Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

AHW07-P01 Room:Poster Time:April 29 18:15-19:30

Evaluation of transpiration in a mature stand of Japanese cedar in Kanto region, Japan

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Forests cover about 70% of land area of Japan, and Japanese cedar (*Cryptomeria japonica*) occupies about 20% of total forested area. To understand the hydrologic cycle in Japan, we need measurements conducted in forested area, especially for the most representative species of Japanese cedar. Recently, the water balance of a stand of Japanese cedar has been made clear quantitatively by using eddy-covariance method and sap flow technique in Kyushu Island, south-western part of Japan (Kumagai et al., 2014; Shimizu et al., submitted). However, although Japanese cedar is most representative species in Japan, very few studies have been carried out in other part of the country. Based on the sap flow technique, we started to evaluate the amount of transpiration of a stand of Japanese cedar located in Kanto region, in the central part of Japan. In this paper, we show the relationship between outermost sap flow (Q_{0-20}) and single-tree transpiration (Q), tree-size parameter affecting Q, and correlation between stand transpiration (TR) and meteorological factors.

We conducted measurements in a mature stand of Japanese cedar, whose age is 61, within Tsukuba Experimental Watershed located in southern part of Mt. Tsukuba, Japan. Tree density is 1115 trees/ha, and annual mean leaf area index measured with LAI-2000 (LI-COR, USA) is 3.6. We set an observation plot in a Japanese cedar stand, and measured sap flux densities for all trees of the plot, 13 trees, with Granier method (Granier, 1985). Based on the wood core sampling with an increment borer, we determined the width of sapwood for 13 trees. Japanese cedar has white zone, in which water movement stops, in the sapwood area. We injected acid fuchsin into stem, and distinguished colored area as sapwood. The length of Granier sensor was 20 mm: in case that the width of sapwood was more than 20 mm, additional sensors were inserted into the sapwood at the depths from 20 to 40 mm and 40 to 60 mm. The sap flow at each depth is calculated as the product between the sapwood area corresponding to the depth and measured sap flux density. Q is finally obtained as total sum of sap flow of all depths. We calculated TR as the sum of Q of 13 trees divided by the area of the plot. On the meteorological tower, air temperature, humidity and net radiation were measured. Analyses are performed in the period from August to November, 2013.

The value of $Q/(Q_{0-20})$ had positive linear relationship with canopy projection area unshaded by other trees (CPA_{TH}). This trend implied that the contribution of Q_{0-20} to Q is small for trees having good light condition. Q had positive linear correlation with diameter at breast height (R^2=0.62), however, the higher correlation (R^2=0.70) was found between Q and CPA_{TH}. In this stand, CPA_{TH} is probably important factor affecting distribution of sap flow within the stem and tree-to-tree difference in Q. On the other hand, through the analysis period, TR had high positive correlation with equilibrium evaporation (R^2=0.83), but had lower correlation (R^2=0.39) with vapor pressure deficit (D). Focused on the summer period from August to September, we found higher correlation between TR and D (R^2=0.74). Thus, in summer, the driving energy of transpiration is mainly D due to the large aerodynamic conductance at the stand. However, the correlation between TR and D became small in the autumn. This stand is located in the north-facing slope, and has very high contrast in meteorological condition between summer and autumn. The different relationship between TR and D probably implies that plant physiological response of Japanese cedar in summer is different from that in autumn.

Cited paper
Granier 1985. Ann. Sci. For. 42: 193-200.
Kumagai et al. 2014. J. Hydrol. 508: 66-76.
Shimizu et al. Submitted for publication.

Keywords: Japanese cedar, sap flow, transpiration, tree-size parameter, vapor pressure deficit

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SURFACE RUNOFF ESTIMATION BASED ON TOTAL RAINFALL-TOTAL LOSS RAINFALL RELATIONSHIP FOR CATCHMENTS IN ISHIKARI RIVER

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One of the main objectives of research in hydrology is to improve the accuracy of surface runoff estimation for enhancing flood prediction. Rain water falling to the ground surface will infiltrate into the soil and the excess rainfall will be surface runoff. The infiltrated water is defined as loss rainfall and loss rainfall is subtracted from total rainfall (actual rainfall intensity) to obtain the surface runoff (excess rainfall intensity). The non-linearity of surface runoff phenomena in the mountainous basins based on universal lumped kinematic wave model has been studied. Current study about total rainfall-total loss rainfall relationship by using tanh fitting curve has been conducted for 65 catchments located in 27 prefectures in Japan. Hourly rainfall and hourly runoff observation data for 10 years during summer time is used as required input data. Runoff parameters in the tanh function represented by *a* and *b* parameters are utilized to estimate effective rainfall based on water holding capacity theory. The purpose of this study is to estimate surface runoff by using effective rainfall for semi-ungauged river basins at the upper catchments area in Ishikari River Basin, Hokkaido Island, Japan. The obtained results are compared to the observation data for validation purpose.

Keywords: Surface Runoff, Flood Prediction, Total Rainfall-Total Loss Rainfall, Water Holding Capacity Theory

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Integrate simulated annealing algorithm and WASH123D to develop an automatic identification system for Chuoshui River in

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Taiwan is located in the subtropical areas and often suffers from typhoons and heavy rains. In order to reduce the threat caused by typhoon, it is necessary to accurately estimate the water level of a river for flood disaster prevention and mitigation. Hydraulic analysis of a river is important in river management planning and engineering design. The identification of hydraulic parameter has huge impact on the water level estimation of a river during the hydraulic analysis. Manning ′ s roughness coefficient is usually used to describe a river ′ s surface roughness and sinuosity in hydraulic modeling. This coefficient is usually determined empirically in the past, which is tedious and time-consuming. Therefore, the optimization algorithms become an effective tool for engineers to select the Manning ′ s roughness coefficient.

The concept of simulated annealing algorithm (SA) is based on an analogy to crystallization process of the physical annealing from a high temperature state. Since SA has the Metropolis mechanism to escape local optimum trap, it has been applied to various types of optimization problems. In addition, the hydraulic model plays a crucial role for flood simulation and the WASH123D, an integrated multi-media, multi-processes and physics-based computational model suitable for various spatial-temporal scale, is selected in this study to simulate the water level. The purpose of this study is to integrate SA and WASH123D to develop a system for automatically identifying the optimal Manning ′ s roughness coefficients of the reach according to the given upstream and downstream boundary conditions of the river. Firstly, the cross sections and related hydrological data of the river are collected for flood hydrograph simulation in WASH123D and make sure the model can be executed for the reasonable range of the Manning ′ s roughness coefficient. Then, the system incorporates SA with WASH123D to identify the optimal Manning ′ s roughness coefficient according to the objective function for minimizing the difference between observed and simulated water level. The system is applied to the Chuoshui River in Taiwan. Flood in two typhoon events is simulated and the flood hydrograph is analyzed in this study to find the optimal Manning ′ s roughness coefficient. Results demonstrate that the system proposed in this study has feasibility to automatically identify the Manning ′ s coefficient.

Keywords: Simulated annealing algorithm, WASH123D, Manning's roughness coefficient, Automatic identification system

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Groundwater levels and qualities in megacities of Korea

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This study was conducted to evaluate the groundwater levels and groundwater qualities in six metropolitan cities (Seoul, Busan, Daegu, Incheon, Daejeon and Ulsan) of Korea. For this purpose, we collected the groundwater level data of 2001-2011 from the Korean National Groundwater Monitoring Stations in the cities and semi-annual groundwater quality data analyzed by the Korean Ministry of Environment for the same period. Using these collected data, we analyzed the change in the water levels in and outskirt of the cities and in groundwater qualities in the cities. The groundwater levels in the outskirt were generally higher (0.84-15.66 m bgs), compared with those in the central part of the city (3.89-75.16 m bgs), and well responded with the seasonal rainfall (higher in the summer but lower in the winter). However, the groundwater levels in the central part of the city were largely affected by pavement, deep underground building such as subway, and artificial pumping, not by the seasonal effect. The six metropolitan cities showed ranges of 0-507 mg/L and 0-22,000 mg/L for NO_3-N and coliform, respectively. In addition, groundwater contamination with TCE (0.00-4.50 mg/L), PCE (0.00-0.48 mg/L) and 1.1.1 TCA (0.00-0.11 mg/L) was also found. The groundwater contamination with these contaminants was relatively severe especially in Seoul and Busan, which may be attributed to their high densities of populations and industrial facilities. This research was supported by Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (NRF-2011-0007232).

Keywords: groundwater levels, qualities, metropolitan cities, contaminants, Korea

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Variation in groundwater-stream water interaction with season: focus on water level, temperature and chemistry

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This study was conducted to reveal seasonal variations of the groundwater and stream water interaction in Gangwon province of Korea using analyses of measured water levels, water temperature and water chemistry from August to November of 2013. For measuring the water levels in the hyporheic zone, four piezometers (IYGW-1˜4) were installed at depths of 0.830˜1.565 m below stream bed, perpendicular to stream flow direction and the stream level was also measured at IYSW-1. The water level and water temperature were measured every hour using an automatic logger (DIVER). In addition, nearby groundwater, hyporheic water and stream water were collected for ion and stable isotope analyses in the wet (September) and dry seasons (November) along with field measurements of pH, EC, DO and ORP. The water levels of the piezometers generally increased with rainfall, and they were lower than the stream water level in September, indicating a losing stream, but the former was higher than the latter in November, indicating a gaining stream. The reversal of the heads occurred at October 10. The stream water temperature (IYSW-1), directly affected by the surrounding air, was between 0.9˜22.9 ℃ with a large fluctuation. However, the hyporheic water (IYGW-4; 1.565 m depth) showed a small range of 13.2˜17.8 ℃. The water temperature at IYGW-4 was lower than those of the other piezometers but the reversal of the water temperatures also occurred at October, like the water levels. The groundwater, hyporheic water and stream waters were all classified as Ca-HCO_3 type by Piper diagram, which is indicative of effect of ambient air. The EC of IYGW-4 was the highest (136.7 μS/cm), indicating relatively higher influence of the groundwater. This research was supported by Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (NRF-2011-0007232).

Keywords: hyporheic zone, interaction, groundwater, piezometer, Korea

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Change of groundwater condition by operation of geothermal heat pump

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This study was conducted to evaluate the influence of open loop geothermal cooling and heating system (OLGCHS) and closed loop geothermal cooling and heating system (CLGCHS) on temperature and water level of local groundwater. For this study, groundwater temperature and level were measured daily using level logger at two sites where OLGCHS and CLGCHS are installed for approximately 30 months. In OLGCHS, fluctuation of groundwater temperature was similar to seasonal variation of ambient air temperature. However, this is not attributed to influence of air temperature. The groundwater temperature was fluctuated according the load of OLGCHS. The groundwater temperature was largely changed by operation of OLGCHS in summer compared to those in winter. These results represent that load of OLGCHS in summer is larger than that in winter. The groundwater levels were mainly controlled by precipitation and were slightly influenced by operation of OLGCHS. In CLGCHS, the groundwater temperature and level did not affected by operation of CLGCHS. The groundwater temperature was changed with 3^{o}C. The groundwater level was mainly influenced by precipitation because groundwater is not used directly in CLGCHS. In addition, response of groundwater level for precipitation was slower than those at OLGCHS because of difference of hydraulic conductivity. These results show that groundwater temperature and level did not significantly changed by OLGCHS and CLGCHS. However, it is necessary that long-term monitoring of groundwater temperature and level at sites, where OLGCHS and CLGCHS are installed, because OLGCHS and CLGCHS can affect the hydrological properties of aquifer with scale and type of use of geothermal energy. This work is supported by the Energy Efficiency and Resources of the Korea Institute of Energy Technology Evaluation and Planning (KETEP) grant funded by the Korea government Ministry of Knowledge Economy (No.20123040110010) and by the Korean Ministry of Environment under ”The GAIA project (No. 171-101-011)”.

Keywords: open loop geothermal cooling and heating system, closed loop geothermal cooling and heating system, time series analysis, groundwater level, groundwater temperature, Korea

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Impact of ground source heat pumps operation on groundwater condition

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This study was conducted to summarize status of installation of open loop geothermal cooling and heating system (OLGCHS) and to evaluate impact caused by its operation on groundwater condition. In this study, six facilities where OLGCHS is installed were considered. Groundwater is directly used in OLGCHS. The facilities considered in this study have been operated over two years. Groundwater temperature ranged from 6.0 to 24.2oC. Water temperature of natural groundwater and groundwater used to operating of OLGCHS showed difference of 5 to 9oC. pH and EC ranged from 7.5 to 9.1 and from 138 to 465 uS/cm, respectively. pH and EC of natural groundwater and groundwater used to operating of OLGCHS did not show significant difference. All groundwater meet Korean standard of water quality for domestic purpose In addition, saturation indexes of most major dissolved components except H4SiO4 showed lower than 1. These results represent undersaturated condition and that there are no minerals which can be precipitated from groundwater used in OLGCHS. Consequently, impact of ground source heat pumps operation on groundwater condition do not observed. However, these monitoring have been conducted continuously because contamination by ground source heat pumps operation can occur in any time. This work is supported by the Energy Efficiency and Resources of the Korea Institute of Energy Technology Evaluation and Planning (KETEP) grant funded by the Korea government Ministry of Knowledge Economy (No.20123040110010).

Keywords: Heat pump, groundwater, ground source

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Change of the stream discharge process affected by the rainstorm magnitude in the small headwater catchment

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Recently, because rainstorm characteristics such as total and peak rainfall is increasing along with global warming, a lot of disaster as flood and landslide has been occurring in many areas worldwide. This change might engender changes in the water resource of a particular area. Therefore, this study was conducted for the two component hydrograph separation using EC value during rainstorm event between July 2012 and November 2013 in two small adjacent forest and grassland catchments at the headwaters of the western foot of Mt. Aso, Kumamoto prefecture, southwestern Japan, aims to understand the relationship between the groundwater discharge ratio and rainstorm magnitude. EC values of the stream water were recorded at 10-min interval at each Parshall flume using EC logger. We compared our results and data which we summarized, with published literature (Onda et al.,2006; Ichiyanagi and Kato, 1998; Ichiyanagi et al.,1994; Iwagami et al.,2010; Ohrui et al.,1992; Katsuyama et al.,2000; Katsuyama et al.,2001).

We observed 18 rainstorm events of varied magnitude in which total rainfall range from 9 mm to 727 mm and peak rainfall range from 5 mm/h to 94 mm/h. As a result, we reaffirmed that the groundwater discharge ratio decreased due to increase total rainfall and peak rainfall for small rainstorm event where total and peak rainfall were less than 200 mm and 20 mm/h respectively, and agreed with previous studies. The total discharge also increased in conjunction with an increase of ”new water” component. However; increasing of groundwater discharge ratio was observed for large rainstorm event where total and peak rainfall were larger than 200 mm and 20 mm/h, respectively. In this case, the total discharge increased in conjunction with an increase of ”old water” component. Therefore, we found that the rainstorm magnitude has an impact on the formation of the peak stream discharge during rainstorm. The peak stream discharge phenomena from catchment can be classified into two stages based on previous literature and our present studies. In the first stage, stream discharge is dominated by the old water before rainstorm, but the old water component of stream discharge decrease gradually with an increase of rainstorm magnitude. As the total rainfall reach 200 mm, most of stream discharge is dominated by the new water. Under larger rainstorm events, additional stream discharge increased in conjunction with an increase of ”old water” component (the second stage).

Keywords: Two component hydrograph separation, Stream discharge process, Rainstorm magnitude, Groundwater discharge

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General discussion on insight into change and evolution in hydrology

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Fluctuations in the water and chemical cycles icluding floods, droughts, and water-quality impacts are influeced by long-term changes and/or evolutions in catchment properties and climate conditions. For example, to predict stormflow responses only from the cachment topography is difficult because the runoff mechanism is strongly controlled by bedrock-weathering and soil-evolution processes.

Such a concept of change and evolution is raised by IAHS, called 'Panta Rhei,' as its decadal intiaitive from 2013 following PUB (Predictions in ungauges basins), and the international disscussions have started.

In paralle with this activity, we are now conducting a project on dependences of rainfall-runoff responses on a temporally-nested structure of topographic, soil, and vegetation developments under the JSPS budget from 2011 to 2015.

In this session, presentaions addressing effects of natural changes and their interactions on the water and chemical cycles are encouraged, and chaneges originated from human influences including the disturbances and managements are also welcomed.

Keywords: general discussion