Geophysical Research Abstracts
Vol. 12, EGU2010-2338, 2010
EGU General Assembly 2010

Biochar Carbon Sequestration – A Manipulation of the Carbon Cycle

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Carbon dioxide (CO2) is removed from the atmosphere through photosynthesis and stored in organic matter. When plants grow they utilize sunlight, carbon dioxide (CO2) and water (H2O) to synthesize organic matter and release oxygen (O2). This accumulated organic matter is returned to the atmosphere by decomposition of dead plant tissue or disturbances, such as fire, in which large amounts of organic matter are oxidized and rapidly transferred into CO2.

Reduced decomposition is an advantage of carbonized organic matter (charcoal, biochar). Thus, biochar formation has important implications for the global carbon cycle. In natural and agroecosystems residual charcoal is produced by incomplete burning. As the soil carbon pool declines due to cultivation, the more resistant biochar fraction increases as a portion of the total carbon pool and may constitute up to 35% of the total soil organic carbon (SOC). The half-life of biochar was estimated to be 1400 years, and thus a permanent form of carbon sequestration.

Biochar can be produced by thermo-chemical conversion of biomass. Burning biomass in the absence of oxygen produces biochar and products of incomplete combustion (PIC). The PIC include burnable gases such as H2 and CH4. These gases can be used to fuel the conversion of biomass into biochar and/or renewable energy generation. Larger molecules can be condensed into bio-oil and also used as a renewable fuel. The resulting biochar consists of mainly carbon and is characterized by a very high recalcitrance against decomposition. Thus biochar decelerates (manipulates) the second part of the carbon cycle (decay, mineralization) and its non-fuel use would establish a carbon sink. Lenton and Vaughan (2009) rated biochar as the best geo-engineering option to reduce CO2 levels.

It is predicted that 109 hectares of natural ecosystems would be converted to agriculture by 2050. This would cause a further massive loss of ecosystem function and species extinction. Reducing these impacts and at the same time doubling and sustaining food production, and mitigating climate change and adapting to a changing climate probably represents the greatest challenge facing humankind.

There is hope that biochar carbon sequestration could sequester significant amounts of carbon while simultaneously increasing the resilience of agricultural systems to environmental influences. Throughout the world intensive agricultural land use often has resulted in soil physical and chemical degradation, and higher losses than input rates of nutrients and organic materials. In contrast, the intentional and unintentional deposition of nutrient-rich materials within human habitation sites and field areas has in many cases produced conditions of heightened fertility status. An anthropogenically-enriched dark soil found throughout the lowland portion of the Amazon Basin and termed Terra Preta de Índio is one such example. Its fertility is the secondary result of the transport of natural and produced foods, building materials, and fuel to prehistoric dwelling places. These materials and their byproducts were then transformed and differentially distributed within the zone of habitation and associated garden areas. This is in contrast to today's urban wastes which are deposited as contaminated toxic material far away from settlements or agricultural fields.

Sustainable agricultural practices will need to reverse soil degradation without an increase in greenhouse gas emissions, despite the challenge to double food production until 2050. This will require a material flow management involving both nutrients and carbon. This presentation will summarize the present knowledge, historical use and global prospects of biochar carbon sequestration.