Monitoring of uranium in environmental samples in regional uranium reserves in the state of Ceara

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Highlights:

Environmental concerns: Naturally occurring uranium isotopes pose a toxicological and carcinogenic risk and require strict monitoring of environmental samples.

Regional uranium reserves: The Itataia mine in Ceará, Brazil, is home to significant uranium phosphate deposits, which underlines the importance of local monitoring measures.

Impact on the community: The contamination of groundwater in rural areas underlines the social impact and highlights the need for strict monitoring and remediation measures.

Keywords: uranium; groundwater; state of Ceara

INTRODUCTION

Uranium occurs naturally in the environment in the form of three radioactive isotopes, with proportions of 0.005% ^{234}U, 0.72% ^{235}U and 99.2% ^{238}U (DE SOUZA; COTRIM; PIRES, 2013). Due to its potential acute toxicological effects and carcinogenic properties, the presence of uranium in environmental samples is a cause for concern. The Itataia mine in the state of Ceara in northeastern Brazil is the largest uranium phosphate reserve in Brazil and contains about 1800 mg kg^{-1} U_3O_8 and 140 mg kg^{-1} ThO_2 (RIBEIRO *et al.*, 2008). Groundwater samples from rural communities in Caninde and Itatira, Itataia region, showed uranium concentrations of 2 to 48 µg L^{-1}, which has a significant social impact, as these wells are the main sources of water for the communities, used both for human consumption and for the irrigation of local fruits and vegetables. Brazilian environmental legislation (Conama) establishes a maximum allowable uranium concentration of 15 µg L^{-1} for irrigation water (BRASIL, 2005) and 30 µg L^{-1} for human consumption (BRASIL, 2017). An exploration project for this uranium mine is

underway, and the possibility of its implementation could pose risks to the communities surrounding the mine.

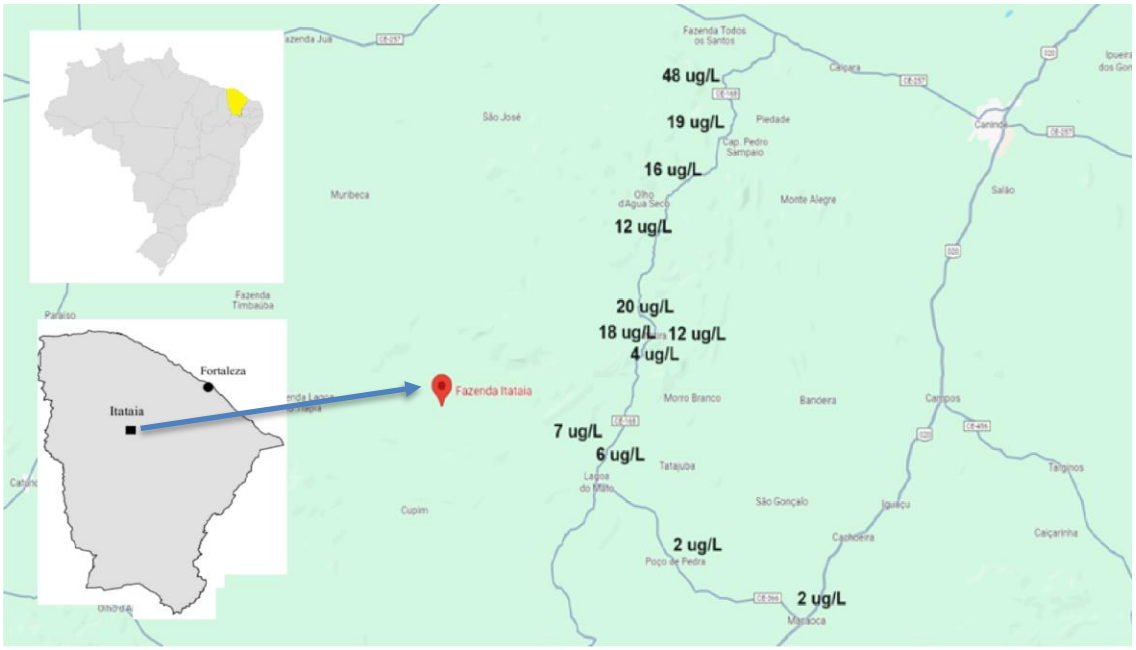
Therefore, there is a need for rapid, sensitive and reliable analytical methods to detect and monitor uranium concentrations in the Itataia mining region.

The aim of this study is to monitor and determine the uranium concentration in groundwater samples in the Itataia region using inductively coupled plasma mass spectrometry (ICP-MS).

METHODOLOGY

Groundwater samples were collected from communities in the region surrounding the Itataia mine in Ceará, Brazil, during the period from 2022 to 2024 (Figure 1). Water samples were acidified and stored in pre-cleaned polypropylene bottles, while sediment samples were stored in sealed plastic bags at 4°C. Reagents included ACS grade chemicals and NIST standards from Sigma-Aldrich, LGC and Dinamica.

Figure 1 - Water Sampling for Uranium Analysis in the State of Ceará (2022-2024)



Uranium concentrations were determined using Agilent 7500C series inductively coupled plasma mass spectrometry (ICP-MS) at the Pontifical Catholic University of Rio de Janeiro. Limits of detection and quantification were calculated according to INMETRO guidelines (INMETRO, 2020). The uncertainties of the measurements were estimated.

RESULTS AND CONCLUSIONS

Uranium concentrations of more than 15 µg/L were detected in the groundwater. These values exceed the thresholds for agricultural use set by Conama No. 396. The sampling points are listed in Table 1. Elevated uranium levels were detected in the water of rural communities in the municipalities of Itatira and Caninde, about 160 km east of Fortaleza, near the Itataia mine.

Uranium concentrations in the groundwater of Caninde and Itatira ranged from 2 to 48 µg/L, which has a significant social impact as the communities rely on well water for consumption and irrigation.

Table 1 - Uranium determinations (ug/L) by ICPMS in region of Ceará. Period from 2022 to 2024.

Point	Identification	Latitude	Longitude	Uranium ug/L
1	Itatira – CE	-4.52952	-39.6449	18
2	Barra (Canindé)	-4.39850	-39.58333	16
3	Vazante do Curú (Canindé)	-4.39846	-39.58283	12
4	Itatira – CE	-4.53672	-39.62822	20
5	Itatira – CE	-4.53072	-39.62822	12
6	Lagoa do Mato (Itatira)	-4.64161	-39.68829	6
7	Itatira – CE	-4.6418	-39.68829	4
8	Fresco - CE	-4.32129	-39.56073	48
9	Oiticica - CE	-4.39712	39.57296	19
10	Itatira – CE	-4.53061	-39.62768	4
11	Itatira – CE	-4.53066	-39.62793	7
12	Lagoa do Mato / Itatira – CE	-4.64161	-39.68835	7

In the Canindé region, specifically in the communities of Barra and Oiticica, uranium levels in water have exceeded the limit set by CONAMA, which is 15 µg/L. This threshold is considered the maximum safe concentration of uranium in water over a 20-year irrigation period to protect plants and other organisms. Particularly concerning is the community of Fresco de Canindé in Ceará, which reported the highest uranium concentration in groundwater, reaching 48 µg/L (Table 1).

Fresco de Canindé is characterized by isolated residual hills and vegetation typical of the arboreal-shrub and shrub-herbaceous caatinga. The community relies heavily on agriculture and livestock, primarily family-run operations, utilizing both natural and cultivated pastures. This local farming is essential for producing food, generating income, and acquiring other necessary goods and services.

The presence of elevated uranium levels poses significant risks to both the environment and human health. Long-term exposure to such contaminants can lead to detrimental effects on crops, livestock, and the local population. Consequently, it is crucial to monitor and address the uranium contamination to safeguard the health of the community and ensure sustainable agricultural practices.

The unique topography and vegetation of Fresco de Canindé contribute to the region's reliance on groundwater for irrigation and livestock. Therefore, maintaining the quality of this water source is vital. Efforts to mitigate contamination should include thorough testing, implementing filtration systems, and exploring alternative water sources.

Overall, addressing the uranium contamination in Fresco de Canindé and surrounding areas is imperative for the well-being of the community and the preservation of their agricultural livelihood. In conclusion, the presence of uranium in groundwater at 48 µg/L, well above the 30 µg/L potability limit, raises significant concerns. This elevated concentration poses serious risks to both human health and the environment, requiring urgent remediation efforts. Given the region's reliance on groundwater for agriculture and livestock, ensuring water quality is essential. Comprehensive monitoring, mitigation measures, and alternative water sources are critical to safeguard the local community and ecosystem.

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