学位論文の要旨

論 文 題 目　Evaluation of Human Impacts on Groundwater Resources in Mountainous Catchments, Western Japan

広島大学大学院総合科学研究科
総合科学専攻
学生番号 D196030
氏　　名 SHARON BIH KIMBI

論文の要旨

The long-term cumulative effect of increasing urbanization, population and climate change on watershed hydrology has altered the spatial availability of groundwater resources in many regions. In recent years, demographic trends have led to concerns on how population growth will affect water resources. In many Asian and Western countries, population densities are declining despite global population growth with a significant increase in the proportion of the elderly. With an increasing number of citizens over 65 and many cities experiencing depopulation, Japan has experienced this demographic change faster than most Western and Asian countries. Despite these social changes, it still faces serious environmental problems related to groundwater quality and quantity. Population growth and increasing economic condition have led to the continuous expansion and transformation of many Japanese's mountainous rural catchments with associated groundwater resource problems. Despite the significant impact of urbanization (population growth) on groundwater resources, most studies have focused on qualitative, regional impact, with little attention focused on the combine effects of social and environmental issues on groundwater resources in mountainous rural catchments. Therefore, it is necessary to understand how environmental and social aspects affects groundwater resources. This study provides an insight into groundwater resources degradation resulting from an aging and depopulation society as well as urbanization and climate change effects. The effects of population aging and depopulation on groundwater nitrate contamination in an island with intensive citrus cultivation, was examined by comparing two neighbouring villages and watersheds with little different in their social aspects. The northern one (Kubi) has a little higher farmer average age of 76 years, and the decreasing rate of farmland for 10 years from 2005 to 2015 of 46%, as compared with the eastern (Ocho) of 73 years and 37%, respectively. The population in Ocho was 830, and twice of that in Kubi. Higher mean concentrations

of NO_3^-–N were recorded in Kubi village (6.55 mg/L) than in the Ocho area (4.75 mg/L). NO_3^-–N contamination mainly was estimated to originate from chemical fertilizer in Kubi and Organic fertilizer in Ocho, using stable nitrogen isotopes and a Bayesian isotope mixing model. These source distributions were closely associated with a greater extent land use and social aspects such as aging and depopulation. A substantial quantity of chemical fertilizer applied by the more aged farmers in more depopulated Kubi was suggested to lead to inefficient nitrogen uptake by plants, which results in higher leaching that pollutes its groundwater more than those of Ocho.

Likewise, the hydrochemistry and dual isotope approach was used to evaluate groundwater contamination status in Saijo watershed. Results showed that, calcium (Ca^{2+}) and bicarbonate (HCO_3^-) were the most abundant cation and anion respectively and the major water type in the study area was of Ca–Mg–HCO3 type. Inferring from the contamination sources in the watershed using $\delta^{15}N\text{-}NO_3^-$ and $\delta^{18}O\text{-}NO_3^-$ measurements indicated that two major contamination sources with values characteristic for nitrate derived from nitrification of soil organic nitrogen (+0.2 ‰ to +7.3 ‰ for $\delta^{15}N$) and nitrate derived from animal wastes or human sewage, e.g., via septic systems (+8.9 ‰ to + 12.3 ‰ for $\delta^{15}N$) in two distinct zones. Despite agricultural activities in the study area, we found no evidence of nitrate originating from synthetic fertilizers in the groundwater.

Furthermore, the spatial variation in groundwater recharge under the effects of urbanization and climate change, was investigated using SWAT over a period of three decades. Results suggest, the water balance in the last 30yrs is greatly influenced by land-use change with urbanization. The most significant change was observed in the decrease in the mean annual groundwater recharge by approximately 25% (i.e., from 184.5 mm in the 1980s to 120.2 mm in the 2000s). Rice paddy areas are observed to be the major recharge zones in the catchment, with the highest recharge compared to forest and residential areas. Higher rainfall interception by forest canopy were responsible for the lower recharge values observed at forested sites. Furthermore, the predicted scenario highlighted that groundwater recharge will be significantly affected by future climate change which is projected to decrease groundwater recharge by 29% in the next 30years. Land and water resource management can be improved if the findings from the study are used by decision-makers, planners, and managers the region. planners, and managers the region.