

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**

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

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44 **Keywords:** aquatic toxicology; biomonitoring; ecotoxicology; heavy metals  
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