Biochar Application Effects on Soil Phosphorus Sorption and Release

B. Dari, V Nair, Rao Mylavarapu and W G Harris

The behavior of the soil after biochar application is mostly unexplored although much has been mentioned about the importance of biochar in reducing excess nutrient loss. The objective of this study was to determine the effects of commercially available biochars on P sorption and release from soils after addition of biochar at different rates. Hardwood biochar (HWB) and poultry litter biochar (PLB) were added to each of two soils (Candler and Apopka) at rates of 1%, 2% and 5% (w/w). Soil and each mixture were incubated at 25 ^{0}C for 14 days. At the end of the incubation period, 8 levels of P in the form of KH_2PO_4 solution were added to each of the treatments. Results showed that after certain limits of P addition (~4.5 mL/g for Candler and 15 mL/g of P for Apopka), corresponding to a threshold P saturation ratio (PSR), P began to be released from the soils for all treatments irrespective of the nature of the biochar. The amount of P sorbed in the solid phase was higher for PLB (~500 mg/kg) as compared to HWB (~320 mg/kg) for all rates of application. The absolute amount of additional P that can be added to a soil as fertilizer will depend on the P retention property of the soil and not on the biochar, and therefore would be site-specific. Increase in S_{max}, the Langmuir P retention maximum, with increase in biochar rates might be a result of additional moisture being retained by biochar.

Title: Residential Exposure to Arsenic & Hexavalent Chromium from CCA Wood

Authors: Ky Gress and Lena Q. Ma

Prior to 2004, most new residential decks, fences, picnic tables, and exterior staircases were made from wood that was pressure-treated with chromium copper arsenate (CCA). Concern about children's exposure to arsenic from direct contact with leaching CCA wood led to its withdrawal from use in new construction in 2004, but many of these wood structures are still in everyday use. This is a particular issue in Florida, where 15% of all CCA wood produced in the US was used in residential construction, with an estimated 60 million tons of soil impacted by leaching CCA wood decks alone.

This series of studies evaluated residential exposures to arsenic and Cr(VI) from leaching CCA wood under 3 different scenarios: while living in apartment complexes with a large exterior CCA wood staircase, from cleaning wood decks using different methods and in zoo animals living in CCA wood enclosures. Wipe sampling was used to quantify amounts of dislodgeable metals on the wood surface and concentrations of metals in rinsate and in soil were found. Arsenic dose estimates in children ages 1-6 were made and compared to regulatory levels, finding increases in cancer risk above acceptable risk levels. In the zoo study, biological samples are being analyzed and compared to background levels and regulatory limits.

The results of these studies are most relevant to people who have CCA wood structures around their home, particularly those with young children.

Title: Molecular-level Characterization of Dissolved Organic Nitrogen in Urban Waters

Authors: Mary Lusk, Gurpal Toor, and Patrick Inglett

Dissolved organic nitrogen (DON) is an important fraction of the total nitrogen (N) pool in aquatic systems and can be a significant source of N to the phytoplankton and bacteria that cause eutrophication and algal blooms. DON is a complex mixture of thousands of potential compounds that are to date largely uncharacterized, especially in urban systems. We used ultra-high resolution fourier transform ion cyclotron resonance (FTICR) mass spectrometry to characterize the molecular composition of DON from urban stormwater runoff, an urban stormwater treatment pond, an urban stream, and an agricultural stream. A 5-day bioassay of the streamwaters was also conducted to compare DON formulas before and after biodegradation. van Krevelen diagrams were used to plot H:C vs. O:C of identified compounds and visually divide their molecular formulas into lipids, proteins, amino sugars, and lignins. There were 1302 and 1305 N-bearing organic compounds in the runoff and pond waters, respectively. Of these, we identified 156 lipid-and protein-like compounds in the runoff sample that were not present in the pond sample. Conversely, there were 159 lignin-like compounds in the pond sample that were not in the runoff sample. Thus, biochemical transformations in the pond are removing some labile compounds (those present only in the runoff), while adding new, more refractory compounds to the pond export. However, both the runoff and pond waters still contained hundreds of compounds characteristic of the highly bioavailable lipids, proteins, and amino sugars, suggesting that urban runoff and pond water may be the sources of bioavailable DON in downstream waters. Streamwaters from both the urban and agricultural areas contained formulas expected of bioavailable DON as well as numerous low H:C formulas (typically considered characteristic of more refractory lignin-like material). During the 5-day bioassay, N-bearing organic formulas decreased by 1.8% (from 13.4 to 11.6%) and 3.4% (from 14.8 to 11.4%) of the total dissolved organic matter in the urban and agricultural streams, respectively, indicating net mineralization and conversion of some organic N to inorganic N. The bioassay showed that many of the lipids, proteins, and amino sugars were consumed, as well as lignin-like compounds with O:C ratios less than 0.5. Thus, even some lignin-like formulas often thought of as refractory in both urban and agricultural samples were reactive over the 5-day bioassay.

Title: Temperature Sensitivity of Anaerobic Carbon Processing under Two Contrasting Rates of Warming

Authors: Debjani Sihi*, Patrick Inglett, Stefan Gerber, Kanika Sharma Inglett

Temperature sensitivity of anaerobic carbon processing in wetlands remains poorly represented in most climate models, especially for warmer systems which account for a significant proportion of global CH_4 emission. Several studies of experimental warming have documented acclimation of soil respiration involving adjustments in microbial physiology or the efficiency with which microbes use carbon substrates (i.e. carbon use efficiency, CUE). These studies have observed an initial decline in CUE with increasing temperature followed by a partial recovery in CUE at a later stage, implies that the rate of warming may impact the microbial CUE and the rate of CO_2 and CH_4 production. Here, we have assessed the effects of warming rate on decomposition of subtropical peats using either a large single-step (10°C) or a slow ramping (0.1°C day^{-1}) temperature increase over the range of 15°C to 25°C. Results demonstrated the slow warming rate resulted in lower production of CO_2 and CH_4, whereas the rapid single-step warming resulted in both higher loss of gaseous carbon as well as a higher proportion of CH_4 over CO_2 (On average, CO_2-C:CH_4-C range over 0.71-1.4 and 0.73-1.6 in +10°C step vs. +10°C ramp, respectively). Microbial CUE declined from an initial value of 0.59-0.96 in the control to 0.30-0.36 and 0.44-0.50 unit in response to the single-step and slow-ramping temperature treatment, respectively. These results indicate that microbes are better able to adjust their physiology under a slow temperature increase. This has implications for the estimation of seasonal patterns n wetland systems emission.

Title: Back-diffusion from Thin Low-Permeability Layers

Authors: Minjune Yang, Michael D. Annable, and James W. Jawitz

There has been increasing recognition of the importance of interaction between aquifers and aquitards on contaminant fate and transport. Aquitards can serve as long-term contaminant sources to aquifers because contaminant mass diffuses out of the aquitards when source mass is depleted by aquifer remediation. This study describes analytical and experimental approaches to understand reactive and non-reactive solute transport in a thin aquitard bounded by an aquifer system. We solved a one-dimensional solute diffusion and transport equation for an aquifer with a finite aquitard using the method of images, and we demonstrated the application in a series of well-controlled laboratory experiments. Solute concentrations in the aquitard were measured in situ using dyes and a light-reflection visualization technique. The analytical solutions with image sources showed very good agreement with aquitard concentration distributions measured in situ in laboratory experiments. Additionally, reactive and non-reactive solute concentration breakthrough curves (BTCs) were measured from effluent samples and compared to analytical solutions. These results enabled quantitative assessment of the effect of back diffusion on plume persistence. The measured BTCs were predicted very well by solutions that included image sources compared to without image sources. Low-retardation solutes accumulated more stored mass with greater penetration distance in the aquitard, and then generated relatively higher back diffusion flux compared to high-retardation solutes that stored less mass with lower penetration depth in the aquitard. However, because the duration of aquitard mass release was much longer, high-retardation solutes have a great effect on long-term back diffusion risk.