

## Water and solute dynamics in soils under different environments

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The water and solute flux in soils was measured at lower slopes and upper slopes in the Katsura experimental forest (KEF) and the Tsukuba experimental forest (TEF), both located in Ibaraki, Japan. The soil water flux was around 300 mm less than throughfall at the upper slopes and exceeded the throughfall at the lower slopes and the same level at the lower slopes. The percentage of the flux of nitrate-N to inorganic-N below litter layer was about 70 at the upper slope and larger than 90 at the lower slopes, reflecting high nitrification rate in moist conditions. The nitrogen deposition by throughfall was less than 10 kg ha<sup>-1</sup> y<sup>-1</sup> in KEF and was near 20 kg ha<sup>-1</sup> y<sup>-1</sup> in TEF. The nitrate-N flux at 100 cm depth was almost zero at KEF and exceeded 40 kg ha<sup>-1</sup> y<sup>-1</sup> at TEF. In TEF, the nitrogen input is thought to exceed the ecological demand. High nitrate concentration in TEF soil caused leaching of Ca and mobilization of Al.

Keywords: Forest soil, water, solute, site environment

## Comparison of evapotranspiration obtained through multiple observation methods from a planted forest on complex terrain

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### Introduction

Temperate evergreen conifers in eastern Asia are largely distributed in the warm-temperate region and subtropical region, and they grow in rather humid environment under the effect of monsoon, and it is significant to quantify the evapotranspiration (ET) and its characteristics of seasonal variation in such area from the point of view of global and local water cycle. Among the warm-temperate region, southeastern part of Japan is characterized by the highest precipitation rate. Further, planted conifers are the most dominant species in Japan, and about 18% of the land surface of the country is covered with conifers planted in 1950's. Since the trees were planted patchy and have grown usually on a mountainous terrain, it is difficult to estimate ET factor from a single method of observation. Thus, in this study we apply multiple observation methods for a planted coniferous forest in southeastern part of Japan, and try to examine ET estimated from each method.

### Materials and Method

Measurement was carried out at Kahoku experimental watershed (KHEW: 33° 08' 13.3" N, 130° 42' 34.3" E) in Kyushu Island, southwestern part of Japan. The main vegetation is Japanese cedar (sugi), planted around the valley to lower hillside, and Japanese cypress (hinoki) planted at upper hillside to the ridge. Runoff was measured at 2 small watersheds (Shimizu et al., 2003; Shimizu, 2007), and net rainfall was measured at an outer open space near the watersheds. Rainfall interception was obtained from 3 plots observation (middle-sugi plot, large-sugi plot and hinoki plot), from the measurements of stem flow and rainfall on the forest floor. Sap flux observation was carried out by applying Granier type sensors at sugi forest stands, to compare the effect of slope position on the plot scale evaporation (Kumagai et al., 2007). The latent heat flux was measured through closed-path method, with a sonic anemo-thermometer and a sampling intake to an IRGA installed at the top of the 50-m meteorological tower, which was built on the middle of the smaller watershed. The data used mainly for the analysis was obtained between 2007 and 2008.

### Results

In the year 2007, the annual net rainfall was 1956.5mm, and rainfall interception measured at middle-sugi plot was estimated as 435.3mm. The annual runoff values between the 2 watersheds are remarkably different, and it would be caused the difference of the bedrock inclination direction from the surface landform (Ikawa, 2008). The area-based evaporation values from overstory sugi trees were differed by slope position, but it might be compensated by evaporation from understory which grew more thickly at the upper slope position. The trend of latent heat flux divided by two wind direction was significantly different from each other, which might be related with steep slope and relatively small hinoki trees in the south direction from the tower. In the presentation, we will apply these results to discussion about the annual water budget.

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Keywords: Planted Coniferous forest, Complex terrain, Evapotranspiration, Rainfall-runoff, Latent heat flux, Sap flux measurement

## Community structures and activity of denitrifying microbes in forested catchment: survey using nitrite reductase genes

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To elucidate the mechanisms of denitrification processes in the forested catchment, microbial ecological approaches have been applied in an experimental watershed that has previously investigated its hydrological processes. The study catchment is located in the Chiba prefecture in central Japan under the temperate Asian monsoon climate. Potential activities of denitrification of soil samples were measured by incubation experiments under anoxic condition associated with  $\text{Na}^{15}\text{NO}_3$  addition. Existence and variety of microbes having nitrite reductase genes were investigated by PCR amplification, cloning and sequencings of nirK and nirS fragments after DNA extraction. Contrary to our early expectation that the potential denitrification activity was higher at deeper soil horizon with consistent groundwater residence than that in the surface soil, denitrification potential was higher in shallower soil horizons than deeper soils. This suggested that the deficiency of  $\text{NO}_3^-$  as a respiratory substrate for denitrifier occurred in deeper soils especially in the summer. However, high denitrification activity and presence of microbes having nirK and nirS in surface soils usually under aerobic condition was explainable by the fact that the majority of denitrifying bacteria have been recognized as a facultative anaerobic bacterium. This also suggests the possibility of that denitrification occurs even in the surface soils if the wet condition is provided by rainwater during and after a storm event. Community structures of microbes having nirK were different between near surface and deeper soil horizons, and ones having nirS was different between saturated zone (under groundwater table) and unsaturated soil horizons. These imply that microbial communities with nirK are sensitive to the concentration of soil organic matters and ones with nirS is sensitive to soil moisture contents.

Keywords: forest soil, denitrification, microbial community, functional gene

## Denitrification rates in different shallow aquifers

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Denitrification rate in the shallow aquifer strongly depends on the hydrogeological setting and land-use conditions. The objectives of this presentation are to review and compare denitrification rate obtained under different hydrogeological setting and land-use conditions and to examine simple model of denitrification rate in different shallow aquifers.

Keywords: denitrification, shallow aquifer

## Groundwater discharge mechanism and hydro- geological structure in Tottori sand dune

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Tottori sand dune is located in Sanin Kaigan national park, Japan. This dune is a valuable worldwide natural landscape and is registered in the global geoparks network. There is a small water area, called an oasis, in this sand dune. The oasis is grows after the rainfall, and an important factor of a natural landscape in the dune. There is a groundwater discharge point that is not dry up throughout the year near the oasis. It has been thought that this groundwater discharge point greatly contributed to the generation of the oasis. But another groundwater discharge points are discovered in the dune. Then, the generation mechanism of the oasis is clarified by spatial water quality and hydro- geological structure.

The groundwater flow in the observation region was classified into two of the east and west. It is suggested that three groundwater discharge points located in the east region contributes to the growth of the oasis. It has been understood that there is a relation up to the oasis and B-1 discharge point from oxygen isotope ratio. A-1 discharge point doesn't have a strong relation in the generation of the oasis. From the resistivity tomography model, the low resistivity material below 200 ohm deposit horizontally at several meters depth from surface. The detected low resistivity material is thought to be a volcanic ash layer, for example, Daisen Kurayoshi pumice fall deposit. This volcanic ashes deposited as to be deep as the eastern, shallow as the western. This result explained the phenomenon that the eastern groundwater contributes to the generation of the oasis.

Keywords: Groundwater discharge, Tottori sand dune, Oxygen Isotope Ratio, Resistivity tomography

## Water and Nutrients Dynamics in and around Eucalyptus Forests

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Brazil is the biggest eucalyptus forestation country in the world, and 0.6% of a country or 3,500,000 ha is eucalypt forest already. Though there have been several studies reporting environmental impacts of eucalyptus plantation such as over-uptake of water and nutrition, biodiversity loss, volatilized or emitted harmful substances, in Brazil salient issues have not occurred. At first, this project evaluates scientific backgrounds and finds threshold conditions to environmental mal-impacts. Based on verifying environmental functions of eucalyptus such as uptake of over excessed or contaminated nitrate from groundwater and soil erosion control, sustainable crop producing systems with coupling with eucalyptus plantation in land-use sequences could be proposed. Two study sites, Rio Claro and Mandacaru, were set around the area of Piracicaba, Sao Paulo State of Brazil, where sugar cane field and eucalyptus forest are set out sequentially. Piracicaba area is covered by silty sand layers on the undulating peneplain. The annual mean temperature is 21.4 degree C, and average annual precipitation is 1279mm. The stands of the eucalyptus are about 4 years old and their heights are around 15m. Sets of monitoring wells of 3 to 8 m-depth were installed, and groundwater chemistry is analyzed and water levels are surveyed regularly. As preliminary results, groundwater in the sugar cane fields are affected a little by fertilization, that is relatively high nitrate concentration, and surface soil or organic matters are degraded, while those in the eucalyptus forest are fairly good. More research in the next two years could propose possible sustainable farm systems including eucalyptus plantation.

Keywords: eucalyptus, land-use sequences, environmental conservation, groundwater contamination, Sao Paulo, Brazil

## Relationship between Geogenic Solute Concentration and Residence Time in Groundwaters

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Mineral dissolution rate into groundwater may imply rock weathering and, release and accumulation of geogenic pollutants. In this study, we investigate the relationships between solute concentration and residence time (tR) of spring and well waters in volcanic region, Mt. Yatsugatake, in limestone region, southern Okinawa, and in Holocene aquifer, Bangladesh.

In volcanic region, Mt. Yatsugatake, the residence time of groundwaters ranges from 15 to 50 years. The real velocity is estimated to be from 100 to 500 m/y. The relationship between SiO<sub>2</sub> and tR is linear in each watershed, and the slopes of the straight line range from 0.45 to 2.8 mg/L/y. It is inferred that the weathering continues at a constant rate for recent fifty years in each watershed in Mt. Yatsugatake. In limestone region, southern Okinawa, the tR of groundwaters ranges from 15 to 35 years. The relationship between Ca dissolved from the limestone and tR is also linear with the wide slope ranging from 4.3 to 8.0 mg/L/y. The dispersive value of the Ca dissolution rate into groundwater may reflect the effect of a wide range of flow velocities due to heterogeneous hydrogeological structure of limestone. In groundwater As-hotspot zone of Holocene aquifer, Bangladesh, the relationship between total As released into groundwater and tR is also linear for groundwaters recharged from 1970 to 1980, which the slope of the straight line ranges from 26 to 37 micro-g/L/y. Stute et al. (2007) reported that the slope ranges from 19 to 23 micro-g/L/y for groundwater in Holocene aquifer of their study area in Bangladesh, indicating that As release rate into groundwater in As-hotspot zone may be higher than other zones. For groundwaters recharged after 1980, As tends to increase with decrease of tR. For three groundwaters recharged after 1990, the As-release rate are estimated to be 56, 91 and 120 micro-g/L/y calculated simply by dividing As concentration by residence time, suggesting that the As-release into groundwater increases in rate after 1990. This might be related to the increase in groundwater flow velocity due to irrigation pumping started about thirty years ago.

Keywords: groundwater, residence time, Mt. Yatsugatake, Ryukyu limestone, Bangladesh, Arsenic

## Characteristics and fluctuation factors of groundwater quality on Ryukyu limestone region in southern part of Okinawa

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Characteristics and fluctuation factors of groundwater quality(the four major cations (Na<sup>+</sup>, K<sup>+</sup>, Mg<sup>2+</sup>, Ca<sup>2+</sup>) and four major anions (Cl<sup>-</sup>, HCO<sub>3</sub><sup>-</sup>, SO<sub>4</sub><sup>2-</sup>, NO<sub>3</sub><sup>-</sup>) is investigated using observed data on groundwater at springs and observation wells in the southern part of Okinawa Main Island, Japan, where Ryukyu limestone is extensively distributed. In this study, FS6 survey was conducted to examine the residence time of groundwater in limestone aquifer. The distribution of Ca<sup>2+</sup>and HCO<sub>3</sub><sup>-</sup>were similar trend because the CO<sub>2</sub> charged water first encounters a calcite layer below the groundwater table. It was found that the residence time obtained from FS6 were related with the concentrations of Ca<sup>2+</sup> and HCO<sub>3</sub><sup>-</sup>.The composition of groundwater was dominated by Na<sup>+</sup> and Cl<sup>-</sup> reflecting salt water in coastal area. It was considered that NO<sub>3</sub>-N and SO<sub>4</sub><sup>2-</sup> concentrations were influenced by the rainfall, geological structure and agricultural land use.

Keywords: Groundwater, Water quality, Ryukyu limestone, Characteristics and fluctuation



## Aquifer structure and groundwater flow related to arsenic contaminated groundwater in Sonargaon, Bangladesh

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Ganges delta plain has been known as the largest arsenic contaminated groundwater affected area in the world. Mechanism of the arsenic contaminated groundwater formation is explained by microbial reduction-dissolution of Fe-oxyhydroxides, which adsorb As. However, we proposed chemical weathering of As-bearing detrital biotite or chlorite was the mechanism to release As into the groundwater. Also, anthropogenic activity such as excess use of groundwater would promote the As release into the groundwater, although the relationship has not been revealed until present. In this study, actively recharging area in Sonargaon, Bangladesh was targeted to document groundwater aquifer structure, primary host mineral of arsenic, change of the As host in the aquifer sediments, recharging age of the contaminated groundwater, and the relation to anthropogenic activity.

Core drilling and test tube well drilling were performed at the area close to the highest arsenic polluted well (1.2mg/L As). In this area, the arsenic contaminated groundwater occurs in the Holocene aquifer divided by the underlying impermeable clay layer at -30 to -40 m depth from the uncontaminated Pleistocene aquifer. While, the impermeable clay layer lacks and the two aquifers directly contacts beneath this site. Recharging age of >800 mg As contaminated groundwater is after 1990, implying that the lowering hydropressure due to excess use of groundwater of the Pleistocene aquifer promotes vertical infiltration of surface water to release arsenic into the Holocene aquifer.

Arsenic in the contaminated aquifer is mostly fixed in insoluble phases including silicate and sulfide minerals, and the primary host phase is chlorite. While, the arsenic in and adsorbed onto the Fe-oxyhydroxides increases at the depth where the groundwater level changes. The As(III)/As(V) (0.4:0.6) of groundwater at -5m depth is the same as those of the chlorite, indicating that the arsenic is released via concordant dissolution of this mineral. The As(III) ratio becomes 0.95 below -10 m depth, and the reduction of groundwater promotes the reduction of arsenic. The release of arsenic is most active between -5 and -10 m depth, where the oxygen penetrates into the uppermost part of the groundwater.

Thus, the arsenic contaminated groundwater of the study area was formed via chemical weathering of detrital Fe(II) enriched and As-bearing chlorite promoted by the recently activated infiltration of aerobic groundwater. Reductive condition of the groundwater prompts the reduction of arsenic, however, is not essential as a release of arsenic. Since the chlorite is known as a major mineral in the arsenic contaminated groundwater aquifer sediments, this mechanism can be the generally earliest stage of arsenic contaminated groundwater in the Ganges delta plain.

Keywords: Ganges delta, arsenic contaminated groundwater, chlorite, chemical weathering, sequentially extracted chemical analysis

## Relationship between critical depth and residence time as controlling factors to retention and release of nutrient

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Generally, nutrient cycle within river system could be easily affected by impoundments and natural lakes due to retention by biogeochemical process. Capacity of nutrient retention depends on depth and residence time. Once impoundments start to receive nutrient into own water bodies, the capacity would be decreased due to its getting shallow. Someday, impoundments would turn sink to source beyond turning point. In this study, we defined the turning point as the Critical Depth. The objective of this research is to clarify the relationship between critical depth and residence time as controlling factor to retention and release of nutrient using numerical model. The study site is the Hayata reservoir which is located in the Takaya watershed, western Japan. It has the depth of 1.5m, the volume of  $2.1 \times 10^4 \text{m}^3$  and the residence time of approximately 2days. Numerical estimation were conducted in 4 scenarios with deferent depth (0.5m, 1m, 2m and 3m) using 1D eco-hydrodynamics model which is developed by CRW, the University of Western Australia. The results indicate that nitrogen has trapped only 3% of total inflow in the scenario of 0.5m while 41%-48% of total inflow in other scenarios (1-3m). Though phosphorus has trapped 23%-31% of total inflow in three scenarios (1-3m), has released 113% of inflow in the scenario of 0.5m. Consequently, the critical depth was conducted to 0.33m and 0.59, nitrogen and phosphorus, respectively. The results also suggested that there is a relationship between critical depth and residence time.

Keywords: Nutrient, Reservoir, Critical water depth, Retention, Release

## Diffusion pattern of red soil runoff on a bay reef flat, Okinawa-jima Island, using delta13C and delta15N.

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In Okinawa, sudden farmland development of sugar cane and pineapple advanced around from the 1972 Okinawa Mainland Reversion, and red soil runoff was with the times to accept an environmental problem critically here. In 1994 the Okinawa Red Soil Flowout Prevention Regulations were established, but a red soil runoff is still observed at the time of the heavy rain at a river and the shore. Therefore, We need to evaluate carbon of the land origin deposits observed in boring cores and sea bottoms to contribute somewhat to environmental estimation improvement.

Haneji Inland Sea is a rare case of inland bay environment in Okinawa. We collected the outer layer deposits of the dozens of centimeters thickness on two ca. 350 m long vertical longitudinal sections during the low tide of the summer of 2011 in the southern tidal flat of Yagachi-jima Island. We used GPS and a total station for surveying.

Almost all land source deposits, which spread out in this tidal flat, are supplied from Yagachi-jima Island where cane fields spread through. Hermatypic coral does not inhabit near here, but a bay reef flat exists beneath this tidal flat from former air photos. The upper fine sandy layer is ca. 20 cm thick, and the lower gravelly layer is composed of mollusk shells without matrix sand. Sand ripples are well developed on the tidal flat. The upper sandy layer is well sorted and shows planer or trough laminations. The mud parts were observed in form of mud drape. We mainly present the stable carbon/nitrogen isotope ratios of these mud sediments.

We show the results of research of this stable carbon isotope ratio next (an attached figure of reference). The cross axis on the charts shows the distance from the coastline.

Please refer to a lower chart below. The most landward sampling point was located in distance of 21m from the coastline, and the result of a measurement of the delta 13C was -19.6 permil in a red soil layer covered by the sandy layer more than 10 cm thick. The isotope ratios of the sandy layer increase as leaving the coastline. One logistic curve was recurred (0.9652 decision coefficient), and converged to -9.8 permil at approximately 500m.

Please refer to an upper figure next. Stable isotope ratios measured from the deposits are concerned to reflect mixing ones between land water mass (L) and seawater mass (S):  $\alpha L + (1-\alpha) S$ , and are expressed as  $(-19.6) \alpha + (-9.8) (1 - \alpha)$ . In this upper figure, a logarithm regression curve was obtained. As a matter of course, the land source sediment disappears at approximately 500m. For reference, the -9.8 permil value accords with adhesive alga along the shore.

As supposed from particle size distributions and sedimentary structures, the distribution tendency of the stable carbon isotope ratios provided here shows dilution's and diffusion's results after red soil was supplied to the sea area till now. In other words, it may be said that the environment where red soil is, so to speak, continuously supplied brings about this result.

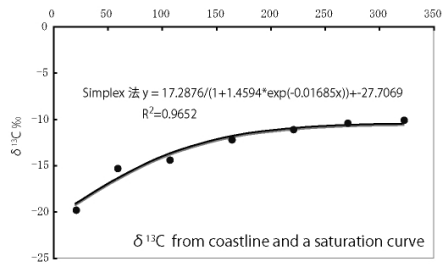
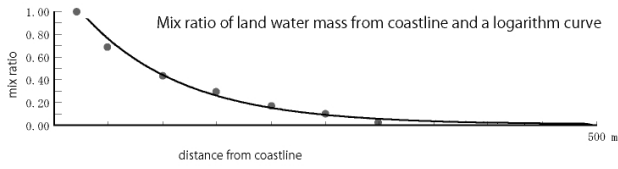
There was much weight about some samples, and a spectrum had got out of the scale, and it was totally three points among seven points, one point from a landward edge and two points from a seaward edge, but nitrogen isotope ratios delta 15N are all 5.7 permil. This may show the specific possibility of the basin in the origin of the red soil outflow and may divide tongues or aprons of deposits in a bay or boring core.

Keywords: red soil runoff, bay reef flat, particle size distribution, stable isotope ratios of C and N, Okinawa's Haneji inland sea

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## Characteristics of nutrient change via submarine groundwater discharge at large tidal flat.

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Many previous researched had reported the significant nutrient supply by the submarine groundwater discharge. To clarify spatial variation of nutrient discharge in one of a largest tidal flat of Seto Inland Sea, we observed subsurface flow and dissolved nitrogen, phosphorus, and silica, using piezometer and tracer method. The study area is located on Saijo city, Ehime prefecture, western Japan. The tidal flat has the width and length of 1km. We installed three piezometers for observing water potentials, and we collected pore water samples at the about 50 plots. In addition, 222Rn concentrations of seawater were monitored in front of the tidal flat.

The 222Rn and salinity of pore water indicated that discharges of shallow groundwater at the landside and deep groundwater at the shoreside of the tidal flat, respectively. The discharge volume was larger in shallow groundwater than in deep groundwater. The nutrient included the nitrogen as well as phosphorus and silica. Based on these observations, the large contribution of nutrient was confirmed from groundwater to this coastal area. The temporal variation of 222Rn indicated that shallow and deep groundwater affected to offshore before and after the low tide, respectively. The time lag between shallow and deep groundwater discharge was about 4 to 6 hours.

Keywords: large tidal flat, vertical distribution, nutrient, submarine groundwater discharge

## Evaluation of the effect of submarine groundwater discharge on the coastal lower tropic ecosystem in the Seto Inland Sea

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Recent studies have revealed that submarine groundwater discharge (SGD) is one of the important pathways for nutrients to the coastal ecosystems. Seto Inland Sea is the largest semi-enclosed coastal sea in Japan. Recently, some researchers tried to evaluate SGD at the specific area of the Seto Inland Sea by field research and numerical model approach. Nevertheless, its effect on the coastal ecosystem is still not clear. The objective of the study is to evaluate the effect of SGD on coastal lower tropic ecosystems in the Seto Inland Sea. The study area is southwestern part of the Hiuchi-Nada located in central part of the Seto Inland Sea. There is no input of large river into this area, whereas the terrestrial area is characterized by abundant groundwater recharged in mount Ishizuchi, which is the highest mountain (1982m) in western Japan.

The special distribution of the concentrations in radon (<sup>222</sup>Rn) and nutrients suggest that nutrient supply by SGD occurs around the tidal flat area and near the coastline. Nitrogen stable isotope ratio (δ<sup>15</sup>N) of seaweeds harvested in the coastal area indicates that they uptake the nitrogen derived from groundwater and river water as well as seawater. Besides, relatively low δ<sup>15</sup>N of seaweeds collected near the submarine fresh water spring suggests the effect of groundwater-derived nitrogen with low δ<sup>15</sup>N. It means groundwater would be one of the important pathways for nitrogen from terrestrial area to the coastal lower tropic ecosystems in the study area.

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Keywords: submarine groundwater discharge, coastal lower tropic ecosys, seaweed harvesting, Seto Inland Sea

## Short time variation of phytoplankton species in the Yodo River

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Chlorophyll a. concentration, water temperature, photon in the water and other related parameters were observed every 10 minutes during 16 days in Yodo River estuary in Japan. Cell density of each species of phytoplankton and nutrient concentrations were also observed every two or three days. And the factors of the temporal variation of composition of phytoplankton species were analyzed. However, the ratio of diatom decreased and the ratio of dinoflagellate increased. Growth of dinoflagellate was limited by phosphorus throughout the term. The limiting nutrient of diatom growth was phosphorus at first and was changed to silicate. When phosphorus limited the growth of phytoplankton, diatom had advantage because the half saturation constant is smaller. After growth of diatom began to be limited by silicate, dinoflagellate grew more due to the decrease in phosphorus concentration. Moreover, because water temperature also increased, environment for growth of dinoflagellate became good. The factors of dinoflagellate increase are the limitation of the diatom growth by silicate and the water temperature rise.

Keywords: Yodo River, Phytoplankton

