

## Iron and spring water which have been ignored in material cycles in coastal marine ecosystems

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Material cycles in coastal areas can be calculated by freshwater and salinity budgets using a standardized method proposed by LOICZ (Land-Ocean Interaction in the Coastal Zones) Working Group if the targetted area is estuaries with an obvious salinity gradient. In the manual, material loads from spring water can be ignored in case no data are available. However, it is assumed that bottom spring water contains higher concentration of dissolved matter particularly minerals than that of river water, because it passes through the underground lithosphere. Eventhough the water volume is smaller than that of river water, it may contribute greatly to the material budget in coastal areas.

In enclosed coastal seas of Japan, the number of red tide occurrence has been decreased and the transparency has also significantly been increased by reduction measures of material loads from land. There are several areas in which the growth of fish and other organisms is depressed by nutrient depletion, which is called "oligotrophication".

Unexpectedly, the anoxic water mass is still formed in the bottom layer of coastal areas whereas the material loads was reduced. This evidenced that the anoxic water mass may be formed not only by decomposition of organic matter but also by chemical oxidation of hydrogen sulfide. This also suggests that depletion of iron which is an essential element for the growth of algae.

The author recently determined the concentration of dissolved iron from the upper area of the Ohta River which flowing into Hiroshima Bay to lower river and seawater of the bay. Iron and nutrient concentrations in a spring in the bay were also investigated. The author hopes the presentation would be a hook to promote material cycle study of coastal seas.

Keywords: nutrient, material cycle, iron, spring

## Estimation of distribution and discharge flux of submarine groundwater using Rn-222 in the Yatsushiro Bay

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Continuous Rn-222 monitoring method has been developed around a decade ago, and with this method, evaluation of spatial distribution and flux of submarine groundwater discharge (SGD) in/along ocean coastal bay/line is becoming popular worldwide. In this presentation, we will introduce a case study in Yatsushiro Bay, describing distribution and flux properties of SGD, deduced by Rn-222 data collected during recent four years. We try to show and confirm the merit and limit of Rn-222 monitoring method and propose a new approach to solve several potential problems on Rn-222 study.

Yatsushiro Bay is one of the largest inland sea in Japan, surrounded by Kyushu mainland to the east and Amakusa Islands to the west. Its total area is around 1,200 km<sup>2</sup> with a total coastal line of around 220 km. The hinterland of this bay is composed of watersheds with various topographic and geological features. Therefore, Yatsushiro Bay should provide an ideal setting to understand the factors, i.e., watershed area, topographical gradient, presence of tidal flat, geological constituent materials and geological structure, controlling SGD distribution properties in wide scale coastal sea area. By summarizing these features, we can confirm interesting SGD distributing natures in coastal environments.

After analyzing Rn-222 samples of 61 flowing rivers into Yatsushiro Bay, we realized that river waters contain considerable Rn-222, which value cannot be ignored when interpreting Rn-222 signal in the sea. In order to evaluate the effect of river-originated Rn-222 in the coastal sea water, we developed sea water Rn-222 distribution model within whole Yatsushiro Sea, based on a previously constructed ocean currency simulation model. The net SGD-originated Rn-222 concentrations were estimated by subtracting simulated river-originated Rn-222 concentrations from the observed towing Rn-222 monitoring data.

A total SGD flux within the Yatsushiro Bay was evaluated following traditional box model concept, by multiplying advection rate deduced from continuous Rn-222 monitoring results at mooring survey sites, and SGD patch area estimated by Rn-222 towing survey results. Consequently, it was concluded that 15% of the total water transported toward the Yatsushiro Sea from the land is SGD origin. Furthermore, we tried to understand the possible components contributing to Yatsushiro coastal water, FSGD, RSGD, river water, and sea water, with their contribution degree quantitatively. Our analysis also suggested interesting aspect that wind velocity on the coastal sea surface would be an important triggering factor of SGD.

As a result of our study, it was suggested within the Yatsushiro Sea that Rn-222 concentration could not play as a direct tracer of groundwater because the Rn-222 in the coastal sea water can be partially derived from rivers flowing into the bay. Although previous studies have not taken this effect into account in interpreting sea water Rn-222 observation results, our findings, and our solution idea, would be essential to be incorporated in a future study in an area of similar climate and topographical condition like Yatsushiro area. With this topic, we will propose distribution property, estimated flux, and discharging mechanism of submarine groundwater comprehended by a recent Rn-222 study in the Yatsushiro Sea.

**Keywords:** SGD, Rn-222, simulation, tidal flat, discharge rate, distribution

## Analyses of submarine groundwater discharge based on Radon-222 concentrations of the coastal water in Japan

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Radon-222 is one of the useful tracers for evaluating submarine groundwater discharge (SGD), because the groundwater has extremely high concentration in <sup>222</sup>Rn compared with surface water. In this study, we attempted to compile and compare radon data observed in ten study areas in Japan, with SGD observed by seepage meters as well as local environmental parameters such as precipitation, gradient, permeability, basin area, tidal range, and others. We used geographical information system (GIS) and digital elevation model (DEM) to evaluate the characteristics of the basin. The highest <sup>222</sup>Rn concentrations was recorded in Yuza (Northwestern Tohoku area) in Japan, where the highest SGD by seepage meter was observed. <sup>222</sup>Rn concentrations increases with precipitation within the study areas of four bays in Yuza and four bays in Otsuchi. Multivariable analyses of driving factors of submarine groundwater discharge were performed in the ten study areas.

Keywords: submarine groundwater discharge, Radon, coastal groundwater

## The origin of submarine groundwater discharge in the coastal zone of Hiji, Oita prefecture

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It is believed that groundwater discharges from the seabed of the coastal zone of Hiji, Oita prefecture. The marbled sole which lives around this submarine groundwater discharge (SGD) is called the "Shirosita Karei", and is held in high regard by the local community. From ancient times, local people have believed that this Shirosita Karei grows because of SGD. However, the ecological link between marbled sole and SGD has not been well established. Moreover, although it is clear that there is SGD in the area, there is almost no information about the origin and dissolved components of the SGD. In this study, we directly collected SGD and analyzed its chemical composition and water stable isotopes. Additionally, we analyzed the chemical composition and water stable isotopes of the inland cold spring water. We considered the origin of the SGD by comparing the result of the SGD analysis and the inland cold spring analysis. Since we expected that the temperature of SGD would be different than seawater, we used a thermometer for the identification of the discharge location. We inserted a stainless steel pipe in the identified location and collected SGD water. The sodium concentration from the collected SGD water was 12.1 mg/l, indicating fresh water. The isotopic composition of the SGD water resembled that of the inland cold spring water. The recharge area of the inland cold spring water is at an elevation of 200 m or more. These results suggest that the SGD water comes from an elevation of 200 m or more. It indicates that the origin of SGD is water recharged in the forest area of the mountain slope, and that the water moves under the plain and is discharged at the seabed.

**Keywords:** Submarine groundwater discharge, Stable isotope, recharge area, Hiji

## Submarine groundwater discharge and nutrients state of around coastal seawater

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In recent years, the importance of nutrient input to the coastal seawater through submarine groundwater discharge (SGD) has been pointed out in several studies. The coastal area of Hiji town in Oita Prefecture, it is known that there is a submarine groundwater discharge. However, the effects of SGD-derived nutrients has not yet been clarified in this area. Therefore, we investigated the spatial distribution of SGD using radon-222 isotope as a groundwater tracer and assessed the impact on the nutrient (DIN and DIP) concentrations of surrounding seawater. In May 26-30, 2014, we monitored <sup>222</sup>Rn and nutrients along the coast of Hiji. In addition, we collected the spring water on the land and the spring water of a salt water mixture discharged on the coast. As a results, <sup>222</sup>Rn concentrations was clearly highest on SGD point. Nutrients concentrations around the SGD point were higher DIP concentrations than elsewhere and the N/P ratios lower than the Redfield ratio. These results imply that SGD is main source of DIP in coastal area of Hiji.

Keywords: Submarine groundwater discharge, <sup>222</sup>Rn, Nutrients, Primary production

## The influence of groundwater discharge on primary production in a shallow coastal sea, Obama bay, Japan

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Submarine groundwater discharge (SGD) often influences on biogeochemical properties in coastal seas. We observed spatial and temporal variations in SGD using <sup>222</sup>Rn and seepage meter along the shoreline of Obama bay, Japan. The results showed SGD exists even in the shallow sea adjacent to the small water catchment area (~1 km<sup>2</sup>), where the range of the tide is relatively small (10 ~30 cm). The spatial and temporal variations in chlorophyll observed at the same time suggest that the SGD influences on primary production.

Keywords: land-ocean interaction, submarine groundwater discharge, costal ecosystem, primary production

## Location estimation of submarine groundwater discharge from Mt. Fuji in Suruga Bay (II)

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Around the foot of Mt. Fuji, the main flow passages of groundwater are thought to be in the Younger Fuji volcano, which consists of the pervious basaltic lavas in new volcanic stage. Especially, the Fujikawa-kako fault zone, which stretches south to north in the southwestern side of Mt. Fuji, has a potentially effect on the local groundwater flow system into Suruga Bay. Therefore, precipitation at Mt. Fuji have been considered to be discharging partly from seabed in Suruga Bay and making a great impact on the biological production at the coastal sea area.

For the purpose of contribution to make sense of the rich coastal ecosystem in Suruga Bay, we conducted a survey for submarine groundwater discharge (SGD) in Oku-Suruga Bay: from the mouth of the Fuji River, at which the fault is found, to Tagonoura, where the lavas of the Younger Fuji volcano are distributed from 100 to 200 m below sea level. We are trying to estimate some locations of SGD from bottom topography, condition of seabed and geological structure by using multibeam sonar, side scan sonar and sub-bottom profiler, respectively. We also use a remotely operated vehicle (ROV) for photographing for the image of the extrapolated spring points. In this presentation, we introduce our works noted above.

Keywords: submarine groundwater discharge (SGD), Mt. Fuji, multibeam sonar, side scan sonar, sub-bottom profiler, remotely operated vehicle (ROV)

## Effects of submarine groundwater discharge on coastal fishery production: emphasizing on fish community

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Biotic and abiotic surveys were conducted at four sites in Japan, where submarine groundwater discharge has been confirmed. In order to evaluate the contribution of nutritional input from the terrestrial ecosystems to production of fishery resources in coastal areas, sampling for fish and their prey organisms were conducted. Number of fish species, fish abundance and biomass were compared between areas of different levels of Radon concentration at each site.

Keywords: coast, water-food NEXUS, Fishery resources, biodiversity, submarine ground water, biological production



## The evaluation of the effectiveness of the $\delta^{13}\text{C}$ signature in bivalve shells as proxy for environment of SGD

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Submarine groundwater discharge (SGD) is often characterized by high concentration of nutrients and documented as an important pathway between land and sea contributing to the biological productivity in coastal waters. However, to our knowledge, no scientific information about the relationship between environmental conditions of SGD and the extent of biological productivity of the primary consumers is available. The carbon stable isotope composition of dissolved inorganic carbon ( $\delta^{13}\text{C}\{\text{DIC}\}$ ) is generally different between SGD (low  $\delta^{13}\text{C}_{\text{DIC}}$ ) and sea water (high  $\delta^{13}\text{C}_{\text{DIC}}$ ). Bivalves record chemical and biological environment-signal in their shell. In this study, to examine whether the  $\delta^{13}\text{C}$  of bivalve shell ( $\delta^{13}\text{C}_{\text{SHELL}}$ ) reflect the  $\delta^{13}\text{C}_{\text{DIC}}$  of the ambient water or not, we conducted the rearing experiments of Manila clam *Ruditapes philippinarum* under laboratory and field conditions. Manila clam was reared at three different salinity in the laboratory; 100% sea water (100 % SW), 80% sea water + 20% underground water (80 % SW) and 60 % sea water + 40% underground water (60 % SW). Water temperature of three salinity groups was maintained at 25 °C and the same amount of diet (*Chaetoceros gracillis*) was fed every day during experiments (3 months). There was a high positive correlation between  $\delta^{13}\text{C}_{\text{DIC}}$  and salinity ( $r^2 = 0.997$ ,  $n = 32$ ,  $p < 0.001$ ). Although the significant difference among 100 % SW, 80 % SW and 60% SW was not found (ANOVA,  $p > 0.05$ ), the  $\delta^{13}\text{C}_{\text{SHELL}}$  of 80 % SW and 60 % SW was tend to be lower than that of 100 % SW. The field experiment was carried out at 6 sites under different SGD condition in Obama Bay, Japan from July to August 2013. Manila clam was reared in the small containers with bottom sand, which were kept at the depth of 2 m under natural condition. There was a high negative linear relation between  $\delta^{13}\text{C}_{\text{SHELL}}$  and Radon 222 ( $^{222}\text{Rn}$ ) concentration at surface layer of each rearing site, which is a useful tracer of SGD ( $r^2 = 0.920$ ,  $n = 6$ ,  $p < 0.01$ ). Thus, it seems that the  $\delta^{13}\text{C}_{\text{SHELL}}$  shows some possibility of being proxy for environmental reconstructions of submarine groundwater discharge. However, the value of the  $\delta^{13}\text{C}_{\text{SHELL}}$  was lower by about 5 ‰ than that of the  $\delta^{13}\text{C}_{\text{DIC}}$  of ambient water in the laboratory experiment. It was the possible reason that isotopically light metabolic carbon, derived from food, is incorporated into shell carbonated.

**Keywords:** Dissolved inorganic carbon, metabolic carbon, bivalve shell, carbon stable isotope ratio, submarine groundwater discharge

## The application of regional groundwater flow model to the underground dam in the ryukyu limestone aquifer

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The underground dam was construction in the Ryukyu limestone aquifer and groundwater is used to agricultural water. Water quality change of groundwater and that affect to sea water quality through submarine groundwater discharge to be expected due to agricultural use.

Groundwater model for understanding and predicting hydraulics and contaminant transport in aquifer make assumptions about the distribution and hydraulic properties of geologic features that may not always apply to karst aquifers. In this study, a finite difference groundwater model (MODFLOW-NWT) was applied to construct an equivalent single layer two-dimensional mathematical model of the Ryukyu limestone aquifer, which is located a southern part of Okinawa main islands. In order to handle problems at regional scale groundwater model in the aquifer, automated parameter estimation method (PEST) and coupling the conduit flow process was used in this model. Groundwater level measurements collected in 1994 were used to calibrate a steady state model of the study area. This study shows the ability of MODFLOW-NWT and PEST to simulate regional groundwater flow in highly karstified aquifer such as Ryukyu limestone aquifer, which is important for water resource and groundwater management in the area.

Keywords: Underground dam, groundwater flow, conduit flow, PEST, submarine water discharge

## Analysis about the condition of sea water intrusion to Yodo River estuary by the fluid model

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Red tide of *Alexandrium tamarens* occurred in Yodo River estuary in recent years. *A. tamarens* is marine phytoplankton and causes shellfish poisoning. Sea water intrusion to Yodo River is one of the reasons of marine phytoplankton survive. We investigated the distribution of the sea water intrusion by in-situ observation, then reproduced it by the fluid model. Fluid structure of Yodo River estuary consists by the runoff of fresh water, the estuary circulation, the tidal current and the wind driven circulation. These had contributed at almost same rate to sea water ascension.

Keywords: Yodo River, sea water intrusion, Red tide, shellfish poison, fluid model

## Diurnal variation of pH in Oshoro Bay, Hokkaido: A monitoring study assessing and projecting impacts of ocean acidific

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Coastal marine species have already been experiencing a low pH environment ( $<7.9$ ) that is not predicted until 2100 in open oceans in a high CO<sub>2</sub> world. To properly assess impacts of ocean acidification on them inhabiting wide ranges of diurnal variation of pH, we need to conduct long-term and high-frequency monitoring measurements of environmental parameters. In this study, to investigate the diurnal variation of pH in subarctic region, which is less known than tropical and subtropical regions, we conducted monitoring measurements of pH, seawater temperature, and salinity in Oshoro Bay, Hokkaido from 2013 to 2014. Mean, maximum, and minimum pH values obtained by a pH meter were 8.02, 8.47, and 7.33, respectively. Although ranges of diurnal variation of pH were different with season, increases in pH during the day and decreases during the night were found in all periods. There are no statistically significant relationships between the variation of pH and that of seawater temperature or salinity except in some cases. These results suggest that observed diurnal variations of pH may be driven by photosynthesis and/or respiration in resident organisms in Oshoro Bay.

Keywords: subarctic region, ocean acidification, coastal ecosystem, diurnal variation

## Ongoing stress of transboundary pollution: Assessment of atmospheric N deposition influence by means of nitrate isotopes

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Anthropogenic emissions of reactive nitrogen (N) due to fossil fuel combustion and modern agriculture practices have dramatically increased in global scale. In the Japanese watershed along the Sea of Japan, large amounts of reactive N emitted from northeastern Asia have deposited onto forest ecosystems, and thus N concentrations in rivers and groundwaters have been increased year to year. Remotely modified N concentrations of terrestrial waters in local watersheds would affect coastal ecosystems. However, quantitative influence of N deposition on the watershed along the Sea of Japan is still unclear. In this study, we assessed the influence of atmospheric reactive N deposition on the watershed in Wakasa Bay by means of the <sup>17</sup>O anomaly ( $\Delta^{17}\text{O}$ ) in nitrate, which is an alternative tracer for atmospheric nitrate ( $\text{NO}_3^-_{\text{atm}}$ ). As a result, fractions of  $\text{NO}_3^-_{\text{atm}}$  in stream waters of the Kita River observed in 2014 changed from >10% in winter to 6% in summer. This seasonal variation corresponded to monthly changes in reactive N (=  $\text{NO}_3^-$ ,  $\text{NH}_4^+$  and others) deposition rates onto the watershed. However, most of  $\text{NO}_3^-$  in stream water was derived from remineralized  $\text{NO}_3^-$  by nitrification ( $\text{NO}_3^-_{\text{re}}$ ) within the watershed. Apparent nitrification rates estimated by  $\Delta^{17}\text{O}$  were significantly higher than total N deposition rates. Although fractions of  $\text{NO}_3^-_{\text{atm}}$  in groundwater and spring water (mean $\pm$ SD =  $4.3\pm 0.3\%$ ), which was dated from 2001 to 2009 by  $\text{SF}_6$ , were significantly lower than that in stream water, yearly variation in  $\text{NO}_3^-_{\text{atm}}$  fractions showed exponential increasing trend in the recent decade. These results imply that atmospheric reactive N deposition would affect severe influence on not only the forest ecosystem but also the coastal ecosystems.

Keywords: transboundary pollution, atmospheric nitrogen deposition, triple oxygen isotope, nitrogen saturation, retrospective analysis, Sea of Japan

## Primary production in the eastern part of the Seto Inland Sea

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In the 1970's and 80's, the Seto Inland Sea was affected by eutrophication. Since the 1980's anthropogenic nutrient loads from rivers have been reduced and subsequently the occurrence of environmental problems has decreased. However, new problems such as reduced fishery yields and nutrient deficiencies for seaweed culture have occurred. This implies a change in the ecosystem structure from the 1970's to the present. Primary production in the Seto Inland Sea was extensively surveyed during the 1960's - 90's, but recently information is more limited. In this study, we investigated primary production in the eastern part of the Seto Inland Sea and compared the results with those in the 1980's and 90's.

We measured primary production at 7 stations in Osaka Bay (2), Harima Nada (2), Bisan Seto (2), Hiuchi Nada (1). Water samples were taken from five different depths, corresponding to 100, 48, 33, 14, 8.3% photon fluxes. The water samples were then transferred into replicate 1-L polycarbonate bottles in the laboratory. After the addition of  $\text{NaH}^{13}\text{CO}_3$ , the samples were incubated for 2 hours in a Plant Growth Chamber. The incubations were conducted at in situ temperature under the corresponding light intensity regulated using filters. Photosynthetic rate at each depth was calculated according to the  $^{13}\text{C}$  methods of Hama et al. (1983). A trapezoidal integration was applied to calculate primary production throughout the euphotic zone. These investigations were carried out in September, November, 2013, and February, May, August, 2014.

The estimated primary production varied among the dates (Fig. 1). Primary production in February and May, 2013, was lower than that in September and November, 2013, and August, 2014. Uye et al. (1987) and Tada et al. (1998) described that primary production in the Seto Inland Sea was low in winter. Their results also showed that the primary production in spring was similar to those in summer and autumn. The trends shown in our results differ with the previous studies.

Primary production measured in summer and autumn (September and November, 2013 and August, 2014) varied widely among the stations. Primary production in the central part of Osaka Bay and Hiuchi Nada were consistently lower throughout the investigation period. Primary production changed largely at the inner part of Osaka Bay, Harima Nada and Bisan Seto. The maximum production was observed at Harima Nada in September and November, 2013, and at the inner part of Osaka Bay in August, 2014. Primary production showed a peak at the inner part of Osaka Bay and showed decreasing trends through Harima Nada to Bisan Seto in February, May and August, 2013. On the other hand, primary production showed a different distribution pattern in September and November, 2014, when high primary production was also observed at Bisan Seto. These results are different from those of Tada et al. (1998), in which they noted low primary production in Bisan Seto.

In the present study, the maximum primary production ranged from 1.0 to 1.6  $\text{gC m}^{-2} \text{day}^{-1}$  in summer and autumn. This range was similar to the value observed in the same season in the 1990's. However, we also found differences in trends between previous studies and the present study. In order to examine structural changes in the primary production in this region, further analysis is needed on the factors controlling the distribution pattern of primary production.

### References

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Keywords: the Seto Inland Sea, primary production, phytoplankton

ACG33-P01

Room:Convention Hall

Time:May 26 18:15-19:30

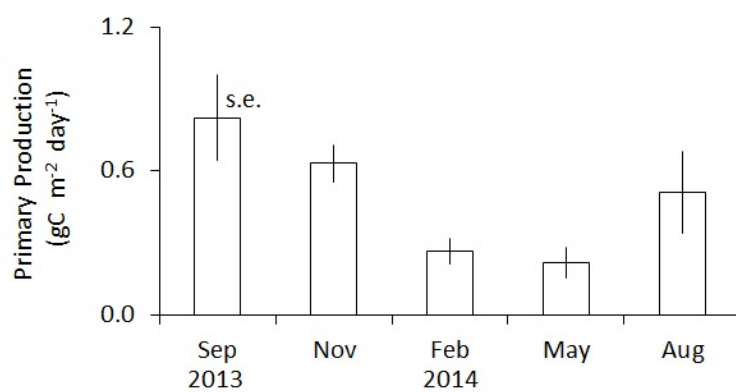


Fig. 1 Primary production in the eastern part of the Seto Inland Sea .

## Distribution of benthic microalgae and nutrients in tidal flat sediments estimating from chemical composition and $\delta^{13}\text{C}$

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Community compositions of microalgae that respond to environmental fluctuations have been often used as indicators of paleoenvironmental ploxis, organic water pollution, and so on. Benthic microalgae potentially adapt to wide ranges of environmental conditions, and their growth is mainly controlled by intensity of light and feeding pressure. However it is possible that specific nutrients determine the community compositions under the similar physical conditions. In order to contribute to our knowledge about relationship between community compositions of benthic microalgae and nutrients in estuarine tidal flat, this study provides the results of analyses of chlorophyll *a*, elemental compositions,  $\delta^{13}\text{C}$  ratio and  $\delta^{15}\text{N}$  ratio in tidal flat sediments.

Study site is located at Fujimae-higata inner part of Nagoya Port in Aich Prefecture, central Japan. Samples of surface sediments (1.5 cm depth, n=25) were subjected to analyses of chlorophyll *a*, TOC, TN,  $\text{SiO}_2$ ,  $\text{TiO}_2$ ,  $\text{Al}_2\text{O}_3$ ,  $\text{Fe}_2\text{O}_3$ ,  $\text{MgO}$ ,  $\text{MnO}$ ,  $\text{CaO}$ ,  $\text{Na}_2\text{O}$ ,  $\text{K}_2\text{O}$ ,  $\text{P}_2\text{O}_5$ , Cr, Cu, Pb, Zn, Zr,  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$ .

The surface sediments are characterized by high positive correlations of chlorophyll *a* with TN ( $r = 0.70$ ,  $p < 0.001$ ) and TOC ( $r = 0.68$ ,  $p < 0.001$ ). On the other hand the correlation between chlorophyll *a* and excess-P that is available for microalgae is very low ( $r = 0.09$ ,  $p > 0.5$ ). Based on analysis of principal component chlorophyll *a* and other elements can be categorized into three groups, i) elements associated with coarse-grained materials, such as Al, Ca, and K, ii) elements adsorbed and/or bounded to fine-grained materials such as Cr, Cu, Pb, Zn, Fe, and P, iii) elements associated with organic matter, such as TOC, TN, and chlorophyll *a*. According to these results, three segments were identified for Fujimae-higata, including Segment 1 closest to the river mouth where sediments are dominated by coarse-grained materials, Segment 2 away from the river mouth, characterized by fine-grained materials, and Segment 3 between Segments 1 and 2, characterized with organic matter. Values of  $\delta^{13}\text{C}$  of surface sediments (average =  $-25.99\text{‰}$ ,  $n = 25$ ) are almost the same as those of suspended matter in the closest river (average =  $-25.94\text{‰}$ ,  $n = 9$ ). Benthic microalgae tend to have heavier  $\delta^{13}\text{C}$  ratio (approx.  $-18\text{‰}$ ) than phytoplankton and the highest  $\delta^{13}\text{C}$  ratio in the analyzed sediment samples is  $-24.6\text{‰}$ . This suggests that the contribution of benthic microalgae to the sediment organic matter is small. The organic matter in Fujimae-higata sediments is likely supplied largely by riverine inflow.

Keywords: benthic microalgae, nutrients, tidal flat sediments



## Geochemical investigation for evaluation of submarine groundwater discharge in Suruga Bay

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Submarine groundwater discharge (SGD) has been recognized as an important pathway for material transport from land to ocean and it is expected as ubiquitous phenomenon in coastal area. Our study site, Suruga Bay is adjacent to the southern foot of Mt. Fuji where the permeable lava flow deposits and the active groundwater flow system exist. Therefore, large amount of SGD could be occurred at the coastal area.

To estimate the spatial distribution of SGD, geophysical surveys such as multi-beam sonar, side scan sonar and sub-bottom profiler, have been conducted in this area. This study attempts to evaluate SGD by using geochemical tracers, such as radon and radium in coastal water. We will show the spatial distribution of these tracers in Suruga Bay and discuss their relationship to SGD.

Keywords: submarine groundwater discharge, Suruga Bay, geochemical tracer

## Investigation of environmental factors related to regional differences in radon concentration in Japanese coasts

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In recent years, submarine groundwater discharge (SGD) have received considerable attention in hydrology and oceanography. Radon-222 (<sup>222</sup>Rn) is a useful tracer to detect SGD because <sup>222</sup>Rn in groundwater has extremely high concentration compared with surface waters. In Japanese coasts, many researches have been done SGD observations using <sup>222</sup>Rn tracer techniques. If we compiled <sup>222</sup>Rn data from many coasts with different environmental condition, we can get generality related environmental parameters to SGD. Therefore, objectives of this study are to compile the existing observed data in Japanese coasts and to evaluate environmental parameters concerning the regional difference in <sup>222</sup>Rn activities. Firstly, we consolidated <sup>222</sup>Rn data in coastal waters at 10 sites from the northern part to the southern part of Japan. We also prepared environmental parameters in each watershed such as precipitation, geological data and geomorphological characteristics to examine and effect of driving forces on the regional difference of <sup>222</sup>Rn activity. In this presentation, we will show the regional difference of <sup>222</sup>Rn activities in Japanese coasts and statistical analysis results of relationship between compiled <sup>222</sup>Rn data and environmental parameters.

Keywords: <sup>222</sup>Rn, SGD

## Using stable isotopes to measure the groundwater connection between land and sea in the Wakasa area

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The Wakasa area within Obama city, Fukui Prefecture is a very small area where the mountain and the sea connect. Though groundwater is abundant, there is no conspicuous surface outflow in this area. Groundwater may flow into the sea directly. In order to clarify the connection of groundwater between the seabed of the coastal zone and the land, we sampled groundwater under the seabed and at inland wells, and analyzed the water's stable isotopes in this area. The piezometers for collecting groundwater samples in the seabed (depth: 1m) were installed in eight places along the shoreline. The groundwater from inland well was collected at six wells. The results of isotope analysis of these samples show that the groundwater from the seabed was different from groundwater from the inland well. The origin of groundwater collecting near the shore line recharged from a low elevation area. This result shows the possibility that the groundwater from inland well at the village flows at a deeper place, and discharges at a more offshore seabed.

Keywords: Submarine groundwater discharge, Stable isotope, Discharge area

## Seasonal variation in saline submarine groundwater discharge and associated nutrient fluxes into Obama Bay

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Submarine groundwater discharge (SGD) is now recognized as a major conveyor of dissolved materials from land to the sea. Nutrient loads carried by SGD are commonly calculated as the product of SGD rate and concentrations of coastal fresh groundwater with the assumption that chemical transport through the coastal aquifer is conservative. However, most of the discharging water is usually saline groundwater (recirculated seawater) except in some karstic, volcanic and glacial areas where it is composed principally of fresh meteoric water. Recent studies have shown that biogeochemical processes in the subterranean estuary would have an important effect on concentrations of the dissolved species. Therefore, it still remains unclear how to identify endmember concentrations in a subterranean estuary for calculating SGD-derived nutrient fluxes. In this study, to evaluate nutrient fluxes through the saline SGD and their seasonality, we conducted monthly observation from March to November 2014 in the shallow coast in Obama Bay using a Lee-type seepage meter for SGD rate and piezometers for nutrient endmembers in the subterranean estuary. Estimated SGD rates which mainly composed of recirculated seawater ranged from 0.01 cm d<sup>-1</sup> to 3.86 cm d<sup>-1</sup>. This seasonal variation was dominated by integrated precipitation for 30 days before observation date with time lags of 1.5-2.5 months, suggesting that the recharging water takes time to percolate through the unsaturated zone to the water table. Assuming that endmember of nutrients concentrations is derive from saline groundwater in 0.9 m beneath the bottom, fluxes of dissolved inorganic nitrogen (DIN), dissolved inorganic phosphorous (DIP) and dissolved silica (DSi) were 1.9-479.7  $\mu\text{mol m}^{-2} \text{d}^{-1}$ , 0.1-15.1  $\mu\text{mol m}^{-2} \text{d}^{-1}$  and 7.4-1092.6  $\mu\text{mol m}^{-2} \text{d}^{-1}$ , respectively. If we used nutrient concentrations in fresh groundwater, fluxes of DIN and DSi were overestimated while DIP was underestimated, because nutrient concentrations in fresh groundwater were enriched in DIN and DSi while depleted in DIP. These results show that biogeochemical processes in subterranean estuary affect crucial impact on nutrient loads carried by saline SGD.

**Keywords:** saline submarine groundwater discharge, nutrient flux, seasonal variation, subterranean estuary