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Research Article

Evaluation of Heavy Metals Loading of Yamoussoukro Lake System (CÔTE D'IVOIRE)

[1]AW Sadat, [1]Kouakou Koffi Amoulaye, [2]Adamou Mahaman Moustapha and [1]Siaka Sorho
[1]Laboratoire des Procédés Industriels de Synthèse, de l'Environnement et des Energies Nouvelles (LAPISEN) Institut National Polytechnique Houphouët Boigny Bp 1313 Yamoussoukro, Côte d'Ivoire
[2]Département Génie rural, Eaux et Forêts, Faculté d'Agronomie, Université Abdou Moumouni BP 10960 Niamey, Niger

Abstract: The present study was conducted to provide baseline data for metal concentration in Yamoussoukro lake system, a tropical lake system. For this purpose, seventeen stations were selected as sampling sites. Water samples were collected monthly, between January and December 2011 and analyzed using Inductively Coupled Plasma (ICP-OES) spectrometer to determine metal content. Iron (Fe), Manganese (Mn), Zinc (Zn), Copper (Cu) and lead (Pb) concentration were determined. On average, the level of heavy metal varied from 0.005±0.011 to 1.048±0.421 for Fe, 0.012±0.003 to 0.440±0.137 for Mn, 0.192±0.054 to 0.347±0.045 for Zn, 0.008±0.02 to 0.019±0.005 for Cu and 0.015±0.005 to 0.021±0.003 for Pb; all in mg/L. Heavy metals presented in the study area presented en heterogeneous variation and iron tops the list with a value of 111.52%. Furthermore, all the samples analyzed contained the five heavy metals studied each in varying concentrations. These parameters concentrations indicated that the Yamoussoukro lake system is fairly polluted according to the WHO standards.

Keywords: Heavy metals, Inductively Coupled Plasma (ICP-OES), tropical lakes system, water quality, Yamoussoukro

INTRODUCTION

Heavy metals are sometimes called "trace elements". They are the metallic elements of the periodic table. Heavy metals have become of particular interest in recent decades within the framework of environmental investigation. Heavy metal contamination of surface water is a worldwide environmental problem. Trace amounts of heavy metals are always present in fresh waters from the weathering of rocks and soils and a variety of anthropogenic activities (Al-Rousan *et al*., 2007; Bozkurtoglu *et al*., 2006; Zhang *et al*., 2012). Research on heavy metals has met with strong growing interest in recent years. This is partly a consequence from the concern for environmental protection and is due to increasing knowledge about the role and effect of metallic elements in living organisms. Rapid urbanization and industrial development during last decade have provoked some serious concerns for the environment. Trace metals contamination of water is one of the major quality issues in many fast growing cities, because maintenance of water quality and sanitation infrastructure did not increased along with population and urbanization growth especially for developing countries (Reza and Singh, 2010).

Heavy metals are regarded as serious pollutants of aquatic ecosystems because of their environmental persistence, potential toxicity and ability to be incorporated into the food chain (Ololade *et al*., 2008; Chary *et al*., 2008; Tao *et al*., 2012; Volpe *et al*., 2009). They can cause serious health effects with various symptoms depending on the nature and quantity of the element ingested (Gutiérrez *et al*., 2008; Khan, 2011).

The focus of this study was Yamoussoukro lake system waters from Côte d'Ivoire, an African tropical developing country. Even though there is information about the physic-chemical properties and bacteriological pollution (Aw *et al*., 2011a, 2011b), what is lacking is the knowledge of trace metals distribution in the water. The purpose of this research was to establish the dissolved heavy metals (Fe, Mn, Zn, Cu, Pb) concentration in waters and to provide a baseline data.

Corresponding Author: AW Sadat, Laboratoire des Procédés Industriels de Synthèse, de l'Environnement et des Energies Nouvelles (LAPISEN) Institut National Polytechnique Houphouët Boigny Bp 1313 Yamoussoukro, Côte d'Ivoire

MATERIALS AND METHODS

Study area: The study area is located in the town of Yamoussoukro, in the centre of Côte d'Ivoire, 250 km to the north-west of Abidjan at about 6°5' North latitude. A set of lakes was built there on two connected rivers. These lakes are small, shallow and eutrophic (Aw *et al*., 2011b; Parinet *et al*., 2004). The rainfall is about 1100 mm/year and temperatures range from 27 to 33°C. There is no major industrial development in the region. The activities along the lake system include catering, petroleum services, fishing, bathing, swimming, breeding and irrigation. There is not efficient sewage treatment system and untreated domestic and municipal wastewater is directly released in to the lakes.

Sampling and analysis: Seventeen sites along the part of the Yamoussoukro lake system were selected for sampling collection. Surface water samples (0-50 cm) were collected monthly from January to December 2011 at each station by submerging a sterile container and placed in a cooler at 4°C and shipped to the laboratory. All samples were acidified to pH 2, using HCl (0.1 N) and filtered through a GF/C filter (Whatman) to remove the suspended material.

The evaluated metals were Iron (Fe), Manganese (Mn), Zinc (Zn), Copper (Cu) and lead (Pb). The concentration of metals was done using an Inductively Coupled Plasma-Optical Emission Spectrometer (ICP-OES) (Perkin Elmer Optima 4300 DV) according to the normalized French standard method (AFNOR, Association Française de NORmalisation) NF EN ISO 11885. For the different element's determination, standards of know concentration were prepared for each element, followed by calibration of the wave longitude, plasma position, gas flux and sensibility for each element.

Statistical analysis of data: All individual result was recorded using Microsoft Excel 2007 software (Microsoft Corporation) and the statistical analysis was performed with the Statistical Package for Social Sciences 18 for Windows (SPSS Inc.).

RESULTS AND DISCUSSION

Dissolved trace metals concentration at surface water are summarized in Table 1 (levels per sites) and 2 (total averages). Among examined variables, Fe has the highest mean (0.287 mg/L) followed by Zn (0.273 mg/L) while Cu remained the least (0.014 mg/L). Also, Fe recorded the highest standard deviation (0.320 mg/L), this is followed by Mn (0.145 mg/L) while Pb record the least value (0.005 mg/L). The result of the coefficient of variation shows that the examined variables are heterogeneous. Iron tops the list with a value of 111.52%. Higher values of iron were recorded at station 1 with a maximum concentration of 1.048 mg/L. Conversely, zinc experienced higher concentration of 0.347 mg/L at station 10.

The heavy metals are environmental contaminants, very common from metal mining and processing, as well as from many other industrial, municipal and agricultural activities. According to Zhang *et al*. (2012), local geological and anthropogenic influences determine the concentrations of heavy metals in aquatic system. The absence of efficient sewage treatment in Yamoussoukro city may be contributing to the levels of trace metals in the lakes. In view of the fact that the major use of water in the study area is fishing, agricultural and domestic and according to WHO (2004), the safe limits in Yamoussoukro lakes was not observed high levels of contamination by heavy metals in water excepted for lead. In some sampling stations,

Table 1: Concentrations (mean values±S.D.) of trace metals (mg/L) at different station

Stations	Fe	Mn	Zn	Cu	Pb
Station 1	1.048±0.421	0.394±0.093	0.305±0.071	0.019±0.008	0.019±0.004
Station 2	0.740±0.204	0.440±0.137	0.236±0.067	0.016±0.003	0.019±0.007
Station 3	0.123±0.050	0.102±0.033	0.212±0.051	0.010±0.003	0.019±0.007
Station 4	0.143±0.021	0.149±0.052	0.192±0.054	0.013±0.002	0.018±0.060
Station 5	0.108±0.009	0.073±0.015	0.277±0.054	0.014±0.002	0.021±0.003
Station 6	0.052±0.009	0.045±0.007	0.264±0.038	0.018±0.003	0.015±0.005
Station 7	0.055±0.009	0.012±0.003	0.300±0.025	0.018±0.002	0.019±0.001
Station 8	0.050±0.011	0.022±0.003	0.277±0.071	0.019±0.005	0.017±0.004
Station 9	0.066±0.005	0.035±0.004	0.317±0.026	0.013±0.002	0.020±0.007
Station 10	0.255±0.056	0.127±0.027	0.347±0.045	0.012±0.002	0.018±0.006
Station 11	0.080±0.014	0.067±0.009	0.294±0.065	0.011±0.002	0.017±0.001
Station 12	0.218±0.031	0.213±0.047	0.274±0.053	0.016±0.002	0.019±0.003
Station 13	0.290±0.032	0.255±0.026	0.261±0.033	0.010±0.002	0.020±0.003
Station 14	0.353±0.071	0.265±0.056	0.254±0.051	0.012±0.004	0.021±0.005
Station 15	0.280±0.037	0.094±0.015	0.226±0.030	0.011±0.002	0.018±0.002
Station 16	0.151±0.028	0.184±0.044	0.263±0.073	0.008±0.002	0.017±0.004
Station 17	0.877±0.130	0.383±0.125	0.340±0.090	0.011±0.002	0.018±0.007

Table 2: Descriptive statistics of heavy metals in Yamoussoukro lake system and WHO standards limits

Parameters (mg/L)	*WHO standard	Mean	Min.	Max.	S.D.	C.V. (%)
Fe	0.30	0.287	0.014	1.881	0.320	111.52
Mn	0.50	0.169	0.002	0.644	0.145	85.97
Zn	3.00	0.273	0.026	0.995	0.109	39.74
Cu	2.00	0.014	0.002	0.057	0.007	50.08
Pb	0.01	0.019	0.004	0.042	0.005	28.91

*WHO (2004); Min.: Minimum; Max.: Maximum; S.D.: Standard deviation; C.V.: Coefficient of variance

the levels of Fe and Pb exceeded the recommended limits, suggesting more caution in the monitoring process of these sites.

The highest levels of Fe and Mn concentrations were recorded at stations 1, 2 and 17. The presence of iron in this area could be attributed to high organic matter and low dissolved oxygen content (Aw *et al*., 2011b).

The WHO permissible level of Zinc was above the recommended limit (Table 2) of the sampled water in all the stations. This indicates that water contains the right proportion of Zn which is an essential plant and human nutrient element and there is no detrimental effect for aquatic ecosystem regarding Zn toxicity.

Lower concentration of copper persisted for all the stations. At normal concentration, Cu is a biologically important trace element; at elevated concentration it is toxic for living organisms (Khan, 2011). The low value of Cu indicates there is no significant source of pollution (Reza and Singh, 2010).

The concentration of lead exceeded the WHO permissible (0.01 mg/L) limit in all the station. Pb presence at high concentration in the study area could be related to atmospheric deposition, industrial and other technical uses most of which are: electric storage batteries, leaded gasoline and lead in paint (Emoyan *et al*., 2006). The Beneficial effects of lead are not known.

CONCLUSION

The levels of heavy metals, namely iron, manganese, zinc, copper and lead were analyzed in Yamoussoukro lake system. The study revealed the mean concentration of all measured metals except lead conforms to the maximum permissible limits of WHO standards for water quality.

On the pattern of relative variation, the result shows that all the examined variables are heterogeneous. Iron for example tops the list with a value of 111.52 %.

The present study had its limitations. Therefore to have more conclusive results, a comprehensive study of physicochemical parameters should be carried out on the sediments of Yamoussoukro lake system.

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