Water Quality Variability in the Chimehuín River Over the 2000-2025 period

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Abstract

Over the past 25 years, Junín de los Andes, in Northern Patagonia, has undergone significant urban expansion, nearly doubling in size. The Chimehuín River, a vital freshwater resource for the region, has experienced various environmental changes. This study analyzes the water quality of the Chimehuín River by examining physical-chemical parameters and macroinvertebrate populations following The GLOBE Program Hydrosphere Protocols. Historical data from 2000 to 2025 were compared with new sampling data to identify trends and potential causes of water quality variations.

This research seeks to answer the following questions: What changes have occurred in the Chimehuín River's water quality over the last 25 years? Which of the analyzed parameters have varied the most in water quality?

Results show that while physical-chemical parameters largely remain within normal ranges, fluctuations in dominant macroinvertebrate taxa and EPT% suggest localized anthropogenic and climatic impacts. Notably, a decrease in maximum river flow was seen, likely influenced by prolonged drought periods, urbanization, and sediment deposits from volcanic activity. The 2015 Calbuco volcanic eruption contributed to a temporary decline in water quality, particularly affecting macroinvertebrate communities in the following years. However, recent data from 2025 suggest a recovery trend in both macroinvertebrate populations and water quality indices.

This study underscores the importance of long-term monitoring to assess the interplay between natural disturbances and human activities, highlights the need for sustainable land-use planning and continued water quality assessments to mitigate potential future impacts. Further research should focus on integrating additional biological indicators and expanding sampling efforts to enhance understanding of long-term environmental changes in the Chimehuín River.

Keywords: Water quality, Chimehuín River, Macroinvertebrates, Volcanic impact, Anthropic impact.

Research Questions

- What changes have occurred in the Chimehuin river's water quality over the last 25 years?
- Which of the analyzed parameters have varied the most in the water quality of the Chimehuin river during the last 25 years?

Introduction & Review of Literature

The Chimehuín River is a key water system in Lanín National Park, contributing 23% of its riverside environments (Funes et al., 2006). Originating at Lake Huechulafquen, it flows 53 km to the Collón Cura River, receiving waters from the Curruhué and Quilquihue rivers. Urban expansion along its shores has altered riverbanks and may impact water quality (Bruno Cubero, 2001). Despite overall good water and bank conditions, urbanized areas show macroinvertebrate population shifts (Aigo et al., 2015). New lots have been conducted, and the Chimehuín River springs and shores are being urbanized, which can lead to changes in riverbanks and water quality. The river supplies water to the city and rural areas.

The river's flow fluctuates seasonally, peaking in winter (rain) and spring (snowmelt), with the lowest levels in summer and early fall when recreational, domestic and industrial use is the highest. Volcanic eruptions—Puyehue-Cordón Caulle (2011) and Calbuco (2015)—have affected terrestrial and aquatic ecosystems (Craig et al., 2016), influencing recovery rates based on ash thickness, precipitation, and humidity. Documented impacts include health issues in herbivores, agricultural losses (Craig et al., 2016), and changes in phytoplankton, zooplankton, macroinvertebrates (Brand & Miserendino, 2014; Pepe et al., 2018), and terrestrial arthropods.

Research Methods

Water quality assessments were conducted at various rural and urban sites along the Chimehuín River following The GLOBE Program Hydrosphere Protocols (GLOBE Program, 2024). Land cover was recorded using the GLOBE Observer App and classified with the Modified UNESCO Classification (MUC) System (GLOBE Program, 2024). Landsat satellite images were analyzed to assess land cover changes, and the Köppen-Geiger system was used for climate classification (Beck et al., 2023).

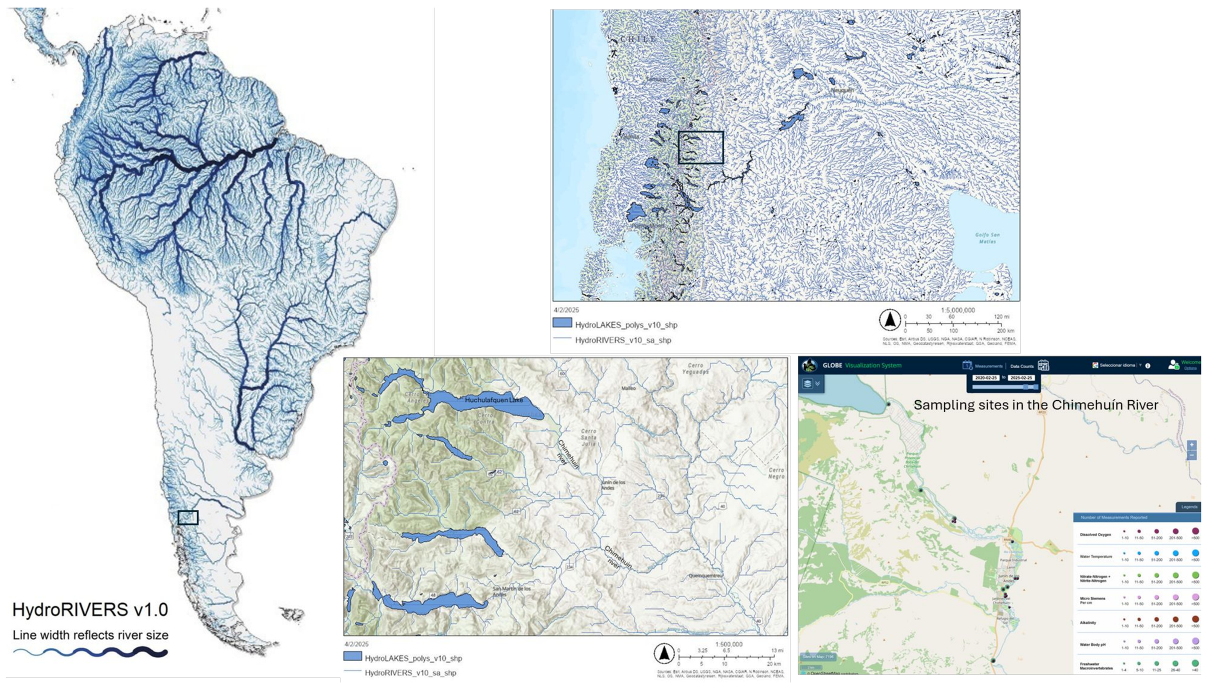

Figure 1: Studied area: Chimehuin River. Source: HydroRIVERS v1.0, Google Maps and GLOBE visualization system.

Water Analysis: Physical-chemical parameters, including pH, turbidity, temperature, dissolved oxygen, electrical conductivity, and nitrates, were measured using LaMotte kits and waterproof testers. Benthic macroinvertebrates were identified with a dichotomous key, and EPT% (Ephemeroptera, Plecoptera, Trichoptera) richness was calculated to assess water quality. Multiple samples were taken at each site to ensure data validity. **Historical and Satellite Data:** Sampling data from 2000 to 2025, collected by GLOBE students and researchers, were analyzed. Land cover and urban expansion were compared using historical Landsat images (Google Earth Timelapse), showing significant growth in the city and changes in the Lanín Volcano's snow cover.

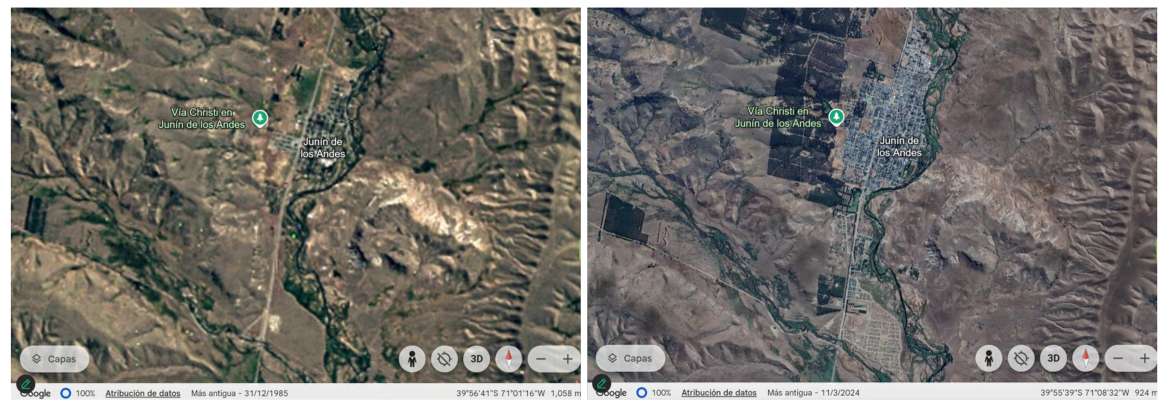

Figure 2: Satellite comparison of Junín de los Andes in 1985 and 2024. Source: Google Earth timelapse.

Hydrological Trends: A linear regression model was applied to analyze flow rate variation, while the Kruskal-Wallis test evaluated water quality differences across years and sites. Precipitation data (NASA Goddard) revealed long-term drought trends influenced by La Niña events. **Study Sites:** Ten sampling sites were distributed along the river, covering key urban and rural locations. Site 3, at CEI San Ignacio School, has the longest historical record since 2000. Some sites were affected by volcanic ash deposition from the 2015 Calbuco eruption, sediment influx from construction projects, and urban expansion impacts.

Results

River Flow Analysis

The Chimehuín River's minimum and mean flows showed no significant variations, but maximum flow exhibited a decreasing trend. Seasonal flow patterns remained consistent, with peaks in winter (precipitation) and spring (snowmelt) and the lowest flows are in summer and early autumn. During El Niño, flows were higher, while La Niña years showed reduced and less variable flow. In 2025, sediment levels were unusually low compared to previous years.

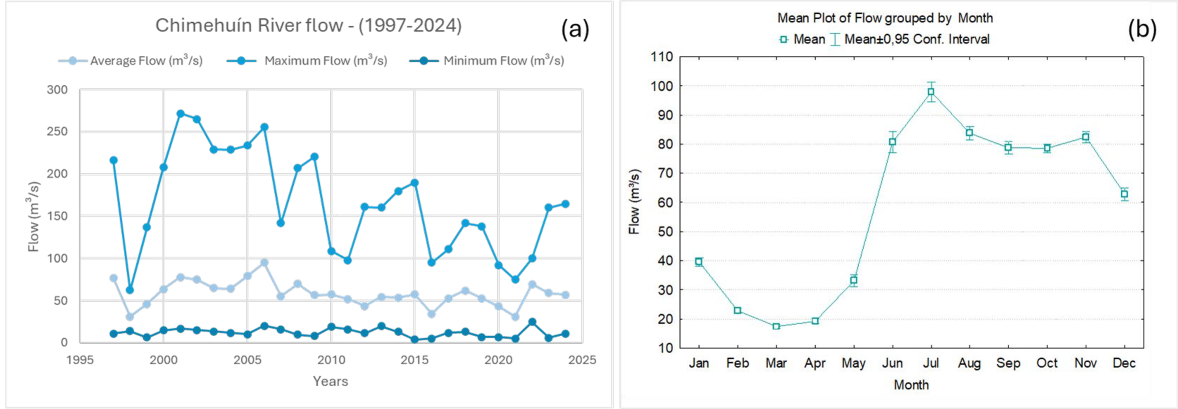

Figure 3: Annual flow variation of the Chimehuin river. Source: AIC.

Water Quality Analysis

Physical-Chemical Parameters:

Water temperature ranged from 10-28°C, with the highest recorded in 2015 (site 3). Dissolved oxygen remained within normal limits (>7 mg/L), pH fluctuated between 6-9, and alkalinity showed a decreasing trend. Conductivity was stable (40-70 µS/cm), and nitrates were below detectable. In 2025, sediment levels were low except at site 3, where sediment banks were observed.

Table 1: 2025 Physical-Chemical analysis.

	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 10
Air Temperature	29,7	32,0	23,0	24,0	21,4	23,1	25,2	23,1
Water Temperature	16	21	19	17,5	16,6	18,6	16,2	17,8
Total Dissolved Solids	30	30	30	40	40	40	40	40
Dissolved Oxygen	9	7,4	7,6	7	8,2	7,8	8	8
Turbidity	0	0	0	0	0	0	0	0
pH	8,4	7,6	7,4	7,5	7,4	7,8	7,3	7,1
Alkalinity	20	28	24	26	24	22	24	28
Nitrates	0	0	0	0	0	0	0	0
Conductivity	50	50	50	50	50	60	50	60

Macroinvertebrate Analysis:

EPT% (Ephemeroptera, Plecoptera, Trichoptera) varied across sites and years, indicating changes in water quality. While some sites showed declines, 2025 data revealed a general recovery, with Ephemeroptera as the dominant taxon across most sites. Sites 4 and 10, with higher anthropogenic impact, had lower EPT% values. The overall trend suggests improving water quality, though not yet statistically significant.

Figure 4: Comparison of Sites in 2025: %EPT and Taxonomic Composition.

Discussion

The Chimehuín River has undergone significant environmental changes due to climate variability and human activities. A prolonged drought ended in 2023 with an El Niño event, increasing rainfall and river flow, possibly affecting sediment presence. Since 2001, urban expansion in Junín de los Andes has doubled water demand for consumption, industry, and recreation. While average flow remains stable, maximum flows show a decreasing trend.

Water quality in summer 2025 was favorable, but past declines (2016–2017) in Ephemeroptera (EPT) and increased gastropods suggest impacts from human activity and volcanic ash from the 2015 Calbuco eruption. Wind-driven ash persisted until rainfall integrated it into the soil. Site-specific impacts include sediment input at site 4 (volcanic ash, road paving, tourism, and goat farming), gradual recovery at site 5 (waterfront remodeling), and potential pollution at site 10 (downstream sewage discharge). Despite signs of recovery, continued monitoring is needed. To raise awareness, short videos were shared on Instagram Reels after each sampling (Pepe, 2025).

Conclusions

The Chimehuín River has experienced environmental changes driven by climate variability and human activities. While average flow remains stable, maximum flow shows a significant decline, likely influenced by El Niño, La Niña, and increasing urbanization. These findings highlight the need for sustainable land-use planning to protect water resources.

Water quality parameters mostly remain within acceptable ranges, though localized anthropogenic impacts are evident. Sediment increases due to volcanic ash and human activity have affected macroinvertebrate communities, altering the %EPT index. In 2025, the dominant taxon shifted from Gastropods to Ephemeroptera at several sites, suggesting improved water quality, though not statistically significant.

Long-term monitoring is essential to understanding the combined effects of natural and human disturbances on the river. Future research should expand data collection, incorporate additional biological indicators, and promote integrated water management strategies. Collaboration with mentors enhances research quality, critical thinking, and communication skills.

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