Damming effect on carbon processing in a subtropical valley-type reservoir in the upper Mekong Basin

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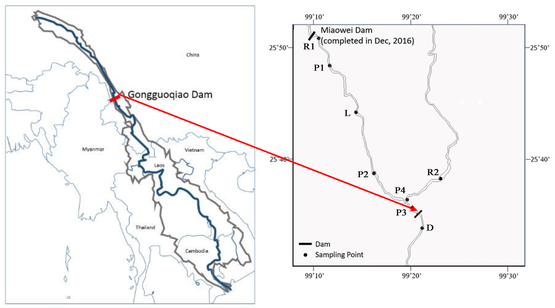
Introduction

- Damming rivers has been identified as one of the most intense artificial perturbations on carbon transportation along the river continuum[1-2].
- Examining the carbon sequestration and transformation in the reservoir can help understand the sink/source effect of impoundments and quantify the artificial interference on carbon transportation along the river continuum.
- Impoundments can effectively sequester more carbon in the sediments [2] as well as mineralize the incoming organic carbon and release the carbon back to the atmosphere[3]. Besides, longer water retention time (WRT) allow more time for decomposition of incoming DOC[3].
- Even though the carbon fluxes have been monitored for large scale, the carbon transformation and sequestration in the mountainous hydroelectric reservoirs, which are generally located in the deep valley at the upper basin where exploitable hydropower concentrates, are rarely examined.

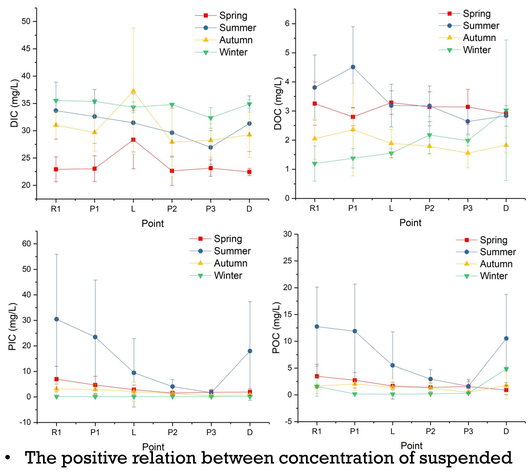


Methods

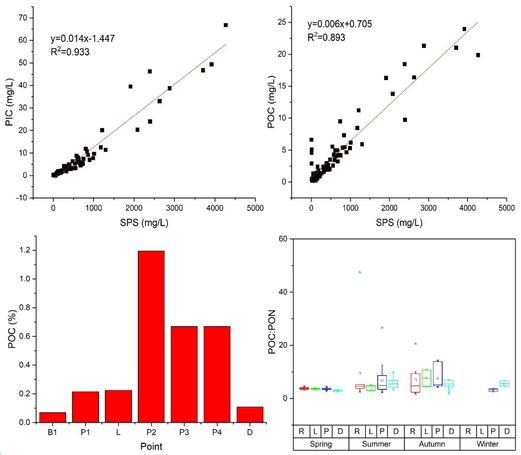
- The carbon flux was monitored along the Gongguoqiao Reservoir (GGQ) in the upper Mekong River Basin (Lancang River) in 2016, including points at riverine inlets (R), pelagic area (P), littoral area (L) and the downstream river channel (D).
- The oligotrophic reservoir with an average water retention time of 1.4 days is prone to South Asian monsoon climate with highest temperature and rainfall occur in summer.
- The water samples were collected twice a month from the top water for monitoring of biogeochemical properties (DO, Cond, pH, Talk, SPS) and analysis of concentrations of dissolved inorganic carbon (DIC, titration method), DOC, particulate inorganic carbon (PIC) and particulate organic carbon (POC, TOC analyzer).

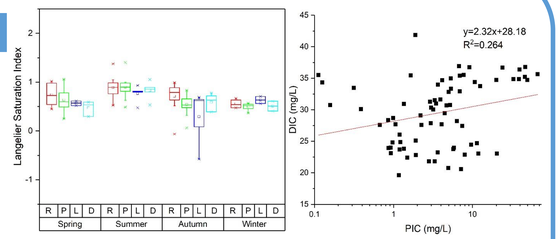
Results and discussion

- The concentrations of carbon decreased much more significantly from the riverine inlet to the reservoir outlet during the warm rainy season with higher water and sediment discharge than in the cool dry season, implying intense carbon sequestration within the reservoir.

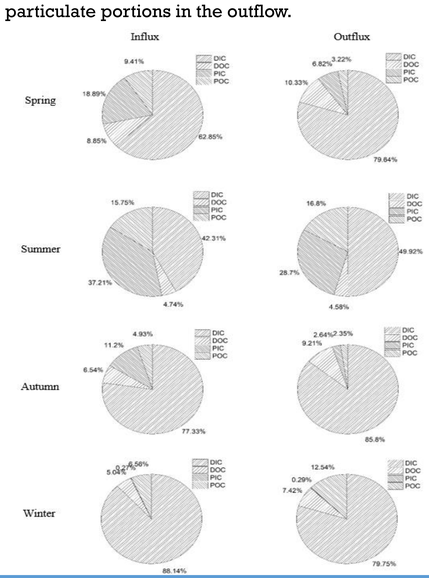


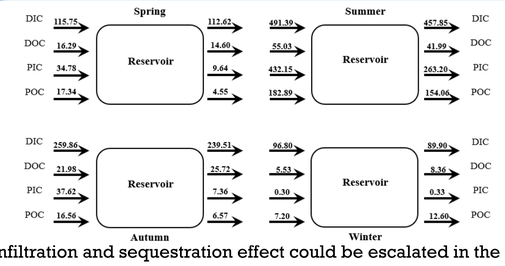
- The positive relation between concentration of suspended sediment (SPS) and particulate carbon (PIC and POC) illustrated that the most of the particulate carbon settle down with fine sediments in the reservoir center due to heavy silting in the rainy season.
- The refractory allochthonous POC buried within the reservoir cannot be decomposed and fuel up carbon evasions from water surface due to short WRT.





- The positive Langelier Saturation Index [5] indicates that the reservoir water was always oversaturated with calcium carbonate under an alkaline environment (pH>8.2).
- DIC tended to precipitate as PIC, which possibly provide additional carbon burial within the reservoir, especially in the dry season when DIC concentration increased.
- Though damming was once considered to help decomposition of DOC due to extended WRT, most of the incoming DOC was released in the outflow during the rainy season for generation of hydropower.
- The reservoir became a net DOC source to the downstream in the dry season when water was cleaner, although shortage of dissolved nutrients might limit the photosynthesis of phytoplankton (Chl a $\leq 2\mu g/L$) in this oligotrophic reservoir.
- Dams are filtering the carbon flow from the headwaters. The differentiated sequestration can increase the proportion of dissolved carbon while reduce the particulate portions in the outflow.





- The infiltration and sequestration effect could be escalated in the cascading reservoir system. The reservoirs at downstream may face higher risk of eutrophication as the effect could be also applied to other nutrients.
- On average, around 20% of the incoming carbon was sequestered in the reservoir. Sedimentation and precipitation of DIC can be important ways of carbon sequestration and transformation caused by dams in the mountainous area.

Summary

- The oligotrophic reservoirs in the mountainous area could be a potential carbon sink as the dams can effectively sequester the carbon flow from upstream catchments.
- With the effect of monsoon climate and alkaline environment, most of the carbon sequestration occur in the rainy season via sedimentation of particulate carbon and precipitation of calcium carbonates while most of incoming DOC was released to the downstream.
- Cascading dams can effectively reduce and filter the carbon flow. Enrichment of dissolved nutrients put higher risk of eutrophication to the downstream reservoirs.

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References

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