別紙４－１（課程博士（英文））

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Abstract (Doctor)

Title of Thesis	Bioavailable phosphorus in runoff suspended sediment in rivers flowing through contrasting land uses

Approx. 800 words

Eutrophication in aquatic ecosystems is intimately linked with the increase in the concentrations of nitrogen (N), phosphorus (P), and carbon (C); though P is the main limiting nutrient for primary production in freshwaters. While considerable information in recent years has pointed to the importance of considering bioavailability in water quality restoration programs, established target P load reduction guidelines are still based on total phosphorus (TP). River water P is usually separated into particulate P (PP) and dissolved P (DP), and the forms of P that support algal growth are termed bioavailable. Dissolved P is mostly available for algal uptake, while PP which consists of P associated with sediment and organic material eroded during runoff, contributes a variable but long-term legacy source of bioavailable PP. Therefore, none of the commonly measured P fractions are accurate measures of bioavailable phosphorus (BAP). In general, PP is much more variable than dissolved P, and storm events are extremely important for PP dynamics because large portions of river PP loads can be transported attached to sediment and organic matter during only a few major high flow events. The fraction of PP that is potentially bioavailable (PBAP), may increase if P is bound to clay minerals and degradable organic matter in suspended sediments (SS). It is still unclear how particulate organic carbon (POC) and particulate organic nitrogen (PON), which are important components of particulate organic matter in rivers influence the potential availability of PBAP. Furthermore, much is less known about the relationship between PBAP, and POC and PON stoichiometry despite the spike in SS during high flow events.

The wide variability in PBAP suggests that both river-flow characteristics and land use patterns in the river catchment may be important in addition to POC and PON concentration. Since PP is usually transported to rivers bound to SS, the quantity and type of sediment in runoff will influence the concentration of BAP by varying the relative amounts of DP and PP entering the river. It is poorly understood how different land-use types influence PBAP in river runoff, and few studies have estimated the amount PBAP during low flow conditions. Besides, there is uncertainty regarding the relationship between PBAP and particulate organic matter constituents under different hydrological conditions in urban and agricultural rivers. In this thesis, we investigated the variation in SS, DP, PP, PBAP, BAP, POC and PON in rivers draining through contrasting land uses.

The objectives of the study were: (i) to estimate PBAP in runoff from agricultural and urban rivers in order to assess whether the PBAP content will be markedly different in the rivers;
(ii) to determine the BAP proportion in river runoff, and to clarify its relationship with TP in the rivers; and iii) to examine the relationship between PBAP, POC and PON, and to relate this to the elemental composition of SS from the rivers.

We used a new rapid procedure that involves ultrasonic treatment to extract PBAP from SS samples. A strong statistical relationship was observed between PBAP and SS in the river classed as agricultural ($r^2 = 0.69$), in contrast to the urban one where no correlation was observed, implying that the particle size and composition of SS in both rivers was markedly different. PP was the dominant fraction of TP at high flow and between 6 to 79% of PP was estimated to be bioavailable. A strong correlation was observed between BAP and TP in the urban river ($r^2 = 0.84$), indicating that merely using TP as a proxy for BAP is questionable as this overestimates the eutrophication potential of some P sources. The BAP and TP relationship in the agricultural river revealed that elevated PP concentration at high flow may not translate into higher BAP in the runoff, implying that quantification of BAP in SS is critical for effective watershed management programs. Besides, elevated POC and PON concentrations in both rivers were associated with low flow. POC and PON concentrations in both rivers declined at high flow presumably due to the mixing effects of water from different sources in the watershed which could have altered the particulate organic matter composition. A significant correlation existed between POC and SS in both rivers, and POC to PON ratios of SS from the rivers point to the change in the particulate organic matter at varying flow conditions. PBAP exhibited a positive relationship with POC and PON concentration in both rivers possibly an indication that particulate organic matter contributes to BAP in the rivers. Iron (Fe) was the dominant element measured in SS from both rivers, and the PBAP concentration in the agricultural river was positively correlated with the Fe to POC ratio unlike in the urban river.

Overall, this study shows that it is important to quantify BAP in SS since TP includes complex P forms that may not be available to algae. Furthermore, the origin of SS under changing flows could be different, with subsurface sediment pathways linked to low flow and contribution from surface runoff associated with rain events, and particulate organic matter constituents and sediment elemental content could greatly impact BAP in river runoff.