Carbon isotope fractionation during photosynthesis in submerged moss and aquatic plants

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Radiocarbon activity ($a^{14}C$) and ratio of stable isotopes $^{13}C/^{12}C$ ($\delta^{13}C$ values) were measured in plant samples collected 2011-2012 in the natural habitat of the Plitvice Lakes, Croatia: terrestrial moss, water submerged moss, marsh and aquatic plants. All collected samples are C3 photosynthetic cycle plants. The $a^{14}C$ and $\delta^{13}C$ values of the plant tissue were compared with values of carbon reservoirs the plants use in photosynthesis: atmospheric CO_2 and/or dissolved inorganic carbon (DIC) as well as with the carbon isotope composition of plants measured 30 years ago [1]. The fraction of each carbon reservoir in plants was determined and the ^{13}C fractionation factor between DIC and organic tissue of a plant was calculated. Since there were no systematic paired measurements for $a^{14}C_{DIC}$ and $a^{14}C$ of plants at some locations in the old data set, we approximated the missing $a^{14}C_{DIC}$ values by the values taken from [2]. There is a very good correlation between $a^{14}C$ and $\delta^{13}C$ of moss plant tissue in both periods which is a result of variation of the ratio of atmospheric and dissolved inorganic carbon in moss. The fraction of atmospheric carbon in submerged mosses ranges from 8 to 66 %. Calculated ^{13}C fractionation factor between DIC and organic tissue of moss is -41 ± 3 ‰. Aquatic plants (algae, submersed species) sampled from ~30 cm depth show higher fraction of atmospheric carbon (~20 %) than a sample from 14 m depth (~0 %). Floating plants have 15 – 20 % of atmospheric carbon, while emersed plants have 90 – 100 % of atmospheric carbon (marsh plants, sedge, grasses). Calculated ^{13}C fractionation factor between DIC and plant tissue for submersed and floating plants is -22 ± 3 ‰, which is the same as the ^{13}C fractionation factor between the atmospheric CO_2 and plant tissue for C3 plants. Emersed samples have higher dispersion in ^{13}C fractionation factor values (from -9 ‰ to -147 ‰). The difference between the determined ^{13}C fractionation factors for mosses and for aquatic plants (algae and floating plants) could be a result of different plant adjustment to photosynthesis of $HCO_3^-(aq)$ and $CO_3^{2-}(aq)$ molecules from DIC. Mosses are known to be adjusted to photosynthetic assimilation of CO_2 there is probably an extra step of transformation of $HCO_3^-(aq)$ and $CO_3^{2-}(aq)$ to CO_2 resulting in a larger ^{13}C fractionation factor between DIC and plant tissue for mosses than for aquatic plants.

[1] Marčenko E, Srdoč D, Golubić S, Pezdič J, Head MJ. Radiocarbon 31 (1989) 785-794.

[2] Srdoč D, Krajcar Bronić I, Horvatinčić N, Obelić B. Radiocarbon 28 (1986) 515-521.