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Characterization And Evaluation Of Anthropogenic Pollution Loads Of Lakeside Villages And Peri-Urban Areas Of Lake Nokoue In Cotonou (Benin)

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Keywords: Solid waste, liquid waste, Lake Nokoué, rainwater collector, physico-chemical parameters, Metal Trace Elements.

Abstract

A survey was conducted on Lake Nokoue of Cotonou in August and October 2010. The objective of this study was to assess the main waste loads brought into Lake Nokoue through anthropogenic activities and to address issues related to their sound management. Two sampling campaigns were carried out respectively in short dry season and short rainy season. Physicochemical parameters and precious metals were measured by ionic chromatograph ICS 1000 and spectrophotometer MERCK spectroquant NOVA 60 to evaluate the lake pollution state. These parameters indicated that the lake was polluted by organic matter. Loads of solid and liquid wastes in 2010 were estimated. Nokoue lake received a large load of solid waste estimated at 58 tons per day or 21,085 tons per year for people in outlying districts and 43 tons per day or 15,673 tons per year for the lakeside villages, and liquid or water waste estimated at 2,297 m3 per day or 838,540 m3 per year for people in outlying districts and 12,912 m3 per day or 471,419 m3 per year to the lakeside villages. The development of a management plan for the safeguarding of the lake is needed.

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Introduction

In Africa in general and in Benin in particular, many human activities are carried on water bodies without clearly empowering the actors by a clear planning policy (Mama, 2010). Indeed, many lakes and rivers, because of their proximity to the population receive almost all waste from human activities being industrial, domestic or agricultural. This state of affairs contributes to enrich the aquatic pollutant and other unwanted or potentially dangerous to the public health elements (Darboux, 2008). Iwugo (1980) published the results of its work to assess pollution loads from wastewater of domestic origin in African cities and have amounted to about 80% above the average proportion of the water consumed is rejected under as wastewater in these cities. Simporé (1994) for his part, evaluated and quantified the volume of domestic waste (from households only) produced daily in Cotonou during the year from 1,994 to 20,886 m^3 / d is 7,623,390 m^3/year. According to the characterization performed in 1997, every household in Cotonou generates each year between 1250 and 1500 kg of waste (MEHU, 2003). A small portion of this waste (about 15%) is recyc1ed (EAP, 2001), the rest is often rejected in the gutters drain rainwater or water bodies.

Lake Nokoue escapes little degradation of quality over the years with population growth and the development of human activities. Several studies have to assess the state of chemical pollution of this water from the point of view, inorganic and organic. Works of Bankole and Olou (2000), Folal and Gonou (2002), Sagbohan (2003) and Tawema (2005) showed strong organic pollution of the lake from discharges of organic waste and faeces in the middle. Other studies such as those of Tossou (2000), Adjalian (2006) and Lawani (2007) found high levels of organic chemical pollution in various compartments of the lake. Montcho (2005), Ayihonsi (2006) indicate high concentrations in nitrogen and phosphorus salts. Dovonou (2009) presents the sources of pollution of Lake Nokoue as solid and liquid wastes arising from households not only of villages on the lake but also from villages surrounding the lake. However, very few studies have focused on the burden of solid and liquid waste made by lake populations and their impact on the lake Nokoue. So this work aims to provide scientific information about it.

Methodology

Study area

Lake Nokoue, is the largest lake of Benin. It is situated in the south-east of Benin, between the parallel 6° 20 'and 6 ° 30' North and the meridians 20 ° 2 'and 2 ° 35' East. Its northern part is occupied by a floodplain Oueme river and river Sô while in its southern part is the city of Cotonou.

Different samples were taken during the study. A total of 14 sampling points were selected (figure1).

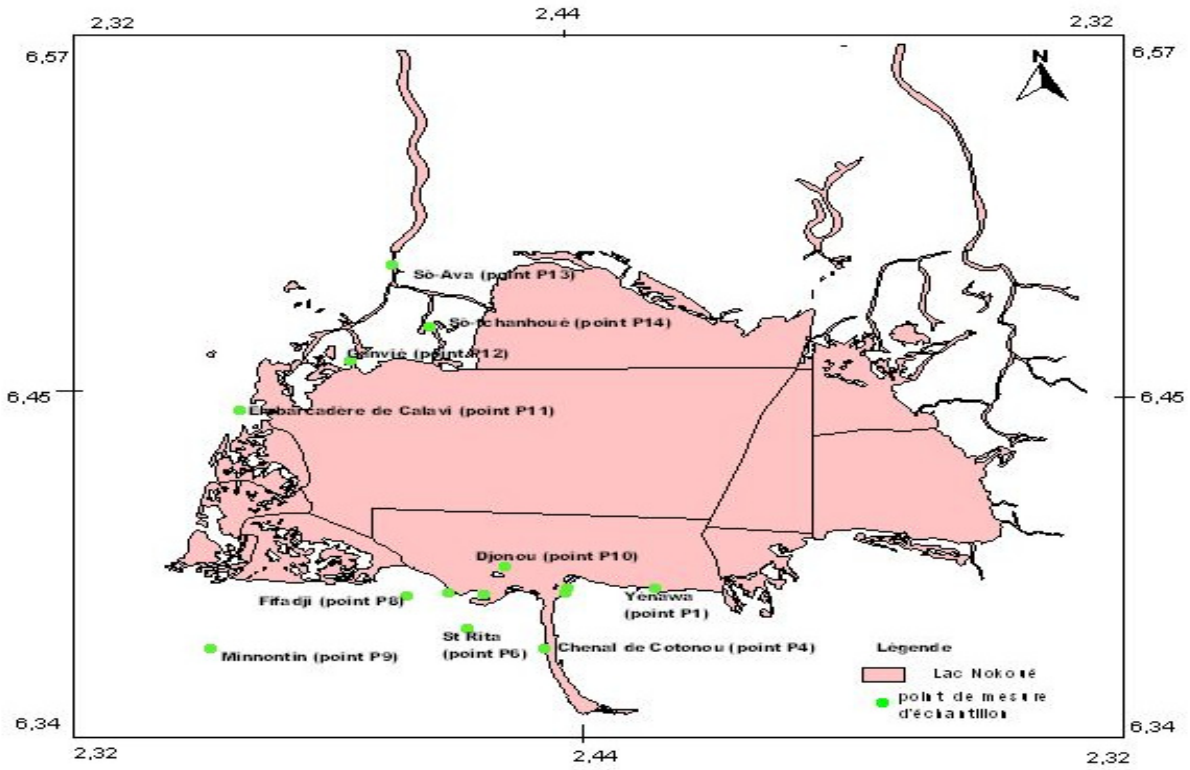

Figure 1: Map showing the sampling points on Lake Nokoué.

Table 1: Physico-chemical parameters and Metal Elements Trace (ETM)

Parameters	Methods used
Dissolved oxygen and pH	pH / Oximetry sensor with a WTW 340i, previously calibrated
T °C, salinity, conductivity and total dissolved solids (TDS)	conductivity meter WTW 340i multiparameter
TSS, turbidity and color	colorimeter HACH DR/890
nitrite ions, nitrate, ammonium, phosphate ion	phosphate ion chromatograph brand ICS 1000
Biochemical Oxygen Demand (BOD)	BOD meter at 20 ° C for five days
Chemical Oxygen Demand (COD)	AFNOR T90-101
Lead (Pb), Iron (Iron II) and Chromium (Cr)	NOVA 60 spectrophotometer Merck Spectroquant

Estimated costs of liquid and solid wastes

The estimation took into account the growth rate of the population calculated on the basis of the results of the 2002 Census. The following formula are used :

$P_{2010} = P_{2002} (1 + t)^{n}$ (DCAM-BETHESDA, 2011)

P_{2010}: Population in 2010

P_{2002}: Population after the 2002 census (INSAE, 2002)

t: growth rate of the population in 2002

n: Difference of the year (in this case, n = 8)
The concept of household is used to estimate loads. Here a household is 5 persons on average (a man, a woman and three children) (Mama, 2010).
For a household was:
Water consumption = 150 liter / day
BOD_5 = 300g / day
Pt = 15g /day
Nt = 70g / day

It was therefore estimated at 20% the amount of liquid waste and solid waste discharged into the lake through the gutters outlying districts and 100% rejected by the lakeside villages considered. The formula was used according to (Simporé, 1994) in the evaluation of domestic waste water produced daily in Cotonou. It was therefore taken into account in the present work for the calculation of design loads of waste produced by district: Theoretical load =% rejection x amounts of waste per household x Nt homemaker Homemaker nt: total number of households per district Practical calculations are performed measures loads taking into account the physico-chemical parameters in the field. By the above formula written volumes (V) of wastewater that is discharged by the various collectors suburbs are estimated, these volumes are then multiplied by the respective concentrations (C) of BOD_5, total phosphorus and total nitrogen taken on the ground in these manifolds. Hence the following formula:
Working load = C.V
N.B:

% Rejection { Suburbs: 20 %
% Rejection { Lakeside villages: 100 %

Inputs in terms of loads Oueme river, the Sô River watershed, air pollution (acid rain), the decomposition of acadjas branches and dead macrophytes are not taken into account. Only expenses solid and liquid waste from the peripheral areas of the lake Nokoué through storm drains and lake villages are taken into account

2. Results

2.1 Physico-chemical parameters

The results of the physicochemical parameters are presented in Table 1.
Table 2: Physico-chemical parameters

1. Stations	T°C	pH	Conductivity	Salinity	OD	MES	NO_2	NO_3	PO_4	DCO	DBO
Yénawa	27,1	7,09	0,78	0,15	0,8	45	5,61	1760,7	9,37	274,5	152
Gangbodo	29,4	7,67	0,53	0	6,27	25,5	4,41	170,4	1,4	335	143
Agbato	28,1	7,38	0,84	0,15	0,6	140,5	5,68	327,5	1,14	360	200
Channel	27,8	7,38	33,6	21,7	3,18	28,5	7,49	3803	2,41	1736	301
Ahouansori	28,55	7,43	1,03	0,3	0,55	84	2,19	224,4	2,17	365	189,05
St Rita	32,2	7,3	0,89	0,2	3,68	108,5	4,69	136,4	1,32	279	82
Vossa Kpodji	27,25	7,61	2,71	1,3	3,06	26,5	1,39	223,4	3,66	279	205
Fifadji	28,65	7,8	1,78	0,7	2,26	29	13,8	194,67	0	341,5	120
Mènontin	29,3	7,25	1,1	0,3	1,32	170	4,03	244	5,38	294	120
Djonou	27,5	6,46	0,15	0	0,52	37,5	11,07	29,5	4,19	221	157
Jetty	25,95	7,25	3,2	1,6	3,64	75,5	3,77	71,25	1,93	642	234

Ganvié	26,55	7,07	0,17	0	1,39	43	9,37	332	2,11	364	250
Sô-Ava	26,85	6,83	0,13	0	0,99	44	4,63	72,5	3,35	334	237
Sô-tchanhoué	26	6,91	0,14	0	0,89	45	1,84	36,3	2,99	453	280

2.2 Elements metal traces

Table 3 presents the results of trace metals namely iron, chromium and lead measured in the water samples.

Table 3: Results of trace metals

Stations	**Fe**	**Cr**	**Pb**
Yénawa	1,05	0	0,3
Gangbodo	0,82	0	0,23
Agbato	1,07	0,01	0,31
Channel	0,94	0	0,49
Ahouansori	1,2	1,77	0,71
St Rita	1,77	0,22	0,08
Vossa Kpodji	0,71	0,21	0,12
Fifadji	0,67	0,17	0,12
Mènontin	1,45	0,24	0,12
Djonou	1,83	0,05	0,12
Jetty	1,35	0,22	0,12
Ganvié	1,95	0,28	0,12
Sô-Ava	1,43	0,27	0,12
Sô-tchanhoué	1,34	0,09	0,12

2.3 Charges of solid and liquid waste

2.3.1 Solid Waste Charges

Table 4: Average charges of solid waste generated per day and per year in nature

Medium loads of solid waste generated (in tons)			
By districts by the lake		By the lake villages Nokoue	
Per day	Per year	Per day	Per year
289	105376,53	43	15674

Table 5**:** Mean Charges solid waste discharged into the lak

Medium loads of solid waste disposed of in the lake (in tons)			
By districts by the lake		By the lake villages Nokoué	
Per day	Per year	Per day	Per year
58	21085	43	15674

1.3.2 Charges liquid waste

Table 6: Charges liquid waste discharged into the environment per day and per year in m3

Medium loads of liquid waste or wastewater discharged into the environment (m3)			
By districts by the lake		By the lake villages	
Per day	Per year	Per year	Per year
9190	3354161	1291,56	471419,4

Table 7: Charges wastewater discharged into the lake (m3)

Charges wastewater discharged into the lake (m3)			
By districts by the lake		By the lake villages	
Per day	Per year	Per day	Per year
2297	838540	1292	471419

Table 8: Theoretical total BOD5 loads discharged into the lake tonne

Theoretical total loads discharged into the lake in terms of BOD5 (in tons)			
By districts by the lake By		By the lake villages	
Per day	Per year	Per year	Per year
4,6	1677	3,2	1178

Table 9: Total practices BOD5 discharged into the lake Charges tonne

Total expenses practices BOD5 discharged into the lake through the neighborhoods around Lake Nokoué (tons)	During dry season	Per day	0,4
		Per year	146
	During dry season	Per day	0,5
		Per year	182,5

Table 10: Theoretical total loads discharged into the lake in terms of Nt (in tons).

Theoretical total loads discharged into the lake in terms of Nt (in tons)			
through the neighborhoods around Lake Nokoué		By the lake villages	
Per day	Per year	Per year	Per year
1,1	391	0,8	275

Table 11: Total Charges practices of total nitrogen during the two campaigns tonne.

Total expenses practices Nt discharged into the lake By the quarters around Lake Nokoué (tons)	During dry season	Per day	0,7
		Per year	256
	During dry season	Per day	0,24
		Per year	87,6

Table 12: Theoretical total expenses total phosphorus tonne.

Total charges discharged into the lake in terms of Pt (in tons)			
By quarters around the lake		By the lake villages	
Per day	Per year	Per year	Per year
0,3	84	0,2	59

Table 13: Total practices tonne total phosphorus loads.

Total expenses practices Pt discharged into the lake By the neighborhoods around Lake Nokoué (tonnes)	During dry season	Per day	0,001
		Per year	0,365
	During dry season	Per day	0,002
		Per year	0,7

Discussions

3.1 Physico-chemical parameters

3.1.1 Physical Parameters

The average values recorded during the short dry season temperatures are respectively 26.14 ° C and 29.82 ° C. Referring to standards set by Fine (1998), these average temperatures between 25 ° C and 30 ° C are favorable to life species from Lake Nokoué.
As for the pH, the values obtained at different sampling points during the short dry season (6.34 to 7.69) and the small rainy season (6.59 to 8.39) are in the range of 6 0.5 to 8, 5 (Fine, 1998) and are consistent with the results (6.5 and 8.2) of Lalèyê et al. (2003) and Alhou et al. (2009) on the Niger River. In view of this, all values for the pH is acceptable.
The analyzes show that even if the values meet the standards, however they are higher in small rainy season in early dry season. These increases in temperature and pH during the short rainy season are probably due to anthropogenic inputs of waste from storm drains and can undoubtedly influence the metabolic reactions that occur in rivers (Djermakoye , 2005).
The mean values obtained at dissolved oxygen for two seasons are below 3 mg / L (Fine, 1998). However, an increase in dissolved oxygen during the short dry season (2.27 mg / L) is noticed. This finding is the result of the presence of organic matter from the rejection of anthropogenic waste on and around the lake. Low dissolved oxygen concentrations in both seasons are due to the reactions of biological degradation of organic material in the waste (Mompoint, 2004).
Conductivity values obtained at the Channel, the Pier and gutters Vossa Kpodji and Fifadji are very high compared to standards set by (Fine, 1998) and provide evidence that wastewater Cotonou are very responsible

minerals which reflect the high levels of pollutants. Measured in the channel during the short dry season (53.2 mS / cm) conductivity and the short rainy season (14.2 mS / cm) remains much higher than the values obtained at the other sites. This is due to the discharge into the channel solid and liquid waste from rain water collectors Akpakpa Central, Midombo of Hlacomey, Jericho, and CEG Dantokpa. The mean levels of TSS are respectively 69.5 and 59.39 mg / L for the short dry season and early rainy season. These results are in the range of 30-70 mg / l set by Fine (1998) for the quality of water and greater than 35 mg / L and 36 mg / L measured by Darboux (2008). High levels of suspended solids can prevent the penetration of sunlight, reduce dissolved oxygen and then limit the development of aquatic life by asphyxiation due to clogging fish gills.

3.1.2 Chemical Parameters

The mean values of nitrates in short dry season (661.46 mg / L) and short rainy season (201.68 mg / L), nitrite in short dry season (6.94 mg / L) and short rainy season (4, 48mg / L), ammonium ions in short dry season (61.32 mg / L) and short rainy season (64.37 mg / L), and phosphates in short dry season (3.31 mg / L) and small rainy season (2.65 mg / L) are moderately high by the standards of water quality (Fine, 1998). These average values are significantly higher than those obtained by Kiki in 2003 between February and June on the lagoon of Porto-Novo. The presence of these nutrients, reveals a faecal contamination, linked to runoff that leach urban land taking with them fecal material and domestic effluents (water laundry, dishes, and urine) (Simpore, 1994). Phosphorus, in its various forms is responsible for eutrophication observed at Lake Nokoué (Mama, 2010). The average phosphorus content for the short dry season (1.08 mg / L) and the short rainy season (0.86 mg / L) of the lake are higher than those recorded in Lake Geneva (0.039 mg / L) knew maximum eutrophication and Ichkeul lake, where the average grade of 0.050 mg / L is considered a sign of eutrophication (Barek, 1995).

3.2 COD and BOD

The mean levels of chemical oxygen demand (COD) are respectively 372 mg / l for the short dry season and 587.5 mg / L for the short rainy season during that level of biochemical oxygen demand (BOD5) are 185.4 mg / L for the short dry season and 242.68 mg / L for the short rainy season. High values of BOD5 during the short rainy season can be explained by the excessive discharge of organic matter. Similarly, the values of the low BOD5 during the short dry season are certainly due to lower organic loads so low oxygen consumption for degradation. Calculating COD/BOD5 reports for the dry season (C1) on the one hand and to the rainy season COD/BOD5 (C2) on the other hand, lead to the respective values of 2.12 and 2.74 to values higher the limit value of 2, recognized urban wastewater can be discharged into the aquatic environment. By comparing these results to that of (Simpore 1994) Wastewater Cotonou, we can say that urban and domestic sewage Cotonou contain a high proportion of readily biodegradable organic material compared to biodegradable substances especially during early season rainy. This situation is the result of runoff into the stream of industrial effluents.

3.3 Trace Elements Metal

The average concentrations of heavy metals for the two campaigns in the water is 1.26 mg / L; 0.14 mg / L; 0.2 mg / L for iron, chromium, and lead. All these values exceed the threshold values of Canadian guidelines for

the quality of the environment (Canadian Council of Ministers of the Environment, 1999). When comparing these values to those obtained in most of the rivers of India (Reza and Singh, 2010), we see that the values obtained in Lake Nokoué are very high. For example, concentrations of iron, chromium and lead in the river Brahmani in India are respectively 66.25 mg / L; 1.13 mg / L; 19.13 g / L. These values are significantly lower than those observed at the lake while India's most populous, most industrialized therefore the impact of human activities should be more important. These metal pollutants pose a threat to aquatic life and human health. These high concentrations of metals in the lake resulting from poor management of liquid and solid waste in general and Benin in Cotonou and Calavi in particular. The highest concentrations are found in almost all stations during the C2 for iron during the C1 specifically at the channel and collectors Yénawa, of Agbato, and Ahouansori.

3.4 Charges of solid and liquid waste

The amount of household waste that receives the Niger River daily is estimated at 273 750 t / year (Alhou et al., 2009). The Nigerian population living in the river basin is estimated at 8.3 million (RGP/H-2001). Comparing the charges of solid waste disposed of annually in Lake Nokoué (21,241.95 tons / year) from a population of 436,755 inhabitants evacuated to those in the Niger river, we see that the highest amount was observed at the river Niger. This is due to the contribution of human activities by the Nigerian population is very high. Nevertheless, supported by residents at the lake Nokoué (0,048 t / year / habt) is higher than that of the Niger River (0.03 t / year / habt). It is the problem of poor solid waste management on African waters west. Regarding waste, information on expenses discharged wastewater discharged into lakes or water are not available, a comparison of results is difficult, however, work Nsabimana (2009) on wastewater discharges and solid waste into Lake Tanganyika in Burundi, and Shabantu (2006) showed that lakes also receive significant wastewater produced by large waterfront communities charges. In comparing the total expenses to total theoretical practices charges, we find that there is a considerable gap between the theoretical total expenses and total expenses respectively practices of BOD5 and total phosphorus during the two campaigns. The difference between the different loads can be explained either by the fact that the water from the laundry or other detergents containing phosphates may then constitute an important source of phosphorus in domestic and urban sewage or either by accumulation of phosphorus in the sediments of different gutters. Phosphorus levels obtained in the lake would come therefore from leachate following rainfall in the catchment area of river Ouémé and Sô (Mama, 2010). By cons, in terms of total nitrogen, total design loads (391 tonnes) and total practice expenses closer to each other centerpieces during the short dry season (256 tonnes). These discharges in quantities so important in the aquatic environment is a threat not only to the species that live there but also to man through the food chain.

3.5 Conclusion

The pollution of Lake Nokoué is quite remarkable, it's main source of human activities, and is compounded by the low level management of urban and domestic waste. These results show high levels of physico-chemical parameters and trace metals and allow the conclusion that the wastewater must be treated before being discharged into the sensitive environment what the lake.

Similarly, the assessment of costs of solid waste and liquid shows that lake level Nokoué, charge by people is very high.

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