Water quality map in the lower reach of the Abe River in Shizuoka Prefecture

*Takafumi Kamitani[1], Akira Ito[1], Koichi Ooyama[1], Sayaka Ogou[1], Mitsuaki Suzuki[1], Rika Kouda[1], Noriaki Fushimi[1], Yasuhide Muranaka[1], Ki-Cheol Shin[2]

1. Shizuoka Institute of Environment and Hygiene, 2. Research Institute for Humanity and Nature

The plains of Shizuoka and Shimizu, which lie on the basin of Abe River in Shizuoka Prefecture, hold a large amount of groundwater. We summarized the quality of spring, well and river waters in the area in map for the purpose of estimating the origin and recharge area of the groundwater.
The Shizuoka Plain has a typical alluvial fan and is formed with a huge amount of gravels from the Abe River. Meanwhile, the Shimizu Plain consists of delta sediments of Tomoe River originating from the northern Shizuoka Plain. In the Shizuoka Plain, the Cl^- concentration of groundwater was lower than those of surrounding mountain areas and Shimizu plain, and in contrast, the Sr concentration was higher, indicating the same tendency as the Abe River water quality. The water isotopic ratio of the Abe River is lower than that of precipitation in the plains of Shizuoka and Shimizu, and the groundwater in the Shizuoka plain shows low water isotopic ratio as well as Abe River, indicating the aquifer of Shizuoka Plain is recharged by Abe River. On the other hand, the water isotopic ratio in the Shimizu Plain was relatively high, suggesting that precipitation in the surrounding area is the main recharge source.
The strontium isotopic ratio of the Abe River and the Warashina River is about 0.7088, which would be a value characterized by old sedimentary rocks (accretionary complex) occupying the major part of the western mountains. Spring water and well water distributed in the Abe River fan area showed the same value as Abe River. On the other hand, the strontium isotopic ratio of the river flowing from the northern mountains composed of sedimentary rocks was 0.7060, and that of the spring water originating from the mountain of volcanic rocks was specifically low value, less than 0.7040.

Keywords: Abe River, groundwater, water quality, stable isotopes

The geochemical study about the aqueous environment of Chikusa River in Hyogo prefecture

*Yudai Yamamoto[1], Ichiro Tayasu[2], Takanori Nakano[2], Urumu Tsunogai[1], Fumiko Nakagawa[1], Tadashi Yokoyama[3], Hiromune Mitsuhashi[4], Ki-Cheol Shin[2], Shiho Yabusaki[2], Tamihisa Ohta[2], Ken'ichi Ohkushi[5]

1. Graduate School of Environmental Studies, Nagoya University, 2. Research Institute for Humanity and Nature, 3. Hyogo prefectual Ako School for Students with Special Needs, 4. Institute of Natural and Environmental Sciences, University of Hyogo, 5. Kobe University, Graduate School of Human Development and Environment

The Chikusa River belongs a class B river system, which runs through the southwestern part of Hyogo prefecture. Because of heavy rain, this river sometimes flows over and its basin is damaged, so Hyogo prefecture has carried out river reforming works to improve the capacity of flow until May, 2016. But the works changed the environment of this river, the impact on the quality of river water and the river ecosystem is concerned and we need the basic data of this river to measure this impact scientifically. In this study, we analyzed concentrations of dissolved ion and trace elements, stable isotopes of water (δD, δ^{18}O), nitrate (δ^{15}N, δ^{18}O), strontium ($^{87}Sr/^{86}Sr$). In addition, we plotted the result of analysis on a basin map with a geographical information system so that the result could be seen easily and we aimed to offer the basic data which was easy to use. Furthermore, we estimated the formation factor of dissolved ion, trace elements and stable isotopes through a comparison between the result of analysis and the land use, geological features and topography of the basin.

In the Chikusa River, Chikusa River Conservation Committee has been holding “The simultaneous survey of water temperature all around Chikusa River” in every August since 2002. In this survey, the committee and many local residents measure water temperature at 94 sites, from headwaters to river-mouth and some tributaries. From 2015, Research Institute for Humanity and Nature, Kobe University and University of Hyogo has joined in this survey and started collecting water samples. In the survey of 2016 (held in August 7, 13:00~16:00), we received the water samples from local residents and we filtered them at once, with cellulose acetate filters whose diameters of holds are 0.2 μm. After filtering, we subdivided the samples into some polyethylene bottles and a glass vial and stored them at 20℃ or -30℃. We analyzed concentrations of trace elements and bicarbonate ion, δD, δ^{18}O (water) and $^{87}Sr/^{86}Sr$ 20℃ samples. We also analyzed concentrations of dissolved ion, δ^{15}N and δ^{18}O (nitrate) with -30℃ samples.

As a result of the analysis, the concentrations of dissolved ion were gradually increased from the upstream toward the downstream. From the upstream to the middle reaches, most of the dissolved ion were likely derived from the rock or the precipitation. On the other hand, the downstream and the tributaries flowing through well-populated areas, the concentrations of it were higher because of living or agricultural wastewater. The concentrations of nitrate or phosphate ion were higher from the upstream to the middle reaches and lower in the downstream. At the high concentrations points, most of them were likely derived from nitrogen load from nitrogen saturated forest areas or livestock wastewater. At the downstream, low concentrations points, the water temperature was higher, so aquatic lives became active and they likely consumed nitrate or phosphate ion.

δD and δ^{18}O were lower in the upstream and higher from the middle reaches to the downstream. From the upstream toward the middle reaches, they became lower as the altitude became higher because of the precipitation affected by the altitude effects. On the other hand, they were higher from the middle reaches to the downstream in spite of the altitude. These areas’ river became shallower and wider in the river reforming works, so the effects of sunlight on the river became big and the evaporation from the surface of river became more active. This is why δD and δ^{18}O became higher in these areas.

Furthermore, rice farming is flourishing in these areas, so the paddy water having high δD and δ^{18}O likely flowed into the river. This is also why they became higher.
There are other analysis points affected by the rock or the wastewater. We will also discuss results of these points in this presentation.

Keywords: Hyogo prefecture, the Chikusa River, river water, concentrations of dissolved ion, stable isotopes, geochemistry

Meridional distribution of isotopic composition of precipitation in the Nobi Plain, central Japan

Hiroka Yamada[1], *Maki Morimoto[1], Nagayoshi Katsuta[1]

1. Faculty of Education, Gifu University

The weekly isotopic compositions of precipitation in the Nobi Plain, central Japan was investigated in the period from August 2016 to December 2016. Rain gauges were installed at six observation sites along the 42km survey line from near the Ise Bay to inland of the Nobi Plain (Gifu city). We made simple rain gauges from 18 cm diameter funnels and wasted 2-litter plastic beverage bottles. The precision of the rain gauge is ±0.5%, that is good enough for practical use. The weekly precipitation and their hydrogen and oxygen isotope ratios obtained show clear seasonal variations from summer to winter. The north to south distribution of precipitation and their isotope ratios varied weekly and seasonally, then we classified them from their characteristics and the weather conditions. We also observed isotope ratios of typhoon precipitation collected half-hourly during the passage of typhoon Malakas on 20th September 2016, and their significant changes were discussed in relation to cyclone systems.

Keywords: precipitation, oxygen isotope ratio, hydrogen isotope ratio, meridional distribution, Nobi Plain

Stream Water Chemistry in a Mountain Forest near the Tokyo Metropolitan Area and the Impact of Atmospheric Deposition (3)

*Mamoru Maniwa[1], Hiroshi Okochi[1], Naoya Katsumi[1], Takanori Nakano[1], Manabu Igawa[2]

1. WASEDA University , 2. Kanagawa University

In the Tanzawa mountains, which is located in the western part of Kanagawa prefecture, it has been reported that fir trees decayed and surface soils were acidified. We have revealed that high concentrations of nitrate run off through stream water on Mt. Oyama (1252 m a.s.l.), which is located in the southeastern part of the Tanzawa mountains and easily affected by air pollutants transported from the Tokyo metropolitan area.
We here report stream water chemistry during the 9 years from 2007 to 2015 in the eastern Tanzawa mountains and evaluate the impacts of atmospheric deposition using stable isotopes of hydrogen and oxygen in water. Total dissolved nitrogen (TDN) concentration (the sum of nitrate nitrogen; NN, ammoniumnitrogen; AN, and dissolved organic nitrogen; DON) in stream water in the eastern Tanzawa mountains during 9 years was 1.12 mgN/L in the southeastern area on average, 0.99 mgN/L in the southwestern area, and 0.67 mgN/L in the northern area. The ratio of the TDN concentration in 2007 to that in 2015 was 0.60 in the northern area, 0.62 in the southeastern area, 0.69 in the southwestern area, respectively. TDN decreased in three areas of the eastern Tanzawa mountains, especially in the northern area. The contribution of NN decreased while the contribution of DON increased in all three areas, especially in the northern area. ANdidn't have a clear trend in all areas. Decrease of TDN was due tothe decrease of NN in stream water, which could be the decrease of atmospheric inorganic nitrogen deposition and/or the suppression of nitrification in surface soils.

The stable isotope ratios of hydrogen and oxygen in stream water on the eastern Tanzawa mountains declined with the increase of altitude. Such a tendency is also reported in surface water in Japan, and is generally due to the evaporation effect, namely light water easily evaporates as surface water runs from the upper reaches to the lower. The stable isotope ratios in throughfall of cedar at the top of Mt. Oyama were higher than those in rainfall and stable isotope ratios in stream water distributed between them. The amount of throughfall in the lowland forest is generally about 70% of rainfall amount due to canopy interception, which makes isotope fractionation occur due to the evaporation in the canopy.Then the stable isotope ratios of hydrogen and oxygen inthroughfall become heavy, but the amount of Cedar throughfallwas 1.8 times more than rainfall amount at the top of Mt. Oyama. The difference in stable isotope ratios between in throughfall and in rainfall could be due to fog water deposition because fog occurs frequently on Mt. Oyama.

Keywords: Stable Isotope, Nitrogen Saturation, Nitrate Nitrogen, Ammonium Nitrogen, Dissolved Organic Nitrogen, Nitrification

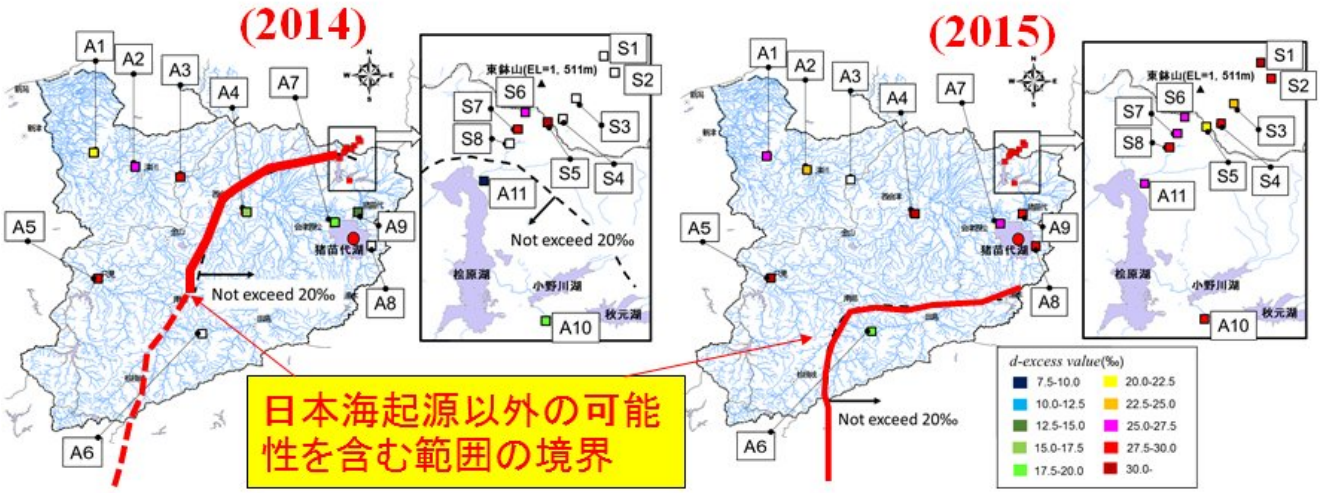
Study on regional snow distribution effect using isotope ratio

*AYAMI SUZUKI[1], SHIHO YABUSAKI[2], SEIKI KAWAGOE[1]

1. Fukushima University, 2. Research Institute of Humanity and Nature

The regional water resource managemnt is estimate difficult opreration in the future because climate change has a connection with snow variation. It is inportant to predict snow environment using climate model outputs to this solution. However this data can not use for regional water management acoording large grid size. It is necessary to develop this management to export small spatial resolution. we tried to study detail climate information using isotope ratio as tracer. The regularity to spatial feature was obtained vy chamical characteristic in this study. And we also understood water effect due to snowconditon. As result, snow depth variation changes depend on sbowfall source as spatial characteristic. Therefore, we could recognize new regularity of acid snow.

Keywords: isotope ratio, snow environment, regional scale



Role of chemical forms for transportation of metals in Tama-Omono Rivers, Akita Prefecture, Japan

*Quyen Pham[1], Daizo Ishiyama[2], Mayuko Fukuyama[1], Yasumasa Ogawa[2]

1. Graduate School of Engineering and Resource Science, Akita University, 2. Falcuty of International Resource Science, Akita University

Chemical forms of elements in river water of Tama and Omono Rivers containing acidic thermal water were determined by successive filtration technique. The chemical forms of elements were divided into the particulate (>0.2 μm), colloidal (0.004 - 0.2 μm) and dissolved (<0.004 μm) forms. This study proposes that the chemical compositions of elements in river water are controlled by variation of chemical forms of elements according to change in geology along the rivers. Tama River which is one of the tributaries of Omono River, runs through the area composed of Quaternary volcanic rocks at the upstream site through the area composed of Miocene volcanic rocks and Quaternary sedimentary strata from Lake Tazawa to Daisen City. Inflow of acidic thermal water into Tama River in upstream changes the pH of the river water to acidic and concentrations of dissolved metals into high concentrations except for Fe and As. Dissolved Fe and As easily change into colloidal and/or particulate forms in river water in upstream of Tama River. According to qualitative analyses by SEM-EDX, the reddish particulate is thought to be Fe hydroxide. Arsenic was adsorbed on the surface of Fe hydroxide. This indicates that Fe hydroxide controls the mobilization of As. The pH of river water of Tama River changes from 4.6 in upstream to 7.1 in downstream. At the downstream site, the influence of acidic thermal water becomes small due to supply of particulate material from the erosion of Quaternary sedimentary rocks. The particulate forms of Al, Fe and trace metals in river water contribute to increase of concentration of these elements. Based on observation and analyses by SEM-EDX and XRD, the particulate materials are thought to be phyllosilicate and clay minerals: chlorite, illite/montmorillonite. Uptake of Al, Fe and trace metals onto these minerals decrease concentration of dissolved metals in river water of Tama River. The amounts of Al and As that are transported by river water of Tama River decreased from upstream to downstream. This suggests that precipitation of these elements in natural lake and dam lakes along Tama River. Therefore, the natural lake and dam lakes could play an important role in reducing the environmental impact. Omono River runs through the area mainly composed of Miocene to Quaternary volcanic rocks in the upstream to the area mainly composed of Quaternary strata covering Miocene sedimentary rocks in the downstream. The difference in geology along Omono River accords with the difference in the distribution of elements in the particulate form in the river water of Omono River. At the upstream site of Omono River, Fe in the river water is present as particulate Fe hydroxides, resulting from river water mixing between Omono River having neutral pH (7.2) and Takamatsu River containing acidic thermal water of pH 3.2. Towards downstream site, reddish gravels along river bank disappear. However, concentrations of Fe as colloidal and particulate forms in the river water increase. This observation and chemical analysis by SEM-EDX and XRD suggests that these particulate materials are clay minerals. The clay minerals derived from the sedimentary rocks along Omono River could be the host of Fe as particulate form in river water of Omono River. The particulate form as clay minerals derived from sedimentary rocks increase concentration of Al, Fe, Mn and trace metals in river water of Omono River. Concentration of Al, Fe, Mn and trace metals in particulate form of river water of Omono River are higher than those of Tama River. The difference of these concentrations accords with the difference in dominance of Quaternary and Miocene sedimentary rocks between Omono and Tama Rivers. Concentrations of elements of river water are controlled by concentration of elements adsorbed on the surface of suspended particles such as clay minerals in river water having near neutral pH.

Keywords: chemical forms, acidic thermal water, river water, geology setting

Applicability of $^{87}Sr/^{86}Sr$ in examining surface-groundwater interactions in extensively irrigated paddy watersheds

*Takeo Yoshida[1], Ki-Cheol Shin[2], Takeo Tsuchihara[1], Hiroki Minakawa[1], Susumu Miyazu[1], Tomijiro Kubota[1]

1. Institute for Rural Engineering/National Agriculture and Food Research Organization, 2. Research Institute for Humanity and Nature

Repeated cycles of water diversion from and return flows to main channels have substantial impacts on the flow regimes of watersheds containing extensive areas of irrigated paddy fields. Numerous studies have attempted to decipher the hydrological processes in such irrigated areas; however, surface-groundwater interactions hinder the understanding of the fate of the irrigation water. Although the stable isotopes of water, deuterium and ^{18}O are the major tracers used to decipher hydrological processes of watersheds, these isotopes cannot be used to track the fate of irrigated water because of mixing of precipitation and irrigation water and fractionation during evaporation from water surfaces. The ratio of strontium isotopes ($^{87}Sr/^{86}Sr$, hereafter Sr ratio) can be used to complement the shortcomings of the stable isotopes of water because it has the following characteristics: (1) temporal changes in the Sr ratio can be ignored at less than geological time scales, and (2) the effects of fractionation are negligible. In other words, the Sr ratio of water will change only because of interactions with the porous media it flows through (soil/rock), or mixing with water that have different Sr ratios. Although the use of the strontium isotopes for studying hydrological processes is increasing, their applicability in irrigated watersheds has not yet been examined.

We carried out the study described here in a typical agricultural watershed located on the alluvial fan of the Kinu River, namely the Gogyo River. The aim was to examine the potential for using the Sr ratios by investigating the following: (1) the variation in Sr ratios between water sources (i.e., precipitation, irrigation water, shallow aquifer, and streamflow), and (2) the temporal variation in the Sr ratios in relation to irrigation periods. We sampled water sources in irrigated (June) and non-irrigated (October) periods and analyzed the Sr ratios and concentrations as follows: (1) 23 samples of streamflow along the Gogyo River at 500 m intervals, (2) 56 samples of shallow aquifers, (3) precipitation in June and October, and (4) irrigation water of the main irrigation channel in June.

The Sr ratios of the samples were plotted against 1/Sr concentration. The streamflow samples were plotted linearly on the diagram, and the Sr ratio and 1/Sr concentration decreased along the direction of flow, indicating that the streamflow was composed of two end-members. One potential end-members was the irrigation water, which plotted near the higher end of the streamflow plot. The other was the water from the shallow aquifer, which plotted near the lower end of the plot.

The Sr ratios of soil water within paddy fields decreased as sampling depth increased. This suggests that as irrigation water percolates into the shallow aquifer, its Sr ratio decreases as it mixes with the soil water; whereas when irrigation water drains from paddies via surface channels, the Sr ratio will be less likely to change. The continuous decline in the Sr ratio along the stream suggests a conceptual model of exfiltration of irrigated water from the shallow aquifers. The water samples in the Gogyo River during the non-irrigated period had lower in Sr ratios and higher in Sr concentrations, suggesting a relative increase in contributions of the water from the shallow aquifers.

The stable isotopes of water also supported the above conceptual model that the streamflow was composed of water originating from the surface drainage system and the shallow aquifers. For stream water samples of the Gogyo River, $\delta^{2}H$ was highly correlated with $\delta^{18}O$. The slope of the regression line was approximately 6.0, suggesting that the streamflow was characterized by water that had been

subjected to high levels of evaporation in the paddies.
Our study shows that the Sr ratio-1/Sr concentration diagram can be used to elucidate the mixing ratio of the water from the surface and subsurface flow paths. The temporal changes in the contributions of flow from each flow path over the duration of the irrigation period will shed new lights on the hydrological processes in irrigated watersheds.

Keywords: strontium isotopes, irrigated paddies, surface-groundwater interactions

Characteristics of water quality and stable isotopes (O, H, and Sr) in 15 rivers of Sado Island, Niigata Prefecture

*Takeshi Saito[1], Naoki Watanabe[2], Hiroshi Kawabe[2], Ki-Cheol Shin[3], Ichiro Tayasu[3], Ken Kawamoto[1]

1. Saitama University, 2. Niigata University, 3. Rsearch Institute for Humanity and Nature

The interactions between water and rocks during chemical weathering release water-soluble substances and form secondary minerals (e.g., clay minerals) with consumption of atmospheric CO_2. The determination of dissolved chemical substances in rivers gives us important information concerning chemical weathering processes including the weathering rate and amount of CO_2 consumption. Since the weathering processes is closely related to sediment disaster such as landslide and debris flow, it is significant to investigate river water quality for better understanding the weathering processes in detail. On the other hand, the Sado Island of Niigata Prefecture has been developed with a gold mine during the Edo Period. In recent years, Japanese crested ibis, a protected species, is steadily increasing by extensive breeding programs. The conservation of water environment in the island is most necessary to preserve natural animals and resources. Based on our investigation, we reveal the characteristics of water quality and isotopic composition (O, H, and Sr) in 15 rivers of the Sado Island. Our findings suggest that water quality and Sr isotopic composition ($^{87}Sr/^{86}Sr$) in 15 rivers were contaminated by airborne sea salt from Japan Sea surrounding the island. The values of O and H isotope ratios ($d^{18}O$ and dD) range from -9.34 to -8.44 per mill and from -53.48 to -47.87 per mill, respectively, and are affected by the average altitude of each watershed. Next step of this study is to investigate and analyze spatiotemporal variations in water quality and isotopic composition.

Keywords: Sado Island, river water quality, isotopic composition (O, H, and Sr)

Multi isotopic analysis of rainwater and inland water in acid sensitive areas

*Tatsuyoshi Saito[1,2], Masayuki Morohashi[1], Yayoi Inomata[3], Naoyuki Yamashita[4], Ki-Cheol Shin[5], Ichiro Tayasu[5], Takanori Nakano[5], Makoto Nakata[2], Tsuyoshi Ohizumi[6], Hiroyuki Sase[1]

1. Asia Center for Air Pollution Research, 2. Niigata University, 3. Kanazawa University, 4. Forestry and Forest Products Research Institute, 5. Research Institute for Humanity and Nature, 6. Niigata Prefectural Institute of Public Health and Environmental Sciences

Introduction: Acid deposition and other materials from atmosphere accumulates in ecosystem and may cause acidification of soil and inland aquatic environment. We’ ve studied about dynamics analysis and ecological impact evaluation of atmospheric deposition by sulfur isotopic analysis in high sensitivity areas for acid deposition. From 2014, we started strontium (Sr), lead (Pb), oxygen and hydrogen of water isotopic analysis for multilateral analysis by isotopic information of multiple elements. In this presentation, we outline isotopic ratio data in our study sites.

Method: Study was conducted in 2 catchments and 6 lakes shown in the figure. We collected rainwater, soil solution and streamwater in catchments and surface water in lakes. We determined Sr isotopic ratio by thermal ionization mass spectrometer (TRITON, Thermo Scientific), Pb isotopic ratio by double focusing type multi-collector ICP-MS (NEPTUNE, Thermo Scientific), oxygen and hydrogen of water isotopic ratios by water isotopic analyzer (L2120-i, Picarro).

Results and discussion: Sr isotopic ratio was determined from Dec. 2013 to Sep. 2015. In both catchments, $^{87}Sr/^{86}Sr$ of rainwater showed seasonal variation in range of 0.709±0.001 by contribution of soluble minerals (0.711±0.001) contained in continental dust in spring and sea salt (about 0.709) in winter. On the other hand, streamwater ratios were stable around 0.707 in Kajikawa and around 0.715 in Ijira, and these were widely different from rainwater. Soil solution indicated middle value of rainwater and streamwater. Sr concentration of rainwater were several μg/L even though in high concentration period, but streamwater were stable around 20 μg/L even though in lower concentration catchment Ijira. These results suggest that Sr leaching into streamwater is strongly contributed by geological Sr. In overviewing lakes data based on these results, Sr concentration of Ohataike, Oike and Banryu were around 15 μg/L, so these suggests that geological contribution is strong in these lakes. On the other hand, Sr concentration were around 3 μg/L in Yashagaike, Meike and Sawanoike which seems to be acid sensitivity is particularly high. In the case of these lakes, effect of bedrock weathering may be small and contribution of atmospheric deposition may be relatively large.

Pb isotopic ratio was determined from Apr. 2014 to Aug. 2015. In the case of $^{206}Pb/^{207}Pb$ and $^{208}Pb/^{207}Pb$, contribution of rainwater clearly appeared in streamwater ratios and response speed was also fast. Particularly in Kajikawa which catchment area is small, response time rag was shorter than one month. In plotting with two components of $^{206}Pb/^{207}Pb$ and $^{208}Pb/^{207}Pb$, all values of our study sites fit in the range of previous reported values of aerosols in East Asia (Nakano *et al.* 2006),especially plotted near range of Russia and Mongolia values.

Oxygen and hydrogen isotopic ratios of water were determined from Jun. 2014 to Jul. 2015. In both catchment areas, rainwater $\delta^{18}O$ and δD showed seasonal variations, but streamwater ratios were stable around yearly average of rainwater, so it suggests that streamwater may leach from rainwater after recharged and averaged in catchments in calm water situation. In both catchments, d-excess values of rainwater showed similar trend with variation range from 5 to 35, and effect of dry continental air masses appeared clearly in winter.

In poster presentation, we also discuss about mutual relationship between these isotopic ratios.

Acknowledgment: Samples used in this study were collected as a part of long-term monitoring of transboundary air pollution and acid deposition by MOEJ. Isotopic analysis was conducted as Environmental Isotope Study in Research Institute of Humanity and Nature. The authors thank relevant persons and organizations.

Reference: Nakano, T. *et al.* 2006. Determination of seasonal and regional variation in the provenance of dissolved cations in rain in Japan based on Sr and Pb isotopes. *Atmospheric Environment* 40, 7409–7420.

Keywords: strontium isotopic ratio, lead isotopic ratio, water isotopic ratio

High-resolution isotope analyses of annually-laminated tufa, Asama volcano

Satomi Hasebe[1], *Nagayoshi Katsuta[1], Maki Morimoto[1], Osamu Abe[2], Sayuri Naito[1], Atsushi Yasuda[3], Shin-ichi Kawakami[4]

1. Faculty of Education, Gifu University, 2. Graduate School of Enrionmental Studies, Nagoya University, 3. Earthquake Research Institute, University of Tokyo, 4. Faculty of Education, Gifu Shotoku Gakuen University

In this study, we present results of the high resolution $\delta^{13}C$ and $\delta^{18}O$ isotopes of annually-laminated tufa and its paleotufa from R. Nigori of Asama volcano, central Japan, and then examine the causes of their variations.

Keywords: Tufa, Stable isotope, Asama volcano

Evaluation of environmental stress on roadside trees in Kyoto city using stable carbon isotope ratio

*Yuko T. Hanba[1], Takashi Kiyomizu[1], Hiroki Horike[1], Saya Yamagishi[1], Etsu Yamada[1], Tomomitsu Kinoshita[1]

1. Kyoto Institute of Technology

Roadside trees have many important roles and functions such as absorption / trapping of air pollutants, preventing heat reflections of the road surface by the formation of tree canopy, and as a result, prevention of temperature rising in urban area in summer. The increase in air pollutants and atmospheric temperature by industrialization and urbanization are serious enviromental problems in Japan as well as in other industriarized and developping countries, and thus, the roles of roadside trees such as alleviating urban warming and reducing air pollutants are very important in these countries. However, many roadside trees seem to "reducing activity", e.g., fallen leaves and increased numbers of dead branches, in the summer. Our previous studies showed that the influence of air pollutants (Kume et al. 2006), as well as a combination of environmental stresses caused by soil and air drought, which are affected by urban warming, reduced photosynthetic capacity in roadside trees (Kagotani et al. 2013). However, it is difficult to evaluate the decline of the physiological activity of roadside trees from their appearance, because photosynthetic capacity often declines during the summer without any changes in their appearance. In addition, significant interspecific differences were found in the decline of photosynthetic capacity in the summer, which was about 50% decrease in *Prunus yedoensis*, contrasting the no decrease in *Ginkgo biloba* (Hanba et al. 2010). However, genetic and physiological factors inducing such interspecific differences in reduction in photosynthetic capacity have not been clarified.
In order to maximize the functions of roadside trees mitigating the high temperature of summer, it is essential to suppress "decline of activity in summer" due to combined environmental stress including air pollution and drought. In order to evaluate the activity of roadside trees, the "4 rank evaluation method" which evalluate the activity by their appearance has been widely performed (Science and Technology Agency Resource Research Committee). However, in this method, it is not possible to evaluate the roadside trees that only the physiological activity is declining. If we can distinguish the influence of environmental stress before its effect appears on their appearance, we can take measures to improve activity of roadside trees by appropriate management. Previous studies showed that stomatal closure occurs at the earliest stage among a series of reactions in response to environmental stress such as air pollution and drought stress. Since the carbon stable isotopic ratio (δ^{13}C) of the photosynthetic product in the leaf reflects the averaged stomatal pore opening, it is widely used for stress determination of natural plants. Although there is a possibility that it can be applied to plants in urban areas, there are only a couple of applications in urban areas, because there are no established methods for correcting the influence of atmospheric δ^{13}C of fossil fuels on leaf δ^{13}C (Wang et Al. 2011).
We used δ^{13}C of roadside tree leaves for major roadside trees to determine the environmental stresses on the roadside trees through stomatal closure in urban areas in Kyoto City. We focus on environmental stress such as (1) drought stress and (2) air pollutants. We performed drought experiment for major roadside trees to investigate their physiological responses. We also performed environmental monitoring and measurement of physiological functions of roadside trees in Kyoto city. The main results obtained so far are as follows. (1) In response to artificial soil drought, remarkable differences were found in physiological functions among species of roadside trees. Specifically, some species sensitively closed stomatal pores in response to drought and maintaining water content in plants, but the other species maintained photosynthetic function by stomatal closure in response to drought. In addition, one month'

drought did not affect $\delta^{13}C$ of leaves of roadside trees. (2) We selected some study sites with different air pollutant levels in Kyoto city, and the physiological functions and $\delta^{13}C$ of *Ginkgo biloba* and *Rhododendron* x *pulchrum* were examined. As a result, no difference was found between the study sites in both tomatal pore opening and leaf $\delta^{13}C$ for the tall tree *G. bilova*, but for the shrubs *R. pulchrum*, the stomata tended to close in the study site where the air pollutant level was high, with the high values of $\delta^{13}C$ in leaves. These results suggested that evaluation of the effect of long - term environmental stress on roaadside trees is possible using $\delta^{13}C$ of leaves at the site where roadside trees are being planted.

Keywords: Stable carbon isotope ratio, Photosynthesis, Stomata, Atmospheric polllutant

Influence of atmospheric pollutants on roadside trees in Kyoto city

*Saya Yamagishi[1], Etsu Yamada[1], Yuko T. Hanba[1]

1. Kyoto Institute of Technology University

Atmospheric pollutants impair physiological activities of plants. The concentration of photochemical oxidant (O_x), which is one of the atmospheric pollutants, has been increased year by year in Kyoto city from 1981 to 2015. Thus, trees growing in Kyoto city are possibly influenced by O_x. In this study, we investigated the effect of O_3 on the roadside trees. We measured O_3 concentration at three study sites in Kyoto city where O_3 concentration is expected to be different, to evaluate the physiological activities of the roadside trees in these sites.

We selected three study sites in Kyoto city, such as Omiya (35˚01'08.N 135˚75'20.E), Yamashina (34˚97'18.N 135˚81'45.E), and Nishinokyo (35˚01'83.N 135˚73'08.E). These sites were selected according to the NO_x concentration in order to compare effects of different levels of O_3 on roadside trees. The species investigated were *Rhododendron pulchrum* and *Prunus yedoensis,* which are major roadside trees in Kyoto city. Average concentration of O_3 were measured twice at study sites, using passive samplers for 7 days in early June and late November in 2016. It is expected that the trees growing in a study area with a high concentration of O_3 have more decreased physiological activity. Photosynthetic activity was evaluated by gas exchange parameters using a portable photosynthesis system, Li-6400 (LI-COR). In addition, stable carbon isotope ratios, which are indicators for long-term water use efficiency, were measured using CN-IRMS. In order to identify factors affecting photosynthetic activity, the relationship between environmental and photosynthetic variables were analyzed by Pearson's moment correlation analysis.

O_3 concentration in early July was 75.8 ppb at Omiya, 80.8 ppb at Yamashina, and 55.6 ppb at Nishinokyo. The photosynthetic rate of *P. yedoensis* measured at PPFD of 1500 μmol m^{-2} s^{-1} was significantly higher in Yamashina than those in the other study sites. The same tends were obtained for stomatal conductance (g_s). Maximum carboxylation rate of Rubisco (V_{cmax}) and electron transport rate in thylakoid membrane (J) were high in Nishinokyo for *R. pulchrum*, which suggests that biochemical activity in photosynthesis was high in Nishinokyo in *R. pulchrum*. Although there was a difference in the photosynthetic activity of these roadside trees between the study sites, correlation analysis showed that there was no correlation between O_3 concentration and photosynthetic activity. The carbon isotope discrimination in leaves of *R. pulchrum* showed high values in Omiya and Yamashina, which suggested that water use efficiency was high at these two sites.

We conclude that O_3 concentration was not related to the photosynthetic rate of the roadside trees in Kyoto city. Possibility the concentration of O_3 in the all three study sites was not so high as to affect the roadside trees.

The comparison of photosynthetic function and water status between roadside shrub trees under drought stress

*Horike Hiroki[1], Yuko T. Hanba[1]

1. Kyoto Institute of Technology University

Roadside trees are expected to play roles for CO_2 absorption and cooling by transpiration. However, plants in urban area are exposed to high temperature and drought stress condition during summer. Drought stress decreases photosynthetic rate of roadside trees because of the stomatal closure. Therefore, summer drought will affect CO_2 absorption and cooling by transpiration of roadside trees, and thus, will reduce mitigation effect on urban warming. Many previous studies have shown that different plant species show different response to drought stress. In this study, photosynthetic function, water status and carbon stable isotopic ratio in five representative roadside shrub trees under drought stress were measured to compare their drought tolerance and recovery from drought stress.
Rhododendron pulchrum, Rhododendron obtusum, Rhaphiolepis umbellate var. integerrima, Forsythia suspense and *Camellia hiemalis* were used for the experiment. Seedlings of trees were pot-grown in a greenhouse in Kyoto Institute of Technology. Drought and recovery experiments were performed sequentially. First, watering was stopped during the drought experiment. Stomatal conductance was measured several times using Li-6400 for a fully matured leaf. When soil fully dried, plants were re-watered to perform recovery experiment. A-C_i curve was obtained using Li-6400. Water potential was measured using pressure chamber in three stages: pre-drought (control), post-drought (when stomatal conductance value becomes 20%~30% compared with pre-drought value), recovery (when increases in pot weights were mostly stopped for three days). Leaves for carbon stable isotope ratio measurement were collected at each stages.
Photosynthetic rate and water potential significantly decreased in all tree species at the post-drought stage, with these values were recovered to those at the pre-drought stage. Maximum decreasing rate of photosynthesis from pre-drought to post-drought was 84% observed for *R. obtusum*, while minimum value was 55% observed in *F. suspense*. Maximum recovery rate of photosynthesis at the recovery stage was 99% observed for *C. hiemalis*, while minimum recovery rate was 67% observed for *R. obtusum.* Minimum decreasing rate of water potential at the post-drought stage was 470% observed in *R. pulchrum*. These results suggest that *F. suspense* can maintain high photosynthetic rate during drought stress, while *C. hiemalis* has high recovery rate from drought stress. R. ×pulchrum has the highest ability to maintain plant water status in post-drought and recovery stages. These results will help for the effective selection of roadside trees.

Characteristics of nutrient supply from forest areas in eastern river in Toyama prefecture read from attached algae

*Ryosuke Masuda[1], JING ZHANG[1], Saki KATAZAKAI[1], Shota Kambayashi[1]

1. University of Toyama

It is pointed out that the origin of nutrient salt flowing from Hayatsuki River located in the eastern part of Toyama Prefecture to Toyama Bay is a forest area upstream from the nitrate nitrogen stable isotopic ratio ($\delta^{15}N - NO_3$) (Zhang ·Sano , 2014). However, in previous studies, the area has remained at an altitude of 1000 m or less, and research has not been conducted on altitudes of more than 1000 m at which alpine forest areas serving as a source spread, and for multiple catchment areas. The aims of this study is to grasp the dynamics of water from the uppermost stream and to the estuary and evaluate nutrient supply.

Magnesium isotope analysis of environmental samples

*Ki-Cheol Shin[1]

1. Research Institute for Humanity and Nature

Stable isotopes (SI) is utilized as a fingerprint of an element to trace its behavior in the environment. Magnesium is a major element of terrestrial rocks and widely distributed throughout the lithosphere and biosphere. The element has been utilized to provide valuable information about geological, biological, and atmospheric processes. With the advent of multi-collector ICP-MS, it is possible to measure precise value of $^{25}Mg/^{24}Mg$ and $^{26}Mg/^{24}Mg$ in Mg solution.
To promote the environmental SI fingerprint, RIHN is desired to determine the isotope ratios of magnesium in an environmental sample with high precision and accuracy, rapidness, and convenience. Further, as biota, soil, and rock is composed of different components (bone, meat, mineral, etc.), whose magnesium concentrations and isotope ratios differ one another. Analytical precision affected sensitively by matrix component of Mg solution according to various sample processing should be evaluated.
Here, I report a simple and efficient one-step separation method and the resulting matrix component of various environmental standards samples. Furthermore, an analytical method was tested using cool plasma and hot plasma-middle resolution by environmental standards from the National Metrology Institute of Japan (NMIJ) and international rock standards (AIST and USGS) with high-resolution multi-collector ICP-MS of NEPTUNE (Thermo Fisher Scientific K. K.).

Keywords: magnesium isotope, environmental standard, cool plasma

