Japan Geoscience Union Meeting 2014
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AHW28-01 Room:314 Time:April 30 09:00-09:15

Spatial distribution and transport of phosphorus in a hillslop profile in Ichikawa City, Chiba Prefecture, Japan

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Transport of phosphorus (P) in subsoil is presumed to be minor in comparison to transport in topsoil. Three Soil columns that located at upland (agriculture land), hillslope and forest (background) were sampled in Ichikawa City (35.76^{o}N, 139.97^{o}E), Chiba Prefecture, Japan. Contents of the total P (STP), organic P (OP) and inorganic P (IP) were determined to assess the spatial distribution, origin and transport pathways of P in the soil of unsaturated zone. In unsaturated zone soil texture is in a sequence surface layer (SF), Kanto loam layer (LO), Joso clay layer (CY) and Narita sand layer (SA) of the upper part of slope profile and SF, the secondary deposited loam layer (SE), clayey sand layer (MI) and SA of the down part of slope profile. Soil samples were obtained from the slope profile at four sites (A, B, C, D). LO, CY and SA is covered the forest soil profile.

In forest soil, the contents of STP, OP and IP were 30-163 mg/kg, 5-63 mg/kg and 19-103 mg/kg, respectively. There averages in different layers were in the order: LO >CY >SA, respectively. In hillslop, the contents of STP, OP and IP were 42-1723 mg/kg, 20-1229 mg/kg and 18-839 mg/kg, respectively. The average in different layers were in the order: SF (1564 mg/kg) >SE (1349 mg/kg) >LO (494 mg/kg) >MI (492 mg/kg) >SA (91 mg/kg) >CY (69 mg/kg). There were similar changing trends between OP, IP and STP with the average in different layers. And the contents of OP were not higher than IP content in most layers, however, more than twice in SF and SE. Ratios of OP/STP in SF and SE were 63% and 64% which were similar with the ratios in topsoil of upland profile. Therefore, it is supposed that P in topsoil of hillslope was transported from upland by runoff and soil erosion. In addition, the average ratios of OP in LO, CY, MI and SA were 30-52%, lower than the average in SF and SEin hillslope profile.

STP contents of subsoil in hillslope were much higher than forest. It is assumed that there was external phosphorus loading on the subsoil in slop profile. The results indicated that P transported form the surface soil to subsoil. Moreover, there was an accumulation on the soil above CY which the depth is 2.8-3.4m than upper LO of A site. The CY is supposed to block the P transport along the profile. In SE, there was no obvious change of site B and C, showing that the soil of SE may be in saturation status of the P adsorption. And STP contents of MI and SA were lower than SE. It means there was no a great phosphorus accumulation on MI and SA. So P could transport toward to deeper stratum with soil water flow. Finally, P would be likely to enter the groundwater.

The results indicated that the contents of STP, OP and IP varied greatly in different stratum. And this study inferred that two P transport pathways. One was P transports as particulate form by surface runoff, soil erosion in the topsoil. The other one was P transports with the infiltration of soil water as soluble phosphate in the unsaturated zone. And P is likely to enter the groundwater, and would be moved towards wetland with groundwater flow, affect the ecological environment finally.

Keywords: phosphorus, spatial distribution, transport, hillslop profile

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Nitrogen budget of a headwater wetland

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As human activities continue to alter the global nitrogen cycle, understanding of the impact of increased nitrogen loading to freshwater systems is becoming more and more important. The study area is a typical headwater wetland, located at Ichikawa City (35.76oN, 139.97oE), Chiba Prefecture, Japan. The wetland valley is U-shaped with an elevation of about 16 m above sea level. The wetland receives discharge (both groundwater and overland flow) from an adjacent upland (elevation 26-31m) area with vegetation consisting of mostly pear orchard. A stream flowing through the wetland valley is recharged by spring water and groundwater in the wetland. Average flow rate of the stream all around a year is 21.7 L S-1 at the export of the wetland. The wetland is with surface area of 48000 m2, corresponding to 4.7% of the watershed. The uplands are covered by pear orchard, whereas the lowland is wetland. The average nitrate load is 501.9 mg S-1 at export of stream and average dissolved N2O load is 151.9 ug S-1 at export around a year. Ammonia and nitrite were nearly undeletable in the upland groundwater stream water in this study.

For the upland, annual nitrogen inputs refer to the sum of fertilizer application and atmospheric deposition, whereas the outputs refer to root absorption, N2O emission from soil surface and leaching of nitrogen. Nitrogen fertilizer is 346 kg ha-1yr-1 which is relative high to other studies. Annual average N deposition by precipitation over Japan was from 7 to 10 kg ha-1yr-1(with a mean value of 8.5 kg ha-1yr-1) during the past few decades (Hara, 1995). The composition in leaching nitrogen is only nitrate and the leached nitrate is 202 kg ha-1 yr-1in upland. The annual N2O emission was 5.77 kg ha-1 from the upland area.

For the wetland, annual nitrogen inputs refer to the sum of nitrate leaching from upland and atmospheric deposition of wetland. Annual nitrogen outputs refer to the sum of export by stream, and gas emission. The wetland receives 20652 kg-N yr-1 from atmospheric deposition and groundwater which recharge from agricultural upland. The nitrogen exports by stream were 15359.8 kg yr-1. The measured emission of N2O was 61.6 kg yr-1 and the calculated emission of N2 was 5218.6 kg yr-1. As a result, our estimate of N retention for the wetland watershed was 26.5%. Valigura (1996) and Whitall and Paerl (2001) estimated that N retention in urban watersheds ranges from 25% to 95%, with a best estimate of 40%. From the view of literature, the nitrate-nitrogen retention by mass was extremely low in this study. It is assumed that the high loading of nitrogen is a limit factor of nitrogen retention in wetland. The reason that the low percentage of nitrate-nitrogen retention may due to the extremely high load of nitrate input of groundwater (430 g-N m-2yr-1 or 4300 kg ha-1 yr-1). However, the nitrate-nitrogen retention was 110 g-N m-2yr-1 which is much higher than that (39 g-N m-2yr-1 and 46 g-N m-2yr-1) in study of William J. Mitsch (2005) and reach the retention level of constructed wetland.

Direct emission factor EF1 was 0.017 which is higher both than the default values of IPCC 1996 and 2006, but was still in agreement with the range of uncertainty. Indirect emission factor EF5-g was 0.003 which is much lower than the default value of IPCC 1996, whereas it was agreement with the default value of IPCC 2006. EF5-g value in this study was also consistent with the result of (0.0025) another study in Japan (Sawamoto, 2005). Ratio of dissolved N2O and NO3- in groundwater ranged from 0.00026 to 0.0157, with an average value of 0.0025. Using 0.0025 as the EF5-g value would revise the estimation of the indirect emission from this wetland, resulting of 51.5 kg yr-1. The measured emission of wetland was 61.5 kg yr -1 which is the same order of magnitude with calculated value, indicating that the method advised by IPCC could reasonable predict the indirect emission of wetland.

Keywords: nitrogen budget, dissolved N2O, wetland

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Influence of the Noboribetsu hydrothermal systems on surrounding water regions

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A variety of hydrothermal systems exist in the Noboribetsu area, Hokkaido, which produces neutral to acidic hot springs. The high δD and δO^{18} values for the hot springs suggest that they originate from magmatic water (Matsubadani et al., 1977). Also, this area, including Lake Kuttara next to Noboribetsu, exhibits high geothermal gradient of 90 ℃/km (Matsubadani et al. 2011). However, a short knowledge of the geological structure makes us difficult to discuss the whole hydrothermal systems. In this research, water and heat budgets of a boiling pond, downstream of the Ohyunuma Pond, were estimated by monitoring water temperature. As a result, the heat fluxes from the bottom of the pond were estimated at 2,482 W/m^2 and 3,360 W/m^2 for two periods. Meanwhile, water temperature of Lake Kuttara was measured vertically and continuously at the deepest point. Using the data of a TCTD profiler, the heat flux at the bottom was estimated at 1.01 W/m^2, suggesting hot water input to the bottom. Henceforth, we will explore the relations between the bottom thermal variations and Noboribetsu geothermal activity.

Keywords: Noboribetsu hot spring, Lake Kuttara, Heat budget, Heat flux, Hydrothermal system

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Nitrogen and phosphorus export to watershed from Water-Conservation Forest

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The purposes of this study are to estimate and validate water contamination of Total nitrogen(T-N) and Total phosphorus(T-P) from forest as runoff, in order to discuss policy measures for controlling non-point source loads. The study area is Doshi village in Yamanashi Pref . Total population of the are is 1,884, forest area is 7,468ha, 4,594ha of whole region is designated as Water-Conservation Forest for Yokohama City. Rest 2,823ha is private forest area for forestry.

The Water-Conservation Forest has been done thining by Yokohama Waterworks Bureau, but private forest, especially coniferous plantation area has been hardly done thining because of the decline of forestry. Therefore it is great concern that decreasing of water supply, declining quality of drinking water by increasing of sediment discharge and non-point source loads from the forest. A mean inflow at Doshi reservoir is 6.7(?/sec), Water transfer to other reservoirs from Doshi reservoir reached 3.0(?/sec), as a result of them water discharge to downstream is 3.7(?/sec). Consequently, increase of non-point source loads of nitrogen and phosphorus influence on water quality of reservoir such as Sagami reservoir and Miyagase reservoir.

Non-point source load of forest depends on surface run-off volume. To take account of this difference InVEST model (P.Kareiva et,al., 2011) is adopted for estimation of non-point source loads. Equations are shown (1)-(3):

$EXPx = EAFx * polx \prod(1-Ey)$ (1)
$EAFx = \log \Sigma Yu / \log \sum Yw$ (2)
$Yx = \sum(1-AETx/Px)Ax$ (3)

Where EXPx is non-point source loading value at pixelx, polx is the export coefficient at pixel x, y is a pixel of the upper reaches of pixel x. u means all grids located upstream of x, w means a basin including x and y. We used the export coefficients at the Fuji river basin(S.Shrestha et. al.,2007) as polx value. E_y is nutrient retention coefficient. Because of calculating E_y by comparing with result of L-Q equation, E_y is set to be equal zero. EAFx is the hydrologic sensitivity score at the pixel x which is calculated as (2). Y_x is the water yield at pixel x. P_x is the annual precipitation. AETx is the annual actual evapotranspiration on pixel x. A_x is the area on pixel x.

In addition, we made two L-Q equations to explain relation of Total Nitrogen and water discharge., Total phosphorus and water discharge based on the observed water discharge from 1956 to 2012, and water quality from 1991 to 2012.

As a result, when nutrient retention coefficient is zero, non-point source loads of nitrogen is 251.5(t/yr) and that of phosphorus is 5.9(t/yr). In these result, artificial load s of nitrogen such as household is 1.8(t/yr) and that of phosphorus is 0.1(t/yr). These results show that non-point source loads come from forest area. Results of L-Q equation are $TN=0.791*Q^{0.0616}$,(R2:0.8374), $TP=0.00762*Q^{0.0238}+0.004$. Using these L-Q equations non-point loads are 192.3(t/yr) in T-N, 2.4(t/yr) in T-P.

In conclusion, the difference of nitrogen between result of InVEST model and L-Q equation is 59.0(t/yr) 23.5%, that of phosphorus is 3.5(t/yr) 59.3%. These difference due to amount of nutrient retention functions of forest area. It is also cleared that discharge of run-off are concentrated in valleys. Therefore, we conclude that it is important and necessary that forests in valleys are managed by appropriate thining.

Keywords: Water-Conservation Forest, Non-point sources, Nitrogen, Phophorus, L-Q Equation

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AHW28-05 Room:314 Time:April 30 10:00-10:15

Estimation of hourly nitrogen flux in a suburban watershed using SWAT model

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The objective of this study is to estimate hourly nitrogen flux from a suburban watershed, using Soil Water Assessment Tool (SWAT). SWAT, which is a model developed by USDA-ARS and Texas A&M University, is a river basin-scale model to simulate the quality and quantity of surface and ground water. The model is widely used in assessing soil erosion prevention and control, non-point source pollution control and regional management in watersheds because one of the reason is that it can estimate reasonable result even if data is limited. However it is not suit for estimation of nitrogen flux in flood condition because the time step of the model is basically calculated in daily. On the other hands, the model has an option for hourly estimation of runoff if sub-daily precipitation data are inputted. So we tried to estimate hourly nitrogen flux in Takaya watershed located on Hiroshima prefecture using the option. Monthly water quality data in ordinary condition and hourly data in flood condition which are observed by authors ' group were used for validation. A result show that although the reproductively of hourly runoff was slightly decreased than daily estimation in validation period, estimated runoff peaks were fitted to observed. It was found that improvement of the model for hourly estimation of nitrogen flux, however, the result of the estimation was almost acceptable.

Keywords: Nitrogen flux, Hourly estimation, SWAT model, suburban watershed

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Trace elements fluxes and budgets in two forest watersheds

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Atmospheric deposition supplies some nutrients to forest ecosystem, serving as a source of reactive nitrogen, sulfur and the trace elements.

The objective of this study was to compare the behavior of four trace elements (Rb, Cs, Sr, Ba) in forest soil profiles in two forest sites: the Tsukuba experimental forest watershed and the Katsura experimental forest watershed.

Keywords: forest watershed, Rb, Cs, Sr, Ba

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AHW28-07 Room:314 Time:April 30 10:30-10:45

The percolation mechanism in a forested drainage basin: The Oikamanai River basin

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The rainwater movement in soils of high permeability is important to know how river runoffs are produced, and how sediment and nutrient are additionally loaded. In this study, we focus on runoff processes in the forested Oikamanai river basin, Tokachi Hokkaido. The catchment area is 62.6km2, consisting of 88.3% forest and 10.6% farmland (mostly, grassland). Surface geology of the basin is mostly Miocene conglomerate, sandstone and mudstone. These are distributed on the hillslope or in mountainous regions. Farmlands are developed on the Holocene flood plane deposits. The Miocene sedimentary rocks are supposed to be highly permeable. We set a soil moisture profiler (4 channels) at each of forested area and grassland, and calculated the amount (mm) of percolation in the rainfall events (total rainfall of more than 50mm). As a result, the amount of percolation is near to total rainfall amount, and the ratio of the percolation amount to runoff height at a gauging station was low at ca. 12% in the forested area and ca. 19% at grassland. These low values suggest that the groundwater recharge to the deep zone is great because of the high permeability of the bedrock with many faults. Meanwhile, there is a soil layer of low permeability at depths of more than 20cm at grassland. Hence, it is suggested that saturated throughflow is more active than in forested area during the rainfall events. We set one more observation point near the upstream end of farmland. We will quantitatively estimate the farmland's contribution to water discharge and nutrient load by their comparison between the upper and lower observation points.

Keywords: percolation, soil moisture profiler, nutrient, river

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The radioactivity of cesium in stream water during base flow from a small watershed in forested headwaters

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The radiocaesium was released by the accident in Fukushima Dai-ichi nuclear power plant. Although the woodland is thought to have strong tendency to maintain radiocaesium within a forest ecosystem, the very small amount of radiocaesium flows downwards through stream water. As stream water was used for agriculture and transported nutrient materials to river and lake. Therefore, radiocaesium discharged from headwaters may influence the ecosystem in river and lake or agriculture, like rice crop. In this time, we report the radioactivity of cesium in stream water during base flow from a small catchment in forested headwaters, Fukushima Prefecture.

The investigation was carried out in a small catchment (drainage area 1.2 ha) in the Tadano experimental forest of the Fukushima Prefecture forestry research center in Koriyama city, Fukushima Prefecture (Annual rainfall 1163 mm and mean air temperature 12.1 ℃; the elevation 358 to 409 m, and the relief 0.42). The geology is a sedimentary rock (sandstone and tuff). As for the vegetation, the deciduous broad-leaved species such as Quercus serratas exists together with the Japanese red pine woods in the Cryptomeria japonica and the Chamaecyparis obtusa plantation (about the 48 years old). The runoff was observed by setting up the v-notched weir and the water level gauge in the catchment end. Stream water was collected twice a month (volume; about 10L) near the weir. The radiocaesium was divided to particulate and dissolved fractions by filtration (Glass fiber filter, 0.7um). Dissolved cesium-137 was measured after concentration by extraction disk(Sumitomo 3M, Empore Raddisk Cesium)

Based on results obtained from June 2012 to March 2013, the radioactivity of cesium-137 tended to be higher in summer and lower in winter. In January and February, the radioactivity of cesium-137 was not detected, but it began increasing in March. There is a possibility that variation in the radioactivity of dissolved cesium-137 has a relation with the decomposition of organic matter according to the temperature elevation. The change in radioactivity of particulate cesium-137 was almost same way as dissolved cesium-137. This is because the discharge of suspended solid was increasing during high flow and because suspended solid concentration kept low while a catchment was covered by snow.

Keywords: radiocaesium, baseflow, streamwater, forest

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Contribution of suspended solids to the migration of radiocaesium in forests

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A wide area of forested land in eastern Japan was seriously contaminated by radiocaesium after the accident of the Fukushima Daiichi Nuclear Power Plant. In the contaminated forests, radiocaesium first trapped at the canopy and the litter layer has migrated to the mineral soil as throughfall (TF) and litter leachate (LL). TF and LL often contain suspended solids (SS) which are thought to transport the radiocaesium. The objective of this study is to clarify the contribution of the SS to the migration of radiocaesium in forests.

Throughfall (TF) and litter leachate (LL) were collected in forested slopes in Ibaraki and Fukushima prefectures. The concentration of Cs-137 of the water samples were measured by germanium detectors before and after filtration using membrane filters with pore size of 0.45 micrometer.

The concentrations of Cs-137 of the TF collected in the Ibaraki site (evergreen coniferous forest) in March and April 2011 were 14 - 60 Bq/L. In this period, the most of Cs-137 was detected as dissolved. Then the total concentration (dissolved + SS) of Cs-137 decreased and the proportion of Cs-137 in SS increased. The total concentration temporarily exceeded 20 Bq/L in the following summer season and the most of Cs-137 was detected from SS. The temporal increase in the radiocaesium in SS also observed in LL. The similar patterns of the concentration change of Cs-137 in summer observed in TF and LL at the evergreen coniferous forest and the deciduous forest in Fukushima. In winter, the total concentration of Cs-137 decreased and the migration rate also decreased. From these results, it was confirmed that the contribution of SS to the migration of radiocaesium as TF and LL in forests increased during summer.

Keywords: Radiocaesium, Forest, Migration, Suspended solid

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Water and radiocesium balance in several paddy fields in Fukushima

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1. Introduction

By the released radionuclides from the Fukushima nuclear disaster in March, 2011, brown rice harvested at a 0.2% of paddy fields exceeded the provisional regulation value in 2011 in Fukushima. Water and radiocesium balance was studied in 3 paddy fields at different geographical sites in Fukushima to estimate radionuclides contamination in brown rice and to develope models for predicting radionuclides dynamics at watershed scale.

2. Monitoring and measurements

Field monitoring has been conducted in the following three paddy fields in Fukushima since spring in 2012. ; (1) a reorganized paddy field facing to forest in one side (clayey soil), (2) mountainous terraced paddy field surrounded by forest in three sides (sandy soil), (3) mountainous terraced paddy field surrounded by forest in three sides (organic soil). Water levels and turbidity of irrigation and drainage water in paddy fields and precipitation have been measured continuously. Water infiltration rates were measured several times during rice cultivation period in (2) and (3) fields. Water samples have been collected once a month for atmospheric precipitation, irrigation, surface drainage, subsurface pipe drainage, and seepage water on a ridge between terraced paddy fields. A membrane filter (0.025μm) was used to suspended solid (SS) and filtrate samples. The radiocesium concentrations were determined by Ge semiconductor detector after drying the SS and filtrate samples, respectively. Rice which was grown experimentally was harvested and measured its radiocesium concentrations by each part. Based on the relationship between turbidity and radiocesium concentrations, and flow rates of irrigation and drainage water, radiocesium concentration in rice plant, in/out flows of radiocesium in paddy fields were estimated for the monitoring period of one year (23rd May, 2012 ˜27th May, 2013). Radiocesium in/out flows induced by heavy rainfalls of 50˜150 mm by in July and October in 2013 were also estimated.

3. Results and Discussions

Monitored precipitation was about 800,900 and 1000mm,the estimated flow-in water (irrigation(+flow-in from spring which could be measured)) was about 300, 1300 and 3300 mm, the estimated flow-out water (surface drainage) was about 600mm, 1000mm and 7700mm for the one year in the (1), (2) and (3) field, respectively. Continuous spring-out of water was observed from side slope of the upper field in (2) and (3) fields. Infiltration and spring-out were almost same level in the surface in (2) field, however, averagely about 4 mm/day of spring-out was measured from the surface of (3) field during rice cultivation period. Furthermore, water flow-in and flow-out on the soil surface under snow and/or ice was observed in winter even in the latter part of January. Therefore, larger amount of water in/out flows were gained in the mountainous paddy fields (2) and (3) in comparison with common paddy fields located in flat areas like (1) field. Radiocesium concentrations of water samples, mainly taken at usual meteorological conditions, were 0.1-0.31 Bq/L for irrigation water, 0.02-1.4 Bq/L for surface drainage, 0.2-0.9 Bq/L for atmospheric precipitation, and 0.01-0.03 Bq/L for pype drainage. Most of the radiocesium was existent in the SS. Radiocesium inflow by irrigation, inflow by atmospheric precipitation, outflow by surface drainage, and carryout by rice harvest were 10^2, 10^2, and 10^3, and 10^2 Bq/m^2 orders in the 3 fields for the one year, respectively. Radiocesium net flow in the 3 fields for the one year was estimated to be outflow of 0.2%, 0.2%, and 0.7% to the amount of radiocesium in soil, respectively. Most of outflows of SS and radiosecium occurred at events such as puddling, transplanting, midsummer drainage, drainage, and heavy rain etc.. The heavy rainfalls in July and October in 2013 induced large amount of SS and radiocesium outflows.

Keywords: radiocesium, water balance, mountainous paddy field, suspended solid

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AHW28-11 Room:314 Time:April 30 11:45-12:00

The characteristics of sediment load from a coastal forested drainage basin and their agents (2)

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Some of the five coastal lagoons in the Tokachi region of southeastern Hokkaido, open a few times per year to the Pacific Ocean. The openings affects water quality and deposits in the marine coastal region by discharging the lagoon water offshore. The Oikamanai River is a main river flowing into the Oikamanai Lagoon. The river basin is almost forested (ca. 88 % in area), from which the discharge and sediment load build up the ecosystem of the lagoon and its back marsh. In order to explore how the suspended sediment discharges into the Oikamanai Lagoon, we obtained hourly time series of discharge, Q (m3/s), and suspended sediment concentration, C (mg/L), in the upper Oikamanai River. As a result, it was found that, following the sediment availability (sediment amount to be eroded), the precedent type (peak C temporally precedes peak Q), synchronous type (two peaks synchronously appear) and antecedent type (peak Q precedes peak C) appear on the Q vs. C diagrams for sequential rainfall runoffs. The river-suspended sediment often originates from the river channels and/or basin slope. Hence, In order to judge the criterion for sediment erosion in the river channel and basin slope, the extended Shields diagram was applied to lognormal subpopulations separated for cumulative grain size distributions of river-bed sediment and basin soils.

Keywords: forested catchment, sediment load, precedent tyep, antecedent type, land collapse

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Changes of mineral composition and load of suspended materials in the Saru River, Hokkaido before and after 2003

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Supply of detrital material from river can affect the continuity, sedimentation rate, and composition of marine sediments deposited in front of the river system, which is controlled by the relief, weathering rate, and precipitation of the hinterland. In spite of the small drainage area, the small rapid rivers in the island arc located under warm humid climatic condition supply a huge amount of detrital materials to the surrounding seas. In addition, sediment transports tend to be concentrated during flooding events. In order to understand the depositional history and utilized it for paleo-climate reconstruction, it is necessary to study a mechanism of suspension generation and controlling factor of its composition.

We conducted a field survey during 2005-2011 in the Hidaka area in Hokkaido, Japan, to evaluate the influence of the flooding mud to marine sediments, promoted by the typhoon precipitation in August, 2003. We selected the Saru River as our target, and conducted the river water sampling and turbidity measurements along the main stream and a major branch called Nukabira River. Water samples were taken from the surface of flow center of each stream and stored in plastic bottles. The collected water was filtered through Millipore filter with 0.4 um opening and the suspended particles were collected and weighed in the laboratory. Mineral composition of the collected suspended materials on the filter was measured using an X-ray diffraction analysis (XRD).

Distribution of the turbidity in the Saru River drainage shows that high turbid water is localized only to the Nukabira River and others are relatively clear. The turbidity seems to be supplied only from one local source. Mineral composition of the suspended material in the Nukabira River does not contain serpentine, while the upper main stream before the junction with the Nukabira River contain serpentine. The suspended material in the lower main stream is also characterized by the lack of serpentine because of higher contribution from the Nukabira River. The surface sediment at the mouth of the Saru River also shows the same character. We also examined the mineral composition of marine surface sediments supplied as flood mud during the typhoon event in August, 2003. The flood mud contains the major amount of serpentine, which was not expected from the mass budget of suspended materials from the upper main stream and the Nukabira River under usual condition.

In order to estimate the suspension loads from the upper main stream and the Nukabira River, we compared the water discharge and suspension loads and established the rating curve for each tributary. Water discharge data for the main stream was available from the Water Information System of the Ministry of Land, Infrastructure and Transport, Japan. However, since the database contains too many missing data for the Nukabira River after 2008, we calculated the water discharge for this branch using the Hydrometeorological and multi-Runoff Utility Model (Nakada et al., 2012). As a result, the rating curve of the upper main stream is steeper than that of the Nukabira River, and the suspension load of the upper main stream could be larger than the Nukabira River at the water discharge of $>$300 m3/s. Therefore, the Nukabira River transports 5-10 times more suspended materials than the main stream during the usual discharge, which is reversed during the flooding situation.

Keywords: river suspended material, Saru River, Typhoon Etau, mineral composition

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

AHW28-13 Room:314 Time:April 30 12:15-12:30

Estimation of Sediment discharge with distributed USLE and L-Q Equation in Water-Conservation Forest

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The purpose of this study is to estimate and validate sediment discharge from forest area for providing water resources in order to discuss policy measures for controlling sediment discharge. The study area is Doshi village in Yamanashi Pref. Its population is 1,884, forest area is 7,468ha, 4,594ha of whole region is designated as forest area preserved for provision of water resource for Yokohama City. Rest 2,824ha is private forest area for forestry. The forest area preserved for provision of water resource has been done thining by Yokohama Water Bureau, nowadays the private forests are seldom do because of a decline of forestry. Therefore, it is concerned that the degradation of provision of water resources, the increase of sediment discharges volume.

To estimate the sediment discharge, we adopted USLE (Universal Soil Loss Equation) model. It considers 5 factors, R (the rainfall erosivity index), K (the soil erodibility factor), LS (the slope length-gradient factor), C (the cover-management factor) and P (The support practice factor).

We converted and integrated sets of data such as forest management plan in Doshi village, soil texture map, precipitation data analyzed by radar-AMeDAS and others to the proper dataset for utilizing GIS. The output data shows sediment discharge in 60 sub-watershed (Max:1,000ha) and in distributed 25m^2 grid. In addition, we tried to estimate more detailed information which is related to the land information, such as slope degree, land use and land cover.

Next, to validate the estimated result, we calculated the annual SS flux derived from L-Q equation, which makes correlation between the water discharge and SS density data. They were observed from 1955 to 2012 at the Doshi reservoir located down-stream of Doshi River. Based on the LQ equation, we estimated the annual sediment discharge.

As a result of evaluation with USLE, sediment discharge per year is valued 97,820 (t/yr). On the other hand, SS flux estimated 400(t/yr) [SS=1.732Q0.0238(R2=0.3223)] and sediment deposition in the reservoir is 62,500(t/yr) with LQ equation. It is known that SS load from households are valued 1.8(t /yr). Therefore the anthropogenic loads is not dominant factor in this area.

The result of USLE does not mean exported sedimentation to observation station. This indicates potential of sediment loss in each grid and their summation in total grid. The reason why sediment loss value decay in runoff process is considered to be the function of sediment retention of each grid. On the other hand, there are three dominant factors of sediment runoff from forest area.

First, more sediment runoff come from natural forest area than coniferous area. Second, more sediment runoff come from abandoned coniferous plantation area. Third, Slope factor is main reason of sediment export.

The results suggests that 1st sediment retention of in this area is able to retain 27% of total sediment discharge in this region, 2nd dominant sediment supply come from natural forest and abandoned coniferous plantation area, preservation measures to control sediment discharge are prioritize forest management in steep area.

Keywords: Water Conservation Forest, Sediment Discharge, Universal Soil Loss Equation, LQ equation

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AHW28-14 Room:314 Time:April 30 12:30-12:45

Sediment loading processes in a tectonic and forested catchment: field observations and modelling

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Exploring fluvial sedimentary processes on catchment scale is useful for studies on the forest management, material cycle and ecosystem of short time scale and topographic evolution of long scale. The fluvial transportation of sediment is also related to sedimentation, material cycle and ecosystem in coastal regions. A considerable portion of suspended sediment discharging into a costal lagoon, the Oikamani Lagoon, Tokachi, Hokkaido annually is contributed by the forested Oikamanai River catchment with many tectonic faults. It is important to find out the sediment source in such forested catchments. Here, we have tried to find how sediment load occurs by rainfall and snowmelt runoffs in the forested (ca. 90% area) catchment. Grain size and mineralogy of catchment soil and stream sediment, survey techniques, and turbidimeters provide the information that allows us to understand fluvial sedimentary processes and the sediment source and its availability. Here, a semi-distributed model, ArcSWAT2012, was applied to time series of discharge and sediment load, which were obtained in 2011 to 2013. In ArcSWAT2012, the total basin area (62.48 km^2) was divided into 3 sub-basins, as subbasin into hydrological response unit (HRU) based on soil type, land use and slope classes that allow a high level of spatial detail simulation. In this study we have used the data of discharge, Q (m^3/s), suspended sediment concentration (SSC; C, mg/L) and sediment load, L (kg/s) of April 2011 to October 2013, weather data of 2008 to 2013, and soil data. Discharge and sediment load simulations by SWAT2012 offer reasonable results. The simulations of sediment load time series and hysteresis analysis indicate that most of the sediment input is coming from sub-basin 2, especially, from its basin slope.

Keywords: tectonic, forested, sediment load, SWAT, hysteresis

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AHW28-15 Room:314 Time:April 30 14:15-14:30

Interaction properties between river and groundwater with assessment of oxygen isotope ratio and nutrient concentration

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In the alluvial fan, there are many palaeo-channels which are composed of more permeable media like gravel and sand, and many springs and wells on those have been useful for human life as well as ecosystem. These type of the springs have the different waveforms of the seasonal thermal variation from those of the river or air which is the thermal source. In detail, the phase shifting and amplitude declining are confirmed in springs. In this research, we examine to confirm the thermal waveforms in the river and springs and to estimate the horizontal bypass flow velocities in palaeo-channels around the river in the alluvial fan. The study areas are Asahi river springs in Okayama prefecture of western Japan. At the springs of Asahi River, the temperature data was collected 1 week interval. The temperature data of Asahi River springs was analyzed, assuming the subsurface water flow only through the bypath as the one-dimensional advection-diffusion equation and heat flux from the ground surface depends on the temperature gradient between the aquifer and the upper layer. The analytical solution of this equation was verified by parameter fittings with the data.

The Darcy velocity of subsurface flow was estimated about 1.3 m/day. The distribution of one-dimensional subsurface temperature in the alluvial fan was simulated that thermal conductive flux from the river exponentially decreased. The flux was mainly controlled by the advection process. In addition, the heat flux from the ground surface varied spatially from the rivers depends on the variation of the heat gradient. Especially, the flux was about 0 at several sites where heat gradient decreased.

Keywords: Surface water-groundwater interaction, Oxygen-18 isotope, Nutrient concentration, Temperature, Alluvial fan

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AHW28-16 Room:314 Time:April 30 14:30-14:45

Surface water ? groundwater interaction and its effect on nutrient transport; the example in Hachiro-gata

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We examined to confirm the surface water-groundwater interaction in Hachiro-gata of Akita prefecture and nutrient transport with the water flow. Hachiro-gata have decreased since 1960s. The reclamation land touches mainly at the east and south side to Hachiro-gata. The height of the reclamation land is lower than the lake water level. Water flow in the underground between the lake and land would have the stable direction from the lake to the land. Because the eutrophication often occurs in Hachiro-gata lake, the nutrient would accumulate in sediment. We installed three piezometers at the bankside of the lake and reclamation land, respectively. The water levels were monitored from September to December in 2013 and water samples were collected in September and December in 2013. We confirmed water flow from the lake to the land with the gradient of from 0.05 to 0.1. In addition, DOC and nutrient concentrations of groundwater were higher in the land than in the lake and lake water. The lake water has recently eutrophic condition, and so many organic matter originated from phytoplankton are deposited. The porewater in the lake bottom near the bank had the high nutrient and DOC concentrations. Based on this research, we can make a hypothesis of nutrient conversion from the lake to the land with groundwater flow.

Keywords: surfacewater, groundwater, interaction, nutrient, Hachiro-gata

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AHW28-17 Room:314 Time:April 30 14:45-15:00

Identification of flow system, sources and behaviors of major anion in a typical soil water-groundwater continuum hillsl

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1 Introduction

In the hydrological system, headwater catchments are source areas for water, nutrients, sediment, and biota for larger steams (Sidle et al., 2000). Unsaturated zone is an important pathway for nutrition leaching in headwater where baseflow dominates (Costa et al., 2002), and the leach pattern is mainly controlled by soil texture and corresponding hydraulic properties. In this study, an intensive study including soil physics investigation, long-term monitoring about the soil water and groundwater hydrochemistry and sources identification of nitrogen by nitrogen isotope are conducted to describe the conceptual soil water-groundwater flow system and discuss the factors controlling the local groundwater hydrochemistry.

2 Study area

The study area is a typical headwater catchment in Ichikawa City (35.76oN, 139.97oE), Chiba Prefecture, Japan (reference). The annual average precipitation is 1,316mm, with the maximum monthly precipitation of 226.5mm/month in study area. The annual average temperature is 15.6 oC while the highest temperature of 31.2 oC occurring in August.

3 Result

From the surface, there are sandy loam (0-1 m), loam (1-2.5 m), clay loam (2.5-3.2 m) and sandy clay (3.2-4.5 m). The porosity shows slight increases from 0.68 at the surface to 0.78 at depth of 4.3m. Due to the occurrence of the Joso clay underlying the loam, the Ks of layer below 3.2 m in depth about two orders lower than the loam and sandy loam. The vertical profile of θr changes little with an average of 0.30.

The average background values for Cl-, NO3- and SO42- were 17.64 mg/L, 0.33 mg/L and 1.52 mg/L, respectively. At the pear orchard, Cl-, NO3- and SO42- concentrations increased dramatically due to anthropogenic inputs of fertilizers. The average concentrations of Cl-, NO3- and SO42- were 32mg/L, 233 mg/L and 85 mg/L, respectively. The concentrations of Cl-, NO3- and SO42- in groundwater of the valley in average are 35.17 mg/L, 129.67 mg/L and 2.39 mg/L, respectively.

4 Discussion

Base on the soil texture of the cross section A-A, there are three flows, interflow along the slope (I), local groundwater flow (LG) and regional groundwater flow (RG), and all of them finally dischage to the valley wetland. In average, the groundwater discharging to the valley at S4 is consisted of waters from LG (43%), RG (56%) and I (less than 1%). Mixing ratios also show seasonal variations. In winter, the ratio of RG with an average of 68% is larger than LG (32% in average), which implies that lateral discharge of groundwater is the dominant factor controlling the groundwater flow in the wetland. While in summer, the contribution of LG becomes higher, and the ratio of LG has exceeded that of RG in May and July, showing the strength of recharge from the upland to LG.

5 Conclusion

An intensive study including both hydrochemical monitoring and numerical simulation are applied to discriminate pollutants sources, evaluate pollutants behaviors and predict long-term effect of soil pollution to local groundwater.

Base on the soil texture and physics investigation, three runoff components interflow (I), local groundwater flow (LG) and regional groundwater flow (RG), are discriminated in the hillslope soil water-groundwater flow system. Two anthropogenic pollutants NO3- and SO42-, which have been approved keep conservation in both soil groundwater according to isotope and redox analysis, are treated as traces to separate these components. And it is found that in average, about 43% of groundwater comes from local groundwater recharge (LG) and 56% comes from regional groundwater recharge (RG). The ratio of interflow (I) only takes up smaller than 1%.

Reference

Sidle, R.C. et al., 2000. Stormflow generation in steep forested headwaters: a linked hydrogeomorphic paradigm. Hydrological Processes, 14(3): 369-385.

Costa, J.L. et al., 2002. Nitrate contamination of a rural aquifer and accumulation in the unsaturated zone. Agricultural water management, 57(1): 33-47.

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AHW28-18 Room:314 Time:April 30 15:00-15:15

Contrasting vertical phosphorus profiles in sediment of Hachirogata ; considering water flow effect

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Coastal shallow lake sediment play an important role in the lake eutrophication process, it should be considered important sinks and sources of phosphorus. The accumulation and regeneration of sediment nutrients would be affected by some hydrological process. Lake Hachirogata is a shallow eutrophic lake located in north of Akita City. It used to be the second largest brackish water lake in Japan before the land reclamation project finished in 1977. A salt water barrier has been constructed at the outlet of the regulating reservoir through which water is discharged intermittently out to the Japan Sea. There probably exists the water flow from lake water into sediment due to the lower altitude of the farmland than lake water level after the land reclamation project. We would like to research on the sediment phosphorus accumulation and its activities base on the sediment phosphorus profiles, in consideration of the water flow effects. In order to better understand the possible change on lake phosphorus cycle by land reclamation.

Two core sediment samples were collected by piston core sampler (7-8 cm diameter), in east and west part of the lake (core HL-1 represents the core samples near river mouth area, core HL-2 represents the core samples which was collected near land reclamation area) during the investigations in September 2013. Samples were sliced at 1cm interval then centrifuged for extracting pore water soon after sampling, pore water nutrient and chlorine ion were determined in the laboratory with a spectrophotometer. The advanced SEDEX methods was used in sediment phosphorus fractionation.

Our results shows different pore water Cl^- and nutrient patterns between two locations. In HL-1 core, it shows an increasing trend of Cl^- from around 50mg/L at surface to around 500mg/L at bottom, however in HL-2 this profile shows relatively a constant range around 40mg/L. Both the DTP and DTN concentrations from the HL-1 core showed an increasing trend towards bottom, and they shows relatively constant and low in the HL-2 core, respectively. In sediment P fractionations, Iron bounded P comprise the main phosphorus species in HL-2 core, which comprises 42-72% of total phosphorus. this value is 15-28% in HL-1. Based on the dating information calculated by ^{210}Pb, it shows a larger sediment accumulation rate in HL-2 than HL-1 but with higher phosphorus burial trend in HL-1.

The sediment pore water profile shows significant change after the land reclamation project. Due to the enclosing of the sluice gate decades before, the changing from saline environment to freshwater could reflected by gradually decreasing trend of Cl^- profile towards current in HL-1. The pore water DTN DTP molar ratio shows large variations in HL-1 core. In HL-2, the low Cl^- and DTP in HL-2 provides an evidence that the diluting and transporting pore water phosphorus by water flow from lake into the sediment. On the other hand, it shows high sedimentation accumulation rate and sediment P accumulation rate in HL-2 core site, both at about 3.5 times of the HL-1 core. The supplying of relatively oxic lake water in into pore water may inhibit the iron bounded phosphorus releasing from sediment, decrease and average the mineralization process in sediment, this change in sediment could also be reflected by high phosphorus content, high phosphorus activities in HL-2 core. The increasing in sediment nutrient may be resulted from filtration by water flow into sediment, enhancing the sediment accumulation. Large mobile phosphorus trapped in sediment may increase the phosphorus releasing risk and intensify the algal bloom in Lake Hachirogata. Due to the high sediment phosphorus content and high activities in core HL-2, it would also be a considerable pollutant resources brought by water flow into coastal groundwater. The detailed results on sediment phosphorus property would be described in the presentation.

Keywords: Lake Hachirogata, sediment, pore water, phosphorus fractionation, water flow, land reclamation

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AHW28-19 Room:314 Time:April 30 15:15-15:30

Effect of DO fluctuation on the manganese cycle around the sediment water interface in bottom of the Lake Biwa

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Enrichment of Mn and As in the surface of sediment has been reported from various lakes in the world. This enrichment is generally caused by the precipitation/adsorption of MnO_2 and arsenate after upward diffusion of Mn^{2+} and arsenite. Lake Biwa is a typical example, in which clear enrichments of Mn and As within thin surface enriched layer (<2 cm) of sediment were observed. However, progressive hypoxia recently reported from the lake can induce release of these elements into water column (Yoshimizu et al. 2010, Itai et al. 2012). In order to reveal the dynamics of Mn and As in the lake bottom, we made geochemical survey through determination and speciation of Mn and As in sediment, porewater and lake bottom water. According to our estimation, total Mn and As in the enriched layer of Lake Biwa was roughly 10000 and 240 tons, respectively (Itai et al., 2012). These amounts are ca. 1800 and 12 times respectively higher than the inventory of these elements in Lake water, suggesting that releasing a portion of Mn and As from enriched layer can be a cause of large increase of these in lake water. The speciation of Mn and As in sediment determined by X-ray absorption fine structure (XAFS) indicated that predominant species of Mn from surface to 2 cm depth was MnO_2 while divalent Mn, likely ionic form, was predominant below enriched layer. Similar to Mn, oxidation state of As was gradually changed with depth, i.e., arsenate was predominant in surface, then arsenite and As in sulfide becomes predominant toward deep. These results suggested that Mn and As in enriched layer should be reduced when DO level in lake bottom becomes lower. The flux of Mn and As from the lake sediment to water column estimated by porewater profile were 3400 - 16000 and 400 - 1800 mg m^{-2} $year^{-1}$, respectively. The fluxes were higher in deeper part of the lake in which sediment character was more reducing than shallower part. With progressive hypoxia, this flux should increase. The monthly monitoring of DO and Mn level in lake water suggested that Mn level in water above 1 m of the lake floor increased from August to December with the highest level was ca. 100 times higher than the baseline level. This trend is consistent with the gradual decrease of DO during thermal stratification period. In the bottom water, the threshold DO level where apparent Mn release started was estimated to be 5-6 mgO_2/L. This value is higher compare to the inter-annual DO minimum ever reported (<4 mgO_2/L). If 40% of Mn released from enriched layer then completely mixed in whole lake, the Mn level becomes 0.6 mg/L which corresponds to lethal levels of some crustaceans and insects. Although such an extreme situation is unlikely, continuous monitoring Mn and As levels is important to safeguard the lake ecosystem and food supply.

Keywords: Lake Biwa, dissolved oxygen, manganese, arsenic, pore water, speciation

Japan Geoscience Union Meeting 2014
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AHW28-20 Room:314 Time:April 30 15:30-15:45

Current status of the research on the phosphorus dynamics in the coastal groundwater discharge area

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A large fraction of phosphorus (P) in groundwater generally exists as the dissolved form which is more efficiently used in nutrient cycle and ecosystem than the suspended form. It suggests phosphorus transport by groundwater discharge (e.g. SGD: Submarine Groundwater Discharge) significantly effects on the coastal ecosystem. In the paper, we aimed to review the previous researches related on phosphorus dynamics in the coastal groundwater discharge area and discuss on the future prospects on it.

Japan Geoscience Union Meeting 2014
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AHW28-21 Room:314 Time:April 30 15:45-16:00

Distribution and sources of uranium in Okinawan rivers, Japan

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We measured natural background concentrations of dissolved U in 194 Japanese rivers and the highest concentrations were observed in two Okinawan rivers in the limestone region, the Hija and Kokuba Rivers (Mochizuki and Sugiyama, 2012). However, the U concentrations in the earth's surface of their drainage areas are relatively low and therefore the mechanisms of U supply to these rivers are of interest. In this study, we determined U concentrations as well as major chemical compositions in 17 Okinawan rivers and estimated the sources of U supplied to these rivers.

The major chemical compositions of the rivers in the northeastern region of the island were the Na-Cl or Na-HCO_3 types, while those in the southwestern region were the Ca-HCO_3 type. The Ca-HCO_3-type composition is derived from the dissolution of limestone, which is widely distributed in the southwestern region. The U concentrations in rivers were much higher in the southwestern region (32 - 3500 ng/L) than in the northeastern region (5.6 - 18 ng/L).

In the 11 rivers with Ca-HCO_3-type compositions, the limestone-derived fraction of U was estimated using the concentration ratio of U/Ca in the limestone and the Ca concentration derived from limestone. The U concentrations were almost explained by the simple dissolution of limestone in 6 rivers, but this mechanism could not account for the concentrations in 5 rivers with higher U levels (710 - 3500 ng/L). These results suggest that the U in these 5 rivers is supplied by other mechanisms, such as selective dissolution of U from rocks in the drainage areas by carbonate ions.

Keywords: Uranium, Okinawan rivers, Limestone

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AHW28-22 Room:314 Time:April 30 16:15-16:30

Longtime behavior (<50 yr) of Groundwater Quality with Dissolution of a Ryukyu-limestone Aquifer in Okinawa Island

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Dissolution of a terrestrial limestone layer by chemical weathering is one of the most important factors affecting the carbon cycle and the transport of calcium from the land to the ocean. Residence times of sulfur hexafluoride (SF_6) and chlorofluorocarbons (CFCs), as well as their chemical composition in the groundwater, were investigated to estimate the longtime behavior of field dissolution of the Ryukyu-limestone aquifer on Okinawa Island, Japan. The Ca, (HCO_3+SO_4) and Pco_2 increase with groundwater residence time. The field dissolution of Ca was estimated to be 0.090 mM(Ca)/L/yr, with groundwater Ca ranging from 1.75 to 4.0 mM/L. The increase observed in groundwater alkalinity and SO_4 over time (0.170 meq(HCO_3+SO_4)/L/yr; 16 to 34 yr) implies that the groundwater acts as a CO_2 sink through chemical weathering of the Ryukyu-limestone aquifer when groundwater CO_2 (gas) concentrations range from 1.0% to 4.5%(logPco_2=-2 ˜-1.35 atom). The (Ca + Mg) content of groundwater was also affected by groundwater alkalinity (HCO_3), SO_4 and NO_3 derived from fertilizers used on Okinawa Island. These findings imply that the influence of fertilizer and the high partial pressure of groundwater CO_2 on the dissolution of Ryukyu-limestone aquifer may not be negligible. pH decreases with dissolution of the Ryukyu-limestone aquifer.

Keywords: Groundwater, Limestone, Dissolution, Residence time, Sulfur hexafluoride, Okinawa Island

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AHW28-23 Room:314 Time:April 30 16:30-16:45

Rapid procedure for d15N and d18O determination and identifying nitrate sources in agricultural watershed

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[1]National Institute for Agro-Environmental Sciences

The natural abundance of nitrogen (δ^{15}N) and oxygen isotopes (δ^{18}O) of nitrate (NO_3^-) can be a powerful tool to discriminate the source of NO_3^- in agricultural watersheds. This dual isotopic approach has been used successfully to evaluate the denitrification process in an upland vegetable-field dominant watershed. Recently, determination of δ^{15}N and δ^{18}O of NO_3^- has been updated using a autosampler for automatic analysis. In this study, we developed a further time-saving procedure, which advanced the time-event efficiency by controlling sample traps and 6-port valves. Moreover, the procedure was used to identify sources of riverwater NO_3^- in a rice paddy watershed in Tsukuba, Japan, where the irrigationwater was supplied from out of the watershed.

The δ^{15}N and δ^{18}O values were determined by isotope-ratio mass spectrometry (IRMS) after converting NO_3^- to N_2O gas using the denitrifier method. We conducted sample purge and determination at the same time. Our developed procedure doubled the sample throughput, saving the amount of He carrier gas and liquid N_2. It also engaged the versatile utility of IRMS, since changeover of equipment was not required. This rapid procedure can be applied to other trace gas analysis, which require cryofocus e.g. CO_2, and will contribute for GWG dynamics studies.

Using the developed procedure, we identified principal sources of NO_3^- in mainstream riverwater of the watershed. The δ^{15}N — δ^{18}O relationship during irrigation period indicated that NO_3^- in mainstream riverwater were mainly provided from mountainstream and irrigationwater, and that significant effects of denitrification on the decrease in NO_3^- concentration were locally limited at some irrigationwaters and drainagewaters in the watershed.

Keywords: agriculture, irrigation, IRMS, nitrate, stable isotope, watershed

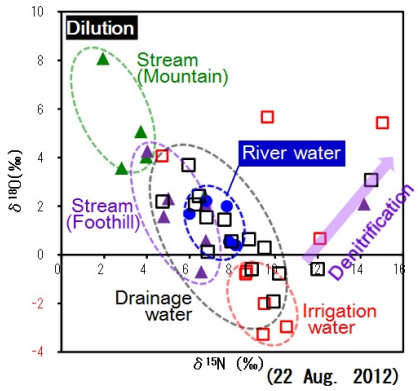

Fig.1 Identifying sources of riverwater nitrate using δ^{15}N and δ^{18}O values in an irrigated rice paddy watershed.

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Study on Effect of Rainfall Distribution and Rainfall Intensity on Discharge at The Concentration Point of The Basin

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In resent years, the damage caused by flood comes obvious because of unprecedented record-breaking rainfall event or largest recorded rainfall. Because of this situation, river planning starts to be looked at again in Japan. For example, it has been reported by MLIT (Ministry of Land, Infrastructure, Transport and Tourism) that even if total rainfall is the same when the rainfall distribution differs in a basin, the discharge at a reference point may differ (refer to MLIT). In other words, it is necessary to innovate a new intellection considering the difference of rainfall distribution when creating river planning.

This study aims to clarify the relation between rainfall distribution in a target basin and peak discharge at a reference point. The authors therefore verified how the peak discharge at a basing point responds to rainfall distribution at an intended basin. Moreover, the authors examine the impact on discharge at a reference point if rainfall intensity increases or decreases in a basin.

A target basin of this study is *Tone* upper river basin. In addition, largest recorded flood of this basin is Kathleen typhoon which 3-days accumulated rainfall is about 320mm(refer to document of Japan Society of Civil Engineers) in the basin. First, the authors separated the target basin into 4 parts (refer to document of Science Council of Japan). Then, we did runoff analysis for a number of rainfall distributions using this typhoon event as basic rainfall pattern. The conditions of this calculation are, first, average rainfall of *Tone* upper river basin is the same in every rainfall distribution. Secondly, soil condition and geotechnical condition do not change in every case. After that, we compared every peak discharge at the reference point. Moreover, the authors also did runoff analysis using a number of average-rainfall over watershed 0.8, 0.9, 1.1, 1.2 times as much as basic rainfall event. And then, we compared the peak discharge in the same way.

In consequence, the authors indicated that peak discharge at the point of reference was about from 20800m^3/s to 23800m^3/s in which case rainfall distribution differs. These range of values is $\pm$7% in contrast with basic design flood of *Tone* river. In particular, the peak discharge of the reference point becomes 22000m^3/s or more in which case heavy rainfall intensity occurred in a watershed nearby the point. Furthermore, it was found that the range of values of peak discharge grows wider as average-rainfall over watershed builds in intensity. Therefore, flood exceeding the designed level is necessary to be defined newly and exactly in *Tone* upper river basin.

Keywords: rainfall distribution, runoff analysis, peak discharge, average-rainfall over watershed

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Increasing Water Level in the Vietnamese Mekong Delta

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The Mekong Delta is highly susceptible to the impacts of flood, sea level rise, and land subsidence. We considered three factors that could have increased the water level: (1) decrease in flood mitigation functions due to dyke constructions, (2) sea level rise, and (3) land subsidence. We used daily maximum water level, daily minimum water level, and daily water level data. We analyzed data of 21 stations from 1987 to 2006. First, we classified the Delta into two groups; one area is dominated by flows from the upstream, while the other is dominated by the tide. Moreover, we obtained the trend of annual maximum and minimum water levels. Regarding land use, we used the NDVI to estimate the area of dyke construction and the area of the flood plain. It is found that (1) the constructed area of the dyke does not coincide with the area of water level increase, (2) the area with the water level increase correlates with the area with the minimum water level increase. The area with the minimum water level increase is located in the tide dominated zone, indicating that the increase in the maximum water level is caused by the relative increase of sea level.

Furthermore, we examined the trend of sea level rise, and detected a 2.4 mm/year sea level rise. The average of the minimum water level increase was 7.3 mm/year, and therefore, 4.9 mm/year must be the subsidence. In addition, we eliminated the trend of the increasing water level and reconstructed the data without sea level rise and subsidence. We estimated the probabilistic value of water level using the reconstructed data set, and estimated the probability of 100-year water level using the current data set. As a result, the 100-year probabilistic water level in the reconstructed data becomes 21.2-year water level in the current.

Keywords: Mekong delta, Increasing water level, Flood, Sea level rise, Land subsidence, Dyke