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Quantitative estimation for solute movement in vadose zone beased on crosshole radar data and petrophysical relationship

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One of the best ways to solve problems with nitrate contamination of groundwater in agricultural areas is to improve fertilization and farming methods to reduce the leaching rate and impacts of nitrate to the groundwater. Recently, we can find some successful examples of the effort of farmers that maintain low input farming to overcome this problem. On the contrary, we can find cases in which the improvement of farming and the reduction of the amount of fertilizer applied have little effect for improving the quality of groundwater.

In order to maintain sustainable efforts in agriculture for environmental conservation, contamination and purification processes must be clarified. However, it is difficult to explain all the processes because they are subsurface phenomena and cannot be observed directly. This uncertainty and opacity are major obstacles to the improvement of water quality in watersheds contaminated by non-point sources. A technique to clarify the contamination process and to assess the effects of nitrate leaching rate, rain infiltration ratio and other principal factors affecting groundwater quality should be established.

Clarification and quantitative estimation of hydrological phenomena in the deep vadose zone are essential and necessary in environmental science and engineering. However, it is difficult to explain these phenomena because of a lack of proper measurement methods. We propose a method to monitor soil water and solute dynamics quantitatively in the vadose zone. This approach is based on time-lapse cross-borehole ground-penetrating radar (GPR) measurements in the vadose zone and petrophysical relationship between electromagnetic property of soil and soil solution.

The objective of this research is to develop a method to clarify the dynamics of soil water and solute quantitatively in the vadose zone, which is a zone of unsaturated soil from soil surface to groundwater. The proposed method was tested in Makinohara Plateau in Shizuoka Prefecture to evaluate the applicability.

Keywords: Ground Penetrating Radar (GPR), Cross-hole geophyisics, Time-lapse, Vadose zone hydro-geophysics, Soil environment, Solute movement