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Toxicity levels and water quality in an urban basin: the environmental problem of the Lindóia stream basin in Paraná, Brazil

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Highlights:

- The Lindóia River basin has urban-environmental problems resulting from irregular occupation.
- The water quality of the Lindóia River basin is influenced by anthropogenic actions, with low levels of dissolved oxygen and fecal contamination.
- Cytotoxicity, genotoxicity and mutagenicity were observed in the meristematic cells of *A. cepa* exposed to the water samples.

Keywords: *A. cepa* bioassay; Microscopic toxicity; Quality parameters.

INTRODUCTION

Societies have developed based on the availability of watercourses in their territories, and these resources have been impacted over time. Due to various anthropogenic pressures, analyzing a river basin is essential for understanding water quality factors. Water monitoring, therefore, involves an analytical procedure that identifies substances or other indicators representative of the natural conditions of an aquatic system. In Brazil, the quality and classification of water bodies are determined by CONAMA Resolution No. 357/2005 (Brasil, 2005).

This study aimed to assess the water quality of the Lindóia River Basin (LRB), located in the northern part of Paraná, Brazil. This region faces recurring issues such as illegal sewage dumping into water bodies, improper solid waste disposal, and vulnerability to industrial pollution.

METHODOLOGY

The LBR, located in Londrina and Ibiporã, northern Paraná, Brazil, is classified as a class III, with bodies receiving treated effluent. Eight water samples were collected from this basin: Lindóia stream (P1, P2, P3, P5, P8), Cabrinha stream (P4), Quati stream (P6), and Água das Pedras stream (P7), as shown in Figure 1. P1 is in a rural area, P2 and P6 in residential areas, P3, P4, and P5 in urban lakes, P6 and P7 near irregular occupations, and P8 after the Sewage Treatment Plant and after irregular occupation. Samples were collected according to the National Sample Collection and Preservation Guide (ANA, 2023) and transported to the Sanitation and Microbiology laboratories at the Federal Technological University of Paraná (UTFPR), Londrina campus.

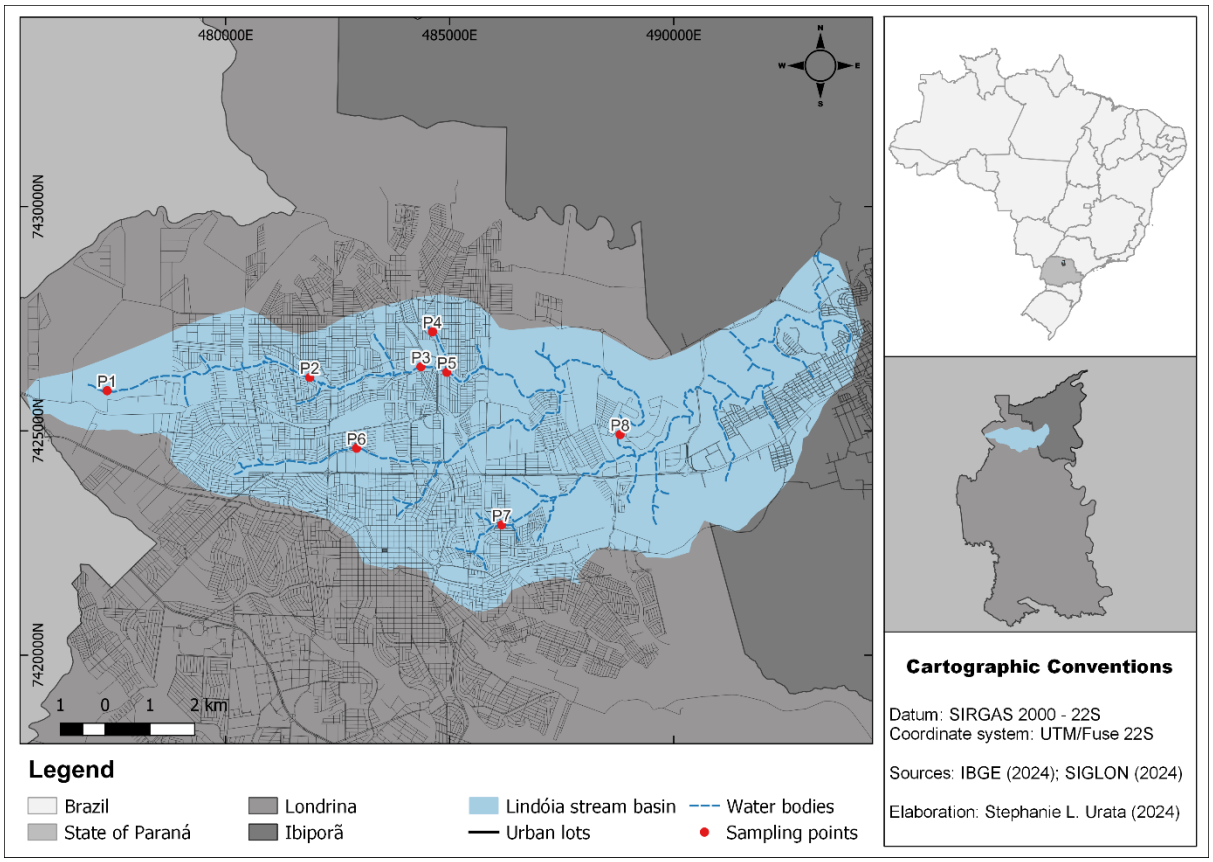

Figure 1 - Geographical location of the Lindóia river basin in the municipalities of Londrina and Ibiporã - PR, highlighting the sampling points.

Physico-chemical analyses included COD, DO, phosphorus, pH, temperature, and turbidity using a multiparameter and bench-top equipment. Microbiological analysis involved counting E. coli colonies on 3M Petrifilm (3M, 2021). Toxicological analysis used bioassays with *A. cepa* seeds (Baia Periforme variety), following methods from Silva and Tofolo (2017) and Pesenti et al. (2021), with distilled water as a negative control and copper sulfate (0.1 mg/L) as a positive control. Cytotoxicity, genotoxicity, and mutagenicity were assessed by observing 2,500 germinated root meristem cells of germinated seeds were observed per replicate under a microscope (40x and 100x objectives). Biomarkers in Box 1 were calculated based on Coelho (2017).

Biomarker	Index	Equation
Cytotoxicity	Mitotic index (MI)	$MI\ (\%) = \frac{no.of\ cells\ in\ mitosis}{no.of\ cells\ observed} . 100$
Genotoxicity	Chromosomal aberrations (CA)	$CA\ (\%) = \frac{no.of\ cells\ with\ chromosomal\ aberrations}{no.of\ cells\ observed} . 100$
Mutagenicity	Mutagenicity index (IMUT)	$IMUT\ (\%) = \frac{no.of\ cells\ with\ nuclear\ abnormalities}{no.of\ cells\ observed} . 100$

Box 1 – Biomarkers and indices calculated in the microscopic analysis of toxicity in *A. cepa* meristem cells

RESULTS AND CONCLUSIONS

The physical-chemical and microbiological results are presented in Table 1.

Sampling	COD[1] (mg.L^{-1})	DO[2] (mg.L^{-1})	pH	P[3] (mg.L^{-1})	T.[4] (°C)	Turbidity (NTU)	*E.coli* [5] (CFU.100mL $^{-1}$)
P1	21,03±6,57	2,11±0,31	6,32±0,10	0,46±0,01	22,40±0,35	13,80±0,46	400
P2	19,56±7,80	3,75±0,16	6,34±0,24	0,00	23,20±0,25	8,00±0,26	2.100
P3	-	2,65±0,04	6,40±0,15	0,00	27,20±0,23	34,70±8,27	5.250
P4	22,69±6,52	4,45±0,91	6,42±0,04	0,00	28,70±0,20	7,50±1,12	400
P5	-	4,17±0,26	7,48±0,15	0,00	26,00±0,32	23,50±0,31	14.850
P6	10,70±2,22	3,36±0,16	6,41±0,08	0,01±0,00	25,30±0,06	2,70±0,61	7.300
P7	-	4,49±0,12	7,58±0,09	0	24,70±0,40	3,40±0,40	15.300
P8	-	3,11±0,06	7,28±0,05	1,01±0,02	28,00±0,40	11,80±0,32	16.550

[1] (COD) = Chemical Oxygen Demand; [2] (DO) = Dissolved Oxygen; [3] (P) = Phosphorus; [4] (T) = Temperature; [5] *(E. coli) = Escherichia coli*.

Table 1 - Physico-chemical and microbiological results of water samples from the Lindóia River basin

COD levels were high at P1 and P4, likely due to excess organic matter. Phosphorus concentrations were elevated at P1 and P8, likely from pesticide residues and effluents, exceeding the national limit (0.15 mg/L). DO levels, required to be at least 4 mg/L for class III waters, were only met at P4, P5, and P7, suggesting pollution from nutrient increase, organic matter decomposition, or low turbulence at other points. pH and turbidity were within legal limits, and temperature ranged from 22.4°C to 28.7°C, E. coli levels exceeded the maximum allowed of 4,000 CFU/100 mL at most points, indicating possible contamination from inadequate disposal of sanitary sewage or effluents, particularly at P5, P7, and P8.

Microscopic toxicity parameters are shown in Table 2.

Sampling	Interphase (no.cells)	Cell Division (no.cells)	MI[1] (%)	CA[2] (%)	IMUT[3] (%)
P1	2.195	308	12,3	4,63	3,00
P2	2.308	197	7,9	2,91	3,75
P3	2.241	226	8,9	2,05	1,73
P4	2.280	223	8,9	3,40	2,84
P5	2.510	197	7,8	3,89	3,77
P6	-	-	-	-	-
P7	2.507	225	8,9	4,67	2,03
P8	-	-	-	-	-
PC[4]	2.405	104	4,1	2,39	7,06
NC[5]	2.229	278	11,1	1,32	0,08

[1] (MI) = Mitotic index; [2] (CA) = Chromosomal Aberrations; [3] (IMUT) = Mutagenicity index; [4] (PC) = Positive Control; [5] (NC) = Negative Control; (-) no data.

Table 2 - Microscopic toxicity in *A. cepa* meristematic cells exposed to Lindóia river basin water samples.

Lower mitotic index (MI) values compared to the negative control indicate chemical effects on cell growth, while higher MIs suggest excessive replication. Chromosomal aberrations (CA) were common, such as lagging chromosomes and c-metaphase, linked to delayed division. P3 had the lowest CA rate, and P7, an illegal sewage site, had the highest. The mutagenicity index (IMUT), which includes micronuclei (MN) and nuclear anomalies (NA), showed the highest MN in interphase cells, with an average of 14 MN per sample and the highest IMUT at P2 and P5.

As a result, water bodies incorporate into their environment the consequences of what happens in their surroundings, reducing water quality and having toxic potential, reflecting anthropogenic pressure on the LRB.

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