Seasonal evolution of the N_2/Ar ratio in the upper ocean of the western subarctic Pacific: a modeling study

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The N_2/Ar saturation ratio (ΔN_2/Ar) in seawater provides a powerful constraint on water column and benthic denitrification. To use ΔN_2/Ar as a tracer of denitrification, accurate knowledge of the influence of abiotic processes, such as air-sea heat flux related to diffusive gas exchange, turbulent mixing, sea-level pressure variation, and bubble injection, on the distribution of these two gases in the upper ocean is required. To this end, we investigate the contribution of each of these abiotic processes to the seasonal evolution of N_2 and Ar saturation anomalies and ΔN_2/Ar in the western subarctic Pacific using a one-dimensional model. Variations in surface heat flux and sea-level pressure tend to create an undersaturation of N_2 and Ar in the mixed layer from winter to early spring, when the mixed layer depth reaches its maximum; this undersaturation is carried to depths below the mixed layer. Mixing induces a small supersaturation of both gases in and below the mixed layer. Because these processes affect both gases in a very similar manner, they lead to only very small ΔN_2/Ar anomalies in and below the mixed layer. In contrast, bubble-mediated gas exchange leads to higher supersaturation of N_2 than Ar, and it accounts for almost all the ΔN_2/Ar anomalies in and below the mixed layer. The contribution of bubble-mediated gas exchange thus needs to be well understood when using ΔN_2/Ar as a tracer for oceanic denitrification.

Keywords: N2/Ar ratio in the upper ocean, abiotic process, seasonal evolution

Nitrification and denitrification processes in sediment and its influence on nitrogen dynamics in Lake Biwa

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It has been well known that excess nitrogen loading on aquatic ecosystems causes severe environmental problems such as harmful algae outbreak and deterioration of water quality. Denitrification is a microbial process that reduce nitrate to di-nitrogen. Nitrification is important microbial process for denitrification because that produces nitrate from ammonium. These mean that co-occurrence of nitrification and denitrification reduces nitrate and ammonium concentration in aquatic ecosystem. In this study, we conducted sediment incubation experiments of sediment to determine nitrification rate and denitrification rate at sediment in Lake Biwa. We also corrected lake water at 14 depths from May 2015 to Dec. 2016 in a month interval at first sedimentary basin of Lake Biwa, and analyze total nitrogen, dissolved nitrogen, ammonium, nitrate and nitrogen and oxygen isotopes of nitrate.

Nitrate concentration was higher in the deeper layer (50-80 m) than the surface layer (0-10 m) at all observation period, and the difference increased in latter stratification period. Moreover, nitrogen isotopes ratio of nitrate increased and oxygen isotope ratio of nitrate decrease in deeper layer at latter stratification period. These results mean new nitrate was generated at deeper layer at stratification period. The results of sediment incubation experiments and nitrate mass balance in water column show that increase of nitrate in deeper layer at stratification period was result of nitrification in water column. Moreover it is considered that the influence of sedimentary denitrification on nitrate consumption in water column was minor.

Keywords: nitrification, denitrification, sediment, Lake Biwa

Nitrogen and phosphorus dynamics in the mainstem of the Fuji River estimated by *in situ* spiralling metric measurements

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Excess land-derived nitrogen and phosphorus often stimulate the primary production of downstream ecosystems such as lakes and coastal waters, thereby causing the eutrophication problems therein. Therefore, elucidating the role of river networks in processing the fluvial nutrients supplied from terrestrial ecosystems has become an important prerequisite for the ecosystem management of downstream ecosystems. Nitrogen and phosphorus dynamics in lotic ecosystems have long been described uniquely by three major variables of spiralling metrics (areal uptake rate, U; uptake velocity, v_f; uptake length, S_w). Areal uptake rate (U) represents the net uptake rates of nutrient atoms by benthic compartments, while uptake velocity (v_f) and uptake length (S_w), respectively, refer to nutrient uptake efficiency relative to concentration and the longitudinal travel distance of a dissolved nutrient atom before removal from the water column. However, until recently, there are only a few studies that have undertaken to measure the spiralling metrics in large rivers at the downstream end of the river networks, especially in large rivers of mountainous watersheds with high relief, as are watersheds in Japan. The objective of the present study is to evaluate the roles of large rivers in fluvial nutrient transports by estimating the nutrient spiraling metrics (U, v_f, S_w) in the mainstem of a sixth-order river (discharge = 37–53 $m^3 s^{-1}$) in a Japanese high-relief watershed.

The field study was conducted during May and December 2015 in the mainstem and tributaries of the Fuji River system in central Japan. We monitored the longitudinal changes of inorganic nitrogen (ammonium, nitrite, and nitrate) and phosphorus (phosphate) concentrations by directly tracking a specific parcel of water and by continuously collecting the samples from the parcel along the river course. Assuming that nutrient removal reactions in river channels obey first-order kinetics, we estimated nutrient spiralling metrics from the longitudinal change of the natural logarithm of nutrient concentrations with distance downstream. In this presentation, we will show the pattern and dynamics of nitrogen and phosphorus in the Fuji River by using the estimated nutrient spiralling metrics. The results emphasize the seasonal dynamics of nutrient uptake and the importance of substrate limitation and nitrification in phosphorus and nitrogen uptake in the river system. Based on these findings, we discuss the functional roles of large river ecosystems in longitudinal nutrient transports from terrestrial to coastal ecosystems.

Keywords: nitrogen, phosphorus, river, spiral metrics

Clarifying sources of methane enriched in oxic water columns by using stable carbon and hydrogen isotopes as tracers

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Although methane is one of the representative greenhouse gases in atmosphere, there are still many uncertainties on the emission sources on earth surface. The hydrosphere is the major source of atmospheric methane, and thus slight changes on the hydrospheric environment will cause a drastic change on the atmospheric methane concentration and thus on global warming. Consequently, we must increase our knowledge on the sources of methane enriched in hydrosphere, together with the behaviors of methane in hydrosphere.
Generally, methane is produced in anoxic environments, while being decomposed in oxic environments. Nevertheless, supersaturation of methane in water relative to that in equilibrium with atmospheric concentration have been frequently found in oxic oceans and lakes. Various studies had been done in past to clarify the reasons of this contradiction, being called as ‘methane paradox’.
So as to clarify the sources and behaviors of methane in such oxic hydrosphere, the $\delta^{13}C$ values of methane have been frequently used as a tracer in past studies, while the studies using δD values of methane enriched in oxic hydrosphere were limited in past. By using both $\delta^{13}C$ and δD values of methane simultaneously as tracers, the changes in the values of $\delta^{13}C$ and δD during oxidation (partial removal of methane in oxic water column) can be corrected. In this study, we used stable isotopes ($\delta^{13}C$ and δD) of dissolved methane in the water columns of Lake Biwa, Ise Bay, and Mikawa Bay as the tracers to specify the sources of methane supersaturated in the oxic water columns and to clarify the behavior of methane in the oxic water columns. Besides, I defined a new parameter $\Delta(2,13)(= \delta D - 11 \times \delta^{13}C)$ in which variations in both $\delta^{13}C$ and δD values during methane oxidation had been corrected and used this parameter as the tracer to differentiate the sources for each methane dissolved in the water columns.
To clarify the sources in the studied fields, I assumed following three methane sources as the possible sources of methane supersaturated in the oxic water columns, (1) river input, (2) lake-floor (or seafloor) sediments, and (3) sinking particles in the water columns, and determined the stable isotope ratios of methane supplied from each. Then, I compared them with those in the water columns, and concluded that methane supersaturated in Lake Biwa and Ise Bay surface water columns is likely to be supplied via river. On the other hand, it was impossible to assume river input as the major source of methane in Mikawa Bay water showing the δD values (-327~-287‰) substantially lower than those dissolved in river input (-175‰). I concluded that the seafloor sediments should be highly responsible for the source of methane enriched in the Mikawa Bay water columns.

Keywords: methane , hydrogen isotopes, carbon isotopes

Elucidation of nitrate dynamics in a temperate region watershed with heavy snowfall using triple oxygen isotopes as tracers

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Atmospherically deposited nitrogen to the terrestrial environment due to human activity has been increased over the last decades. It is important to elucidate the response of ecosystems towards nitrogen deposition. In this study, a triple oxygen isotope approach was used as a tracer for environmental fate of atmospheric NO_3^- in a temperate forest with heavy snow for the years 2015 and 2016. The $\Delta^{17}O$ values of NO_3^- for precipitation and throughfall ranged from 22 to 32‰ and reflect the seasonal variation between summer (minimum) and winter (maximum), this is attributed to the changes in atmospheric formation pathways of NO_3^- over seasons. Based on $\Delta^{17}O$ values of NO_3^- in litter layer and mineral soil at 25, 55, and 90 cm depths respectively, calculated fraction of $NO_{3\ atm}^-$ (f_{atm}) shows that nitrification mainly occurs in the litter layer in the summer. In the winter, on the other hand, relatively high $\Delta^{17}O$ values of NO_3^- in litter layer were observed, indicating that nitrification does not occur in the litter layer due to the existence of snowmelt water. Although different f_{atm} for litter layer were observed over the seasons, f_{atm} of stream water were constant (approximately 10%) in both winter and summer. In addition, gross nitrification rates (GNR) based on f_{atm} for stream water and total NO_3^- input for this study site in summer were lower than those in winter, suggesting higher nitrification activity in winter due to higher loads of NO_3^- and NH_4^+ inputs in the latter season. So far, nitrogen and oxygen isotopic values for biologically produced NO_3^- showed no significant correlation, indicating no detectable trend of assimilation by plants and/or denitrification.

Keywords: stable isotopes, fraction of atmospheric nitrate, gross nitrification rate, biologically produced nitrate

Using triple nitrate isotopes to determine nitrate sources in the streamwater of tropical dry forest

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In southeast Asia a nitrogen emission and deposition increased since 1980s. This could lead to the nutrient imbalances and the degradation of stream-water quality in tropical rain/dry forest which is largely distributed in the area. Quantifying the contribution of atmospheric nitrogen deposition to nitrogen discharge has not been well examined in tropical forest area. Oxygen isotope anomaly ($\Delta^{17}O$) would be a good technique for distinguishing the atmospheric nitrate from the microbe-oriented nitrate. Using this technique, existing studies has determined the fraction of atmospheric nitrate in the stream water mainly in temperate forest located in mid-latitude. However, an applicability of this technique is largely unknown in tropical area. Our objectives of the study are 1) to examine the applicability of $\Delta^{17}O$ techniques in tropical forest and 2) to clarify the contribution of the atmospheric nitrate to the stream water nitrate in the forest established in tropical savanna climate.

The study catchment was established in dry evergreen forest of the Sakaerat silvicultural research center, Nakohn Ratchasima Province in northeastern Thailand (35 ha). The altitude of the study catchment ranges 600 to 680 m. Annual mean precipitation was 1370 mm and annual mean temperature was 25.5 ° C. Climate type was tropical savanna. The period between November and March is extremely dry, with monthly precipitation less than 50 mm. Using bulk sampler, we collected a precipitation in the morning of the day just after the rain event was observed. We mixed the daily precipitation into the monthly composite samples and stored it at freezer. Meanwhile, nitrate in soil water and stream water was collected by anion exchange resin method. The resins for soil water and stream water were put during ca. 6 month and 2 weeks, respectively. We extracted the nitrate from the recovered resins from the field after the period. We measured nitrate concentration and isotopic compositions of the nitrate for each water and extracts samples. $\delta^{15}N$ and $\delta^{18}O$ of nitrate were determined by the denitrifier method. And $\Delta^{17}O$ was measured in Washington University after we transformed nitrate of the sampler to nitrous oxide by the denitrifier method.

As a result, in precipitation $\Delta^{17}O$ -NO_3^- in precipitation was about 21‰ and did not largely fluctuate during wet season. In soil water $\Delta^{17}O$-NO_3^- was 1.3 and 1.4‰ at surface and sub soil, respectively, on the slope. These values decreased on riparian area. This tendency simply suggested that the contribution of atmospheric nitrate steeply declined in soil water in this study catchment. As for the seasonality, $\Delta^{17}O$-NO_3^- of soil water was higher in dry season compared to wet season. Finally, $\Delta^{17}O$-NO_3^- in the stream water ranged 6 to 12‰ during wet season. We also found the significantly relationship between $\delta^{15}N$ and $\delta^{18}O$ in the stream water, which suggested the strong contribution of the denitrifying processes within the study catchment.

We assumed that this technique was effective for distinguishing the atmospheric nitrate from microbe-oriented nitrate even in the tropical forest ecosystems. Meanwhile, in this study $\Delta^{17}O$-NO_3^- of precipitation (21‰) was relatively lower than the value in existing report at mid-latitude. In this

presentation we are going to discuss the fraction of atmospheric nitrate to surface water nitrate by a quantitative approach.

Keywords: Oxygen isotope anomaly, Tropical dry forest, Nitrogen deposition

The influence of dry deposition and wet deposition on streamwater nitrate concentration in forested watersheds

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Nitrogen exported from forest is considered to affect the eutrophication in downstream ecosystems, therefore, the understanding of nitrogen export processes from forest is important. Recently, nitrogen deposition to terrestrial ecosystem is increasing and that enhance nitrate concentration exported from some forested watersheds. Nitrogen deposition to forest generally consists of dry and wet deposition of nitrogen, however, the influence dry deposition on nitrogen export from forested watershed has not clear compared with the influence of wet deposition. In this study, we measured nitrogen compounds concentrations in stream water, througfall and air in forested watersheds near highway to clarify the influence of dry deposition and wet deposition on streamwater nitrate concentration. We collected streamater in 23 sites, throughfall in 13 sites and nitrogen oxide aerosol in 8 sites at north part of Shiga prefecture. Stremawater was collected from March 2016 to November 2016 in a month interval, and throughfall and aerosol were collected from August 2016 in two weeks interval. Nitrate concentrations were higher in streamwater from forested watershed near highway. We will discuss the relationship between streamwater nitrate concentrations and wet and dry depostion in presentation.

Keywords: nitrate, streamwater, dry deposition, wet deposition, forested watershed

Development of stable N isotope model for forest ecosystem

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Since the Industrial revolution, reactive nitrogen in the environment has increased due to the combustion of fossil fuels and increased use of chemically synthesized fertilizers, the amount of which has been doubled in the whole land before the industrial revolution. Excessive reactive nitrogen is a cause of various environmental problems such as generation of nitrous oxide which is a greenhouse gas, nitrate nitrogen contamination of groundwater, eutrophication of closed water area, and decline of biodiversity. Even in forest ecosystems, nitrogen saturation has been confirmed in many suburban areas, but it is still difficult to accurately measure the nitrogen balance in forest ecosystems. This is partilly because it is difficult to quantify the denitrification in forest ecosystem. For this reason, we have also great uncertainties in the nitrogen cycle of the ecosystem (biogeocemical) models. However, the ratio of natural N isotopes is considered to reflect information on N loss rates (i.e., denitrification, leaching) in some extent. So, Houlton et al. (2015 in Nature Climate Change) proposed that implementing the ratio of natural N isotopes in ecosystem model and validate these values could improve their representation of N cycling.

In this study, to implement d15N calculation scheme to ecosystem model "VISIT", we measured the delta15N of leaves, litter and soils, as a validation dataset, in five forest experimental sites across Japanese archipergo (Teshio Experimental Forest of Hokkaido Universiy Ryukyu , Fujiyoshida, Mt. Tsukuba, Tenryu Field of Shizuoka University, Yona Field of Universiy of Ryukyu). First, to estimate soil d15N using VISIT, we implemented Houlton & Bai (2010 in Global Biogeochemical Cycle) scheme to VISIT model. However, the simulation results of soil d15N in VISIT showed smaller values, compared to observation in all site. We will report further progress in the representation 15N in the modified VISIT model.

Keywords: Nitrogen isotope ratio, Forest ecosystem

Seasonal variation of O_3 flux in red pine forest

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The emission and absorption of trace gases at the biosphere affects to atmospheric chemistry, and thus it makes influence with potential indirect effects on carbon cycle and climate (Ollinger et al., 2002). We observed O_3 flux with the gradient method at a meteorological tower in red pine forest (Site Code: FJY) through 2016. We also measured CO_2 flux at the same meteorological tower for validation of the system by comparison with CO_2 flux determined by the eddy covariance method.
The heights of the forest canopy and the meteorological tower were about 25 m and 32 m. Concentrations of O_3 and CO_2 were measured at two heights (26 m and 34 m) above the canopy by an ultraviolet absorption O_3 analyzer (Thermo: 49C) and an infrared absorption CO_2 analyzer (Licor:LI-820). The O_3 instrument was calibrated before the observation, and the CO_2 instruments were calibrated every three weeks at the observation site. The air was sampled every 300 seconds from each two vertical heights and supplied to the analytical instruments through PFA tube. Concentration of CO_2 was also measured by an infrared absorption CO_2 analyzer (Licor: LI-6262) at 26.5 m to determine CO_2 fluxes by the eddy covariance method. Wind speed and wind direction were measured at 26.5 m and they were used to obtain fluxes by the gradient and eddy covariance methods.
The CO_2 fluxes in the day time (9:00-16:00) in 2016 were observed with the gradient and the eddy covariance method as -0.10±0.08 mol m^{-2} d^{-1} and -0.25±0.16 mol m^{-2} d^{-1}, respectively. The CO_2 flux obtained by the gradient method was slightly lower and more scattered than CO_2 flux obtained by the eddy covariance method; however these values reasonably agreed. We made sure the flux observation system with gradient method worked properly.
O_3 concentration showed a seasonal variation and was in a maximum in May. However the primary result showed that O_3 deposition in the red pine forest in the day time (9:00-16:00) had a maximum in July. The peak of O_3 deposition delayed to the peak of O_3 concentration, which was also obserbed in mixed forests of conifers and broad leaved trees inTeshio, Japan (K. Takagi, 2016).

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K. Takagi, 2016, Annual meeting in Japan Society of Atmospheric Environment, 150.

Keywords: ozone, flux, forest

Carbon stock of coarse woody debris in Japanese forests

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The national forest soil inventory project of Japan was launched from 2006 in order to support reporting to the United Nations Framework Convention on Climate Change (UNFCCC). The second phase of the project had been started from FY2011 to FY2015. The project is collecting data from Japanese forests with respect to three carbon compartments in pedosphere; soil, litter, coarse woody debris (CWD). Here, we report our preliminary results of the analyses of CWD compartments based on 2636 plots in the second phase of the project.
The CWD data used in this study include dead wood, stump, and blighted tree. We obtained the average CWD carbon stock of 0.75±0.98 kg m^{-2}, that is 8.3% of total soil carbon stock.
In secondary forests, CWD was produced by mortality dues to environmental stress, snow damage, wind damage, disease, insect pests, competition and aging. In contrast, CWD in plantation was generated by thinning or large-scale felling for forest management. The CWD in secondary forests, cedar plantation, and Japanese cypress plantation has average carbon stocks of 0.60±0.83 kg m^{-2}, 1.16±1.24kg m^{-2}, and 1.14±0.94kg m^{-2}, respectively. These results suggest that the CDW carbon stock differs largely between secondary forest and plantation. Considering other conditions such as management practice and above ground biomass, we plan to report characteristics of CWD carbon stock in Japanese forest through different types and ages.

Keywords: soil carbon stock, forest ecosystem, inventory

表１　枯死木の調査方法とサイズ計測箇所

枯死木の種類	調査方法	サイズの測定方法
倒木	ラインインターセクト法	ライン上の直径
根株	ベルトトランセクト法	直径、地際直径、斜面上部高、斜面下部高
立枯木	ベルトトランセクト法	胸高直径、高さ

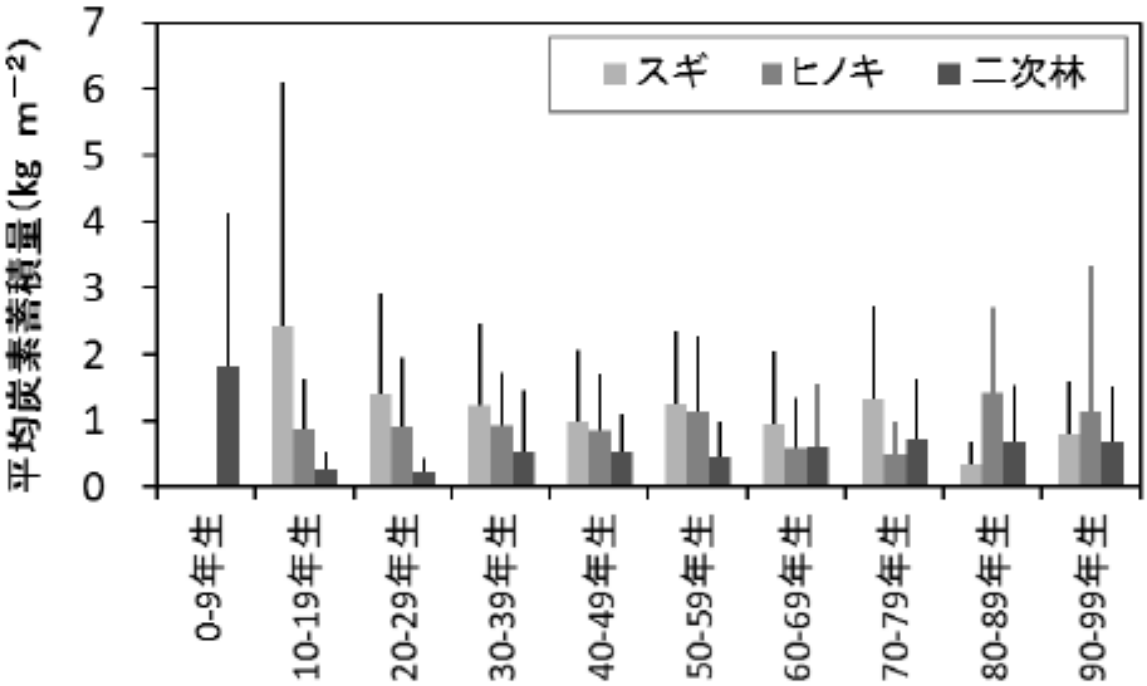

図１ 林齢による枯死木の平均炭素蓄積量
エラーバーは標準偏差を示す。

The sensitive soil chemical properties reflect the vegetation changes caused by overgrazing in Mongolia.

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Human activities and climate changes have altered grassland ecosystems in Mongolia. Especially, overgrazing causes deterioration of vegetation and soil degradation. The process of soil degradation with vegetation deterioration in Mongolian grassland is not clearly understood. We need to find out which soil properties can be a sensitive index of soil degradation to promote sustainable use of grassland in Mongolia. Therefore, to obtain preliminary data for establishing a soil degradation index, we observed soil profile morphology and measured soil physicochemical properties under different grazing pressure in the steppe grassland Mongolia.

Keywords: soil physicochemical properties , soil degradation, overgrazing, Mongolia

Comparison of Different Degraded Grassland Soils in the Qinghai-Tibet Plateau

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The Qinghai-Tibetan Plateau, the largest geomorphological unit on the Eurasian continent, is an important part of the global terrestrial ecosystem. In recent years, the degraded grassland area has reached about $4.251x10^7$ hm^2, accounting for 33% of the available area.
Objective of this study are (1) To identify morphological characteristics and physicochemical properties of soils in alpine degraded grassland (2) To investigate the change of soil micromorphology under different degradation grassland.
Therefore, we chosen 3 site from the Hequ horse farm in the eastern Qinghai-Tibet plateau, there are lightly degraded grassland(HQ1-L), moderately degraded grassland(HQ2-M) and heavily degraded grassland(HQ3-H). HQ1-L in the winter pasture, HQ2-M close to the nest, surrounded by more serious desertification, HQ3-H plots selected in the cow enclosure, the surface vegetation was destroyed. Soil samples from each horizon were systematically collected for physicochemical analysis and 100 cm^3 core samples were taken from 0-5cm surface soils for the micromorphology analysis.
Vegetation coverage decreased with grassland degradation. The characteristics of the OA layer are root mat, because the dominant species of *Kobresia* belongs to the *Cyperaceae* genus, this is easy to form the root mat. In the HQ3-H degraded grassland, a large number of vegetation degradation, secondary vegetation instead of dominant species, the OA horizon was disappeared.
In conclusion, the exchangeable cations, CEC, total nitrogen (TN) and organic carbon (OC) were decreased with grassland degradation degrees; however, the pH value is exactly the opposite. While, from the micromorphology of soil thin section, with the soil degradation, the porosity obviously decreases while the degree of soil microstructure is also reduced, resulted in mineral ions and free water supply to plant growth are also restricted. Also the activity of soil animals was decreased with grassland degradation.

Keywords: Qinghai-Tibet Plateau, Soil, Grassland, Degradation

Effect of epigeic earthworm casting on soil properties of subsoil from an Andosol

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The burrowing and feeding activity of earthworms have the beneficial effect on the soil properties. It is reported that earthworm cast forms a stable aggregate with large size and it increases the water holding capacity, water permeability. Earthworm casts have higher available nutrients and microbial activity than surrounding soils and have a higher rate of decomposition of organic matter. In addition, it is reported that bacterial composition is different between the intestine of large earthworm and surrounding soils. However, the influence of earthworms on the interactions among organic matter - minerals - microorganisms in soil is still unclear. In this study, we conducted the breeding experiment of earthworm to show the effects of earthworm on; (1) the soil aggregation and soil organic matter content, (2) soil enzyme activity and microbial community.
Metaphire hilgendorfi was collected and kept in a rearing container with soil and litter for 2 weeks. After breeding, control soil and earthworm cast were sampled for microscopic observation, measurement of pH, EC, total nitrogen, organic carbon, β-glucosidase and protease activity, and evaluation of microbial diversity using biology eco-plate.

Keywords: earthworm, soil aggregates, microbial activity

Soil carbon loss induced from artificial macropore installation

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Soil carbon loss induced from artificial macropore installation

Keywords: macropore, infiltration, carbon storage

Which fraction of soil organic matter is more vulnerable to rhizosphere priming effect?

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Rhizosphere priming effect (RPE) is defined as the stimulation or suppression of soil organic matter (SOM) decomposition by living roots. It remains unclear which fraction of SOM is more vulnerable to rhizosphere priming. We conducted two experiments in continuous 13CO2 labeling growth chamber to compare the intensity of RPE for the active (or labile) vs. slow (or recalcitrant) SOM. A sandy loam (Alfisol) was incubated at 20oC and 80% water holding capacity for different periods, which created a gradient in the relative proportion of active vs. slow SOM in the remaining soils. We then grew sunflower (Helianthus annuus) and soybean (Glycine max) in these remaining soils for 50 days under the same environmental conditions to compare the RPE of these two plant species on the decomposition of soils that varied in the lability of SOM. In both experiments, as the incubation proceeded from 1 to 8 to 14 months (in experiment 1) and the soil changed from freshly-sampled soil to two-year-incubated soil (in experiment 2), the intensity of RPE increased significantly even after accounting for the changes in root biomass or root-derived CO2. This result suggests that the slow (or recalcitrant) fraction of SOM is likely more vulnerable to rhizosphere priming compared to the active (or labile) fraction of SOM. Although the underlying mechanisms of this finding await further investigation, our study clearly shows that the main component of SOM (slow or recalcitrant SOM, decadal turnover) is vulnerable to rhizosphere priming. Therefore, the RPE has the potential to substantially regulate both short-term and long-term soil carbon dynamics.

Keywords: soil organic matter decomposition, rhizosphere priming effect, labile soil carbon, recalcitrant soil carbon

