

Composition of SOM in the Canadian high Arctic

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Permafrost underlies one fourth of the Earth's surface and contains approximately half of the global organic carbon (OC) in soils. Thawing and rapid losses of OC in the form of CO₂ and CH₄, associated with warming of arctic regions, raises serious concerns about the stability of OC in permafrost soils and its influence on the biogeochemical cycling in the surrounding Arctic Ocean. The composition of extractable OC in a soil profile collected from the McGill Arctic Research Station on Axel Heiberg Island in the Canadian high Arctic has been characterized using ultrahigh resolution mass spectrometry and nuclear magnetic resonance spectroscopy. The OC in this polar desert is oxygen-poor and highly enriched in lipids, because algae and detrital carbon from surrounding rocks are the main carbon sources. The OC is poor in lignin and protein in the high Arctic soils when compared to soils of other climates because of the lack of vascular plants. In addition, the OC composition of the whole soils was analyzed by carbon K-edge XANES, which indicated that the OC consisted of mostly aliphatic carbon as well as smaller contributions from unsaturated OC, carboxyls, and proteins. Most striking was the absence of oxygenated OC, which is often present as carbohydrates in polar region soils with more vegetation.

Such a contrasting composition of OC in Arctic soils may result in carbon losses from climate warming that may disagree with the widely-accepted models based upon the biogeochemistry of temperate soils. Heating experiments are currently underway to investigate how and to what extent the OC composition changes as a function of warming, indicative of how these soils may evolve as a result of climate change. Understanding how recalcitrant this highly aliphatic, oxygen-poor terrestrial carbon is will be critical to identifying its impact on the biogeochemical cycling in the surrounding Arctic Ocean.

Geochemistry of mercury and trace elements captured by activated carbons in a Canadian coal-fired power plant

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Abstract

The coal-fired power plants in Canada are required to reduce the emission of Hg up to 80% by 2018 and beyond to meet the national and regional regulatory targets. Activated carbon (AC) is considered by industry as an efficient sorbent to capture Hg from the flue gas during the combustion process. A widespread use of AC is anticipated by the coal-fired power plants to reduce the emission of Hg and meet their regulatory obligations.

This study investigates the geochemistry of ESP fly ash and related feed coal samples during an experiment trial by a full-scale coal-fired power plant in Western Canada. Furthermore capturing efficiency and retention ability of 5 different commercial ACs were examined. While the significant amount of Hg is being captured by ACs, the ultimate fate of Hg after capture and possible environmental impacts related to handling and use of Hg-rich fly ash has been a major concern. This study investigates volatilization and leachability of Hg and other elements from the captured fly ash.

The results show that capturing ability varies depending on AC's injection rates, fly ash particle size sorting, and temperature of the flue gas. Thermal release of Hg from fly ash samples appears negligible up to a temperature of 80°C. De-volatilization of Hg begins beyond 80°C, showing a sudden increase after 120°C. The constant heating at 140°C resulted in a steady de-volatilization of Hg during the 8 hour experiment that suggests a slow release of Hg during long exposure to heat. We recommend further investigation of possible Hg de-volatilization at higher temperature with the samples being exposed for a longer period of time.

Mercury is mostly leachable under strong acid digestion suggesting strong chemical retention. However, <10% of the total captured Hg can be released under the more moderate chemical digestion. The retention ability tends to decrease significantly in fine-grained fly ashes. The fly ashes injected with high sulphur AC provided the strongest chemical retention for Hg. We conclude that the possible Hg-S binding associated with ACs not only provides the best Hg capture capacity, but also provides the strongest thermal and chemical retention ability.