

Nitrogen in groundwater of agricultural areas in São Paulo State, Brazil

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Nitrogen inputs to natural environments by human activities such as application of nitrogen fertilizers in agricultural area cause various environmental problems. Many previous studies have reported severe nitrate contamination of groundwater and surface water in large-scale agricultural areas in USA, Europe and so on. Brazil is also one of the world's leading agricultural producer. However, the impact of agricultural activities on groundwater environment has not been well evaluated. In the present study, we aimed to confirm the current status for nitrogen in groundwater of agricultural area in São Paulo State, Brazil.

São Paulo state is located southeastern part of Brazil. Mean annual temperature is 19 °C and rainfall is 1,400 mm in São Paulo city. Field surveys were conducted in three agricultural areas (Rio Claro, Pirassununga and São Carlos) in São Paulo State. These areas are mainly cultivated by sugarcane, citrus and eucalyptus. The Guarani Aquifer, one of the world's largest aquifer system covers the São Carlos area. Groundwater and surface water samples have been collected every about 2 months in Rio Claro and Pirassununga from September 2016 to November 2017, and the intensive field campaigns were conducted in September and December 2017 in São Carlos. The samples have been analyzed for nutrients (nitrogen, phosphorus and silicate), major anions and cations, stable isotope ratios of nitrogen and oxygen ($\delta^{15}\text{N}$ and $\delta^{18}\text{O}$) for nitrate (NO_3^-).

The results show that concentrations of nitrate-nitrogen (NO_3^- -N) in groundwater in eucalyptus, grassland and natural vegetation (cerrado) areas were totally low ($< 1.0 \text{ mg L}^{-1}$) with little seasonal variation. However, it was significantly higher in agricultural areas (citrus and sugarcane) with nearly 10 mg L^{-1} in some sites. $\delta^{15}\text{N}$ and $\delta^{18}\text{O}$ for NO_3^- suggest that the source of NO_3^- in groundwater is nitrogen fertilizer and manure in these areas.

Keywords: Nitrogen, Groundwater, Agricultural area, Brazil