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Ecotoxicological water assessment of an estuarine river from the Brazilian Northeast, potentially affected by industrial wastewater discharge

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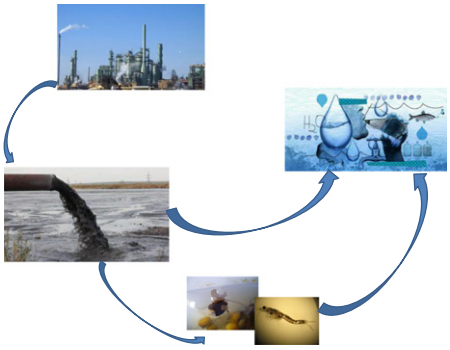
HIGHLIGHTS

- Environmental water quality assessment of a river which receives industrial pretreated waste
- Water quality assessment through physico-chemical and metal content measurement
- Ecotoxicological assessment of water samples through fecundity and dead rate using *M. junie* and *P. lineata*
- Industrial waste pretreated effluent affects the biodiversity and water quality for human use.

GRAPHICAL ABSTRACT



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ABSTRACT

Water pollution generated by industrial effluents discharge is a threat to the maintenance of aquatic ecosystems and human development. The Jundiai River estuarine, located in Northeast Brazil, receives an industrial pretreated effluent load from the city of Macaíba/RN/Brazil. The present study aimed to assess the water quality of this water reservoir through i) physicochemical characterization, ii) quantification of metal concentration and iii) by an ecotoxicological assessment carried out using *Mysidopsis juniae* and *Pomacea lineata*. The study was performed throughout the period comprising May to September 2014. Physicochemical variables such as chloride, total solids and electrical conductivity presented values in the waste discharge point, significantly different with those located out of the waste releasing point. Apart from that, metal concentration showed variable behavior throughout the monitored period. Levels of Al, Fe, Cu, Cd, Cr, Ni, Pb and Ag were over the considered guidelines. Both natural and anthropogenic sources seem to be involved in the resulting environmental scenario. A reduction in the fecundity rate (using *Mysidopsis juniae*) along with an increase in mortality rate (in both species) was observed ratifying the presence of toxic substances in this water reservoir. Moreover, a correlation analysis stated an association of the aforementioned toxicological effects with the delivery of industrial waste products. The ecotoxicological assessment performed highlighted the presence of toxic substance/s in water from the

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Jundiai River. Especially as a consequence of industrial activity, a fact that might threaten the bioma and, therefore, the human health of the population settled in the studied region.

1. Introduction

Human activities, particularly those performed near water bodies such as rivers and lakes, have always posed a threat to the maintenance of aquatic ecosystems. Moreover, contaminated water becomes a vector of dissemination of the pollution, broadening the resulting affected area and becoming a human health concern for the population settled in that region (Chaves et al., 2016; Ellis and Butler, 2015; Miao et al., 2015). Water scarcity is another issue for human development, mainly in deserted areas that can contribute negatively to water potability due to the concentration of dissolved and suspended substances, worsening the environmental scenario (Herweijer and Seager, 2008; Lu et al., 2015; WHO, 2011). In this context, the Brazilian Northeast meets these adverse conditions. This region faces prolonged periods of drought and water scarceness (Araujo and Cedeno-Macias, 2016; Fereres et al., 2011; Lemos et al., 2007; Marengo et al., 2013; Rohman, 2013; Vaz et al., 2011). Moreover, industrial activity carried out in the region can affect the ecosystem by depositing toxic substances, altering water quality used for human consumption, and consequently becomes an important issue for regional development and human health (Birch et al., 2015; Lu et al., 2015; Shulkin and Zhang, 2014; Waszak et al., 2014).

Estuaries are particularly high-diversity ecosystems , and the ending point for rivers flowing toward the sea and consequently for the entire water pollution load (Araujo and Cedeno-Macias, 2016; Araujo et al., 2015; Birch et al., 2015; Lu et al., 2015; Shulkin and Zhang, 2014; Wallin et al., 2015). Therefore, these reservoirs can become storage for a diverse quantity of substances that are able to harm the biota and directly or indirectly the surrounding population (Clark et al., 2015; Waszak et al., 2014). Despite water quality monitoring being considered a priority of environmental safety to assess the conservation of freshwater ecosystems in Brazil (INSA, 2016), pollution of water bodies in arid Brazilian regions has been highlighted in scientific literature. (Lemos et al., 2007; Marengo et al., 2013; Pessôa et al., 2007; Rohman, 2013; Vaz et al., 2010; Vaz et al., 2011). The Jundiaí River estuarine is an important water source located near the industrial city of Macaíba in the semi-arid Brazilian Northeast (CPRM/PRODEEM, 2005), and has not been subjected to monitoring yet.

To understand water quality, analysis of toxic compounds selected based on the studied scenario is needed (e.g. the presence of natural sources of potential contaminants, or as result of the anthropogenic activity). For instance, metal pollution is a health concern worldwide. Metals present high toxicity and persistence in the environment, and consequently the possibility to bioconcentrate and bioaccumulate within the trophic chain throughout the impacted ecosystem (Affum et al., 2015; Ali et al., 2015; Smith et al., 2016). For instance, the Brazilian Northeast is characterized by the presence of pegmatitic rocks, being rich in many minerals and metals such as Fe, Zn, Cu, Al, Ag, Cd, Cr, As and Pb, among others (CPRM, 2016). Previous studies by this research group have documented the occurrence of toxic metals in water reservoirs neither impacted by human activity nor related to other polluted water bodies (Chaves et al., 2016; Garcia-Leston et al., 2010; Marcon et al., 2010). On the other hand, ore exploration can magnify the delivery of metals to other environmental areas such as water reservoirs (Affum et al., 2015; Sibanda et al., 2015; Smith et al., 2016). In the same way, industrial activities can deposit a diversity of metals into their effluents. (Cindric et al., 2015; Clark et al., 2015; Fernandez Severini et al., 2011). As result, metal water pollution can affect human health in many ways, even at low concentrations (Amini, 2011; Egbinola, 2014; Essumang, 2010; Stalder et al., 2012). Jundiai estuary receives pretreated waste products from industrial activities such as textile industry and ore exploitation (CPRM/PRODEEM, 2005; Guedes, 2012). Therefore, the application of sensitive analytical methods to detect and quantify the metals present in water should be performed. Another approach to assess water quality can be performed by applying ecotoxicological tests. They represent a comprehensive way to understand the complexity of the environmental conditions and the dynamic of the toxics present in water sources, broadening the scope of the toxicological assessment (Chung et al., 2007; Deng et al., 2008; Dummee et al., 2012; Wiklund et al., 2012). In this context and based on the fact that the application of environmental policies on the management of industrial waste treatment in Brazil is not properly ruled yet, the hypothesis of this work was that the industrial pretreated waste delivered in the Jundiai River affect water quality and consequently the environmental health. Therefore, the aim of this work was to assess the water quality of the Jundiaí River estuarine and the impact of pretreated industrial effluents discharged into it, through the analysis of physicochemical parameters, the analysis of metal content, along with an ecotoxicological assessment using *Mysidopsis juniae* and *Pomacea lineata*.

2. Materials and method

2.1. Study area

The city of Macaíba is located 30 km away from the city of Natal, the capital of Rio Grande do Norte State, Brazil. It is based in a semiarid region. The studied microregion is characterized as a dry - very dry area. Low and irregular annual rain average doesn't let to diferenciate between dray and rainy seasson, therefore this variable was neglected in the reported results (EMPARN, 2016).

The district has a population of 76,801 inhabitants (IBGE, 2016). The main economic activities carried out in the region involve agriculture and industrial activities, in particular those related to textile production and ore extraction (CPRM/PRODEEM, 2005; IBGE, 2016). Jundiaí River crosses the district of Macaíba becoming an estuary in its encounter with the seawater inlet toward the mainland. The discharge point of pretreated industrial effluent is located on the Jundiai River, in front of the urbanized area of Macaiba city.

2.2. Water sample collection

Water samples were collected monthly between May and September of 2014 at three sampling points. Two points were located about 2 km upstream P1 (5° 54′00.1″ S, 35° 22′51.2″ W) and downstream P3 (5° 51′55.9″ S, 35° 21′18.3″ W), and from the pretreated effluent release point P2 (5° 51′57.5″ S, 35° 21′21.8″ W) (Fig. 1). Firstly, five liters of water from the Jundiaí River were obtained at the sampling point. Then, the water was gently mixed and poured into 1 l flasks for every determination. The Methods for collection, preservation, packaging, transportation, and analysis were performed in accordance with the recommendations of the American Public Health Association (APHA, 2012). For ecotoxicological tests, to avoid salinity as a confounding factor the water sampling was performed at low tide in all cases. Water samples were preserved by cooling, following the recommendations of the Brazilian Association of Technical Standardization (ABNT, 2011).