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The effect of frequent wetting and draining on peat pore water chemistry - a column experiment

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Wetlands are important ecosystems that are sensitive to changes in the hydrologic cycle. Changes in the saturation state of soils by anthropogenic activities such as well pumping can cause changes in the redox state of wetland soils, and thereby affect the chemical properties of the soil in these ecosystems. In order to better understand the effects of changes in saturation state of peat soils, a controlled experiment was conducted to examine the effects of the frequency of draining and rewetting cycles on peat. The goals of this study are : (1) Can long term (months) chemical dynamics be understood simply from the average water table level (seasonal variations, static conditions), or does the high frequency variation (diurnal, precipitation event, flooding pulses) needs to be taken into account? And (2) Which time scale is needed to understand processes where equilibrium is potentially not reached? Peat samples originating from two wetlands subjected to contrasting hydrological regimes in South Normandy, France, were compared. One in the close vicinity of a pumping well extracting water in the underlying aquifer since 1992. The other one, 1.5 km further, potentially non affected by the water extraction. The two peats have similar total N, S, C and O content. An open microcosm system was designed in order to approach field conditions. Undisturbed peat sediment cores were fed by an automatic water inlet and outlet system. Moisture samplers allowed pore water to be extracted at three heights on the cores and air-tight closures were used for CO2 incubation. Four treatments in a 45-day experiment were imposed: continuously saturated, continuously unsaturated, fluctuating saturated/unsaturated every 3 days, and fluctuating saturated/unsaturated every 9 days. The two last short cycles were repeated 8 and 3 times respectively. Four replicates were used in each treatment for a total of 32 columns. The inlet water originated from groundwater in the vicinity of the wetland. At regular time steps, pore water (top, middle and bottom of column) and drainage water were analyzed for: major anions (Cl^-, NO_3^-, NO_2^-, SO_4^{2-}), major cations (Ca^{2+}, Na^+, K^+, Mg^{2+}, Mn^{2+}), Fe(II), NH_4, pH, organic and inorganic dissolved carbon. CO_2 was measured is also followed by punctual incubation of the columns. Initial and final physicochemical and microbial characteristics (biomass, activity) of the peat were analyzed.

Results show that a vertical redox gradient appears in all treatments. According to the classical redox sequence, nitrate reduction, Fe(II) appearance and sulphate reduction are visible. A 3 days saturation is enough to restore anoxic conditions. However, with repeated wetting/drying cycles, a loss of the nitrate reduction capacity is observed. Wetting the peat columns results in a generalized sulphate release throughout the whole column and is maintained through the drying/wetting cycles. This sulphate production is highest at the top of the columns. Statistical analysis (ANOVA and Tukey-Kramer tests) indicates that for most redox sensitive elements, the "9-day" treatment is similar to the continuously saturated cores, while the "3-day" treatment differs significantly. CO_2 emission is higher in the "dry" treatment, for both peats. With respect to the continuously saturated treatment, drying/wetting cycles enhance CO2 emission only in the peat collected in the vicinity of the pumping well. With respect to the two types of peat, significant differences are observed. Firstly, C:N is greater in peats away from the well (10.1) than in its vicinity (2.7). Conversely, sulfate (peak concentrations 6:1) and calcium (peak concentration 4:1) release is much higher in the peat close to the well, than away from the well. Dissolved organic carbon (DOC) is higher in the peat away from the well (on average 81 mg/L compared to 24 mg/L), in accordance with the anti-correlated relation between sulfate and DOC already described in the literature. The results show that the peat near the well is impacted by more stressful draining/wetting cycles.

This study has implications for the wetland water quality and conservative politics regarding peatland dessication, especially critical time of drought.