Geophysical Research Abstracts
Vol. 20, EGU2018-6255, 2018
EGU General Assembly 2018

Allochthonous DOC input can switch a meso-eutrophic lake from being a net sink to become a net source of atmospheric CO_2

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Lakes play an essential role in the global carbon cycle as they are very active sites for carbon transformations. Over the past two decades concentrations of allochthonous dissolved organic carbon (DOC) have increased in surface waters across large parts of the world. Increased DOC inputs can have, at least, three effects. Firstly, increased DOC input may stimulate heterotrophic metabolism and thus carbon dioxide (CO_2) production. Secondly, allochthonous DOC affects water colour and could have a shading effect that constrains primary production resulting in decreased CO_2 bio-uptake. Thirdly, allochthonous DOC may acidify the water which can then lead to decreased pH with a subsequent increase in CO_2. All three effects of increasing DOC inputs would result in increased CO_2 concentrations, yet the relative importance of these are unknown. The knowledge gap is particularly apparent for eutrophic lakes as most studies on carbon processing in lakes have been performed in oligotrophic systems. However, eutrophic lakes are often net autotrophic due to the high internal primary production thus taking up CO_2, particularly during summer. Increased DOC input could potentially switch a eutrophic lake from being a net CO_2 sink to become a net CO_2 source. We tested here the effects of both altered allochthonous DOC input and light conditions through shading on CO_2 production in lake water during summer. We used two mesocosm experiments with crossed full factorial designs in the meso-eutrophic Lake Erken, Sweden to determine the relative importance of bacterial activities, primary production and the carbonate system on CO_2 concentrations. We found evidence that enhanced CO_2 concentrations, resulting from increased DOC input, can switch mesocosms from being net CO_2 sinks to net CO_2 sources. Surprisingly, there was no relationship between bacterial activities and partial pressure of CO_2 (pCO_2). We found a positive relationship between chlorophyll a and pCO_2 with higher chlorophyll in response to increased DOC and to shading. We also found that temporal CO_2 dynamics in the mesocosms with alkaline water from Lake Erken best correlated with pH dynamics. Considering that DOC concentrations in boreal lakes is predicted to increase in a warmer and wetter climate the number of lakes that may switch from being a net CO_2 sink to being a net CO_2 source might be substantial.