



Effect of long-term phosphorus addition on the quantity and quality of dissolved organic carbon in a freshwater wetland of Northeast China



Rong Mao^{a,b,*}, Si-Yue Li^b, Xin-Hou Zhang^a, Xian-Wei Wang^a, Chang-Chun Song^{a,*}

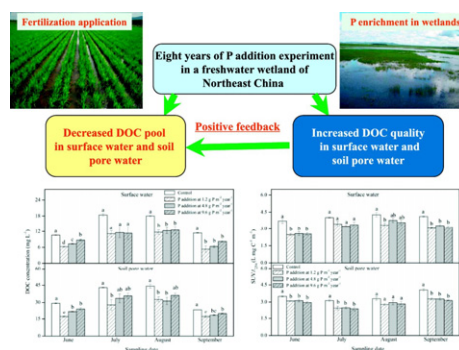
^a Key Laboratory of Wetland Ecology and Environment, Northeast Institute of Geography and Agroecology, Chinese Academy of Sciences, Changchun 130102, China

^b Chongqing Institute of Green and Intelligent Technology, Chinese Academy of Sciences, Chongqing 400714, China

HIGHLIGHTS

- Effect of P enrichment on quantity and quality of DOC remains unclear.
- Eight years of P addition decreased DOC concentration in waters.
- Long-term P addition decreased SUVA₂₅₄ and C:C ratio, but increased E4:E6 ratio.
- Long-term P addition increased the quality of DOC in N-limited wetlands.
- Increased DOC quality after P enrichment would further cause DOC loss from waters.

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:

Received 9 November 2016

Received in revised form 5 February 2017

Accepted 9 February 2017

Available online 16 February 2017

Editor: D. Barcelo

Keywords:

Chemical composition

Eutrophication

Fertilization

Global change

Optical properties

Temperate wetland

ABSTRACT

Understanding how P enrichment alters the quantity and quality of dissolved organic carbon (DOC) is important, because of their role in regulating the C cycle. Here, we established a four-level P addition experiment (0, 1.2, 4.8, and 9.6 g P m⁻² year⁻¹) in a N-limited freshwater wetland in the Sanjiang Plain, Northeast China. The aim of this study was to examine the effects of eight years of P addition on DOC concentration, SUVA₂₅₄ (Abs²⁵⁴/DOC concentration, indicating the aromaticity of DOC), C:C ratio (Abs⁴⁰⁰/DOC concentration, indicating the proportion of colored humic substances in DOC), and E4:E6 ratio (Abs⁴⁶⁵/Abs⁶⁶⁵, indicating the molecular size of humic substances) in surface water and soil pore water (0–15 cm depth) during the growing season (June through September). Our results showed similar changing trends in concentration and optical properties of DOC following eight years of P addition in the both surface water and soil pore water across the sampling dates. Generally, P addition decreased DOC concentration, SUVA₂₅₄, and C:C ratio, and increased E4:E6 ratio, irrespective of P addition levels. These altered optical properties of DOC indicated that P addition decreased the molecular weight and aromaticity of DOC, and thus increased the quality of DOC. These results suggest P enrichment substantially reduces the quantity of DOC in N-limited temperate freshwater wetlands, and imply that increased DOC quality following P addition can further provide a positive feedback to decreased DOC pool.

© 2017 Elsevier B.V. All rights reserved.

* Corresponding authors at: Northeast Institute of Geography and Agroecology, Chinese Academy of Sciences, 4888 Shengbei Road, Changchun, China.

E-mail addresses: maorong@cigit.ac.cn (R. Mao), songcc@neigae.ac.cn (C.-C. Song).

1. Introduction

Dissolved organic carbon (DOC) is a complex mixture of soluble organic compounds that have a wide range of biogeochemical reactivity,

and represents an substantial constituent of the organic carbon (C) pool in the terrestrial and aquatic ecosystems (McDowell, 2003; Kellerman et al., 2014; Williams et al., 2016). In these ecosystems, DOC acts as an important energy source for microbial growth, and thus plays a key role in regulating the C and nutrient cycles, and water quality (Zsolnay, 2003). Meanwhile, DOC serves as a key connection between terrestrial, inland water, and oceanic C cycle due to its transport from riverine upstream to downstream oceans (Battin et al., 2008; Williams et al., 2016). Therefore, the quantity and quality of DOC are tightly linked to biogeochemical cycles from regional to global scales.

Over the past century, anthropogenic activities such as fertilizer application, land use change, and sewage have drastically altered global phosphorus (P) cycle, leading to widespread P enrichment of terrestrial and aquatic ecosystems (Filippelli, 2008). Previous studies have found that increased P availability enhanced plant productivity (Rejmánková, 2001; Mao et al., 2015), increased soil microbial biomass and activity (Liu et al., 2014), and accelerated organic matter decomposition (Debusk and Reddy, 2005; Clivot et al., 2014). Since DOC generally originates from plant litter, soil humus, microbial biomass, and root exudation (Kalbitz et al., 2000; Moore, 2003), P enrichment has been observed to substantially influence the quantity of DOC (McLaughlin et al., 2000; Song et al., 2011; Pinsonneault et al., 2016a). However, these experimental results are highly variable probably due to the differences in the nutrient availability, hydrological regime, organic matter quality, and duration of the experimental treatments. As anthropogenic activities are intensified in response to escalating human population growth, P enrichment will understandably become more widespread (Filippelli, 2008; Williams et al., 2016). Clarifying the effect of P enrichment on DOC quantity from various ecosystem types is needed given the critical roles of DOC in regulating the biogeochemical cycles.

Dissolved organic C is a heterogeneous pool of different organic compounds with varying biodegradability, and thus DOC quality is primarily controlled by its chemical composition (Kalbitz et al., 2003). In general, different fractions of DOC have intrinsic spectroscopic properties (Kalbitz et al., 2003; Weishaar et al., 2003). Consequently, a wide range of absorbances is used to indicate the chemical characteristics of DOC (Weishaar et al., 2003; Wallage et al., 2006; Fong and Mohamed, 2007). For example, specific UV absorbance at 254 nm ($SUVA_{254}$) is a useful parameter for estimating the aromaticity of DOC (Weishaar et al., 2003); the ratio of the absorbance at 400 nm to DOC concentration (C:C ratio) can indicate the proportion of colored humic substances to uncolored non-humic substances in DOC (Wallage et al., 2006); and the ratio of the absorbance at 465 nm to that at 665 nm (E4:E6 ratio) is related to the molecular size of humic substances in the DOC, and has been suggested as an index of the proportion of fulvic acid to humic acid (Thurman, 1985; Fong and Mohamed, 2007). Phosphorus enrichment is believed to change DOC optical properties by altering the chemical composition of plant-derived organic matter (Mao et al., 2015; Pinsonneault et al., 2016b) and microbial activity (Liu et al., 2014; Pinsonneault et al., 2016a). Unfortunately, little information is available on the effect of P enrichment on optical characteristics of DOC in terrestrial and aquatic ecosystems.

In order to understand how P enrichment affects the quantity and quality of DOC, we established a long-term multi-level P addition experiment (initiated since 2007) in a nitrogen (N)-limited freshwater wetland of northeastern China. This P addition experiment consisted of four levels of P addition treatments, 0 P added (CK), 1.2 (P1), 4.8 (P2), and 9.6 g P m⁻² year⁻¹ (P3). Previous studies have found that six years of P addition stimulated plant growth and increased plant N and P concentrations (Mao et al., 2015, 2016). Here, we investigated the changes in DOC concentration, $SUVA_{254}$, C:C ratio, and E4:E6 ratio in surface water and soil pore water (0–15 cm depth) following eight years of P addition. We tested the following hypotheses: (1) long-term P addition would increase DOC concentration in the surface water and soil pore water due to the enhanced plant biomass (Mao et al., 2015); and (2) long-term P addition would change the optical

characteristics of DOC because of altered plant nutrient concentrations (Mao et al., 2015, 2016).

2. Materials and methods

2.1. Study site and experiment design

This study was performed in a herbaceous-dominated freshwater marsh at the Sanjiang Mire Wetland Experimental Station (47°35'N, 133°31'E; 56 m above sea level) located in the center of the Sanjiang Plain, Northeast China. The Sanjiang Plain includes the largest natural freshwater wetlands in China, and *D. angustifolia*-dominated wetland is the main wetland type in this region (Zhao, 1999). Mean annual temperature and precipitation of the study site are 2.5 °C and 566 mm, respectively. The soil is a marsh soil according to the Soil Classification of China, which corresponds to Fluvisols in the FAO Soil Classification. Soil organic C concentration, total N concentration, total P concentration, and pH (with soil:water ratio 1:5) in the 0–10 cm depth are 167.0 mg g⁻¹, 6.8 mg g⁻¹, 1.5 mg g⁻¹, and 5.33, respectively (Song et al., 2011). The plant community was dominated by *D. angustifolia* and *Glyceria spiculosa*, together accounting for >90% of the total above-ground biomass. Other species include *Humulus japonicas*, *Equisetum arvense*, *Lycopus lucidus*, *Hypericum kouytchense*, and *Stachys baicalensis*. This freshwater wetland is regularly flooded from May to October. In this wetland, plant growth and microbial activity are generally limited by N availability (Song et al., 2011; Mao et al., 2015). In the recent decades, wetland ecosystems have been experienced increasingly nutrient loadings via atmospheric deposition and surface runoff mainly due to the fertilizer application in the adjacent agricultural lands (Mao et al., 2015). Annual N and P inputs are estimated to about 1.5 g N m⁻² and 0.4 g P m⁻², respectively.

In order to simulate future P enrichment in this N-limited wetland, we experimentally increased the annual P inputs by factors of 3, 12, and 24. Thus, the experiment consisted of four P addition levels (CK, 0 g P m⁻² year⁻¹; P1, 1.2 g P m⁻² year⁻¹; P2, 4.8 g P m⁻² year⁻¹; and P3, 9.6 g P m⁻² year⁻¹), and started in 2007. This fertilization experiment included twelve 1 m × 1 m plots, and each P addition level replicated three times in a random design. Each plot was separated by a 1-m-wide buffer strips, and was fenced with stainless steel frames (100 cm × 100 cm × 50 cm, 30 cm in soil depth) to prevent the lateral loss of P fertilizer. Board walks were installed for minimizing site disturbance during sampling. Each year, P was added 10 times from May to September as NaH₂PO₄ solution, and the CK plots received the same amount of distilled water.

2.2. Water sampling and analysis

From June to September in 2014, surface water was collected monthly in plastic bottles, and soil pore water at 0–15 cm depth was collected monthly by sippers (Höll et al., 2009). Meanwhile, surface water depth in the plots was measured using a stainless steel rule (50 cm length). In each plot, about 300 mL of water was collected in brown bottles to prevent photodegradation, transported to the laboratory in a cool box, and filtered within 8 h through 0.45 μm membrane filters. After filtration, water samples were split into two parts: (1) 80 mL was stored at -18 °C prior to measurement of DOC concentration, and (2) 80 mL was immediately used to determine the specific UV absorbance. For all water samples, DOC concentration was measured using a total organic carbon analyzer (TOC-5000, Shimadzu, Japan), and the absorbance values at 254, 400, 465, and 665 nm were measured on a UV-7504 spectrophotometer (Shanghai Xinmao Instrument, China) using quartz cells with 1 cm path length. For each water sample, $SUVA_{254}$ was calculated as the absorbance at 254 nm divided by the DOC concentration (L mg C⁻¹ m⁻¹) (Weishaar et al., 2003), C:C ratio was determined by dividing the absorbance value at 400 nm by the corresponding DOC concentration (Wallage et al., 2006), and E4:E6 ratio

Download English Version:

<https://daneshyari.com/en/article/5751195>

Download Persian Version:

<https://daneshyari.com/article/5751195>

[Daneshyari.com](https://daneshyari.com)