The effect of agrochemicals on shallow groundwater quality: A case study from a sandy aquifer alongside the South Han River

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Water contamination by agricultural chemicals such as fertilizers and pesticides threatens ecosystems and human health especially in rural area. In particular, intense land-use activities, especially large-scale fertilizer application, high density animal operations, and septic systems result in elevated concentrations of nitrate in soil, surface water and groundwater, which may cause eutrophication of surface water. Nitrate loading in groundwater by leaching of chemical and organic fertilizers can be typically severe in shallow sandy aquifer. The main objective of this study is to identify the source(s) and processes controlling the groundwater chemistry and nitrate pollution in relation to land use patterns in riverside alluvial setting. For this study, shallow groundwater samples (n=32) were collected from an intensive agricultural field at Daesin, Yeoju in February, 2005. Major dissolved constituents and stable isotopes (δ^2H, $\delta^{18}O$, $\delta^{15}N_{nitrate}$, $\delta^{18}O_{nitrate}$) in water samples were analyzed.

The results of Q-mode hierarchical cluster analysis (HCA) showed the existence of 3 groups of groundwater (Group A, B, and C). Each designated group has distinct chemistry and spatial distribution. In particular, the concentrations of TDS, Ca, Mg, NO_3, SO_4, and K, which are indicative of agricultural pollution, increase from Group A waters to Group C waters. Group A waters are relatively lower in TDS (299±37 mg/L), Ca (43.6±5.6 mg/L), Mg(11.0±1.6 mg/L), and NO_3 (32.0±22.5 mg/L), indicating lesser degree of agricultural contamination. Very low concentrations of NO_3 and SO_4, as well as stable isotope data, in a few localized samples indicate the occurrence of denitrification and sulfate reduction in a restricted area. Group B waters are typically enriched in Na (13.5±3.2 mg/L) and Cl (31.7±7.3 mg/L), which reflects the effect of domestic effluents from nearby residential area. Relatively low concentrations of HCO_3, compared to the enrichments of Ca and Mg, in Group B waters indicate the occurrence of nitrification which produces hydrogen ions to consume HCO_3 in solution. Group C waters are very high in most dissolved constituents except Na and Cl, indicating severe effects from agriculture activities. Nitrogen and oxygen isotope data of nitrate indicate that manure is the dominant source of groundwater nitrate in the study area. During pervasive nitrification of manure in sandy aquifer, proton and CO_2 are continuously generated to promote the carbonate dissolution. This process adds HCO_3 in groundwater. Low Na/Cl ratio (<0.5) in groundwater is explained by the reverse cation exchange which can effectively occur in high TDS waters in sandy aquifer of an intensive agricultural area.

주요어: groundwater quality, stable isotopes, nitrate, agricultural activities

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