



Modelling organic carbon adsorption in Russian taiga and tundra soils

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Dissolved organic carbon (DOC) is an important constituent of terrestrial and freshwater ecosystems. It can exert a significant influence upon soil chemistry, for example, by enhancing mineral weathering and transporting metals and organic pollutants. The potential to release and transport DOC in subarctic river basins is believed to be enormous, because 23-48% of the world's soil organic carbon (SOC) is stored in high latitude regions. In most soils, the majority of organic carbon is insoluble except for a small fraction that is water soluble (WSOC). Therefore, the potential of the soil of providing organic carbon to surface waters depends on the pool of WSOC. The release of carbon to the WSOC pool is controlled by dissolution from solid soil, microbial lysis, plant root exudates, and microbial consumption. The ratio between DOC and potentially WSOC is largely determined by immobilization of organic carbon on solids in the subsoil, rather than microbial degradation. From laboratory studies it is known that organic carbon sorbs strongly to minerals present in subsoil's. Organic carbon comprises a mixture consisting of high molecular weight compounds collectively termed humic substances and low molecular weight hydrophilic compounds. Humic substances represent hydrophobic fraction and consist of humic (HA) and fulvic (FA) acids. Sorption occurs by physical and chemical processes that favour retention of organic carbon fractions having greater hydrophobicity. The mechanisms for sorption in mineral soils appear to be ligand exchange on amorphous iron or aluminium oxides, while in organic horizons H-bonding is more likely and possibly van der Waals forces play a role.

There is a need for better understanding of controls on DOC dynamics in soils of climate zones other than temperate areas. In this study, we investigate partitioning of SOC in soil profiles from a Russian taiga and tundra site. Furthermore, we examine the influence of varying soil chemistry on organic carbon solubility within the soil profiles. By measuring Corg, WSOC and DOC pools in the soils we investigated the proportion of SOC that determines the concentration of DOC. To estimate the reactive surface of the soils associated with amorphous oxides, we used oxalate extractable iron and aluminium. We used the Ligand Charge Distribution (LCD) model in the ORCHESTRA framework to reproduce DOC concentrations based on the potentially WSOC pool and reactive surface of the soils. Using the CD-Music model and the NICA-Donnan equation, the LCD model calculates the distribution of organic molecules over mineral and solution phase and speciation of adsorbed and dissolved molecules simultaneously. The reactive surface, based on amorphous iron and aluminium, is represented in the CD-Music model by goethite. Furthermore, FA and HA were not modelled as separate phases; instead WSOC was assumed to represent the total reactive humic content. Generic FA equilibrium constant were used to represent the ion adsorption properties of WSOC.

We found that the concentration of WSOC in soil is a reasonable estimate for the concentration of DOC that can theoretically be released by desorption without decomposition playing a role. Assuming that release of WSOC by desorption is much faster than the addition of DOC by microbial decomposition. Nevertheless, solubility of potentially WSOC is strongly influenced by for example soil pH, ionic strength, reactive surface and presence of complexing metals. We found that 80-90% of released WSOC was previously adsorbed. As shown by the fact that DOC is only a small percentage (up to 20%) of the potentially WSOC, only a small proportion of the potentially WSOC was released into solution under ambient conditions. Suggesting that the retention of organic carbon by soil is clearly important in regulating DOC concentrations in the soil solution and ultimately in surface waters. The use of LCD for FA adsorption in batch experiments was successful and proved that generic modelling approach applied in the LCD model was successful.

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