Comparação da Qualidade da Água Subterrânea entre Propriedades Rurais e uma Mata Ciliar na Bacia do Rio Urupá, Estado de Rondônia, Brasil

Groundwater Quality Comparison between Rural Properties and a Riparian Forest at Urupa River Basin, Rondônia State, Brazil

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ABSTRACT: Groundwater usage in central Rondônia is of strategic importance for domestic (supply of drinking water), agricultural (irrigation) and cattle breeding uses, especially after intense land use changes (linked with ranching activities) observed in this region in the last few decades. The purpose of this study was to show the role of a riparian forest ecosystem in groundwater quality of wells sampled on surrounding rural areas. There were measured pH, electrical conductivity, dissolved carbon species (organic + inorganic), and major ions in a riparian forest and 18 adjacent wells, situated at the Urupa River basin (SW Amazon). Concentrations of chemical constituents in groundwater varied spatially, with dominance of alkali-earths (Ca^{2+}, Mg^{2+}) and weak acids ($HCO3^-$, $CO3^-$) over alkalis (Na^+, K^+) and strong acids (Cl^-, SO_4^{2-}) at the left margin. At the right margin, an opposite trend was observed, with dominance of (Na^+ + K^+) and Cl^-, for cations and anions, respectively. Our measurements also indicated that the groundwater at the riparian forest was significantly modified by organic inputs from the forest floor (organic layer), contrasting with rural wells. At the forest, concentrations of dissolved organic carbon in groundwater averaged 2.61 (±0.89) mg.L-1, whereas theses values were on the order of 0.90 (±0.53) in rural wells. In general, although some changes were observed in rural wells, especially for nitrate, solute concentrations were within the limits for human consumption, according to Brazilian Health Ministry standards.

Keywords: Amazonia, ecosystem ecology, major ions.

Palavras-chave: Amazônia, ecologia de ecossistemas, íons dominantes.

INTRODUCTION

Groundwater chemistry is highly variable, both seasonally and spatially. Water supply in rural areas of Rondônia State is usually obtained by pumping groundwater both from shallow and semi-artesian wells (tubular). The wells are selected according to the phreatic surface level, with the latter been drilled to much deeper depths (Amaral, 2004). Little information is available for groundwater quality in the Amazon region, most of it focusing on urban wells (Panero & Silva, 2008; Azevedo, 2006, Silva, 2001) and a few on forest (McClain et al., 1994, Williams et al., 1997) and pasture (Chavez et al., 2007) areas.

Hence, in order to increase the knowledge about the chemistry of this important water resource, this study aimed to compare groundwater chemistry dynamics between riparian and rural wells, both located in an intense deforested area in the Amazon region (Rondonia State, Brazil).

MATERIAL AND METHODS

Three wells drilled on a riparian forest fragment were monitored along an entire hydrologic year (2005-2006). Additionally, eighteen sampling stations were defined in the Urupa River basin, nine located at the right margin (at the same side of the riparian forest) and the remaining at the left margin. The wells were selected along dirt roads, starting near the Urupa River margins and going up to 20 km apart from it (in both margins). The sampling of these rural wells was performed over the course of three weeks between January-February 2008, during a rainy period of the wet season.

Temperature, pH and electrical conductivity were determined in situ. Aliquots were taken in the field, filtered through GF/F filters, and stored in HDPE flasks with thymol and glass vials with mercury chloride, for the analysis of inorganic and organic fractions, respectively. Ion chromatography (Dionex DX-500) was used to determine the concentrations of cations (Na^+, Ca^{2+}, Mg^{2+}, K^+, NH_4^+) and anions (Cl^-, SO_4^{2-}, NO_3^-). Dissolved organic and inorganic carbon was analyzed using a Total Organic Carbon Analyzer (TOC-5000A).

RESULTS AND DISCUSSION

The pH was somewhat acidic for all samples, with the right margin exhibiting more acidic values than the left, as shown in Table 1. Riparian groundwater displayed intermediate values, when compared with rural wells, with an average value of 5.52. The acidity found in forest wells is usually associated with carbonic acid dissolution (Buckau et al., 2000), rock weathering (Aris et al., 2007) and litter decomposition over the forest floor, which yields organic acids (Lilienfein et al., 2000). In fact, Williams et al. (1997), studying an intact forest near Manaus found more acidic pH values (4.7) than those observed in Urupa basin.

This watershed can be described as a fragmented landscape, not only for the rural properties but also for the riparian forest. Aside from the factors influencing acidity in groundwater listed above, in rural and urban areas domestic and industrial sewage disposal and soil alteration through corrective products and fertilizers can also influence pH (Conte et al., 2001).

The proximity of wells to septic cesspits could have led to the differences observed between the two riversides, mainly for the shallower wells.

In most of the wells, waters had low electrical conductivity values (Table 1), evidencing the existence of a highly weathered environment, as is common for tropical rainy Amazon basin. A study conducted by Silva (2001) in urban wells (Ji-Paraná city) showed values much higher than those reported in Urupa River basin, averaging from 147.3 to 232.3 $\mu S.cm^{-1}$, for both tubular and shallow wells, respectively.

Concentrations of chemical constituents in groundwater showed high spatial variability, mainly for cations. A dominance of alkali-earths (Ca^{2+}, Mg^{2+}) and weak acids (HCO_3^-, CO_3^-) over alkalis (Na^+, K^+) and strong acids (Cl^-, SO_4^{2-}) were observed at the left margin, while an opposite trend was observed at the right margin, with a dominance of ($Na^+ + K^+$) and Cl^-, as shown in Figure 1. This occurred probably due to different lithological substratum between the two riversides, which could result in distinct nutrient inputs to the Urupa River.

For riparian groundwater, an interesting pattern was observed. The cationic predominance was the same as in the right riverside, but an opposite trend for anions was found, which was similar to that of the left riverside (Figure 1).

A predominance of nitrate was observed among dissolved inorganic nitrogen forms (NO_3^- e NH_4^+). In addition, nitrate was the main anion on three rural wells (GW-8, GW-14 e GW-18), and two wells (GW-3 e GW-18) exhibit very high concentrations of this nutrient, both placed superficially (cladded with concrete tubes). The concentrations of NO_3 at these wells, 10.87 and 11.53 $mg.L^{-1}$, respectively, are slightly above Brazilian potability standards, which restrict nitrate concentrations for water supply to 10 mg $NO_3.L^{-1}$.

COCNLUSION

The results showed changes in the water quality of wells at the Urupa river basin. Although, the overall solute concentrations, except for nitrate, were still within the permissible limits for human consumption according to Brazilian standards (portaria 1469, 2000; CONAMA, 1986).

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Table 1. Physical-chemical and major ion concentration in groundwater sampled on riparian and rural properties in the Urupa River basin (Rondonia, Brazil).

Site	pH	Elect. Cond.	Na^+	K^+	Mg^{2+}	Ca^{2+}	HCO_3^-	Cl^-	SO_4^{2-}	NO_3^-
APU-1	5.25	37.2	3.19	1.08	0.55	1.78	4.68	0.74	0.28	1.56
APU-2	5.49	54.9	9.08	0.80	0.33	0.84	8.11	0.70	0.60	1.55
APU-3	5.81	101.0	8.13	0.89	1.41	3.82	15.66	0.68	0.35	0.16
Riparian	5.52±0.28	64.4±32.9	6.8±3.2	0.9±0.1	0.8±0.6	2.1±1.5	9.5±5.6	0.7±0.1	0.4±0.2	1.1±0.8
GW-1	5.38	59.0	4.43	3.26	0.02	0.76	2.42	1.53	0.16	3.82
GW-2	5.63	98.0	4.96	2.11	1.42	5.03	5.86	1.12	0.12	6.13
GW-3	5.14	102.3	7.54	1.61	1.37	4.03	0.48	12.11	1.19	**10.87**
GW-4	5.01	44.1	4.00	2.61	0.68	0.97	0.73	3.98	0.20	2.72
GW-5	5.75	**203.0**	4.51	0.84	n.a.	0.09	10.20	3.32	2.36	1.48
GW-6	5.21	64.6	2.68	6.83	0.89	1.95	1.15	5.38	0.82	3.04
GW-7	4.54	**187.5**	6.73	1.10	0.27	1.69	0.15	5.32	0.17	5.72
GW-8	5.42	61.8	2.27	5.01	1.69	0.75	1.89	1.77	1.09	7.82
GW-9	4.98	28.0	1.39	2.55	0.56	0.35	0.44	1.30	0.06	2.11
Right Margin	5.23±0.37	94.3±61.9	4.3±2.0	2.9±1.9	0.9±0.6	1.7±1.7	2.6±3.3	4.0±3.5	0.7±0.8	4.9±3.1
GW-10	5.74	**320.0**	2.61	2.76	0.50	1.20	20.67	1.62	0.05	5.40
GW-11	5.96	**187.7**	2.13	3.73	1.75	21.67	22.06	1.29	1.90	5.70
GW-12	6.05	105.4	6.31	6.36	0.65	7.65	15.16	0.46	1.03	1.79
GW-13	5.40	59.4	1.91	2.52	0.90	4.36	2.04	2.67	0.20	1.09
GW-14	5.32	132.6	7.46	3.33	1.45	9.94	2.29	1.01	0.11	4.40
GW-15	6.34	74.1	1.57	1.48	1.76	7.09	17.48	0.44	0.59	0.04
GW-16	5.33	61.6	6.11	1.64	1.03	3.04	2.98	0.24	0.08	0.61
GW-17	5.32	49.5	2.28	1.78	1.32	3.54	2.06	0.31	0.18	0.12
GW-18	5.55	105.9	5.61	0.63	3.76	5.48	3.74	4.04	2.38	**11.53**
Left Margin	5.67±0.38	121.8±86.1	4.0±2.3	2.7±1.7	1.5±1.0	7.1±6.1	9.8±8.8	1.3±1.3	0.7±0.9	3.4±3.8

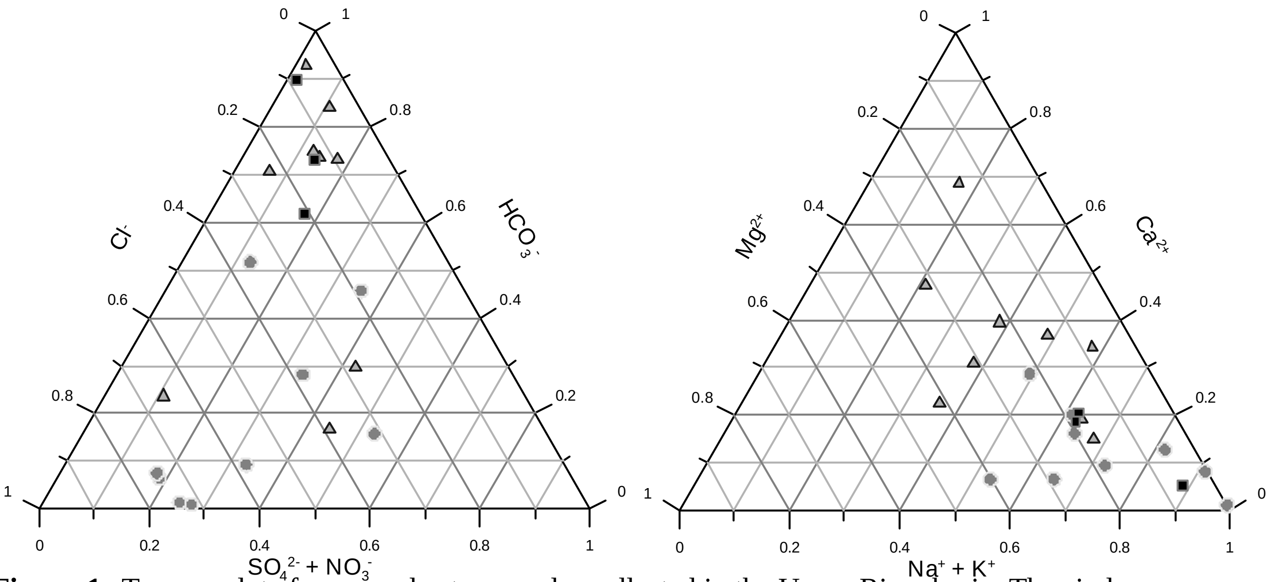

Figure 1. Ternary plots for groundwater samples collected in the Urupa River basin. The circles correspond to the wells located at the right margin, triangles for wells at the left margin and squares for the wells drilled at Fazenda Apuru.