ISSN: 3029-0724

Research Article

Journal of Environmental Science and Agricultural Research

Hydrogeochemical and Groundwater Quality Map of Margarita Island Venezuela

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Received: January 30, 2026; **Accepted:** February 09, 2026; **Published:** February 17, 2026

ABSTRACT

Groundwater on Margarita Island, Venezuela, constitutes a water source for domestic, livestock, and agricultural activities, which is important for the island's economy. Due to this, over the past decades, academic and government institutions studies have chemically characterized the groundwater in different basins on the island. The "Hydrogeochemical and Groundwater Quality Map of Margarita Island, Venezuela" integrates this information from 167 groundwater samples across nine basins into a single tool for the management and monitoring. In this study, five hydrogeochemical facies were identified: Mg2+-HCO3-; Mg2+-Cl-; Na+-Cl-; Na+-HCO3-; and Na+-SO42-; and principal processes that lead to concentrations of Mg2+, Na+, NO3- and salinity, which control the chemical quality of the waters are: chemical weathering of the lithology, cation exchange, saline wedges, and anthropogenic intervention. Groundwater quality is primarily Class 4 (Decree 883, Official Gazette 5.021, 1995), whose direct use may have negative effects on the health of humans, animals, and soil.

Keywords: Hydrogeochemistry, Groundwater, Water quality, Waterwell, Margarita Island

Introduction

Due to the increasing demand of groundwater for residential and agro-industrial supply on Margarita Island, research has been developed in the fields of hydrogeochemistry and hydrogeology throughout each of its basins, over the past few decades. However, no map had been created that integrated this information into a single database, with the purpose of facilitating the management and monitoring of groundwater. Therefore, the objective of the research was to create the Hydrogeochemical and Groundwater Quality Map of Margarita Island, Venezuela [1-3].

Methodology

For this study, a database was created using information from the National Waterwells Inventory of MARNR, INAMEH and MINAGUAS, as well as from other research. Following this, statistical analysis was conducted, the hydrogeochemical characterization of the samples was performed, and their classification was done according to their chemical quality, in accordance with Decree 883 (Official Gazette 5.021, 1995). Finally, the "Hydrogeochemical and Groundwater Quality Map of Margarita Island, Venezuela" was created.

Result

The final database contains 167 groundwater samples from Margarita Island, made up of 142 sampling points, of which 3 are springs and the rest are waterwells. They are distributed as follows: 41.3% in the La Fuente – Paraguachí basin; 15.6% in the Pedro González basin; 12.6% in the Santa Ana basin; 9.6% in the San Juan area; 10.8% in the Guarame basin; 6.0% in the La Asunción area; 3.0% in the El Valle-Porlamar area; 0.6% in the Juan Griego basin, and 0.6% in the San Antonio Sur zone.

Based on the results obtained, five hydrogeochemical facies of groundwater predominate on Margarita Island, with the following percentage distribution: magnesium bicarbonate (Mg2+-HCO3-) representing 44.3%; magnesium chloride (Mg2+-Cl-) accounting for 34.1% of the total samples; 16.8% described as sodium chloride (Na+-Cl-); sodium bicarbonate

Citation: Ana Vilchez, Ramón Montero. Hydrogeochemical and Groundwater Quality Map of Margarita Island Venezuela. J Envi Sci Agri Res. 2026. 4(1): 1-2. DOI: doi.org/10.61440/JESAR.2026.v4.151

(Na+-HCO3-) corresponding to 4.2% and sodium sulfate (Na+-SO42-) representing 0.6% of the total samples. Likewise, the relative abundance of the major ions determined corresponds to the following order: Mg2+ > Na+ > Ca2+ for cations and Cl- > HCO3- > SO42- for anions. The spatial distribution of the sampling points is presented in the map in Figure 1.

The processes modifying the chemical composition of the identified waters include: weathering of ferromagnesian silicates and aluminosilicates, dissolution of calcium and magnesium carbonates and sulfates, oxidation of sulfides, leaching of evaporitic salts in the soils, cation exchange with clays, salinization processes by mixtures with salt or brackish wedges in coastal areas, especially in the Pedro González and La Fuente-Paraguachí basins; possible mixing with deep thermal waters in the Santa Ana basin; and anthropogenic intervention. This aligns with the work of previous researchers.

In another order of ideas, based on the concentration of total dissolved solids (Custodio and Llamas, 1996), the groundwater on the island is primarily classified as brackish water (83.2%), followed by fresh water (16.2%) and saline water (0.6%). Regarding water classification by hardness, 99.4% of the samples studied correspond to very hard water.

The chemical quality of the groundwater in the study area, according to Decree 883 (Official Gazette 5.021, 1995), corresponds to the following classes: Excellent or Class 1 at 0.6%; Class 3 or Good at 1.8% of the samples; and 93.4% is categorized as Class 4 or Acceptable. Additionally, 4.2% of the samples do not meet any of these categories. The control of the chemical quality of the waters is primarily governed by the concentration of magnesium ions, resulting from the chemical weathering of rocks, with values in 95.2% of the samples exceeding the limits allowed for classes 1, 2, and 3. Moreover, the concentrations of nitrate in the groundwater of the island are influenced by agricultural and anthropogenic activities throughout the island, which exceed the maximum level deemed safe by the World Health Organization by 7.5%.

This chemical composition implies that groundwater should not be used for urban supply, irrigation, or livestock watering due to the high content of certain species that may be harmful to human, animal, plant, and soil health.

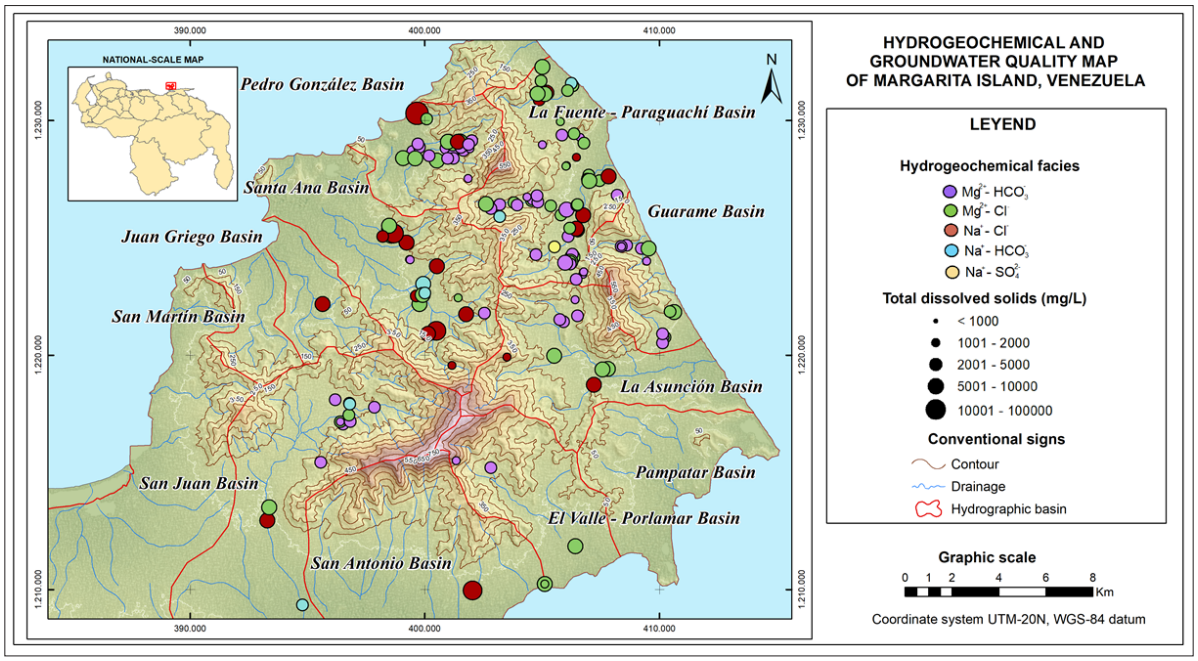

Figure 1: Map of the hydrogeochemical facies of groundwater of Margarita Island.

Conclusions

In conclusion, the Hydrogeochemical and Groundwater Quality Map of Margarita Island contains information from 142 sampling points and 167 groundwater samples distributed across nine basins, where five hydrogeochemical facies (Mg2+-HCO3-; Mg2+-Cl-; Na+-Cl-; Na+-HCO3-; and Na+-SO42-) are represented. It also includes three classes of water quality according to chemical parameters, with the most abundant being Class 4 or Acceptable (Decree 883, Official Gazette 5.021, 1995), improving its quality requires specific and costly treatment systems.

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