Spatial and Temporal Variation of Groundwater Quality in Byoubusan Sand Dune

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1. Introduction

Nonpoint source pollutants such as nitrate, potassium from fertilizer applications may cause groundwater contamination in Byoubusan sand dune because of their high leaching ability in sandy soils. Nitrogen and phosphorus from fertilizer application are of environmental concern for Japan Sea because their excess amount in water bodies may cause eutrophication problem. Micronutrient such as iron concentration in groundwater is of concern due to it can be toxic for plants at high concentration and also subsurface drainage pipe may be clogged by iron deposition. In order to develop best management practices for this sand dune area, well-designed experimental data are needed on groundwater quality. But data on groundwater quality of the Byoubusan sand dune area is not available. Therefore this study was initiated with the following objectives:

i. To assess the spatial and temporal variation of groundwater quality in Byoubusan sand dune area

ii. To evaluate the suitability of shallow groundwater as irrigation in this sand dune area.

2. Materials and methods

The study was conducted in two agricultural fields of Byoubusan sand dune area, which were designated as field-A and field-B, respectively. Field-A was fallow land whereas filed-B was cultivated land. Farmers of the study area cultivate crops from April to November and in winter agricultural farmland becomes fallow due to heavy snowfall. Groundwater level in field-A was ranged from 1.1-1.7 m and in field-B it was 0.9-1.6 m. Three observation wells were installed in both fields to collect the groundwater sample from different depth. In field-A three plastic tubes were installed to collect the groundwater sample from 2.0 m, 2.5 m, and 3.0 m depth. In field-B four plastic tubes were installed to collect the groundwater sample from 2.0 m, 2.5 m, 3.0 m, and 3.5 m. Assessment of groundwater quality was performed on the basis of pH, electrical conductivity (EC), sodium (Na^+), potassium (K^+), calcium (Ca^{2+}), magnesium (Mg^{2+}), total-iron (T-Fe) and nitrate nitrogen (NO_3-N), phosphate phosphorus (PO_4-P).

3. Results and discussion

3.1. pH and Electrical conductivity

pH values of groundwater were found within a range of 6.1 to 7.4 at field-A, whether in field-B it was 5.3 to 6.5. pH values was decreased with soil depth in field A (Figure 1), whereas in field B opposite trend was observed (Figure 2). Nitrogenous fertilizer application in field B might promote low pH at 2.0 m depth. The average EC values of groundwater were 0.30 mS cm^{-1} and 0.33 mS cm^{-1} in the study field A and B, respectively; whereas, recommended EC value for irrigation water in Japan is <0.30 mS cm^{-1} (Hanya and Norio, 1985).

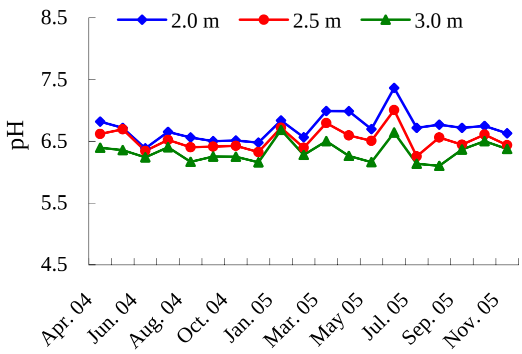

Figure 1: Vertical variation of groundwater pH in field-A

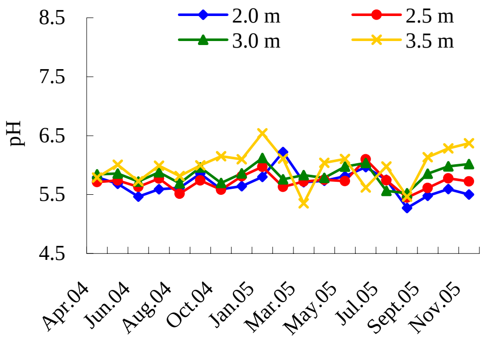

Figure 2: Vertical variation groundwater pH in field-B

Key words: Groundwater quality, irrigation, sodium, iron, nitrate, Byoubusan sand dune

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3.2. Spatial variation of cation concentration

In field-A average concentrations of Na^+, K^+, Ca^{2+}, Mg^{2+} and T-Fe were 20.9, 15.5, 26.1, 9.9 and 23.8 mg L^{-1}, respectively and on the other hand, in field-B concentrations were 27.6, 14.5, 24.9, 10.4 and 18.57 mg L^{-1}, respectively. Concentrations of Na^+, Ca^{2+}, Mg^{2+} and K^+ in groundwater were decrease with increasing the depth (Figure 3) whereas the opposite trend was observed for T-Fe (Figure 4). It might be due to high reduced condition at an increased depth promotes availability of Fe in groundwater. Groundwater of the study area was found not be suitable for irrigation since recommended Fe concentration in irrigation water $\leq$5 mg L^{-1} (Ayers and Westcot, 1985).

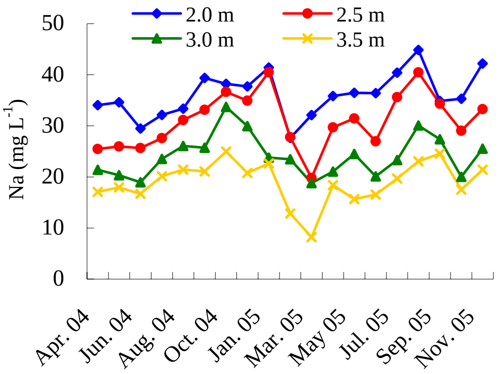

Figure 3: Vertical variation of Na^+ concentration in field -B

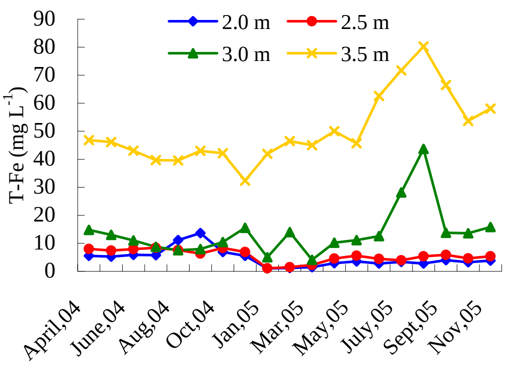

Figure 4: Vertical variation of T-Fe concentration in field -B

3.3. Seasonal variation of NO_3-N and PO_4-P concentration

In field-A NO_3-N concentration in groundwater was found between 0.00-0.15 mg L^{-1} range whereas in field-B it was 0.04 to 9.21 mg L^{-1}. Phosphate phosphorus concentrations in field-A and field-B were ranged from 0.003-0.119 mg L^{-1} and 0.00 to 0.64 mg L^{-1}, respectively. Results indicated that concentration of NO_3-N and PO_4-P was higher in field-B than field-A. Concentration of NO_3-N was found distinctly higher during cultivation period than fallow period in field-B (Figure 6). Application of fertilizer during cultivation period might be served as a source of NO_3-N and PO_4-P in groundwater. Nitrate nitrogen concentration was decreased with soil depth throughout the investigation period (Figure 6). It was observed that NO_3-N contamination from fertilizer application mostly limited in shallow groundwater up to 3.0 m depth from ground surface (Figure 6). So, remediation of fertilizer NO_3-N contamination in groundwater can be considered for shallow groundwater in Byoubusan sand dune.

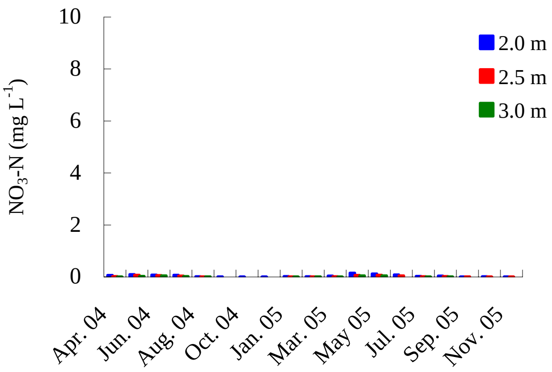

Figure 5: Vertical variation of NO_3-N concentration in field-A

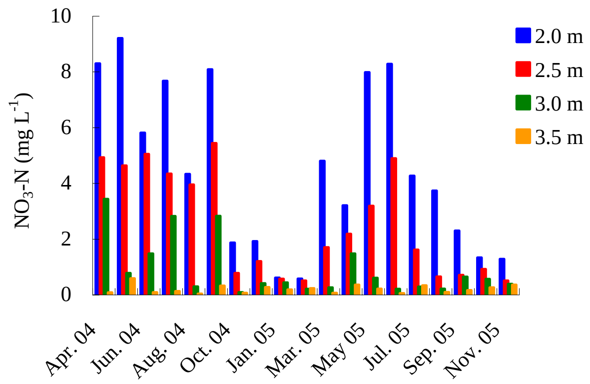

Figure 6: Vertical variation of NO_3-N concentration in field-B

References

Ayers, R.S. and D.W. Westcot. 1985. Water Quality for Agriculture. FAO Irrigation and Drainage Paper No. 29, Rev.1.

Hanya, T., and O. Norio. 1985. Water Quality Investigation Methods. 2nd Edition, Maruzen Co. Ltd. Tokyo, Japan. p. 365. (In Japanese)