News Release

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Steppe soils as climate saviors?

TUM soil researchers debunk an environmentalists' dream

Fertile grasslands cover some 40% of the Earth's dry surface. Indigenous people – in Mongolia for instance – use them extensively as pasture land. Environmentalists would prefer to stop the grazing because grasslands, when left to nature, are supposedly very well suited for carbon sequestration. The underlying assumption is that recovering soil can store large amounts of the climate killer CO2 as a result of plant growth. Steppe utilization is thus viewed as a potential source of relief with regard to the global carbon balance in the atmosphere. Yet soil scientists from the TUM are now casting doubt this idea.

Can unused pastures be contribute to CO2 reduction and thus help alleviate the greenhouse effect? Hopefully yes – so the answer from scientist up to now. Steppes are widely regard as carbon sinks, storing carbon dioxide. The underlying logic is that plants need CO2 to grow. When the vegetation is left where it is to decompose, the resulting organic matter binds carbon consumed during plant growth in the soil. A team of researchers from the Chair of Soil Science at the Technische Universität München (TUM) has now taken a closer look at this theory, which, in light of current climate changes, is of great environmental and political significance.

To this end Prof. Ingrid Kögel-Knabner's assistants flew halfway around the globe – to North China. For thousands of years the very fertile steppe there has served the nomads as pasture land. However, since the 20th century grazing has become so intensive that the soil is beginning to suffer. In overgrazed regions dust storms and desertification are the consequence. This could presumably be mitigated through better grazing management, with improved carbon sequestration as a side effect – or so the environmentalists hope. The TUM researchers asked a fundamental question in examining this effect: How does soil chemistry change when sheep and goats no longer "disrupt" the steppe?

To answer this question the scientists took soil samples from a Chinese test plot that had been subjected to four different grazing intensities for research purposes: Two pastures were left ungrazed since 1979 and 1999, respectively, one area was used for winter grazing only and one pasture was grazed by sheep and goats the whole year round. They then analyzed

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the samples at the laboratories of the Center for Food and Life Sciences Weihenstephan (WZW) with regard to their individual components and their stability. To facilitate the tests, they first broke the Chinese soil down into its individual parts – the so-called fractions – using a complex filtration and separation process.

The organic make-up of soil is, after all, quite varied. Parts of plants that have recently died are loosely mixed in with the soil. In the first stage of decomposition the microorganisms processing this "compost" consume part of the carbon in the soil during respiration, thereby converting it back into CO2 and returning it to the atmosphere. Soil particles that have already been broken up further and chemically decomposed, can clump together to form aggregates. Since these clumps of soil encapsulate organic matter they also prevent it from being decomposed by bacteria and fungi – the carbon they contain is temporarily removed from the atmosphere. However, these aggregates have a lifespan of only a few of weeks to a couple of years. Once they disintegrate, the plant matter continues to decompose and release CO2. Only at the end of this chain can plant remnants adhere to minute clay particles with a diameter of less than 0.002 mm. This allows the climate killer CO2 to be bound in the soil for thousands of years. In theory, anyway.

However, a comparison of soil samples by the soil scientists at Weihenstephan brought to light a rather surprising fact. There was indeed a significant increase in the levels of organic matter in the soil 25 year after the total grazing stop – the worn out steppe had recovered. Yet the bulk of the plant remnants were very young and, as such, mostly unbound or only temporarily protected in aggregated forms. Further watering down the climate balance was the fact that the organic matter clinging to tiny clay particles had not been, as was previously assumed, stable for very long – it was, in fact, quite fresh. "Obviously this fraction is not as stable as had been assumed and can decompose quickly when land utilization changes," says researcher Markus Steffens from the Chair of Soil Science at TUM.

The grazing stop in the Chinese steppe did not have the effect the environmentalists were dreaming of. On the contrary, it seems that the additional mass of plant matter had actually led to a further decomposition of precisely the fraction that was previously considered stable. Apparently vast steppe lands are not a carbon sink at all. And Steffens sees a further danger. "Projections indicate that the local climate will become increasingly humid in the years to come. Should that happen, a large portion of the carbon delicately protected in aggregates may decompose even faster – and thus find its way back into the atmosphere."

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Literature:

Steffens, M., Kölbl, A. & Kögel-Knabner, I. 2009. Alteration of soil organic matter pools and aggregation in semi-arid steppe topsoils as driven by organic matter input. European Journal of Soil Science, 60(2). 198-212.

Abstract online unter: http://www3.interscience.wiley.com/journal/122197559/abstract; the original paper is available from the press office upon request.

Background:
This subject was investigated in the context of the dissertation *Soils of a semiarid shortgrass steppe in Inner Mongolia: Organic matter composition and distribution as affected by sheep grazing* at the Chair of Soil Science at the TU München. The dissertation was funded by the Deutsche Forschungsgesellschaft (DFG) as part of the first phase of the interdisciplinary DFG Research Group 536 MAGIM (*Matter fluxes of Grasslands in Inner Mongolia*). For further information on this research group visit www.magim.net

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