Groundwater Extraction and Water Budget Modeling in Rice Growing Floodplain in the Groundwater Recharge area

Phattaporn MEKPRUKSAWONG NRCT - 10627

Senior Civil Engineer,
Office of Project Management, Royal Irrigation Department

Japanese Advisor : Tadashi YAMADA
Professor, Chuo University

Thailand is located in a tropical, monsoonal area that climate is distinguished by dry and wet seasons, and 85% to 90% of the total rainfall occurs from May to October. The country is one of the world's top ten rice-producing countries. The floodplains in Phichit province, a major rice producing area always suffer from floods in the rainy season and droughts in the dry season. This area is a major recharge area of Thailand where farmers dig wells to draw groundwater for their rice cultivation due to insufficient surface water and no irrigation systems. While paddy fields in floodplains frequently have flood problems, those that require extraction of groundwater for cultivation face problems of the fall of groundwater levels due to over-pumping. Concerned about these problems, the author conducted this study with an aim to find a wise and sustainable use of water resources. The purpose of this study is, thus, to do a precise study on unconfined aquifer in order to reduce flood hazards and recover a suitable groundwater level by using flood water to recharge aquifers. This study covers the groundwater cycle and the possibility of artificial recharge. Part of the low land paddy fields in Phichit floodplains was selected as the study area. Observation systems were installed in one precipitation site, one Yom River water level site and 22 groundwater level sites. The in-situ permeability examination at the time when the observation wells were drilled and pumping tests conducted at two wells.

The author investigated the behavior of the groundwater and factors influencing groundwater levels in the study area, and found that this tropical floodplain area has quaternary sediments and a rather complex water recharge behavior. The detailed investigation of such hydrogeological situation in a floodplain was a first in Southeast Asia. The analysis of relationship between the groundwater levels and the influencing factors showed that GWLs in the river neighborhood area and part of the middle area (4-8 km from the Yom River) were strongly influenced by the Yom River water level, and GWLs in the highland area (8-10 km from the Yom River) had little relations to the Yom River water level. The ranges of the flood periods in 2002, 2003 and 2004 were estimated and the recharge mechanism of the groundwater was examined by comparing GWL distribution with this flood range. The result clearly showed that the GWL quickly rose by infiltration in accordance with floods through high infiltration areas, natural ponds, farming ponds and sandpits.

The recharge through the ground surface from rainfall, floods and water kept in rice fields was estimated by using the ground surface infiltration capacity. The recharge from ponds and sandpits depended on their number and the conditions at their bottoms, which made it difficult to estimate the recharge rate. Thus, the study applied the Tank model concept and used the data collected during the years 2002 - 2004 for the recharge estimation from ponds and sandpits. The recurrence intervals of the maximum discharge in 2002, 2003 and 2004 are approximately 24 years, 2 years and 2 years respectively. In addition, the result of the Tank model showed that the lateral flow to this area was of a small value.

The three-dimensional unconfined aquifer groundwater flow (GWF) model of the study area was developed by using the MODFLOW program. The program presented two results in terms of attaining water balance: 1. in case of present conditions 2. in case of eliminating groundwater extraction by using surface water instead. The simulated groundwater level appeared to be in accordance with the observed values. According to the water balance calculation results, it can be concluded that the main source of groundwater of this area is ground surface recharge (approximately 87-100% of the total inflow), balanced by some leakage to lower aquifers (approximately 72-94% of the total outflow). The recharge from the Yom River to aquifers does not greatly affect the groundwater level of the whole area, but it influences the groundwater level near the river. The groundwater level in this area is likely to be lower in the future since groundwater inflow is less than outflow despite possible floods of a 24-year return period. Therefore, if there is little flood and the number of farm wells continually increases, the GWL in this area will decrease. On the other hand, if surface irrigation can support farmers and thus stop farmers from pumping groundwater, the groundwater can rise by 2-290 cm with the average value of 40 cm.

The recharge system was constructed in the study area to recharge top aquifers with rainfall from the large-roofed area. The artificial recharge experiments were conducted three times. The first experiment result yielded that there was insufficient air ventilation inside the system. The second and third artificial recharge experiments were done to evaluate the system efficiency after the air ventilation system was improved and again after this recharge system had been installed for 3 years. The simulation result of the natural recharge of 23 storms data before the system was improved showed that the system could recharge subsurface with rainfall by about 8.7 % of the total rainfall. After the system was improved, the simulation result of 45 storms data presented a significant increase in recharge efficiency to 45.8 % and 33.0% for the total rainfall depth of less than 15 mm. and more than 15 mm. respectively. The analysis of the relations between the recharged volume and the rise of the ground water level showed the ground water would rise by about 1.10 cm. per 1 m^3 of the recharge volume at location near recharge system. The seepage capacity coefficient of the percolation wells decreased about 50% after 3 years of installation. If this system is constructed in the whole study area of 6,700 houses, the total recharge volume of 200,000 m^3/year can recharge the subsurface

According to the information obtained and the fact that there are a few number of houses, recharge by collecting rainwater from roofs had relatively less impact than that by artificial ponds with bottoms reaching the first aquifer. Thus, the most suitable procedure to preserve groundwater by the gravity method is to build a pond which will readily allow floodwater to seep underground during flood time. This study is, in conclusion, to show an alternative effective method of groundwater maintenance in frequently flooded areas in Southeast Asia.