Geophysical Research Abstracts,
Vol. 11, EGU2009-10644, 2009
EGU General Assembly 2009

Development of bulk density and of total C and N distribution during paddy soil evolution

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In the Zhejiang province (Yangtze River Delta, China), during the past 2000 years new farmland was created through consecutive land reclamation by protective dikes. The construction of the dikes is historically well-dated and provides a unique chronosequence of soil formation under agricultural use. Parts of the land were used for paddy rice, other parts for a variety of non-irrigated crops (control sites). This provides the unique opportunity to document the effect of soil redox conditions over long time periods on the evolution and distribution of soil organic matter (SOM) properties during pedogenesis. During a joint sampling campaign in June 2008, soil profiles of the following sites of a chronosequence were sampled, including paddy sites (a) and control sites (b): 50 y (a+b), 100 y (a+b), 300 y (a+b), 500 y (a+b), 700 y (a+b), 1000 y (a), and 2000 y (a). However, spatial variability cannot be detected by single sampling of a small number of soil profiles. Therefore, a geostatistical sampling approach was used in order to analyze the spatial dependence of SOM parameters of differently aged paddy plots (50/300/1000 y). These samples have been taken with an auger.

From the soil profiles, first analyses include bulk density, total C and N as well as organic C (OC) concentrations. From the auger samples, the data of the spatial distribution of OC and N in the 1000 y paddy site are already available.

The results show distinctly different depth distributions between paddy and control sites. The paddy soils are characterized by relatively low bulk densities in the puddled layer (between 0.9 and 1.3 g cm-3) and high values in the plough pan (1.5 to 1.6 g cm-3) and the control plats by relatively homogeneous values throughout the profiles (1.3 to 1.4 g cm-3). The dense plough layer was already established in the relatively young 50 y old paddy site.

In contrast to the carbonate-rich control sites, we found a significant loss of carbonates during paddy soil formation (decalcification of the upper 20 cm in 100 y old paddy soils, decalcification of the total soil profile in 700, 1000, and 2000 y old paddy soils).

With increasing duration of paddy soil use, OC concentrations in the upper A horizons were found to be constant throughout the chronosequence (approx. 15 mg g-1).

In addition to the OC distribution within the soil profiles, spatial distribution of OC and N in the topsoil of the 1000 y paddy site show a higher range, a higher (semi-)variance and a stronger spatial dependence compared to the subsoil. Furthermore, the spatial pattern of OC and N is considerably different between top- and subsoil, indicating that buried A horizons (found in 700, 1000, and 2000 y old paddy soils) may be more important for the subsoil OC distribution than relocation processes from the topsoil layer.

We conclude that paddy soil formation is firstly characterised by “short-term processes” (physical processes, approx. 50 years) like the formation of the plough layer, which leads to a “cutting-off” between top- and subsoil. Secondly, long-term processes like decalcification and OC accumulation occur, but the translocation of OC and N between top- and subsoil is impeded by the plough layer.