Multi-Isoscape approach to environmental studies

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Environmental traceability method that is comprised of multi-element and multi-isotope information, which indicate water cycling and material cycling, is applicable to the studies on the movement of living organisms and food web structure. The method is thus applicable to study various environmental issue because human beings live under the cycles. It is both important to perform basic researches on elemental cycling and to make spatio-temporal mapping.
“Environmental Isotope Study”, which the Research Institute for Humanity and Nature (RIHN) is operating, proposes co-operative research of the environmental traceability methodology using multi-elemental analysis and multi-isotope analysis. It is possible to understand relationship between local ecosystems if we can show local environmental characteristics using multi-isoscapes. It is only recently considered that research collaboration with local people, local government, and local education is important to solve environmental issue. We propose the importance of research collaboration between universities or institutes.

Keywords: Stable isotopes, Environmental traceability

Study on groundwater flow system at Oshino Village in Yamanashi Prefecture –Report 1. Characteristics of water quality and stable isotopes of shallow and deep groundwater at Oshino Village.

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Oshino Village is located in southern part of Yamanashi Prefecture, Japan. The elevation is 936 m a.s.l. and the area of village is about 8 km from east to west and about 4 km from north to south. The Oshino Hakkai springs that is registered as World Cultural Heritage Site are located in Oshino Village. It is suggested that the Oshino Hakkai springs are recharged at Mt. Fuji as a result of field observation. The objective in this study to clarify the detailed groundwater flow and residence time of springs and groundwater in Oshino Village.

The filed observation in Oshino village were carried out at 18 to 19 in January, 2017. EC, pH, water temperature and depth of water table were measured and spring water and groundwater were sampled for 72 sites. Dissolved inorganic matters, trace elements and stable isotopes of oxygen and hydrogen were analyzed by using the analytical instruments (ICS-3000, Agilent 7500cx, L2130-i).

As a result of this observation, followings are revealed.

1) Dissolved inorganic matters and $\delta^{18}O$ and δD of Oshino Hakkai springs (Okamaike, Choshiike, Nigoriike, wakuike, Kagamiike, Shobuike and sokonashiike) are mostly the same. However, the Deguchiike which is one of the Oshino Hakkai springs showsa little different water quality, it is considerate that the groundwater flow of Deguchiike is different from that of other springs of Oshino Hakkai.

2) The water quality of groundwater mostly show the Ca-HCO_3 type, but there are some sites that contain the Na^+ or Mg^{2+}. The amount of dissolved inorganic matter of groundwater are lower at central part than the other area of Oshino Village. It is expected that the different groundwater flow system is existed.

3) There are some sites of shallow groundwater that show a little high nitrate concentration. It is thought that the high concentration of nitrate is due to fertilization to farmland.

4) The deep groundwater that well depth is about 100 m and some sites of shallow groundwater show the high pH (above 8.2), and also show the high concentration of vanadium and phosphorus and relatively low values of $\delta^{18}O$ and δD. There's a high possibility that these sites' groundwater is recharged at Mt. Fuji.

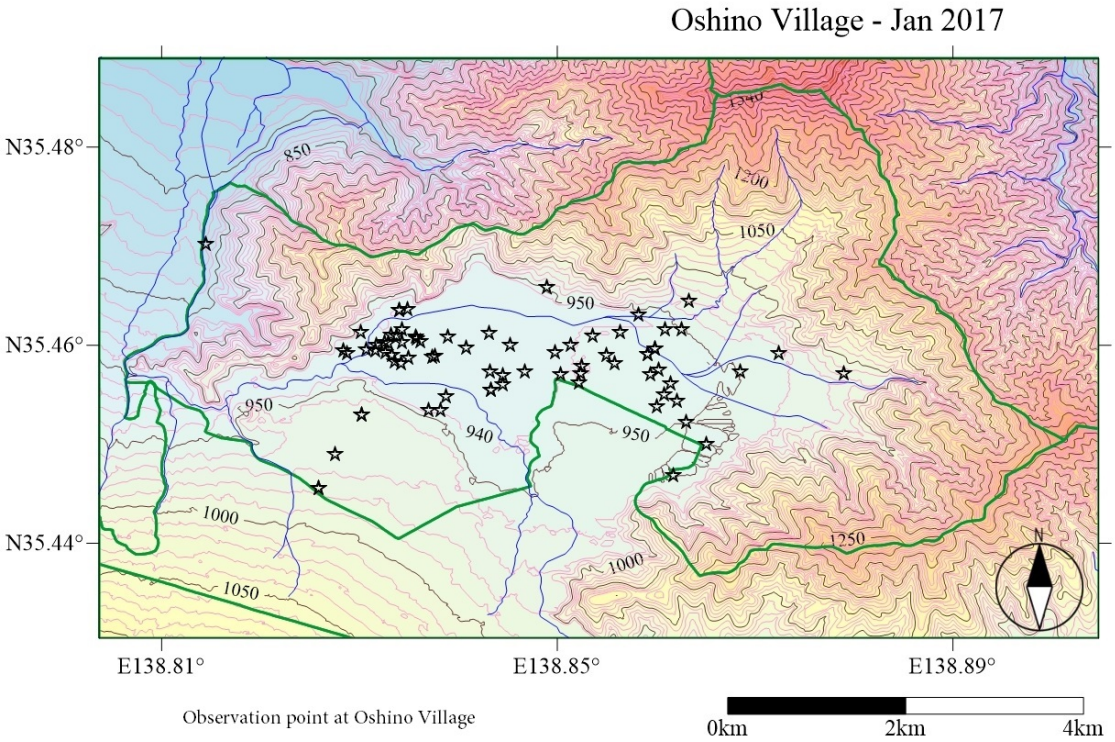
5) It is conceivable that $\delta^{18}O$ and δD values are affected by the difference of recharge area. As a result of correlation chart which showed the EC versus $\delta^{18}O$, observation site was able to divide into three groups. The regression line of $\delta^{18}O$ versus δD is $\delta D=6.2\,\delta^{18}O-5.0$ ($r^2=0.969$).

6) The artesian well which is located at northwestern part of Oshino village shows Na-SO_4 type. In this site, the water temperature is relatively high and $\delta^{18}O$ and δD is relatively low. These water qualities of the artesian well differ from other sites.

7) From the contour map of water table, the groundwater flow at Oshino Village was divided into two. The groundwater flows from southeast to northwest in eastern part and from south to north in central and western part of Oshino Village.

In future, we are going to carry out the field observation at Spring and Summer in 2017, and to estimate the groundwater flow system and residence time.

Keywords: Oshino Village, Oshino Hakkai, groundwater flow, water quality, stable isotope, trace element



Estimation of the groundwater recharge processes using end-member mixing analysis in a paddy-dominated alluvial fan, Japan

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The Tedori River Alluvial fan in central Japan has abundant groundwater resources, serving as sources of the regional drinking and industrial water. The study area is bounded by the Kakehashi River to the south, the Sai River to the north, the Japan of sea to the west, and the mountains to the east. The rice paddy and crop-rotated paddy fields occupy 45% of its total area (170 km^2). The paddy plots are irrigated from the early of May to end of August. Highly turbid water was observed in early of May 2015 and has been continued for a while. This is due to a large-scale landslide occurred at 60 km upper mountainous area from the river outlet. The landslide area has 150 m length 300 m width. Decrements of groundwater level occurred in both 2015 and 2016. The durations with the low groundwater levels were about 6 months in 2015 (from the early of May to the early of November) and 2016 (from the middle of March to the middle of September). Large decrements was observed in the middle section along the Tedori River. From the non-irrigation period, groundwater level raise up to the previous water level before the turbidity accident. Mechanisms of these groundwater fluctuations and the relationship between the groundwater decrements and turbid river water were absolutely not clear. Our study objective is to identify the mechanisms of the changes by the observations of spatial distributions and its temporal changes of groundwater qualities.

We collected 57 water samples including 33 shallow groundwater, 1 deep groundwater, 1 spring water, 11 river water along three rivers, 1 precipitation, and both of paddy irrigation water and standing water at 6 paddy plots during the irrigation period. Water sampling has been conducted with 2 months interval from April 2016. We analyzed stable isotope ratios of hydrogen, oxygen, and strontium and concentrations of major dissolved ions. We had carried out similar water samplings and analysis 4 times from 2008 to 2011. In this area, water samples from the Tedori River show the lowest oxygen and hydrogen isotope ratios and precipitation water samples show the highest. The paddy infiltration water samples show the influence of evaporation. Then, end-member mixing analysis (EMMA) were performed to estimate the contributions of each groundwater source for oxygen and hydrogen isotope ratios of shallow groundwater samples. We compared the EMMA results from the view point of temporal changes in contributions rates.

During the irrigation and non-irrigation period in 2016, groundwater recharge from the Tedori River contributed water balance of the shallow groundwater throughout the alluvial fan. In 3 km buffer area along the river, contributions of the river water ranged from 18% to 97%. Large contributions (over 60%) were calculated around the lower part of the fan. From the comparison between June in 2011 and June in 2016, contributions of river water decreased at the left side of the river, but did not significantly change at the right side. At near the right bank of the Tedori River, contributions of infiltration water from the irrigated paddy fields decreased and contributions of precipitation increased to compensate for it. Turbid water might cause siltation at paddy fields because the irrigation water is derived from the Tedori River. Groundwater recharge from the irrigated paddy fields would be reduced due to the siltation. Future work of this study is quantitative evaluations of groundwater recharge processes by a transient groundwater modeling.

Keywords: shallow groundwater, alluvial river, oxygen and hydrogen isotopes, groundwater level

Spatial variation in chemical soluble ions of the surface ice of the Urumqi No.1 Glacier, Tien Shan Mountains, China

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The chemical soluble ions on the glacier surface are important in order to understand the ecology of the microbes living there and to evaluate the characteristics of melt water and its effect on the ecosystems and local people in the downstream of the glacier. This study aims to describe the spatial variations in chemical soluble ions in the surface ice of the Urumqi No.1 Glacier located in the Tien Shan Mountains, China. We collected surface ices in the ablation area of the glacier in August 2016 and measured the water stable isotopes and the concentrations of major ions (Cl^-, NO_3^-, SO_4^{2-}, Na^+, NH_4^+, K^+, Mg^{2+}, Ca^{2+})of the samples. Based on the results, we created maps of their spatial variation using a GIS software. The results show that the water stable isotopes were relatively higher in the surface of eastern side, while lower in the western side of the glacier. This is probably due to different age of the ice accumulated on the glacier. Since the accumulation area distributed along the ridgeline from south to east of the glacier, the age of ice appears to be older in western side compared with that of eastern side. The chemical soluble ions was also not simply associated with the elevation or glacier flowline, but relatively higher in the area of eastern side of the glacier. This is also likely to be due to age of ice. In contrast, Ca/Mg ratio was generally higher in the lower area of the glacier and had a significant negative correlation with the elevation. This is probably due to additional solutes by chemical weathering of dust deposited on the glacier surface. Results suggest that the spatial variations in chemical soluble ions are mainly determined by the age and flow of the glacial ice and the additional solutes from surface dust on the glacier.

Keywords: mountsin glacier, chemical soluble ion, spatial variation

Geochemical and isotopic analyses of river waters from the Okayama and Tottori Prefectures, Japan

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In order to understand the mechanisms responsible for the geochemical and isotopic variations observed in river waters, we investigated major dissolved components, trace element concentrations, and O-H isotopes of 540 river water samples collected from 379 locations of the Okayama and Tottori prefectures. Some of these samples were also studied for S and Sr isotopes. These data were used to construct high-resolution geochemical and isotopic maps of the two Prefectures.
The O-H isotopes of the studied samples display regional variations that exceed seasonal variations. A clear altitude effect is observed in the O isotopes. The d-excess value is high in the northern Okayama and Tottori Prefectures (>20), and gradually decreases towards the southern Okayama (5~15).
With the exception of a few locations in the northeastern part of the Tottori Prefecture, the SO_4 concentration is low (<5 ppm) in Tottori and northern region of the Okayama Prefecture, and gradually increases towards the southern Okayama (>10ppm). Change in the SO_4 concentration is accompanied by shift in the sulfur isotope ratio, which converges to ~0 in the high SO_4 regions. As proposed by Nakano et al. (2008, Sci. Total Environ., 389, 132), decomposition of fertilizers used in agricultural activities may, at least in part, be responsible for this variation.
The concentrations of major cations such as Ca, Mg, Na, K, as well as trace elements (47 elements) also display regional variations, which can be classified into several groups. By comparing the geochemical maps of these elements with the geological maps, we note that the geochemical variations of some of these elements can be explained by reaction of ground water with rocks exposed in the area. On the other hand, variation of trace elements such as As, Cd, and Zn in some areas requires additional input from sources such as mine drainage.

Keywords: Okayama Prefecture, Tottori Prefecture, River Water

Information visualization for participatory multi-isoscape mapping

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Sustainable environmental monitoring in a region necessarily requires that researchers collaborate with societal actors such as governmental agencies, non-profit organizations, and residents. Such collaboration requires a boundary object as a shared upper-level goal, because different actors may have different motivation, values, beliefs, and incentive.
In water quality monitoring, the co-creation of a map, indicating the location of water sources or springs for instance, can be a boundary object between researchers and civil members. Researchers may input novel scientific knowledge, such as multi-isoscapes to the map and compare the visualized information with the local traditional knowledge, such as characteristics of groundwater in the study area. Mutual learning enables the formation of a community for continuous monitoring by civil members.
In our view, researchers can visualize the vocabulary systems using ontological engineering and can provide participatory GIS (geographical information systems) in order to promote such a participatory citizen science. This study validates the usability of these tools by applying the ontological engineering technique to the researchers' talk on multi-isoscapes and water quality monitoring in public lectures for analyzing their knowledge systems and by applying the spatial principal component analysis to multiple chemical elements of the underground water in Ohno City (Fukui Prefecture, Japan).

Keywords: Multi-isocpaces, Information visualization, Ontology engineering, Participatory GIS, Spatial principal component analysis, Citizen science

Measurement technique of the nitrogen isotope ratio of NOx collected by the filter-pack method and its application.

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NOx (NO and NO2) is quite important in atmospheric chemistry as well as in the biogeochemistry. Although natural abundance of stable nitrogen isotope is a promising tool for the the investigation of NOx dynamics in the enviornments, nitrogen isotopic measurement of NOx is quite difficult due to its high reactivity. We combine the filter-pack method (Watanabe et al. 2006) to capture NOx with the denitrifier method (Sigman et al. 2001) to measure nitrogen isotopic signature of NOx in the actual enviornments.. We found that the filter-pack method can be applied for atmospheric NOx samples including the soil-emitted NOx. We present our preliminary data obtained from the field and discuss the limitation and possibility of our filter-pack method in the presentation.

Keywords: d15N, NO gas, denitrifier method

Using environmental tracers to evaluate dynamics of nitrate sink in Japan Sea stratovolcano areas.

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Atmospheric deposition of nitrogen transported from the East Asia is modifying terrestrial ecosystem of Japan. Although increasing trends of nitrate concentration are reported in several rivers facing to the Sea of Japan, there are little long-term data on the relationship between atmospheric nitrogen deposition and nitrate concentration of stream water. To clarify the relationship, we have retrospectively evaluated the impact of atmospheric nitrogen deposition on three watersheds (Site A: Mt.Daisen, Site B: Mt.Haku, Site C: Mt.Chokai) by using nitrate triple oxygen isotope ($D^{17}O$) and sulfur hexafluoride (SF_6) in spring water and groundwater.

Keywords: nitrogen deposition, eutrophication, triple oxgen isotope, Sea of Japan

Recovery of stream water from acidification due to declining atmospheric sulfur deposition in a Japanese cedar forest near the Sea of Japan

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Introduction: Atmospheric environment in Northeast Asia has been dynamically changing recently. Although SO_2 emissions in China peaked in 2006 and started declining thereafter, emissions of N compounds and related air pollutants have still been increasing. As shown in previous studies in Europe/North America, decline of S deposition promotes recovery of ecosystems from acidification but its process is not uniform. Since the deposition in Asia has just started declining, response of ecosystems should be studied as one of the current subjects in biogeochemistry. In this paper, in addition to the long-term monitoring data, isotopic analysis was applied to discuss the recovery process of ecosystems from acidification due to declining S deposition in a forested catchment.
Methods: The Kajikawa site (3.84 ha) was established in a small catchment within a Japanese cedar plantation in Shibata City, Niigata Prefecture. Rainfall outside the canopy (RF), throughfall and stemflow (TF+SF), and stream water (SW) have been collected biweekly or monthly since January 2002. Discharge of the stream water was measured continuously using the weir. The pH, electrical conductivity, alkalinity (only for SW) and major ions were measured for the water samples. Additionally, soil solutions have been collected since 2012, and then measurement of the sulfur isotopic ratio ($\delta^{34}S$) was started. Moreover, isotopes in Sr, Pb and water (H and O) were also measured for part of the water samples. The water year (WY) in the site was defined from June to May in the next year.
Results and discussion: Fluxes of SO_4^{2-} by RF and TF+SF increased in winter with those of Cl^- and Na^+. This suggested that the area suffered from long-range transported air pollutants due to seasonal winds through the Sea of Japan in winter. The long-term data indicated that the annual flux of non-sea salt SO_4^{2-} by TF+SF started declining after the peak in WY 2006/2007, reflecting the sulfur emissions in China. SO_4^{2-} concentrations in SW declined significantly, and pH and alkalinity increased. This may be the recovery process from the past acidification. The $\delta^{34}S$ values in RF and TF+SF were also lowering in summer (ca. 4‰) and increasing in winter (ca. 12‰). In winter, the rainwater may be affected by high-$\delta^{34}S$ sulfur derived from sea-salt (20.3‰) and coals in China (6.6‰: Ohizumi et al. 2016). On the other hand, the $\delta^{34}S$ values in SW were stable (ca. 9‰). The annual weighted mean $\delta^{34}S$ value in RF was also around 9‰. According to the input-output budget until WY 2013/2014, approximately 76% of the sulfur input was discharged into SW in the study catchment. The $\delta^{34}S$ value in RF and SW suggested that the sulfur input was once cycled and/or retained in the soil-plant system and then the isotopically homogenized sulfur was discharged into SW. Therefore, in the recovery process, the circulation/retention in the plant-soil system may sensitively respond to decline of the sulfur input. In seven lakes monitored by the Ministry of the Environment of Japan (MOEJ), similarly, SO_4^{2-} concentrations started declining after peaks in 2006/2007/2008, and the $\delta^{34}S$ values were stable without seasonality. This suggests that inland water in Japan sensitively responded to decline of the atmospheric sulfur input. In the presentation, results of other isotopic measurements will also be discussed.

Acknowledgements: The surveys in Kajikawa site were conducted under approval by Niigata Prefecture and assisted by the manager, Mr. Takanori Funayama. Monitoring on lake water and part of isotopic measurements were conducted as the Long-term Monitoring on Transboundary Air Pollution and Acid Deposition by MOEJ. Isotopic measurements of elements other than sulfur were conducted as Environmental Isotope Study in Research Institute for Humanity and Nature. The authors thank relevant persons and organizations.
References: Ohizumi, T. et al. 2016. Atmospheric Environment 140, 42-51.

Keywords: sulfur, acidification, recovery

Origin of Sulfate Ion in Precipitation of Chugoku District Estimated by Sulfur and Oxygen Isotope Ratios

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Origin of Sulfate Ion in Precipitation of Chugoku District Estimated by Sulfur and Oxygen Isotope Ratios

We have sampled monthly precipitations at 6 sampling sites in Tottori and Okayama Prefecture in order to observe seasonal and secular change of cross-border pollution from mainland China. We have measured chemical composition, H-O and Sr isotope ratios of precipitation, and S isotope ratio of sulfate ion. Origins of sulfate and their contribution to sulfate ion in precipitation has been estimated using S isotope ratio. In this study, we measured O isotope ratio of sulfate ion to try to restrict the origin of sulfate ion more accurately.
Oxygen isotope ratio of sulfate ion was measured by TC/EA-IRMS. Barium Sulfate precipitated from precipitation occludes nitrate ion and cannot be used directly oxygen isotope measurement. It is purified by dissolving using chelating agent (DPTA) and re-precipitation. Remaining DPTA is removed by heating at 450˚C for 3 hours. Purified barium sulfate is used for oxygen isotope analysis.
Measured isotopic ratios are the mixture of isotopic ratios of seawater sulfate, sulfate resulted from fossil fuel combustion (coal combustion in China and petroleum combustion in Japan) etc. Non-seawater sulfate (nss) oxygen and sulfur isotope ratios of sulfate ion were calculated using chemical composition of precipitation, and oxygen and sulfur isotope ratios of seawater. In a plot of oxygen isotope ratio vs. sulfur isotope ratio, the measured results split into three groups. Group A includes winter high $\delta^{34}S$ group ($\delta^{18}O \approx 7‰$, $\delta^{34}S \approx 7‰$), which is influenced by Chinese coal combustion. Group B includes summer low $\delta^{34}S$ group ($\delta^{18}O \approx 7‰$, $\delta^{34}S \approx 2‰$), which is mainly influenced by Japanese petroleum combustion. Group C includes intermediate $\delta^{34}S$ and high $\delta^{18}O$ group ($\delta^{18}O \approx 15‰$, $\delta^{34}S \approx 4‰$) in March. Nss-Sr isotope ratio of group C is highest among samples, indicating the contribution of soluble component of yellow sand. Thus, high $\delta^{18}O$ of group C may be due to the soluble sulfate ion of yellow sand. Measurement of $\delta^{18}O$ for soluble component of yellow sand is necessary to prove this hypothesis. Unfortunately, oxygen isotope ratio of sulfate is found not to be a good indicator to discriminate between sulfate from Chinese coal combustion and that from Japanese petroleum combustion.

Keywords: precipitation, Chugoku district, Sulfate ion, S isotope ratio, O isotope ratio

Geographic variation of Japanese cedar (*Cryptomeria japonica*) may have a different effect on soil ecosystem

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Soil organisms can be affected by differences in aboveground vegetation, often driven by the chemical quality of the soil and litter. *C. japonica* is the most popular plantation tree species in Japan, and plantations of *C. japonica* account for 12% of the total land area in Japan. *C. Japonica* has many geographic variations such as Yakusugi and Yoshinosugi, and has been planted at each provinances. Our previous studies showed plantation of *C. japonica* affect community structure of soil invertebrate by altering calcium availability in soil. However, we have not estimated whether the effects of plantation on soil organisms vary depend on the geographic variation. In Wakayama Experimental Forest, Hokkaido University, there are common gardens that planted various provenances of *C. japonica*. We investigated the soil solution and leaf litter chemistry, root exudation rates of organic acids and soil invertebrate community, and we compared between plots that planted a different provenances of *C. japonica* (Yakusugi, Yanasesugi, Yoshinosugi and Itoshirosugi). Our results showed the diversity of soil invertebrate and concentrations of essential nutrients (calcium and phosphorus) in soil and litter significantly higher at the plot where native provenance, Yoshinosugi, was planted. Furthermore, root exudation rates of organic acids were also significantly higher at the plot where Yoshinosugi was planted. Supply of the organic acids from root systems of tree can alter dynamics of soil nutrients. Therefore, variation of rhizosphere environment might create differences in soil nutrients availability and soil invertebrate community.

Keywords: Soil invertebrate, Calcium availability

Ecology of collembola (springtails) living on seasonal snow in the deciduous forest in Yamagata Prefecture, Japan

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There are diverse organisms living in snow and ice environments. They are adapted to cold temperature, thus they are active and growing on snow and ice. For example, snow algae, heterotrophic bacteria, and insects can be found on snow fields in Japan. Collembola is one of the typical insects living on snow surface. However, their ecology is still not well-known. It is important to understand the ecology of such organisms for quantification of the carbon and nitrogen cycles in the snow and ice ecosystems.
In this study, we investigated life history and food resources of the collembola living on the snow surface in the deciduous forest in Yamagata Prefecture in Japan. We described their population density and body size on the snow surface. We also analyzed their carbon and nitrogen stable ratio to identify their main food resources. The study site is located at 750 m a.s.l. in elevation close to Mt. Gassan (altitude). The collembola specimens collected there were mostly *Desoria yukinomi*, which is common species living on snow surface. They were also found in a trunk of trees in the season without snow (Octorber), suggesting that they migrate seasonally between the tree trunk and snow surface. The carbon and nitrogen stable isotopes of the collembola showed generally low nitrogen isotope values. The nitrogen isotope of two species of lichens, grown on a trunk of trees, was lower than that of collembola, suggesting that they are most likely food source of collembola.

Keywords: Snow and ice organisms, soil organisms, carbon stable isotope, nitrogen stable isotope

Stable isotope ratios of Sr, Nd and Pb as environmental traceability index

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The stable isotopic ratios of Sr, Nd and Pb in environmental and artificial materials reflect the regional values of rock minerals and ores which are their origin. In this presentation, I introduce recent examples applied to atmospheric and terrestrial environments of Sr-Nd-Pb isotopes, which have been used in geological studies.
The isotope ratios of Sr, Nd, and Pb in Asian dust are known to differ depending on the particle size and constituent minerals and also to differ from those of coal ash and road dust. It also becomes clear that the Sr-Nd-Pb isotopic ratio of wet precipitation in Japan changes both locally and temporally, and the weak-acid soluble substances in the atmospheric aerosol have Sr-Nd-Pb isotopic ratios which are similar to the wet precipitation but are different from the acid-insoluble substances. These information suggests that the Japanese atmosphere is contributed by a variety of transboundary substances from the Asian continent as well as the substantial amounts of domestic substances. The areal and temporal change in the Sr-Nd-Pb isotopic ratio of the atmospheric precipitation is different from the sulfur isotope ratio, suggesting that the emission area and the atmospheric behavior of primary particles containing Sr, Nd, and Pb is different from secondary particles containing sulfur.
The Sr-Nd-Pb isotopic ratio of the atmospheric fallout is effective for the discrimination and of elements from basement rock, Asian dust, and volcanic ash, which are the source materials of Japanese soil. While the Sr and Nd isotopic ratio of river water and plants changes in accordance with the basement geology, the Pb isotopic ratio reflects the value of atmospheric fallout. Sr-Nd-Pb isotopes can be used as a traceability index of environmental materials and agricultural products. The Sr isotopic ratio of Japanese vegetables tends to be low in Northeast Japan and in the central and southern parts of Kyushu, where volcanic materials of Neogene-Quaternary time are dominant, while to be high (>0.708) in Southwest Japan and especially in the Kinki district, where Jurassic and Cretaceous-Paleogene accretionary prism and Cretaceous granitic rocks are widely distributed, However, the contribution of Sr from fertilizer is obvious in Japanese vegetables, suggesting that stable isotopes of Sr as well as Nd may be used for artificial impact assessment like Pb isotopes. In order to advance Sr-Nd-Pb isotopes as environmental traceability index, distribution on the Sr-Nd-Pb isotopic ratio for river water and groundwater are indispensable.

Keywords: Stable isotopes of Sr, Nd and Pb, traceability index, atmospheric environment , soil and vegetation ecosystem, product area identification of vegetables

Nd isotopic variation of seawater along the Pacific coast of Tohoku district and its causal factor

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Nd isotope ratio of seawater is known to vary between regions or water masses in the ocean. This contrasts to the fact that Sr isotope ratio of seawater is quite homogeneous. Therfore, Nd isotope ratio has the potential to become an effective tracker of marine animals or marine products. However, Nd isotopic variation in coastal sea region is not investigated well compared to that in global scale. In this study, we investigate the alongshore variation of the Nd isotope ratio of seawater and its causal factor at the Pacific coast of Tohoku district, northeast Japan, of which hinterland is composed of varied geology.
The Nd isotope ratios of seawater samples, which were taken from 14 coastal sites located between 38.17N and 40.55N, vary from -8 to +1 in ε_{Nd}. These values are well correlated (r=0.72) with Nd isotope ratios of river water samples taken from the adjacent river of each coastal site, which ranges from -8 to 2 in ε_{Nd} . This indicates that the ε_{Nd} of coastal seawater is largely defined by the value of land water. On the other hand, the range of Sr isotope ratios of seawater samples is quite narrow and high (0.70916 to 0.70919) despite that the value of river water ranges widely from 0.7055 to 0.7085. The Nd isotope ratios of seawater and water of the adjacent river differ from each other in most sites although they are correlated significantly. Nd contribution from offshore seawater should be considerable. Mixing of river water and offshore seawater of Tohoku district (-4 to -3 in ε_{Nd}; Amakawa et al, 2004) is consistent with the linear regression expression of ε_{Nd} of seawater to that of river water (y=0.65x-0.83).
Contribution of land water is suggested to be limited to nearshore regions. Surface seawater samples were taken along an offshore-directed line from the Abukuma River mouth in December 2015 (winter) and July 2016 (summer). Nd isotope ratios in summer were almost uniform around -9 in ε_{Nd} in the interval between 2km and 60km from the shore, whereas in winter it increases offshore from -6 to -2 in the interval between 35 km to 60 km from the shore. The ε_{Nd} of about -9 is considered to be that of the Kuroshio Current (Amakawa et al., 2004), which dominates in summer at the region, whereas that of -2 is consistent with the value of the Oyashio Current (Amakawa et al., 2004). On the other hand, the ε_{Nd} of the Abukuma River water (-2.9) is not reflected even at the site only 2 km apart from the shore. In spite of this regional limitation, Nd isotope ratio can newly provide a tool to trace animals and products at least in coastal seas.

Keywords: Nd isotope ratio, seawater

Using Sr isotopes to determine the contribution of volcanic ash to Sr and Ca in stream waters, a preliminary study in a chert watershed.

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The sources of Ca in Japanese forest ecosystems have been assumed to be sea salt, bedrock, and Kosa (Asian dust). Volcanic ash may also be an important contributor of Ca in volcanic areas. In our previous study (Koshikawa et al. 2016), an attempt was made to estimate the contribution of volcanic ash to Sr and Ca in stream waters and plants in a granite watershed. The fraction of atmospherically derived Sr in the stream water was evaluated using Sr/Cl ratio of stream water and atmospheric precipitation. Then, the fractions of Sr in stream water derived from granite and volcanic ash were estimated using Sr isotope ratios. The results confirmed that information about the Sr-isotopic composition is useful for determining the sources and contributions of Sr and Ca in stream waters and plants, even in complex systems containing volcanic ash and bedrock weathered products. Now, we are planning to apply this estimation to other regions where the Ca supply from parent materials is anticipated to be low. In this study, we report Sr isotope ratios of stream waters in a chert watershed, Mt. Amemaki (Tochigi, Japan), and a preliminary estimation of the contribution of volcanic ash to Sr in stream waters.

Keywords: Volcanic ash, Sr isotopes, Stream water, Ca sources, Chert

Assessing strontium isotope mixing model to reveal human diet and migration of the Jomon period

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Strontium isotopes are a useful tool to reveal past human migration directly from the skeletal tissues of human. Although strontium isotope ratios of skeletal remains from Yoshigo and Inariyama shell mound of the Jomon period were revealed, the concentrations of strontium and its relationship with the isotope ratios were still unclear. This study investigated the concentrations of Sr against Ca of teeth and bones from the Yoshigo and Inariyama shell mound. The concentration of Sr were highly varied in enamels and bones, and the relationship between the concentrations and Sr isotope ratios in enamels suggested several sources of Sr. The concentrations of Sr were high and showed small variation of Sr isotope ratios, suggesting significant diagenetic alteration. The results of this study indicated that the utility of measuring strontium concentrations in addition to strontium isotope ratios is important to reveal past human diet and identify migrants in human population.

Keywords: Isotope, Strontium, Bone

Food web analysis of Toyama Bay and seasonal changes of zooplankton: Using stable carbon and nitrogen isotopic ratios

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The isotopic ratios of stable carbon and nitrogen can be a key to finding out the influence that the environmental changes such as rising seawater temperature have on marine food web. The main aims of this study were i) to explore the food web in Toyama Bay, which has separate water masses in the water depth shallower than approximately 200m and deeper than that respectively, and ii) to analysis primary producers by measuring zooplankton. Aquatic samples of fishes and zooplankton inhabiting in the two layers of water were collected in offshore Toyama Bay as well as sinking particles organic matter, sedimentary organic matter and POM (particulate organic matter). We also collected sample of zooplankton from Yamato Basin in the Central Japan Sea, and NYUZEN DeepSeaWater Park in order to analyze the stable carbon and nitrogen isotopic ratios.
Both on the analysis of these isotopic ratios, we reached the following findings. Aquatic creatures in Toyama Bay are located on a food web starting from POM and phytoplankton is the primary producer of both the shallow water and deep water creature. The $\delta^{13}C$ values of zooplankton collected in Toyama Bay were higher than those from Yamato Basin. It is suggested that this is because the growth rate of the phytoplankton in Toyama Bay is faster than that in Yamato Basin. The $\delta^{15}N$ in zooplankton depleted with the increase of the nitrate concentration in the surface seawater, and $\delta^{13}C$ enriched with the increase of chlorophyll*a* concentration in the surface water. Thus, it is considered that the $\delta^{15}N$ value reflects the supply of nitrate and the $\delta^{13}C$ value reflects the growth rate of phytoplankton.

Keywords: Stable isotope ratio, Toyama Bay, Zooplankton

Reconstruction of stable isotope chronology by asegmental analysis of bone.

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Isotope analysis is a powerful tool in ecological studies of animals for reconstructing their dietary sources, trophic positions, and movements. One of an important point to apply stable isotope analysis in ecological study is the timescale of the isotopic records in the target tissue, because different tissues have different turnover time of stable isotope elements.

For instance, stable isotopes in blood plasma of animal reflects information in shorter timespan which is 1 to 2 weeks, whereas that of muscle records isotopic information of last 1 to 2 month. Most of previous isotope studies focused on a single tissue and timeframe, and compared the differences of isotope values among individuals or populations within the same timescale. However, the utility of isotope analysis would be greatly improved if we could reconstruct the history of isotope values at multiple growth stages of animal using single tissue.

In this presentation, I present a new analytical method to reconstruct isotope chronology of multi-isotope elements by segmental analysis of bone of teleost fish and mammal species. I also show the validity of this method by incremental sulfur stable isotope analysis for an anadromous salmon, masu salmon (*Oncorhynchus masou*), and incremental radiocarbon analysis for mammals which lived in the end of 20th century. If this method correctly reconstruct stable isotope chronology of these species, I can detect isotopic information in their early life stage from their bone sections.

In all samples of masu salmon, the bone section closest to the center of the vertebral centrum had the lowest sulfur isotope ratios, which were similar to those of freshwater. The sulfur stable isotope ratios gradually increased from the center to marginal sections, finally reaching constant values similar to those of seawater. For this reason, my results show that the vertebral centra of teleost fish record isotopic information from juvenile to adult life-stages. In mammal, radiocarbon isotope ratios in later age have been detected from center and margin of femur, whereas other parts showed isotope values in former age. The result showed that the central part of femur is the subject of bone metabolisms and thereby the turnover of bone influenced the radiocarbon values in the central part of the bone. However, we also confirmed that there are few effect of turnover in the other part than central part of bone, and this method can be used for the reconstruction of stable isotope chronology of mammal species.

Keywords: stable isotope, bone, chronology

