

Study on the interaction of groundwater flow and denitrification process, using N isotope

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We examined to confirm the importance and limitation of nitrogen isotopic approaches for clarifying the nitrogen cycle processes by the review works in our presentation. First of all, the nitrogen isotopic method which can detect the nitrogen cycle process in the subsurface environments has been established. The experimental report by Mariotti et al. (1981) had been listed up as the benchmark paper of Riparian zone Hydrology. In addition, the isotopic fractionation of nitrate-nitrogen and nitrate-oxygen by Botcher et al.(1990) was also listed up as it of Isotope Hydrology. Based on these approaches, nitrogen cycle process has been confirmed.

Ishizuka and Onodera (1997) confirmed the shallow groundwater flow and denitrification process in the flow path with 100m of the distance from the upland to lowland, using nitrogen isotope. The enrichment ratio was so large even though the short distance. But because it is impossible to collect the information of the detail valuable end-members of the groundwater recharge on the every area, it is not easy to determine the denitrification amount in shallow groundwater.

Saito and Onodera (2009) indicated denitrification process with groundwater flow in a coastal agricultural mountain, using nitrogen isotope. Though the most of the tracer researches have tended to assume the groundwater flow as the simple mixing in the one box, this research considered two flow lines in an unconfined groundwater, using the oxygen isotope. Consequently, they confirmed quantitatively the mixing of two end-member component and denitrification in groundwater. In addition, the spatial distribution of them was also determined. The groundwater flow and denitrification rate is usually the different order in time scale. But we tend to discuss in similar order. We should apply to research on the transient process in groundwater flow, such as the surface water and groundwater interaction.

Keywords: groundwater flow, denitrification, nitrogen isotope

Triple oxygen isotopic compositions of DO in natural spring water seeping at the foot of volcanoes

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Many natural springs are located around volcanoes. Natural springs, located at the foot of Fuji volcano, are enriched in DIC (up to 1.2 mmol L⁻¹), nitrate (up to 0.12 mmol L⁻¹), and DO (up to 0.3 mmol L⁻¹, close to air saturated). The stable isotopic compositions of DIC and nitrate suggest that the respiration (remineralization) reaction of organic matter as the primary source for both DIC and nitrate. Because the respiration reaction consumes DO, we must assume some external sources for DO in source groundwater of the natural springs to explain the apparent unbalance between DIC, nitrate, and DO during the respiration reaction within the groundwater. In this study, we determined the triple oxygen isotopic compositions of DO in water taken from the natural springs to clarify both the source of DO and the system that regulate the groundwater enriched in DO.

The ¹⁷O anomalies of DO always coincided with that of atmospheric oxygen, so that atmospheric oxygen must be the only source of DO in groundwater. On the other hand, DO exhibited ¹⁸O over ¹⁶O ratios lower than the atmospheric oxygen (up to 11 per mil in delta notation).

The ¹⁸O over ¹⁶O ratios of DO in meteoric water must be equal to those of atmospheric oxygen. Besides, they become higher during the respiration through the kinetic isotope fractionation under closed system. Thus, some DO addition processes that accompanied kinetic fractionation must be responsible for both DO enrichment in the groundwater and ¹⁸O-depletion in DO. We concluded that the groundwater was not a complete closed system. Rather, atmospheric oxygen had been supplied to the groundwater through molecular diffusion via soil/rock pore accompanying large isotopic fractionation.

Keywords: natural spring, dissolved oxygen, isotopic compositions, gas exchange, diffusive fractionation, soil pore

Quantitative reconstruction of freshwater discharge of Yangtze River during the past 7000 years based on oxygen isotope

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In this study, $d^{18}O$ of seawater ($d^{18}O_w$), which is an indirect indicator of sea surface salinity, in the northern ECS during the last 7 kyr is reconstructed using Mg/Ca ratio and $d^{18}O$ of planktic foraminiferal shells. According to modern observation, interannual variations in sea surface salinity in summer in the northern part of the ECS is mainly controlled by the discharge from the Changjiang, i.e., rainfall in the drainage area of the Changjiang River. Thus, changes in the sea surface salinity in the northern ECS are interpreted as reflecting variations in the EASM precipitation in South China. It is confirmed that the relationship between salinity in the northern ECS and Changjiang discharge by analyzing the observational salinity data from 1950 to 1994.

However, it is difficult to obtain absolute salinity value with high accuracy in the past, because there are large uncertainties in salinity- $d^{18}O_w$ regression slope or end-member salinity or $d^{18}O_w$ values. Hence, I used $d^{18}O_w$ balance calculation for estimation of freshwater contribution on the northern East China Sea in the past to avoid the large uncertainty in past salinity reconstruction generated by the process of conversion from $d^{18}O_w$ to salinity scale. Today, there is a positive relationship between salinity and $d^{18}O_w$, $d^{18}O_w$ can be used for estimation of freshwater contribution on a given site when end-member $d^{18}O_w$ values are available. This method is better than reconstruction of the past salinity.

During the Holocene, temporal $d^{18}O_w$ record from the southern East China Sea where the Kuroshio Current lies is used as seawater end-member. While, temporal $d^{18}O_w$ obtained by calcite equilibrium equation using speleothem records. During the Holocene, temporal $d^{18}O_w$ record from the southern East China Sea where the Kuroshio Current lies is used as seawater end-member. While, temporal $d^{18}O_w$ obtained by calcite equilibrium equation using speleothem $d^{18}O_w$ from Chinese cave. Then, temporal variations relative contribution of the freshwater on the core site is calculated by using two temporal data of end-member $d^{18}O_w$, indicating that there is no long-term decreasing trend in the Changjiang freshwater discharge since the middle Holocene. This suggests that the temporal changes in precipitation amount in the South China do not follow the gradual insolation change from middle to late Holocene.

In order to estimate the Holocene flux of Changjiang freshwater (Q_{CFW}) into the ECS, modern relationship between Q_{CFW} and the relative contribution of the freshwater KY site is examined at first. Then temporal changes in the flux of the Changjiang freshwater are estimated during the Holocene using the regression line derived from the modern relationship between relative contribution of the Changjiang freshwater at the core site and the flux of the Changjiang freshwater analyzed from 1951 to 1998. The result revealed that variability of the flux of the Changjiang freshwater during the Holocene on centennial to millennial timescale is much lower than interannual time scale, but similar to decadal time scale.

Cl isotopes in pore water beneath the New Jersey Shallow Shelf, IODP Exp.313

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Previous expeditions and oil explorations have found that pore water beneath the New Jersey shallow shelf has very wide range of Cl concentration (from tens to about 1200 mM). IODP Expedition 313 "New Jersey Shallow Shelf" also found pore water with wide range of Cl concentration (about 20 to 995 mM) in the middle of the shelf. The variation of Cl concentration is considered to reflect the history of salinization and desalinization of pore water with sea level change. Also, as for brine, source of Cl is considered to be evaporite or salt-diapir. We measured Cl isotopes (^{36}Cl , d^{37}Cl) to clarify the origin and behavior of Cl using pore water samples taken by IODP Exp. 313.

IODP Exp. 313 collected core samples of Eocene to Pleistocene units at three sites in the middle of the shelf. At H0027A, onshore side, Cl concentration of pore water was lower than 100 mM at the depth from 200 to 320 mbsf (middle Miocene). However, at the bottom part (614 mbsf; late Oligocene), Cl concentration was about 450 mM. On the other hand, at H0029A (offshore side), Cl concentration exceeded 530 mM at 345 mbsf (middle Miocene) and achieved to about 995 mM at 712 mbsf (late Oligocene). From the result of ^{36}Cl , Cl at the bottom of H0029A is considered to be in radioactive equilibrium. That is, the residence time of the Cl is estimated more than one million years. As for d^{37}Cl , difference between the deep part of two sites was not clear. Considering the lithology of sediments (mainly silty layers), it is estimated that Cl is mainly transported by advection of pore water through bedding plane and fracture of sediments.

This study is supported by CDEX/JAMSTEC.

Keywords: IODP, Expedition 313, New Jersey, continental shelf, pore water, Cl isotope

An attempt to investigate the impacts of long-term sea level changes on groundwater systems using ^{36}Cl and ^4He

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In the Japanese islands, long-term sea level fluctuations induced by climate change can have caused large impacts on groundwater flow regime especially in coastal areas. This study explores the evidence of such influence in coastal deep groundwater, which has been formed through the repeated mixing of meteoric groundwater (freshwater) and seawater. A coupling approach between ^{36}Cl and radiogenic ^4He was adopted in crystalline rock and sedimentary rock areas.

In the subsurface, both of the production of ^{36}Cl and the accumulation of radiogenic ^4He can theoretically be described with residence time (age). When seawater-derived saline water mixes with meteoric groundwater, the ^4He concentration would be enriched or diluted depending on the relative difference in their ages, and the $^{36}\text{Cl}/\text{Cl}$ ratio would change accordingly with Cl concentration. Therefore, any deviation of measured data from an equal age line (a "growth curve") in a ^4He - ^{36}Cl plot can be interpreted as a result of freshwater-seawater mixing.

The Seto Inland Sea area is characterized by granitic rocks, which can constitute fractured-rock aquifer systems. Majority of saline deep groundwater samples exhibited extremely low $^{36}\text{Cl}/\text{Cl}$ ratios ($\sim 1 \times 10^{-15}$ or less) with radiogenic ^4He concentrations greater than the growth curve, clearly indicating the mixing of younger seawater and older meteoric groundwater. The ages of seawater and meteoric groundwater fractions were separately calculated from the $^{36}\text{Cl}/\text{Cl}$ ratios of seawater end-members and the ^4He concentrations of meteoric groundwater end-members, respectively. Seawater ages in saline deep groundwaters were mostly less than a few tens of thousands years, while meteoric groundwater fractions showed older ages. This may indicate that the seawater intruded into the aquifer during the Holocene transgression period. The results in turn suggest that the groundwater in a fractured granitic aquifer is relatively easily replaceable during a transgression-regression cycle.

The sedimentary basin in Aomori Prefecture is mainly filled with Neogene to Quaternary sediments including "Green Tuff" formations of lower to middle Miocene ages. Deep groundwater samples were more likely to show radiogenic ^4He concentrations comparable to or less than the growth curve, which suggests the mixing of older seawater and younger meteoric groundwater. Assuming a young meteoric groundwater end-member of $^{36}\text{Cl}/\text{Cl} = 100 \times 10^{-15}$ (Cl = 5 mg/L), $^{36}\text{Cl}/\text{Cl}$ ratios of seawater fractions (Cl = 19,000 mg/L) were calculated to estimate their ages. Overall, calculated seawater ages become older from coastal to inland areas. Relatively old ages of seawater fraction were encountered in the west of Lake Ogawara, corresponding to the deepest part of the basin as indicated by the negative gravity anomaly. At the same time, in the central Kamikita Plain, relatively young seawater ages range inland from the coastal area. These results may imply hydrogeological controls on the flow of old seawater and on the intrusion of young seawater during transgression in a sedimentary rock area.

Keywords: deep groundwater, groundwater dating, ^{36}Cl , ^4He , sea level change

A multi-isotope study on Cl-rich groundwater in the lower reaches of Tone River, Japan

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Groundwater in an alluvial plain extending along the Tone River in the southern parts of Ibaraki Prefecture and northwestern parts of Chiba Prefecture, Japan is known to have a high Cl concentration. A multi-isotope study based on ²H, ¹⁸O, ³H, ¹³C, ¹⁴C, ⁴He and ³⁶Cl has been in progress to elucidate groundwater system of the region with special reference to the origins and residence times of both water and Cl. Around 95 groundwater samples from a depth interval between 5 and 250m were analyzed to have a clear grasp of the geochemical status quo of groundwater in the Holocene sediments (alluviums) of the alluvial plain and the underlying Pleistocene sediments. As a result, it was found that groundwater in the Pleistocene sediments in the depth of 80-150m has a Cl concentration of 62-200 mg/L and is characterized by the depleted delta-¹⁸O and delta-D values as well as a relatively old ¹⁴C age of about 20,000 yrs. With regard to origins of water, 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 an 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. In contrast, groundwater in the overlying Holocene sediments in the depth of 30-40m, which has a much higher Cl concentration of up to 768 mg/L, is characterized by a relatively young ¹⁴C age of ca. 9,000 yrs. and the enriched delta-¹⁸O and delta-D values. Taking these measurements and ³⁶Cl/Cl analyses into account, groundwater in the Holocene sediments is assumed to have its Cl and water origins in sea water of the Jyomon transgression period starting around 10,000 yrs. BP and isotopically-enriched precipitation of the same period, respectively.

Keywords: Tone River, alluvial plain, Cl-rich groundwater, multi-isotope study, residence time, origins of water and Cl

Stable isotopic compositions of river and spring waters in the southeastern part of 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 since 2011. The results of the investigation was that delta-18O and delta-D of groundwater samples mainly showed -8.8 to -10.6 permil and -50.7 to -62.7 permil, respectively. Stable isotope composition of the samples roughly resemble those of meteoric water ($dD=8d18O \times 20$), thereby indicating that these are local meteoric water. Moreover, isotope composition confirmed that they are affected by altitude.

At that we focused southeastern part of the Shirakami Mountains and collected sixty new water samples from these area between March and November, 2012.

Keywords: Shirakami Mountains, hydrogen and oxygen isotopes

Stable isotopic composition of nitrate in stream and river water of the southeastern Shirakami Mountains

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Recently, volume of nitrogen load has been increasing in mountainous area because of acid rain. The concentration of T-N keeps increasing in the water of Subari Lake in the Shirakami Mountains at Akita Prefecture. To elucidate of nitrogen cycle in forest is importance problem in view of effects of ecosystem in the Shirakami Mountains. Then, in this study, We have studied about the chemical and nitrate-nitrogen ($\delta^{15}\text{N-NO}_3^-$) and oxygen ($\delta^{18}\text{O-NO}_3^-$) stable isotopic compositions of stream and river waters in the southeastern area of the Shirakami Mountains, to verify the loaded nitrate source in investigation basin and spatial distribution of nitrogen isotope values originated from forest.

Water sampling were collected from 22 streams and rivers in Fujikoto river basin, Kohinai river basin and Kasuge river basin on May, 2012 to November, 2012 in the southeastern area of the Shirakami Mountains. The main water sampling points were in the river, stream, spring, lake and marsh. Chemical components were analyzed using ion chromatograph.

NO_3^- concentration ranged from 0.5mg/L to 3.1mg/L. but almost samples around 1mg/L, there is almost the same results as those obtained in the 2011. However, 2 spring water showed relatively high NO_3^- concentration (more than 2.0mg / L - 3.0mg / L) in Kasuge river area.

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

CO₂ exchange between the atmosphere and terrestrial waters - Case studies in the Ganges, Brahmaputra, and Meghna rivers

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In the context of the carbon cycle, terrestrial water is typically considered as the horizontal export of carbon from the continents to the ocean. Also, recent studies reported significant vertical exchange of abundant CO₂ between the terrestrial water and the atmosphere. Thus in order to capture the whole picture of terrestrial water in the carbon cycle, CO₂ exchange between the waters and the atmosphere remains open. However, the study areas with regard to CO₂ exchange have not been evenly distributed geographically in the world. In addition, the effect of biogeochemical processes in the water to CO₂ partial pressure (*PCO₂*) in the water has not studied well.

In this study world largest rivers flowing in Bangladesh were investigated: the Ganges, Brahmaputra, and Meghna rivers. These rivers originate from the high Himalaya, the region having high rates of uplift. Reflecting such geological settings, the river waters showed an active chemical weathering of carbonate. Although chemical weathering consumes CO₂, higher *PCO₂* values were observed in the river water than the atmospheric level. Through the spatial and seasonal variations of *PCO₂* and dissolved matters in this study, we propose that soil respiration, which supply CO₂ to the water, is the dominant factor controlling river water *PCO₂*, while in situ biological activity has a minor impact on river water *PCO₂*.

Keywords: PCO₂, river, weathering, soil respiration, Bangladesh, carbon cycle

Intensive Observation of Stable Isotopes in Precipitation over Japan in 2013

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Stable isotopes in precipitation (Oxygen-18, Deuterium) are useful for a tracer of hydrological cycle, a proxy of peleo-climate, and a certificate of food origins. There are a lot of precious studies which observed stable isotopes in precipitation over Japan, however, most of them were observed only one or a few stations and observation periods were limited.

The observation network of stable isotopes in precipitation over Japan was set up by the Isotope Mapping Working Group in the Japanese Association of Hydrological Sciences (IMWG-JAHS). The objectives of IMWG-JAHS is to observe the spatial distribution and seasonal variability of stable isotopes in precipitation over Japan and to make an empirical formula of stable isotopes in precipitation over Japan from the geographical information, meteorological parameters, and observed isotope data in all sites. In order to archive these objectives, monthly precipitation are sampling at about 100 stations over Japan during 2013 (IOP2013). In addition to IOP2013, the data of stable isotopes in precipitation are collecting from published articles and reports, and also unpublished observational data (data rescue). The website of these database will be opening soon.

Keywords: precipitation, stable water isotopes, d-excess, Japan

Monthly Oxygen-18, Deuterium and Chloride characteristics of precipitation in the Ndop plain, North West Cameroon

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Knowledge of stable isotopes and chemical tracers in meteoric water has been used as a valuable tool in various environmental studies. A systematic monthly sampling of precipitation, in the Ndop plain, was carried out to generate basic data on d18-O, dD and Cl-, determine their seasonal variations and controlling factors to be used as baseline data in hydrological studies. The d18O-dD relationship of rainfall gives a regression line: $dD = 7.93 d18O + 13.26$ ($R^2 = 0.99$), which represents the Ndop Meteoric Water Line (NMWL). The slope is similar to the Global Meteoric Water Line (GMWL), but, with a high d-excess, which suggests a contribution of continental recycled moisture to precipitation. Precipitation shows a wide variation, throughout the year (2012) in d18O and dD, from +3.86 and +38.62 per-mille in January to -7.98 and -53.18 per-mille in September, respectively. The volume-weighted mean of precipitation, which plots close to June rainfall, is -5.61 and -31.93 per-mille for d18O and dD, respectively. Light convective pre-monsoon and post-monsoon showers, under low relative humidity conditions, are isotopically more enriched than heavy orographic monsoon rain, under high relative humidity conditions. Chloride varies from 1.56 mg/l in the pre-monsoon to 0.06 mg/l during the monsoon rains; like d18O and dD, it shows high values in early and late rains. Apart from January, all d-excess values in monthly rains are >10 per-mille. The high d-excess values at the beginning and end of the rainy season suggest the contribution of recycled moisture to precipitation occurs during these periods, under low relative humidity conditions. Assuming a constant condensation temperature, the observed seasonal variation in isotopic composition of precipitation is probably as results of the (1) rain out of Atlantic moisture, (2) monthly rainfall amounts, (3) addition of inland recycled moisture, (4) rain formation mechanism, and (5) varied relative humidity. The varied Cl- concentrations are due anthropogenic and oceanic sources, and rainfall amounts.

Keywords: monthly rainfall events, stable isotopes, chloride, Ndop Meteoric Water Line, Cameroon

Groundwater isoscapes in Japan and in the world - utility of bottled waters

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The importance of "isoscapes", that is, the mapping of large-scale spatiotemporal distributions of stable isotope compositions in various environments, is being recognized as providing a framework for fundamental and applied research questions at large scales. In the field of hydrological science, groundwater isoscapes are potentially important, for example, as a background data for observation studies and as a validation data for modeling studies. Bottled waters, many of them are from natural groundwater sources and contain the information of sampling location, are easily available in many countries. Here, we present a dataset of stable isotope ratios for bottled waters collected from worldwide, and consider potential applications of such data for groundwater isoscape studies. We collected 378 bottles from Japan and 216 bottles from 42 nations except Japan. We successfully present the isoscape of the Japanese bottled waters based on this dataset. There is a clear linear relationship between $\delta^{18}\text{O}$ and δD for the Japanese bottled water. Generally, these values decrease from south to north. The correlations of $\delta^{18}\text{O}$ with the latitude and with the ground surface elevation are negative. Thus, the latitude and altitude effects, which are commonly observed in precipitation, are also reflected to the bottled waters. The large part of the world samples are from the Northern Hemisphere. The weak latitude effect for $\delta^{18}\text{O}$ is found in the Northern Hemisphere. On the other hand, the effect is unclear in the Southern Hemisphere. These patterns are similarly found in the global maps of $\delta^{18}\text{O}$ in precipitation derived from the Global Network for Isotopes in Precipitation (GNIP). Moreover, the spatial distributions in Europe and in East Asia are similar to the published groundwater isoscapes in some European and Asian Countries. Our findings suggest that the commercial bottled waters will be a good proxy of natural environmental water on average, and a potential tool for the global isoscape studies and for the database of isotope values of groundwater if samples are available from all over the world.

Keywords: Bottled water, stable isotope of water, isoscape, Japan;, the World

Characteristic of water quality and stable isotope in groundwater at Aizu district, western part of Fukushima prefecture

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Aizu district, which is located at western part of Fukushima prefecture, has some different geology, that is volcanic area (Mt. Bandai, Mt. Azuma, Mt. Hiuchigatake and Numazawa) and no volcanic area. In the volcanic area of Mt. Bandai, Mt. Azuma, Mt. Hiuchigatake, the andesite is distributed. In the Numazawa volcanic area, the rhyolite and dacite are distributed. In the non-volcanic area, the sedimentary rock, granite and accretionary prism spreads widely. Because the different geology is distributed in the Aizu district, it is thought that the water quality of groundwater and spring water is different in this area. For example, thus the igneous rocks (e.g. andesite, granite) include a lot of SiO₂, groundwater and spring water of these area includes highly-concentrated SiO₂. The research of water quality in large area of Aizu district has not been carried out. So, the objective of this study is to clarify the characteristics of water quality and stable isotopes in Aizu district.

The study area is 17 municipalities, which are Aizuwakamatu City, Bandai Town, Inawashiro Town, Kitashiobara Village, Kitakata City, Nishiaizu Town, Aizubange Town, Aizumisato Town, Yanaizu Town, Mishima Town, Kaneyama Town, Tadami Town, Showa Village, Shimogo Town, Tenei Village, Minamiaizu Town and Hinoemata Village. The investigation point for spring water is 70 points, groundwater is 3 points, river water is 12 points, lake water is 7 points and tap water is 2 points, it is 94 points in total. The EC, pH, water temperature and ORP were measured in each point. The water quality (Na⁺, K⁺, Mg²⁺, Ca²⁺, Cl⁻, NO₃⁻, SO₄²⁻, HCO₃⁻), SiO₂, stable isotopes of oxygen and hydrogen were analyzed for all samples, and stable isotope of carbon was also measured at some point.

The EC values is under 100 μ S/cm at many points. The pH indicates from the neutrality to the acidity. The water quality indicates the Ca-HCO₃ type or Na-HCO₃ type at most points. However, in Mt. Bandai area, Ca-SO₄ type is existed and dissolved materials is relatively large. Around or near Mt. Bandai, it is suggested that the water quality was affected by the volcanic gas and volcanic hot spring. Na-Cl type and other types slightly existed. Because the dissolved materials are low in the mountainous region, it is thought that the residence time in this area is relatively short. The SiO₂ concentrations are varied by a region because of different geology.

The average of $d^{18}\text{O}$ is -11.0 permil and $d\text{D}$ is -69 permil. The stable isotopes are relatively low in the Minamiaizu Town and Hinoemata Village. Minamiaizu Town and Hinoemata Village are located at inland with heavy snowfalls, so the stable isotope values decrease in these areas. The relation between stable isotopes and elevation is not clearly in the large area as Aizu district. However, the negative correlation between stable isotopes and elevation is existed around Mt. Bandai and Mt. Azuma area. For most point, the d-excess values are distributed from 15 to 25, it appears that d-excess values are affected by the origin of water vapor (i.e. Pacific origin or Japan sea origin). The local meteoric water line of Aizu district is $d\text{D} = 6.4d^{18}\text{O} + 1.3$ ($r^2 = 0.780$), the slope and intercept of y axis are lower than that of Craig's meteoric water line ($d\text{D} = 8d^{18}\text{O} + 10$). It is expected that the evaporation affects the stable isotopes in these area. And volcanic gas may also affect the stable isotopic ratios.

Keywords: Aizu district, groundwater, spring water, water quality, stable isotopes