Groundwater flow systems in eastern half of Fukushima prefecture and its surrounding ~calculation of mean residence time based on CFCs and SF_6~

*Yusuke Murasaki[2], Harue Masuda[2], Souma Yamano[1], Ryo Inoue[2], Yusuke Sakamoto[2], Tsuyoshi Shintani[2], Nozomu Hirai[2], Fumie Chikaoka[2], Goto Aoi[2], Shinji Nakaya[3], Atsunao Marui[4], Masahiko Ono[4]

1. Osaka city University Faculty of Science Department geoscinces , 2. Department of Geosciences, Faculty of Science, Osaka City University, 3. Department of Water Environment and Civil Engineering, Faculty of Engineering, Shinshu University, 4. Geological Survey of Japan, AIST

Introduction
The tsunami occurring at the time of Tohoku Pacific Ocean earthquake on March 11, 2011, caused Fukushima Nuclear Power Plant accident happen to emit radioactive nuclei in the atmosphere. In Fukushima, groundwater has been used as not only agriculture but daily purposes. Since the radioactive nuclei move slowly in the groundwater system, it is necessary to continue observing groundwater for a long term to understand movement process and residence time. For that reason, it is important to understand groundwater flow system. The purpose of this study is to document the groundwater flow systems of the eastern half of Fukushima prefecture and its surrounding i.e. south of Miyagi and north of Tochigi prefectures. Here, the residence time of groundwaters collected in November, 2016 in July and October, 2015 and discussed based on the result of CFCs and SF_6 analyses.
Results
The study area was divided into three areas; area A (Hamadori and eastern slope of Abukuma mountains), area B (between the ridges of Abukuma and Echigo mountains included Nakadori), and area C (the southernmost part of Sendai plain).
The groundwaters from area A contained CFC-12 60-5000ppt, CFC-11 10-8000ppt and CFC-113 5-300ppt. The concentrations were lower in the groundwaters from the plains along the seashore than those from mountain area Those from area B contained CFC-12 100-10000ppt, CFC-11 10-10000ppt and CFC-113 8-500ppt. The concentrations were lower in those from the northern plain than the others. Although the concentrations of SF_6 were obtained only for the samples collected only from the central to southern part of the plain of this area, most of these waters contained excess SF_6 over the atmospheric one. The groundwaters from area C contained CFC-12 190-1000ppt, CFC-11 50-2000ppt and CFC-113 10-60ppt. Although the ranges of those value were overlapped with those of area A, only a few samples had the high concentrations.
Combination of the obtained concentrations suggest the four different models of groundwater flow i.e. Piston flow(PFM), Exponential mixing(EMM), the intermediate of PFM and EMM(PFM/EMM), Binary mixing(BMM). Some data could not be explained by these models. Most groundwaters can be explained EMM, BMM or PFM/EMM. Therefore, most of the studied groundwaters, especially from the plains, have more than two origins. However, the groundwaters from the mountain area had a single origin. Calculated mean residence times were 6-82 years and about 70% these were 15-40 years old. Groundwaters having short residence time within 15 years were concentrated from the slope to the foot of mountains over areas A and C. Many groundwater were 15-30 years old in the area B, while those older than 31 years were concentrated on foot of the mountains and in the plains. The residence time of areas A and C was generally longer than area B.
Discussion

Samples dissolving excess SF_6 were concentrated on the plain of area B probably because factories near the sampling sites discharged it in the 1990s, which was calculated recharge ages. According to Fukushima prefecture prevention of global warming promotion center, the amount of SF_6 discharge in Fukushima would reach the peak to cause the dissolution of the excess SF_6.
In the plains between Abukuma Mountains and Echigo Mountains (Nakadori), precipitations recharged on these mountains and the plain part were mixed in the aquifer. It must be the reason why many groundwaters can be applied to mixing model. The mixing model can explain the groundwater flows especially at the foot of mountains because there is meeting of groundwates originated from the dofferent recharge areas.
The shorter residence time of groundwater from the areas A and C than those from B would be due to the elevations of recharge areas. Groundwaters in areas A and C were mainly recharged on the lower Abukuma mountains and those in area B did mainly on the higher Echigo mountains; i.e., paths to the sampling sites at the lower altitudes are comparatively short from the Abukuma mountains than Echigo mountains.

Groundwater flow transition in the southwestern Tokyo Metropolitan Area after restriction of groundwater abstraction

*Takeshi Hayashi[1], Akinobu Miyakoshi[2], Masabumi Kawai[3], Shin-ichi Kawashima[3], Kuniyuki Kokubun[3], Hideki Hamamoto[4], Shoichi Hachinohe[4]

1. Faculty of Education and Human Studies, Akita University, 2. Geological Survey of Japan, AIST, 3. Civil Engineering Support and Training Center, Tokyo Metropolitan Government, 4. Center for Environmental Science in Saitama

Regional groundwater flow located in the southwestern Tokyo Metropolitan Area (southwest region of Kanto plain) is previously called “Urawa groundwater flow (e.g., Kino, 1970)”. Groundwater in this region has been developed largely since 1950s, and huge amount of groundwater abstraction has induced land subsidence not only in upland area but lowland area in this region. Thus, the national government and local governments have restricted groundwater abstraction in stages. That is, history of groundwater development and restriction largely differ between the areas in this region.

Although the groundwater development has affected the regional groundwater flow, transition of the regional groundwater flow is not clarified. This study aims to clarify transition and present situation of the regional groundwater flow in this region based on the dataset of groundwater levels that has been monitored by Tokyo metropolitan government and Saitama prefectural government to contribute to sustainable groundwater management.
We present the characteristics of transition and present situation of the regional groundwater flow.

Keywords: groundwater level fluctuation, groundwater development, municipalities, restriction of groundwater abstraction, groundwater basin management, Tokyo Metropolitan Area

Evaluation of subsurface warming in the Tokyo metropolitan area, Japan

*Akinobu Miyakoshi[1], Takeshi Hayashi[2], Masafumi Kawai[3], Shinichi Kawashima[3], Kuniki Kokubun[3], Hideki Hamamoto[4], Shoichi Hachinohe[4]

1. Geological Survey of Japan, AIST, 2. Faculty of Education and Human Studies, Akita University, 3. Civil Engineering Support & Training Center, Tokyo Metropolitan Government, 4. Center for Environmental Science in Saitama

Three-dimensional subsurface temperature distribution and its long-term change were examined by repeated observations of temperature-depth profiles at monitoring wells from 2000 to 2016 and groundwater temperature monitoring from 2007 or 2012, to evaluate effects of regional groundwater flow and environmental changes due to urbanization on subsurface thermal environment in the Tokyo metropolitan area, Japan.
Subsurface warming has been found at shallow depths in the whole study area by our previous study (Miyakoshi et al., 2010). Especially, subsurface temperature beneath the city center was particularly high not only at shallow part but also deep part. In contrast, relatively low temperatures were found beneath the suburban area. Comparison result between past subsurface temperature data (2003 to 2005) and present subsurface temperature data (2013 to 2016) shows that subsurface warming is found at the shallow part in the last 9 to 10 years. Subsurface temperature increase in the city center is larger than the suburban area, and the temperature difference between both areas shows an increasing tendency. Additionally, subsurface warming in the present data was recognized deeper than the past data. This result suggests that distribution of subsurface warming is expanding toward the deeper part.
Subsurface monitoring data showed constant warming rates at observatories in the southeastern area of Saitama Prefecture and the eastern area of Tokyo Metropolis. These observatories are located in the alluvial lowland, and the warming tendency was formed by effects of surface warming due to urbanization. On the other hands, subsurface warming was not a constant rate at observatories in the southwestern area of Saitama Prefecture and the western area of Tokyo Metropolises. These observatories are located in the Musashino Uplands, and the warming rate show a time and a depth variation. Additionally, subsurface temperature changes were found at not only the shallow part but also deeper part than 100m in this area. These complex subsurface temperature changes are recognized around areas where significant changes of hydraulic heads were observed, and it was considered that subsurface thermal environment was affected by artificially-induced groundwater flow changes. Results of this study suggest that mechanism of subsurface warming is able to be evaluated by combined analysis of geological condition, groundwater flow and subsurface temperature changes.
This study was conducted as a part of Civil Engineering Support & Training Center, T.M.G.- Akita Univ. - AIST Joint Research and Saitama Pref. –Akita Univ.– AIST Joint Research.

Keywords: subsurface temperature, groundwater flow, subsurface warming, groundwater development, urbanization, Tokyo metropolitan area

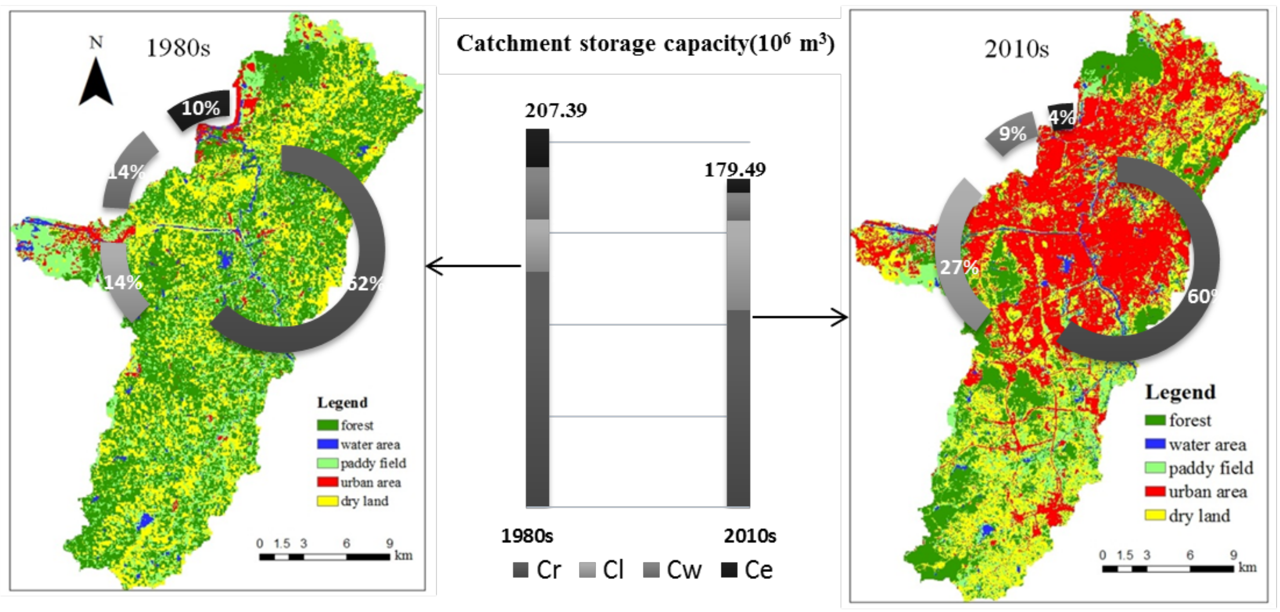
The effects of urbanization on catchment storage capacity of surface water –a conceptual model in plain catchment in Yangtz river delta

*Song Song[1], Youpeng Xu[1], Liu Yang[1]

1. School of Geographic and Oceanographic Science, Nanjing University, Nanjing, China

Hydrological processes in Yangtze river delta area have been significantly changed due to rapid urbanization in the last 30 years. A conceptual model involving four modules - river network, lakes/reservoir, wetland/floodplain, and ecological land use –was proposed to evaluate the surface water storage capacity, as well as its temporal variation and its structural sensitivity from 1980s to 2010s in Qinhuai River Basin, Yangtz River Delta. The data sources include MSS/TM images, thematic maps, Digital Elevation Model, and gauged hydrological data from 1980s and 2010s. The main findings indicated that, 1) the main driver of the storage variation is the construction land expanded and forest decrease; 2) although the total water area increased, the complexity and stability of river network declined; 3) the surface water storage capacity of Qinhuai river catchment decreased by 13.45%, from 207*10^6 m^3 to 179*10^6 m^3 during the study period; 4) the lake/reservoir storage is the most sensitive module to the urbanization, while the river network module serves as main contributor to the total storage. More effects should be made in the protection and restoration of the low-level rivers, forest and wetlands to protect and restore the catchment storage capacity. The results of the study would provide support in policy formulation and intervention strategies.

Keywords: Storage capacity, urbanization, conceptual model, effect analysis, Yangtze River Delta



Urban flooding risk mapping using hydrodynamic and GIS models

*Boyu Feng[1], Chuiqing Zeng[1], Jinfei Wang[1], Ying Zhang[2]

1. University of Western Ontario, 2. Canada Centre for Mapping and Earth Observation, Natural Resources Canada

Rapid urbanization and unpreventable climate change have resulted in severe urban flooding events that hit worldwide cities more frequently and heavily. An instructive and up-to-date monitoring and evaluation on the distribution of flooding risks in cities is necessary and valuable for urban planning. This research applied two major approaches in current urban flooding studies: hydrodynamic and GIS models in a case study in London, ON, Canada. From the hydrological view, hydrodynamic models employ a series of hydraulic equations to calculate the motion of water from fluvial/pluvial-based sources. The inputs of such hydrodynamic models are often composed of detailed hydrological parameters (e.g. river crossing section), which need to be inputted by experienced hydrodynamic experts. Besides the high standard of hydrological expertise, hydrodynamic models involve heavy calculation and are often difficult to run with high spatial resolution data. For end-users who do not have hydrological background, the two features impede the easy access to hydrodynamic models. On the other hand, GIS models can be easily equipped with multiple high spatial resolution GIS layers. But in GIS models, hydrodynamic physics does not apply and the key parameters are often generated from historical flooding events or empirical models. Therefore, a bond between hydrodynamic and GIS models needs to be made in urban flooding studies, in order to take advantage of both models strength. This study used the water level result derived from one open-source hydrodynamic model (PCSWMM) as a known flooding event. According to the hydrodynamic model result, the parameters that the GIS model requires were decided. In this way, the GIS model can be considered as a simplification of the used hydrodynamic model. The used GIS layers in this study include DEM (digital elevation model), slope, curvature, landuse/landcover, and road system density. As a result, an urban flooding risk map is generated using the hydrodynamic-model-trained GIS model.

Keywords: Urban flooding, GIS model