DETERMINATION OF TOXIC METALS IN SEDIMENTS OF LAKE IZABAL, GUATEMALA

Juan Francisco Pérez Sabino[a]*, Bessie Eevelyn Oliva Hernández[a], João Paulo M. Torres[b]
[a] Escuela de Química, Universidad de San Carlos de Guatemala, Ciudad de Guatemala, Guatemala. [b] Instituto de Biofísica Carlos Chagas Filho, Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brasil.
e-mail: fpsabino@terra.com.gt

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ABSTRACT

Total and available toxic metals concentrations were determined sediments of Lake Izabal during 2004. Total lead was found in concentrations between 4.4 and 49.3 mg/Kg (dw). Pb-Zn carbonate-hosted deposits located 100 Km at west of the lake partially explains lead concentrations. Discharges from the polluted Polochic River could also be responsible for this contamination. Nickel mining during 1970s and 1980s is considered to be responsible of ecosystem contamination by toxic metals. El Estor, the nearest site to the mining facilities, showed the highest total and available mean concentrations for nickel (1648.2 mg/Kg and 1,114.6 mg/Kg) and for chromium (1923.8 mg/Kg and 205.6 mg/Kg). Levels of cadmium were found for the first time in Lake Izabal sediments (0.23-0.59 mg/Kg) which could indicate increasing anthropogenic contamination. The results are useful as baseline for Lake Izabal sediments, since new concessions of nickel extraction are operating again in the basin.

INTRODUCTION

Lake Izabal, the largest lake in Guatemala is located at northwest of Guatemala and has an extension of 717 km^2 and mean depth of 11.6 m. The basin includes Dulce River which discharges its water to Caribbean Sea. The basin has a population of approximately 320000 living in towns that have not the minimum services for wastewater treatment. The Lake has overcame significant deterioration during the last three decades, because of deforestation, intensive agriculture and cattle, mining and lack of wastewater treatment in the basin. Lake Izabal represents a source of food and water for different purposes for people living in the basin. The uses of water and the high biological diversity levels found into different protected areas in Lake Izabal and Dulce River basin, have increased the concern on environmental pollution and water monitoring.

Lake Izabal is actually in eutrophic state showing high levels of nutrients coming from its main tributary, Polochic River, which supports almost a 70% of the water of Lake Izabal. Polochic River is highly polluted since it receives the untreated wastewater from important human villages. Thus different pollutants, such as nutrients, metals and pesticides are discharges to Lake Izabal through this river. There are lead and zinc deposits in the basin which could be natural sources of contamination. Another source of metal contamination is the mineral extraction in the region. Nickel was extracted in the 1970s and early 1980s using methodology which did not include treatment of wastewater nor impact mitigation. Nowadays nickel extraction has been authorized again, thus the actual levels are important for impact assessment. The aim of this study was to assess the levels of toxic metal, for getting information useful for the management of protected areas and hydrological resources in Lake Izabal basin.

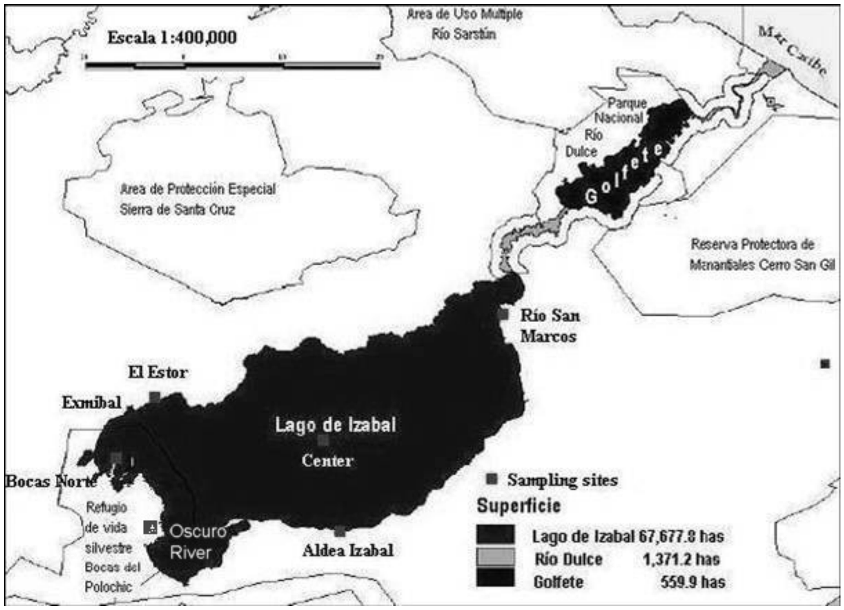

Figure 1. Sampling sites in Lake Izabal.

METHODOLOGY

Superficial sediments were sampled in October 2004, using an Ekman dredge in six locations in Lake Izabal (Figure 1), and were dried at 60°C; Metals were determined by Atomic Absorption Spectrophotometry (AAS), using IAEA Soil-7 certified reference material for quality control. 0.2 g dried sediment were digested with 5 mL concentrated HNO_3 and 4 mL concentrated HF in a teflon pump, by 12h at 120°C. After that, the samples were transfered to a teflon beaker, and evaporated to dryness. Then, the samples were dissolved in 20 mL 0.1 N HCl and measured by AAS. For metal available fraction, 0.2 g dried sediment were digested with H_2O_2 by 2 h and then with 0.3 N HCl by 2 h. The samples were filtered and measured by AAS. Table I shows the mean total and available concentrations of eight metals in sediments of Lake Izabal found in this work.

RESULTS AND DISCUSSION

The basin geology is characterized by showing ophiolites at north of Lake Izabal and carbonate-hosted deposits located at the west of the lake, are responsible for inputs of lead and zinc into the lake and its sedimentation and accumulation at bottom (Machorro, 1996).

Mean concentration values of 221 mg/Kg of lead and 86 mg/Kg of zinc were previously reported (Basterrechea *et al*., 1993), but the sampling sites were different to the ones of this study. A partial explanation for the concentrations of lead (highest value in the Lake center, 49.3 mg/Kg) is suggested from a geological basis, since Pb-Zn carbonate-hosted deposits are located 100 km at west of the lake**.** The discharges of untreated wastewater to Polochic River could also be responsible for contamination by lead, as other rivers in Guatemala are contaminated by lead because of direct wastewater discharges. Lake Petén Itzá, Another lake located in the north of Guatemala, has showed levels of lead between 13 to 65 mg/Kg (Oliva *et al*., 2007). For comparison, levels of lead between 11.7 and 17.5 mg/Kg have been found in Lake Nakuru in Kenya (Ochieng *et al*., 2007). Zinc showed the highest total mean concentration (101.9 mg/Kg) in the Lake center and the highest available concentration in El

Estor (80.9 mg/Kg). The sediments of the south and the east of the Lake showed lower concentrations for this metal (Aldea Izabal, Oscuro River and San Marcos River).

Table 1. Mean concentration of metals in sediments of Lake Izabal in 2004 (mg/Kg, dw).

Sampling site	Form	Zn	Ni	Mn	Cr	Pb	Cd	Cu	Fe
Polochic River Bocas Norte	T	77.5	107.2	341.4	88.2	22.4	0.34	23.2	26086.1
	A	54.6	66.8	76.4	11.6	21.5	N.D.	16.2	14852.2
El Estor	T	96.6	1648.2	507.4	1923.8	20.8	0.59	56.8	55289.0
	A	80.9	1114.6	77.5	205.6	17.9	0.08	27.0	27793.0
Lake Izabal Center	T	101.9	333.6	610.8	159.4	49.3	0.50	49.0	69762.6
	A	59.7	186.4	78.0	39.4	41.1	0.47	22.2	34159.5
Aldea Izabal	T	41.3	166.4	463.5	472.8	4.4	0.32	20.0	40157.1
	A	9.7	40.7	76.5	19.5	4.3	0.08	5.3	8304.2
San Marcos River	T	42.5	43.4	240.5	17.6	9.3	0.23	15.3	38447.7
	A	11.2	6.9	77.0	2.1	6.9	0.00	4.8	10763.1
Oscuro River	T	29.6	180.7	226.3	545.0	14.5	0.26	7.8	25790.0
	A	12.9	146.4	66.5	10.2	4.9	0.05	4.6	9216.0

T: Total; A: Available fraction; N.D.: Not determined.

Nickel mining during seventies and early eighties is considered to be one of the main activities that increased the levels of metals in the sites near the ore (Exmibal, in Figure 1). Thus, El Estor which is the site nearest to the mining facilities and to the most populated town in the region, showed the highest total and available nickel mean concentrations (1648.2 mg/Kg and 1114.6 mg/Kg, respectively) which are very high when compared to levels found in Lake Petén Itzá (1.5-69.9 mg/Kg) (Oliva *et al.*, 2007) and Lakes Bagoria and Nakuru in Kenya (highest values of 37.8 and 55.4 mg/Kg, respectively) (Ochieng *et al*., 2007). El Estor showed also the highest total and available chromium mean concentrations (1923.8 mg/Kg and 205.6 mg/Kg, respectively), which are much higher than the levels found in Lake Petén Itzá (4.18-166.73 mg/kg) (Oliva et al., 2007) and lakes Bogoria and Nakuru in Kenya (highest values of 4.87 and 1.96 mg/Kg, respectively). The values of nickel and chromium found in El Estor are significantly higher than concentrations found in the other sampling sites, as for example, sediments of the Lake center and San Marcos River sites showed total nickel concentrations of 333.6 mg/Kg and 43.4 mg/Kg, respectively.

Levels of cadmium were found for the first time in sediments of Lake Izabal (0.23-0.59 mg/Kg) in this work, which could indicate that anthropogenic contamination is increasing. Cadmium has been found also in Lake Petén Itzá in concentrations between 0.30 and 5.26 mg/Kg (Oliva *et al.*, 2007). Lead, nickel and zinc showed a high proportion of available fraction regarding the total concentration. Instead, chromium and cadmium showed a lower available concentration fraction in almost all the cases. However, the high level of available chromium found in some sampling sites must be considered in order to investigate the sources of the pollution by this toxic metal.

CONCLUSION

The results are useful as the baseline for levels of toxic metals in sediments in Lake Izabal and for making decisions regarding the aquatic environment management, since recent concessions for nickel extraction are starting to operate in the basin. The contamination of sediments by nickel and chromium is higher in El Estor, apparently due to the nickel extraction in the area.

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