INFLUENCE OF THE RAINFALL REGIME ON THE HYDROCHEMISTRY OF URBAN LAKES: A STUDY ON THE UFMA CAMPUS USING GLOBE OBSERVER

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Abstract

This study assessed how rainfall affects water chemistry in two urban lakes on the UFMA campus (São Luís, Brazil). From November 2025 to January 2026, Technical Course students acted as citizen scientists, collecting physicochemical measurements and field observations using GLOBE Observer protocols. The shift to the rainy season altered both lakes, with Lagoa Dom remaining more stable and Lagoa do Jambeiro—more exposed to urban influence—showing stronger changes. In both systems, rainfall caused simultaneous dilution (lower salts and pH) and sediment input (higher turbidity). The results emphasize the seasonal and landscape-dependent behavior of urban lentic ecosystems and highlight continuous monitoring and citizen science as valuable tools for knowledge generation and conservation.

Keywords: Hydrochemistry; Urban lakes; GLOBE; Citizen science.

Research Question

How does seasonal variation in precipitation, considering rainfall accumulated over 24 h and 48 h prior to sampling, influence hydrochemical parameters (especially pH and electrical conductivity) and visual indicators of water quality (such as turbidity, coloration, and the presence of particulate matter) in the urban lakes Lagoa Dom and Lagoa do Jambeiro, located on the campus of the Federal University of Maranhão (UFMA), and to what extent do these responses differ between the two systems as a function of surrounding land-use characteristics and the degree of anthropogenic interference?

Introduction

Urban lakes may be easy to overlook, but they provide key services such as water storage, runoff buffering, biodiversity support, and spaces for recreation (Dos Santos Lima & Pamplin, 2023; Esteves, 2011). Research consistently shows strong seasonal shifts in urban lake water quality, with rainfall driving changes in dissolved oxygen, nutrients, and physicochemical indicators depending on land use and hydrological inputs (Matos Silva et al., 2021; Fukushima, Kitamura & Matsushita, 2021). In tropical lentic systems, rain can trigger rapid alterations in water chemistry by both diluting dissolved ions (lowering electrical conductivity) and enhancing runoff-driven inputs of sediments and pollutants, which increase turbidity and nutrient loads (Wetzel, 2001; Zhou et al., 2022; Yang et al., 2021). Because variability and spatial heterogeneity are normal features of these ecosystems, interpreting their dynamics requires linking in-lake measurements to recent rainfall and surrounding land-use conditions (Gomes & Ibañez, 1994; Li et al., 2025; Tundisi & Tundisi, 2008).

On the UFMA campus in São Luís, Lagoa Dom and Lagoa do Jambeiro are urban lentic systems with limited accessible documentation, making systematic monitoring especially valuable. Using standardized citizen-science protocols from GLOBE Observer (GLOBE, 2022; GLOBE Protocols, 2023), this study examines how rainfall accumulated over 24 h and 48 h influences pH, electrical conductivity, and turbidity, helping clarify how seasonal precipitation shapes hydrochemical dynamics in these campus lakes.

Research Methods

The study was conducted in two urban lakes—Lagoa Dom and Lagoa do Jambeiro—located on the campus of the Federal University of Maranhão (UFMA) in São Luís, Brazil. Lagoa Dom lies in the central campus area near academic buildings, while Lagoa do Jambeiro is situated in the eastern portion of the campus, closer to sports facilities and the urban boundary. Both lakes are embedded in an urban-university setting and are influenced by surrounding land use and the local rainfall regime (GLOBE, 2022).

Figure 1 – Location map of Lagoa Dom and Lagoa do Jambeiro on the UFMA campus, São Luís, Maranhão, Brazil.
Source: Prepared by the authors based on GLOBE Observer data.

Monitoring was carried out between November 2025 and January 2026, with biweekly sampling over three months, covering the transition from drier to wetter conditions.

Figure 2 – Field sampling conducted at Lagoa Dom and Lagoa do Jambeiro within the GLOBE Project.
Source: Prepared by the authors.

Field activities were performed by students from the Technical Course in Environmental Studies, who were previously trained under the GLOBE Program Hydrosphere–Water Protocol to ensure standardized sampling, proper instrument use, and consistent data recording (GLOBE, 2022; GLOBE Protocols, 2023).

During each campaign, in situ measurements were taken and water samples were collected using a manual sampler to minimize surface disturbance. Water temperature was measured with an infrared thermometer, while pH and electrical conductivity were determined using calibrated portable meters (Wetzel, 2001; Esteves, 2011; Oliveira et al., 2019). Laboratory analyses were conducted at the COLUN/UFMA Chemistry Laboratory under teacher supervision. Dissolved oxygen, ammonia, chlorine, and nitrite were analyzed using colorimetric methods (Gomes & Ibañez, 1994), turbidity was measured with a turbidimeter (Esteves, 2011), and total solids were determined gravimetrically. Alkalinity was obtained by acid–base titration following Tundisi and Tundisi (2008).

Results

The two studied lakes showed clear hydrochemical responses to seasonal rainfall, with overall similar patterns but different response intensities. Lagoa do Jambeiro presented slightly higher mean values of turbidity and electrical conductivity throughout the monitoring period, along with greater variability, indicating higher sensitivity to external inputs. This behavior is consistent with its greater exposure to surrounding urbanized areas and surface runoff, a pattern commonly reported for tropical urban lentic systems (Esteves, 2011; Oliveira et al., 2019; Zhou et al., 2022). In contrast, Lagoa Dom exhibited slightly lower mean temperature, pH, and conductivity values, suggesting a relatively more stable hydrochemical environment, although still influenced by seasonal rainfall dynamics (Wetzel, 2001; Tundisi & Tundisi, 2008).

As shown in Figure 3, turbidity and electrical conductivity displayed marked seasonal behavior in both lakes. Higher conductivity values were observed during the dry period, followed by a pronounced decrease during the rainy season, while turbidity increased after the onset of rainfall. This pattern reflects the combined influence of dilution of dissolved ions and increased input of suspended particles during rainfall events.

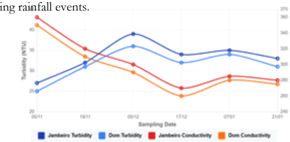

Figure 3 – Temporal variation of turbidity (NTU) and electrical conductivity (µS cm⁻¹) in Lagoa Dom and Lagoa do Jambeiro.
Source: Prepared by the authors based on GLOBE Observer data.

Rainfall accumulated over 24 h and 48 h increased markedly from December onward, coinciding with immediate declines in pH and conductivity and increases in turbidity and total solids. Despite these fluctuations, alkalinity indicated sufficient buffering capacity in both systems (Tundisi & Tundisi, 2008).

A strong negative correlation was observed between pH and rainfall accumulated over 48 h in both lakes, reinforcing the dominant role of precipitation in controlling water chemistry (Jia et al., 2021; Yang et al., 2021). Nitrogen compounds and punctual reductions in dissolved oxygen were mainly detected after rainfall events, indicating organic matter inputs and early signs of eutrophication typical of urban lentic environments (Gomes & Ibañez, 1994).

This pattern reflects the combined influence of dilution of dissolved ions and increased input of suspended particles during rainfall events. Despite these seasonal shifts, the temporal trends were similar in both systems, reinforcing the dominant role of the regional rainfall regime as a controlling factor (Table 1).

Table 1 – Mean values of physicochemical parameters and observational summary for Lagoa Dom and Lagoa do Jambeiro.

Period	Rainfall Condition	Turbidity	Electrical Conductivity	pH	Observation
Nov/2025	Dry period (0 mm)	Low (26.4 NTU)	High (360.2 µS/cm)	Alkaline (9.18)	More stable and clearer water
Dez/2025 - Jan/2026	Rainy period (6–28 mm)	High (34.8 NTU)	Low (266.0 µS/cm)	Less alkaline (8.48)	Turbid water; simultaneous dilution and runoff input effects

Source: Authors elaboration based on GLOBE Observer data.

Discussion

TThe results show that both Lagoa Dom and Lagoa do Jambeiro respond rapidly to rainfall variability, confirming precipitation as a key driver of hydrochemical dynamics in urban lentic systems. The shift to the rainy season produced two concurrent effects—dilution of dissolved ions (lower electrical conductivity and pH) and increased runoff inputs (higher turbidity)—consistent with patterns described for tropical lakes (Wetzel, 2001; Esteves, 2011; Oliveira et al., 2019). Despite similar overall conditions, lake-specific responses suggest that surrounding land use and anthropogenic pressure modulate the intensity of change. In practice, this means that the same rainfall pulse can generate different magnitudes of response depending on shoreline condition, connectivity with paved areas, and the presence of vegetated buffers. The rainy period also coincided with higher total solids and visual signs of suspended material (e.g., brownish water), reinforcing the role of surface runoff as a transport pathway for sediments and associated contaminants. Rainfall-related detection of nitrogen compounds and occasional drops in dissolved oxygen indicate organic matter pulses and early eutrophication signals (Gomes & Ibañez, 1994; Tundisi & Tundisi, 2008). These coupled shifts point to an interconnected response chain linking precipitation, external loading, decomposition processes, and oxygen dynamics. Standardized GLOBE protocols and student participation supported consistent monitoring and reinforce the value of continuous observation for urban water management (Tundisi & Tundisi, 2008).

Conclusions

Monitoring of Lagoa Dom and Lagoa do Jambeiro demonstrated that these lentic environments respond rapidly to variations in the rainfall regime, confirming precipitation as one of the main controlling factors of hydrochemical dynamics on the UFMA campus. The transition between less rainy and rainy periods directly influenced water quality, particularly through particulate matter input, dilution of dissolved ions, and changes in the chemical equilibrium of the system. Although the lakes share similar general characteristics, they exhibited distinct responses depending on local conditions, such as surrounding land use and the degree of anthropogenic interference, reinforcing the need for site-specific analyses even within closely located areas. The application of GLOBE Program protocols proved effective in generating consistent data and highlighted the potential of citizen science as a tool for environmental monitoring and scientific education.

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DESCRIPTION OF BADGES

This project qualifies for four VSS badges. It follows official GLOBE protocols, with students collecting, analyzing, and submitting data via GLOBE Observer. It also demonstrates data science by integrating field measurements with 24 h and 48 h rainfall totals to identify seasonal patterns and dilution/runoff effects. As an Earth system study, it links rainfall, lake processes, and runoff-driven inputs of sediments and organic matter. Finally, it creates impact by generating practical evidence to support management, conservation, and continued monitoring of UFMA's urban lakes.