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Significance of terrestrial aquatic photosynthesis in the global carbon cycle

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It has been known that approximately 50% of the photosynthesis on Earth each year occurs in aquatic environments. Therefore, aquatic carbon fixation is of enormous importance in the regulation of the global climate. Previous work concentrated mainly on the role of ocean aquatic photosynthesis in the $CO_2$and/or DIC-dissolved inorganic carbon uptake. However, recent studies show that the role of terrestrial aquatic photosynthesis in the CO_2 uptake, which utilizes DIC (mainly HCO_3^-, the major species of DIC in natural waters at pH 7-9) by rock weathering to form the autochthonous organic carbon, and thus decreases the CO_2 release to atmosphere from terrestrial aquatic systems, should not be neglected in global budgeting in the carbon cycle. The magnitude of this carbon sink could be in the order of a few hundred million tons of carbon per year, and will increase with the rise in DIC caused by global warming and anthropogenic activities.

The finding of the role of terrestrial aquatic photosynthesis in DIC (CO_2) uptake has broad implications.

First, it provides the link between autochthonous organic carbons in terrestrial aquatic ecosystems and rock weathering-related CO_2 sink by the following chemical reaction:

$\mathbf{CaCO_3+CO_2+H_2O \Rightarrow Ca^{2+}+2HCO_3^- \Rightarrow}$

$\mathbf{CaCO_3\downarrow+x(CO_2\uparrow+H_2O)+(1\text{-}x)(CH_2O\downarrow+O_2)}$.

Second, it shows that the rock weathering-related carbon sink are largely underestimated if only DIC concentrations at river mouths are considered due to the transformation of DIC to autochthonous TOC. River TOC is generally considered to derive from soil leaching and erosion of soil and sedimentary rocks**.** However**,** recent studies showed that the autochthonous organic matter contributions in the Mississippi river could be larger than 50%. Therefore, to obtain accurate rock weathering-related carbon sink from river chemical data, both concentrations of DIC and autochthonous TOC must be considered.

Third, it indicates that the atmospheric CO_2 sink by carbonate weathering might be significant also in controlling the long-term climate changes due to the substantial production and burial of autochthonous organic carbon in the sequence:

$\mathbf{CaCO_3+CO_2+H_2O \Rightarrow Ca^{2+}+2HCO_3^- \Rightarrow}$

$\mathbf{CaCO_3\downarrow+x(CO_2\uparrow+H_2O)+(1\text{-}x)(CH_2O\downarrow+O_2)}$

This challenges the traditional point of view that only chemical weathering of Ca–silicate rocks potentially controls long-term climate change.

Finally, due to the DIC (CO_2) fertilization effect, the carbon sink by aquatic photosynthesis in terrestrial aquatic ecosystems operates as a positive feedback system: transformation of DIC to terrestrial organic carbon will increase with the rise in DIC caused by global warming and anthropogenic activities.