Nitrate attenuation process controlled by groundwater flow condition in a coastal agricultural catchment

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The objective of this study is to confirm the nitrate attenuation process along with groundwater flow in the coastal agricultural catchment characterized by large nitrogen load. Especially, we have confirmed 1) groundwater flow condition like as groundwater velocity and residence time at the granitic catchment with steep topographic gradient, 2) spatial and temporal variations of nitrate-nitroten (NO3–N) concentration in groundwater and its controlling factors, 3) and finally the simple model on characteristics of NO3–N attenuation using the groundwater velocity as index was suggested.

1) The study catchment is located on the coastal area of Ikuchijima-island, which is one of the islands within the Seto Inland Sea, southern Japan. The orange groves cover approximately 50% of the total catchment area. The aquifer is mainly composed of the 3 different geological stratums from the surface; sandy soil with clay (0˜-9m), sand and gravel (-9m˜-17m) and weathered granite (-17m˜-30m). The distributions of hydraulic head and CFC-12 concentration indicate that the direction of groundwater flow is from the mountainside to the ocean side at all depths, and groundwater velocity is faster at the intermediate layer in the aquifer with 15m depth than that in the shallower and the deeper layers. This result also suggests that the groundwater flow system is different between the shallower and the deeper layers. The altitude of recharge area is estimated using oxygen stable isotope (18O) ratio in groundwater. The results show that the shallow groundwater with 2˜5m depth was recharged at 30˜100m altitude, and the deep groundwater with more than 15m depth was recharged at 200˜350m altitude.

2) The concentrations of NO3–N in the groundwater were more than 20mgL-1 in the midstream, whereas it decreased less than 5mgL-1 near the coastal line. The altitude of recharge area of the deeper groundwater with more than 15m depth is estimated to be more than 200m where is no distribution of orange groves. However, NO3–N concentrations in the deeper groundwater is higher than that in the spring water (0.3mgL-1) collected at the headstream of the catchment. It indicates the mixing between the shallow groundwater with high NO3–N and the deep groundwater. The NO3–N concentration originated from the mixing effect was estimated using delta-18O based on the assumption of that the downstream deep groundwater is composed of mixing between the local groundwater flow with 100m recharge altitude and regional groundwater flow with 350m recharge altitude. Consequently, the estimated NO3–N concentration was higher than the observed value. This result indicates that another function like as nitrate reduction process contributes to NO3–N attenuation other than the dilution effect.

3) The negative relation between the pore velocity or Darcy flux and nitrate attenuation in groundwater was confirmed from the result in Ikuchijima. This result suggests significant decrease of nitrate occurres in the region with relatively slow groundwater velocity. Moreover, also negative relation between the hydraulic gradient or topographic gradient and nitrate attenuation in groundwater was confirmed. From these results, it is suggested that nitrate attenuation in groundwater is able to predict from the topography.