Journal of Ecosystem & Ecography

Ivlev, J Ecosys Ecograph 2016, 6:4
DOI: 10.4172/2157-7625.1000e125

Editorial OMICS International

# Comments on the Role of Photosynthesis in the Global Redox Carbon Cycle

**Ivlev AA***

*Russian State Agrarian University of KA Timiryazev, Moscow, Russia*

***Corresponding author:** Ivlev AA, Russian State Agrarian University of KA Timiryazev, Moscow, Russia, Tel: +7 (499) 976-0480; E-mail: aa.ivlev@list.ru

**Received date:** December 27, 2016; **Accepted date:** December 28, 2016; **Published date:** December 30, 2016

## Editorial

In a recently published works devoted to the global redox cycle of carbon [1-3], some points require further explanation. Applied to the global carbon cycle term "photosynthesis" should be understood more broadly as "global photosynthesis" what is somewhat different from normal photosynthesis of individual organisms.

Global photosynthesis is the term describing the cumulative photosynthesis all organisms living at the moment on the Earth. In contrast to the photosynthesis of individual organisms, global photosynthesis is not limited by ontogenesis and doesn't depend on time. Photosynthesis conditions for each habitat on the Earth are regarded as unchangeable.

However, "global photosynthesis" has the same features that characterize a normal photosynthesis. It consists of two reciprocal processes of $CO_2$ assimilation and photorespiration. The strengthening of one of them is accompanied by the weakening of the other. The effect of each of the processes on the total biomass growth is opposite and depends on the concentration ratio of the $CO_2$ and $O_2$ in the environment. The increase of $CO_2$ concentration enhances the $CO_2$ assimilation and supplies the total biomass growth whereas the increase in oxygen concentration stimulates photorespiration and reduces the total biomass.

Like a normal photosynthesis, global photosynthesis is accompanied by carbon isotope fractionation. $CO_2$ assimilation is followed by the enrichment of the total biomass in a "light" isotope $^{12}C$ relative to the assimilated carbon, while photorespiration leads to the enrichment of the total biomass in a "heavy" isotope $^{13}C$. The carbon isotope composition of the total biomass depends on the relative contribution of the two above processes to the biosynthesis. The increase in the concentration of $CO_2$ in the environment leads to the enrichment of the biomass with $^{12}C$, whereas the $O_2$ growth in the atmosphere provides $^{13}C$ enrichment of the total biomass.

We also used the term "living matter", introduced by Vernadsky, which includes the total biomass of all living organisms, including photosynthesizing ones. Taking into account that photosynthesizing biomass is the first unit of the food chain, the "living matter" can be regarded as a product of photosynthesis and can be used in the photosynthesis reaction. The assertion is particularly true since it is known that carbon isotope fractionation in heterotrophic assimilation is negligible and isotope effect of "living matter" is mainly determined by photosynthesizing biomass.

When studying the global natural carbon cycle the isotope composition of carbonate carbon is usually applied as arguments to substantiate isotopic variations of $CO_2$. The reason for this is isotope-exchange equilibrium observed in the modern natural "carbon dioxide – bicarbonate – carbonate" systems. Due to equilibrium the isotopic composition of carbonates reflects the changes of the isotopic composition of $CO_2$. Similarly, the isotopic composition of organic matter of sedimentary rocks is considered to be analogous to the isotopic composition of contemporary "living matter".

Indeed, a rationale for this analogy is the fact that the sedimentary organic matter is a product of transformation of "living matter" and hence inherits its isotopic composition. Some differences between them can be explained by isotope heterogeneity of the "living matter" which is a result of intracellular isotope fractionation and subsequent partial oxidation of the fractions after burial. However, the associated isotopic shifts are insignificant.

If one takes into consideration the maximal isotopic differences observed between lipid - protein and carbohydrate fractions are around 5% (in most cases much less), and keep in mind that the range of isotopic differences related to the photosynthesis conditions in different ecosystems are up to 20% or more, it can be argued that the isotopic composition of sedimentary organic matter should be determined mainly by the photosynthesis conditions in the ecosystems. Following this logic and having compared the isotopic composition of carbon in carbonates and coeval organic matter sampled in the same facies (i.e., the same ecosystem), it can be claimed that the ε difference ($\delta^{13}$Ccarb - $\delta^{13}$Corg. matter) is analogous to the isotopic discrimination $\Delta^{13}C$, widely used for the characterization of carbon isotope fractionation in modern photosynthesizing organisms. In other words, the value of ε is the isotopic discrimination in photosynthetic organisms in the past. Another important conclusion derived from the above is the following: in the reaction of global photosynthesis sedimentary organic matter can be regarded as photosynthesis product whereas carbonates can be used instead of $CO_2$ as substrate.

In conclusion one more assertion associated with regulatory role of photosynthesis in global carbon cycle should be underlined. As was said, the increase of oxygen in the environment causes the intensification of photorespiration in the photosynthesizing organism. It increases till the moment when photorespiration becomes equal to the $CO_2$ assimilation. This state is called compensation point. With oxygen growth a photosynthesizing organism spontaneously strive to the compensation point. Below this point the physical existence of the organisms is impossible. Due to this ability of photosynthesizing organisms global photosynthesis has the same feedback mechanism which makes the global carbon cycle to move spontaneously to the point when the amount of the reduced carbon (the amount of total biomass produced in photosynthesis), becomes equal to the amount of the reduced organic carbon converting back into the oxidized inorganic form. This state is called ecological compensation point. Since the emergence of the photosynthesis and up to the achievement of ecological compensation point, the carbon balance was shifted to the production of the reduced carbon. It means that the excess of the reduced carbon was accumulated in sediments in the form of organic matter. Correspondingly another product of photosynthesis, oxygen, is accumulated in the atmosphere. Upon reaching the ecological compensation point the global carbon cycle reaches a steady state, in which there is a stabilization of oxygen and carbon dioxide concentrations in the atmosphere. Further accumulation of organic matter in sedimentary rocks is terminated. Orogenic cycles on the Earth that appeared with photosynthesis origin turned into climatic oscillations.

## References

1. Ivlev AA (2015) Global redox cycle of biospheric carbon: interaction of photosynthesis and earth crust procsess. Biosystems 137: 1-11.
2. Ivlev AA (2016) Global redox carbon cycle and photosynthesis development. J Ecosys Ecograph S5-003.
3. Ivlev AA (2016) Global carbon cycle and organic matter accumulation in the Earth crust. Geoinfor Goestat: An Overview 4: 1.