Workshop on

"Water, Nitrogen, and Agriculture in the State of São Paulo, Brazil"

Proceedings

Room 217, Advanced Research Building A,

the University of Tsukuba

February 28, 2014

ワークショップ 予稿集

「ブラジル・サンパウロの水，窒素，農業」

筑 波 大 学

総合研究棟Ａ ２１７ プレゼンテーションルーム

2014 年 2 月 28 日

University of Tsukuba

HIROSHIMA UNIVERSITY

HOKKAIDO UNIVERSITY

Universidade de São Paulo Brasil

Kumamoto University

Rissho University 立正大学

Nutrient component of groundwater in agricultural land

S. Onodera, N. Tase, R. Terada, F. Saraiva, R. Hirata, M. Saito, Y. Maruyama

Introduction

Agricultural activities with appling much fertilizer have expanded nitrate contamination in the world. To conserve the watersheds environment, it is important to confirm the impacts of nitrate contamination and to manage the risk of its expansion. For example, the rapid increase of nitrate load by human activity causes the inbalanced nutrient components in ecosystems (Umezawa et al., 2009 etc.). Consequently, it would affect negatively the biodiversity, such as the eutrophication in aquatic environment and aciddification of soil.

In case of Sao Paulo region in Brazil, the large-scale agriculture is mainstream as US. Therefore, it is necessary to consider the its impact on nutrient components of grondwater in agricultural lands. We examined the nutrient componet in groundwater in an agricultural land.

Study area and water collection

The study site is located on Rio Claro, 35km north of Piracicaba, Sao Paulo State of Brazil (Fig.1). This area is mainly covered by sugar cane plantation and eucalyptus forest. The shallow groundwater flows in silty sand layers. The annual mean temperature and

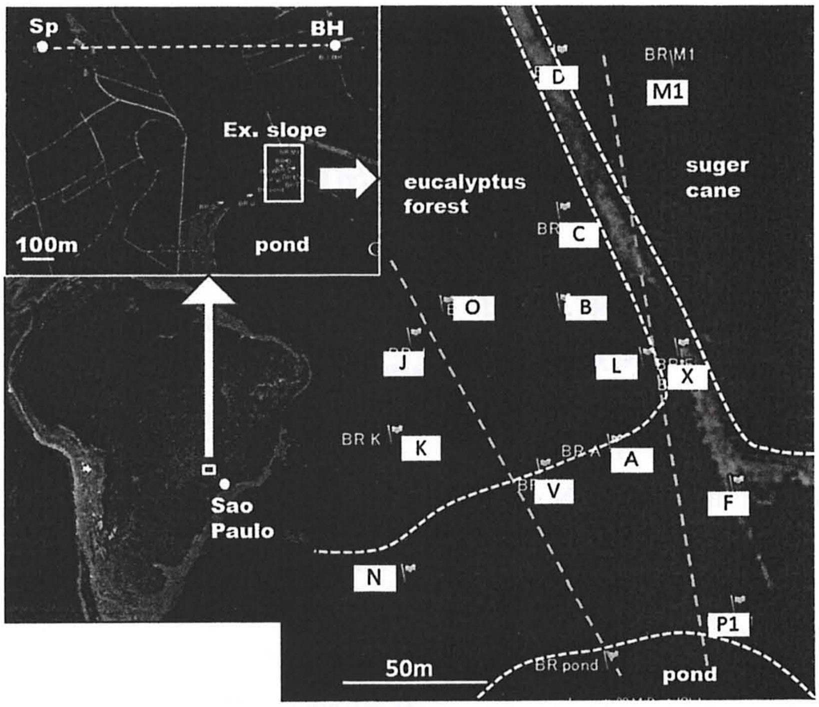

Figure 1 The location of study site

precipitation are 21.4°C and 1,279mm, respectively.

The many piezometers with the depth from 4m to 18m are installed in the experimental slope from the upland to the small pond with the altitude from 633m to 620m. Water samples were collected from some piezometers and one borehole, spring water and pond water in November 2012 and September 2013. Piezometric heads and EC, pH, DO and ORP values were measured in situ at all piezometers with water collections. After bringing back the samples to the laboratory under freezing condition, nutrients, inorganic ions and dissolved organic carbon (DOC) were analyzed by automated analyzer of photo-spectrometer, ion chromatography, ICP-AES analyzer, and TOC analyzer, respectively.

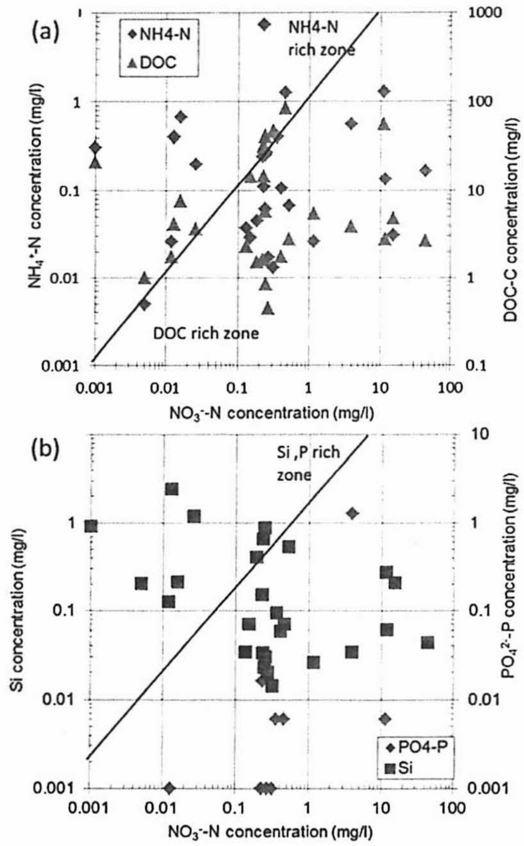

Figure 2 Nutrient components in collected water samples, the relationship between the NO_3^--N and DOC-C and NH_4^+-N (a), and PO_4^{2-}-P and Si (b).

Results and discussion

1. Nutrient components

Figure 2 shows the nutrient components in collected water samples, which is the relationship between the NO_3^--N and DOC-C and NH_4^+-N (a), and PO_4^{2-}-P and Si (b), respectively. Nitrate (NO_3^--N) was totally major form in the dissolved nitrogen, while ammonium (NH_4^+-N) was higher than NO_3^--N in a part of collected samples, such as pond water and deep groundwater near the pond. Phosphorus (PO_4^{2-}-P) was minor compared with the other nutrients and was not detected in the most of samples. On the other hand, dissolved organic carbon (DOC) was mainly higher than the NO_3^--N. Especially, it was hundred times higher in a part of the deep groundwater, spring and pond water. Silica (Si) was also higher than the NO_3^--N in a part of deep groundwater in the forest. Increase of NO_3^--N in groundwater around the agricultural land would be due to the fertilizer application. In addition, the high DOC concentration in the pond and groundwater around the pond would be contributed from the deposition of sediment eroded and transported from the slope.

Table 1 Comparison of average nutrient components in the agricultural land in Brazil and Japan.

(μM/l)	NH_4^+	NO_3^-	PO_4^{2-}	Si	DOC
Rio Claro, Brazil	37.3	242.2	1.58	11.6	1,175.3
Hiroshima, Japan	14.7	744.0	7.11	331.5	182.9

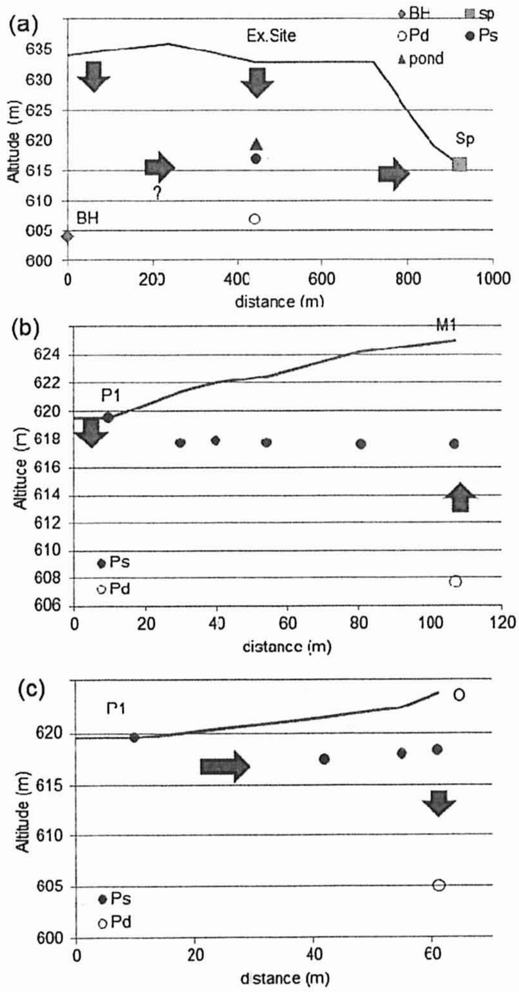

Figure 3 Schematic diagrams of groundwater flow direction in three cross sections on the lines in Fig.1, BH-Sp line (a), M1-P1 line (b), and O-P1 line.

Table 1 shows the comparison of average nutrient components in the agricultural land in Brazil and Japan. The data in Brazil is based on Fig.2 and the values in Japan were summarized based on Onishi et al. (2014) and Saito and Onodera (2009). NO_3^--N concentration in Brazil was lower than that in Japan, especially the PO_4^{2-}-P and Si was approximately one tenth lower in Brazil. On the other hand, the ratio of NH_4^+-N to NO_3^--N was higher in Brazil, while DOC concentration was tenfold of that in Japan.

2. Solute transport with water flow

Based on the measured water level data, groundwater flow directions were estimated as shown in Fig.3. There were flows from the central part of the upland to the spring at the slope foot in (a), and from the pond to the inside of the slope in (b) and (c) in Fig.3, according to the water level. The water flow with the inverse direction as compared with the slope would be caused by the large evapotranspiration of this vegetation. In the eucalyptus forest, the water head in deep groundwater was lower than that in shallow groundwater, and the flow direction was downward. The evapotranspiration in the forest was estimated to be larger than the other area.

Figure 4 shows relationships between the NO_3^--N and aluminum (Al) (a) and the pH and NO_3^--N (b) of groundwater. The values of the deep groundwater in a borehole and the spring water were

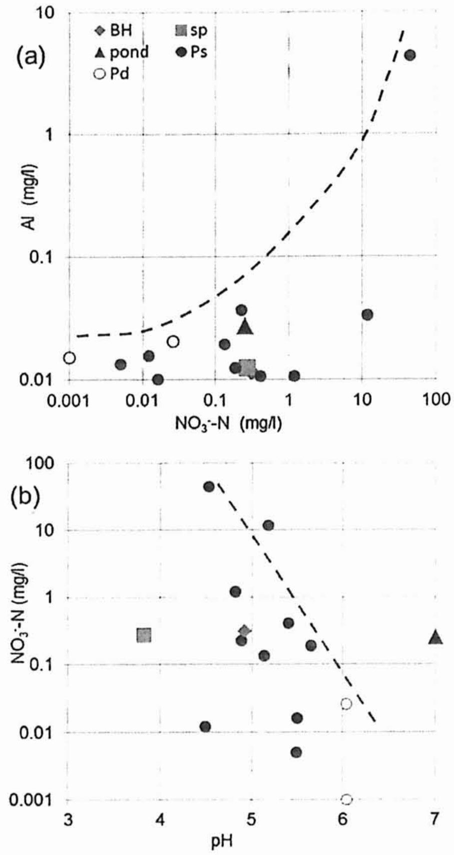

Figure 4 Relationship between the NO_3^--N and Al (a) and the pH and NO_3^--N (b) of groundwater.

plotted in this figure. Al concentration increased and the pH decreased with the increase of NO_3^--N concentration. This means that acidifications occurred with the application of nitrogen fertilizer in an agricultural land. However, the DOC concentration was not related to the pH and Al concentration.

In the Fig. 4, the water of the spring and borehole were plotted on the central part. Though the NO_3^--N and acid were supplied so much in an agricultural land, they didn't expanded. It is suggested that the denitrification process occurs actively due to the DOC supplied from the forested land and pond. In addition, calcium (Ca) and magnesium (Mg) concentrations in groundwater were low as well as the high concentrations of acid and Al. Because of the tropical acid soil, the pH of water was also low.

Conclusion

In this study, we examined to confirm the nutrient components of groundwater in an agricultural land in Brazil. NO_3^--N and DOC concentrations were high, as compared with the PO_4^{2-}-P and Si. It was suggested that the denitrification occurred actively due to the large supply of DOC from the forest and pond. In addition, the acidification of water was confirmed.

Acknowledgements: This study is partly supported by Grants-in-Aid for Scientific Research, Scientific Research (B) of JSPS, which is much appreciated.

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