

THE DISCHARGE OF EFFLUENTS AND THE CONTAMINATION BY TOXIC METALS AND ORGANIC MATTER IN LAKE OF SEMIARID NORTHEAST, BRAZIL

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ABSTRACT

In recent years, the process of urbanization has been growing in Iguatu, important city of the semi-arid region of Brazil. This process has influenced the quality of aquatic environments due to effluent discharge and the emission of pollutants. Iguatu has modern and efficient sewage treatment system, but only 15% of the population benefits. This paper aimed at the determination of 9 metals and 12 physical-chemical parameters to characterize of Bastiana Lake-CE and to evaluate the influence of effluent discharge. The results of the analysis of toxic metals showed presence of Zinc

(Zn) and manganese (Mn) at levels above of maximum limits established by Brazilian legislation. Exposure to Mn can affect the IQ (Intellectual quotient). Water samples showed high concentration of organic matter (BOD), nitrogen, phosphorus, soluble substances hexane and presence of floating materials. The level of nutrients (N and P) classified the lake as eutrophic and hypereutrophic and may cause risk to human health. Results suggest that actions must be taken by government agencies to prevent the complete degradation of Lake Bastiana (Ceará, Brazil).

PALAVRAS-CHAVE: urbanization, wastewater, aquatic environment, metals, nutrients

O DESCARTE DE EFLUENTES E A CONTAMINAÇÃO POR METAIS TÓXICOS E MATÉRIA ORGÂNICA EM LAGOA DO SEMI-ARIDO NORDESTINO, BRASIL

RESUMO

Nos últimos anos, o processo de urbanização tem sido crescente em Iguatu, importante cidade da região semi-árida do Brasil. Este processo tem influenciado a qualidade dos ambientes aquáticos devido à descarga de efluentes e da emissão de poluentes. Iguatu tem o sistema de tratamento de esgoto moderno e eficiente, mas apenas 15% da população se beneficia. Este trabalho teve como objetivo a determinação de 9 metais e 12 parâmetros físico-químicos para a caracterização da Lagoa da Bastiana e avaliar a influência do descarte de efluentes. Os resultados da análise de traços de metais tóxicos mostrou presença de zinco (Zn) e manganês (Mn)

em níveis acima dos limites máximos estabelecidos pela legislação brasileira. A exposição a Mn pode afetar o QI (quociente intelectual). As amostras de água apresentaram alta concentração de matéria orgânica (expressos em DBO), nitrogênio, fósforo, substâncias solúveis em hexano e presença de materiais flutuantes. O nível de nutrientes (N e P) classificou o lago como eutrófico e hipereutrófico e pode causar risco para a saúde humana. Os resultados sugerem que ações devem ser tomadas por agências governamentais para evitar a degradação completa do Lago Bastiana (Ceará, Brasil).

KEYWORDS: urbanização, efluente, ambiente aquático, metais, nutrientes

1 INTRODUCTION

The northeastern semiarid region's main characteristic is the shortage or high spatial and temporal variability of rainfall. These weather conditions make the regional society to seek better use of water resources for carrying out their economic activities related to agriculture and livestock.

The urbanization occurred in recent years has significant impact on environment (Bougheira *et al.*, 2014). Urban development has produced a cycle of contamination caused by the discharged wastewaters and residues (Tucci 2008; Dsikowitzky & Schwarzbauer 2014). Contamination of aquifers is one of the major public health problems nowadays (Milhome *et al.*, 2015; Mazoud *et al.*, 2016). The collection of sewage is still not widespread service in most of Brazil and the treatment is scarce, causing serious consequences to the environment and public health. In Brazil, the sewer system covers about 55% of the municipalities, but only a portion of 29% own treatment system (IBGE, 2008).

In the city of Iguatu, located semi-arid region, the urbanization process was similar. Iguatu is also known as "land of lakes", due to the five ponds existing around the city and six ponds in rural. Bastiana Lake there is a nature conservation area which was instituted by Municipal Act in the early 1990s. The urbanization process has been responsible for the increased volume of effluents and siltation of lakes. Industrial and domestic sewage has a large amount of organic matter, pathogenic microorganism and toxic residues and generates environmental impacts if not properly treated. Marques, Oliveira & Machado (2003) reported that due to the accelerated process of urbanization, the indiscriminate dumping of such waste into waters without any treatment damage the environment and human health.

The process of pollution by trace elements of water resources has been observed in several regions (Sun *et al.*, 2011; Hu *et al.*, 2013; Subramanian *et al.*, 2015). Hahladakis *et al.* (2013) analyzed sediment samples from Lake Koumoundourou and Elefsis Bay, Athens, Greece to determine and assess the anthropogenic contribution six toxic metals (Cr, Ni, Cu, Zn, As and Pb) in the contamination of lakes. The results indicated that Lake Koumoundourou was contaminated with heavy metals in a moderate degree. An integrate study on the occurrence of major, minor and trace elements in the coastal environment of Thermaikos Gulf, Northern Aegean Sea, was carried out by Violintzis *et al.* (2009). The pollution status of marine sediments was evaluated by employing enrichment factors and sediment quality guideline. Zn, Cu, Pb, As and Ag were found to have significant contribution from anthropogenic sources. The contamination has affected the level of metals in aquatic species (Yi *et al.*, 2011; Obaidat *et al.* 2015).

Urbanization has contributed on changes in the ecosystem (Hong *et al.* 2012; Ren *et al.* 2014). Several studies have cited the problems caused by eutrophication of water sources (Nyenje *et al.* 2010; Humphrey *et al.* 2014). Vidal and Capelo Neto (2014) determined the nutrient load in the Gavião Dam (Ceara, Brazil) to evaluate the process of eutrophication. Analysis of samples collected from January to May 2011 showed that the Gavião dam was classified as eutrophic, being liable to encourage blooms of cyanobacteria. Tropical water bodies have a higher phosphorus assimilation capacity that water bodies in temperate climates. The aim of this study was to characterize the Lagoon Bastiana, in the semi-arid environmental through the levels of metals and

physico-chemical parameters to evaluate the influence of the urbanization process and the disposal of sewage and suggests an environmental diagnosis.

2 METHODS

2.1 Local of study and sampling

The Iguatu city is located in state of Ceará, in semi arid northeast of Brazil. It has an area of 1029.2 km² and about 100,733 habitants (IBGE, 2008). Its temperature varies from 20°C to 35°C. The vegetation is dense shrub savanna. Its climate is characterized of low humidity and rainfall (1079 mm annual), with brief periods of rain (January and April).

The effluent treatment system covers only 15% of the city, with about 4649 links. Currently the sanitary system of Iguatu using *Upflow anaerobic ludge blanket (UASB)* technology for the treatment of domestic sewage, which act through anaerobic degradation of organic matter. The majority (85%) of sewage originates from individual systems such as septic tanks, followed sinks and swales.

The Bastiana Lake (Figure 1) is inserted in the urban area of the Iguatu-CE, it has an area of approximately 79.8 hac, and about 2 m deep. Bastiana Lake water samples were collected in a bottle of one liter (1L) glass amber and stored under refrigeration (4 °C), at two different points (A and B), as shown in Figure 1.

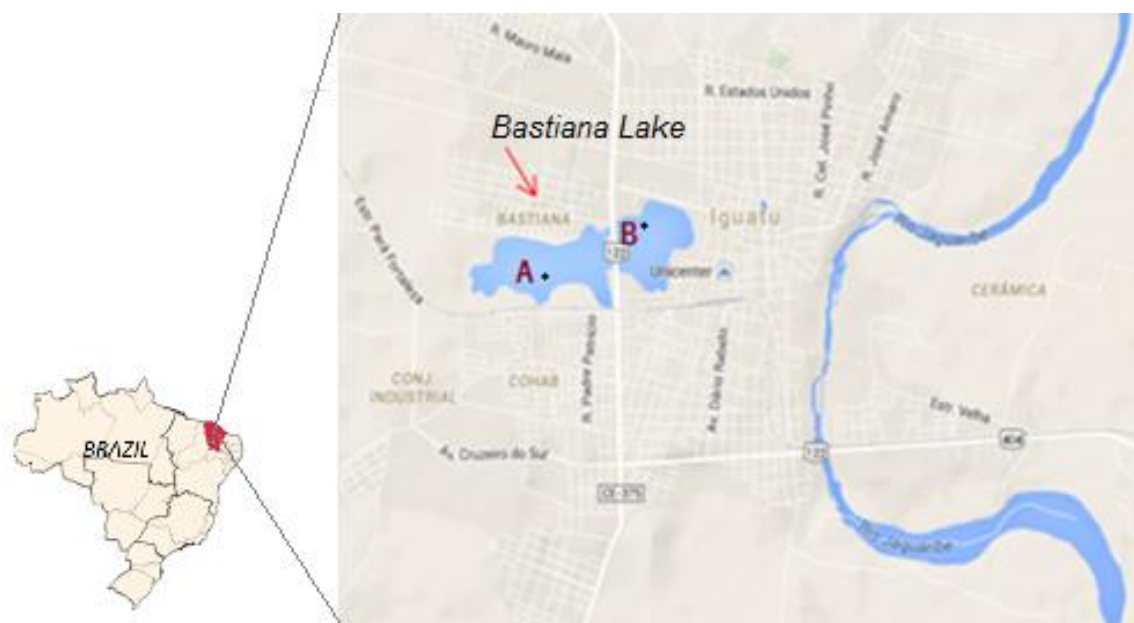


Figure 1 – Bastiana Lake, Iguatu, Ceará, located in semi arid of northeast of Brazil.

2.2 Determination of metals

The determination and quantification of metals Cadmium (Cd), Zinc (Zn), Lead (Pb), Cobalt (Co), Chromium (Cr), Iron (Fe), Copper (Cu), Manganese (Mn) and Nickel (Ni) in aqueous samples were obtained by Atomic Absorption Spectrophotometer (Sollar, Serie S, Thermo) of Federal Institute of Education Science and Technology of Ceará (IFCE-Campus Iguatu), with support of the Laboratory Nucleus of Waters of the Federal University of Ceará (UFC). Analysis was performed

according to the recommendations of the Standard Methods for the Examination of Water and Wastewater (APHA *et al.* 2005). The limits of detection (LODs) of the method ranged from 0.001-0.1 mg/L.

2.3 Physico-chemical parameters

The physico-chemical analyses of the samples were performed in the Chemistry Laboratory of Federal Institute of Education Science and Technology of Ceará (IFCE-Campus Iguatu), with support of Foundation Industrial Technology Center of Ceara (NUTEC). The analysis of the pH, temperature, solid sedimentary, suspended solids, floating materials, Chemical Oxygen Demand-COD, Biochemical Oxygen Demand- BOD, hexane-soluble substances, chlorides, total phosphorus, total ammonia nitrogen and salinity followed the procedures established by the Standard Methods for the Examination of Water and Wastewater (APHA *et al.* 2005).

3 RESULTS AND DISCUSSION

3.1 Determination of metals

The investigation of the level of contamination by toxic metals was performed by determining the nine metals (Cd, Zn, Pb, Co, Cr, Fe, Cu, Mn and Ni) in the samples (A and B) Bastiana Lake- CE and are described in Table 1

Resolution CONAMA 357/2005 defines the water quality standards, which are established maximum limits for various physical and chemical parameters, as well as organic and inorganic compounds. According to the legislation, Class II waters are intended for supply for (a) human consumption after conventional treatment, (b) the protection of aquatic communities, (c) the primary contact recreation and (d) irrigation

Table1 – Concentration of metals in the Bastiana Lake and limits by Brazilian legislation

Metal	Bastiana Lake Samples		CONAMA 357/05 Resolution
	A	B	Class 2
Cd (mg/L)	< LOD	< LOD	0.001
Zn (mg/L)	0.357	0.286	0.180
Pb (mg/L)	< LOD	<LOD	0.010
Co (mg/L)	< LOD	< LOD	0.050
Cr (mg/L)	< LOD	< LOD	0.050
Fe (mg/L)	0.180	0.209	0.300
Cu (mg/L)	< LOD	<LOD	0.009
Mn (mg/L)	0.243	< 0.288	0.100
Ni (mg/L)	< LOD	<LOD	0.025

Limit of Detection (LOD) = 0.001-0.1 mg/L

The results show the presence of Zn, Fe and Mn. The Fe levels remained below the maximum limit (0.3 mg/L). However Zn and Mn levels showed slightly above the allowable value (0.18 and 0.1 mg/L respectively), which is possibly indicative of pollution due to anthropogenic factors. Researchers conducted in Mexico and Brazil indicated that exposure to manganese can affect the IQ (Intellectual quotient) (Menezes-Filho *et al.*, 2009; Riojas-Rodríguez *et al.*, 2010).

Bouchard *et al.* 2011 showed that water supply contaminated by manganese has been associated with lower scores on QI of children 10 years old. Contamination by zinc in river water and sediment has also been reported by Shikazono *et al.* (2008) in Japan. Thus, it is important to control and continuous assessment of the levels of toxic elements, to prevent the water contamination.

3.2 Characterization of Bastiana Lake

The analysis of physical-chemical parameters of samples "A" and "B" Bastiana Lake can be seen in the table 2 in comparison with CONAMA 357/05 Resolution.

Table 2 - Physico-chemical characterization of water Bastiana Lake and limits by Brazilian

Parameters	Bastiana Lake Samples		CONAMA 357/05 Resolution
	A	B	Class 2
pH (25° C)	7.27	7.34	6.0 – 9.0
Temperature (°C)	25.0	25.0	Ne
Settleable solids (mL/L.h)	≤ 1.0	≤ 1.0	Ne
Suspended solids (mg/L)	68.2	79.7	Ne
Floating materials	Absent	presence	virtually absent
COD (mg O ₂ /L)	103.3	130.0	Ne
BOD (mg O ₂ /L)	38.0	41.0	5
Substances soluble in hexane (mg/L)	50.0	123.0	virtually absent
Chlorides (mg Cl ⁻ /L)	200.5	235.3	Ne
Total phosphorus (mg P/L)	0.06	3.5	0.03*
Total ammonia nitrogen (mg N/L)	0.8	18.0	3.7 (pH≤7.5)
Salinity (‰)	0.373	0.427	≤ 0.5

Ne: Not established

The presence of floating materials in B sample is considered unsatisfactory by Brazilian law. Organic matter was expressed as COD (103.3 -130.0 mg O₂/L) and BOD (38.0- 41.0 mg O₂/L), above the acceptable under Brazilian law (Table 2). Substances soluble in hexane were 50.0 mg/L and 123.0 mg/L for samples A and B, respectively, while for legislation CONAMA should be virtually absent.

The results showed increasing trophic level Bastiana Lake through the high nutrients (N and P), according Figure 2. Total phosphorus for samples A and B were 0.06 mg P/L and 3.5 mg P/L, respectively, being above the maximum value for class II (0.03 mg P/L, lentic environments). Total ammonia nitrogen for samples A and B were 0.8 mg/L N and 18 mg /L N, respectively, and the maximum allowed for class II is 3.7 mg/L N (pH≤7.5), so the sample B in compliance with the legislation. Salinity for sample A and B were 0.373% and 0.427 % being within the established by CONAMA Resolution 357/05 (salinity or less 0.5%). Nitrogen analysis in water provides an indication of the type of pollution. High levels of ammonia indicates recent pollution, where the process of full conversion to nitrate is not yet completed.

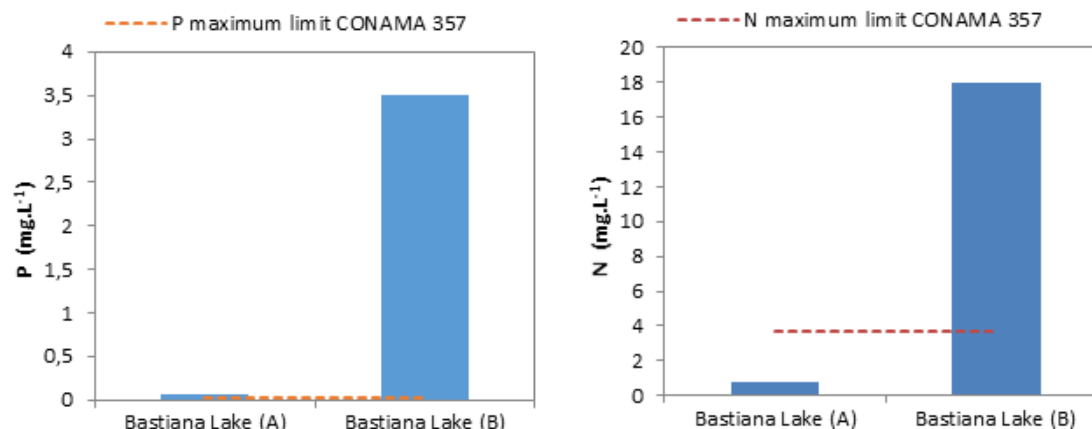


Figure 2 – P and N level of A and B samples of Bastiana Lake and limits established by CONAMA 357/05

According to von Sperling (2005) trophic status of a lake can be classified as: oligotrophic (low productivity), mesotrophic (intermediate productivity) and eutrophic (high productivity) and other trophic levels as ultraoligotrophic, mesotrophic, hypereutrophic.

A concentration of 0.06 mg/L of phosphorus (60 mg/m^3 in the lake), and 3.5 mg/L of phosphorus ($3,500 \text{ mg/m}^3$ in the lake) were detected in the A and B samples, being characterized as eutrophic and hypereutrophic, respectively (von Sperling, 2005). One of the main problems related to eutrophication is the proliferation of cyanobacteria, which can produce toxins that affect the health of animals and humans (Vidal and Capelo Neto, 2014)

Therefore, public investment and the expansion of the sewage treatment system is required for all sewage generated in the region may have a suitable destination and treatment given the entire population. Environmental education is needed to encourage the public about the importance and benefits of conservation of aquatic systems. One must promote correct and efficient use of water, proper disposal of sewage generated in order to reduce the environmental impacts and bring quality of life for the Iguatu population.

4 CONCLUSION

This paper shows that Iguatu-CE has an efficient sewage treatment system, but only a small part of the population is benefited (only 15% total volume of wastewater is treated). Thus, the release of untreated effluent contributes significantly to increasing of toxic substances presents in Bastiana Lake, and also influences other physico-chemical parameters such organic matter (BOD), oil and grease causing its degradation. The presence of Zn and Mn in Bastiana Lake above limits of the Brazil can cause risk to human health and it becomes necessary continuous monitoring of the levels of toxic elements in waters of the region. Discharge of wastewater has been one of the great responsible for the pollution of lakes of Iguatu-CE, contributing with process of eutrophication and increasing the level of nutrients (N and P). Thus, it is relevant public investment and the expansion of the sewage treatment system so that sewage generated by the population has appropriate destination, maintaining the quality of water resources.

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