



**MINISTÉRIO DO MEIO AMBIENTE
INSTITUTO CHICO MENDES DE CONSERVAÇÃO DA BIODIVERSIDADE
DIRETORIA DE PESQUISA, AVALIAÇÃO E MONITORAMENTO DA BIODIVERSIDADE
CENTRO NACIONAL DE PESQUISA E CONSERVAÇÃO DA BIODIVERSIDADE AQUÁTICA
CONTINENTAL- CEPTA**

PLANO DE AÇÃO PARA A CONSERVAÇÃO DA FAUNA AQUÁTICA E SEMIAQUÁTICA DA BACIA DO BAIXO IGUAÇU

**Relatório Levantamento atualizado sobre o efeito de poluentes em organismos
aquáticos na área do PAN Baixo Iguaçu**

Pirassununga, 2022

OBJETIVO ESPECÍFICO 1: Reduzir a emissão de efluentes e os níveis de poluição nos rios da bacia do Baixo Iguaçu, em especial nas áreas estratégicas.

AÇÃO 1.2: Analisar o efeito de poluentes em organismos aquáticos na área do PAN.

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COMENTÁRIOS:

VERSÕES E DATAS: 2022

A divulgação do produto do PAN foi autorizada pelos autores



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RELATÓRIO

PAN Baixo Iguaçu

Objetivo

1. Reduzir a emissão de efluentes e os níveis de poluição nos rios da bacia do Baixo Iguaçu, em especial nas áreas estratégicas

Ação

1.2. Analisar o efeito de poluentes em organismos aquáticos na área do PAN.

Produtos

Relatório com o levantamento atualizado sobre o efeito de poluentes em organismos aquáticos na área do PAN.

Relatório com o levantamento atualizado sobre o efeito de poluentes em organismos aquáticos na área do PAN.

Introdução

Inúmeros organismos aquáticos podem ser utilizados como indicadores biológicos, sendo os peixes e os invertebrados aquáticos os mais comuns, pois estes organismos apresentam uma enorme gama de tolerância e respostas frente a diferentes níveis de perturbação (LENAT & BARBOUR, 1994; WHITFIELD & ELLIOT, 2002), além de sua amostragem ser relativamente simples (BRANDIMARTE et al., 2004).

De acordo com JOHNSON et al. (1993), um indicador biológico "ideal" deve ser um organismo de fácil identificação, deve apresentar ampla distribuição geográfica, ser abundante e apresentar baixa mobilidade e longo ciclo de vida. Além disso, os organismos bioindicadores devem expressar sintomas particulares (respostas), como alterações em suas funções vitais ou acúmulo de toxinas, que podem indicar danos no ambiente (BARTELL, 2006). Os peixes são considerados excelentes bioindicadores, pois suas funções biológicas e ecológicas se correlacionam com determinados fatores e eventos ambientais, os quais podem ser empregados como indicadores na avaliação de impactos (WASHINGTON, 1984; CAIRNS JR. et al., 1993).

Vários são os parâmetros biológicos que podem estar alterados como consequência da interação entre o agente químico e o organismo (FAUSCH et al., 1990; BOUDOU & RIBEYRE, 1997). Biomarcadores, por definição, são características quantificáveis de processos biológicos e compreendem substâncias (ou seus produtos) ou alterações bioquímicas, cuja determinação nos fluidos biológicos, células ou tecidos permite a avaliação da intensidade da exposição e o risco à saúde (AMORIN, 2003). Os biomarcadores servem como uma resposta dos organismos ao agente tóxico, pois representam variações bioquímicas, celulares, fisiológicas ou comportamentais que podem ser avaliadas nos tecidos ou nos fluidos dos organismos (DEPLEDGE, 1993),

demonstrando diferentes respostas a diferentes estressores ambientais (HUGGET et al., 1992).

O objetivo deste relatório foi levantar dados disponíveis sobre o efeito de poluentes em organismos aquáticos na área do PAN, identificar as principais tendências de pesquisa assim como as lacunas de conhecimento existentes, de forma a gerar subsídios e direcionar ações futuras.

Procedimentos metodológicos

O levantamento de dados sobre o efeito de poluentes em organismos aquáticos na área do PAN foi realizado por meio de informações obtidas em bancos de dados, bibliografias, entidades ambientais públicas e privadas.

As seguintes bases de dados foram utilizadas para o levantamento e a sistematização dos dados secundários:

- Base de dados do Sistema de Bibliotecas da UFPR.
- Base de dados do Sistema de Bibliotecas da UNIOESTE.
- Base de dados do Sistema de Bibliotecas da UEPG.
- Base de dados do Sistema de Bibliotecas da UEM.
- Biblioteca Digital da Produção Científica, Tecnológica, Artística e Cultural da UEL.
- Base de dados do Repositório Institucional da UFSC.
- Base de dados do Sistema Integrado de Bibliotecas da USP (www.usp.br/sibi).
- Base de dados do Portal de Serviços e Conteúdo Digital da CRUESP - Unibibliweb - USP, UNESP e UNICAMP (bibliotecas-cruesp.usp.br/unibibliweb/cruesp_ebooks.html).
- Portal da informação – UFSCar (www.ufscar.br).
- Base de dados Scielo – Fapesp (www.scielo.org).

Resultados

Foram selecionados 17 estudos sobre os efeitos de poluentes na água e em organismos aquáticos na área do PAN entre os anos de 2015 e 2022, os quais foram listados abaixo:

(01) SANTOS, L. C. 2015. **Determinação de cafeína, paracetamol e ibuprofeno para identificar atividade antrópica no Rio Iguaçu**. 2015. 49 f. Trabalho de Conclusão de Curso (Tecnologia em Processos Ambientais) - Universidade Tecnológica Federal do Paraná, Curitiba, 2015.

Resumo: A água é uma das substâncias de fundamental importância para a manutenção da vida na terra, porém o aumento populacional fez com que fosse encontrada em uma disponibilidade cada vez menor desse recurso, determinada pela degradação dos corpos hídricos que então inviabiliza o seu uso. Os contaminantes emergentes têm grande contribuição para o agravamento da poluição nos corpos hídricos, sendo que uma das principais fontes de contaminação são as atividades antrópicas. Levando em consideração a influência antrópica, o presente trabalho teve como objetivo determinar as concentrações de cafeína, paracetamol e ibuprofeno e assim avaliar através dos parâmetros físicos, químicos a qualidade da água em alguns pontos do Rio Iguaçu. Para isso foram realizadas três amostragens (dezembro de 2014, fevereiro e junho de 2015) em quatro pontos no rio Iguaçu e foram analisados os parâmetros de nitrogênio amoniacal, nitrito, nitrato e ortofosfato, além dos contaminantes emergentes através da análise por cromatografia líquida de alta eficiência acoplado a um detector de arranjo de diodos. A cafeína foi o composto mais presente nas amostras com uma concentração máxima de 9,366 $\mu\text{g.L}^{-1}$, esse valor foi encontrado na primeira coleta no ponto de Curitiba; o ibuprofeno foi encontrado em maiores concentrações somente na primeira coleta realizada, com valores que variaram de 0,747 á 6,733 $\mu\text{g.L}^{-1}$ e não detectado nos outros períodos amostrais e o paracetamol foi detectado em menores concentrações. Através dos resultados obtidos foi possível verificar uma influência antrópica no rio Iguaçu, e também que os micropoluentes estudados se comportam como um indicador de contaminação em águas residuárias.

(02) BUENO-KRAWCZYK, A.; GUILOSKI, I.; PIANCINI, L.; AZEVEDO, J.; RAMSDORF, W.; IDE, A.; GUIMARÃES, A. T. B.; CESTARI, M. M.; SILVA de ASSIS, H. C. 2015. **Multibiomarker in fish to evaluate a river used to water public supply**. Chemosphere, 135, 257-264.

Resumo: We aimed to evaluate the ecological integrity of a large river, which receives agricultural and urban effluents and is used to water public supply. The fish species *Astyanax bifasciatus* was used as bioindicator during winter and spring 2012, and summer 2013 at the Middle Iguaçu River basin in Paraná state, Brazil. Water chemical and physical measures and ecotoxicological tests were carried out as well biochemical and genetic biomarkers in sampled fish in each period. The studied area was divided in three sample points: SP1, located where the water is collected to public supply; SP2, located in an urbanized area, and SP3, located at an urbanized area with the discharge of the sewage treatment. Although water chemical and physical analyzes were range of the Brazilian law to hydric bodies, anticholinesterasic effects were found in winter, oxidative stress in summer and spring. The higher genotoxic effect was in winter to all sample points. The temporal variation in biomarkers and the detection of caffeine in the water call attention to the water quality in this river mainly to be used to public supply.

(03) FREIRE, C.; SOUZA-BASTOS, L.; CHIESSE, J.; TINCANI, F.; PIANCINI, L.; RANDI, M.; PRODOCIMO, V.; CESTARI, M. M.; SILVA-DE-ASSIS, H. C.; ABILHOA, V.; VITULE, J. R. S.; BASTOS, L. P.; OLIVEIRA-RIBEIRO, C. A. 2015. **A multibiomarker evaluation of urban, industrial, and agricultural exposure of small characins in a large freshwater basin in southern Brazil**. Environmental Science And Pollution Research, 22(17), 13263-13277.

Resumo: Iguaçu River is the second most polluted river of Brazil. It receives agrochemicals and contaminants of urban and industrial sources along its course. A multibiomarker approach was employed here to evaluate the health of a small characin (*Astyanax* spp.) at two sites along the river, sampled during a dry (autumn) and a rainy (spring) season. Biomarkers were condition factor and somatic indices (gonads and liver); genetic damage (comet assay and micronucleus test); enzyme

activities such as hepatic catalase (CAT) and glutathione S-transferase (GST), lipoperoxidation (LPO), branchial and renal carbonic anhydrase (CA), acetylcholinesterase (AChE) in the muscle and the brain, histopathology of the liver and gills, and concentrations of polycyclic aromatic hydrocarbons (PAHs) in bile. There were no consistent differences in biomarker responses between the two study sites. Some biomarkers revealed greater potential impact in the rainy season, when increased amounts of contaminants are washed into the river (combined CAT inhibition and LPO increase, CA upregulation). Other biomarkers, however, revealed potential greater impact in the dry season, when contaminants potentially concentrate (GST induction, AChE inhibition, and liver histopathological alterations). Although of a complex nature, field experiments such as this provide rich data for monitoring protocols and assessment of general risk of exposure to pollutants of river systems.

(04) KRAWCZYK, A. C. D. B. 2016. **Biomonitoramento da bacia hidrográfica do médio rio Iguaçu em União da Vitória, PR, utilizando biomarcadores de contaminação ambiental**. Tese (doutorado), Programa de Pós-Graduação em Ecologia e Conservação, Universidade Federal do Paraná.

Resumo: A maioria dos corpos hídricos brasileiros recebe despejo inadequado de esgoto e resíduos agrícolas e industriais. Na região do Médio Iguaçu, a atenção voltada para o Rio Iguaçu é de cunho econômico e ambiental, principalmente pelo fato de a água ser utilizada no abastecimento público. Assim, avaliações da integridade ambiental neste rio são essenciais para entendimento de possíveis fontes poluidoras que possam prejudicar a qualidade da água que é utilizada e os xenobióticos que se destacam no comprometimento da biota. O primeiro objetivo deste trabalho foi monitorar a resposta da espécie *Astyanax bifasciatus* por meio de um conjunto de biomarcadores bioquímicos no fígado, no cérebro e na musculatura axial e biomarcador genético nos eritrócitos, aliados a análises físicas e químicas da água, incluindo contaminantes emergentes, no Rio Iguaçu, na região do Médio Iguaçu. Além disso, foram utilizados testes ecotoxicológicos com *Daphnia magna* e *Desmodesmus subspicatus* para a compreensão de efeitos de toxicidade da água sobre outros organismos. Desta forma, a qualidade da água desta região foi avaliada durante três estações sazonais para compreender as alterações na biota entre estações sazonais e a

ação antrópica. O segundo objetivo foi avaliar efeitos subletais em peixes saudáveis expostos à água do Rio Iguaçu. Neste contexto, foi feita análise de metal na água e no músculo dos animais. Os resultados confirmaram a importância da utilização dos biomarcadores para avaliar efeitos de contaminação ambiental na biota aquática, e, também, demonstraram que a água do rio apresenta xenobióticos que desencadeiam efeitos de neurotoxicidade e estresse oxidativo nos peixes. As atividades das enzimas acetilcolinesterase, glutatona, glutatona Stransferase e glutatona peroxidase foram as que responderam às alterações entre estações sazonais em adição aos agentes estressores na água. A cafeína foi o contaminante emergente identificado durante o biomonitoramento, caracterizando poluição aquática por efluente doméstico. No tecido dos animais analisados no bioensaio, verificou-se acúmulo de alumínio, metal sem consideração em pescado na legislação brasileira. Os peixes expostos apresentaram resultados semelhantes em relação às repostas de neurotoxicidade, estresse oxidativo e danos de membrana, o que foi atribuído à qualidade da água e à possível mistura de contaminantes disponível à biota. O estudo mostra a necessidade de se discutir as fontes poluidoras nos limites jurisdicionais, bem como maneiras de mitigar a poluição aquática nesta região. Palavras-chave: bio ensaio, ecotoxicidade, contaminantes emergentes, metais.

(05) YAMAMOTO, F.; PEREIRA, M.; LOTTERMANN, E.; SANTOS, G.; STREMEI, T. R. O.; DORIA, H. B.; GUSSO-CHOUERI, P.; CAMPOS, S. X.; ORTOLANI-MACHADO, C. F.; CESTARI, M. M.; FILIPAK-NETO, F.; AZEVEDO, J. C. R.; OLIVEIRA RIBEIRO, C. A. 2016. **Bioavailability of pollutants sets risk of exposure to biota and human population in reservoirs from Iguaçu River (Southern Brazil)**. Environmental Science and Pollution Research, 23(18), 18111-18128.

Resumo: The Iguaçu River, located at the Southern part of Brazil, has a great socioeconomic and environmental importance due to its high endemic fish fauna and its potential to generate hydroelectric power. However, Iguaçu River suffers intense discharge of pollutants in the origin of the river. In a previous report, the local environmental agency described water quality to improve along the river course. However, no study with integrated evaluation of chemical analysis and biological responses has been reported so far for the Iguaçu River. In the current study, three

different Brazilian fish species (*Astyanax bifasciatus*, *Chrenicicla iguassuensis*, and *Geophagus brasiliensis*) were captured in the five cascading reservoirs of Iguaçú River for a multi-biomarker study. Chemical analysis in water, sediment, and muscle indicated high levels of bioavailable metals in all reservoirs. Polycyclic aromatic hydrocarbons (PAHs) were detected in the bile of the three fish species. Integration of the data through a FA/PCA analysis demonstrated the poorest environmental quality of the reservoir farthest from river's source, which is the opposite of what has been reported by the environmental agency. The presence of hazardous chemicals in the five reservoirs of Iguaçú River, their bioaccumulation in the muscle of fish, and the biological responses showed the impacts of human activities to this area and did not confirm a gradient of pollution between the five reservoirs, from the source toward Iguaçú River's mouth. Therefore, diffuse source of pollutants present along the river course are increasing the risk of exposure to biota and human populations.

(06) YAMAMOTO, F., GARCIA, J., KUPSCO, A., & OLIVEIRA RIBEIRO, C. 2017. **Vitellogenin levels and others biomarkers show evidences of endocrine disruption in fish species from Iguaçú River - Southern Brazil.** *Chemosphere*, 186, 88-99.

Resumo: The adverse effects of endocrine disrupting chemicals (EDCs) on aquatic wildlife and human health represent a current issue of high public concern. Even so, they are still poorly studied in aquatic environments of South America. The aim of the present study was to investigate the impact of EDCs in five cascading reservoirs from the Iguaçú River, evaluating reproductive endpoints in three native fish species (*Astyanax bifasciatus*, *Chrenicicla iguassuensis* and *Geophagus brasiliensis*). Additionally, a polyclonal antiserum anti-vitellogenin from *G. brasiliensis* and a capture ELISA assay were developed for detection of estrogenic or anti-estrogenic activities in male and female fish, respectively. Vitellogenin (VTG) levels in male fish from the Iguacu River was observed, as well as decreased levels of vitellogenin and estradiol in the plasma of female fish. These findings were associated with immature gonads and lower gonadosomatic index in *G. brasiliensis* adult females from the Foz do Areia (FA) Reservoir. Additionally, both endemic species (*Astyanax bifasciatus* and *Chrenicicla iguassuensis*) displayed immature gonads and histological changes, such as degeneration of germ cells, in other studied reservoirs. The current results suggest that

these reproductive responses may be associated with the bioavailability of EDCs in the Iguaçú River. These impacts are likely related to chemicals released by human activities, especially from sewage and industrial sources and agricultural production, detected in previous studies. Overall, the FA reservoir was potentially the most affected by chemicals with endocrine properties, and further studies are necessary to identify and quantify these chemicals.

(07) NIMET, J.; GUIMARÃES, A. T.; DELARIVA, R. L. 2017. **Use of Muscular Cholinesterase of *Astyanax bifasciatus* (Teleostei, Characidae) as a Biomarker in Biomonitoring of Rural Streams.** Bulletin of Environmental Contamination and Toxicology, 99(2): 232-238.

Resumo: Cholinesterase (ChE) activity was measured in *Astyanax bifasciatus* maintained in controlled conditions. Muscle ChE activity of individuals collected in field conditions in two seasons was compared among specimens collected in seven streams (forest and rural) of the lower Iguaçú river basin in association with physical, chemical, pesticides and biological factors. Significant differences in muscle ChE activity between control fish and fish collected in streams in both seasons were found, with higher activity in natural conditions. This the first time that differences in muscle ChE activity have been found among fish collected from different streams, suggesting synergism among multiple factors (e.g. temperature, pH, animal weight) and ecological attributes (richness and abundance) as influencing the variation in biomarkers. It is necessary to evaluate the quality of aquatic environments for a more accurate biomonitoring approach.

(08) SANTANA, M., YAMAMOTO, F., SANDRINI-NETO, L., FILIPAK NETO, F., ORTOLANIMACHADO, C., OLIVEIRA RIBEIRO, C., & PRODOCIMO, M. 2017. **Diffuse sources of contamination in freshwater fish: Detecting effects through active biomonitoring and multibiomarker approaches.** Ecotoxicology and Environmental Safety, 149, 173-181.

Resumo: Aquatic organisms are usually exposed to a mixture of xenobiotics that may exert a large effect even in low concentrations, and when information is obtained exclusively from chemical analyses the prediction of the deleterious effects is

potentially hindered. Therefore, the application of complementary monitoring methods is a priority. Here, in addition to chemical analyses, an active biomonitoring study using multiple biomarker responses in Nile tilapia *Oreochromis niloticus* was conducted to assess the effects of a contamination gradient along four reservoirs in Iguaçu River. Chemical analysis in the muscle showed high levels of metals in fish from the reservoir closest to an industrialized and environmentally degraded area, however fish exposed to all studied reservoirs showed hepatic alterations (necrosis and inflammatory processes). Also, significant variations of biochemical biomarkers were observed with no clear indication of contamination gradient, since an indicative of higher impact was found in an intermediary reservoir, including high concentrations of biliary polycyclic aromatic hydrocarbons (PAHs). However, nuclear morphological alterations (NMA) were less frequent at the same reservoir. Thus, the multi-biomarker approach allied to active biomonitoring is a practical and important tool to assess deleterious effects of contamination in freshwater, providing data for monitoring and conservation protocols.

(09) NEVES, M., DE ARRUDA AMORIM, J., & DELARIVA, R. 2018. **Influence of land use on the health of a detritivorous fish (*Ancistrus mullerae*) endemic to the Iguassu ecoregion: relationship between agricultural land use and severe histopathological alterations.** Environmental Science And Pollution Research, 25(12), 11670-11682.

Resumo: This study aimed to evaluate the histopathological biomarkers of the gills and liver of endemic catfish to test the hypothesis that, in environments under intense land use by agricultural activities, histopathological alterations occur more severely. Samples were collected by electrofishing in seven streams in the Lower Iguaçu basin quarterly from August 2015 to February 2016. The gills and livers were processed according to routine histological methods and examined by light microscopy. The histopathological alterations observed in fish from the streams with a higher percentage of natural vegetation cover were considered modest and indicated normal functioning of the organ (such as edema, hyperplasia, and leukocyte infiltration). As predicted, fish collected in streams with higher agricultural influence presented moderate to severe damage (aneurysm, vacuolization and cytoplasmic

degeneration, and pyknotic nucleus). The abundance of chloride cells was significantly increased in the gills of *Ancistrus mullerae* collected in rural streams. In addition, in most streams, mucous cells were more abundant during the rainy period. Significant differences were observed in the histopathological index (HI) of the gills and livers, where severe histopathological alterations occurred in fish from streams with a higher agricultural influence. The observed alterations were more severe in the liver than in the gills, which are indeed related to the liver's key role in the detoxification of xenobiotics. We conclude that more severe histological alterations occurred in fish from streams with the highest land use by agricultural activities. Thus, our work provides important insight into the conservation and management of natural resources.

(10) NIMET, J., AMORIM, J., & DELARIVA, R. 2018. **Histopathological alterations in *Astyanax bifasciatus* (Teleostei: Characidae) correlated with land uses of surroundings of streams.** *Neotropical Ichthyology*, 16(1): e170129.

Resumo: This study evaluated gills and liver of *Astyanax bifasciatus* as histological biomarkers for biomonitoring of streams along areas with different land uses. The fish were collected by electrofishing in six streams in the basin of the lower Iguaçu River. The objective was to correlate the presence and degree of histopathological alterations of gills and liver with the environmental variables among streams along different land uses. The low frequency of histopathological alterations found in fish from the forest streams suggested normal organ functioning. In fish from the rural and urban streams, the histopathological alterations occurred were in higher frequency, indicated light to moderate damage in gills and liver of fish from the rural streams, and moderate to severe damage in liver of fish from urban streams. The histopathological alterations in gills (lamellar aneurysm) and livers (vascular congestion) verified in impacted streams were significantly more frequent and severe. It was possible to distinguish streams along different land uses, suggesting that these histopathological alterations can be used as biomarkers for biomonitoring studies. The health integrity of fish from streams in forest areas further reinforces the importance of maintaining preservation areas in basins under intensive land use.

(11) SOBJAK, T., ROMÃO, S., CAZAROLLI, L., SAMPAIO, S., REMOR, M., & GUIMARÃES, A. 2018. **Evaluation of the antioxidant system and neurotoxic effects observed in *Rhamdia branneri* (Teleostei: Heptapteridae) sampled from streams of the lower Iguazu River basin.** *Ecotoxicology And Environmental Safety*, 155, 162-170.

Resumo: The use of multiple biomarkers has been shown to be an efficient method for evaluating environmental contamination. In this work, we evaluate neurotoxic effects and the antioxidant system responses of the *R. branneri* collected in two streams of lower Iguazu River basin, relating them with different percentage of vegetation cover, presence of pesticides and fall and winter seasons. The biological samples were collected in March and August of 2015, from two streams that belong to the lower Iguazu River basin (Brazil): the Manoel Gomes River and the Arquimedes Stream. Soil analyses were performed, and the results showed the presence of the following organophosphates in the Manoel Gomes River and the Arquimedes Stream: disulfoton, methyl parathion, and ronnel. The present study detected inhibition of cholinesterase activity in the brain and muscle of fish samples during the fall from the Manoel Gomes River and the Arquimedes Stream. In the Manoel Gomes River, elevated lipoperoxidation was also observed during the fall. It was observed that the increase or decrease of biomarkers was related to temporal variation and, possibly, to the exposure of animals to agrochemicals. Although the Manoel Gomes River and the Arquimedes Stream are located in regions with large areas of vegetation, the soil analyses show that agrochemical residues are able to reach these locations, which suggests that the fauna are in contact with oxidant and anti-cholinesterase agents during the fall, in addition to respond differently during each season.

(12) YAMAMOTO, F., DIAMANTE, G., SANTANA, M., SANTOS, D., BOMBARDELI, R., & MARTINS, C. ET AL. 2018. **Alterations of cytochrome P450 and the occurrence of persistent organic pollutants in tilapia caged in the reservoirs of the Iguazu River.** *Environmental Pollution*, 240, 670-682.

Resumo: Environmental chemicals originating from human activities, such as persistent organic pollutants (POPs), may interfere with the endocrine system of aquatic organisms. The effect of these chemicals on biota and human populations is of

high public concern but remains poorly understood, especially in aquatic environments of South America. The aim of this study was to investigate the bioavailability of POPs and the related effects in caged male tilapia (*Oreochromis niloticus*) in four cascading reservoirs of the Iguaçu River, Southern Brazil. POPs including organochlorine pesticides (OCPs), polychlorinated biphenyl (PCBs), and polybrominated diphenyl ethers (PBDEs) were determined in the reservoir water and tissue samples of tilapia after two months of exposure. The PCB levels in water (14.7 ng L^{-1}) were 14 times higher than the limits permitted by the Brazilian legislation in the Salto Santiago (SS) reservoir. Similarly, concentrations of aldrin and its metabolites (6.05 ng L^{-1}) detected in the water sample of the Salto Osório (SO) reservoir were also above the permitted limits. RT-qPCR analysis revealed different transcript levels of cytochrome P450 enzymes (CYP1A and CYP3A) in the liver among the four groups, with induced activity in tilapia from the SS reservoir. Quantification of the CYP3A mRNA expression and catalytic activity showed higher values for fish caged at the SS reservoir. The fish from this site also had a higher number of eosinophils observed in the testes. Although overt measurements of endocrine disruption were not observed in caged fish, alteration of CYP enzymes with co-occurrence of organochlorine contaminants in water may suggest bioavailability of contaminants from agricultural sources to biota. Additional studies with feral or caged animals for a longer duration may be necessary to evaluate the risks of the waterways to humans and wildlife.

(13) WACHTEL, C. C.; OLIVEIRA, E. C.; MANIGLIA, T. C.; SMITH-JOHANNSEN, A.; ROQUE, A. A.; GHISI, N. C. 2019. **Waterborn Genotoxicity in Southern Brazil Using *Astyanax bifasciatus* (Pisces: Teleostei)**. Bulletin of Environmental Contamination and Toxicology, 102(1): 59-65.

Resumo: Water bodies are often negatively affected by unmediated expansion of surrounding human populations. This makes it essential to establish growth planning strategies that balance productivity and sustainability when creating a viable ecological equilibrium. This study aimed to evaluate genotoxic effects in southern Brazil, using biomarkers in the fish *Astyanax bifasciatus*, during summer and winter of 2016. The erythrocytic nuclear abnormalities test and the micronucleus test as well as the blood and liver comet assay were used to determine genetic biomarker damage.

Four locations and a control point (CP) were sampled in this study. The results demonstrated genotoxicity at all sample locations in the river as compared to the CP in all tests. This is concerning as this water source is the only supply for human populations adjacent and further flows into the greater Iguaçu river basin.

(14) LEHUN, A. T.; MENDES, A. B.; TAKEMOTO, R. M.; KRAWCZYK, A. C. D. B. 2021. **Genotoxic effects of urban pollution in the Iguaçu River on two fish populations**, Journal of Environmental Science and Health, 56(9): 984-991.

Resumo: Environmental impacts on water resources and discharges of pollutants are some of the main problems of aquatic ecosystems. Currently, the Iguaçu River is considered the second most polluted river in Brazil, therefore, given the importance of understanding the effects of water pollution on living organisms, this study aimed to analyze the possible genotoxic effects in *Astyanax bifasciatus* (Characiformes; Characidae) and *Geophagus brasiliensis* (Perciformes: Cichlidae) in response to the water quality of the Iguaçu River. Four sampling points were determined on the Iguaçu River, with different levels of environmental impact. The micronuclei and nuclear abnormalities were quantified by counting 2000 erythrocytes from each specimen. There was a statistical difference in the frequency of nuclear abnormalities both for *A. bifasciatus* (Kruskal-Wallis 3;30 = 10.9; $p = 0.01$) and for *G. brasiliensis* (Kruskal-Wallis 3;26 = 12.27; $p = 0.006$), with point 1 (critically degraded) showing a higher frequency of nuclear abnormalities and point 4 (moderately degraded) showing a lower frequency of nuclear abnormalities for both species, showing genotoxic potential in fish erythrocytes. This result demonstrates the need for further discussion on the conservation of the Iguaçu River as well as broadening the discussion on its potability.

(15) RUBIO-VARGAS, D. A.; OLIVEIRA RIBEIRO, C. A. FILIPAK NETO, F.; CORDEIRO, A. L.; CESTARI, M. M.; SOUZA, A. C.; MARTINS, C. C.; PINTO DA SILVA, C.; CAMPOS, S. X.; GARCIA, J. R. E.; PRODOCIMO, M. M. 2021. **Exposure to pollutants present in Iguaçu River Southern Brazil affect the health of *Oreochromis niloticus* (Linnaeus, 1758): Assessment histological, genotoxic and biochemical**. Environmental Toxicology and Pharmacology, 87: 103682

Resumo: Urban sewage is a source of major contamination in aquatic systems and contributes to environmental and human health disturbances. This study investigates the effects of sewage-polluted waters from Iguaçu River on the health of juvenile *Oreochromis niloticus*. Two hundred four specimens were exposed to riverine water in four groups: no diluted, 25 and 50 % diluted water and a control group without tested water for 72 days. Biological samples were obtained for histopathological, neurotoxicity, antioxidant defenses, genotoxicity, metallothionines expression and polycyclic aromatic hydrocarbons (PAHs) metabolites. The results showed histopathological alterations in liver and gills, genotoxic alteration in erythrocytes, reduction of acetylcholinesterase activity in brain and muscle, activation of antioxidant defenses in the liver, recruitment of metals by metallothionein and the detection of PAHs metabolites in bile. These results demonstrate that juveniles of *O. niloticus* are susceptible to Iguaçu River exposure water and they can be used as indicator of water quality.

(16) GOLINA, N.; BARRETO, L. S.; ESQUIVEL, L.; SOUZA, T. L.; NAZÁRIO, M. G.; OLIVEIRA, A. P.; MARTINS, C. C.; OLIVEIRA RIBEIRO, C. A. 2022. **Organic and Inorganic Pollutants in Jordão and Iguaçu Rivers Southern Brazil Impact Early Phases of *Rhamdia Quelen* and Represent a Risk for Population**. *Chemosphere*, 303 (1): 134989

Resumo: The Iguaçu River basin presents high ecological importance due to its expressive endemic ichthyofauna rate, but chemical pollution may threaten this biodiversity. Jordão River is one of the main tributaries of Iguaçu River and contribute to this pollution status, since it drains large agricultural areas receiving domestic and industrial effluents before flowing into the Iguaçu River. The objective of the current study was to evaluate the toxic effects of the Iguaçu, Jordão, and the combination of their waters to the embryo-larval phase of *R. quelen*, investigating the consequences to the population by means of mathematical modelling. *R. quelen* fertilized eggs were exposed for 96 h to water samples from Iguaçu River upstream (IR), Jordão River (JR), and downstream of both rivers (MR). The analysis of micropollutants in the water showed that JR presented the most complex mixture of substances and elements, followed by IR, while MR showed the lower number of micropollutants detected. Survival rate was not a sensitive endpoint, while the

deformity indices were higher in individuals exposed to water from the three studied sites. Superoxide dismutase activity was increased in MR, while non-protein thiol levels were reduced in MR and JR showing the antioxidant mechanism activation. The mathematical modelling revealed that fish exposed to JR would lead to the greater population reduction (46.19%), followed by IR (40.48%) and MR (33.33%). Although the results showed toxicity in all studied sites, the JR site is the most impacted by micropollutants but decrease its toxicity after dilution with Iguaçú River.

(17) SCIPIONI, B.; ANDRADE, M. C. K.; PEIXOTO, L. O. M.; MIZUKAWA, A.; FILIPPE, T. C.; AZEVEDO, J. C. R. 2022. **Use of Caffeine for the Evaluation of the Anthropic Influence over the Upper and Middle Iguaçú River Basins.** Journal of Water Resource and Protection, 14(3): 273-291.

Resumo: Many parameters are usually used as gauges to describe water quality worldwide, such as the concentrations of phosphorus, forms of nitrogen, dissolved oxygen (DO), among others. Though legislative limits for the concentrations of these substances are in place, such is not the case for caffeine. Caffeine is a pharmacologically active alkaloid, from the xanthine group, which can be used as a chemical tracer for anthropic influence over water resources. The objective of this study was to analyze the pollution indicators over the Iguaçú River, one of the main rivers in Southern Brazil, through the examination of nutrients, DO and their correlations to caffeine. The water samples were collected from 10 sampling sites along the river course, unevenly spaced to better represent the different environmental scenarios present in its basin, extracted from 2014 to 2017. Caffeine was detected and quantified through high-efficiency liquid state chromatography. Results show that both nutrient and caffeine concentrations increased in intensely urbanized areas, specially from IG2 to IG5 sampling sites. Downstream from IG6 the contaminant concentrations decreased mainly due to higher river flows and lower population density. Caffeine was detected in 82% of the samples, indicating that most of the sampling sites were under anthropic influence.

Conclusões

- As informações obtidas sobre o efeito de poluentes em organismos aquáticos na área do PAN indicam 15 estudos realizados com as espécies *Geophagus iporanguensis*, *Chrenicicla iguassuensis*, *Oreochromis niloticus*, *Ancistrus mullerae*, *Psalidodon bifasciatus*, *Rhamdia branneri*, *Rhamdia quelen* e *Rhamdia voulezi*.
- Dois estudos (SANTOS, 2015; SCIPIONI et al., 2022) avaliaram as concentrações de cafeína, paracetamol e ibuprofeno na água em alguns pontos do rio Iguaçu e foram incluídos na listagem por indicar que os poluentes estudados se comportam como um indicador de contaminação dos organismos aquáticos.
- Os prejuízos e alterações observadas nos indicadores (biomarcadores) utilizados na avaliação da condição de saúde da ictiofauna indicaram que a poluição promoveu danos aos indivíduos.
- Os resultados dos estudos foram utilizados para aferir o nível de comprometimento da saúde dos organismos aquáticos e avaliar o grau de degradação ambiental na região, com o objetivo de utilizar esta informação em programas de controle de qualidade.
- Não foram encontrados estudos específicos sobre ingestão e acumulação de microplásticos por organismos aquáticos, entretanto investigações sobre a dieta de *Bryconamericus ikaa* no reservatório da UHE Caxias indicaram a ocorrência deste poluente nos conteúdos alimentares (SILVA & ABELHA, 2021). Sobre este assunto é importante destacar o projeto “Avaliação integrativa ampla de microplásticos em uma bacia de alta relevância ambiental e econômica (Rio Iguaçu)”, em execução (início em 2022) por UTFPR/UNIOESTE/UFPR/MHNCI, contemplado no Edital Universal do CNPq 40609320210, que tem como objetivo realizar uma avaliação integrativa de microplásticos na bacia, incluindo os peixes, associada a uma revisão sistemática e avaliação por bioensaios.

Recomendações

- Estimular o aprofundamento de estudos avaliando a presença e capacidade de assimilação de microplásticos por peixes na região do PAN.

- Incentivar pesquisas sobre o efeito de poluentes em populações de espécies alvo do PAN.
- Fomentar atividades que possibilitem a redução da contaminação de corpos d'água na bacia, tais como recuperação de vegetação nas margens dos rios, a melhoria dos sistemas de coleta e tratamento de esgoto e as boas práticas agrícolas.
- É importante o mapeamento da vulnerabilidade ambiental dos corpos d'água da bacia, com foco nas diversas fontes poluidoras, contribuindo assim para melhores ações de conservação.

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