent          |
| P10    | 15.670±0.057^j              | 13.170±0.056^j         | 7.900±0.113^h                | 10.080±0.042^df      | Absent          |
| P11    | 24.010±0.099^k              | 19.260±0.170^k         | 12.710±0.099^i               | 12.390±0.028^i       | Absent          |
| P12    | 16.250±0.099^b              | 14.090±0.042^b         | 9.260±0.113^cf               | 11.340±0.099^bj      | Absent          |
| P13    | 17.890±0.057^d              | 15.840±0.127^i         | 11.710±0.071^j               | 12.540±0.084^i       | Absent          |
The study assesses the presence of staphylococcus (pathogen) at high concentrations in the lake water. The high prevalence of diarrheal diseases and skin diseases reported by health workers lake communities as highlighted by 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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