Hydro-geomorphological conditions that cause iron reduction process in forested watersheds

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Iron is an essential element for phytoplankton and can be a factor that limits photosynthesis in some oceanic waters (Martin et al., 1994). Nowadays, it is considered that rivers can be an important agent of dissolved iron (dFe) source for marine environment. (Natsuike et al., 2016). There are some studies that found a strong relationship between the dFe concentrations of rivers and the topography of catchments (Yamamoto et al., 2008; Onishi et al., 2010). However, there is no theory that explains the relationship between topography and iron reduction process occurring in catchments. Iron reduction process in reduced environment is one of the important processes forming dissolved iron. This study purpose is (1) to clarify the location of iron reduced zone in two forested watersheds and the relationship between iron reduced zone and hydro-geomorphological conditions and (2) to investigate the dissolved iron discharge from the aquifer of research sites.

As seen from Figure 1, the topographic gradient decrease from 12.7° (head hollow) to 6.4° (head floor). At head floor, the water table was very shallow (< 1 m) and the hydraulic gradient was smallest (0.08). Ferrous iron was detected in this area. Ferrous iron concentrations were highest at the soil horizon deeper than 1.2 m from the water table. Therefore, in this study site iron reduced zone has been located at the saturated zone of the head floor. It is considered that there is enough organic matter to form reduced environment at the area of shallow water table, because generally is organic matter abundant near the soil surface. At the iron reduced zone, NO_3^- and SO_4^{2-} concentrations were very low and dissolved manganese concentration was high. It means that denitrification, manganese reduction and sulfate reduction have occurred. On the other hand, at bottomland which topographic gradient is 2.5°, the water table became deeper, hydraulic gradient became larger, ferrous iron didn’t detected. Iron reduction has not occurred (Figure 1).

Another forested watershed, the topographic gradient decreased at the head floor from 12.6° to 7.9° and the water table depth became smaller (< 1 m). In this area, iron reduction has occurred and dissolved iron was detected in stream water. It is considered that dissolved iron has discharged from head floor saturated zone to stream water depending on the situation (ex. Bottom land topography, precipitation and so on.).

From the above, it is hydro-geomorphological condition that the topographic gradient decrease (12.7°→ 6.4°, 12.6→7.9°) and shallow water table depth (<1 m), because it is considered that big topographic gradient decrease cause the rising the groundwater level. In addition, there is a possibility that iron reduction occurring at the head floor is important as a one of the sources of dissolved iron in stream water. U-shaped valley which possesses flat head valley bottom are often found at hill (rolling land).

Iron reduced zone has located at the head hollow of U-shaped valley of two study sites. At one forested watershed, dissolved iron has discharged to stream water from head hollow saturated zone. There is a possibility that it plays the important role of occurring iron reduction at head hollow that the big change of topographic gradients at valley head and the very shallow water table depth at head hollow.

Keywords: forested watershed, ferrous iron, iron reduction, topography, groundwater level, dissolved iron