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ORIGINAL ARTICLE

CO_2 emission and organic carbon burial in the Xinanjiang Reservoir

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Abstract In order to understand the effect of river impoundment on carbon dynamics, a large reservoir in a subtropical area, the Xinanjiang Reservoir, was investigated in detail. CO_2 emissions from the water–air interface was studied, as was organic carbon burial in sediment. The results show a significant seasonal difference in CO_2 emissions. River impoundment led to the enhancement of aquatic photosynthesis, generating large amounts of authigenic organic carbon that was then buried in sediment.

Keywords The Xinanjiang Reservoir · Carbon emission · Sediment · Carbon retention

1 Introduction

Carbon emission from artificial reservoirs has become a hot topic in global climate change research (Giles 2006; Barros et al. 2011). However, for a comprehensive understanding of the carbon source or sink effect of reservoirs, it is necessary to quantify not only carbon emissions, but also the flux of carbon accumulating in sediment. In addition, as the riverine ecosystem transforms to a lacustrine ecosystem, CO_2 absorption due to aquatic photosynthesis should be considered. Little current research includes an integrated evaluation of the carbon effects in reservoirs. This has led to disagreement on how to treat the carbon source or sink effect of reservoirs (McCully 2004; Steinhurst et al. 2012). In this study, a large subtropical reservoir—the Xinanjiang Reservoir—was investigated. Carbon content and isotopic composition in surface water and sediment were determined. The main objective was to clarify the role and mechanism of carbon retention in large reservoirs.

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2 Sampling and analytic methods

The Xinanjiang Reservoir (Fig. 1), in Chun'an County, Zhejiang Province, China, was constructed in 1959. It has a surface area of 567 km^2, and a total volume of 220×10^8 m^3.The climate is typically subtropical monsoon. In terms of lithology, the drainage basin is mainly composed of granite, phyllite, and slate, with sparse limestone and red sandstone.

Surface sediments along the Xinanjiang River were sampled with a small crab bucket in May 2012 (Fig. 1). From August 2013 to June 2014, surface water was sampled along the same route as sediment sampling, with a bimonthly sampling interval. In-situ parameters were determined using an YSI-6600v2 m during the sampling process. pCO_2 was measured with a Contros system. Samples were frozen in the field and taken back to the laboratory for concentration and isotopic composition analyses.

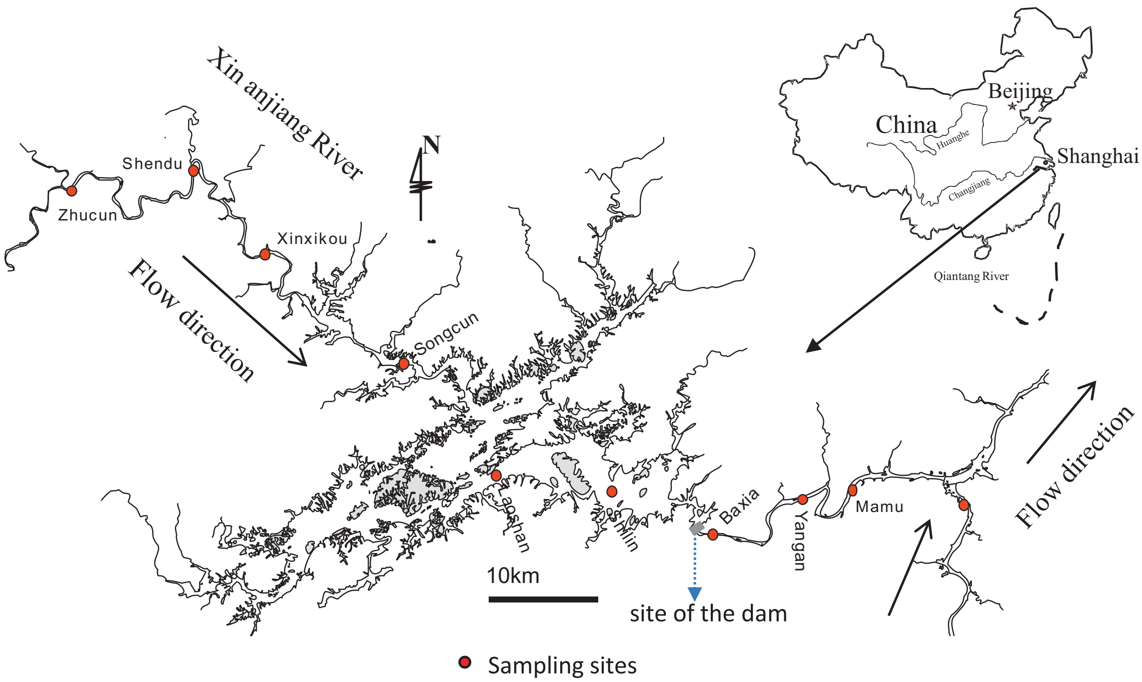

Fig. 1 Location of the Xinanjiang Reservoir and sampling sites

3 Results and discussion

3.1 Surface water of the river-reservoir system

In general, hydrodynamic forces in the reservoir will be weakened after impounding, and water turbidity consequently will show a decreasing trend. In the river reach of the Xinanjiang Reservoir, water turbidity had a significant seasonal variation, but decreased rapidly when the river flowed into the central reservoir (Fig. 2a), enhancing aquatic photosynthesis. As a result, dissolved CO_2 in surface water was absorbed in warm seasons, with pCO_2 becoming lower than atmospheric levels (ca. 390 ppm) (Fig. 2b). This process also influenced dissolved inorganic carbon (DIC) concentrations, which significantly decreased from upstream to reservoir center. Consequently, δ^{13}C-DIC gradually became more positive (Fig. 2c, d). Due to deep water discharge from the hydropower dam, tailwater was

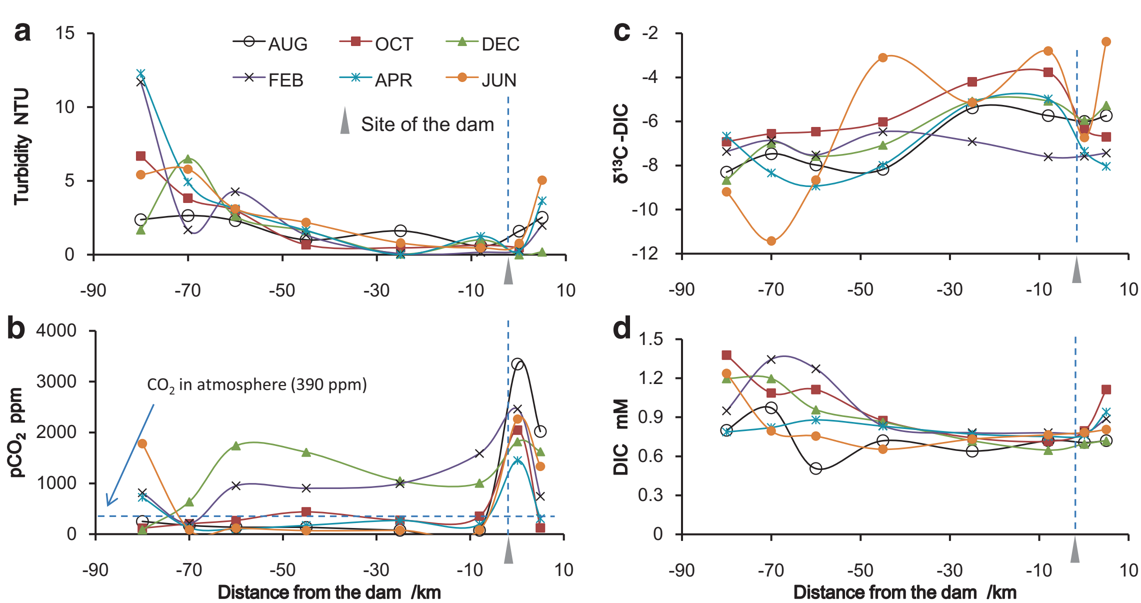

Fig. 2 Turbidity, *p*CO2, DIC concentration and its isotopic compositions in surface water along the Xinanjiang Reservoir

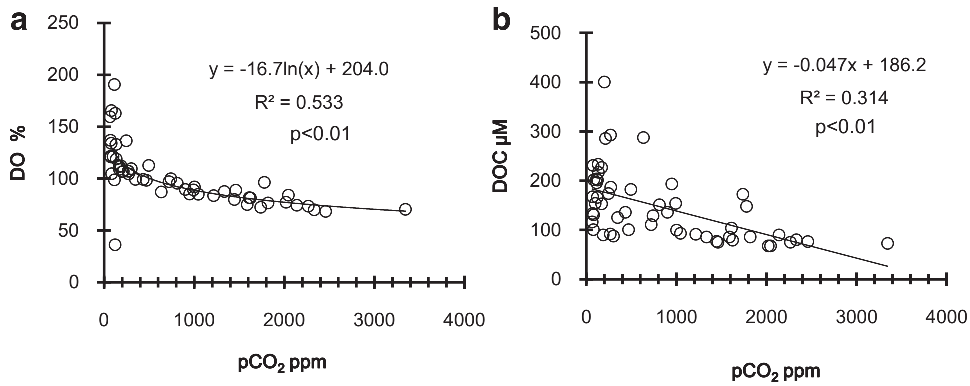

Fig. 3 Correlation analysis among DO, pCO2, and DOC concentration in surface water

quite high in pCO_2 and had more negative δ^{13}C-DIC throughout the year (Fig. 2b, c).

The good relationship between pCO_2 and dissolved oxygen (DO) saturation revealed that pCO_2 in surface water was mainly controlled by the shift between photosynthesis and respiration (Fig. 3a). In the cold season, pCO_2 in the reservoir surface was notably higher than atmospheric levels, indicating a release of CO_2. pCO_2 showed a negative relationship with DOC, revealing that the decomposition of DOC is the major carbon source for CO_2 emissions (Fig. 3b).

3.2 Sediments along the river course

Information about major biogeochemical processes of carbon in water can be recorded in sediment. Particulate organic carbon (POC) and nitrogen (PON) were lower in upstream sediment, but showed a rapid increase toward the reservoir center. This is in accord with increased aquatic photosynthesis. Impacted by the dam, the sediment downstream was quite low in POC and PON (Fig. 4).

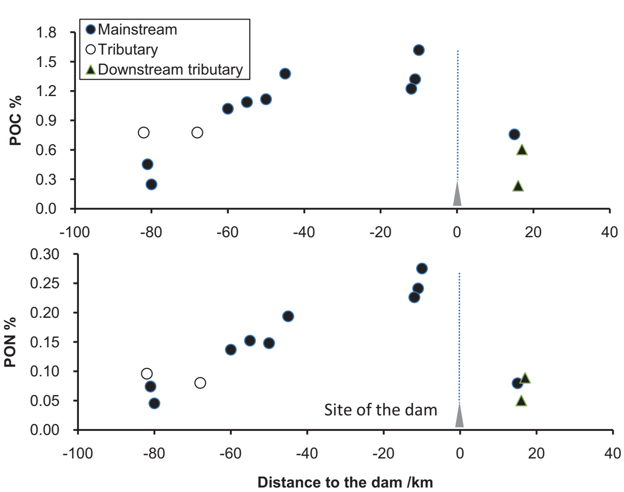

Fig. 4 POC, and PON content in surface sediments along the Xinanjiang Reservoir

C/N-δ^{13}C-OC end-member analysis showed that OC in upstream tributary sediment was mainly from soil in the drainage basin, while OC in the reservoir surface sediment was mainly from phytoplankton. This suggests that after river impounding, aquatic photosynthesis increased sharply in the Xinanjiang Reservoir, fixing a large amount of inorganic carbon, and indicating a potential carbon sink. In our other research, the average OC burial rate in this reservoir was estimated as $43.4\ g \cdot m^{-2} \cdot yr^{-1}$ (unpublished data). For a conservative estimate, 70% of the water area was regarded as valid sedimentation area. Then, the total OC burial flux should be 1.76×10^{10} gC/a. Taking the CO_2 emission flux (1.46×10^{10} gC/a, Wang et al. 2015) into account, the net OC retention of the Xinanjiang Reservoir should be 0.3×10^{10} gC/a, suggesting an important carbon sink.

4 Conclusions

Controlled by the decomposition of organic matter from the drainage basin and authigenic OC in the reservoir, as well as C-absorbing photosynthesis in the reservoir, the Xinanjiang Reservoir showed a seasonal CO_2 emission pattern. In addition, river impoundment favors the enhancement of phytoplankton biomass, which supports the theory of a carbon sink in reservoir sediment.

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