TB-214L

Visualization of the Dynamic of Soil Moisture in Terraced Paddy Fields by Using Geoelectric Resistivity Tomography

Hsu, Shao-Yiu; Huang, Qun-Zhan; Tsai, Yi -Zhih Authors' affiliations
Department of Bioenvironmental Systems Engineering, National Taiwan University

Terraced paddy field constructed by modifying the slope into several flat steps is an important paddy rice cultivation system and, also, an important characteristic landscape in regions where lack the area of plains. An irrigation plan of the terraced paddy field requires an understand of the changes of the soil moisture, overland flow, as well as the subsurface return flow as shown in Figure 1. Unlike the plain fields, the terraced fields involve rapid terrain change. Each step of the field distributes at different elevations and connects to upper and lower steps with constructed slopes. The surface overland flow and the subsurface flow are controlled by the terrain morphology and the subsurface soil and geohydrological conditions.

Due to the complicated water flow system and very limited rice, studies on the irrigation and the hydrologic system in the terraced paddy field are rare (Deb et al., 2006). Only a few studies tried to investigate the subsurface flow under the field to show the effect of the subsurface return flow on the irrigation saving (Onishi et al.,2003). However, some studies show that irrigation water contributes to the next step through the subsurface flow, but some argue that the amount of the subsurface return flow is very little (Liu et al., 2004).

In order to observe the soil moisture changes during irrigation and rainfall and clarify the subsurface flow in terraced paddy fields, we applied the geoelectric resistivity survey on a terraced paddy field located in northern Taiwan from March to July 2021. The inversion two- dimensional electrical resistivity tomography (ERT) can picture the change of electrical resistivity of the soil. Since the change of the soil moisture is strongly linked to the soil water content, the increase of the electrical resistivity implies the decrease of the soil moisture. Also, the fertilizer dissolved in the soil water can decrease the electrical resistivity as well. Therefore, the change of the electrical resistivity below the surface represents the dynamic of the soil moisture and the potential flow path during irrigation or rainfall.

From the measured ERT images of the paddy field, we found that the rainfall and irrigation indeed changed the soil water content. The map also shows an unexpected water flow pathway under slopes. The newly discovered subsurface flow path along the slope should provide an important to the field practices and irrigation management. The resistivity change after fertilizing (in mid-April) illustrates the flow path, in which the pond water infiltrated vertically into the deep soil layer as shown in Figure 2. The result of ERT shows that the infiltration of the ponded water contributed very little to the next step under initial unsaturated conditions. After a long period of irrigation, the change of the electrical resistivity was also found in the deeper subsurface area, but a clear subsurface return flow path connecting different steps of the paddy field was not found. Based on our field, the subsurface return flow might not be considered a significant returned water resource in this study area. Nevertheless, the effect of groundwater table level, surface ponding height, and soil saturation should also be measured to better understand the hydrologic cycle in the terraced paddy field.

Keywords: Subsurface return flow, irrigation, rice field, ERT

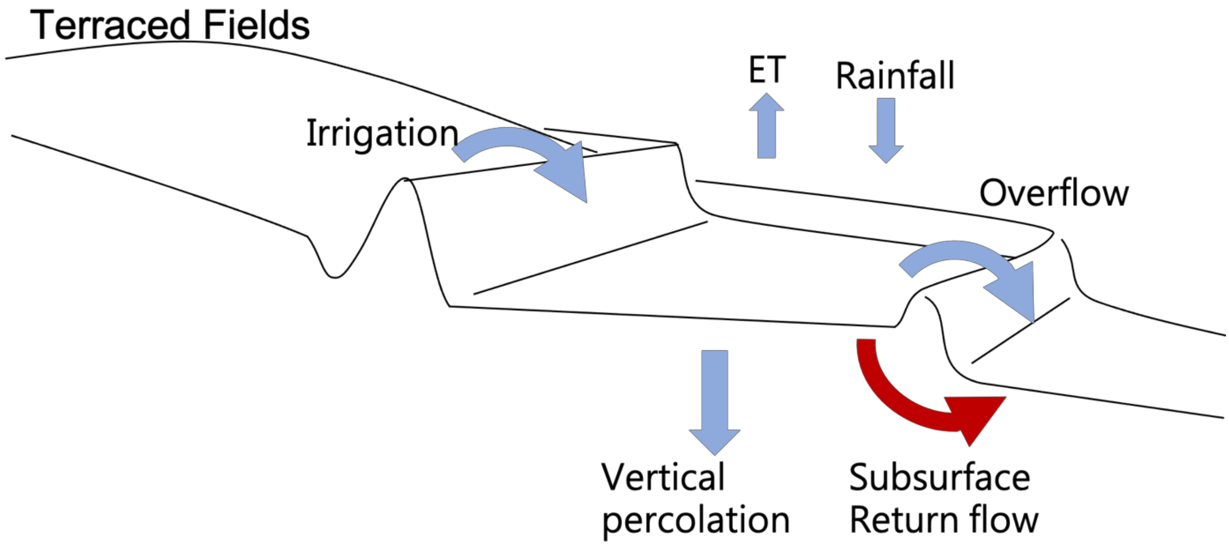

Figure 1. the conceptual model of the hydrologic processes in a terraced paddy field.

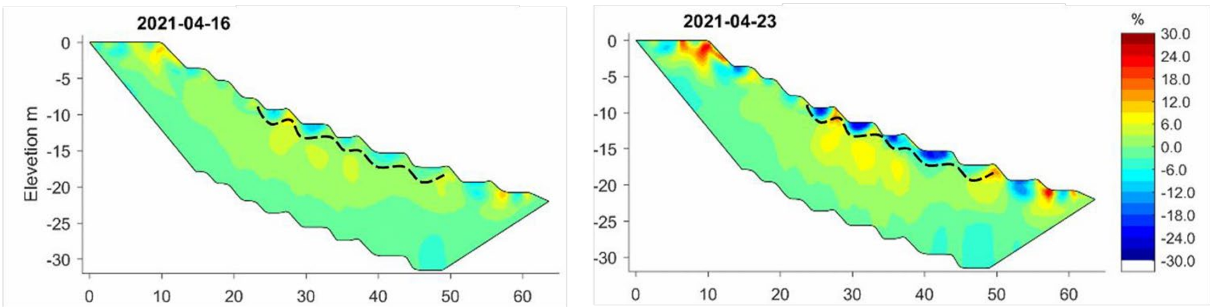

Figure 2. the changes of the electrical resistivity in the terraced paddy field (left) before fertilization (right) after fertilization.

Reference

1) DEB, S. K., MIYAZAKI, T., MIZOGUCHI, M. & SEKI, K. 2006. Return flow generating point on a hillslope layered with traffic pan.
Transactions of the Japanese Society of Irrigation, Drainage and Reclamation Engineering (Japan).
2) LIU, C.-W., HUANG, H.-C., CHEN, S.-K. & KUO, Y.-M. 2004. SUBSURFACE RETURN FLOW AND GROUND WATER RECHARGE OF TERRACE FIELDS IN NORTHERN TAIWAN1. JAWRA Journal of the American Water Resources Association, 40**,** 603-614.
3) ONISHI, T., HORINO, H., NAKAMURA, K. & MITSUNO, T. 2003. Evaluation of groundwater properties in terraced paddy fields using transient unsaturated-saturated water flow analysis. Transactions of the Japanese Society of Irrigation, Drainage and Reclamation Engineering (Japan).