Toward synthesis of watershed sciences

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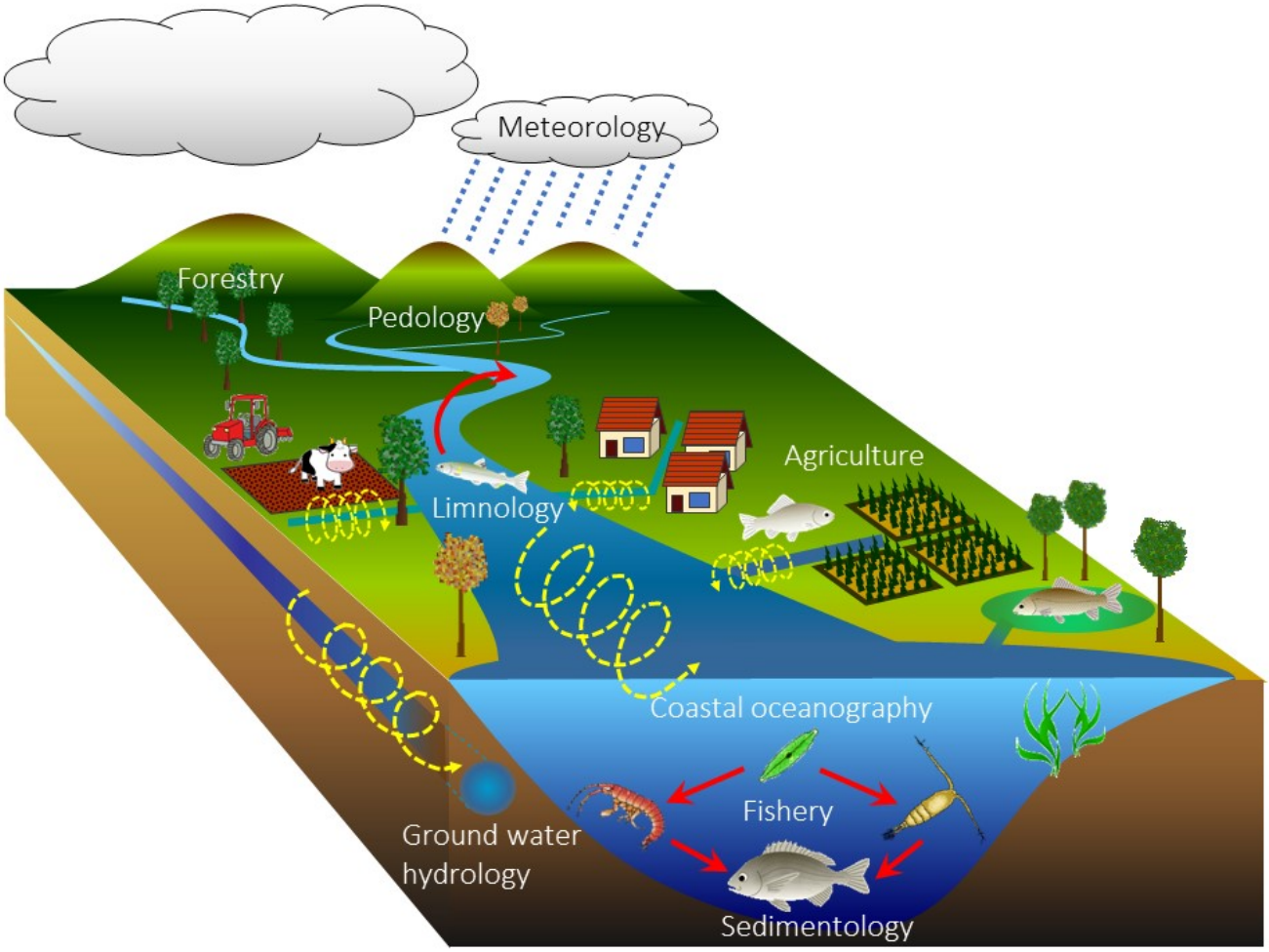
I organize this session for synthesis of watershed sciences, through which we aim to understand dynamical processes of interactions between organisms, nutrients and other materials in watersheds from mountain tops to receiving water. The session will be integrating a variety of research disciplines including limnology, pedology, ground water hydrology, sedimentology, coastal oceanography, meteorology, forestry, agriculture, fishery and more. The watershed sciences also challenge us to solve environmental issues emerged in the watersheds through our profound understanding of relations between humanity and nature in social-ecological systems. For instance, on one hand, human land uses alter dynamics of sediments, macro- and micro-nutrients and pollutants in soils and waters on catchment scales, while changing climates may alter the frequency and intensity of natural disaster, sometimes having catastrophic effects on the watershed systems. On the other hand, globalization causes transboundary pollution and biological invasion between watersheds. Such anthropogenic disturbances, in turn, reduce quality and quantity of natural resources in watersheds and coasts and thus deteriorate ecosystem services, posing a risk to sustainable human development. The dogma of watershed sciences may lead us to the solution for sustainable future of watershed systems as the basis of our existence. This session also calls for ideas on new methods for the watershed sciences, such as tracer and molecular technique, modeling and paleontological approaches, laboratory and field experiments, and so on, in order to elucidate biological, chemical and physical mechanisms for shedding light on natural phenomena and their changes over time in complex and dynamic watershed systems. Through this session, we would like to facilitate interdisciplinary collaboration among participants to create new knowledge on watershed sciences.

Keywords: Interdisciplinary science, Social-ecological system, Solution-oriented science, Sustainability, Watershed



Nutrient Dynamics in Watersheds

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Watersheds and the processes that take place within them are complex and important modulators of nutrients that ultimately drain into receiving water bodies like streams, rivers, lakes, wetlands and the coastal ocean impacting the aquatic ecosystems and the people that depend on them. It is essential to consider these processes and downstream impacts when developing and implementing water quality protection and restoration actions. In this presentation an overview of the sources and transformation of major nutrients (C, N and P) within a watershed and the processes that affect nutrient dynamics at various settings in a watershed along the drainage network will be presented with emphasis on innovative isotope tools to track nutrient dynamics.

Keywords: Watersheds, Nutrients, Isotopes

Trends in precipitation and stream water chemistry in a forested watershed in the Kanto region, Japan

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It is widely accepted that forested watershed play an important functional role in maintaining and improving water quality. It has been an important issue to investigate the effect of environmental change (e.g. atmospheric deposition, climate change) and forest management practice on the water chemistry of forested watersheds. For the above purpose, we have been monitoring rainwater and stream water chemistry over 14 years at a forested watershed in Ibaraki prefecture, Japan. In the period 2001 –2014, the annual flux of precipitation nss-SO_4 tended to decrease. On the other hand, the annual flux of precipitation Inorg-N exhibited an increasing trend. Annual mean concentration of stream water SO_4 was almost constant in the period 2001-2011, increased after forest thinning operations conducted in 2012 and 2013. Annual mean concentration of stream water NO_3 tended to decrease before the thinning operations, and turned to increase after the operations. Similar increasing patterns after the thinning operations were observed in the concentrations of Ca and K. Stream water Si concentration exhibited very small fluctuation and tended to increase gently.

Keywords: Forest, water chemistry, monitoring

Long-term dynamics and future perspective of streamwater chemistry in forested headwater catchments

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In Japan, rainfall patterns have been changing and extreme storm events are increasing as the effects of climate change. These events will cause some kinds of changes of hydrological and hydrochemical responses of the catchments. However, the responses may different depending on the attributes and/or background conditions of each catchment. In this study, we discuss about past, current, and future hydro-biogeochemical responses in a forested headwater catchment in Japan.
The observation was conducted in Kiryu Experimental Watershed (KEW). The area of KEW is 5.99 ha. The bedrock material is weathered granite, and the vegetation is Japanese Cypress planted about 60 years ago. Now, the forest is unmanaged, and it is the typical of Japanese artificial forest. We set up the nested catchments, K and M. The K catchment correspond to the whole of KEW, and the M catchment (0.68 ha) is one of a subcatchment of K. The observation have been conducting since 1972 for precipitation and discharge rate at K, and since 1990 for discharge rate at M and for streamwater chemistry at both catchments, respectively.
The number of rainy days is decreasing but days with larger rainfall intensity is increasing in KEW. The annual baseflow ratio is decreasing and annual direct runoff ratio is increasing at the K catchment as the result of the changing pattern of rainfall. The sediment transport at the K catchment was constrained by the erosion control dams, however, it abruptly increased since 2010 because overaged dams were damaged and destroyed by recent large precipitations.
The effects of rainfall patterns are unclear in the monthly streamwater chemistry. However, the chloride concentration is decreasing for decadal periods at both catchments. At the M catchment, the vegetation was disturbed at about 20% of catchment area around 1990, and the nitrate concentration was highest around 1997-1999, then gradually decreased till 2005. However, it is increasing again in recent 10 years. At the K catchment, the effects of disturbance occurred at the M catchment was not so clear, but it is also increasing in recent 10 years. The dynamics of the streamwater chemistry in recent 10 years may be a result of the forest degradation, that is, chloride shows the decrease of evapotranspiration and nitrate shows the decrease of nutrient uptake.
The direct runoff rate and nitrate load at dormant (Oct. to Mar.) and glowing (Apr. to Sep.) seasons were estimated and considered the relationship to the precipitation in each season for K catchment. The nitrate load was estimated using the power-law relationship of concentration (C) and discharge rate (Q). The direct runoff rate is larger in the glowing season, that is, in rainy season in Japan, and consequently the nitrate load also larger in the season. This fact means that the nitrate load is mainly controlled by the hydrological processes. Moreover, it is suggested that the increase of extreme storm events especially in summer may cause the explosion of nitrate export from the headwater catchment to the downstream.
For the future perspective under the climate change, forested headwater catchments will respond both hydrologically and biogeochemically. In our site, the solute transport mainly controlled by the hydrological responses. However, the forest degradation can cause the change of the biogeochemical condition, and it will be the base of the streamwater chemistry. Therefore, we need to keep on monitoring to detect these changes with the state-of-the-art techniques.

Keywords: long-term monitoring, streamwater chemistry, forested headwater catchment, hydrological processes, forest dynamics

Estimation of nutrients sources for surface and ground water in an abandoned meadow adjacent to mire area

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Recently, abandoned meadows have been becoming evident due to their poor drainage and wet condition in the margins of the Kushiro Mire, eastern Hokkaido. Increase of abandoned meadows brings various negative impacts on the management of dairy farm and the rural landscape. Therefore, effective utilization of abandoned meadows is an important issue. Focusing on the water quality improvement function in wetlands, we are considering about the role of abandoned meadows as buffer zone between agricultural and mire areas. Objectives of the study are to examine (1) the present status of water quality in surface and ground water and (2) the nutrient sources from the spatial variations of water level and quality, and the nitrogen stable isotope ratio of groundwater, aiming the quantitative assessment for nutrient cycling function of abandoned meadows.

We set a plot of approximately 100 m×175 m surrounded by open drainage ditches at an abandoned meadow in Tsurui Village. The ground surface gently down from the north to the south and slightly down along the east and west drainage ditches. We comparted the plot into 28 cells of each 25 m×25 m. A well and three piezometers (30, 80, and 130 cm depths) were installed at the center of each cell. Surface and ground water at each piezometer, surface flowing water at the drainage ditches and adjacent rivers, and rain water were sampled in August and October of 2015 and about once a month from May to November of 2016. Water quality including EC, pH, DO, ORP, nitrogen and phosphorous concentrations was measured. Additionally, the concentrations of the stable isotope $\delta^{15}N$ were analyzed for the 30 cm depth groundwater at four point in the plot and two point in the riparian wetland of the adjacent river in November 2016. Water level was automatically recorded at a continuously waterlogged point in the plot and drainage ditches on the north and south sides of the plot.

Water level was higher at the point in which ground elevation was slightly lower than the maximum point. Lower area on the east and southwest of the plot along drainage ditches was continuously waterlogged. Water level measurement showed about 90 cm variation during investigation period. In the extreme flooding event of August 2016 by the continuous typhoons, backward flows were observed in the drainage ditches and the whole study plot was inundated.

The highest concentration of dissolved total nitrogen (DTN) was appeared at 30 cm depth groundwater in the center of the plot. Dissolved organic nitrogen (DON) and NH_4-N represented large portions of the DTN. The highest concentration of dissolved total phosphorous (DTP) was appeared at 30 cm depth groundwater in the continuously waterlogged points along drainage ditches. Dissolved organic phosphorous (DOP) represented a large portion of the DTP. The concentrations of DTN and DTP of surface and ground water in the study plot were higher than those of drainage ditches and rivers.

For the extreme flooding event of August 2016, the concentrations of DTN and DTP at surface water in the plot were higher than those for normal hydrological period. Dissolved inorganic nitrogen (DIN), mainly consist of NO_3-N, represented about 60% of the DTN. PO_4-P represented about 70% of the DTP. Every water quality variables were similar between surface water in the plot and the drainage ditches. Thus, the ditches' water likely flowed into the study plot, affecting directly the water quality of the surface water in the plot.

Groundwater near the drainage ditches, which represented higher DTP concentration, showed relatively higher $\delta^{15}N$ values of 15-30‰. This suggests animal waste might to be a nutrients source. In contrast,

groundwater at the center of the plot, which represented higher DTN concentration, showed relatively lower δ^{15}N values of 5-8‰. This suggests a different nutrients source exists at the center of the plot, becoming the major nitrogen source in the groundwater.

Keywords: nitrogen stable isotope, nutrient cycling function, peatland, spatial variation, waterlogging

Effect of tidal variation on sediment nutrient releasing from Osaka Bay.

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Understanding the nutrient discharge into the coastal area is important in environmental managing and eutrophication control. Nutrient releasing from coastal sediments has been considered to be a major resource contributing to coastal nutrient cycle, particularly in the tidal river mouth area. Due to the complicated physical/chemical mechanisms. it is difficult to quantify the nutrient releasing rate in these areas. Our objective is to clarify the processes of nutrients across the sediment-water interface affected by tidal pumping, internal diffusion flux, and flood events, based on onsite monitoring, lab experiments, and hydrological model simulations.
Several cores and surface sediment have been taken in September 2016 for laboratory incubation experiments. Sediment samples were used for incubation experiments with/without an additional pressure variation of 2 meters. Surface water and bottom water were also taken along the transaction line from the river mouth to open bay. Water samples were analyzed for nutrient contents and then releasing flux were calculated.
Results show that nutrient contents are higher in bottom water during falling tide while in surface water are higher during rising tide, represents the nutrient transport are mainly in surface layer with river discharge in falling tide with high sediment releasing flux. In rising tide, tidal movements prohibit the transporting of nutrient during and decrease the sediment releasing flux. Core pore water profile shows decreasing trend upwards in Nitrate, ammonium, and phosphate. It indicates a strong releasing pattern of nutrient from sediment. Incubation results show high releasing flux similar to the diffusion flux calculated from pore water concentrations. The tidal pumping can double the ammonium and phosphate releasing flux in one week periods.

Keywords: sediment, nutrient releasing , tidal pumping, sewage treatment plant

Nitrogen and phosphorus dynamics in two Japanese river networks with contrasting watershed land use

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Riverine transport of nitrogen and phosphorus from watersheds can be an important flux that affects the integrity of their downstream ecosystems. Thus, numerous nutrient-transport models have been developed to predict nitrogen and phosphorus flux from lands to the oceans. However, nutrient removal by stream ecosystems in the entire river network, from headwater streams to downstream rivers, has remained unknown. Here, we developed the nutrient transport models that explicitly incorporate stream ecosystem metabolism in order to understand the roles of in-stream processes (i.e., nutrient uptake) in controlling the nitrogen and phosphorus flux to downstream ecosystems.

We performed two field sampling campaigns covering the whole area of Yasu River and Ado River watersheds, central Japan, during September and October in 2012 and 2014, respectively. Both rivers are major tributaries of the Japan’ s largest lake, Lake Biwa, with their watershed land-use patterns differing from each other significantly. Ado River watershed is characterized by forested vegetation with no strong anthropogenic impacts, while Yasu River watershed is composed of various land uses including urban development, agricultural fields (mostly rice paddies), and planted forests. In each watershed, we established a number of sampling sites in streams/rivers to measure discharge, nitrogen and phosphorus concentrations, and other physico-chemical variables. We then developed the modified version of spatially referenced process-based model (SPARROW) to describe the observed flux of nitrogen and phosphorus in the entire area of each river networks. In the models, we formulated the in-stream processes of N and P uptakes as kinetic equations of stream metabolism, which depends on water temperature, light, and/or substrate abundance.

In this presentation, we show the predictions by our models for the effects of watershed land uses on the amount of nitrogen and phosphorus exports by rivers. The model also predicts how land-use patterns, as well as other watershed attributes, affect the nutrient spiraling metrics: the estimates of areal uptake rates (U), uptake velocity (v_f) and uptake length (S_w) of nitrogen and phosphorus in the river ecosystems. The results clarify the nitrogen and phosphorus dynamics in river networks with contrasting watershed land use to emphasize that stream ecosystem function can alleviate the negative effects of watershed human activities on the nutrient transport to downstream river and lake ecosystems.

Keywords: SPARROW, spiralling metrics, river network

Quantification of phosphorus and nitrogen uptake in a tropical freshwater ecosystem in Southeast Asia suggests N limitation

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Nitrogen and phosphorus kinetics plays an essential role in the sustainability of watersheds but their increased availability also brings adverse impacts to water quality, species diversity, human health and ecosystem balance. This study reports on nitrogen limitation in headwater streams in Silang-Santa Rosa Subwatershed (SSRS). Moreover, this is the first attempt in studying nutrient spiralling in Philippine headwater streams using Tracer Addition for Spiralling Curve Characterization (TASCC). Phosphorus uptake kinetics showed shortest uptake length (Sw_{amb} = 25.27m), highest aereal uptake rate (U_{amb}= 37.46 mg-P/m^2/min) and uptake velocity (Vf_{amb} = 162.12 mm/min) in an agricultural site and longest uptake length (Sw_{amb}= 109.24m), lowest aereal uptake rate (U_{amb}= 0.31 mg-P/m^2/min) and uptake velocity (Vf_{amb} =2.76 mm/min) in a residential site. Nitrogen uptake showed undetected peaks that is suspected as N limitation supported by significant correlations for U_{amb}-P and NH_3 (R=0.919, 95%) and N:P ratio (0.4923). Overall, this research aids in the Philippine land use planning and watershed management for ecological sustainability and serves as a contribution in tropical studies particularly in nutrient dynamics.

Keywords: Tracer Addition for Spiralling Curve Characterization, Philippines, nutrient dynamics

The quantitative evaluation of bio-available particulate phosphorus discharged from Yasu River.

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It is well known that primary production in Lake Biwa is limited by phosphorus, and that means phosphorus load into Lake Biwa influence on its environment. In general, it is considered that algae in aquatic ecosystem use soluble reactive phosphorus (SRP) as a phosphorus source, however, it has been revealed that a part of particulate phosphorus (PP) also might be used as phosphorus source in recent study. It has been reported that PP discharge from watershed increases during ploughing and irrigating the fields or rainfall event, and most of the annual phosphorus load discharged through river is PP. Those mean that discharge of bio-available PP from watersheds has critical potential to control primary production in aquatic ecosystems. However, there are a few studies that clarify the sources and amount of bioavailable fraction of PP discharged from watersheds in Japan. The purpose of this study is to estimate sources and amount of bioavailable fractions of PP discharged from Yasu river watersheds.
River water samples were collected in 5 sites in Yasu river from one to four weeks interval from April 2014 to May 2015. Drainage from paddy fields were collected from Koka city, where locates in middle part of Yasu river watershed 3 times from May 2015 to July 2015. River water during rainfall events was also collected at 2 times in down stream site and 1time in up stream forested site in Yasu river watersheds. We separated several fractions of PP from suspended sediment (SS) by sequential extraction methods (1M ammonium chloride, 0.11M bicarbonate dithionite (BD), 1M NaOH, 0.5M HCl extraction) in water sample. SRP extracted from the particle fraction was determined by the molybdenum-blue method. We assumed that SRP extracted by ammonium chloride (NH_4Cl-SRP) and bicarbonate dithionite (BD-SRP) were bio-available PP because NH_4Cl-SRP release SRP in low SRP concentration environment and BD-SRP release SRP in reductive condition.
PP concentrations in Yasu river were higher during ploughing period and rainfall events. BD-SRP was dominant in base-flow in Yasu river, however NH_4Cl-SRP was also important in small rainfall event (15.5 mm) at ploughing period, and non reactive phosphorus (NRP) extracted by NaOH (NaOH-NRP) was also important at large rainfall (97 mm) in August. We will discuss the source of these fraction of PP and estimate the amount of discharge rate of those.

Keywords: particulate phosphorus, bioavailability, watersheds

Biogeochemical cycling of phosphate in the Yasu River Watershed: Insight from oxygen isotope of phosphate

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1. Introduction

Phosphorus (P) is an essential element for all living organisms and can be a limiting factor for primary production in river ecosystems. Therefore, its biogeochemical cycling is very important in proper land management and understanding of natural systems. Recently, oxygen isotope ratio of phosphate ($\delta^{18}O_{PO4}$) has been used as a tool to elucidate the P cycle. Previous studies showed the possibility to evaluate P sources, metabolism by organism in some ecosystems (Paytan & McLaughlin 2011). However, there are few research to show the spatial distribution of $\delta^{18}O_{PO4}$ in the watershed scale, and it is not clear whether $\delta^{18}O_{PO4}$ is useful for evaluating the biogeochemical cycling of P in the watershed scale. The purposes of this study are to show the $\delta^{18}O_{PO4}$ distribution in the watershed scale and to examine the relationship between $\delta^{18}O_{PO4}$ distribution and environmental factors, such as P sources, land use and physical characteristics of a river.

2. Material and Method

The investigation was conducted in the Yasu River Watershed in Shiga prefecture, central Japan. River water samples were collected at 15 sites including tributaries in May 2016. As a P source to the river, rocks (granite, sedimentary rock, accretionary complex), soils from forest and paddy filed, chemical fertilizers mainly used in Shiga prefecture and wastewater treatment plant water were collected. For $\delta^{18}O_{PO4}$ analysis, phosphate in all samples was converted to silver phosphate by McLaughlin et al. (2004) procedure with solid phase extraction method to remove dissolved organic matter. The $\delta^{18}O_{PO4}$ values were measured by a TC/EA-IRMS (thermal conversion elemental analyzer connected to a Delta plus XP isotope ratio mass spectrometer via ConFlo III, Thermo Fisher Scientific). The $\delta^{18}O_{PO4}$ values of biologically cycled phosphate ($\delta^{18}O_{PO4\ Eq}$) in the river water samples were calculated by *Eq*. 1 (Longinelli & Nuti 1973):

$$T = 111.4 - 4.3\ (\delta^{18}O_{PO4} - \delta^{18}O_{w}) \quad (1)$$

Where T is water temperature (˚C); $\delta^{18}O_{PO4}$ and $\delta^{18}O_{w}$ are the $\delta^{18}O$ of phosphate and water, respectively.

3. Result and discussion

The $\delta^{18}O_{PO4}$ values in the river water samples ranged from 10.1‰ to 17.8‰. These values were different from the $\delta^{18}O_{PO4\ Eq}$ values at each site, indicating that the $\delta^{18}O_{PO4}$ values in river water samples can be used as a tracer for P sources in the Yasu River Watershed. Significant correlations were found between the $\delta^{18}O_{PO4}$ values in river water and the proportion area of the agricultural land and each rock. In addition, the direction of the regression line agreed with the $\delta^{18}O_{PO4}$ values in soil from paddy filed and each rock. These data suggest that agricultural land and rocks are main P sources to the river. Our investigation showed that the $\delta^{18}O_{PO4}$ is useful for evaluation of biogeochemical cycling of P in the watershed scale.

Reference
Longinelli, A. & Nuti, S., 1973. Revised phosphate-water isotopic temperature scale. Earth and Planetary Science Letters, 19(3), pp.373–376.
McLaughlin, K. et al., 2004. A precise method for the analysis of $\delta^{18}O$ of dissolved inorganic phosphate in seawater. Limnology and Oceanography: Methods, 2, pp.202–212.
Paytan, A. & McLaughlin, K., 2011. Tracing the sources and biogeochemical cycling of phosphorus in aquatic systems using isotopes of oxygen in phosphate. In M. Baskaran, ed. Handbook of Environmental Isotope Geochemistry. Berlin: Springer-Verlag, pp. 419–436.

Keywords: Oxygen isotope of phosphate, Freshwater system

Comparisons of oxygen isotope ratio of phosphate in river water and rocks between two watersheds in central Japan

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Excess phosphorus (P) utilization by human activities has resulted in a large amount of P loss from terrestrial to aquatic ecosystems, which in turn can induce eutrophication and subsequently algal bloom in enclosed waters. To control the P loss, the phosphate oxygen isotope ratio ($\delta^{18}O_P$) technique is expected to be applied for clarifying P dynamics in terrestrial ecosystems. This is because $\delta^{18}O_P$ in river water could reflect sources of phosphate within the river watershed. However, very few studies have applied the $\delta^{18}O_P$ technique to clarifying watershed-scale P dynamics and thus little information is available about what the river $\delta^{18}O_P$ value indicates specifically within the watershed. To examine this, we compared the $\delta^{18}O_P$ values in river water and rocks between two watersheds with different land-use and geological compositions. For this, we collected river water and rock samples and analyzed their $\delta^{18}O_P$ in subwatersheds of the Ado River and the Yasu River watersheds, which were dominated by forests and covered by large areas of agricultural lands, respectively, belonging to the Yodo River system in central Japan. The river $\delta^{18}O_P$ value was significantly higher in the Ado River watershed than in the Yasu River watershed (u-test, $p < 0.05$). This could not be explained by the forest area ratio within a subwatershed. The relationship between river $\delta^{18}O_P$ values and subwatershed areas revealed that the $\delta^{18}O_P$ value tended to increase and reach a plateau as the subwatershed area increased. Additionally, the result showed that the river $\delta^{18}O_P$ value was higher in the Ado River watershed than in the Yasu River watershed at a given subwatershed area. These findings are attributable to the fact that high values of $\delta^{18}O_P$ in river water could derive from those in the accretionary complex. This is because geological compositions in the subwatershed with large area (10 km^2) contain the accretionary complex in the Yasu River watershed and also because geology in the Ado River watershed is composed mostly of the accretionary complex. On the other hand, the river $\delta^{18}O_P$ value could change not only by the geological factor, but also by biologic uptake of phosphate. It is possible that changes in the river $\delta^{18}O_P$ value with the subwatershed area resulted partly from an increase in the opportunity for the biologically-mediate oxygen isotope exchange between water and phosphate associated with the increased river length.

Keywords: Stable isotope analysis, Source of phosphate, Diffuse pollution, Lake Biwa, Accretionary complex

Transportation mechanism of arsenic (As), cesium (Cs) with iron (Fe) from river to paddy rice through irrigation in river water system

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Some toxic trace elements are often transported to paddy field through irrigation from river water. The transportation mechanism of toxic trace elements in a local river water system is important for sustainable, environmental conservation and for risk reduction. In order to clarify the transportation process on As and Cs in the grain of paddy rice, we analyzed the concentrations of trace and major elements in three river waters, paddy field waters, and paddy rice, root, shoot, leaf, and grain, and paddy soil, separately, in three areas. From the complex relationships between As and Fe, and Cs and Fe in various situations, it is inferred that Fe works as an attracter to As and Cs within paddy rice, though these elements are often transported in river water, separately. The As and Fe in rice grain correlates with Fe in paddy water, while they are not correlates with Fe in paddy soil, suggests the As in rice grain comes from river water through irrigation. The Cs in rice grain correlates with Cs in paddy water, indicates Cs comes from river water through irrigation.

Keywords: As, Cs, river, paddy rice, Fe

Denitrification in the banks of fluctuating rivers: the effects of river stage amplitude, sediment hydraulic conductivity and dispersivity, and ambient groundwater flow

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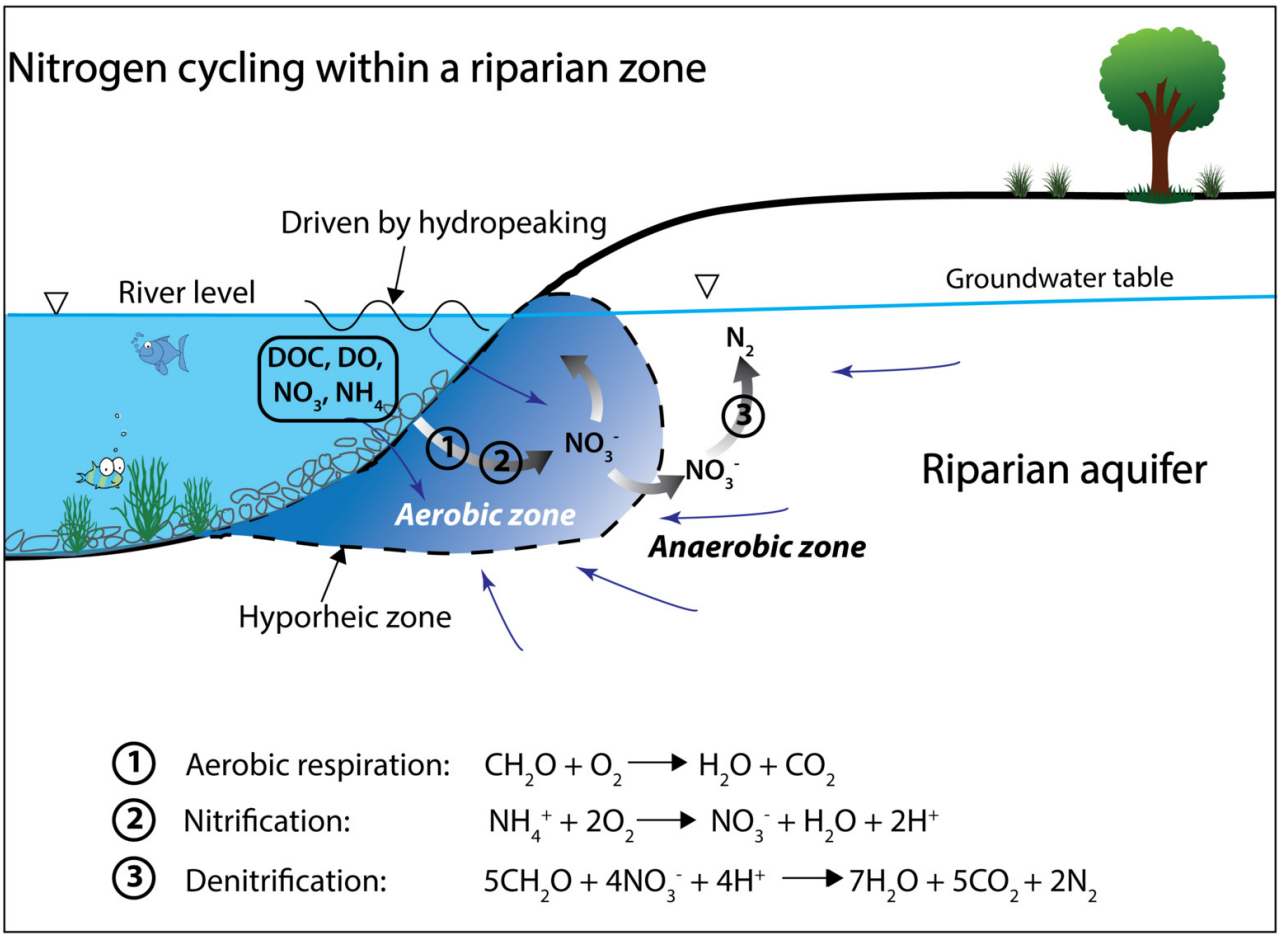
Hyporheic exchange induced by periodic river fluctuations leads to important biogeochemical processes, particularly nitrogen cycling, in riparian zones (RZs) where chemically distinct surface water and groundwater mix. Based on field observations, we developed a two-dimensional coupled flow, reactive transport model to study the influence of river fluctuations on nitrogen cycling within the RZ during a single 24 h pulse. Sensitivity analyses were conducted to quantify the effects of river amplitude, sediment hydraulic conductivity and dispersivity, and ambient groundwater flow on nitrate removal efficiency. The simulations showed that nitrification occurred in the shallower zone adjacent to the bank where oxic river water and groundwater interacted while denitrification occurred deeper into the aquifer and in the riverbed sediments where oxygen was depleted. River fluctuations greatly increased the amount of nitrate being removed; however, the removal efficiency, the ratio of the mass of nitrate being removed due to denitrification and the total mass of nitrate entering aquifer, decreased as river amplitude increased. Similarly, increasing hydraulic conductivity increased overall nitrate removal due to a large denitrifying zone but with decreasing efficiency. In contrast, increasing sediment dispersivity increased the removal efficiency of nitrate. The presence and direction of ambient groundwater flow had a significant impact on nitrate removal efficiency when compared to neutral conditions. A losing river showed smaller removal efficiency (3.5%) while a gaining river showed larger removal efficiency (17.1%) compared to neutral conditions (5.4%). Our results demonstrated that daily river fluctuations created denitrification hot spots within the RZ that would not otherwise exist in a neutral or gaining conditions under natural baseflow.

Keywords: Riparian Zone, Denitrification, River fluctuation



Land-use patterns in watershed influence denitrification process in stream sediment

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Land-use patterns can affect various nutrient cycles in stream ecosystems, but little information is available on their effects on denitrification processes at the watershed scale. In the presented study, we investigated the controlling factors of denitrification rates within streams of the Han River Basin, Korea with different land-use patterns in order to enhance the effectiveness of water resource management strategies. Ten small watersheds were classified into three land-use patterns (forested, agricultural and urban) using satellite images and a geographic information system technique, and *in-situ* denitrification rates were determined using an acetylene blocking method. Additionally, sediment samples were collected from each stream to analyze denitrifier communities (T-RFLP) and abundances (real time qPCR) targeting *nirS* and *nosZ* genes. *In-situ* denitrification rates were found to be in the order of agricultural streams (289.6 mg N_2O-N m^{-2} d^{-1}) > urban streams (157.0 mg N_2O-N m^{-2} d^{-1}) > forested streams (41.9 mg N_2O-N m^{-2} d^{-1}). The quantity of *nirS* genes was the highest but that of *nosZ* genes was the lowest in agricultural streams. In contrast, genetic diversity of denitrifying genes was not affected by watershed land-use patterns, but exhibited stream-dependent patterns. While land-use pattern is the most prominent evaluator for the denitrification rates at a landscape scale, other factors such as clay content, DOC and temperature are as important at a local scale.

Keywords: Denitrification, Land use patterns, Microbial communities, Stream

Bacterial community composition and richness in biofilms of the Yasu and Ado Rivers

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Biofilm bacteria play important roles in the biogeochemical cycling of river ecosystems through processes such as accumulation, decomposition, and assimilation of organic matter. Although bacterial community compositions (BCCs) have previously been reported, factors determining their spatial distribution patterns are still poorly understood. It is difficult to disentangle confounding factors affecting the BCCs in stream/river biofilms due to the high spatial correlation among environmental variables within stream networks. In this study, we focused on BCC variations within and between tributaries of two rivers which have different land use patterns in their catchments in order to evaluate the relative importance of geographical and local habitat variables on BCCs.
Samples were collected from several tributaries in the Yasu and Ado Rivers draining into the Lake Biwa, Japan. Five stones were collected at each site and biofilm was detached from 6 cm square surface of each stone for DNA extraction. The extracted DNA was sequenced on Illumina MiSeq and clustered into operational taxonomic units (OTUs) at a 97 % sequence similarity level. Environmental parameters were measured and separated into two categories: geographical variables (altitude, catchment area, and land use) and local habitat variables (river depth, current velocity, water temperature, canopy openness, electric conductivity, total nitrogen, and total phosphorus).
8,547 OTUs were obtained after rarefying reads to the lowest coverage of reads and *Bacteroidetes*, *Alphaproteobacteria*, *Betaproteobacteria* and *Cyanobacteria*, all of which has been often regarded as common taxa in river biofilms, dominated in both rivers. BCCs were significantly different at the catchment scale between Yasu and Ado Rivers (PERMANOVA, $p < 0.001$). When the data from both rivers were pooled, two local habitat factors, water temperature and electric conductivity, significantly accounted for the dissimilarity of BCCs in both rivers (Mantel test, $p < 0.001$). However, when the data were analyzed separately between the two rivers, neither geographical nor local habitat factors significantly determined the spatial variation of BCCs within the river network system (PERMANOVA, $p > 0.05$ and Mantel test, $p > 0.05$). In both rivers, bacterial richness decreased with increasing current velocity (Spearman rank test, $p < 0.01$).
Our data suggest that (1) BCCs across Yasu and Ado River watersheds are more influenced by local habitat factors than by geographic factors; and (2) physical disturbance by high current velocity could be a primary factor affecting bacterial diversity in biofilms of river ecosystems.

Keywords: Freshwater, Microbe, Biofilm

Alpha and beta diversity of benthic macroinvertebrates in natural and disturbed river watersheds and their environmental driver

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Knowledge about habitat transformation and disturbance of wildlife is important for concern in biodiversity conservation. The number of species coexisting in ecological communities between different levels of disturbance and how it contributes to species diversity due to symbiotic dependencies with environments is little to be known in freshwater ecosystems. We estimated alpha and beta diversity of benthic macroinvertebrates and relationships between species diversity and environmental predictor variables by sampling the diversity of local sites in Ado River (natural) and Yasu River (intermediate disturbance) watersheds, Japan, separately. The alpha diversity was consistently slightly higher in the natural system than in the intermediate disturbed system but was not equivalent in their spatial distributions. The opposite pattern was evidenced for the beta diversity assemblages. The values of species richness and abundance showed a highly linear positive correlation, except that alpha richness and abundance in Yasu River watershed consisted of the bell-shaped correlation. Significant differences on environmental variables between two watersheds were exhibited, especially high chlorophyll a concentration detected in the intermediate disturbed system. The alpha diversity were not correlated with similar environmental variables whereas water temperature and chlorophyll a concentration across sites were the two most significantly important predictor variables for beta diversity in the two river watershed systems. These results suggest that patterns of local and regional diversity in freshwater benthic macroinvertebrate communities are differently influenced by levels of disturbance, which may benefit to increasing species diversity than previously thought through generating habitat heterogeneity processes, and understanding how both alpha and beta diversity vary with disturbance and how they relate to environments is essential for protecting local to regional diversity and can directly assist conservation planning.

Keywords: Benthic macroinvertebrates, Disturbance, River watershed, Biodiveristy, Environmental driver

Benthic macroinvertebrates response to water quality and canopy cover of a heavily impacted tropical subwatershed

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Benthic macroinvertebrates have been shown to respond to varying degrees of physicochemical changes in freshwater ecosystems. However, studies on the assemblages and how these macroinvertebrates respond to changes in environmental factors are poorly understood in a tropical, archipelagic setting. Such changes have potential adverse effects on stream macroinvertebrates but we do not know if the same pattern may be observed in the streams of Silang-Santa Rosa Subwatershed (SSRS). Thus, we are testing this hypothesis in the SSRS which is an ideal representative for the tropical scenario. This study investigated stream benthic macroinvertebrates in the SSRS, which has recently been shown to have changed its land cover due to conversion of farmlands into non-agricultural uses and further urbanization. On November 2015, 13 sites were sampled for benthic macroinvertebrates and monitored for environmental variables such as canopy openness, pH, water temperature, dissolved oxygen (DO) , total dissolved solids (TDS), conductivity, salinity, nitrates, ammonia, dissolved inorganic phosphates (DIP), and total phosphorus (TP). Biodiversity indices and biomonitoring metrics were calculated and analyzed along with environmental variables. Results of both principal component analysis and hierarchical cluster analysis indicated differences in environmental variables among land cover categories. First principal component described a gradient from primarily vegetated sites (agricultural or residential land uses) with relatively good water quality to primarily non-vegetated sites (residential or industrial land uses) with poor water quality. Primarily vegetated sites generally exhibited relatively high DO and nitrates while primarily non-vegetated sites showed high canopy openness, ammonia, TP, conductivity, salinity and TDS. Canopy openness, conductivity, DO, and water nutrients appeared to be the most important factors predicting benthic macroinvertebrate assemblages. Sensitive genera from Ephemeroptera, Trichoptera, and Coleoptera dominated primarily vegetated sites while tolerant blood worms, *Chironomus* sp., were abundant in primarily non-vegetated sites. Benthic macroinvertebrate assemblages respond to anthropogenic changes which can be observed among nutrient-densed tropical stream ecosystems such as Silang-Santa Rosa Subwatershed. This paper highlights the potential of these macroinvertebrates together with water quality parameters for biomonitoring purposes and conservation initiatives in such heavily impacted subwatershed.

Keywords: Philippines, biomonitoring, canopy openness, land use, water chemistry, tropical streams

Mesozooplankton, a key transporter of anthropogenic nutrients from headwaters to the coastal ocean in a highly urbanized drowned river valley estuary.

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I will present the results of a 12 month study in which we sought to elucidate the relationship between anthropogenic nutrient inputs and mesozooplankton community structure in an urbanized, temperate, drowned river valley estuary system. Sydney Estuary on the East coast of Australia receives pulsed nutrient inputs primarily through storm water runoff from its highly urbanized (80%) catchment, with the majority of loading introduced through three head waters. Despite the relatively short distance from headwaters to mouth (15-30km) little of the introduced nutrient is transported directly to the coastal ocean. Instead the majority of the nutrient is assimilated into the estuarine food web exerting bottom up control on zooplankton community size structure and abundance. Our results using stable isotope analysis indicate the role of mesozooplankton in assimilation of anthropogenic nutrients and carbon varies on a gradient from the estuarine headwaters to the coastal ocean. It has been previously hypothesized that the coastal ocean acts as a source of mesozooplankton, supporting the productive fisheries and biodiversity of the lower harbour. We show the inverse to be true, in the more impacted upper estuary nutrients are incorporated into phytoplankton biomass which is eventually consumed by mesozooplankton in the middle and lower estuary. As zooplankton abundance greatly exceeds demand from predation within the harbor, the mesozooplankon provide a significant transport of N & C to the coastal ocean, presumably contributing to the diet of coastal ocean zooplanktivores.

Keywords: Mesozooplankton, Stable Isotopes, Biogeochemistry, Fisheries, Anthropogenic Nutrients, Urbanization

Spatial Variation in Lacustrine Groundwater Discharge (LGD) as a Nutrient Source in Lake Biwa, Japan

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Groundwater discharge and nutrient flux into a lake has not been confirmed enough in terms of spatial variation including those in deeper zone. Biwa Lake has different characteristics between in northern and southern. In northern, the water depth varies up to 100m, groundwater discharge is also expected not only in beach sides with shallower depth but in deeper zones. We examined to indicate spatial variation of Rn-222 and to compare with the results of seepage observations by Kobayashi (1993).
Radon radioisotope (Rn-222) concentrations were measured by a RAD7 at 500 m interval along the whole shoreline of the northern lake, and surface water samples were coincidently collected. Oxygen stable isotope ratio ($\delta^{18}O$), Chloride anion and nutrients (nitrogen, phosphorus, and silicon) concentrations were measured in the laboratory in order to evaluate inflow of the groundwater into the lake. Those dissolved materials were also measured from the groundwater samples were collected in ca. 20 wells situated along the shore of the lake as well as those in river waters. In the eastern coast (Hikone), artesian groundwater was also collected because of aquiclude at 10m deep under the ground. Lake waters at the surface, middle and bottom layers and interstitial waters in the bottom sediments were collected for measuring Rn-222 concentrations.
At the both sites of Yasu and Takashima, high pressures of groundwater indicated flow of the water to the lake under the ground. Spatial distributions in Rn-222, Cl^- and nutrient concentrations with those in $\delta^{18}O$ along the coasts also indicated discharges of groundwater into the lake. High concentrations of dissolved phosphorus phosphate (> 0.1ppm) were detected from several wells out of 15 ones investigated. Based on the comparative results with the seepage observations, we could confirm good correlation between Rn-222 concentration and seepage observation results.
In addition, Rn-222 concentrations in lake waters were measured in the surface and bottom layers at the 4 stations with different water depths (5m, 10m and 20m) in October 2015 and July 2016. The highest Rn-222 was observed in the bottom layer at 20m-deep site in both periods. The concentration was more than 2-fold of that in the littoral site. It suggests high possibility of deep-LGD from offshore lake floor.

Keywords: lacustrine groundwater discharge, phosphorus, radon

Spatial evaluation of submarine groundwater discharge (SGD) on an island scale in a temperate coastal sea

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Submarine groundwater discharge (SGD) is defined as subsurface water flow at continental margins from the seabed to the coastal ocean. As a component of the hydrological cycle, SGD plays an important role in the overall coastal water budget, which can rival or even exceed surface runoff in some coastal areas. In addition, because it often contains higher nutrients than river water, SGD delivers comparatively large quantities of nutrients to coastal ecosystems. However, there are few studies to evaluate the spatial relation among SGD, nutrient condition and coastal ecosystem such as seagrass meadows. In the present research, we aimed to examine the spatial variation of SGD and its effect on coastal environment in an island scale.

The study area is Ikuchijima Island in Seto Inland Sea, southern Japan. The regional climate is mild, with an annual mean precipitation of 1,100 mm and temperature of 15.6 ˚C. The whole island is characterized by steep slopes and is widely covered by citrus farms with more than 40% of the island. To evaluate the spatial distribution of SGD at the small island scale, we performed a radon (^{222}Rn) monitoring survey along the coastline of Ikuchijima Island. Large variability in SGD was observed, with significant discharges seen in areas of steep topography and much lower discharges from low-lying areas. Topographic influences are likely to be the major driver of spatial variability in SGD. Based on a ^{222}Rn mass balance model, the SGD rates were estimated to range from 8.38 cm d^{-1} to 17.02 cm d^{-1}, with an average of 12.98 cm d^{-1}. The results were in good agreement with SGD estimated by the topographic model based on Darcy’ s law and inland topographic gradient near the coastline. Estimated nutrient loading through the SGD were comparable to or even higher than that from local streams. It suggests SGD is an important source of nutrients to coastal ecosystems in the area. Distribution of seagrass meadows tend to correspond totally to the spatial variation of SGD, especially the fresh submarine groundwater discharge (FSGD) estimated by the topographic model.

Keywords: submarine groundwater discharge, island, nutrient, seagrass meadows

Nutrient imbalance and diversity of plankton community in lagoon lakes around Lake Biwa

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There were a lot of environmental problems during the past eutrophication period in Japan. The situation has been improved after 1980's due to reduction of N and P loadings from point sources. However, potential fluxes of N from atmosphere and farmland may cause N/P imbalance in several aquatic environments, though there are no clear evidences how such nutrient imbalance influences aquatic ecosystems until now. In this study, we determined dissolved nutrients and sestonic C/N/P ratios in several lagoon lakes around Lake Biwa, the largest lake in Japan, and species composition of phyto- and zooplankton living there, to evaluate effects of the nutrient imbalance on diversity of plankton.

Methods

Field observations were made at Lakes Kohoku-nodanuma (KN), Hasu-ike (HI), Katada-naiko (KD), Yanagi-hirako (YH), Jinjo-numa (JI), Hamabun-numa (HN) in August and October 2014, February, May, and July 2015. >70% of land use in 4 lakes out of 6 was rice paddy except for KD (17%) and HI (52%). Water samples for chemical analyses and phytoplankton counts were collected at outlet, inlet and two pelagic sites in each lake. Zooplankton was collected with a 40-μm-mesh, and then preserved with 4-5% sugar-formalin. Water temperature, pH, EC and turbidity were measured with a Horiba U-50. The water samples were filtered in the laboratory. Nutrients (NH_4-N, NO_3-N, NO_2-N and PO_4-P) for the filtrates were measured. Suspended solid (SS), sestonic C, N, P and chlorophyll *a* concentration (chl. *a*) for the residuals were measured. Phyto- and zooplankton species in each preserved plankton samples were counted, and then diversity indices (H') were calculated.

Results

Water temperatures seasonally varied 10-29°C in all lakes studied. Chl. *a* largely varied with lakes, and lowest in HI (<15 μgL^{-1}) while highest in YH and JI (40-60 μgL^{-1}). SS showed similar trend with turbidity, and the correlation coefficient between them was high (r=0.79), while correlation coefficient between SS and chl. *a* was not so high (r=0.59). Both sestonic C/N and C/P ratios were higher than those of Redfield ratio, but lower than the threshold values in Healey and Hendzel (1979, 1980) in all lakes studied. Sestonic N/P ratios in all lakes ranged 5-25, being higher than that in Redfield ratio, suggesting relatively high nitrogen loading to the lakes. NH_4-N and PO_4-P were quite high in YH and JI compared with those in other 4 lakes. PO_4-P at inlet tended to increase with increasing land use of rice paddy. Correlation analyses showed that chl. *a* in pelagic sites were positively correlated with PO_4-P at inlet. The differences in DIN and DIP between inlet and outlet were also larger in both YH and JI, indicating large consumption of them within the lakes. H' in phytoplankton showed high values and large seasonal variability in KN, YH and JI, while not so high values and small seasonality in HI and KD, being negatively correlated with sestonic N/P ratios. On the contrary, H' in zooplankton were almost the same among the lakes except for that in KD, showing no relationship between H' and any sestonic C/N/P ratios.

Discussion

Chl. *a* was correlated with PO_4-P at inlet, which increased with increasing land use of rice paddy. Therefore, phytoplankton biomass depended on land use of rice paddy around watershed of the lakes studied. Species diversity in phytoplankton seemed to decrease with increasing sestonic N/P ratio, but

not in zooplankton. Probably, nutrient imbalance might affect phytoplankton diversity, while not apparently in zooplankton diversity, because other interaction like predation pressure might mask the bottom-up effect on zooplankton.

Keywords: Nutrient imbalance, biodiversity, small lagoon lakes around Lake Biwa

Biodiversity Assessment of Littoral Macrozoobenthos in Laguna de Bay, Philippines

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Laguna de Bay is home to various macroinvertebrates which play an important part in freshwater ecosystems. These macroinvertebrates or macrozoobenthos participate in the decompositional pathways and interact with the fish and zooplankton communities in water systems. Due to their restricted mobility, they are crucial bioindicators that detect trends in pollutant concentrations and their biodiversity typically reflects changes in the local environment. Despite their ecological importance, macrozoobenthos are still understudied and researches conducted on the effects of changes in water physicochemistry on their communities remain to be poorly known in the Philippines. Thus, this study gathered samples of macrozoobenthos species from 33 littoral sites of Laguna de Bay to determine the richness and diversity of the macrozoobenthos species present in the lake. The results have recorded 6 identified families (Ampullaridae, Corbiculidae, Pachychilidae, Planorbidae, Thiaridae, and Viviparidae) of macrozoobenthos and one unidentified species. Computation of Shannon–Wiener index (H’) showed the highest diversity which was recorded from Pinagdilawan, Binangonan (H’=1.20) while the lowest was in Pulong Ligaya, Bogombong, Jala-Jala (H’=0.04). The output of this study serves as an update on the biodiversity of littoral macrozoobenthos present in Laguna de Bay.

Keywords: Laguna de Bay, Macrozoobenthos, Biodiversity, Shannon–Wiener index

Thermal regime of a subarctic deep lake and its response to climate change: the non-freezing effect on the ecosystem

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According to the Köppen-Geiger climate classification, the Hokkaido Island, Japan, belongs to the southernmost subarctic area, but lakes in Hokkaido belongs to dimictic, temperate ones. This research focuses on non-freezing of a temperate deep lake, Lake Kuttara, Hokkaido, and its effect on the ecosystem (Fig. 1). Using 3-yr water-temperature and hydrometeorological data, we got the intra- and interannual changes of the heat storage. As a result, it is seen that, if accumulated heat storage change is more than -500 W/m^2, the lake could be unfrozen. The sensitivity analysis to main meteorological factors indicates that an increase in air temperature is most effective to an increase in the heat storage change, and that the lake could be eternally unfrozen in a few decades.

Keywords: non-freezing, heat storage change, climate change, deep lake

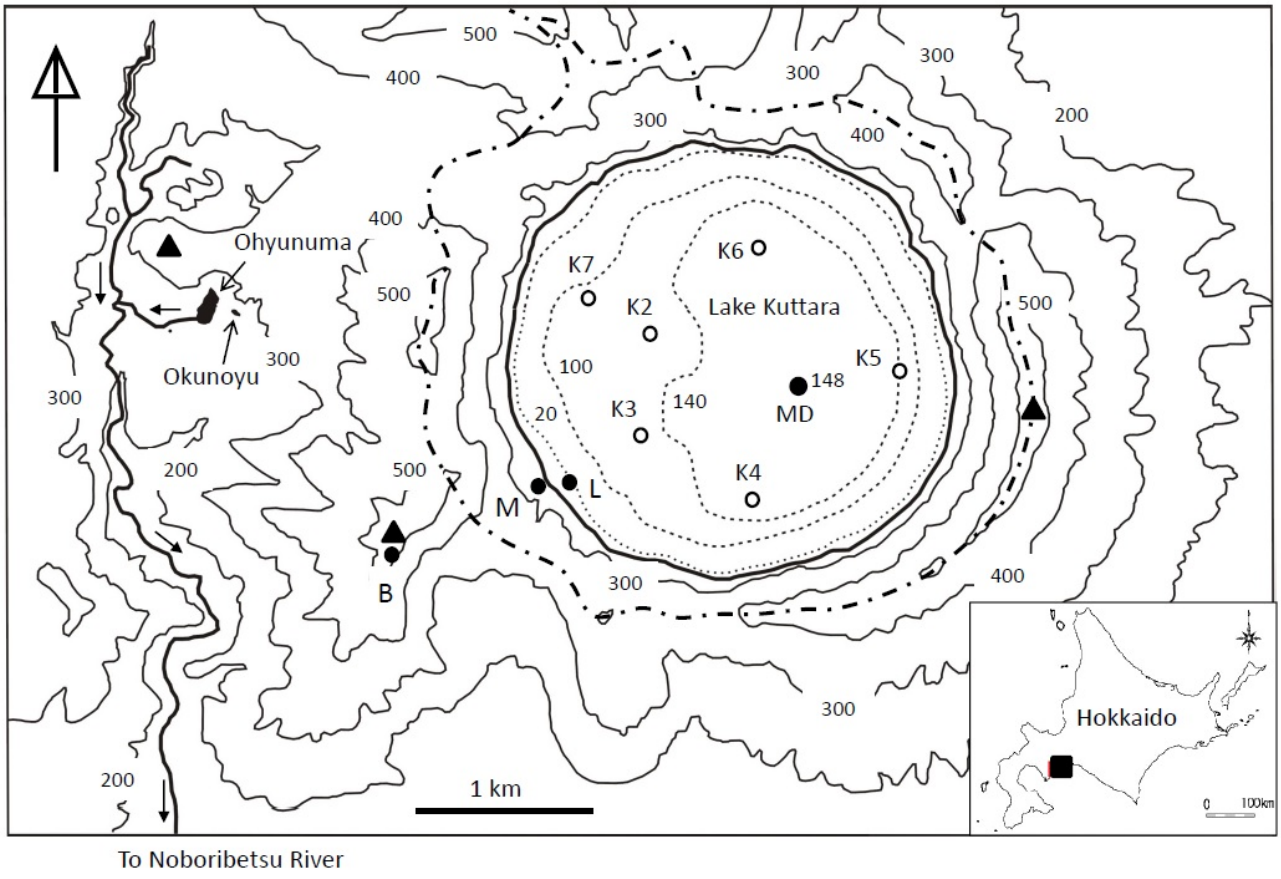

Fig. 1 Location of Lake Kuttara and observation sites on the bathymetry (water depth in m by dotted lines). The dashed dotted line shows a water divide of the lake.

