

Nitrate contamination and temporal trends in volcanic Barva and Colima aquifers (1988-2018), in an urban and agriculture-dominated region, Costa Rica

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In the Great Metropolitan Area (GAM) of Costa Rica, 65% of the population, equivalent to 1.7 million people, is supplied by the most important volcanic aquifers in the country: Barva, phreatic and the most superficial, Colima Superior, and Colima Inferior, both phreatic in some sectors and confined in others. The GAM has the highest urban and industrial growth and, in addition, agricultural activities related to the intensive use of nitrogen fertilizers. About 70% of the population use septic tanks for the disposal of domestic wastewater and, in most cases, these systems lack the appropriate technical specifications in their construction. Due to the risk of contamination to which the groundwater is exposed, this research aimed to evaluate temporal trends in nitrate concentration in Barva, Colima Superior, and Colima Inferior aquifers. In total, 43 sites have been monitored, some from 1988 to 2018 (1,388 observations). Samples were analyzed in the Environmental Hydrology Laboratory, Universidad Nacional, Costa Rica, quarterly.

Of these sites, 42 exceeded the reference level of 0.1 mg/L of NO_3^- , found in a spring in the high lands of the Barva aquifer, an area covered by forests and grasslands. At middle and lower elevations of this aquifer, coffee crops and urban use dominate; average concentrations averaged between 12 and 75 mg/L of NO_3^- , with maximums of up to 110 mg/L. Wells that extract a mixture of groundwater from Barva and Colima Superior presented average concentrations between 5 and 44.5 mg/L of NO_3^- , while the sites that extract water from Colima Superior and Colima Inferior showed averages between 2 and 24 mg/L of NO_3^- , with a maximum of 39 mg/L.

Of a total of 29 sites that extract water from the Barva and from a mixture of Barva and Colima Superior, 18 exceeded 25 mg/L of NO_3^- , each one up to 106 times, while five sites exceeded the Maximum Value of 50 mg/L of NO_3^- , each one up to seven times. Based on the Mann-Kendall test, a temporary increase was found in 13 sites extracting water from Barva aquifer. There is larger nitrate pollution in areas close to coffee plantations and urban use, due to the use of nitrogen fertilizers and septic tanks. Permanent monitoring of nitrates and other pollution indicators is necessary to support the establishment of regulatory policies on a national scale, focused on reducing nitrates loading to groundwater.