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RESISTIVITY SEASONAL MONITORING OF THE SUBSURFACE IN URBANIZED CRITICAL ZONE

Victoria Malta Pereira de Lima (IAG/USP), Leticia Rangel Dantas (IAG-USP), Andrea Ustra (Instituto de Astronomia; Geofísica e Ciências Atmosféricas da Universidade de São Paulo (IAG/USP))

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Abstract Summary

The Critical Zone is the planet's most superficial region that require multidisciplinary collaboration and integration of geophysical methods. One of the central elements for studying it is water, which permeates all life-related systems. This work presents preliminary results of groundwater investigation in the Tietê Ecological Park, located on the border between São Paulo and Guarulhos. The research is part of the Seed Site Critical Zone Observatory, developed in partnership with the USP East campus, and uses the electrical resistivity method, along with physicochemical data, to characterize the region's groundwater.

Introduction

The Critical Zone (CZ) extends from the treetops to the groundwater, encompassing processes involving the atmosphere, biosphere, lithosphere, and hydrosphere. Understanding it requires the integration of different fields of knowledge (Brantley et al., 2017). Critical Zone Observatories (CZO) are connected areas where studies dedicated to the CZ are conducted. They must operate over a long period in order to monitor the CZ's dynamics and the mechanisms that regulate its functioning.

Water plays a fundamental role in the CZ, permeating all systems that compose it. It is essential for life on Earth and is a key element in geological and biological processes. Geophysics achieves excellent results in imaging water, particularly through geoelectrical methods, as water presents high contrast relative to the geological medium. These methods also allow for broader area coverage with lower environmental impact.

The Tietê Ecological Park (PET) is located in the Environmental Protection Area of the Tietê River Floodplain, a highly anthropized area in the cities of São Paulo and Guarulhos. It has a complex history, including sediment deposition from the Tietê River removed during its straightening. The study is associated with the Seed Site Critical Zone Observatory, which includes the University of São Paulo campus and the Fazenda do Carmo Municipal Natural Park.

The objective of this work is to understand the groundwater dynamics in the PET, focusing on the influence of the Tietê River and the spatial and temporal variation of electrical resistivity.

Method

Three electrical resistivity lines, each 110 meters long, were defined (Fig. 1). Two lines are parallel to the Tietê River, separated by the lake, and one is perpendicular to the river. The data acquisitions were planned for February, May, August, and November 2025. Resistivity measurements were made using the dipole-dipole array in the time domain, with the Syscal and Elrec instruments (IRIS Instruments), a 1000 ms current injection time, 12-volt battery, and 2 and 4-meter spacing between electrodes.

Data were processed using RES2DINV (IRIS). Data with errors above 5% and negative resistivity values were removed. Data inversion was performed to generate models, and those with RMS error below 8% were kept. Pseudosections were generated based on these models.

In monitoring wells near lines 1 and 2 (Fig. 1), the water table was measured during all campaigns, and physicochemical water parameters were measured in February using a multiparameter probe (Hanna). The wells are 8 meters deep and intersect the pseudosection. The physicochemical parameters measured were: electrical conductivity, pH, oxidation-reduction potential, dissolved oxygen, temperature, salinity, and total dissolved solids. These data will be measured again in August.

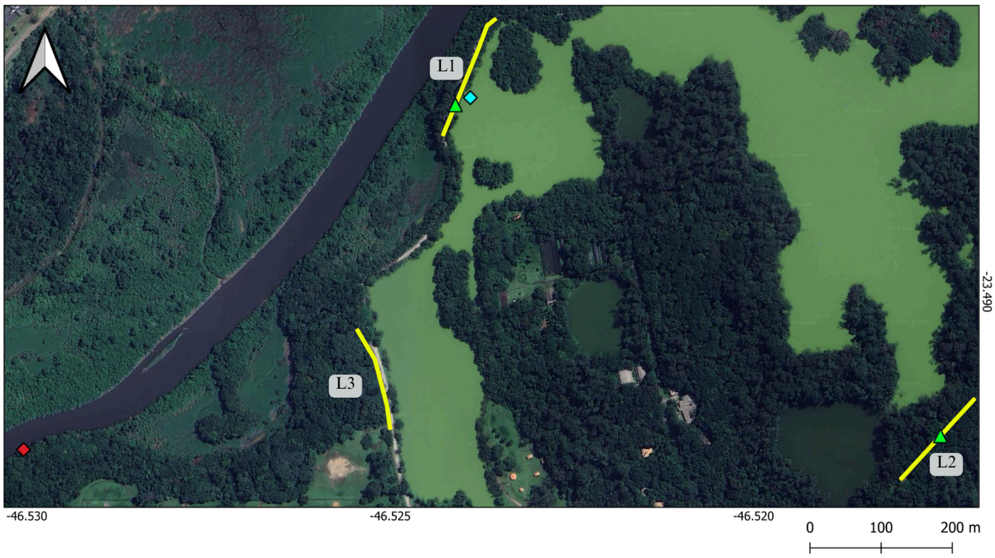

Figure 1: Map showing spatial layout of processed data. Yellow lines represent ER traverses; diamonds and triangles mark points where physicochemical measurements were taken. Green triangles are monitoring wells; the red diamond marks the Tietê River point; the blue diamond marks the lake point.

Results and Discussion

Figures 2 and 3 show the resistivity models obtained for February and May, respectively. Line 1 (Fig. 2a), closest to the river, presents significant surface resistivity variations, above 150 Ω·m. Between 1.35 and 4.30 m depth, there is a zone of intermediate values, around 90 Ω·m, followed by a more conductive region with values below 60 Ω·m. Around 50 m along the line, this pattern shifts upward, with less resistive features appearing. Line 2 (Fig. 2b) shows a similar pattern but with higher resistivity values. Noteworthy is a feature between 28 and 68 meters, at 3.46 meters depth, with higher values ranging from 200 to 350 Ω·m. Line 3 (Fig. 2c) is more heterogeneous. The first meters of depth show regions with higher resistivity, above 233 Ω·m. Below 1.99 meters, there are three regions with low resistivity (below 50 Ω·m), interspersed with more resistive regions around 80 Ω·m.

In May (Fig. 3), surface resistivity values increased in all three lines. The features observed in February remain, with more pronounced contrast. Line 2 shows increased resistivity in central features and at the surface. Line 3 shows intermediate behavior, with increased surface resistivity and variations in deeper zones.

Table 1 shows the physicochemical data collected in February. There is a progressive increase in electrical conductivity from the lake to the Tietê River, passing through wells 1 and 2.

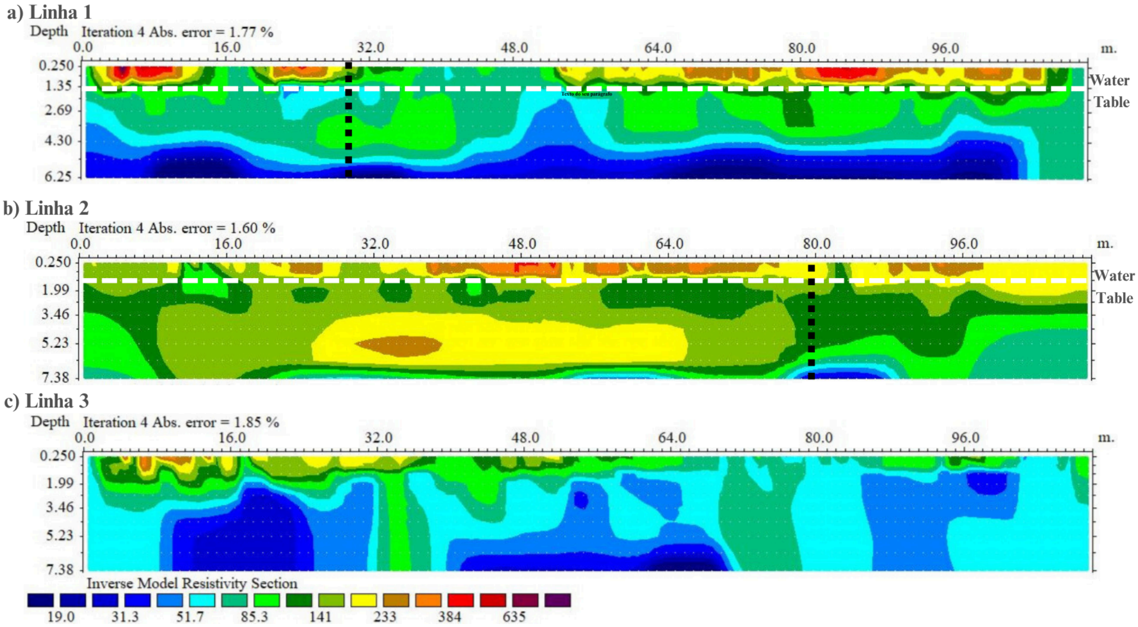

Figure 2: Resistivity model calculated by Res2DInv from February 2025 acquisitions. The dotted black lines represent monitoring wells and the dotted white line represents the water level. a) Shows results from Electrical Line 1. b) Line 2. c) Line 3.

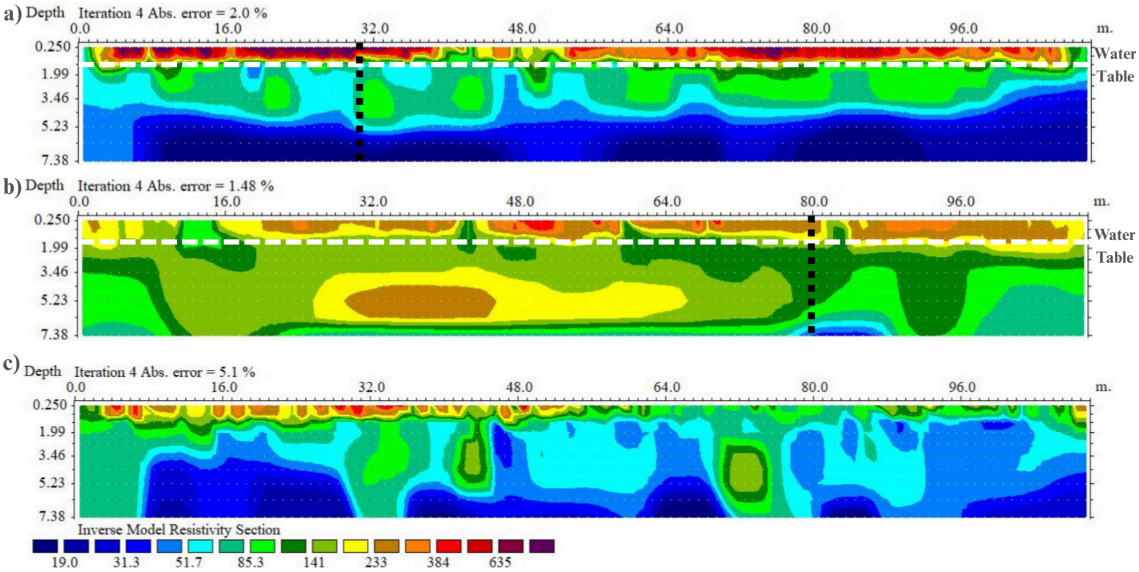

Figure 3: Same as Figure 2 for May 2025 acquisitions.

Points	Tietê River	Lake	Well (L1)	Well (L2)
EC (microS/cm, Feb 2025)	356	142	374	209
Water Level (m, Feb 2025)	-	-	1,37	1,47
Water Level (m, May 2025)	-	-	1,36	1,73

Table 1: Physicochemical data of water from the Tietê River, lake, and two wells in the area obtained in February 2025. Electrical Conductivity (EC).

An increase in surface resistivity values was observed in all lines between February and May campaigns, with intensification of already-identified features. This suggests seasonal variations and subsurface flows with distinct compositions. The resistivity models indicate a possible preferential path for subsurface flow, marked by values below 30 Ω·m.

The physicochemical parameters showed a gradual increase in electrical conductivity from the lake to the wells and to the river, consistent with the geoelectrical models. This distribution indicates the influence of the highly polluted Tietê River on groundwater quality and reveals important seasonal dynamics. Differences between wells reinforce this interpretation. The water from Well 1 (Line 1) was more conductive than that of Well 2 (Line 2), consistent with the more conductive models from Line 2 in both periods.

The results show good agreement between direct data (water level and parameters) and indirect data (resistivity), highlighting the heterogeneity of the environment and possible recharge and flow zone.

Conclusions

This preliminary study shows the relevance of integrating geophysical and physicochemical methods to investigate the Critical Zone in urban environments. The upcoming campaigns will allow for a more accurate assessment of the Tietê River's influence on the region's groundwater.

Acknowledgments

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