Chemosphere 189 (2017) 609–618

Contents lists available at ScienceDirect

Chemosphere

journal homepage: www.elsevier.com/locate/chemosphere

Full Length Article

# Water quality parameters, biomarkers and metal bioaccumulation in native fish captured in the Ilha River, southern Brazil

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## HIGHLIGHTS

- High levels of some water parameters were found at both sampling sites.
- Genotoxic effects were found in fish from the source of the River.
- Lower condition factor was observed in fish from the source of the Ilha River.
- Gill histopathological analyses evidenced impacts at both sampling sites.
- Higher levels of chromium and nickel were detected in fish from the source.

## ARTICLE INFO

*Article history:*
Received 7 July 2017
Received in revised form
15 September 2017
Accepted 18 September 2017
Available online 19 September 2017

Handling Editor: David Volz

*Keywords:*
*Bryconamericus iheringii*
Condition factor
Gill histopathology
Ilha River
Metal bioaccumulation
Micronucleus

## ABSTRACT

The Ilha River is one of the main tributaries of the Sinos River, southern Brazil, and it is located in an area characterized by low population density and presence of agricultural activities. Thus, this study aimed to assess the water quality of two sites of the Ilha River (source and mouth, S1 and S2 respectively) in five sampling periods using water physicochemical and microbiological analyses, biomarkers, such as condition factor, micronucleus test, gill histopathological analysis, and metal bioaccumulation in the native fish *Bryconamericus iheringii*. Mean values of $BOD_5$, thermotolerant coliforms, aluminum, iron and lead exceeded the limits established by the Brazilian legislation for surface waters at both sampling sites. Significant higher micronucleus, nuclear abnormalities and mucous cells frequencies were found at S2 in, at least, one sampling period, whereas fish from S1 presented significant lower condition factor, higher frequencies of lamellar alterations and higher concentrations of chromium and nickel in muscle. Additionally, concentrations of cadmium, chromium and lead in fish muscle exceeded the limits considered safe for human consumption at both sites in at least one sampling period. Data from our study evidenced the mouth of the Ilha River suffers from point genotoxic effects, whereas the source is also contaminated by metals, despite being located in an area under minor anthropic activities.



## 1. Introduction

The Sinos River basin is located in the eastern region of the state of Rio Grande do Sul, southern Brazil, and covers 32 municipalities with different economic activities, such as industry, agriculture and farms (Figueiredo et al., 2010; Benvenuti et al., 2015). Additionally, the river courses are used as a mean of sewage dilution (Comitesinos, 2009). Although the basin supplies water for 1.6 million inhabitants, the Sinos River – the main river of the basin, is among the most polluted rivers in Brazil (IBGE, 2010). The Ilha River

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https://doi.org/10.1016/j.chemosphere.2017.09.089
0045-6535/

is located in the middle section of the basin, being one of its main tributaries. It is characterized by low population density and presence of predominantly rural areas (Comitesinos, 2009). The main economic activities in the area are rice cultivation and cattle farms. Agricultural activities have impacts on both water quality and quantity, since water is used for irrigation and agricultural runoffs favor the transport of pesticides, fertilizers and other soil impurities into the rivers (Polard et al., 2011).

Some authors have evidenced the poor water quality of the Sinos River using different approaches, such as water physicochemical analyses (Blume et al., 2010; Konzen et al., 2015), plant assays (Nunes et al., 2011; Costa et al., 2014; Cassanegro and Droste, 2017), fish assays (Scalon et al., 2010; Bianchi et al., 2015; Steffens et al., 2015) and cell cultures (Terra et al., 2008; Nunes et al., 2011; Trintinaglia et al., 2015; Bianchi et al., 2017). However, studies on the tributaries of the Sinos River, such as Ilha River, are still scarce. Fontanella et al. (2009) have analyzed some physicochemical and microbiological parameters and classified sampling sites along the Ilha River as class 2 (water intended to human consumption after simplified treatment according to the Brazilian National Environment Council (CONAMA) Resolution 357/2005 (Brazil National Environment Council, 2005). Also in the Ilha River, Rodrigues et al. (2016) have reported concentrations of some metals, among other parameters above the limits established by the Brazilian legislation. Additionally, the same authors have also observed cytotoxic potential of water samples collected at both the source and mouth of the river using the *Allium cepa* bioassay. Nonetheless, the water quality of the Ilha River is not monitored by the State Environmental Protection Agency – FEPAM (*Fundação Estadual de Proteção Ambiental Henrique Luis Roessler*) (Comitesinos, 2009).

Because chemical analyses can only detect the presence or quantify substances in water, environmental biomonitoring studies with different test organisms have been increasingly required for assessing the real impact of a substance (or mixture of substances) on the health of organisms (Marcato et al., 2014). Fish species are very important for the aquatic food webs and human intake. For this reason fishes are widely used to evaluate the aquatic ecosystems quality (Baptista et al., 2013). The *Bryconamericus* genus (Characiformes order) includes small-sized species, usually not exceeding 10 cm in length, showing omnivorous behavior (Britski et al., 1988; Cruz et al., 2013). Some species of this genus are described as nonmigratory (Bizzotto et al., 2009). The *Bryconamericus iheringii* occurs in south Brazil, Uruguay and Argentina (Lampert et al., 2004). This specie has been previously found in different environments, being considered as tolerant to environmental stress (Caetano et al., 2016).

Given that environmental contaminants occur as mixtures, chemical interactions during the exposure may have profound consequences on aquatic organisms (Adeogun et al., 2016). In this scenario, the biomarker approach is an important tool in environmental diagnosis. A biomarker can be defined as a quantitative measure of changes in molecular or cellular components, processes, structures and functions related to exposure of organisms to environmental contaminants (Depledge et al., 1995; He et al., 2012; Fasulo et al., 2013). Among the biomarkers in fish, the condition factor (CF), a somatic biomarker, is indicative of health and reflects feeding conditions as well as energy consumption and metabolism (Schulz and Martins-Junior, 2001; Alberto et al., 2005). Toxic substances in the water may affect the growth of fish by directly changing metabolism and increasing the energy required to maintain homeostasis, or they can indirectly impact growth by reducing food availability (Sadauskas-Henrique et al., 2011). The gills histopathological analysis is another biomarker that has been widely used in biomonitoring studies. This organ represents the major site for respiration and is, therefore, always in close contact with the water and its associated pollutants. The gill functions, such as gas and ion exchange, acid-base balance and nitrogenous waste excretion are maintained by different cell types, such as pavement cells, chloride cells, or mucous cells (Gernhöfer et al., 2001). In order to assess the genotoxic potential of surface water, the micronucleus (MN) test is the most applied technique to assess DNA damage in different organisms (Al-Sabti and Metcalfe, 1995; Campana et al., 2003; Fuzinatto et al., 2013; Bianchi et al., 2015; Prado et al., 2015). The high mitotic rate of hematopoietic tissue provides a rapid response to genotoxic exposure, revealed as chromosomal damage in peripheral blood (Bolognesi and Hayashi, 2011). The DNA damage is one of the most important critical events following the exposure to carcinogenic and/or genotoxic agents (Bolognesi and Hayashi, 2011). The concomitant analysis of the occurrence of erythrocyte nuclear anomalies allows the evaluation of another toxicity biomarker (Pacheco and Santos, 1998).

In addition to biomarker responses, the quantification of metal concentrations in tissue of resident species represents an integrated and ecologically-relevant image of site-specific metal bioavailability (Jonge et al., 2015). The main sites for metal metabolism and bioaccumulation in fish are the gills and the liver, where metals are stored for detoxification through metallothioneins (Van der Oost et al., 2003). Although the muscle is not an active tissue for accumulating heavy metals, the study of potential metal accumulation in this tissue is justified because it is the edible part of fish for human consumption, posing a health risk (Costa and Hartz, 2009). In Rio Grande do Sul state, only a few studies were conducted analyzing metal accumulation in fish tissues. Weber et al. (2013) observed low metal concentrations in two fish species collected in the Sinos River basin. Additionally, Costa and Hartz (2009) assessed the presence of some metals in tissues of a commercially important fish from the Guaíba Lake. However, despite the detection of Cd, Cr, Cu and Zn in muscle and liver of fish, no risks for human health were evidenced. On the other hand, Rodrigues and Formoso (2006) have found increased values of Hg in fish from the Cadeia and Feitoria Rivers, near the Sinos River Basin.

In this context, the present work aimed to assess the water quality of two sites (source and mouth) of the Ilha River using water physicochemical and microbiological parameters, biomarkers and metal bioaccumulation in muscle of *B. iheringii*.

## 2. Material and methods

### 2.1. Study area

The Ilha River is located in the Taquara municipality, whose population corresponds to 54.656 inhabitants (17% living in rural areas). Two sampling sites were selected in the Ilha River: S1 is located at the source of the river (29°33′21.16″S and 50°37′45.55″W), whereas S2 is located approximately 2 km from the mouth of the river (29°40′56.42″S and 50°44′22.86″W), 30 km from S1 (Fig. 1). S1 is under minor anthropic impacts, where only a few small farms and low population density are observed. On the other hand, S2 is in an agricultural area (mainly rice cultivation) and the population density is increased compared to S1. The climate of the study area is Cfa according to the Köppen classification (Moreno, 1961); the mean annual temperature is approximately 20 °C, and rainfall is approximately 1.600 mm per year, distributed in four seasons (Comitesinos, 2009). Local data on rainfall were supplied by a meteorological station located in the city, considering the total precipitation in 10 the days prior to each collection at each sampling site (Weather Underground, 2015).