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Stabilization of organic carbon isolated from cryoconite holes in polar and mountain systems by ^{13}C NMR spectroscopy

Vjacheslav Polyakov and Evgeny Abakumov
Department of Applied Ecology, Faculty of Biology, St. Petersburg State University

Black carbon is one of the short-lived climatically significant factors. This term refers to climate-forming substances that are located for a short amount of time in the atmosphere - from several days to several years. To identify the role of cryoconite in the conditions of a possible climatic crisis, the stabilization of organic matter isolated from cryoconite holes was assessed. Humic acids are part of the organic matter accumulating in soils and cryoconites and are heterogeneous systems of high-molecular condensed compounds formed as a result of the decomposition of organic remains of plants and animals in terrestrial and aquatic ecosystems. Climatic parameters, precursors of humification, and the local position in the landscape determine the diversity of the composition and properties of HAs. Stabilization of organic material is defined as the transformation of organic matter into a state inaccessible to soil microorganisms, and the very property of stabilization is a characteristic stage in the dynamics of carbon. Using 13C NMR spectroscopy, we determined the proportion of aromatic and aliphatic compounds in the composition of HAs in order to assess the stabilization of organic matter in cryoconites from Mount Elbrus (Caucasus Mountains, Russia), the Arctic (Severnaya Zemlya archipelago, Russia) and Antarctica (King George Island, West Antarctica).

Samples for qualitative analysis of carbon accumulated in cryoconites were carried out during fieldwork in 2020. The studied samples were analyzed at the Department of Applied Ecology, St. Petersburg State University. Humic acids (HAs) were extracted from each sample according to a published IHSS protocol. Solid-state CP/MAS ^{13}C-NMR spectra of HAs were measured with a Bruker Avance 500 NMR spectrometer.

Thus, it follows from the obtained results that aliphatic fragments of humic acids predominate in all studied cryoconites. A similar composition of humic acids testifies to a single mechanism of accumulation and development of organic matter in glacier regions. Low biological activity and climatic features prevent condensation of high-molecular compounds in the organic matter of cryoconite holes. This is an essential prerequisite for high rates of carbon dioxide emissions into the atmosphere under the conditions of deglaciation of the studied regions. With the thawing of glaciers and the ingress of cryoconites into warmer conditions, an additional contribution of carbon dioxide to the atmosphere can occur and, therefore, increase the possible climate crisis on our planet.

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