

Factors Influencing the Partitioning of Metal Residues (Lead) in Nokoué Lake, Benin

Alassane Youssao Abdou Karim^{1,2*}, Michael Kpèssou Saizonou¹, Magloire Acakpo Nonvignon Gbaguidi¹, Emmanuel Azokpota², Léonce Firmin Dovoanon¹, Daouda Mama² and Henri Houénoukpo Soclo¹

¹Unité de Recherche en Ecotoxicologie et Etude de Qualité (UREEQ)/Laboratoire d'Etude et de Recherche en Chimie appliquée / Ecole Polytechnique d'Abomey-Calavi / Université d'Abomey - Calavi, 01 BP 2009 Cotonou, Benin.

²Laboratoire d'Hydrologie Appliquée (LHA)/ Faculté des Sciences et Techniques/ Université d'Abomey – Calavi.

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ABSTRACT

The impacts on housing and living species (fish, shrimp) related to the disposal of untreated sewage by municipalities and discharges of solid waste was studied by assessing the whole Organic Matter (OM) of the sediments, Chemical Oxygen Demand (COD), Suspended Materials (SM), nitrogen pollution indicators (nitrate-NO₃⁻, nitrite-NO₂⁻, ammonium-NH₄⁺), phosphated (ortho-phosphate ions- PO₄³⁻), sulphide (sulphate-SO₄²⁻, sulphite SO₃²⁻, sulphides S²⁻) of water and total Pb contents of water and sediments of Lake Nokoué. The organic matter content of sediments (19600 to 17164 mg / kg) and COD (130 to 1880 mg/L) of water are very high and indicate an increase in organic pollution of the lake compared to in previous years (Youssao, 2011, Mama et al., 2011). The strong variations in pH are dependent on the contributions of marine origin (basic to neutral) and the mineralization of the organic matter (pH < 7) in the areas of human settlement resulting in a greater or less mobility of the residues of metals in making sulphur available in its reduced form (sulphide and sulphite). The assessment of pollution indicators in the central part of the lake shows that it is heterogeneous in terms of source and impact of pollution. The sediment Pb concentration (Pbsed) / concentration of Pb in water (Pbw) ratio, represented by Pbsed/Pbw ratio shows that lead is 200 to nearly 1000 tiSM more concentrated in sediments than in the water showing a predominance of the organic form of Pb in the ecosystem of Nokoué lake. Indeed, organic lead residues are massively released into this ecosystem by oil traffickers who use motorized canoes to transport their products from Nigeria.

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1. Introduction

Rapid population growth in the cities of Cotonou, Abomey-Calavi and lake villages is followed by heavy pollution of lake ecosystems (Daouda, 2010) in the southern part of Benin. This situation is exacerbated by mismanagement of septic tank emptying waste and the unhygienic behavior of a large section of the poor population living in the surrounding area, near or on natural water bodies FIFI (2010). Surface waters become sites for the disposal of solid and liquid wastes and even excreta that are discharged directly through the stilt latrines built on the lake. However, Nokoué Lake is one of the most important wetland ecosystems of southern Benin and the West African sub-region from a socio-economic point of view (Lalèyé et al., 1995). The Beninese population draws a good part of its protein requirements (fish and others) and these resources are also a source of foreign currency because exported to European countries. In some places, the proliferation of aquatic vegetation hostile to aquatic life is an evidence showing the destruction of this environment. The lakeside villages are also established transforming the lake into a real dump. Now, despite the important services it offers to humans and because of its limited capacity, the aquatic environment cannot ensure the self-purification of all these anthropogenic toxic releases. This is becoming more difficult

in urban areas, especially in African capitals, which have not yet sufficiently integrated a fully functioning waste management system. The purpose of this study is to understand the reaction mechanisms of metals in anthropized natural environments. An assessment of indicators of organic and inorganic pollution of the environment in relation to metals generally allows a better understanding of these phenomena of chemical transformation of metallic pollutants and their mechanism of migration in food chains. The mastery of these mechanisms contributes to the establishment of effective models for managing the regeneration capacity of surface water quality.

2. Material and methods

2.1 Presentation of the study area

Lake Nokoué is located in the southern part of Benin between parallels 6°20' and 6°30' North and meridians 2°20' and 2°35' East Nokoué Lake in the lower valley of the Ouémé River and the Sô river. It stretches from East to West about 12 km long and from North to South, 7 km wide parallel to the Atlantic coast from which it is separated by a coastline. It is connected to the Atlantic Ocean by the Cotonou Channel. The shores of Lake Nokoué are marshy and its depth does not exceed two (02) meters in some places (Figure 1). This ecosystem is marked by a very abundant human presence in and around the area, which throws away

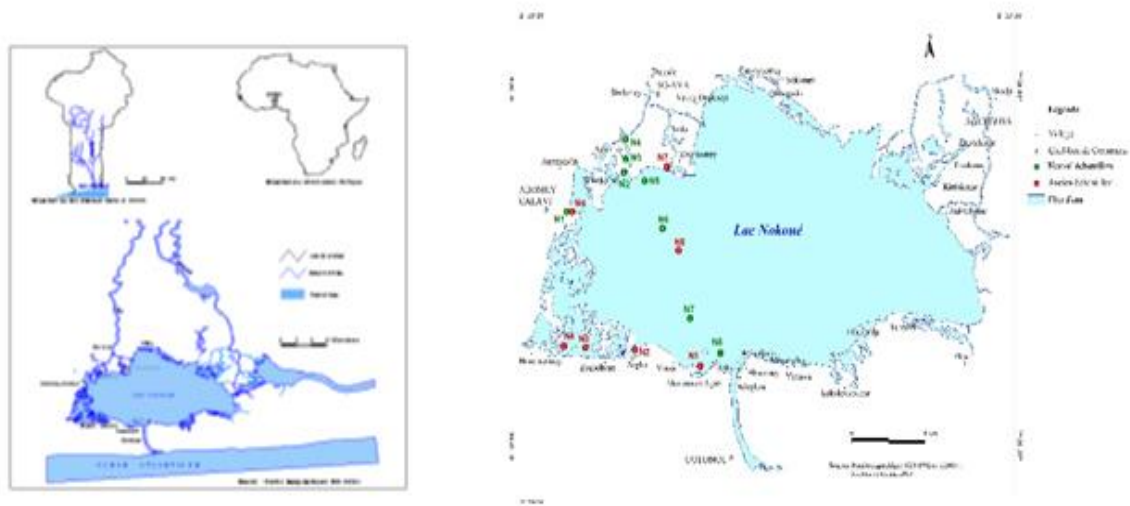


Figure 1. Location map of sampling sites on The Lake Nokoué.

all the wastes and carries out dangerous activities such as the trafficking of petroleum products from the oil-producing country of Nigeria located in the East of Benin.

2.2 Selection of sampling sites

A previous study was carried out in the area indicating a high level of pollution in the surrounding areas at garbage dumps and discharges in the peripheral areas of the effluents transported via the gutters and collectors. To deepen the paradox of a higher contamination in the sediment lead core area, the present study focused a little more on the central zone where four sites were identified in more than four others in the peripheries which were already followed during from the previous study.

2.3 Sampling and conditioning technique for water samples

The taking of a water sample is a delicate operation to which great care must be taken; it conditions the analytical results and the interpretation that will be given (J. Rodier, 1978). For this, the containers used for sampling are a function of the physicochemical characteristics of the element to be analyzed. As part of our study, we used glass and plastic bottles, previously washed and dried in an oven at 105 °C. Water was taken with a bottle plunged about 10 cm below the surface. The bottle is filled flush to avoid trapping air bubbles. All samples of water, sediment, fish are kept in a cooler. Cold accumulators are used to keep them cool in the cooler. Once brought back to the laboratory, the water samples are refrigerated at 4 °C while the sediment samples are placed in the freezer.

2.4 Measurement of physical parameters

These are temperature, pH, conductivity, total dissolved solids (TDS) and total salinity. The pH was measured in the field with a PCS Testr 35 multimeter by immersing the probe in the water taken from a 50 mL beaker by immersing the probe about 10 cm from the surface of the water, and reading digital display of pH and temperature, as well as conductivity, TDS, and salinity successively. These parameters were measured using the PCS testr multi parameter mark 35. The multiparameter's probe has been immersed in the water about 10 cm below the surface and the reading is done on the screen of the device. The soil pH determination method consists in weighing 20 g of fine sediment screened to 2 mm, add 50 mL of demineralized water and shake for 15 minutes. Leave the suspension at rest for 30-60 minutes, immerse the pH-meter probe in the supernatant water and read to the nearest 0.1; the pH meter is calibrated beforehand. This protocol is that of ISO 1842: 1992.

2.5 Determination of organic and inorganic pollution indicators

The indicators of organic pollution measured are the total organic soil material (OM), the Chemical Oxygen Demand (COD) and the Suspended Material (SM). The OM of the soils was determined by loss on ignition (Rodier, 1978) by carrying a determined quantity of sediment in the oven at 105 °C, weighing after 24 hours and then at 550 °C and weighing again. The difference in mass allows the determination of total organic matter (OM). This parameter was measured by the gravimetric method using a filter with a diameter of less than 45 µm. The Determination of the Chemical Oxygen Demand (COD) by potassium dichromate in an acid and a hot medium.

Indicators of inorganic nitrogen pollution were determined by:

- the ammonium molybdate method for phosphate ions. The principle is based on the fact that in acidic medium and in the presence of ammonium molybdate, the phosphates give a phosphomolybdic complex which, reduced by ascorbic acid, develops a blue colour susceptible to a colorimetric dosage.
- the Nessler (alkaline potassium iodo-mercurate) reactive method for ammonium ions with formation of dimercuriammonium iodide which can be assayed spectrophotometrically at the wavelength of 400 to 425 nm.
- the sodium salicylate colorimetric method for nitrate ions by the use of sodium salicylate in the presence of nitrates which gives sodium paranitrosalicylate colored in yellow and which is capable of a colorimetric assay at the wavelength of 420 nm.
- the Zambelli reagent method and the sulphanilic acid in hydrochloric acid medium for nitrite ions. The complex formed with the NO_2^- ions is colored yellow and is capable of a colorimetric assay at the wavelength of 435 nm.

Sulphur and orthophosphate pollution indicators were determined by kit-based colorimetry, except sulphate ions, which were determined gravimetrically using barium chloride. The lead residues were determined by the colorimetric method exposed by Youssao et al. (2018b).

3. Results and discussion

3.1 Evolution of the physical parameters

The conductivity is 7.94 at the Middle Lake site1 (Mil1) at 392 mS/cm at the mouth of the river with an average of 105.27 mS/cm. These values are well above those of Dongui et al. (2017) in fresh water (48.2 to 98.6µS/cm) in the Aghien lagoon and Bhangé et al. (2018) whose values are in the range of 149 to 348 µS/cm; but close to the results of Dimon et al.