Soil carbon cycle of different saline and alkaline soils under cotton fields in Tarim River Basin

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Calcium carbonate is the most common form of carbon (C) in semiarid and arid soils. Depending on pH and salinity changes, soils can act as sink or source of atmospheric CO$_2$ as well as contribute to C exchange between CO$_2$ and CaCO$_3$ leading to formation of pedogenic carbonates. However, the rates of these processes and the effects of environmental factors remains unknown. 14CO$_2$ was used to assess carbonate recrystallization in 4 saline and alkaline soils (Aksu alkaline, Aksu saline, Yingbazar alkaline, Yingbazar saline) (EC = 0.32, 1.35, 1.72, 3.67 (1:20) mS cm$^{-1}$, pH = 8.5, 8.2, 8.9, 7.9 respectively) and to trace the C exchange in the soils of the Tarim River basin depending on CO$_2$ concentrations in soils (0.02%, 0.04%, 0.2%, 0.4% and 4%). 14C was traced in soil water and air as well as in carbonates. The highest 14C in 14CO$_2$ (95% of the 14C input) was observed in Aksu alkaline soil and the highest 14C incorporation in CaCO$_3$ (54%) was observed in Yingbazar saline soil. There were close negative linear relationships between initial CO$_2$ concentrations (0.04%, 0.4% and 4%) and the 14C in Ca14CO$_3$ and in 14CO$_2$. The carbonate recrystallization rate increased with the CO$_2$ concentration and were depended on the recrystallization period. The average carbonate recrystallization rate was highest at 4% CO$_2$ concentration for Yingbazar saline soil (6.59×10$^{-4}$ % per day) and the lowest at 0.04% CO$_2$ concentration for Aksu alkaline soil (0.03×10$^{-4}$ % per day). The carbonate recrystallization rate linearly increased with the soil EC and with 0.04% and 0.4% CO$_2$ concentration, whereas the carbonate recrystallization rate decreased with pH. The highest CO$_2$ concentration of 4% can 10 to 100 times shorten the full carbonate recrystallization of the remaining primary carbonates compared to lower CO$_2$ concentrations 0.4% and 0.04% for complete (95%) recrystallization of soil carbonate. We conclude that microbial and root respiration affecting CO$_2$ concentration in soil is the most important factor of CaCO$_3$ recrystallization in alkaline and saline soils. Nevertheless, centuries and millennia are necessary for nearly complete CaCO$_3$ recrystallization and formation of pedogenic carbonates.

Keywords: CaCO$_3$ recrystallization, CO$_2$, 14CO$_2$, saline, alkaline, pedogenic carbonate, Tarim River Basin