

Development of multi-tracer of water toward Asian geo-isoscape study

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Research Institute for Humanity and Nature (RIHN), an Inter-university Research Institute Corporation, aims to elucidate the linkage of interactions between human activity and natural environment. Most elements have stable isotopes (SI), which are known to be powerful as a tool to promote this linkage study. RIHN has been establishing an analytical system to get multiple SI information, and will assure the proper use of this system and support its accessibility in order to propel cooperative studies through RIHN and related projects. As such an attempt, RIHN starts the geographical mapping of multiple SI and elements for environmental materials in collaboration with local universities and research institutions.

Quality of fresh water is a function of human activities and natural environment such as industry, climate, geology, vegetation, and so on. The concentrations of dissolved elements and the ratios of SI in groundwater and surface water at base-flow periods are temporally stable, while they are spatially variable. This indicates a potential that the water quality can be served as indexes to characterize the local environment and the traceability information of ecosystem and biological body since water is indispensable for the life of biota and the ultimate source of most elements in biota is attributable to water. Accordingly, the geographical map of SI and dissolved components in fresh water is fundamental for environmental studies such as water circulation, pollution, ecological and health risk, source identification of agricultural products and food, which are main problems of global environment to be solved urgently. However, in order to apply the water-quality map for water management and to extend it for exploring a new science, SI researchers should cooperate with local autonomies and citizens and with scientists of other disciplines, respectively. Building the data-base system of SI in different spatial scales is also prerequisite for these purposes. I will introduce an application example of this map into environmental diagnosis and water management in Saijo city of Ehime prefecture and its extension to joint studies in Japan and East Asia through RIHN projects.

Saijo city is known to be rich in groundwater of good quality and uses the water for drinking, agriculture and other industries. By working with municipal organization, we collected more than 1000 samples of groundwater and 400 samples of surface water in the city and determined the compositions of 50 elements and stable isotopes (H, O, S, N, Sr, and Pb). Comparison of both waters have elucidated the impact of atmospheric deposition to the surface water, the recharging area and flow route of the groundwater, and human impacts of the two waters (nitrate pollution by excess use of fertilizer, salt intrusion by over pumping, antimony pollution by abandoned mine, industrial waste disposal etc). For example, map of water isotope ratios and chlorine concentrations have successfully visualized the flow direction of groundwater from its recharging area. Based on this map, we started the biweekly to monthly monitoring of water quality over three years, which have shown the geological structure, flow rate, and salt intrusion process of groundwater.

In order to enhance environmental literacy of citizens, we have been returning obtained results into Saijo citizens through symposium and book. The SI map can contribute to studies of food-web analysis, identification of habitat of plant, trace of animal behavior as well as social problems of the source identification and false description of food. This collaborative map study is conceptually analogous to isoscape project in U.S.A. The water quality map shows a wide geographical variation of multiple tracer components in different scales. RIHN calls for universities and research institutions to join this map study, which aims to explore an academic seed and meet social needs for environmental management.

Keywords: water-quality map, stable isotope, water management, environmental diagnosis, environmental tracer, database

Spatial distribution and seasonal variation of stable isotopes in precipitation over Japan

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This study revealed spatial-temporal variations of stable isotopes in precipitation over Japan from previous observed data. Also, the d-excess in winter precipitation was used to estimate the origin of water vapor over Japan. Observed stations were divided into 3 regions (Pacific Ocean side, Japan Sea side and Southern Japan) from precipitation patterns. The d18O in precipitation were high in April, October and November, but low in June over Japan. Distribution of annual d18O was recognized latitude effect over Japan, and also altitude effect only in Pacific Ocean side. The d-excess in precipitation were lower than 10 permil from May to August and higher than 15 permil from November to March over Japan. The d-excess in winter precipitation in Pacific Ocean side were about 20permil, however that of Japan Sea side was higher than 25 permil. It cannot estimate the origin of water vapor to be Japan Sea even d-excess in winter precipitation is more than 20permil.

Keywords: stable isotopes in precipitation, origin of water vapor, d-excess, Japan Sea

Chemical weathering in Himalaya: Insights from trace element geochemistry of the Ganges-Brahmaputra River sediments

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The Ganges-Brahmaputra River drains a greater part of the Himalaya, including the western and eastern Himalayan syntaxis, a tectonically active region in the world. Rivers play a vital role in earth surface processes and are regarded as the key carrier of terrestrial materials into the ocean. Major and trace element analyses of the river sediments have been used to investigate their provenance, physical and chemical processes of silicate weathering.

The chemical index of alteration (CIA), chemical index of weathering (CIW), and elemental ratios (Ca/Ti, Na/Ti, Al/Ti, Al/Na, and Al/K) are sensitive to terrestrial chemical weathering intensities in sediment source area. SiO₂ in both rivers show a linear trends and marked negative correlation with grain size, suggesting quartz dilution, mineral sorting as well as compositional maturity during transportation of sediments in fluvial system. The distribution of Fe, Ti, Zr and Th is controlled by their association with heavy or coarse minerals, but Al is independent of hydrodynamic processes. Low CIA (~62) and CIW (~64) values in the river bed sediments are due to fresh detritus within the active channel or most likely favored physical over chemical weathering. High CIA, CIW with high Al/Ti and Al/Na ratio values in the river suspended sediments, suggesting a significant chemical weathering in its source rocks. Discriminant diagrams and trace element ratio plots show the influx of sediments were derived from felsic continental crust sources. Geochemical similarity between the Ganges-Brahmaputra River sediments and various lithologies of the High Himalayan Crystalline Series, Lesser Himalaya, Tibetan Himalayan batholiths and Siwalik sedimentary rocks in Nepal indicates homogenization of material derived from the Himalayan source region.

Keywords: Geochemistry, fluvial sediments, chemical weathering, Ganges-Brahmaputra River, Bangladesh

The carbon cycle, nutrients cycle, heavy metal flux changes in Kushiro mire

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We investigate riverine acidification effects on carbon cycle, nutrients cycle, and heavy metal flux changes in Kushiro mire and Bekanbeushi marshland. Peatlands occupy approximately 5% of the Earth's land area, and the northern peatlands play the important role in global carbon cycle. The surface water in peatlands are highly colored and acid due to humic substances originated from peats. This locally acidification process influences material transportation in adjacent river. In this research, we discuss dissolved iron concentration, the chemistry form of dissolved iron, humic substance concentration and nutrient concentration in Kushiro and Akkeshi, and finally discuss the influence on marine organism production.

Keywords: Kushiro mire, pH, biogeochemical cycle

Studies on defining the effect of chemical weathering on river water PCO₂ rates

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Previous studies show that total carbon rates are mainly controlled by only weathering and respiration, and because of this, it is highly possible that river water generally acts as a source of CO₂. This fact is confirmed by data in a local scale, but when standing on a more nationwide perspective, there is still no compiled data to suggest it.

Based on the works of Kobayashi (1960) and the further datasets of Kobayashi (Harashima et al., 2006) and the data data published by the Japan Meteorological Agency, the PCO₂ of the Japanese river water was mapped. Using this, this study worked on determining whether Japanese rivers generally act as a CO₂ taker or not. It will then discuss why, looking at the effects of each presumable parameter, especially focusing on the effects of weathering and respiration.

As a general result, it can be said that (1) Japanese rivers act as a source of CO₂. (2) Especially, Hokkaido, Kinki area, and the Kyushu area have a high contribution. (3) Urban areas show artificial increase in PCO₂. (4) In the Japanese river system, soil respiration has a critical effect on PCO₂, and weathering does not. (5) Therefore, defining the effects of weathering on PCO₂ is still challenging. (6) Areas with steep slopes have a tendency to have lower PCO₂ rates than that of the flat lands. This can be related to the amount soil, which is possibly controlled by the currency of the carrying river.

Keywords: PCO₂, chemical weathering, land water

Aquifer structures and flow systems of groundwater in the Osaka sedimentary basin

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Withdrawal of groundwater in urban areas of Japan has been strictly controlled for the mitigation of disasters caused by groundwater such as subsidence and salinization, which were serious social problems until 1970s. However, the withdrawal of groundwater increases as a cheap water resource recently and the groundwater attracts the attention as an emergent water resource when the natural disaster occurs and water supply lines are damaged. We should evaluate accurately the potential of groundwater, including scale and structure of the aquifers and the flow rates of each aquifer, as a water resource to use effectively without the groundwater disasters. We have studied to visualize groundwater flow beneath the Osaka Plain, where is one of the largest urbanized area. The Osaka sedimentary basin, which is one of the largest groundwater aquifers of this country, has rather simple structure than the other sedimentary basins of this country, and it is easy to trace the groundwater flows. In this report, the groundwater aquifers and those structure and flow systems are documented, and the recharging paths will be discussed mainly based on the data of oxygen and hydrogen stable isotopes of the groundwaters.

Groundwater aquifers beneath the center of the Osaka Plain can be roughly divided into three categories; the unconfined and uppermost confined aquifers <50 m depth, confined aquifers in Tanaka Formation of Osaka Group, and confined groundwater in Miyakojima Formation of Osaka Group and basement rocks. The Tanaka formation comprises freshwater sandy sediments as groundwater aquifers and intercalated less permeable marine clay layers. The Miyakojima Formation is composed of freshwater sediments and the aquifer is not separated by less permeable layer. The depths of boundary between Tanaka and Miyakojima Formations are commonly 600 to 700 m depth and the basement rock underlies at 800 m depth beneath the Uemachi Daichi at the center of the plain and 1000 to 1500 m beneath the lowland of the plain.

Uppermost groundwaters are recharged by the local precipitation. The groundwater has high quality, and is used as the washing water for temples and shrines at the Uemachi Daichi and gardening for the residences in the suburban area. While, the groundwaters of lowland contain present seawater in the western part and are stagnant in the eastern part from Uemachi Daichi. Thus, the groundwaters of this area are not used and give high hydropressure to be a potential cause of liquification.

The confined groundwaters in the Tanaka Formation are recharged at the Uemachi Daichi and surrounding hills of lowland of Osaka Plain. This formation contains unconsolidated marine clay layers, which was subsided due to excess uptake of groundwater, thus, the groundwaters have not been used after 1970s. Recently, the groundwaters at 100 to 300 m depths are used for supplied water for each buildings and prepare for emergency. Since the groundwaters of this level at the location apart from recharging area occasionally gives the light oxygen isotope shift, squeeze of porewater from the clay layers may occur. The groundwater at 300 to 500 m depths are not used, and probably at the stagnant condition.

Deep groundwaters from Miyakojima Formation and basement rocks are used for bathing purpose. Those from upper part of Miyakojima Formation are diluted Na-HCO₃ type chemistry, and highly saline waters are occasionally found in the deeper portion. Temperature of the groundwaters are 50 degreeC at the highest. Active faults works as recharging paths for the groundwater in Tanaka Formation, however, the groundwaters in the Miyakojima Formation and the deeper are fossil water. Some of the saline waters, probably originated from seawater judged by Br/Cl ratio, give the heavy oxygen shift for those oxygen isotope ratios, suggesting that those are formed at low water/rock ratio.

Keywords: Osaka Plain, groundwater, oxygen hydrogen stable isotopes, saline water

Groundwater quality in the Ndop Plain, a CVL depression, N.W. Cameroon, Central Africa

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The Ndop Plain is a depression along a chain of volcanoes that cuts diagonally across Cameroon known as The Cameroon Volcanic Line. With population increase, there is a high water demand for domestic and irrigation uses. 70 % of the population depends on ground water sources of little known chemical quality. The Rocks in the area are of igneous (granitic and volcanic) and metamorphic origin and constitute a natural source for the enrichment of water chemistry. The convergence of numerous rivers in the centre of the plain poses a potential pollution from the varied geology and human activities. Wirmvem (2010) revealed water of poor microbial quality hence, prevalence of water borne diseases in the area. The spatial and temporal components of groundwater have not been evaluated for possible pollution pathways and duration. The on-going study seeks to a. Assess in detail, the physic-chemical properties of the groundwater; b. Characterize the resource (flow regime, evolution, recharge mechanism and age) by using stable isotopes (D and O18) and environmental isotopes (CFCs, SF6 and 3H); and c. Asses the geological control on water composition. The following outcomes are expected: suitability of water sources for human and animal consumption and irrigation, a baseline hydrogeochemical data and source rock chemistry, a water management tool for the government hence, a great input to the lacking knowledge on numerous groundwater resources in Cameroon highly used.

Keywords: Cameroon, Ndop Plain, Geology, Groundwater, Drinking quality

Characteristics of groundwater age tracers' concentration (CFCs, SF₆ and Tritium) in Kumamoto area

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In Japan, groundwater residence time is relatively young (within 50 years) because of its steep gradient and high rainfall. So, young age tracers are useful to estimate residence time of groundwater in this country. However, each tracer has disadvantages when groundwater age dating due to anthropogenic sources, microbial degradation, sorption, terrigenous source, and so on. It is required to know the characteristics of each tracer's behavior during groundwater flow in the aquifer.

Groundwater samples were collected from various hydrological aquifers (pyroclastic flow deposit, volcanic rock, alluvium and marine deposit) in Kumamoto area. And samples were analyzed for young age tracers (CFCs, SF₆ and Tritium) to evaluate its characteristics of concentration in each aquifer.

Water samples were collected from Kumamoto area in April and October 2011. Almost all samples were analyzed for CFCs, SF₆, major dissolved components and stable isotopes (δ¹⁸O-*H₂O*, δD-*H₂O*). Tritium results were quoted from previous studies.

On our presentation, "the characteristics of age tracer concentrations in each aquifer" and "factors for over- and/or under-estimation of groundwater age" will be presented.

Keywords: Young age tracers, Groundwater, CFCs, SF₆, Kumamoto area

The water quality of underground dam in Miyakojima and Izena Island.

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It is well studied that the surface dam constructions have a significant impact on nutrient and carbon cycles via photosynthesis in dam lakes. Underground dams are recently emerging, new type of dams developed for an effective use of groundwater, which shut groundwater flow and raise ground water level. However, detailed researches on impact of subsurface dams on water quality are quite limited to date. In this research, I analyzed water quality of storage water and compared with unperturbed spring water nearby, to evaluate their impact on water quality in groundwater. The results show that alteration of water quality in underground dams was quite little, whereas surface dam water was highly altered from unperturbed river water by photosynthesis.

Keywords: undergrounddam, water quality, nutrient carbon cycle, photosynthesis

Interaction between surface water areas and groundwater in Hanoi area, Viet Nam

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Hanoi is the capital of Viet Nam and the second largest city in this country (population: 6.45 million in 2009). Urbanization of this city has reduced number of natural water areas such as ponds and lakes by reclamation not only in the central area but the suburban area. Rivers also have been reclaimed or cut into pieces. Contrary, number of artificial water areas such as fish cultivation pond has increased. On the other hand, various kind of waste water flow into these natural and artificial water areas and induce pollution and eutrophication. These waste waters also have possibility of pollution of groundwater that is one of major water resources in this city. Therefore, we focus on the interaction between the surface water areas and groundwater. Water samples of ponds and groundwater were collected from four communities in suburban areas and stable isotopes of oxygen and hydrogen were measured.

Correlations between delta-18O and delta-D of precipitation in Hanoi that were compiled by GNIP was shown as $\delta D = 8.2\delta^{18}O + 14.1$ (LMWL). Weighted mean values of precipitation in rainy season were delta-18O: -9.1 permil and delta-D: -60.5 permil, respectively. According to Berg (2007), Red river waters were distributed along GMWL. On the other hand, groundwater samples were mainly distributed along other lines. These lines crossed the LMWL around the weighted mean value of precipitation in rainy season and slope of these lines were from 5.3 to 6.5. Thus, groundwater in these communities is mainly recharged by mixing of precipitation and evaporated water bodies. In addition, Red river water also recharges groundwater near the river. This result suggested that the evaporated water were recharged through the natural/artificial water areas, and surface water and groundwater were widely connected in the suburban area.

Keywords: Hanoi city, surface and ground water interaction, water cycle, environmental isotopes

Behavior of iodine in sedimentary rocks based on iodine speciation and $^{129}\text{I}/^{127}\text{I}$ ratios

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[Introduction]

Japan is the second largest country for iodine production in the world, and iodine is mostly produced from brine. Iodine ages, determined by $^{129}\text{I}/^{127}\text{I}$ ratio, in brine are often older than host rocks (Muramatsu et al., 2001). However, formation process of iodine-rich brine is still unclear. On the other hand, radioactive iodine (^{129}I) is one of the most problematic radionuclides contained in nuclear waste, because of its long half-life (15.7 million years) and high mobility. To investigate behavior of iodine in sedimentary rocks is important to evaluate the effectiveness of the natural barrier for nuclear waste repositories. In order to predict behavior of iodine in the environment, speciation of iodine is essential because of different mobility among their species (ex. IO_3^- , I^- , I_2 , and organic iodine). In this study, we determined iodine distribution, speciation, and isotope ratios ($^{129}\text{I}/^{127}\text{I}$), to investigate long-term migration of iodine in Horonobe area.

[Experimental]

All rock and groundwater samples were collected at JAEA Horonobe underground research center. The region is underlain mainly by Neogene to Quaternary marine sedimentary rocks, the Wakkanai Formation (Wk Fm), and the overlying Koetoi Formation (Kt Fm): siliceous and diatomaceous mudstones. Iodine species in rock samples were determined by iodine K-edge XANES (SPring-8 BL01B1). Thin sections of rock samples were prepared, and iodine mapping were obtained by micro-XRF analysis (SPring-8 BL37XU). Iodine species (IO_3^- , I^- , and organic iodine) in groundwater were separately detected by high performance liquid chromatography (HPLC)-ICP-MS. The $^{129}\text{I}/^{127}\text{I}$ ratios in groundwater and rock samples were measured by accelerator mass spectrometry (MALT, Univ. of Tokyo). Iodine in rock samples were separated by pyrohydrolysis and water extraction.

[Results and discussion]

Concentration of iodine in groundwater varied widely and was much higher than that of seawater showing a high correlation with that of chlorine ($R^2 = 0.90$). Species of iodine in groundwater was mainly I^- . Iodine in rock samples decreased near the boundary between Wk and Kt Fm. Based on iodine K-edge XANES, iodine in rock was a mixture of organic and inorganic I. Iodine mapping showed that iodine accumulated to micro region. Carbon content was also high in iodine rich region, suggesting that iodine existed as organic I. Iodine isotope ratios ($^{129}\text{I}/^{127}\text{I}$) were higher in rocks compared with those in groundwater. According to these results, migration of iodine in this area can be expected as follows. During sedimentation of Wk and Kt Fm, iodine accumulated as organic iodine in siliceous sediment. Iodine was released as I^- from the layers deeper than Wk Fm during diagenetic processes. Subsequently, iodine-rich groundwater was distributed to Wk and Kt Fm due to the compaction of the layers. During uplift and denudation processes, both iodine and chlorine were diluted by meteoric water from the surface.

It was suggested that I^- is released to the ground water during the maturation of organic matter. However, the mechanism of dissociation of iodine from organic matter is still unclear. Speciation of carbon in rock at various depths should be investigated in future study.

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Keywords: Iodine, XANES, HPLC-ICP-MS, $^{129}\text{I}/^{127}\text{I}$ ratio

Estimating groundwater residence times in southern part of Mt. Yatsugatake from environmental tritium, CFCs and SF₆

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To estimate residence times of groundwater in southern part of Mt. Yatsugatake, groundwater samples were collected from 27 springs, and tritium, CFCs and sulfur hexafluoride were analyzed for all samples. Most of the springs have detectable ³H concentrations ranging from 2.4 to 6.9 TU, indicating that these springs were mainly recharged during the post-bomb period. Apparent CFCs and SF₆ ages for springs were ranged from 4 to 32 years and from 1 to 26 years, respectively. Results of tracer plots between CFCs and SF₆ suggests that the springs are discharged after well-mixing in volcano body. Based on the exponential mixing model, residence times of the groundwater are estimated to be 1 to 32 years, and relatively longer residence time over 20 years are appeared in springs in 1000 m zone.

Keywords: Groundwater age, Mt. Yatsugatake, spring, tritium, CFCs, Sulfur hexafluoride

Water quality and stable isotope for springs in the Kirishima volcanic area

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Kirishima is located at north part of Kyushu and extended from the northeast at Kagoshima prefecture to the southwest at Miyazaki prefecture. Kirishima is a one of most active volcanoes in Japan. Kirishima consists of more than 15 volcanic mountains, for example, Karakuni mountain, Shinmoe mountain, Kurino mountain and Takachiho mountain. The annual precipitation amount around Kirishima is very large (more than 2,000 mm), and precipitation amount is especially large from June to August. It is estimated that the amount of groundwater recharge in Kirishima is large. The purpose of this study is to make clear the characteristics of water quality and stable isotopes in groundwater and spring water, and estimated the groundwater flow in Kirishima volcano. The observation was carried out at July 19 to 21 in 2011 and December 3 to 5 in 2011. The water samples were sampled at 24 points in July and at 30 points in December.

As a result of field survey, EC (electric conductivity) and pH values of spring water are almost same between July and December. In many points, however, the groundwater discharge in December is relatively smaller than that in July. It is considered that the groundwater discharge is influenced by the precipitation amount which is large in summer period. The water temperature is slightly high in July. Water temperature may be influenced by air temperature. The EC value of hot spring is very high (1,255uS/cm), and relatively high at southeast in Kirishima. The water quality type is mainly Ca- HCO₃ and Na- HCO₃ in spring water. For the hot spring, the water quality type is (Na+Mg)- HCO₃. Thus the spring water which is located at southeast in Kirishima also show the (Na+Mg)- HCO₃ type, it is estimated that the hot spring is mixed in the spring water at southeast in Kirishima. The NO₃⁻ concentration is contained in several sites.

Stable isotopes of oxygen ($d^{18}\text{O}$) and hydrogen ($d\text{D}$) in spring water which is located at high elevation are relatively light. The altitude effect thus exists in Kirishima volcano site. The local meteoric water line at Kirishima is $d\text{D} = 5.59 d^{18}\text{O} - 5.92$ ($r^2=0.769$) in July and $d\text{D} = 4.13 d^{18}\text{O} - 16.81$ ($r^2=0.548$) in December. These local meteoric water line are different to the Craig's meteoric water line. As a result of $d^{13}\text{C}$ and water quality, the volcanic CO₂ gas is mixed the groundwater or spring water for the area which is extended from northeast to southeast at Kirishima. In future, the detailed groundwater flow can be clarified by using the result of groundwater residence time.

Keywords: Kirishima volcanic area, spring water, water quality, stable isotope, groundwater flow

Nitrogen and oxygen isotope composition of nitrate in river and spring waters of the Shirakami Mountains

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Introduction

In recent years, volume of nitrogen load has been increasing in mountainous area because of acid rain. The concentration of NO₃⁻ keeps increasing in the water of Subari Lake in Shirakami Mountains at Akita Prefecture. To elucidate of nitrogen cycle in forest is importance problem in view of effects of ecosystem in Shirakami Mountains. Then, in this study, to verify the loaded nitrate source in investigation basin and spatial distribution of nitrogen isotope values originated from forest, thirty river and spring water samples from Shirakami Mountains southern region were analyzed for nitrate concentration and nitrate-nitrogen (d¹⁵N-NO₃⁻) and oxygen (d¹⁸O- NO₃⁻) isotope values.

Method

So far the investigation and water sampling has been carried out on November 2011 in the Shirakami Mountain southern region at Akita Prefecture. The main water sampling points were in the river, stream, spring, lake and wetlands. Physicochemical parameters (pH, ORP, DO, Temperature) were measured in the field investigation. Water samples were determined NO₃⁻ concentration and major water chemistry.

Results

The results showed that NO₃⁻ concentration was in the range of 0.5mg/L to 3.1mg/L. In each basin of the western study area (Tokiwa River Basin, Hanawa River Basin, Mizusawa River Basin), there was a more than 2.5mg/L concentration of NO₃⁻. By contrast, at each point in the inland area (The upper stream of Subari Lake, Fujikoto River Basin), NO₃⁻ concentration was less than 1mg/L.

Keywords: shirakami mountains, nitrate, nitrate-nitrogen and oxygen isotope ratio, acid rain

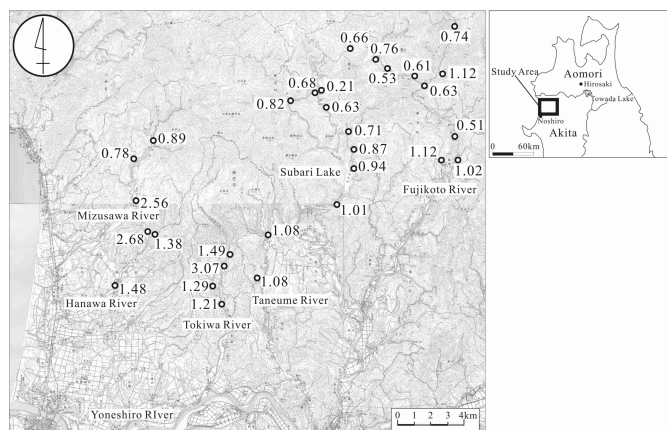


Fig. Distribution of NO₃⁻ concentration in the water sampling point. Figure shows NO₃⁻ concentration(mg/L)

Preparation of the river water quality map and analysis of the organic pollution in the region of small precipitation

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Introduction

In the northern part of Shikoku Island, where there is small precipitation, particulate organic substance concentration in the river water is high, because the water is stored in a basin for efficient water use, leading to organic pollution of the river water. In a previous study, it was demonstrated that majority of the particulate organic substances in the Shin river, a major river in the Kagawa Prefecture, were from the basin (Yamada et al. 2010). The other hand, the basins in the Kagawa Prefecture is supplied with the water from the Yoshino river (Kagawa channel water, from central Shikoku Island) during the irrigation period. Since the organic substance concentration of the Yoshino river water is low, it may have dilution effect on the polluted river water in Kagawa Prefecture. In the Kagawa Prefecture, mechanism of ensuring river water quality becomes complicated because of efficient water use. In this study, the relationship between water pollution and water utilization were analyzed under the preparation of the water quality map.

Material and method

The investigation was conducted in the Shin river basin, one of main rivers in the Kagawa Prefecture. The total length of the Shin river is approximately 19 km, and the pond density (over an area of 1 ha) is 0.05 km²/ km² in the middle and lower river basin. To analyze water and the source of organic substances in the Shin river, investigations of temporal variation (in the Shin river) and distribution (in its basin) for organic substances were conducted. Particulate organic carbon (POC), delta¹⁸O, and phytoplankton composition in the sample were measured.

Result and discussion

The delta¹⁸O of the Shin river decreased in the irrigation period, during which the supply of water from the Kagawa canal was increased (before supply, approximately 7.5par-mil; after supply, approximately 7par-mil). The delta¹⁸O of water from the Kagawa canal was low, at 7.5par-mil. Supplying the Kagawa canal water for the irrigation seems to lower the delta¹⁸O value of the river water. During the non-irrigation period, it was considered that the irrigation pond was the source of much of the water in the middle and downstream because delta¹⁸O values of river and the irrigation pond were similar. The POC of the river water was low, at 2 mg/L, after the supply of Kagawa canal water, whereas it was 8 mg/L before the supply. Because the POC was low for the Kagawa canal water, the inflow of this water could cause the reduction in the POC of the river.

In spatial distribution, the POC and delta¹⁸O increased from the upper stream to the middle stream in June and October. This rise was consistent with the rise in pond density in the basin. The proportion of the rise in October was higher than that in June. In October, the POC concentration rose from approximately 0.0?2.0 mg/L to 2.8?6.4 mg/L after the inflow of the largest irrigation pond in the basin. At the same time, delta¹⁸O also increased from approximately 7.2??6.1par-mil to 7.4??5.1par-mil. It was indicated that POC in the river water rose because of the inflow of water from the irrigation pond. The fact that the POC of the river in June is low, when the water in the irrigation pond is predominantly discharged, was because low POC water, such as Kagawa canal water, flowed into the river during the irrigation period.

The phytoplankton species (*Microcystis aeruginosa* and *Cyclotella meneghiniana*) in both river and irrigation pond were similar, and the composition ratio was also similar.

From these results, it is thus proved that water from the irrigation pond was the source of organic substances in the middle and downstream river. However, during the irrigation period, when considerable water is discharged from the irrigation pond, the river POC was reduced because of dilution of organic substances due to inflow of low POC water from Kagawa canal.

Keywords: Organic pollution, Oxygen isotope ratio, River, Irrigation pond, Water quality map, Irrigation water

Geochemical and isotopic map of Asahi River, Okayama Prefecture

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The Asahi River, one of the largest rivers in the Okayama Prefecture, has a drainage area of 1800km². Because the water from the river supports approximately 1/3 of the population of the Prefecture, understanding the origin and the circulation process of the water through construction of geochemical map is essential. We have undertaken a detailed geochemical and isotopic study of water samples collected from the Asahi River, Okayama Prefecture. A total of 77 samples were collected from the mainstream and tributary of the Asahi River from March to November 2011. All samples were filtered with 0.2 micrometer filter prior to the analyses for major dissolved constituents (F, Cl, NO₃, SO₄, Br, PO₄, Ca, Mg, Na, K), trace elements and O-H-Sr isotopes. The results obtained so far have revealed that there are systematic changes in the deuterium excess (DE), Sr isotope ratio and the concentrations of elements such as Ca, Mg, Sr and Ba from the upstream towards the downstream. Similar but less obvious changes were also observed for elements such as As, Li, Rb, Cs, Ge and Ga. These changes are interpreted to be the result of (1) difference in the air mass contributing to the meteoric water of different locations, (2) interaction with rocks with distinct geochemical characteristics, and (3) various human input. Further discussions including the seasonal changes in the geochemical characteristics of the river water will be given in the presentation.

Keywords: Geochemical map, Asahi River, Okayama Prefecture, Isotope, Trace element

Water quality map of rivers in the eastern Shimane and western Tottori Prefectures

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This study aims to create maps showing the water quality of rivers in the eastern Shimane and western Tottori Prefectures, in order to provide fundamental information for the sustainable use of the river water. This area is widely composed of granitic rocks with local distributions of Miocene sedimentary rocks in the coastal area and Quaternary volcanic rocks of Mt. Daisen in the eastern area. It is active in agriculture and fishery as well as metal mining from the Edo period including Tataro iron-manufacturing. Further the atmosphere is affected by materials and pollutants from the Sea of Japan and the Asian continent by westerly winds. Human activities in the watershed from the past and recent changes in the atmospheric environment would affect the aquatic ecosystem in this area. To evaluate these effects on the freshwater quality, we determined the compositions of four stable isotopes and fifty-five dissolved components for totally 291 stream water samples, which were collected during base-flow periods of spring to autumn from 2009 to 2011. Analytical results are summarized as follows:

1. Geological contribution: Sr isotope ratios in stream water varied in accordance with the watershed geology; 0.705 - 0.706 in Mt. Daisen area, 0.706 - 0.707 in many areas with the acidic igneous rocks, and 0.707 - 0.709 in the coastal Miocene rock areas. There is a positive correlation between Ca and Sr contents, indicating that both elements are largely derived from Ca-minerals through chemical weathering. Many trace elements such as Ba, Cs and V also displayed a geographical variation dependent on the watershed geology, demonstrating that they are utilized as a hydro-geological tracer.

2. Atmospheric contribution: The concentrations of Cl and Na decreased regularly from the northern coastal area to the southern mountainous area, indicating the inland decrease of sea-salt inputs through the atmosphere. The very high values of seawater component in the stream water of Shimane Peninsula suggest that this peninsula has been acting as a topographic barrier, possibly suppressing the sea-salt impact from the Sea of Japan to Matsue and Izumo Cities. Water isotope ratios also tended to decrease, whereas deuterium-excess value (d-value) to increase, with distances from the Sea of Japan. Stream waters with low water isotope ratios and high d-values (20 - 23) distribute in the mountainous area of southeastern Shimane, where the precipitation of snow is high. Stream waters of Shimane peninsula had high SO₄ concentrations (10 - 30 mg/L) and low d³⁴S values (-2 - 5 per mil), indicating a dominant source of rock sulfur. In contrast, most streams in the Hiigawa watershed had low SO₄ content (2 - 6 mg/L) and high d³⁴S value (8 - 12 per mil), indicating that the Hiigawa sulfur is enriched in marine sulfur and anthropogenic one from the Asian continent rather than granite-derived sulfur. The integrated use of Cl, SO₄, and water and sulfur isotopes are powerful as a hydro-atmospheric tracer.

3. Anthropogenic contribution: The concentration of NO₃ tended to be high in the lower reaches where the anthropogenic effect is expected to be large. The distribution of Fe was similar to those of Cr, As and Se, but they did not show any meaningful relationship with areas where the Tataro mining took place.

Keywords: Riverine water quality map, Strontium isotope ratio, Hiikawa River System, Hinogawa River System

Water quality map in the southern part of Mt. Fuji

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We summarized the quality of spring waters in the southern part of Mt. Fuji in map for the purpose of estimating the origin and recharge area of these springs. The study area is the foot of Mt. Fuji in Shizuoka Prefecture, including surrounding mountains (e.g. Mt. Ashitaka, Mt. Hakone, Tenshu Mountains). This area is an important industrial region, expected as a greenfield site for companies using high-quality groundwater. On the other hand, the problem of saline groundwater in coastal area arose in 1960s due to excess-pumping, not being solved completely today. Moreover, recently the amounts of spring waters tend to decrease at the foot of Mt. Fuji. The stable use of groundwater is important for the sustainable development of this area, and it is necessary for developing strategy for groundwater conservation and use to elucidate the mechanism of groundwater flow in the basin.

We collected 133 spring water samples from the study site in early winter (November to December 2009). Water samples were analyzed for major ions, trace elements and hydrogen, oxygen, and strontium isotopes. Geographic Information System was used to make the water quality map, which also contains information of e.g. geology, vegetation, land use and social conditions, in the study area.

The isotopic composition of oxygen and hydrogen in spring waters shows a linear relationship between $d^{18}\text{O}$ values and $d\text{D}$ values. The d -values in Mt. Ashitaka area, facing Suruga bay, and in the southwestern foot which altitudes are between 300 and 500 meters above sea level, are relatively low (<12). The low values indicate that the precipitation in both areas would be strongly affected by water vapor from the Pacific Ocean. The isotopic composition of oxygen in spring waters shows that low $d^{18}\text{O}$ values between -8 and 10 permil are observed in the foot of Mt. Fuji except for spring waters in the southwestern foot, which represent -8 permil or less. The isotopic enrichment of these springs is probably caused by the superficial aquifer recharged by precipitation in the vicinity.

The spring waters in the basaltic rock area (Mt. Fuji, Mt. Ashitaka and Mt. Hakone) display low $^{87}\text{Sr}/^{86}\text{Sr}$ values under 0.7040. In contrast, the $^{87}\text{Sr}/^{86}\text{Sr}$ values of spring waters in sedimentary rock area (Tenshu Mountains) are much higher (over 0.7055). The high Sr isotopic signature in the western foot of Mt. Fuji (Inokashira springs) suggests that the groundwater recharged in Tenshu Mountains would partly flow into the area.

The principal component analysis of the 19 components dissolved in the spring water was conducted. The first principal component can be regarded as an index of human activity, because its scores were low for springs in the southern foot of Mt. Ashitaka and the southwestern foot of Mt. Fuji, where tea plantation predominates. We consider the high concentrations of NO_3 observed in these areas to be of agricultural origin. The concentration of Cl is also high in the areas, probably caused mainly by airborne salt. We can also separate oxyanion-forming elements (e.g. V, P, As, Mo) from other dissolved components on the basis of their distribution on the second principal components. The concentrations of these elements are negatively correlated with $d^{18}\text{O}$ values. The high concentrations are interpreted as resulting from the elution of the elements by long-term interaction between rock and groundwater recharged at high altitude of Mt. Fuji. The third principal component separates trace elements (e.g. Cs, Ba, Rb) from the other components, relatively low in the eastern foot and high in the western foot of Mt. Fuji.

As described above, we can clarify the regional characteristics of spring water through the analysis of stable isotopes and dissolved elements. Mapping the information of water quality with GIS made it possible to analyze factors which contribute to the regional variations and, in addition, to form a basis for building a groundwater governance in the study area.

Keywords: water quality, spring, stable isotopes, principal component analysis, GIS, Mt. Fuji

Mapping of water quality in the Obitsu and Kamo rivers on the Boso Peninsula, Japan.

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This study investigated downstream variation in the chemical composition of river waters in terms of the interaction between hydrologic cycles, human activity, and geologic composition in a drainage area. We used the Obitsu and Kamo rivers and their tributaries in the central part of the Boso Peninsula, as a case-study field of this research. We analyzed 50 dissolved elements and stable isotopes of hydrogen, oxygen, sulfur, and strontium using 150 water samples taken from the two river systems during three summer seasons from 2009 to 2011. On the basis of spatial variations in the concentration of dissolved elements and stable isotopic ratios of the four elements, we discriminated the following three major factors, which seem to have controlled the water quality in the two river systems.

(1) Air-water cycles: The deuterium-excess shows local decreases as a response to the construction of some reservoirs and also shows higher values in the upstream areas, as having already been observed in other areas. In contrast, the hydrogen isotopic ratio shows spatial variation opposite to the altitude and continental effects in the upstream areas. Thus, we need to clarify spatial variation in the isotopic composition of rainfall for the better understanding of a major process of air-water cycles in a small drainage area.

(2) Artificial contribution: The concentration of nitric acid increases in lowlands and also at the foot of small mountains as a response to the increase in population, housing, and agricultural fields in local association with stock raising. The concentration of Cl and Na, together with K, Rb, and Cs, show local increase in some tributaries in the upstream areas. These areas are also characterized by a higher $^{87}\text{Sr}/^{86}\text{Sr}$ ratio in river waters, and the water quality is interpreted to be polluted locally by water drained from chloride mineral springs. Furthermore, the sulfur isotopic data suggest that the chloride mineral springs have seeped after fossil brine had been affected by sulfate reduction, mixing with rainwater, and reacting with the host sedimentary successions in a subsurface environment.

(3) Geological effects: The southern tributaries of the Kamo River flows out from the Mineoka Mountains, which consists mainly of mafic and ultramafic rocks, and are characterized by a higher concentration of Mg, Ni, and Cr, and by a lower concentration of Si, K, Rb, Cs, together with a lower $^{87}\text{Sr}/^{86}\text{Sr}$ ratio. A lower $^{87}\text{Sr}/^{86}\text{Sr}$ ratio also characterizes upper reaches of both the Obitsu and Kamo rivers, where volcanoclastic sediments are developed. The drainage basin of the Obitsu River consists mainly of siliciclastic sedimentary rocks and is also characterized by the Kanto Loam in the uppermost sedimentary successions in the lower reaches. Thus, the water quality of the lower reaches is characterized by a higher concentration of Mg, Si, V, in association with a lower $^{87}\text{Sr}/^{86}\text{Sr}$ ratio. In contrast, the middle reaches of the Obitsu River are represented by turbidite successions and the river water is represented by a higher concentration of Mo and by a higher $^{87}\text{Sr}/^{86}\text{Sr}$ ratio. Locally, the upper reaches of the Kamo River are also characterized by a higher concentration of Cl and Na, in association with a higher $^{87}\text{Sr}/^{86}\text{Sr}$ ratio. This locally observed higher signal is interpreted to represent an effect of fossil brine from the sedimentary successions. Although the $^{87}\text{Sr}/^{86}\text{Sr}$ ratio in river waters is sensitive to the geologic composition in the drainage basins, we have not found any distinct spatial variation in the $^{87}\text{Sr}/^{86}\text{Sr}$ ratio of channel-floor sediments of both the Obitsu and Kamo rivers. Thus, we should separately analyze chemical composition of primary and secondary minerals of the channel-floor sediments for the better understanding of the interaction between the river waters and channel-floor sediments.

Keywords: Water quality, Obitsu River, Kamo River, Boso Peninsula

Water-quality diagnosis of Sabanakett district in central Laos

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Water cycle in the Indochinese peninsula is strongly affected by Asian monsoon, and people strongly depend on the water in rainy season. Rain in this tropical area accelerates chemical weathering to have formed lateritic soil, which is deficient of base cations and is enriched in iron and aluminum. Lao People's Democratic Republic is a landlocked country in the peninsula and its water resource receives high demands as electric power from the surrounding countries. Development of industrial system and growth of population in Laos, although they are not so rapid, become concerned with pollution and other human impacts on the aquatic ecosystem. Nevertheless, there is few geochemical study on the fresh water in Laos. Water stable isotopes and dissolved components in surface water and shallow groundwater, as they are of meteoric water origin, provide basic information on the water cycle, material behavior in ecosystem, and human health. In RIHN, project focusing on infectious disease such as Malaria and Clonorchis sinensis disease have been implemented at Xepon and Lahanam areas in Savannakhet district of southern Laos. These areas are located in the watershed of the Banhyang River, which is one large tributary of the Mekong River. Here we report the compositions of stable isotopes and dissolved components for surface and ground waters at about 200 sites in this area. All analyses were done for water using 0.2 μ m acetate-cellulose filter.

The $d_{18}O$ values and dD values of all waters are plotted along the meteoric water line. It is notable that the water isotope ratios of surface waters show a large areal variation ($d_{18}O$ values; -11.4 - -7.4 permil) and dD values, whereas those of most ground water (<50m from the surface) fall in a relatively narrow range ($d_{18}O$; -8.1 - -6.5 permil). This isotope value of groundwater is close to the annual average of rain water at Luang Phabang in northern Laos ($d_{18}O$; -7.4 permil), suggesting that the groundwater and surface water in small streams are derived largely from precipitation in Lao Heights. In contrast, the Banhyang River and some tributaries had low water isotope ratios. This result is also consistent with that this river flows from the Annamite Mountains where the precipitation would have low isotope ratios due to elevation effect.

Dissolved components are divided into three groups (A, B, and C) based on the water type and the water isotope ratio. Regardless of the water type, the concentration of dissolved component in the water with high $d_{18}O$ value (-8.1 - -6.5 permil) showed a large variation. On the other hand, for waters with $d_{18}O$ values less than -8.1 permil, Group-A and Group-B components are characterized by low concentrations and high ones, respectively. Component of Group-C is intermediate between the two groups. Cl, SO₄, and alkali and alkali-earth elements are classified into the Group-A, and are considered to be dissolved as ions in the water. The Group-A components are very high in the groundwater of Lahanam area, which is derived from the dissolution of evaporate minerals. In contrast, Group-B is composed of Al, Ti, Fe, Mn, Y, and REEs, which are the major constituent of minerals resistant to chemical weathering. It is likely that the Group-B elements are present as small mineral and/or colloidal particles in the water. The widespread distribution of surface water with high Fe and Mn contents suggest a contribution of lateritic soil. This result is also consistent with the comparison of Sr isotope data between water and rock, suggesting that the water is affected by rainwater input rather than the dissolution of primary minerals. Group-C is composed of NO₃, Zn, and K. These components are affected by human activities in addition to atmospheric precipitation and mineral dissolution, which are the major source of group-A and ?B components. Indeed, NO₃ tended to be high in populated area. Zn was also high in groundwater pumped through Zn-coated steel pipe.

Keywords: Laos, water circulation, water isotope, material behavior, strontium isotope, trace element

Water quality maps of Laguna de Bay Basin, Philippines

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This study, conducted in Laguna de Bay Basin, aims at creating water quality maps for the Basin and its watersheds. The Laguna de Bay is the largest lake in the Philippines, with a surface area of 900 km² and its watershed area of 2920 km² (Santos-Borja, 2005). It is located on the southwest part of the Luzon Island and its watershed contains 5 provinces, 49 municipalities and 12 cities, including parts of Metropolitan Manila. The water quality in Laguna de Bay has significantly deteriorated due to pollution from soil erosion, effluents from chemical industries, and household discharges. Recent studies have suggested that concentration of heavy metals in the edible fishes and aquatic plants in the Laguna de Bay are high and likely to have health risks to eating them (e.g., Molina 2011). In this study, we performed multiple element analysis of water samples in the lake and its watersheds for chemical mapping, which allows us to evaluate the regional distribution of elements including toxic heavy metals.

We collected water samples from 24 locations in Laguna de Bay and 160 locations from rivers in the watersheds. The sampling sites of river are mainly downstreams around the lake, covering urbanized and rural areas. We also collected well water samples from 17 locations, spring water samples from 10 locations, and tap water samples from 21 locations in order to compare their characteristics with the river and lake samples and to assess the quality of household use water. The samples were collected in dry season (March and May in 2011) as well as wet season (October and November in 2011) of the study area in order to evaluate seasonal differences. Water samples were filtered through a cellulose acetate disposable filter (0.2 micrometer pore size), then brought to the Research Institute for Humanity and Nature (RIHN), where the analysis was performed. The concentrations of the major components (F, Cl, NO₃, SO₄, NO₂, Br, PO₄, Ca, Mg, Na, and K) dissolved in the samples were determined with Ion Chromatography System (Dionex Corporation ICS-3000). We also analyzed major and trace elements (Li, B, Na, Mg, Al, Si, P, K, Ca, Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ga, Ge, As, Se, Rb, Sr, Y, Zr, Mo, Ag, Cd, Sn, Sb, Cs, Ba, La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, W, Pb and U) with Inductively Coupled Plasma-Mass Spectrometry (ICP-MS, Agilent Technologies 7500cx). We used Geographic Information System (GIS) to create water quality maps for each components.

At most sampling locations, concentration of dissolved components in the wet season samples are lower than those in the dry season samples which can be attributed to dilution effect of rain water during wet season. The element concentrations of rivers are characterized by remarkable regional variations. For example, heavy metals such as Ni, Cd and Pb are markedly high in the western region as compared to the eastern region implying that the chemical variation reflects the urbanization in the western region. On the other hand, As contents is relatively high in the south of the lake and some inflowing rivers in the area. The higher concentration of As is also observed in the spring water samples in the area. Therefore, the source of As in the area is probably natural origin rather than anthropogenic.

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Keywords: Water quality map, Laguna de Bay, Philippines

The influence of the Ganges, Brahmaputra river, and Meghna river on global carbon cycle

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In the perspective of global biogeochemical cycles, continental rivers are important paths transporting vast amounts of solids and solutes from land to ocean. However these rivers are not just pathways to ocean. There are various chemical reactions occurring in river water, e.g. respiration and photosynthesis. These reactions can alter chemical character of river water and play some parts in global carbon cycle. In this study, we investigated three continental rivers in Bangladesh: the Ganges, Brahmaputra river, and Meghna river. We measured pH, total alkalinity, pCO₂, nutrients, and major ions in the river water. In these rivers, pCO₂ values were higher than the atmospheric level, which indicates that the river water works as a source of CO₂ to the atmosphere. Respiration and photosynthesis rather than weathering may play an important part in the river flow. We evaluated how continental rivers themselves affect global carbon cycle.

Keywords: respiration, photosynthesis, pCO₂, river, limnology, carbon cycle

Distribution of oxygen-18 and deuterium across the Tunisia

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Groundwater use in Tunisia

In their fourth report, the Intergovernmental Panel on Climate Change (IPCC) warns that temperature will increase and rainfall will decrease especially in the Mediterranean coastal areas of North Africa with a global warming increase. People in Tunisia located in north Africa largely depends on groundwater use for irrigation, which caused the drawdown of groundwater.

For sustainable groundwater use, it is essential to understand the groundwater system.

Isotopic Mapping

Kendall (2010) pointed that large scale spatial isotope studies of water cycle can provide important insights into the groundwater recharge process. Kendall (2001) also showed the effectiveness of isotopic mapping by taking surface water samples over large areas, because surface water can be representative value of rainfall water of whole basin.

High resolution isotopic mapping also can help us to identify the important sites such as recharge area in the surface and groundwater flow system.

Objective and Methodology

The objective of this research is showing isotopic map and clarifying the groundwater recharge process across the Tunisia.

Sampling survey was conducted from July 7th to 11th and, from Nov 12th to 20th in 2011. Water samples were taken mainly from river across the whole of Tunisia. We measured electrical conductivity, ORP, and pH in situ. We also analyzed the stable isotopes (D, ¹⁸O) in laboratory.

However, in southern area, wadi river were dry up even in rainy season. Then we took water from some Magels (traditional water tank to collect rainfall during rainy season). Magel is covered by concrete and prevent evaporation effect. Then the water in Magel can be integrated value of rainfall during rainy season.

Results and Discussion

Stable isotopic values were plotted on river system map and compared with topographic map. Generally, isotopic values in eastern coastal area tended to be relatively high ($\delta D = -27.6 \sim -6.9$ per mill, $\delta^{18}O = -4.4 \sim 0.1$ per mill). Meanwhile, values in western inland area were relatively low ($\delta D = -41.9 \sim -27.7$ per mill, $\delta^{18}O = -7.9 \sim -4.5$ per mill). This tendency is remarkable especially in Mejerda River watershed located in northern Tunisia. Isotopic values along the mainstream increased with distance from coast to inland (inland effect).

However isotopic values at some points located in northern coastal area were low. These values were lower than average precipitation value at nearest observation point of IAEA. There is possibility that these low value come from not base flow but short time rain event.

More sampling are planned in gap area on the map and, in same points to see seasonal change.

Keywords: groundwater, stable isotope, tracer, isotopic mapping

Temporal variation of stable isotope ratio in precipitation on Chubu-mountainous areas: case study of Mt. Ontake in cent

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In order to clarify the temporal variation of the stable isotope ratio in precipitation on the mountainous area in Japan, monthly precipitation was collected at 11 sites on Mt.Ontake from Jan 2003 to Dec 2005, and determined their delta-values. d-excess values ranged from 5 to 34 per mil, and showed clear seasonal variations in which values are low in rainy season from spring to fall and high in snow season (winter), reflecting the change of monsoon. The isotope ratios showed high delta-values in spring, low delta-values in winter and intermediate delta-values in summer to fall throughout the observation period, and these seasonal variations can not be accounted for the amount effect and the temperature effect. Rain-bearing weather condition and spatial variation of rainfall amount around Mt. Ontake were investigated, and discussed a factor controlling the seasonal variation of delta-values. In the warm rainy season, the low delta-value in precipitation were observed in the period at which the rainfall amount of windward (south-east) area of Mt. Ontake was high, suggesting that delta-values variation on Mt. Ontake during the warm rainy season depend on the rainfall amount during the vapor mass transpiration from Pacific coast to Mt. Ontake. Moreover, it is indicated that the low delta-values of snow cover in winter was caused by the inland effect, considering the existence of heavy snowfall area in windward. These variations of delta-value associated with the rainfall amount on surrounding area is considered to be reflect the geographical location of Chubu-mountainous area which is away from the ocean generating a vapor mass.

Keywords: Chubu-mountains areas, Mt. Ontake, precipitation, stable isotope, vapor mass transpiration,, inland effect

Stable isotope distribution of Springwater in Kanagawa Prefecture.

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It is necessary to clarify the altitude effect of precipitation in the object region to presume the altitude of recharge area of the spring and the stream using the hydrogen and oxygen stable isotopes. However, it is known that the altitude effect of precipitation changes with altitude, latitude, slope direction, seasons and others. For this reason, it is very difficult to extract the rain sample which covered these. In such a case, the recharge altitude is presumed with the groundwater occurrence curve drawn from an isotopic ratio in the small-scale springwater which gushes from mountainous watershed and altitude. However, this method is mainly used in the comparatively narrow ranges, such as mountain land. On the other hand, examination in the wide area containing a plain and a plateau part is seldom performed.

In this study, areal distribution of the stable isotope ratio of springwater in Kanagawa prefecture was clarified and the broad-based groundwater recharge isotopic ratio was examined.

Summary of investigation

The springwater was sampled at 163 point in Kanagawa Prefecture and a neighboring area. The investigation went from April, 2009 to August, 2010. Measurement of the water temperature, pH, and electrical conductivity in springwater was performed, and analysis of dissolved ion, and hydrogen and an oxygen isotopic ratio was conducted. Moreover, the amount of springwater was measured as much as possible. As a result of investigating with the springwater of 163 points, the gush part from underground has been checked at 119 points. However, it is fixed as a springwater institution and 40 points were not able to check a gush place, and 4 points were springwater ponds. From the point which has checked the gush point, the isotopic distribution figure was created using the isotopic ratio in the springwater of 114 points which excepted five points which showed the unusual isotopic ratio.

Oxygen isotopic ratio distribution in springwater

The minimum values of oxygen stable isotope ratio in springwater of Kanagawa Prefecture was -9.3permil and the highest was -6.8permil and arithmetic mean value was -7.9permil. The areal distribution of the oxygen isotopic ratio in springwater was low in Hakone in western Kanagawa, and the Tanzawa area, and the tendency which becomes high in an area along the shore and an eastern part of prefecture was seen. The altitude effect of oxygen stable isotope in the springwater calculated using all the points is -0.104permil/100m and coefficient of determination was 0.375.

Then, the west of the west longitude of 139.15 degrees was classified with the western prefecture. Moreover, the longitude between 139.15 to 139.45 degree was classified with the central prefecture, and the east of 139.45 degree were classified into the eastern prefecture, respectively. And it analyzed for every area about the relation between altitude and an oxygen isotopic ratio, latitude and an oxygen isotopic ratio. As a result, the altitude effect of oxygen stable isotope in the western prefecture is -0.086permil/100m and coefficient of determination was 0.474, in the central prefecture is -0.278permil/100m and coefficient of determination was 0.287, and in the eastern prefecture is -0.275permil/100m and coefficient of determination was 0.016, respectively. On the other hand, it is about the relation between latitude and an oxygen isotopic ratio in the western prefecture is -0.032permil/min and coefficient of determination was 0.146, in the central prefecture is -0.064permil/100m and coefficient of determination was 0.582, and in the eastern prefecture is -0.017permil/100m and coefficient of determination was 0.134, respectively. As a result, the central prefecture showed the value with inclination and the highest correlation coefficient. Since a central prefecture has the Tanzawa place in a northern part, this is considered because the direction of high latitude and the high altitude direction overlapped.

Keywords: Springwater, Hydrogen and Oxygen stable isotopic ratio, areal distribuion

Stable isotopic composition of river and spring waters in the Shirakami Mountains, Japan

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The Shirakami Mountains is the general name given to an extensive mountainous region of 130,000 hectares ranging from the southwest of Aomori to the northwest of Akita prefecture. Within this area are 16,971 hectares of land, enclosing virgin forests of Japanese beech, which were registered as a world heritage region in December 1993. However, environmental impact by acid rain at the Shirakami Mountains is becoming an issue these days. Acid rain deposits nitrates that can lead to increases in nitrogen in forests. So we have studied about the chemical and isotopic compositions of river and spring waters in the Shirakami Mountains area, to clarify origin and geochemical characteristics.

Delta-18O and delta-D of groundwater samples mainly showed -8.8 to -10.6 permil and -50.7 to -62.7 permil, respectively. The hydrogen and oxygen isotopic ratios of water collected at inland side are higher than shoreline side samples.

Keywords: Shirakami Mountains, hydrogen and oxygen isotopes

Characteristics of stable isotopes of oxygen and hydrogen in precipitation at Saku City

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Stable isotopes of oxygen and hydrogen in precipitation have several characteristics e.g., amount effect, temperature effect, altitude effect, latitude effect and longitude effect. For the altitude effect, however, there is little investigation about precipitation samples which are taken at different slopes. The objective of this study is to make clear the temporally variation and altitude effect of stable isotopes in precipitation which are sampled at different slope in Saku City, eastern part of Nagano prefecture. The precipitation samples were taken in September 21 and 22, 2011 that is before and after the typhoon No.15 for the three points in northeast slope (elevation is 800m, 1,000m and 1,200m) and at the eight points in southwest slope (elevation is 800m, 1,000m, 1,200m, 1,400m, 1,600m, 1,800m, 2,000m and 2,100m).

The stable isotopes of oxygen ($d^{18}\text{O}$) and hydrogen ($d\text{D}$) are relatively light for the precipitation samples which are taken after the typhoon had passed through. The reason of this may be estimated that the influence of the amount effect appears. The altitude effect is existed both northeast slope and southwest slope. The altitude effect for $d^{18}\text{O}$ at southwest slope is -0.25 permil/100m which is before the typhoon and -0.39 permil/100m which is after the typhoon. The altitude effect for $d\text{D}$ at southwest slope is -2.1 permil/100m which is before the typhoon and -2.6 permil/100m which is after the typhoon. The altitude effect is high for the precipitation samples which were taken after typhoon had passed through. The local meteoric water line is $d\text{D} = 7.95d^{18}\text{O} + 9.30$, it is almost the same as Craig's meteoric water line. The d-excess values in precipitation samples which were taken after the typhoon passed through are relatively higher rather than those in precipitation samples which were taken before the typhoon passed through. This cause may be considered that the difference in source of water vapor affects. In future, it will be make clear the factor of d-excess variation by performing the detailed and regularly investigation of rainfall or typhoon event.

Keywords: precipitation, typhoon, stable isotope, altitude effect, d-excess

Characteristics of stable isotopes for precipitation at the mountainous region in the eastern part of Matsumoto

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Matsumoto basin is located to slightly northward from the center of the Nagano Prefecture and surrounded the mountains (Hida-mountains and Tsukuma mountains). The complex alluvial fan is formed by the Metoba and Susuki river in the east part of the Matsumoto basin. There is some aquifer in the Matsumoto basin and large quantity of groundwater is stored in the basin. The people who live in Matsumoto city have been used the groundwater or spring water for long period, and now that the water supply facilities is completed people use the groundwater or spring water for drinking water.

For estimating the recharge area of groundwater or spring water in Matsumoto basin by using the stable isotopes of oxygen and hydrogen, precipitation samples have been taken at four points on the east side of Matsumoto basin since June, 2009. The water samplers which have the parts to prevent the evaporation of water are settled at P-1 to P-4. The elevation of P-1 is 592m, P-2 is 1,000m, P-3 is 1,300m and P-4 is 1,900m. The monthly precipitation samples are taken at four points from May to November and taken at only two points (P-1 and P-2) from December to April.

Thus the stable isotopes of oxygen ($d^{18}\text{O}$) and hydrogen ($d\text{D}$) in precipitation are relatively low in the place of high elevation, the altitude effect is existed. The altitude effect is Matsumoto is -0.17 permil/100m ($r^2=0.998$) for $d^{18}\text{O}$ and -1.0 permil/100m ($r^2=0.994$) for $d\text{D}$. Since the precipitation amount is large with increasing the elevation, the amount effect also will probably exist. Usually the $d^{18}\text{O}$ and $d\text{D}$ in precipitation have no seasonal variation in Japan, however those in Matsumoto are relatively low in winter season (from November to February). As a result of calculation by using the stable isotopes of precipitation and groundwater samples, it is estimated that the average recharge are of groundwater in Matsumoto basin are estimated at the area from 1,300m to 1,600m above the sea.

The d-excess values have a seasonal variation which is relatively low at summer period and relatively high at winter period. However, the d-excess values in Matsumoto is relatively low than other area (e.g. Niigata prefecture, southern part of Nagano prefecture and western part of Yamanashi prefecture).

The local meteoric water line (LMWL) is $d\text{D} = 7.16d^{18}\text{O} + 2.58$ ($r^2=0.928$) for P-1, $d\text{D} = 7.12d^{18}\text{O} + 2.26$ ($r^2=0.902$) for P-2, $d\text{D} = 6.18d^{18}\text{O} + 7.00$ ($r^2=0.681$) for P-3 and $d\text{D} = 8.00d^{18}\text{O} + 13.3$ ($r^2=0.976$) for P-4. The slopes of LMWL at P-1, P-2 and P-3 are relatively gentler than that of Craig's meteoric water line ($d\text{D} = 8d^{18}\text{O} + 10$). On the other hand, the slope of LMWL at P-4 is relatively steeper than that of other points and almost same the slope of Craig's meteoric water line. Thus there is almost no the observation in the mountainous region where the elevation about 2,000 meter, it is important to continue the observation of this study.

Keywords: Matsumoto basin, Utsukushigahara plateau, precipitation, groundwater, stable isotope

Clarification of recharge source and emergence/disappearance mechanism of an oasis in Tottori Sand Dune

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1. Introduction

The Tottori sand dunes, located in the Sanin Kaigan national park, are the most famous sightseeing sand dunes in Japan. In this sand dune, there is an oasis which repeats emergence and disappearance. There is a perpetual spring near the oasis. It has been considered that the spring is the recharge source of the oasis. The emergence/disappearance mechanism of the oasis and the recharge source of the spring are longtime academic concerns. In addition, because the Tottori sand dunes were registered in the global geoparks network in 2010, clarification of the emergence/disappearance mechanism of the oasis has been strongly expected. Although some local researchers have advocated that the water in the spring comes from the Tanegaike pond which located on the south side of the sand dunes, this hypothesis has not been confirmed due to limitation of investigations in the national park. The objectives of this study were to clarify (i) emergence/disappearance mechanism of the oasis, (ii) the recharge source of the spring and (iii) elapsed time from rainfall events to discharges from the spring, through hydrological observation and water stable isotope ratio analysis.

2. Material and Methods

2.1 Water level observation in the oasis

Pressure type water level loggers were buried into the ground at the oasis emergence area. The inside and around area of the oasis were surveyed and three-dimensional shape of the oasis was determined. The shape was used to estimate contribution rate of evaporation to reduction of the oasis volume by combining water level data and pan evaporation data.

2.2 Water stable isotope ratio analysis

Precipitation water for all daily precipitation events was collected from Nov. 2010 - Dec. 2011. Also the oasis and Tanegaike pond water was collected every one-three days. Oxygen ($\delta^{18}\text{O}$) and hydrogen (δD) stable isotope ratio of the water samples were analyzed by an isotope ratio mass spectrometry. The d-excess value was calculated using of the $\delta^{18}\text{O}$ and δD values for each sample.

3. Results and Discussion

The emergences of the oasis were strongly affected by the precipitation within a few hours. The contribution rate of evaporation to reduction of the oasis volume was about 10%, meaning that the most of the oasis water was lost by infiltration to the ground. The values of $\delta^{18}\text{O}$ of the spring and Tanegaike pond did not cross through the whole year, indicating low probability of water flow from the Tanegaike pond to the spring. The annual variation of the d-excess values in the precipitation and spring water suggested that the source of the spring water was reserved and averaged precipitation for long period. However, after very heavy rainfall events, the rainfall water discharged from the spring within about 10 days.

Keywords: oasis, hydrological observation, water stable isotope ratio analysis, d-excess

Tracing the source and fate of nitrate in groundwater using ^{15}N , ^{17}O and ^{18}O

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The stable isotopic compositions of nitrate in precipitation (wet deposition) and groundwater were determined for Toyama prefecture, Japan, so as to use the ^{17}O anomalies (D^{17}O) to trace the fate of atmospheric nitrate that had deposited onto the groundwater catchments. Both d^{15}N and d^{18}O of nitrate were also used together with D^{17}O to trace the non-atmospheric sources of nitrate in the groundwater. Wet deposition (precipitation) samples were taken every week at the Kosugi Station of Toyama Prefectural Environmental Science Research Center from April 2010 to March 2011. Groundwater samples were collected at 47 sites, mostly located on Kurobe, Joganji or Shougawa alluvial fan, in Toyama prefecture. Samples were filtered through a 0.2 micro meter pore-size membrane filter and stored in a refrigerator until analysis. To determine the stable isotopic compositions of nitrate, the sample nitrate was chemically converted to nitrous oxide using a method originally developed for $^{15}\text{N}/^{14}\text{N}$ and $^{18}\text{O}/^{16}\text{O}$ isotope ratios of seawater and freshwater nitrate (McIlvin and Altabet, 2005) with slight modification (Tsunogai et al. 2008). The stable isotopic compositions of nitrous oxide were determined using our Continuous-Flow Isotope Ratio Mass Spectrometry system (Komatsu et al. 2008). Concentration of nitrate in ground water samples varied widely from less than 0.1uM to more than 100uM due to the difference in biological activity among the groundwater catchments. All the groundwater samples in this study had small but positive D^{17}O values in nitrate ranging from +0.4 to +4.0 permil as compared to those in atmospheric nitrate; the annually averaged D^{17}O value of atmospheric nitrate was determined to be +26.8 permil at Kosugi Station. We conclude that only less than 15% of the nitrate in groundwater originates directly from the atmosphere being processed in the soil, and substantial portion of nitrate is remineralized origins that undergo biologic processing in soil before being exported from the ecosystem.

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Keywords: triple oxygen isotopes, nitrogen isotope, nitrate, groundwater, nitrogen cycle

Sources and processes of nitrate in forest soils: a case study at sites with heavy nitrogen deposition using nitrogen an

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Nitrogen is one of the indispensable nutrients for plant growth and microbial activities. The nitrogen cycle is an important part of the forest ecosystems. Atmospheric nitrogen deposition remains elevated in industrial regions of the world and is accelerating in many developing regions. Chronically elevated atmospheric N inputs to forest can lead to changes in tree growth, mortality, and species composition and to possible declines in soil fertility and drainage water quality. Combined oxygen (O) and nitrogen (N) stable isotope analyses are recently used in the source determination of NO₃⁻. The source of NO₃⁻ can be determined based on distinct O and N isotopic signatures (d18O and d15N) of various sources and isotopic effects during NO₃⁻ transformation processes. There two major sources in forest soil nitrate (NO₃⁻): atmospheric deposition and microbial production. In Tanashi where have a high amount of nitrogen deposition, we analyzed d18O and d15N of NO₃⁻ in the samples consisted of the rainfall, though fall, stew fall, litter layer water and the soil water.

The results were: 1) the d18O of NO₃⁻ had a decreasing trend from rainfall, though fall, stem flow to soil water. It indicates that NO₃⁻ derived from the atmosphere is absorbed by plants and/or microbes when the rain through forest vegetation. 2) the d18O of NO₃⁻ values was 0~20 permil while d15N of NO₃⁻ values was -5~5 permil in the soil water. This suggests that the major portion of NO₃⁻ of the soil water is comes from the nitrification in soil by microbes, meaning that most of atmospheric NO₃⁻ was replaced by NO₃⁻ produced by microbes. 3) A large range of d18O values 12~95 permil and d15N values -9.2~6.6 permil in the litter layer water what shows that nitrate in the litter layer water has complex sources including nitrification and atmosphere, and those change temporarily.

Keywords: nitrate, oxygen and nitrogen stable isotope, Tanashi, temperate forest

Keywords: nitrate, oxygen and nitrogen stable isotope, Tanashi, temperate forest

Analysis of nitrate variation by source and hydrologic factors in spring water of Mt. Yatsugatake

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Concerns regarding ground-water contamination in the Mt. Yatsugatake on the west slope have arisen due to a steady increase in averaged nitrate concentrations (from 1.2 to 3.5 NO₃-mg/l) during t

he past 15 years (from 1987 to 2002) in spring waters (Shimizu et al. 2007). Mt. Yatsugatake is volcano in central Japan having elevations of 2899m. The artificial and local resort towns are locating blow 1100m elevation. The stock farms are expanding from upper 1100m until 1400m elevation.

Twenty-nine water samples were collected from 750m to 2380m elevation. Multiple isotopic tracers were used to identify the sources and extent of nitrate dynamics in groundwater under the recharging systems.

The ranges of nitrate-N concentration were from <0.05 to 17.8mg/l. Few samples of high nitrate-N concentrations (5.8 and 17.8 mg/l) were located in locally concentrated of agricultural and local resort town. And 80% of collected samples were <0.9 mg/l. Although delta 15N-NO₃ values (from -0.4 to 10.5permil) were highly variable both spatially and vertically. The high delta 15N-NO₃ values are decreasing with the averaged recharge elevation of springs which was estimated by elevation effects of water hydrogen isotope values on Mt. Yatsugatake reason. Relatively high isotope value samples (4.4-10.1permil) were detected blow 2000m elevation indicated that nitrate in springs mixed from human/animal wastes consistent with landuses. The relationship between NO₃-N concentration and delta 15N values was insignificant. However the high NO₃-N concentration (>0.9 mg/l) springs having relatively small amount of discharges (850 m³/day) indicated the effects for the distribution of NO₃-N concentration is nitrogen sources rather than quantity of the groundwater.

Keywords: Spring water, Mt. Yatsugatake, Nitrate, Nitrate nitrogen and oxygen isotopes, Water hydrogen and oxygen

Source and residence time of groundwater around Battambang region in Kingdom of Cambodia

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Management of groundwater is vital for maintaining social systems under Asian monsoon climate. At Battambang, which is situated west of the Lake Tonle Sap, hydrological system is strongly related to the lake level changes. The river water level of the Sangkae River, the main river running Battambang, fluctuates up to 7 m and the water level almost drops to riverbed in dry season. Groundwater level also fluctuates seasonally. Thus, it is very important to study the relationship between surface water, i.e., river water and lake water, and groundwater for understanding the hydrological system of the area, and to propose appropriate management system. For achieving the objective, we conducted field survey on November 2011 at around Battambang. Groundwater samples were collected from 15 wells, and stable isotopes of oxygen and hydrogen, water chemistry, tritium and sulfur hexafluoride were analyzed for all samples. Based on the results, we discuss source and residence time of the groundwater around Battambang region.

Keywords: Kingdom of Cambodia, Battambang, Groudwater age, Sulfur hexafluoride, Tritium, Stable isotopes

Existence of the long-term groundwater flow system in the Nakano-shima Island, Oki-Dozen, Japan -A preliminary study-

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It is known that groundwater flow system in the coastal area is affected by sea level changes. We have been attempting to reveal the groundwater flow system in the Nakano-shima Island, which is situated in the Sea of Japan, using several indices of the residence time of groundwater (CFCs, ³H, SF₆, and ¹⁴C). In this paper, end-member waters with different residence times are clarified, and the formation of groundwater and hot spring water in the Nakano-shima Island are discussed.

The Nakano-shima Island was formed by volcanic activities which erupted alkali basalt lava c.a. 6Ma (Tiba et al., 2000). Thickness of the lava is about 300 to 400m. The lava overlies the sedimentary rocks of which deposition ages were Lower to Middle Miocene (Tiba et al., 2000).

Groundwater samples were collected from five springs, thirteen water-supply wells (screen depth: GL-10 to -100m) and a hot spring well (screen depth: GL-560 to -870m). All samples were analyzed for CFCs, ³H, SF₆, and stable isotopes of oxygen and hydrogen. Samples from four water-supply wells and the hot spring were analyzed for ¹⁴C and isotopic ratios of helium.

Stable isotopic ratios of oxygen and hydrogen of all samples were plotted on or near the meteoric water line. Those values of the hot spring were lower than other samples. Samples from two water-supply wells and the hot spring well showed much lower CFCs and ³H concentrations than other wells, and their ³H concentrations were close to detection limit (0.2 TU). ¹⁴C concentrations were analyzed for samples from the hot spring, two water-supply wells containing lower CFCs and ³H, and a water-supply well containing higher CFCs and ³H concentration. ¹⁴C concentrations of these samples were 17pMC, 57 to 77pMC, and 96pMC, respectively. The samples analyzed for ¹⁴C were also analyzed for ³He/⁴He and ⁴He/²⁰Ne. Those values of all samples were plotted in the zone which can be explained by the mixing of air, mantle, and crust components, suggesting that mantle-derived fluid is added to groundwater. Thus, pMC values are considered to be higher than those measured by subtracting the addition of ¹⁴C-free fluid derived from mantle. In addition, groundwater containing lower CFCs and ³H and the hot spring water are considered to be the mixture of young groundwater containing CFCs and ³H and old groundwater free of CFCs and ³H, and hence, it is necessary to consider the mixing effect to estimate the pMC values. This analysis is under progress.

Lower delta D and delta ¹⁸O values of the hot spring suggest that the hot spring water might be recharged in colder climate, and this result is consistent with lower pMC value of the hot spring water. It is considered that fresh groundwater recharged during the last glacial period still remains in the aquifers. Further consideration is needed for understanding the formation process of such long-term groundwater flow system in the island, with the focus on the effect of sea level changes and the paleo-topography of the island and its surroundings.

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Preliminary results of groundwater age-related isotopic tracers for shallow groundwaters in the Eastern Osaka Basin

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High chloride groundwaters are often found in the coastal regions, possibly due to intrusion of sea water, squeezing pore water from clay layers by excessive pumping of the wells and/or infiltration of sea water during the sea level rise period. Groundwater age is a key factor for investigating the nature of high chloride component. However, the ages measured by isotopic and chemical methods give only 'mean age' if mixing of groundwater has occurred. This 'mean age' has no meaning when we consider the nature of high Cl water. It is important to know the age for the timing of the high Cl water infiltration into the fresh water.

Since the 1950s, the groundwaters with high Cl concentrations as high as 800mg/L were found in the Eastern Osaka Basin (Kawachi Plain), especially in the region around Yodo River (e.g., Tsurumaki, 1967). The high Cl groundwaters are still found in this area (Nakaya et al., 2009). In this study, we preliminary investigated the mixing condition between the high Cl water and the freshwater and inferred the age of high Cl water using tritium, helium, carbon-14 and chloride-36.

Both He concentration and isotope ratio in shallow groundwaters in the studied area are almost identical to those in air saturated water, indicating these groundwaters are very young sufficient to accumulate little amount of crustal (and mantle) He. It is not contradict with tritium results. Significant amounts of tritium (up to 3.4 T.U.) are detected from most of selected samples analyzed in this study. The ¹⁴C/¹²C ratios show various values ranging from -33 to -809 permil, but these values are significantly high relative to the deep groundwaters in this region which is mostly composed of dead carbon. Four analyses of the ³⁶Cl/Cl ratios also show various values (2.8 - 52.4x10⁻¹⁵). Considering with the relatively low Cl concentration (55 - 230mg/L) and the detection of significant amount of tritium, the samples with the high ³⁶Cl/Cl ratio may be due to the contribution of cosmogenic ³⁶Cl dissolution during recharge. After subtracting the contribution of cosmogenic ³⁶Cl, the ³⁶Cl/Cl ratios in these groundwaters are in the range of those in seawater. High Cl shallow groundwater in the Eastern Osaka Basin may originate from mixing with relatively modern sea water and fresh water, although both the He and ³⁶Cl results for saline groundwaters in the deeper region of this area show the characteristics of nearly stagnant saline water (Morikawa et al., 2011).

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Keywords: Groundwater, Osaka Basin, Tritium, Helium, Carbon 14, Chroline 36

Comparison between volcanic and non-volcanic thermal waters using the chloride type thermal waters in Kanagawa Pref.

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The sodium-chloride type thermal waters which are discharged in the Hakone volcano, located in the west margin of Kanagawa Prefecture, central Japan, are widely known as the typical volcanic thermal water originated from magma, that is, slab-derived fluid (Oki and Hirano, 1970). Recently, the sodium or calcium-chloride type saline waters and brines have been obtained from deep wells installed in the Kanto sedimentary basin of the eastern Kanagawa Prefecture. Itadera et al. (2011) suggests that these deep well saline waters are probably originated from modern or fossil seawaters. The purpose of this study is to understand the difference of the geochemical features between volcanic and non-volcanic chloride type thermal waters discharged in adjacent regions.

The sources of the deep well waters in Kanagawa Prefecture were divided into three groups, (1) modern seawater, (2) fossil seawater and (3) meteoric water, on the basis of the relationship between Cl^- and SO_4^{2-} concentrations (Itadera et al., 2011). On delta-diagram the saline waters of group 1 are plotted along the mixing line between meteoric water (group 3) and V-SMOW (modern seawater), while those of group 2 are plotted below the mixing line (type A) or on the meteoric water line (type B). Almost all the saline waters of type A are discharging from Kazusa formation (Pliocene to Pleistocene), having higher Br/Cl ratio (4.0×10^{-3}) than that of modern seawater with natural gas as well as the natural gas brine in the Minami-kanto natural gas field (Maekawa et al., 2006). The source water of type A seems to be interstitial water of marine deposits, since the depletion of ^{18}O and Mg^{2+} perhaps produced by alternation of volcanic materials in sediments are found as well as pore water from sediments in oceanic crust (Lawrence and Gieskes, 1981). The saline waters of type B are discharging from Hayama formation (Miocene) which is lower than Kazusa one. On the figure of $d^{18}\text{O}$ vs. Cl^- concentration, the most saline waters of type B are plotted on the left-hand side of mixing line between meteoric water and modern seawater, namely the chloride ion is depleted and ^{18}O enriched in seawater. Similar saline water samples are produced from deep wells drilled in Miocene sedimentary rocks at Niigata and Miyazaki Plain. These saline waters seem to be diagenetic water originated from dehydrated interlayer water in smectite. (Ito et al., 2004 and Ohsawa et al., 2010).

The sodium-chloride thermal waters in Hakone volcano are discharging in Gora area, located on the flank of central cones in the caldera, and Hakone-Yumoto, located in the eastern margin of the caldera along valleys which is deeply dissected by Hayakawa and Sukumogawa rivers. Chloride concentration (below 3500m/L) of thermal waters is less than that of the deep well saline waters in the Kanto sedimentary basin. Though the isotopic shift is a little, the thermal waters in Hakone volcano are linearly plotted from meteoric water and high temperature volcanic steam (Matsuo et al., 1985). However, the Li/Cl ratios of thermal waters, which are useful value when seawater and slab-derived fluid are distinguished, differ between Gora and Hakone-Yumoto areas. Most thermal waters of Gora area have higher value ($0.5 \sim 1.0 \times 10^{-3}$) than those of Hakone-Yumoto ($0.25 \sim 0.1 \times 10^{-3}$) with closer value of seawater. The Br/Cl ratio of Gora area is inversely lower value ($1.5 \sim 2.5 \times 10^{-3}$) than that of Hakone-Yumoto area (around 3.0×10^{-3}) in relation to the Br/Cl ratio of seawater is 3.46×10^{-3} . These characteristics of thermal water in both areas seem to be attributed to the effect of the common source water (provably high temperature volcanic steam) and different geological settings and sources of dissolved components.

Keywords: deep hot spring water, Hakone hot springs, interstitial water, diagenetic fluid, volcanic fluid

An isotopic study on Cl-rich groundwater in the lower reaches of the Tone River, Japan

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In the Kanto plain, Japan, there are three regions whose groundwater is characterized by a high Cl concentration: 1) central Kanto plain (eastern parts of Saitama Prefecture), 2) lower reaches of the Tone River (southern parts of Ibaraki Prefecture and northwestern parts of Chiba Prefecture), and 3) northwestern Kanto plain (southeastern parts of Gunma Prefecture and southern parts of Tochigi Prefecture). A study based on water chemistry, delta-18O, delta-D, 3H, 13C, 14C, 3He/4He and 36Cl/Cl has been in progress to elucidate groundwater system of the respective regions with special reference to origins and residence times of both water and Cl. As a part of the study, eighty water samples from the depth interval between 30 and 250m were analyzed in this paper to have a clear grasp of the geochemical status quo of groundwater in the lower reaches of the Tone River.

As a result, groundwater in the Pleistocene sediments in the depth of 80-150m along the Tone River course proved to be characterized by a high Cl concentration of 62-173mg/L as well as highly depleted delta-18O and delta-D values. With regard to the origin of this groundwater, a potential source is assumed to be the precipitation of low stable isotopic composition in the Last Glacial Maximum (peak period at around 20,000 yrs. BP) when the sea level of the Tokyo Bay was lower than the present by more than 100 m. The 36Cl/Cl analyses indicate admixture of 'fossil' sea water trapped in the sediments during the Shimosueyoshi transgression (peak period at around 125,000 yrs. BP) or even earlier transgressions is likely to account for its elevated Cl concentration. On the other hand, groundwater in the overlying Holocene sediments in the depth 30-40m, which is also have a high Cl concentration of 768mg/L, is assumed to have its origins of Cl and water in sea water of the Jyomon transgression period starting around 10,000 yrs. BP and precipitation of the same period, respectively.

Keywords: Kanto plain, Cl-rich groundwater, water chemistry, multi-isotope study, residence time, origins of water and Cl