Aquatic Botany 150 (2018) 53–63

Contents lists available at ScienceDirect

Aquatic Botany

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

Addressing bioassessment of tropical rivers using macrophytes: The case of Itanhaém Basin, São Paulo, Brazil

Cristiane Akemi Umetsu[a], Francisca C. Aguiar[b,*], Maria Teresa Ferreira[b], Leonardo Farage Cancian[c], Antonio Fernando Monteiro Camargo[a,c]

[a] Programa de Pós-graduação em Aquicultura, Universidade Estadual Paulista, Jaboticabal, São Paulo, 14884-900, Brazil
[b] Centro de Estudos Florestais, Instituto Superior de Agronomia, Universidade de Lisboa, Tapada da Ajuda, 1349-017, Lisboa, Portugal
[c] Departamento de Ecologia, Universidade Estadual Paulista, Rio Claro, São Paulo, 13506-900, Brazil

ARTICLE INFO

Keywords:
Ecological quality
Tropical catchment
Macrophyte IBI
Multimetric index
River monitoring

ABSTRACT

We developed a pilot study on the potential of aquatic plants as indicators of ecological quality in tropical rivers to provide an index of biotic integrity for monitoring, conservation, and restoration purposes. We used floristic, environmental, and anthropogenic disturbance data from a 950 km^2 river basin in the southern littoral area of São Paulo State, Brazil (Itanhaém River Basin), and proposed a five-step methodological framework for the development of a macrophyte index in tropical river basins. Field surveys were carried out in 137 sites (Spring 2013–2014) of Itanhaém River for the index development and in 27 sites of Itapanhaú River (Spring 2015) for its validation. A total of 44 aquatic plant species were recorded in the study area, and 11 metrics were evaluated as potential core metrics of the index. Principal Component Analysis distinguished two river types mostly related to geomorphological characteristics – the Upper river type in the mountainous region (average slope 23.7°) and the Middle-low river type (average slope 9.2°) in the floodplain. The Upper river catchment was characterized by extensive areas occupied by banana plantations, low water conductivity, sandy substrates, and homogeneous aquatic vegetation, whereas the Middle-low river catchment had more urban settlements and displayed high nitrogen and phosphorus contents in water and sediments. The index (MIBI-ITA) is preliminary and was based on species richness and life forms (e.g. submerged hydrophytes, helophytes). MIBI-ITA could only be developed for the lowlands and displayed a high discriminatory ability for distinguishing disturbance and a good performance with external data. Bioassessment in tropical rivers require further investigation on biogeography and long-term responses of macrophyte populations to stressors, as well as knowledge-base on river typology and functional traits of macrophytes, other than morpho-anatomic traits and diversity measures.

1. Introduction

Rivers are dynamic entities that run across a wide range of landscapes and ecosystems and are threatened worldwide by multiple stressors, such as intensive agriculture, urbanization, and overfishing (e.g. Tockner and Stanford, 2002). Consequently, declines in freshwater biodiversity are increasingly reported, compelling governments to provide guidance and legislative tools to assess and monitor the ecological quality of these environments. For instance, the US Environmental Protection Agency Clean Water Act enacted in 1972 and later the EU-Water Framework Directive (WFD; EC 2000) provided the framework for the standardized assessment of the ecological condition of surface and groundwater over large regions, with the ultimate goal of improving water quality and regulating quality standards. These water policy instruments had the novelty of using unimpacted conditions as benchmarks in a goal-setting approach, and both established criteria for down-grading standards to provide for no further degradation and undesirable substances (Bouleau, 2008). In several countries, such as Brazil (South America), there is still no legislation in monitoring and assessment of surface and groundwater and the setting rules are still based on purely physical and chemical variables regardless of the relevance of bioindication by aquatic biota in tropical rivers (Kennedy et al., 2016). In such development countries, biomonitoring tools and water policies are needed more than ever, due to the increasing threats to aquatic habitats, especially pollution, fragmentation by agricultural intensification (Barretto et al., 2013), deforestation (Fernside, 2005), and construction of dams (Fernside, 2006; Sanches et al., 2006).

Aquatic macrophytes are key-components of freshwaters and

* Corresponding author at: Centro de Estudos Florestais, Instituto Superior de Agronomia, Universidade de Lisboa, Tapada da Ajuda, 1349-017, Lisboa, Portugal.
E-mail address: fraguiar@isa.ulisboa.pt (F.C. Aguiar).

https://doi.org/10.1016/j.aquabot.2018.07.004
Received 21 February 2018; Received in revised form 4 July 2018; Accepted 5 July 2018
Available online 07 July 2018

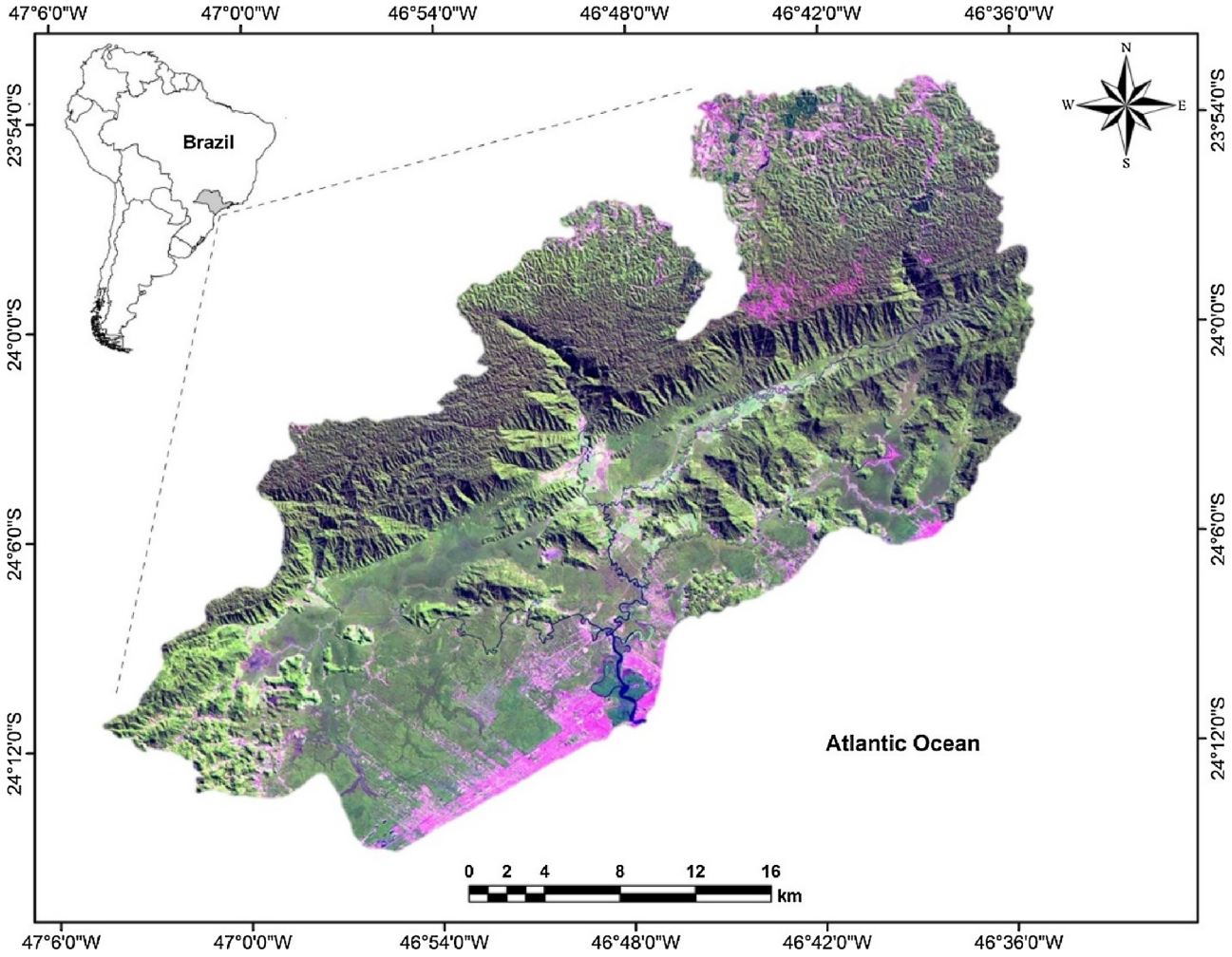

Fig. 1. Location map for Brazil (South America) and the satellite image of the Itanhaém River Basin.

constitute a group of aquatic photosynthetic organisms that actively grow permanently or periodically submerged below, floating on, or growing up through the water surface, and are large enough to see with the naked eye (Chambers et al., 2008). Worldwide, many studies have used macrophytes as biological indicators of quality in aquatic environments, such as lakes and reservoirs (e.g. Nichols et al., 2000; Beck et al., 2010; Radomski and Peleberg, 2012), rivers and streams (e.g.; Mackay et al., 2010; Aguiar et al., 2014), and wetlands and transitional waters (e.g. DeKeyser et al., 2003). Compared with temperate, mediterranean and boreal regions, few studies have been developed in the tropical and sub-tropical climatic setting (Junk et al., 2014). Murphy et al. (2003) were amongst the first to use large-scale macrophyte surveys to predict change in Brazilian tropical rivers. Recently, Hegel and Melo (2016) assessed the bioindication potential of eight macrophyte species recorded in the Rio Grande do Sul, Brazil, and Neiff et al., (2014) studied the relevance of aquatic plants as indicators of hydrological phases in Paraná River. Pereira et al. (2012) evaluated the potential of macrophyte communities as indicators of water quality in small shallow lakes in southern Brazil, and Lufí et al. (2012) developed Functional Fluvial Indices for rivers (IFF) and for lakes (IFL), based on species sensibility to nitrogen enrichment in the aquatic environment.

However, as far as we know, no macrophyte index was developed to assess the ecological quality of Brazilian rivers, despite the various studies on the distribution of aquatic plants (e.g. Thomaz et al., 2009; Henry-Silva et al., 2010; Xavier et al., 2016), and the support from regional plant checklists (e.g. Pott and Pott, 2000; Lufí et al., 2012; Moura-Júnior et al., 2015). Moreover, in tropical freshwater ecosystems, only three frameworks are known in the literature, including the first attempts to develop a metric for the Itanhaém River Basin (Kennedy et al., 2016).

Karr (1981) was one of the first to develop an operational regionalized system for assessing the effect of stressors upon biological conditions in aquatic environments, so-called indices of biological integrity. This framework has been successfully applied to aquatic flora and implemented internationally, but predominantly in the temperate zone (Hering et al., 2006; Aguiar et al., 2009; van Oosterhout and van der Velde, 2015).

The present research aims ultimately to assess the suitability of macrophytes for bioindication in a Brazilian tropical river basin (Itanhaém River Basin) and then provide an index to monitor the impacts of agriculture and urban land use in water quality. The catchment is characterized by a large and complex network of tributaries derived from the Precambrian mountain sources of both the Rio Preto and Rio Branco across an agricultural landscape dominated by banana farming.

In the lower coastal area, the Itanhaém River receives non-treated domestic effluents from the small coastal tributaries near Itanhaém municipality (Camargo et al., 2002). Over the past two decades research has been undertaken in this system to address environmental concerns about physico-chemical water quality, and especially the effects of enrichment in nitrogen and phosphorus. However, macrophytic vegetation has been understudied, especially regarding the potential for assessment of ecological quality. For this study, we first collected floristic, environmental and stressor data throughout the river basin. Then, we assessed the distinctiveness of the river network in relation to the