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Impact of the urban development of the Mingoa River watershed on the Municipal Lake of Yaoundé, Cameroon

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Abstract

Currently, Africa is the less urbanized region in the world. But that trend will change by 2020. Their urban development and globalization have promoted developed countries lifestyle, despite poverty. That means the use of chemicals. Sanitation issues have led to the discharge of untreated wastewater, and as a result, to the emission of persistent pollutants, harmful for human health and for the aquatic environment. Chemicals leading role in economy and in the improvement of life quality has to be weight against their potential negative impacts. The risk represented by these impacts makes chemicals management, an issue of sustainable development. According to a UNEP report, that topic is little documented in Africa. Our work aims at reconstructing an historical link between the urban development of the Mingoa River watershed and the Municipal Lake organic pollution. Thus, we are going to examine the sedimentary compartment using pollutants as tracers.
Given that we have not started yet the laboratory work, this article is an introduction to the study.

Keywords

Contaminants, developing countries, pollutants, wastewater, sediments

INTRODUCTION

In African cities, lifestyle has promoted the use of chemicals in all fields. But contrary to developed countries, the management of their impact on the environment, particularly on water resources is not optimal.

African lakes participate in a significant way to the socio-economic development of the region. But they are subject to the demographic pressure, to the urbanization, and to the industrialization. These issues have modified the working of aquatic ecosystems. Thus, lakes are threatened by the lost of their biodiversity, by the enrichment of water, and by chemical contamination. In this work, we present the case of Yaoundé Municipal Lake, in Cameroon.

Urban context of Yaoundé

Yaoundé is characterized by a lawless occupation of space due to the complex procedure to obtain land property. It is very expensive for poor households. In addition, the residential segregation inherited from the colonial period, has been maintained « WETHE et al. (2003) ». There are two towns in Yaoundé:

- The organized and administered town represents the previous colonial sites. There we will find residential neighbourhoods, new administrative and commercial shopping

centres. These areas have well constructed roads, water supply, sanitation and electricity. Hardly 40 % of Yaoundé households live in these conditions.

- Poor urban settlements are the places were indigenous populations used to live during the colonial period. These areas are suburbs over populated, and located close to industrial areas. There **is** are no social services like water supply, sanitation and waste management facilities.

Urban context of the Mingoa River watershed

The Mingoa River watershed is located in the centre of Yaoundé, between 3°51’31’’ and 3°52’27’’ of north latitude and between 11°29’46’’ and 11°30’49’’ of east longitude. Its relief is steep. It is part of the Mfoundi watershed, the river that drains an important part of the town. Its surface area is 362 ha. In its upstream part, (217.2 ha), there are 12 neighbourhoods and the Municipal Lake.

Figure 1: Upstream part of the Mingoa River watershed (Google Earth modified, 2006)

The watershed is drained by the Mingoa River. This one is fed by the Ntap – Ntap source from Melen 4, Commando source from Melen 1, and by its affluent Ntougou from Elig-Effa 7.

The built of a dam on that river at the beginning of the 1950’s has led to the Municipal Lake of Yaoundé. For years, the lake has been a leisure place. But since the 1980’s, the sanitation infrastructures located upstream are not operating. Thus, untreated water enters the lake continuously.

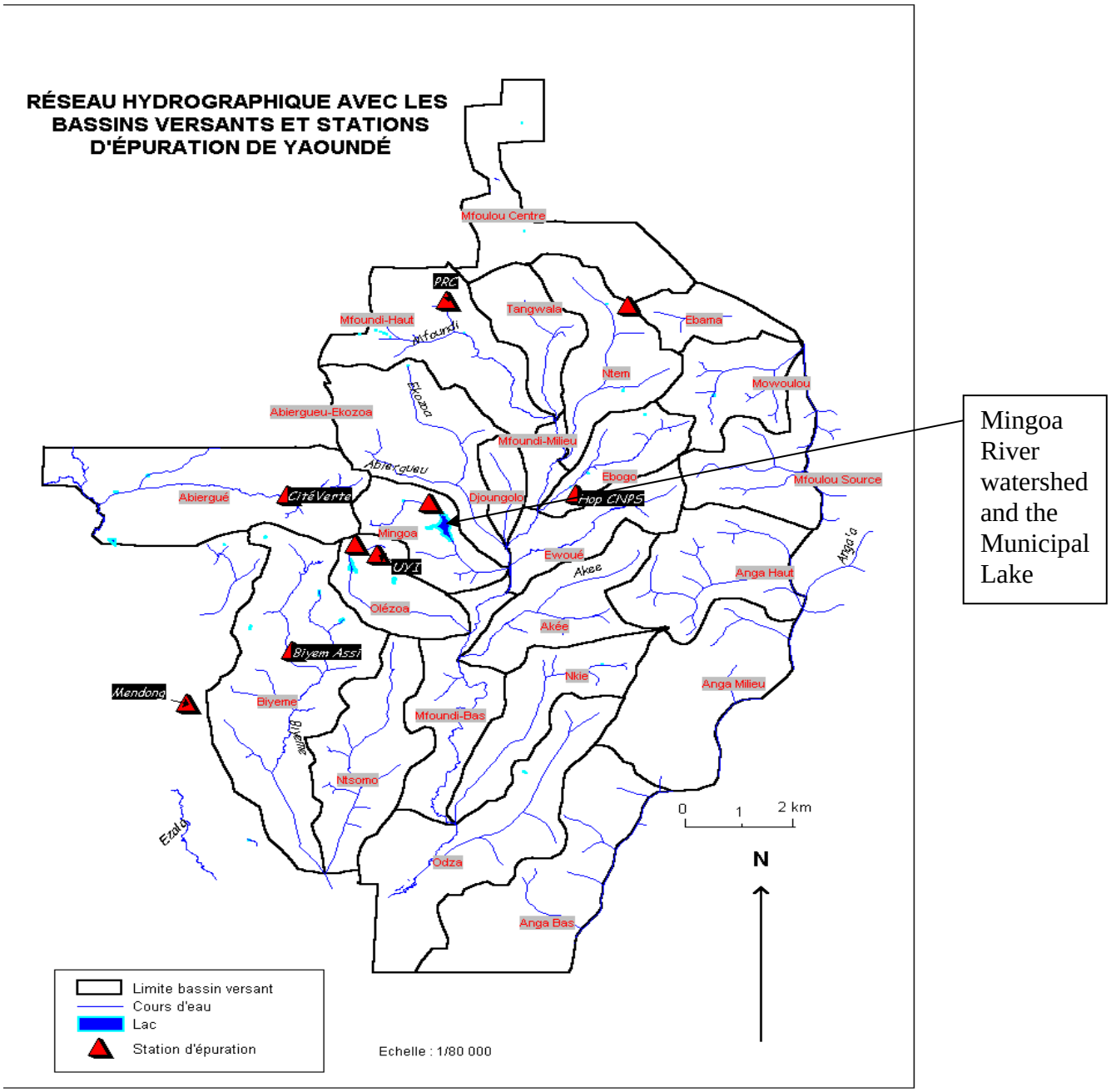

Figure 2: Water system of Yaoundé (LESEAU, 2007)

There are 21500 inhabitants in the watershed, with 478 inhabitants/ha. There are luxury houses, commercial establishments, schools, slums, hospitals and hostels « TANAWA et al. (2004) ».

The pollution coming from the upstream part of the watershed is characterized by a continuous discharge of domestic wastewater (baths, emptying toilets, washing, and dishwater). One of the main causes of the pollution is the mal functioning of a wastewater treatment plant located before the lake. The pollution is accentuated by the use of pesticides and by livestock farming (pigs and chickens). That context has led to the contamination of soils, and of groundwater. In addition, it has promoted the proliferation of pollutants like:

- Solids (suspended solids, solid wastes)
- Chemicals (heavy metals, detergents, solvents, hydrocarbons)
- Microorganisms, viruses, bacteria.

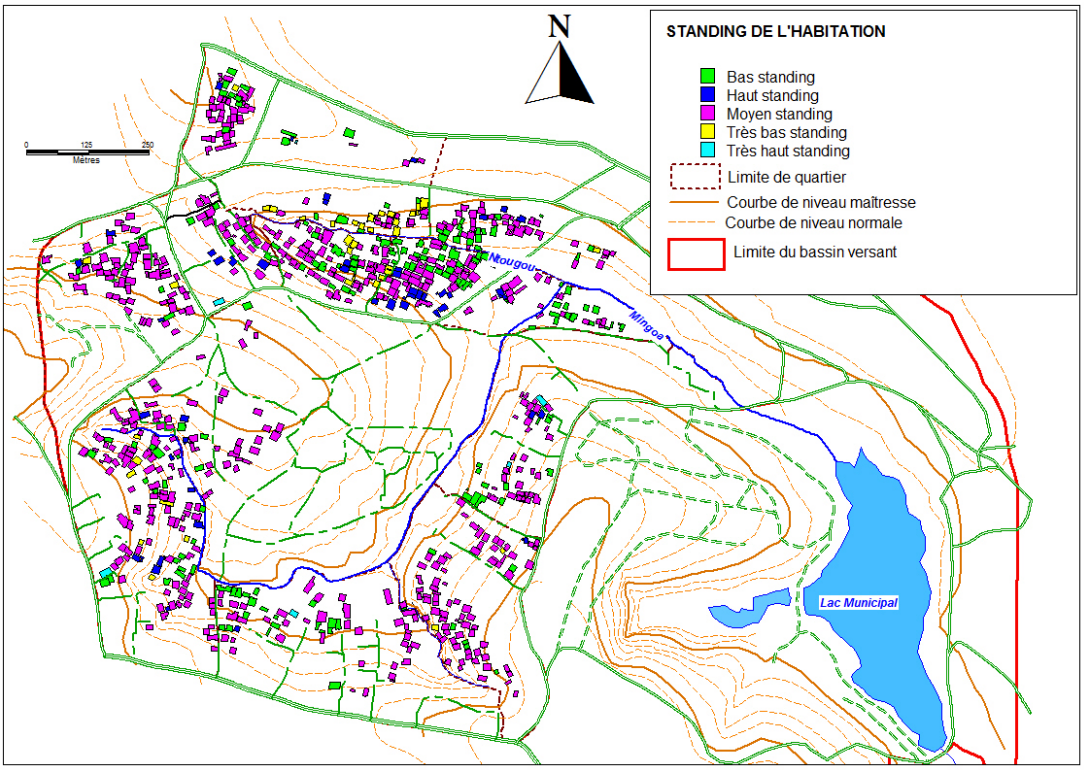

Figure 3: Standing of housing in the upstream part of the Mingoa River watershed (NGIKAM, 2008)

Assessment of the Municipal Lake pollution and its management at the watershed level

Studies have been made in different fields in order to describe the pollution. Bacteriology has been studied by JUGNIA et al. (1998, 1999, 2001); and by NJINE et al (2001). The impact on aquatic wildlife has been presented by ZEBAZE TOGOUET et al. (2005, 2007); and TADONLEKE et al. (1998). KOUAM (2004) has worked on the vulnerability of the superficial water table against the watershed pollution. WETHE (2003) and TANAWA (2004) have suggested techniques for the management of wastewater. NGIKAM (2007) has studied the public health issue. A study of LEOPOLD (2008) has presented the water pollution by heavy metals.

It is important to note that among all the studies we have found, the majority is represented by Masters and PhD dissertations.

In our literature review, there was no work on persistent organic contaminants. Thus, our goal is to recreate the historical link between the Municipal Lake pollution and the urban development of the Mingoa River watershed in order to produce data. Therefore, we are going to examine the sedimentary compartment using pollutants as tracers. We have chosen to study PAHs, PCBs, parabens and triclosan. Heavy metals have been added to the list given their daily use in various products.

Because we are just starting the field work, we will not show results in this work. We are going to present:

- The analytical methods of the solid phase by gas and liquid chromatography,
- And the difficulties we have met in Cameroon.

MATERIAL & METHODS

Field study

The physical and chemical properties of the lake are those of small shallow tropical lakes.

Table 1: Characteristics data of the Municipal Lake of Yaoundé (Source: NJINE T. et al, 2007)

Characteristics	Altitude	length	Width	Surface area	Maximal depth (Zm)	Minimal depth
data	710,8 m	576,5 m	267,5 m	80 000 m^2	4,3	2,4

These lakes have a stable temperature, along the water column. Light intensity, dissolved oxygen, and nutritive elements are modified along the water column. These data are dependent of Yaoundé climate (two rainy and two sunny seasons). ZEBAZE TOGOUET et al., (2004) have established that dissolved oxygen lacks at the bottom of the lake, instead of the permanent saturation of the superficial layers. They have also concluded to the enrichment of the lake by nutrients.

Choice of the studied pollutants

In order to choose the studied pollutants, we have put forward two hypotheses:

- The use of personal and household care products has been more and more important along the years. They contain substances that are not degraded in the environment, particularly in water. They can accumulate in the sediment and become tracers of urbanization and of its pollution.
- Urban activities like transport or solid waste burning facilities produce persistent pollutants. We suggest that the restrictions made in developed countries for some chemicals in the 70/80's are not implemented in developing ones, in particular in Cameroon. We think we are able to find these products in the deep layers of the sediment as well as in the superficial ones.

Choice of sampling sites

In order to take a sample of sediment, we are going to locate peaks and troughs. In the context of a temporal study, it is important to keep the order of deposit. The lake bathymetry has made possible the identification of shallow areas. We have used a Garmin GPS during the study, and a software called Surfer in order to process data.

Methods analysis of sediments

The literature review has been made using Science Direct and ISI Web of Knowledge.

RESULTS AND DISCUSSION

Studied pollutants

Parabens and triclosan are among the most used chemicals in personal and household care products. PAHs, PCBs and heavy metals are produced by urban activities like transport and

burning waste. These substances are not degraded in the environment and are able to accumulate in sediments. Their log Kow values are presented in table 2.

Table 2: Log Kow of studied organic pollutants

HAPs	PCBs	Parabens	Triclosan
4,79 – 8,20	4,3 – 8,26	1,96-3,61	4,8-5,4

Bathymetry

The results are presented in figure 4. It suggests that the central part of the lake is the deepest with the point 29.

Actually we are thinking to a sampling method to high depths, without a core drill. Indeed in Cameroon, laboratories are not well equipped for that kind of study. And even if it had been the case, it would not have been possible to rent because the cost is very important.

However, we have tried to do the sampling with a PVC pipe (diameter: 12.5 cm; length: 2.60 m). Given that the pipes are sold with a 6 meters length, the sampling can be done everywhere in the lake. But there are inconvenient:

- It is very difficult to eliminate the water preceding the sediment in the pipe during the sampling;
- It is not easy to reach the sediment layers we need for a temporal analysis given that man strength is not enough when he is working on a pedal boat or on a canoe.

We have sampled at the point 18 (see figure 4). We have only reached the superficial layer. The sample is mud containing plants and trees waste.

After the sampling, the pipe's part containing the mud has been kept at 4°C in a cool box. Then it has been sampled in small glass pill-boxes. We have used a plastic one for the heavy metals analysis. Finally, we have lyophilized the material.

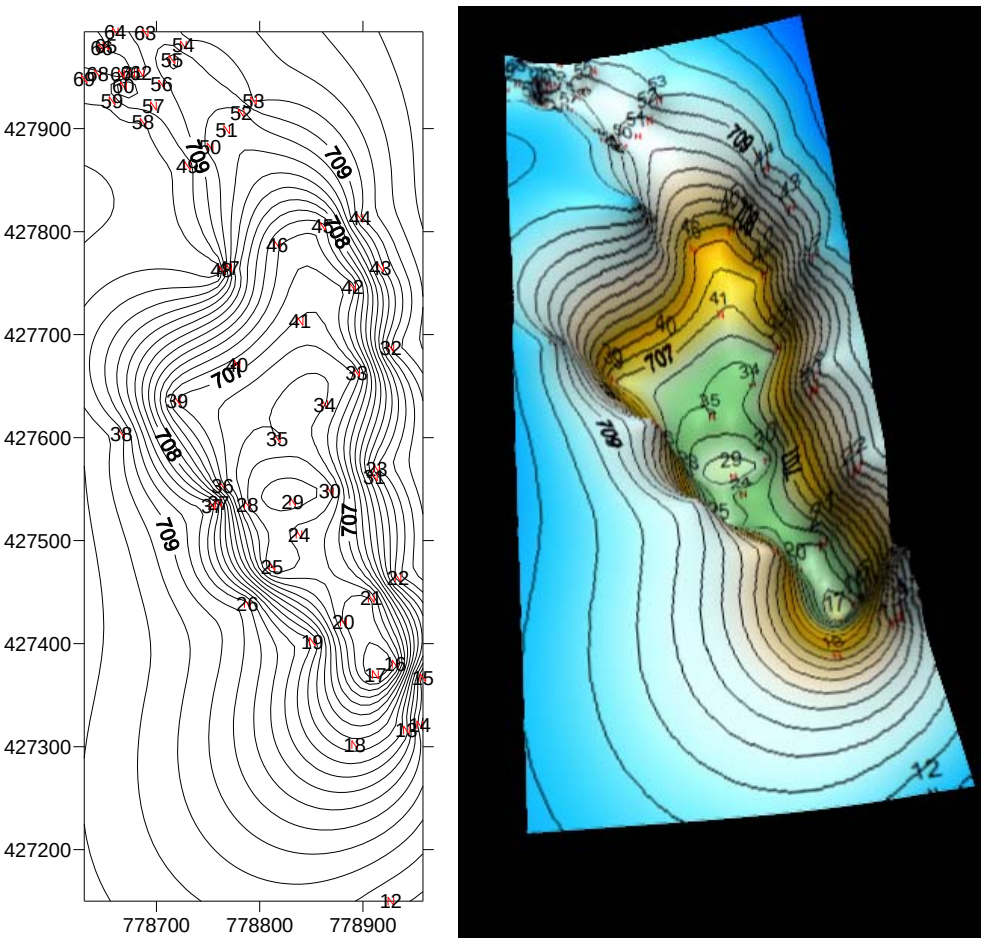

Figure 4: Municipal Lake bathymetry

Methods analysis

The literature review has facilitated the building of a method for the analysis of sediments.

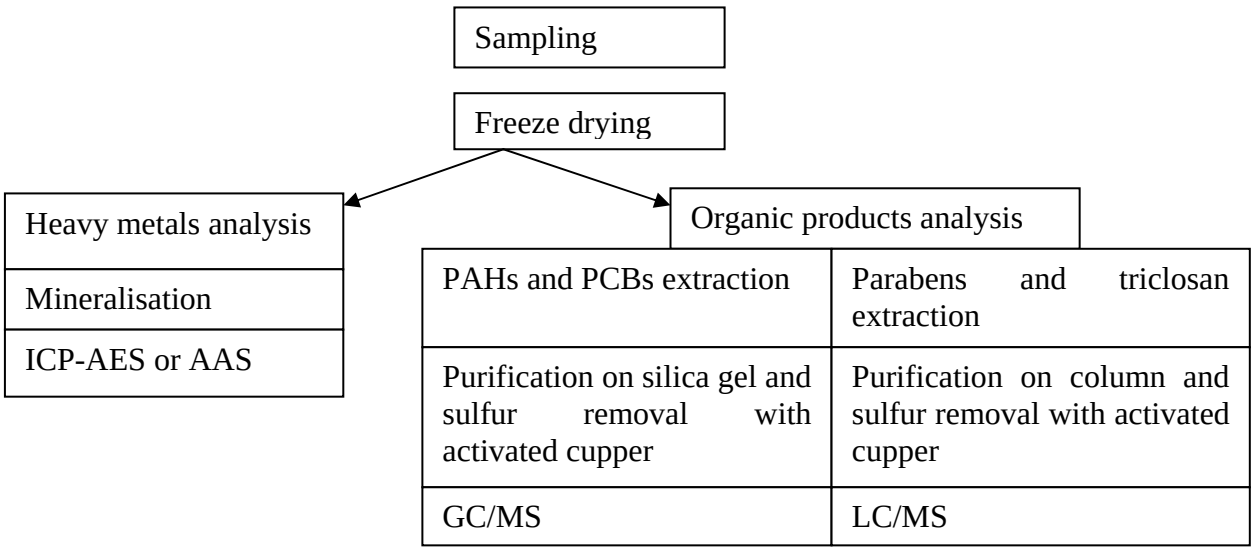

Figure 5: Methodology for sediment analysis

A protocol analysis has been validated by LEESU on certified samples of PAHs and PCBs. It recommends an extraction with microwaves, and with a mix of CH_2Cl_2/MeOH as extraction solvent. Purification of PAHs and PCBs extracts has been made on silica gel. In the literature, the extraction of triclosan using microwaves and different solvents is presented (table 3). For the purification step, different stationary phases are used with various elution solvents. Analytical methods for triclosan and parabens are presented in tables 3, 4, 5.

Table 3: Analytical methods for triclosan and its derivatives

Extraction methods	Soxhlet	Pressurised Liquid Extraction (PLE)		Microwaves	Ultrasonication
Extraction solvent	Ethyl acetate	Acetone	CH_2Cl_2	acetone/MeOH	Ethyl acetate
Stationary phase for purification	SPE with silica, and GPC		Silica gel	SPE – Oasis HLB and silica cartridge	Sep Pak C18
Elution solvent	SPE– ethyl acetate, GPC - cyclohexane		CH_2Cl_2	Ethyl acetate	Ethyl acetate
Author	BESTER K. (2003).	HEIDLER J. (2007).	SINGER H. et al. (2002).	MORALES S.et al. (2005).	YING G.G. (2007).

Table 4: Analytical methods for triclosan and parabens (Me, Et, Pr, Bu, iPr)

Extraction methods	Matrix Solid Phase Dispersion (MSPD)	Pressurised Liquid Extraction (PLE)
Extraction solvent	acetonitrile	Ethyl acetate
Stationary phase for purification	SPE florisil	florisil
Elution solvent	CH_2Cl_2	Hexane
Author	CANOSA P. (2007a).	CANOSA P.et al. (2007b)

Table5 : Analytical methods for parabens (Me, Et, Pr, Bu, iPr)

Extraction methods	Ultrasonication
Extraction solvent	acetonitrile
Stationary phase for purification	
Elution solvent	
Author	NUNEZ L.et al. (2008.)

CONCLUSIONS

Cameroonian authorities wish to rehabilitate the lake. Thus, the site could be a place of sport and leisure. However, such activities can bring back persistent pollutants in the water column. Given that these chemicals have negative impacts on human health and on the aquatic environment, it is important to pay attention to them. There are no data available regarding their levels in Cameroon. Our study is a good introduction in order to reach that goal, furthermore if we are able to reconstruct a historical link between that pollution of the lake's sediments and the urban development of the Mingoa River watershed.

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