

1 **POTENTIALLY TOXIC AND ESSENTIAL ELEMENTS AND ENZYMATIC**
2 **BIOMARKERS IN TWO NATIVE FISH SPECIES FROM THE MIDDLE**
3 **TOCANTINS RIVER: INSIGHTS INTO ECOSYSTEM AND HUMAN HEALTH**

4
5 Thiago Machado da Silva Acioly^{1*}; Karuane Saturnino da Silva Araújo¹; José Iannacone²; Lilian Amado
6 Lung³; Muhammad Ilyas⁴; José Fábio França Orlanda⁵; Diego Carvalho Viana^{1,5}

7 ¹ Postgraduate in Animal Science (PPGCA/UEMA), Multi-User Laboratories in Postgraduate Research
8 (LAMP), State University of Maranhão, São Luís, 65081-400, Brazil. E-mail: tmsacioly@gmail.com*

9 ² Animal Ecology and Biodiversity Laboratory (LEBA), Universidad Nacional Federico Villarreal, 15007,
10 Lima, Peru.

11 ³ Laboratório de Ecotoxicologia (ICB) e Laboratório de Pesquisa em Monitoramento Ambiental Marinho,
12 Universidade Federal do Pará, Av. Augusto Corrêa, 01, Guamá, Terra Firme, 66075110 Belém, Pará, Brazil.

13 ⁴ Department of Environmental Sciences, International Islamic University, Islamabad 44000, Pakistan.

14 ⁵ Center of Agrarian Sciences, Center for Advanced Morphophysiological Studies (NEMO), State University
15 of the Tocantina Region of Maranhão (UEMASUL), Imperatriz, 65900-000, Brazil.

16 **ABSTRACT. INTRODUCTION:** The interface between the Cerrado and Amazon biomes
17 is increasingly exposed to environmental stressors, yet few studies have addressed
18 contaminant bioaccumulation and biological responses in native ichthyofauna. Understanding
19 the presence of toxic elements and their effects on fish health is essential for ecological risk
20 assessment. **OBJECTIVE:** This study provides a first comprehensive ecotoxicological
21 evaluation of potentially toxic and essential elements (PTEs and EEs) in two native fish
22 species, Branquinha (*Psectrogaster amazonica*) and Branquinha-cascuda (*Caenotropus*
23 *labyrhinthicus*), from the middle Tocantins River, Maranhão, Brazil. **MATERIALS AND**
24 **METHODS:** Specimens were collected from two contrasting sites: the urban riverside zone
25 of "Beira Rio" and a fluvial beach near the rural community of "Embiral". PTE and EE
26 concentrations were analyzed in liver and muscle tissues, while biochemical stress was
27 assessed using enzymatic biomarkers (AChE, AST, ALT, and ALP). To estimate potential
28 human health risks from fish consumption, several indices were applied, including
29 bioconcentration factor, risk quotient, risk index, and estimated daily intake. **RESULTS**
30 **AND CONCLUSION:** In *P. amazonica* from urban area, concentrations of As (muscle: 1.83
31 mg/kg; liver: 1.6 mg/kg), Pb (liver: 3.90 mg/kg), and Se (muscle: 9.30 mg/kg; liver: 13.91
32 mg/kg) exceeded national and international safety thresholds. In contrast, *C. labyrhinthicus*
33 from rural zone showed no detectable Pb or Zn, suggesting lower local contamination,
34 although elevated levels of As (muscle: 2.85 mg/kg) and Se (muscle: 15.94 mg/kg) remain
35 concerning. Bioaccumulation of Fe and Se was observed in both species. Biomarker analyses
36 revealed significant enzymatic alterations associated with urban pollution, indicating
37 physiological stress. These findings highlight potential public health risks and underscore the
38 importance of continued biomonitoring. They also provide critical baseline data for
39 environmental management, public health strategies, and regional conservation planning in
40 the Cerrado–Amazon ecotone.

41
42 **Keywords:** aquatic toxicology; biomonitoring; ecotoxicology; heavy metals

43
44
45