

Spatio-temporal variation of phosphate concentration at a high P concentration groundwater in the Hachirogata polder

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[Aim] The present study was conducted to elucidate spatio-temporal variation of phosphate (PO_4) concentration and the PO_4 release mechanism at a high PO_4 concentration groundwater in the Hachirogata polder, Akita, Japan.

[Materials and Methods] The study site was at a pristine wilderness area after the land reclamation in southwest part of the Hachirogata polder. Groundwater samples were collected once a month from December 2013 to December 2014 from seven groundwater wells at a depth of 3.1, 4.3, 5.6, 6.6, 12.4, 19.5, and 45.0 m, respectively. The 30 m (ϕ 5 cm) boring core sample was collected from near the wells in Feb. 2013. We measured water temperature, pH, and electrical conductivity (EC) using a pH/EC meter (D-54, Horiba, Kyoto, Japan) and measured oxidation-reduction potential (ORP) using a ORP electrode (D-55, Horiba) on site. The water samples were also filtered through a 0.45 μm membrane filter on site. The concentrations of PO_4 in the groundwater were determined using an autoanalyzer (QuAAtro2-HR, BLTEC, Osaka, Japan). The fresh boring sediment was extracted twice with distilled water (soil:water, 1:2.5 for pH and 1:5 for EC), and pH and EC of in the extract were determined using pH/EC meter (LAQUA F-74BW, Horiba). Water soluble P were determined using an autoanalyzer (QuAAtro2-HR, BLTEC, Osaka, Japan). Sediment samples were digested with a combination of $\text{HF-HNO}_3\text{-HClO}_4$ acids in Teflon beakers at 180 $^\circ\text{C}$ and element concentration in solutions were determined by ICP-OES (iCAP 6000, Thermo Fisher Scientific).

[Results and Discussion]

TP content in sediments increased in clay and silt layers while PO_4 content increased in sandy layers. This indicated that clay and silt layers were a P sink/source and released PO_4 was moving in sand layers. Sediment EC increased in clay layer and drastically increased from 21 m deeper layer likely influenced by sea water. Groundwater ORP showed a moderately reducing (-113 ± 42 mV) environment in all the wells. PO_4 concentration in groundwater was ranged from 5.7 to 18.2 mg L^{-1} , and the highest concentration was observed at the well of 6.6 m depth (18.2 ± 0.7 mg L^{-1}) at sandy layer, the second was at the well of 12.4 m depth (10.2 ± 0.9 mg L^{-1}). Positive correlation was observed between PO_4 and F^- concentrations in groundwater ($r = 0.96$, $P < 0.01$, $n = 7$), indicated fluorapatite would be a PO_4 source. At the well of 6.6 m depth, Cl^- concentration was the lowest (29.8 ± 2.9 mg L^{-1}) value and was similar to the lake (Lake Hachiro) water (20.6 mg L^{-1}), suggesting that freshwater was preferentially flowing into the land through groundwater around the depth. At the well of 6.6 m depth that had little fluctuation of water qualities all year round, Na^+ , bicarbonate and carbonate ion were higher but Ca^{2+} concentration was lower compare to other wells. At the well of 12.4 m depth that had a large fluctuation of water qualities, PO_4 , pH, Na^+ , bicarbonate and carbonate ion, and Fe increased while Ca^{2+} and ORP decreased when Cl^- concentration decreased from 72 to 33 mg L^{-1} during May to Oct. 2014. These phenomena indicated PO_4 release induced likely by Na-saturated sediment might be due to release of P associated with oxide surfaces or to dissolution Ca-P at clay layer by increasing pH and dissolution of CaCO_3 (from shell) by inflowing freshwater to the groundwater.

Keywords: phosphate, groundwater, polder, Na saturation, freshwater