学位論文の要約

学位論文題名

Sediment-water interactions of degrading floodplain waterbodies in the Ishikari River

（石狩川の氾濫原水域における堆積土砂と水の相互作用）

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学位：博士（環境科学）

Floodplain waterbodies (FWBs) substantially have degraded worldwide due to the expansion of agricultural and urban areas. The human activities contribute the external loading of nutrient pollution into FWBs and have become one of the important factors causing the decline of biodiversity. However, knowledge gap exists concerning the sediment-water interactions in waterbodies in degrading floodplain despite their importance of various ecosystem services. Therefore, the aim of this dissertation was to understand sediment properties and its effects on water quality in FWBs in the Ishikari floodplain, Hokkaido, Northern Japan (Chapter 1).

In Chapter 2, the spatial and temporal changes in sediment properties in relation to their controlling factors of 29 FWBs along the Ishikari River where were investigated. Sediment data was measured twice (around 2005 and 2019) to study the temporal changes in sediment properties. The controlling factors of sediment properties including catchment characteristics and morphometry, were examined. The results showed that the temporal changes in sediment properties over the decades were largely driven by morphometry while land use in the catchment relatively played a minor role in those changes. The rate of change in OM positively correlated with the rate of changes in TN and TP. Additionally, the rate of change in OM differed among FWBs depending on their morphometry. The small and shallow FWBs provided suitable habitat for macrophyte that led to OM deposits, resulting in an increase in OM and OM to TN ratio while TP was decreased. The consequences of these changes are important for internal source management.

In Chapter 3, the association between sediment and water of FWBs, and driving mechanisms were investigated. Water quality (summer and autumn) and sediment properties data were collected twice around 2005 (MLIT data set) and 2019 (2019 data set) to examine the relationship between sediment and water pre and post temporal change in sediment properties in different seasons. Nine FWBs were selected for monitoring and investigating the main factors that dictate water quality and in association with sediment it changed across

the season. The results showed that mean Chl-a decreased over the decades possibly from the decrease of TP in sediment. Moreover, sediment properties correlated with Chl-a in both data sets, through the correlated properties were differed between years and seasons. MLIT data set, TN_{sed} correlated with Chl-a in both seasons (Chl_{sum} and Chl_{aut}), while OM correlated with Chl_{sum} only. For 2019 data set, there was no correlation appeared in summer but TP_{sed} correlated with Chl_{aut} in autumn. This suggests that sediment associated with water quality even though sediment properties changes over the decade. Moreover, seasonality dictates sediment interaction with water quality that can be confirmed by monitoring results. The fluctuation of Temp and DO caused limiting nutrients which differed between seasons due to the contribution on (de)nitrification and P (im)mobilization. High denitrification potential in summer caused N to become limiting nutrient, while high P immobilization potential in autumn caused P to become limiting nutrients. Therefore, relationship between sediment and Chl-a appeared due to the availability of limiting nutrients that can be supplied by sediment in each season. Importantly, PCA results showed that Chl-a was stronger related with TP than TN and this suggests that P could be more limiting nutrients than N. Controlling of P needs to be considered for FWBs sustainable management.

In Chapter 4, the influence of OM on P adsorption efficiency in FWBs sediment was investigated according to the major findings from the Chapter 2 that found the positive relationship between change rate of OM and TP. This suggests that OM can influence on P adsorption in sediment. Six sediment samples that contain the high variation of OM content were selected to test P adsorption efficiency by Langmuir adsorption isotherm. Nevertheless, the results from adsorption experiment were not fully supported because OM% level was not consistent with adsorption efficiency in the two highest OM level (OM5 and OM6), while the lower OM% sample (OM1 to OM4) showed the consistency between OM% and adsorption efficiency. Possibly, the saturation of OM in sediment that contained very high OM% level and OM competing with P at the sorption site that caused lower adsorption efficiency. On the other hand, it accumulated organic P from the high change rate of OM.

Overall, the major findings from this dissertation showed that internal nutrients cycle could become as important as other factors. Internal nutrients cycle influences water quality and controls phytoplankton bloom (Chapter 3). Moreover, the main factors that contribute to accumulation of nutrients in sediment of FWB system were largely driven by morphometry, especially in small and shallow FWBs (Chapter 2). The continuous deposition of OM from macrophyte causes the changes in sediment properties over the decades. Importantly, the rate of change in OM positively correlated with the change rate of TP (Chapter 2). In addition, P adsorption experiment also partially supported that OM could contribute to P accumulation in sediment (by physicochemical adsorption in non-OM saturated sediment and organic P accumulation in OM saturated sediment) (Chapter 4). However, sediment TP decreased over the decades while OM increased which was controversial on the positive relationship between the rate of change in OM and TP. This suggested that the potential of TP accumulation was weaker than removal. Therefore, the increase of OM in sediment played an important role in retaining or increasing P in sediment that delayed the recovery of water quality over the decades by continuous supplying P from sediment to water column. The availability of TP in sediment could control Chl-a concentration depending on biogeochemical processes in each season (Chapter 3). This could be the reason that relationship between TP_{sed} and Chl_{aut} appeared in 2019 data due to the decrease of TP over the decades, might cause P to become more limiting nutrient in the present (Chapter 3). Consequently, OM reduction can reduce the accumulation of nutrients and will be helpful for internal source management and FWBs restoration.

This study, however, still has limited perspective on the other roles of FWBs, for example, as a sink of C for ecosystems. It is widely known that wetlands play a vital role in C sequestration. The balance between reduction and accumulation of OM should be considered in relation to C emission and water quality. Consequently, OM level should be controlled under appropriate range, especially for the sediments that contain greater than 20% OM because this has lower adsorption efficiency than expected (Chapter 4). Therefore, reducing OM in sediment to lower than 20% could reduce the internal source of nutrients, leading to FWBs being also able to act as an effective sink of C. Most importantly, however, the choice of management policy should be made based on the needs of local people balanced with socioeconomic constrains.