Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

AHW26-P01 Room:Convention Hall Time:May 27 18:15-19:30

Modeling of Surface Water and Groundwater Cycle System in a Mountainous Catchment Underlain by Granite

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A mountainous watershed plays an important role as a recharge area, and many studies have been conducted regarding the groundwater flow. However, there have not been enough studies in headwater catchment with large topographical relief. Also, there have been few studies applying numerical simulation to the groundwater flow in the headwater catchment.Therefore, the aim of this study is to reproduce groundwater flow in a steep mountainous catchment underlain by granite using numerical simulation.

The study area is the headwater catchment of Jingu River in Yamanashi, which is one of the mountainous catchments underlain by granite. The highest relative height of the catchment is about 1400 m. The numerical simulator is GETFLOWS, which can analyze three dimensional surface and groundwater flow. In this study area, residence time and recharge altitude of groundwater have been estimated using CFCs and stable isotopes tracers previously, and this study aims to reproduce those values by numerical simulation.

The permeability was examined, and trials of reproduction of the groundwater flow system were performed. The permeability seems to have an effect on the groundwater flow system such as groundwater level and flow path. Also, in the north of the catchment, it has been found that several springs have longer residence time estimated by CFCs than the others have, and the similar result was shown by numerical simulation. Furthermore, the recharge altitude of springs showed appropriate values except some springs.

Keywords: groundwater, simulation, GETFLOWS, residence time, recharge altitude

Japan Geoscience Union Meeting 2015
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Spatial analytic reasons of eutrophication in Baiyangdian Basin, China

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Baiyangdian is the closed lake located in North China Plain, about 150 km to the south of Beijing. The lake provides domestic and industrial water to surrounding area. The lake has functions of flood mitigation, water purification, conservation of biodiversity, that is ecosystem services. However, water shortage and pollution becomes serious problem, and ecosystem services are deteriorated.

Recent economical development in China leads increase in local industries, and population is increasing in the surrounding area. Water demand is also increasing, that lead to decreased storage and dry up of Baiyangdian lake.

Baiyangdian collects nine streams from Taihangshan mountains and effluent stream flows into Bohai Bay. Swamp area include about 3,700 of creeks connecting 146 water areas through channels. Total area is about 366 km2 including 36 villages in the swamp area. The climate is temperate monsoon climate, which has dry and cold winter, and hot and moist summer. Average annual precipitation is 563.9 mm, and annual average pan evaporation reaches 1369 mm. About 80% of precipitation is concentrated from June to September.

Baiyangdian as natural wetland has many functions, namely ecosystem services. Proper conservation is required to maintain local agriculture and industries. The final goal of the study is conservation of ecosystem services of natural wetland. In this paper, we report the interannual and seasonal changes in water area and wetland vegetation in Baiyangdian by using satellite remote sensing. Field survey of water quality had conducted in 2010. The relationship between the condition of surface water and vegetation and water quality is investigated.

China 1km Mesh Grid Land Cover data in 1980 and 2000 shows the residential land and industrial land increased in Baiyangdian, and the arable land in the middle and mountain areas tend to increase, but decrease in plain area. Reduction of arable land area corresponds to the residential and industrial land increased area.

In addition, Water area and vegetated area in the lake has a decreasing tendency between 1989 and 2001. This is caused by housing and agricultural developments in the reclaimed land. Especially the upper part of Baiyangdian suffers development activities. On the other hand, it is proved that large water areas of Baiyangdian had been separated.

Field survey was carried out on April, June and September in 2010. Total nitrogen, total phosphorus, nitrate-nitrogen were measured at plural sampling points. The concentrations of the items are high at the inlet channel of Baiyangdian lake. It seems wetland vegetation (mainly reed grass) absorb the nutrients. The concentration in September is the lowest in the season. This is considered to be the absorption of the nutrients by vegetation in the growing season. It remains as the next point to discussion. Moreover, the observation months results are compared. The absorption rate of the nutrients in September is more high than it in April and June. One the reasons is that reed grass absorb the nutrients in the growing season from April to July. In addition, the transparency at inlet is much lower than center and outlet . The concentration distribution and the seasons change of water projects , are based on the pollutants from the upper steam, wetland vegetation purification function and the seasonal distribution of precipitation to illustrate.

Baiyangdian is a enclosed water which is near to the city , and solve the problems about enclosed water is the world common project . For example , in Japan , they are using Water Pollution Prevention Law and Lake Water Quality Prevention Measure to improve the water quality . In the future, the research of comparative hydrology based on around the world about enclosed water subject , to master the lake water environment problems as the earth in environment problems.

Keywords: Ecosystem services, Water pollution, Water area, Wetland vegetation

Japan Geoscience Union Meeting 2015
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Hydrological Environment of Surface Water and Groundwater in Ninh Thuan Region, South-east Coast, Vietnam

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The Government of Vietnam is planning to construct two nuclear power plants in Ninh Thuan province, a coastal region of Vietnam with semi-arid climate conditions. This research aims to investigate the hydrological environment of surface water and groundwater in the planned site of Ninh Thuan 2 in order to obtain basic information for the construction of the plant. Inorganic solute ion concentrations and stable isotopes of oxygen and hydrogen in surface water, groundwater and seawater were analyzed to understand their chemical characteristics and hydrological process. The results demonstrate that water resources in this region are limited and groundwater is considered to be a main water source. The groundwater flows in Holocene and Pleistocene aquifers, with the depths of 10 m and 16-21 m, respectively and the dominant flow is from southwest to northeast, corresponding to the river flow direction in this area. There seems to be an interaction of surface water and groundwater in this region. Streams and wells near the shoreline are affected by brackish water with high Na-Cl concentration. Groundwater in the Holocene aquifer shows a chemical characteristic of Ca-SO4 and Ca-HCO3 type, whereas Na-HCO3 water type is dominant in the Pleistocene aquifer. The water chemistry is being influenced by freshwater - brackish water mixing, weathering processes and human activities. The nitrate concentration of groundwater in the Holocene aquifer is higher than that in the Pleistocene aquifer, and much higher than WHO drinking water standards. This means that water in this region is affected by agricultural production activities. Therefore, the project developer should have a careful consideration when consuming water in this region for Ninh Thuan 2 nuclear power plant project.

Keywords: nuclear power plant, environmental impact assessment, water resources

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(May 24th - 28th at Makuhari, Chiba, Japan)

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The origin and formation mechanism of the water quality of deep hot springs from the northern foothills of Mt. Fuji

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Since the mid-1990s, drilling wells for hot spring bathing purpose was performed on a deep aquifer at depths reaching 1,500m below the surface in the northern foothills of Mt. Fuji. Meanwhile, the origins of the water and the formation mechanisms of the water qualities have not always been investigated thoroughly. Clarification of the forming environment of the hot spring waters is indispensable for the protection and sustainable development of hot spring sources.

In this study, water samples were collected from wells for hot spring bathing purposes and from natural springs in the northern foothills of Mt. Fuji and the adjacent Misaka and Tanzawa Mountains area, and were subjected to chemical and isotopic analysis of hydrogen, oxygen, and sulfur (δD, δ^{18}O, δ^{34}S). Based on the analytical results, the origin of the water and water-rock interactions, which affect the water quality of the deep hot springs, were discussed.

The water in samples were thought to be originated through mixing of meteoric water with very small amounts of altered seawater, which had been trapped in the pore space in the basement rock, so-called green tuff formation. After subtraction of the seawater-derived components, concentrations of major components of the water samples were thought to be controlled by the dissolution of gypsum and/or anhydrite, calcite precipitation, and the formation of Na-smectite by weathering of albitized plagioclase. Around the distribution areas of volcanic products of Mt. Fuji, the weathering process of olivine may also influence the concentrations of Mg^{2+} ions. The δ^{34}S values of SO_4^{2-} ions of hot spring waters were higher on the Misaka and Tanzawa Mountains side, whereas they were lower on the foot of Mt. Fuji side (down to +8.2 ‰), indicating the presence of different SO_4^{2-} ion sources; the former SO_4^{2-} ions with high SO_4^{2-} values are derived from marine anhydrite and/or gypsum, whereas the latter SO_4^{2-} ions with low δ^{34}S values are involved in volcanic anhydrite and/or gypsum.

Keywords: northern foothills of Mt. Fuji, deep hot spring, water quality, water-rock interaction, stable isotope ratio

Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

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Historical Rainfall, Runoff and Flood of Wadi Siham Basin, Yemen

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Wadi Siham Basin (WSB) is one of the most important agricultural areas, and one of the seven largest wadis in the western region of the Republic of Yemen. This study aims to evaluate the quantity and spatial and temporal variation of rainfall and runoff. The rainfall (1979-2008) as well as runoff and floods (1990-2009) data were collected and treated statistically in order to evaluate the rainfall and runoff trends. The areal catchment rainfall was estimated by using the Thiessen polygon method, while the recurrence interval and probability analysis were carried out using the Hazen method. The Mann?Kendall and Sen's slope analyses results showed that the Wallan and Al-Amir stations produced significant negative values (-4.72 and -6.11 mm/year respectively). However, the rainfall trend in Dhamar had a significant positive value of 50.20 mm/year. The average annual rainfall in WSB was 346.39 mm/year. The total amount of rainfall was 1711.26 Mm^3. The mean annual water runoff was 82.92 Mm^3. A total of 570 events of flood occurred with a total volume of 53.10 Mm^3. The total water runoff was 4.85% of total rain precipitated on WSB indicating that the total amount of water loss was 95.15% varied between evapotranspiration and infiltration. In conclusion, the study results suggested the need for an urgent and sustainable water resource management in WSB.

Keywords: Rainfall, Runoff, Flood, Mann Kendal Test, Wadi Siham, Yemen

Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

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The characteristics of mercury deposition on to forest ecosystem observed in Yakushima Island

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Mercury (Hg) is a global pollutant that affects human and ecosystem health. Atmospheric Hg can be removed from the atmosphere by wet or dry deposition. Many studies suggest that the interactions between atmospheric Hg and the forest canopy may be a key process influencing Hg input to forested watersheds. These studies are mainly conducted in Europe, however, only a few studies were reported in Asian monsoonal area. The characteristics of the seasonal variation of a precipitation is different between Asian monsoonal area and Europe region, i.e., there is a rainy season (June-July) and typhoon season (July-September) in Asian monsoonal area. It has been reported that the most of atmospheric mercury is supplied as a wet deposition. Therefore, it is important to evaluate the characteristics of Hg atmospheric deposition in Asian monsoonal area. Yakushima island has more than 8,000 mm of annual precipitation. Therefore, it is suitable site to evaluate the mercury dynamics in the forest ecosystem.

Study sites are located at a height of 200 m and 1600 m above sea level of the broad-leaved evergreen forest in the western area of Yakushima Island, respectively. In 200 m experimental site, the experiment was conducted at a 100 m x 100 m experimental site around the observation tower. We installed automatic rain samplers which can collect rain water every 10 mm precipitation, bulk deposit samplers (within canopy and without canopy) and groundwater collecting devise, respectively. In addition, we sampled stream water which flow down near the observation tower. In 1600 m experimental site, we installed automatic rain samplers. These experiments are conducted during 2011-2014 sampling campaign and each samples are collected once a month basis. Hg, major ions, and DOC were analyzed. From these result we will discuss the characteristics of Hg deposition in Yakushima Island.

Keywords: Yakusima, mercury, forest ecosystem, Asia monsoon, precipitation

Japan Geoscience Union Meeting 2015
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Study on a numerical model for fluid flow and heat transport through permeable porous media

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Interaction between the atmosphere, the surface and the subsurface is one of the most important keys in understanding, managing and utilizing the water environment. Recently, technologies for estimating the shallow subsurface thermal environment adequately are required along with the popularization of the ground-coupled heat pump system and the heating and cooling system by direct use of groundwater. A numerical simulation model for being able to estimate processes of fluid flow and thermal transport in unsaturated and high permeable porous media is required in order to develop the technique of shallow geothermal energy utilization.

In this study, the one-dimensional infiltration experiments using a cylinder column and improving the numerical simulation model were carried out. In the experiment, highly permeable porous media 3 and 5 millimeters in diameter were used. The flow velocity and the temperature changes in the column were measured. The experimental results were represented by the numerical model.

As the results, the high-velocity flow in the permeable porous media was simulated by the model using multi-phases system. In addition, in the model the temperature of soil, liquid (water) and air were able to be simulated individually and the calculated results were agreement with the experimental results.

Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

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Potential map of Borehole Heat Exchanger system for the central part of Kanto Plain and the Obama Plain

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A Borehole heat exchanger (BHE) is an economically and environmentally friendly technology that is widely used in Europe and North America, but rarely used in Japan. One of the reasons for this is the relatively complex topography and geological structure in Japan compared with those in Europe and North America.

Complex structures produce regional differences in subsurface thermal properties and temperature structures, leading to regional variation in the efficiency of BHEs. Thus, it is important to evaluate the available subsurface heat energy through thermal response tests and/or numerical simulations and to design appropriate systems (depth and number of boreholes for heat exchange). Geological structures, groundwater properties, and subsurface temperatures are essential input data for numerical simulations.

We performed BHE numerical simulations using measured data and present a new method for constructing a BHE potential map from regional geological structure models for typical Japanese plains. Our target areas are the central part of the Kanto Plain and the Obama Plain. The Kanto Plain contains the capital city of Japan and has a population of more than 40 million. On the other hand, the Obama Plain is located in the central part of Japan and faces the Sea of Japan. And population density of the Obama Plain than that of the Kanto Plain. It is important to evaluate the energy potential of BHE in a part of this area for socio-economic studies. We have performed measurements of subsurface temperatures at 23 stations in the central part of the Kanto Plain (Saitama region). Subsurface temperatures and thermal conductivities at four stations at Obama Plain. In our presentation, we discuss that the difference of subsurface thermal environment and efficiency of BHEs.

Results of the numerical simulations show that the BHE efficiency increases by 20% when the subsurface temperature increases by 5 degC and the efficiency also increases by 30% when the groundwater flow varies from 0 m/year to 15 m/year.

In addition, the results of the subsurface temperature profiles show long-term subsurface warming in the Kanto plain during the last century. The influence of subsurface warming effects on the BHE efficiency through numerical simulations is discussed. We show that subsurface warming effects cause the BHE efficiency of heating to increase.

Keywords: Borehole Heat Exchanger system, groundwater, Kanto Plain, Obama Plain

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Analysis of groundwater flow system for potential assessment of ground-source heat pump system in regional scale

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Ground-source heat pump system is an energy efficient and environment friendly technology that utilizes natural heat stored in a subsurface of shallow depth up to about 100m. It is used for space-heating, space-cooling, hot water supply and snow-melting purposes. Development rate of GSHP system is gradually increasing in Japan. However, the pace is still lacking behind America and European countries because of higher initial cost resulted by oversized design of ground heat exchangers (GHE) and lack of information on its advantages. To promote the development of GSHP system, evaluation of suitable locations for its installation is essential.

Regarding geology, Quaternary System usually exists in the shallow subsurface which mainly consists of sand and gravel. In this Quaternary System, groundwater is actively flowing. For this reason, hydrological and geological information are necessary because they largely influence the subsurface temperature distribution, and consequently affects heat exchange rate of GHE as well as overall operation of GSHP system.

In this study, groundwater flow system of the Tsugaru Plain in Aomori Prefecture was comprehended in order to assess the potentiality of GSHP system. A regional scale 3D groundwater flow ? heat transport model was developed for this purpose. Horizontal dimensions of the model were 64km in east-west and 78km in north-south direction. In the model, layers 1 ? 4 belonged to Quaternary System, layers 5 ? 7 to Neogene and layers 8 ? 12 to Paleogene. Saturated steady state simulation of groundwater flow and heat transport was conducted with this model. In Tsugaru Plain, hydrological field data such as groundwater level could not be measured as groundwater observation wells were not sufficient. Therefore, the analysis model was verified by comparing the computed hydraulic heads and water table with past studies and literature values. Additionally, computed results were validated by inspecting the path of simulated groundwater flow at natural springs, confirming if groundwater was flowing in upward direction.

Based on the simulation results of the analysis model, distribution maps of groundwater flow velocity, water table depth from subsurface and subsurface temperature were prepared using geographic information system (GIS). Groundwater flow velocity was found higher at peripheral areas. It can be due to higher hydraulic gradient near the mountainous areas. At areas with higher groundwater flow velocity, improved heat exchange rates of GHEs can be expected because of advection effect. Water table depth from surface was found to be shallow in most of the areas of the plain, which indicates the sustainable operation of GSHP system from the view point of groundwater availability and saturation of geological layers. Aomori Prefecture (2011) and Machida and Yasukawa (2008) showed similar results of water table. Subsurface temperature computed from heat transport simulation was found higher at the central area of plain, which is thought to be due to the heat transfer by groundwater advection. For space-heating with GSHP system, the central area can be suitable from temperature perspective. In this way, the comprehension of regional scale groundwater flow system accompanied with subsurface temperature distribution can provide useful information to assess suitable locations for the installation of GSHP system.

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Keywords: ground-source heat pump system, groundwater flow, heat transport, potential assessment