Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

AHW026-01 Room:201A Time:May 27 14:15-14:30

Distribution properties of phosphorus concentration in coastal groundwater: hydrogeological background

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Nutrient condition in water environment controls the ecosystem. Groundwater discharge to the oceans is significant as nutrient supply (Slomp et al, 2004 etc). Especially, phosphorus and silica concentration generally are relatively high in coastal area. However, it has not been enough to confirm the source of phosphorus in coastal groundwater in previous studies. This study aims to confirm hydrogeological properties in coastal groundwaters, and estimate the possible phosphorus sources of groundwater.

The study areas are Osaka, Marugame, Okayama, and Fukuyama alluvial plains and small island groundwaters in Hiroshima prefecture. We arranged hydrogeological and groundwater quality data sets in previous studies of Hiroshima University. The phosphorus concentrations were high in anoxic condition. In addition, shallow aquifers around alluvial clay had high concentrations. The phosphorus contents in alluvial sediments of Okayama plain were relatively high around alluvial clay. These results suggest the contribution of phosphorus from alluvial sediment to groundwater.

Keywords: phosphorus, coastal groundwater, hydrogeology, sediment

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Residence Time estimation for the Highly Arsenic Contaminated Groundwater in Sonargaon, Bangladesh

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Large-scale natural arsenic contamination of groundwater has been a serious problem in a number of areas around the world, especially in Asian countries, in many cases having a major impact on potable water.

Throughout a series of our studies in Sonargaon, Nayakaganj, Bangladesh (Mitamura et al., 2008; Itai et al., 2008; Seddique et al., 2008), vertical infiltration of surface water into the shallow aquifer would promote the As contaminated groundwater. In those studies, Mitamura et al. (2008) reported that the highly As contaminated wells are occasionally installed into the finer and micaceous sediment, and that the geological structure of the aquifers is an important control on the formation of As-contaminated groundwater in Bangladesh. Seddique et al. (2008) pointed out that the detrital biotite is a primary source of As, and chemical weathering of this mineral is an essential mechanism forming chemical composition of groundwater including As concentration. Heterogeneous distribution of major chemical component and oxygen and hydorogen isotopic ratios of the groundwaters indicated vertical infiltration of surface groundwater into the shallow sediments (Itai et al., 2008). The three-dimensional groundwater flow model numerically predicted that water recharged from the ground surface beneath the flood plain moves approximately 10 m to 20 m vertically downward, with a gradually increasing horizontal flow, toward the underlying Pleistocene middle mud layer (aquitard) (Nakaya et al., 2010). Groundwater pumped up from tube wells in the Holocene aquifer for daily use is recharged in several areas in the flood plain. The model also predicted that hotspots with the highest As concentrations ($>$ 700 ppb) are formed on the vertical groundwater flow paths during surface water recharge and not on the horizontal flow paths. Therefore, the model supported the view that chemical weathering of detrital minerals in Holocene sediment (shallow aquifer) is an essential mechanism forming chemical composition of groundwater including As concentration.

In this study, to estimate the residence time of As highly contaminated groundwater in Holocene aquifer, we measured the concentrations of CFCs, 3He/4He and As in groundwater samples, including DO, sampled carefully at 20-25 m depth private tube wells in a recharge zone, As hot-spot in September and December, 2010. The apparent residence time is estimated to be from about 30 to 10 years from 3He/4He and from about 43 to 27 years from CFC-113. The As in groundwater ranges from 100 to 1250 ppb. The apparent residence time for high As groundwater ($>$500 ppb) ranges from about 40 to 27 years from CFC-113 in September samples, while it ranges from about 43 to 27 years from CFC-113 and from 28 to 10 years from 3He/4He in December samples. For December samples, higher As indicates shorter residence time. Moreover, As increases in concentration with depth from 100 ppb at 5 m depth to 700 ppb at 10 m depth for groundwater samples from survey wells. Since shorter residence time means shorter path length of groundwater flow from three-dimensional groundwater flow model (Nakaya et al., 2010), at our study site, the results lead to the As mobilization model that As is strongly released during vertical infiltration from surface to about 20 m depth for 10-20 years in As rich Holocene aquifer and As is transported by horizontal flow path without As release.

Keywords: groundwater, arsenic pollution, Bangladesh, residence time

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Study on characteristics of NO3-N concentrations in groundwater of Ryukyu limestone region in southern part of Okinawa

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The study area is located in the southern part of Okinawa Main Island, Japan, where Ryukyu limestone is extensively distributed. We studied the behaviour and characteristics of NO3-N in groundwater in this region by using observation data at 13 springs through long term monitoring

It was found that the NO3-N concentrations at in springs ranged from 6.2 mg/L to 16.6mg/L during 17years in this area. The No3-N concentrations had decreased from the mid-1990s to early 2000s.And The No3-N concentrations not have been decreased or increased since early 2000s. Distribution of NO3-N concentrations show various form according to location and differences of various form are approximately classified into two types (stable type and unstable type). It was considered that NO3-N concentrations were influenced by the rainfall, geological structure and land use of upland fields. The equation between T-N concentrations and NO3-N concentrations could be obtained from observed data. The predicted values of NO3-N concentrations were approximately in agreement with the observed values.

Keywords: NO3-N, groundwater, spring water, Ryukyu limestone

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Quantitative analysis for nitrogen contamination of tea plantation area caused by excess fertilizer

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In this study, it is proposed that nitrate nitrogen concentration of spring and river water is estimated from land use, amount of fertilizer, absorption for plants, and precipitation and then it can be applied for another area. In order to establish an estimation method, spring and river water chemistry, land use for each catchment, amount of fertilizer, precipitation, and flow rate of river were studied at the hilly terrain with tea plantations in Shimizu, Shizuoka city. The nitrate nitrogen concentration estimation method for river and spring water was proposed based on the results.

Estimation method 1

There are three kinds of land use in this area, tea plantation, orange grove and coniferous forest. The measured nitrate nitrogen concentration for spring water at the catchment increased when annual total amount of nitrogen fertilizer was over 20 kg/10a and when the value was less than 20 kg/10a the measured concentration was low. Then the 20 kg/10a was thought to be permissible range for plant absorption. Plant absorption was added for the estimation. Therefore, groundwater nitrate nitrogen concentration for each land use was estimated from each land use area, amount of fertilizer for each land use, absorption for plants and the measured nitrogen concentration for spring water in the catchment. The annual amount of nitrogen fertilizer for tea plantation and orange grove were 54 and 24 kg/10a. The annual absorption for tea and orange were 21.6 and 16 kg/10a. The estimated nitrate nitrogen concentration for tea plantation, orange grove and coniferous forest were 19, 2.8 and 0 mg/l. Nitrate nitrogen concentration at each catchment can be estimated from land use and the estimated nitrogen concentration of groundwater at each land use and in this area, the estimation and concentrations was in good agreement with the measured concentration.

Estimation method 2 : Estimation method 1 + precipitation

Precipitation was not accounted in the estimation 1. When the precipitation was different, the estimation 1 can not be applied for another field. As most of nitrogen fertilizer was ammonium sulfate and it was directly sowed on the ground, then, it was proposed that fertilizing nitrogen was diluted by precipitation on the ground and some water directly flowed on the slope and others infiltrated. The infiltrated nitrogen was absorbed by plants in the ground. Then, estimation 2 was as follows.

Nitrate nitrogen concentration = (amount of nitrogen fertilizer∗infiltration rate of precipitation - absorption by plants)/[(precipitation - evapotranspiration)∗infiltration rate of precipitation]

The nitrate nitrogen concentration estimated by estimation method 2 was in good agreement with the measured concentration. In this area, 13 % nitrogen of the amount of nitrogen fertilizer sowed on the ground directly flowed on the ground and 87 % nitrogen of the amount of nitrogen fertilizer sowed on the ground infiltrated into ground and some nitrogen was absorbed. 11 % of water for infiltrated water was deep groundwater.

Keywords: tea planation, fertilizer, nitrogen contamination

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Characteristics of contamination and attenuation of nitrate in groundwater with different scale of flow system

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For the sustainable use of groundwater resources for the future, it is important to clarify the characteristics of nitrate contamination and natural attenuation (e.g. denitrification) in an aquifer. In recent years, several researchers have suggested that landscape hydrogeology can provide an important framework for understanding nitrate removal capacity at the riparian zones. However, few studies discussed about the relation between groundwater flow condition and nitrate attenuation process on the catchment scales. The objective this study is to confirm the characteristics of nitrate contamination and attenuation in the groundwater with the different scale of flow system. We compared the data on the groundwater flow, nitrate concentration and nitrogen stable isotope ratio (d15N) in groundwater in the three study sites (IK, YD and JK). All these study areas are characterized by the large nitrogen load from agricultural, domestic and industrial activities. The IK (Ikuchijima) aquifer is located in southern Japan with the catchment area of 44ha and topographic gradient of 1/50. The YD (Yellow River Delta) aquifer is located on the lower reaches of the Yellow River, which covers approximately 5200km2 and topographic gradient is approximately 1/1000. The JK (Jakarta) aquifer is located on the metropolitan area of Jakarta that is lower reaches of the Ciliwung River catchment and the topographic gradient is approximately 1/400.

In the all study sites, groundwater in the recharge area is characterized by relatively high concentrations of NO3–N and relatively low d15N. Especially in the IK and YD, NO3–N concentration exceeds 20mgL-1. However, NO3–N concentration decreased and d15N increased along with groundwater flow in all study area. These results suggest that NO3–N attenuation by the processes of dilution and denitrification occurs. Especially in the YD, isotope enrichment ratio is higher than the other two sites (IK & JK). NO3–N attenuation potential is estimated to be YR >JK >IK based on the geological condition, groundwater velocity and isotope enrichment ratio.

Keywords: groundwater, nitrate, contamination, attenuation, different scale of flow system

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AHW026-06 Room:201A Time:May 27 15:30-15:45

Simultaneous use of natural attenuation and permeable reactive barrier in nitrate contaminated groundwater

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Since the implementation of the Law on Promoting Proper Management and Use of Livestock Excreta in 1999, the number of the farmers that do not meet the management criteria is on the decline. However, there is a possibility that many of the animal waste disposal pits that have been either abandoned or refilled according to the law have been the potential contamination source.

In this study, we discussed the possibility of simultaneous use natural attenuation and permeable reactive barrier in nitrate contaminated groundwater. As a result, after 55 days from the startup of the experiment, the nitrate concentration decreased from 151 mg/L (upstream observation wall) to 0 mg/L inside the permeable reactive barrier.

Keywords: groundwater, NO3-, permeable reactive barrier, natural attenuation, denitrification, animal waste

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AHW026-07 Room:201A Time:May 27 15:45-16:00

Evaluation of artificial effect to the regional groundwater flow system in the southern Fossa Magna area

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In order to evaluate the artificial effect to the regional groundwater, the concentration and source of minor and major elements in the groundwater, spring as well as river water were investigated based on the geological and geochemical features in the southern Fossa Magna area. Most elements except vanadium, phosphorus and uranium, which do not give sensitive characteristics in igneous rocks also showed obscure characteristics in groundwater, spring and river water. However, the geological source classification of some major elements in groundwater which reflects the geology was successfully achieved using differences in the distribution area in Fossa Magna area. Thus, it is possible to estimate the excess concentration of some major elements in the groundwater in this study.

Keywords: groundwater, major elements, minor elements, Fossa Magna

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Study on management of groundwater reservoir with example from Ryukyu limestone aquifer in southern part of Okinawa

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The Komesu and Giiza underground dams are first full scale underground dam facilities constructed for irrigation in Japan. A groundwater flow analysis was conducted with three dimensional numerical model (MODFLOW2000) apply for these dam reservoir areas. Through the comparison with calculation and observed data, the cut off wall of dams effectively storage the groundwater in the reservoir areas. This also found the Komesu underground dam can reduce the movement of salt-water into the reservoir areas, salt-water masses remained behind the dam at the time of it is completion.

The observed groundwater level at the reservoir areas were almost reproduced by this model, but there were a few differences between the calculation and observation, response analysis could be carried out to improved the model by inputting various data of geological-structure of Ryukyu limestone and introducing non-darcy flow.

The results of examination make it possible to improve the management of groundwater reservoir in the limestone aquifer area behind the underground dam.

Keywords: underground dam, Ryukyu limestone, numerical simulation, menegement of groundwater

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Nutrient exchange between surface water and subsurface water in ponded shallow reservoir of a suburban river catchment

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This research aims to clarify the nutrient exchange processes within the reservoir in a suburban river with considering of interaction between subsurface water and river water. The vertical distribution of nutrient concentration in the water column and sediment pore water indicates there was large concentration gradient of dissolved nitrogen and phosphorus across the water-sediment interface. NO3–N was dominated in the water column although NH4+-N and PO42–P were dominated in the sediment pore water. The hydraulic gradient between the surface water and pore water in the sediment indicates that this reservoir has advection from the water column to the sediment throughout of a year. As a result, it was confirmed the surface water infiltration in this reservoir. Based on the estimation of nutrient flux by diffusion and advection, diffusive fluxes of NH4+-N and PO42–P was larger than advective fluxes. Totally, it was confirmed that this reservoir worked as a source of on the material transport in the river system. However, diffusive fluxes of NO3–N and NO2–N indicated downward (water column to sediment) as same as advective fluxes, because NO3–N and NO2–N would be attenuated by denitrification near the surface sediment. This result suggests the reservoir works as attenuation zone for nitrogen.

Keywords: Lentic water, Nutrient, Sediment, Diffusion, Advection, Takaya River

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AHW026-10 Room:201A Time:May 27 16:45-17:00

Subsurface flow processes of the soil and bedrock in a small headwater catchment

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The hydrometric and tracer approaches were applied to investigate subsurface water flow processes of the soil and bedrock in a small headwater catchment underlain by sandstone, Karasawasan University Forest, Tokyo University of Agriculture and Technology, Tochigi prefecture, eastern Japan.

During the observation period (June 19, 2010 - December 29, 2010), 862 mm precipitation were observed and the runoff ratio of the monitored spring discharge was 32%, that suggesting a large amount of groundwater infiltrate into the bedrock.

Groundwater level changed in the boreholes drilled into the bedrock with a similar trend of hydrograph at spring. The lag time from rainfall peak to the runoff peak shows a good correlation with that of groundwater level. This suggests that the groundwater flow hydraulically connects with the spring discharge.

End-member mixing analysis was applied to evaluate the runoff components using SiO_2 and HCO_3^- concentrations as tracers. Contribution ratio of the bedrock groundwater to the runoff was estimated to be more than 60% during a secondary runoff peak.

The CFCs concentrations show an average residence time of the spring water to be approximately 20 years.

Keywords: headwater catchment, sandstone, rainfall-runoff process, bedrock groundwater, end-member mixing analysis, CFCs

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Do ion dynamics represent the hydrochemical characteristics in headwater catchments?

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To understand the effect of complexation in transporting major metals, the concentrations of Na, Mg, Ca, Si, and fulvic acid like materials (FAM) were measured in two headwater streams of coniferous and deciduous catchments. The differences of concentration between total elements (T-Na, -Mg, -Ca) and ionic materials (Na+, Mg2+, and Ca2+) were equated with the concentration of non-ionic materials (NIM). The rates of NIM to the total elements in the coniferous and deciduous catchments respectively ranged 0% to 40% and 0% to 70% in stream baseflows and 5% to 60% and 20% to 60% in stormflows. In the stream baseflows, the relationships between NIM and total Si (T-Si) showed the high correlation ($r>0.9$) in both catchments. In contrast, in the stormflows, the relationships between T-Si and FAM showed good correlations ($r>0.8$) in both catchments, implying the organic-inorganic complexation was promoted. However, in the coniferous catchment, the good correlations ($r>0.8$) between NIM and T-Si or FAM were provided mainly at the rising limbs of the hydrograph, contrastive to the good correlations ($r>0.8$) both at the rising and falling limbs of the hydrograph in the deciduous catchment. These things exhibited that #1) in the low flow conditions, the complexation of the major metals with clay minerals could be the main process in transporting NIM in both catchments, #2) throughout the storm events, the complexation of clay minerals and humic substances (organic-inorganic complex) could be promoted in both catchments, #3) only at the rising limb of the storm hydrograph in the coniferous catchment, the complexation of the NIM with the organic-inorganic complex may have been the main process in transporting NIM, however, at the falling limb of the hydrograph, the NIM transport may have resulted from the effect of other materials such as organic acids, likely due to the more active production of organic acids in the soils of the coniferous than in the deciduous catchments, and #4) in the deciduous catchment, the NIM transport in the stormflows could be mainly controlled by the organic-inorganic complex throughout the storm events, on account of the small effect of the organic acids that may have resulted from low production in the soils. These findings emphasize that not only the ion dynamics but also the active complexation of Na, Mg, and Ca in freshwater environments, as well as the effect of differing vegetation on their complexation, should be carefully examined in the headwater hydrology.

Keywords: fulvic acid, organic acid, major metal, fresh water environmt, organic-inorganic interaction

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AHW026-12 Room:201A Time:May 27 17:15-17:30

Nitrogen leaching from two forested watershed in Ibaraki, Japan

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Increased atmospheric nitrogen deposition to forested watersheds will increase the nitrate concentration in stream water. In Japan, high nitrate concentrations in stream water have been observed at some forested areas around the Kanto region, suggesting the occurrence of ”nitrogen saturation”. We observed the concentration and flux of inorganic nitrogen of bulk precipitation, throughfall, soil water, and stream water at two forested catchments with deferent N input, Katura experimental forest (KEF) with low N deposition and Tsukuba experimental forest (TEF) with high N deposition. The amounts of nitrogen deposition by throughfall at KEF and TEF were 7.8 kg ha^{-1} y^{-1} and 22.4 kg ha^{-1} y^{-1}. The inorganic nitrogen flux at 100 cm depth were lower than 0.5 kg ha^{-1} y^{-1} at KEF and higher than 50 kg ha^{-1} y^{-1} at TEF. The nitrogen runoff as stream water were 1.9 kg ha^{-1} y^{-1} at KEF and 11.1 kg ha^{-1} y^{-1} at TEF. In TEF, the nitrogen input is thought to exceed the ecological demand.

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Relationship between gully erosion and soil-layer hardness on grazing pastures

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At present, large-scale grasslands such as public pastures are about 900 spots in Japan. Most of these are located on sloping lands. Therefore, gully erosion has occurred in some grasslands.

In this study, distributions and cross-sections of gully erosion were surveyed in the public pasture in Tochigi prefecture, Japan. Soil hardness of shallow and deep layer were also investigated using the SH type handy dynamic cone penetrometer etc. along gully channels. The cross-sectional profile of the gully channel was compared with the depth of a hard layer that appeared in the soil layer. The results indicated that the maximum depth of the gully cross-section was governed by the hardness characteristic of the soil layer (Fig.1).

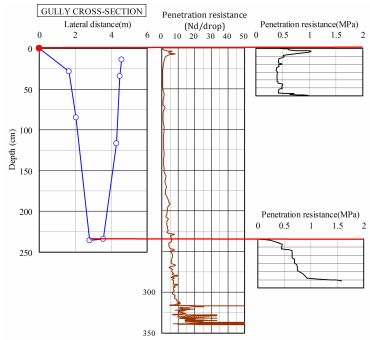

Fig.1 Relationship between gully channel profile and characteristics of penetration resistance

Keywords: Grazing pasture, Soil erosion, Gully erosion, Soil hardness

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Transport of sediment with phosphorus

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Eutrophication is caused under the rich nutrient condition. Nutrient transport by terrestrial water to marine has been reported by so many researchers. Not only artificial water pollution but also the leaching from natural rocks and/or soils affects the eutrophication in the coastal area in various time scales, respectively. However, the source and transport of phosphorus (P) in various watersheds has not been clarified enough. Transporting sediment with high P concentrations has been identified as a major hydrological pathway for sediment associated P delivery to surface waters, and is considered a major threat to water quality. Especially, some researches have not been considered the mineralogical sources and carriers of phosphorus, and hydrological dynamics of phosphorus transport, respectively. So, it is important to determine kinds of minerals including P, and concentrations of P in each mineral. By the study about the characterization of P in the granite distributed area, it is known that P is included in mica minerals and/or iron hydroxide minerals.

This study is aimed at clarifying the relations of P contents and minerals weathering of rocks and sediments from drilling core at four points around Asahi River, Okayama Prefecture. Collected samples were examined the identification of mineral in sediment by the X-rays diffractometry and chemical composition of sediments by the X-ray fluorescence analysis. Furthermore, carbon and nitrogen contents in each collected samples were analyzed.

The constituted particle of the drilling core is comparatively big in particle size rather an upper basin than the lower basin. Quartz, feldspars, hornblende and clay minerals were recognized in all points. Mica minerals, kaolin minerals, chlorite, vermiculite and smectite were confirmed as clay minerals. XRD analyses show a decrease in mica minerals contents and a increase in vermiculite formed in altered sediment. Vermiculite has been formed as altered mineral from mica minerals such as biotite. The phosphorus concentration has negative relation to the potassium content. On the other hand, it was shown that it had equilateral relation to iron and magnesium content. The phosphorus content tends to increase in a part with much vermiculite. It is thought that phosphorus is adsorbed in vermiculite; however we must consider adsorption of phosphorus of the amorphous iron hydroxide. Sediment transport with a high phosphorus concentration has been identified as a major role to total phosphorus supply to the marine. Therefore, it is necessary to determine kinds of minerals including P, and concentrations of P in each mineral in stream sediments.

Keywords: phosphorus, mica mineral, vermiculite

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100 years variation in nutrient discharge reconstructed, using the sediment profile of an artificial lake in west Japan

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Coastal sediments are an important sink for terrestrial derived nutrients. Sediment cores extracted form these environments can provide vertical phosphorus distribution which correlate with historical patterns of phosphorus sedimentation. Coastal lake sediment therefore provides information on phosphorus which can be used to reconstruct the paleoecological and pollution history of the lakes and their catchment basins. And also some climatic changes could also reflect on its recorded.

One 124-cm long core sample was taken by piston core sampler in Kojima Lake during September 2009. Sediment total phosphorus (TP) and total inorganic phosphorus (TIP) were determined by Aspila method. Local precipitation data, population data and paddy field data were also considered in the research.

The reconstruction of phosphorus discharge for last 100 years was conducted. We use the ^{210}Pb activity and ^{137}Cs activity to determine the dating data of the core sample. Sediment TP in sediment showed a slightly decreasing trend with the depth and through obvious peak in the core suggests the eutrophication in Kojima Lake for last century and the peak of nutrient load in around 1970s. As In Sasagase Basin and Kurashiki Basin, there is significant amount of farmland and residences area. And the construction of dike enhances the Nutrient retention in lake sediment. So the impact of intensive human activity and diversity of heavy nutrient discharge form the Rivers leads to abrupt changes of phosphorus in sediment both in organic and inorganic forms. The high P content of sediments in the eutrophic Kojima Lake is hypothesized to result from high P content of sediment in the inflow.

In addition, sediment TP and TIP contents in sediment indicated yearly variation. Relationship between TP content and factors were determined through liner correlation ship analysis. The variations of TP content were not clearly affected by the annual precipitation(1900-2000),population change(1920-2000)and paddy field area change(1949-2006) whereas it was related to the annual number of the event with daily rainfall over 100mm. Intensive extreme precipitation events results most of the points which sediment TP content is over 1.000mg/g . In 1976, there was 3 times of over 100mm daily precipitation leads to a high TP content recorded in sediment core at 1.161mg/g. The 2 times big precipitation year in 2005 also leads to a high TP record (1.155mg/g).The two big precipitation in year 1971 and 1972 related to a TP content of 1.023mg/g . Same trend also show on sediment TIP result which consist of most part of sediment TP content. This may because of the regional high rainfall carries more nutrients of the two basins farmland into the lake and the storm may have a direct effect of erosion. And high rainfall also brought more suspending sediment property and storm water runoff. An increase in the number of torrential rainfall events are hypothesized to increased phosphorus transported to ocean.

The climate change by global warming may expected to appear in the alternation in rainfall patterns and an increase in the occurrence of extreme climate change events, which may lead to a change in the frequency and intensity of storms. This influence has already been confirmed in Japan from daily precipitation including typhoon .Accordingly; it would be further enhanced over Japan due to the increase in atmospheric moisture availability. If precipitation changes more intensive and more sever, it may lead to a result that high soil erosion and high phosphorus river discharge. The phosphorus resources in sediment may also increase due to increase of extreme precipitation event. It would be a potential release pool of phosphorus to the environment again because the most part of TP in sediment is consists of inorganic forms. Consequently, climate change may enhance phosphorus discharge to open-sea.

Keywords: sediment, phosphorus, precipitation, extreme rainfall event