Black carbon concentration and bulk carbon composition in central Arizona-Phoenix

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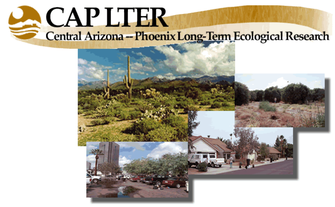
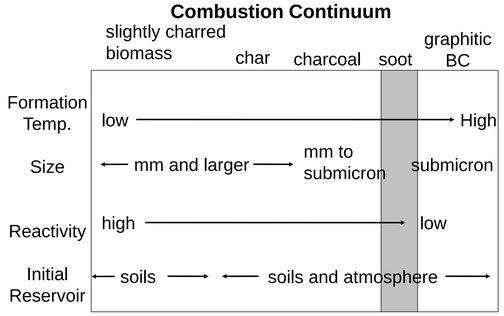


This project investigates the composition and distribution of black carbon (BC) in soil samples from Phoenix, AZ collected during the Central Arizona Phoenix Long-Term Ecological Research Program (CAP LTER) 200-point Survey.

Black carbon is the product of incomplete combustion of fossil fuels and biomass and has a range of physical structure from slightly charred biomass to graphitic BC. This poster shows preliminary work done to investigate the chemical composition of various BC samples. Chemical composition (structure) is of interest because it allows us to infer information about the reactivity of BC molecules. The presence of certain chemical functional groups can help indicate whether a molecule can undergo a chemical reaction.

Combustion Continuum



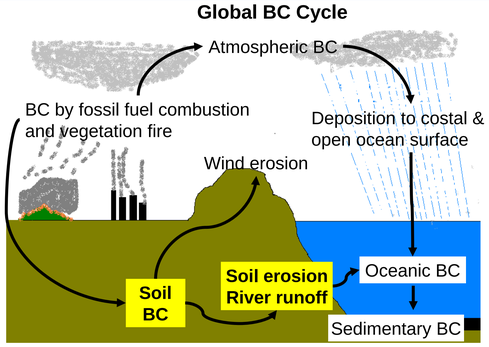
Shaded region denotes the component of the black carbon pool under investigation

Masiello C.A. *New directions in black carbon organic geochemistry.*Marine Chemistry. 2004.

Essential questions for this investigation:

- How much black carbon is stored in Phoenix-area soils?
- How is that carbon distributed across the city?
- **What is the structure and reactivity of soil black carbon?**

Global BC Cycle



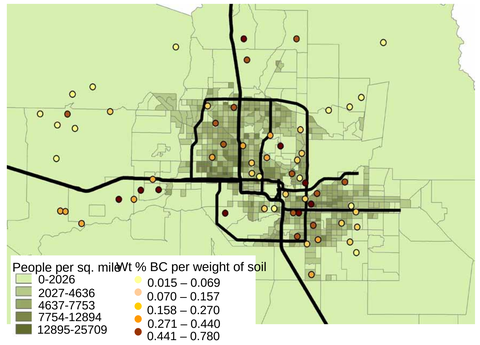
Summary of Survey 200 soils AVG (n = 63)

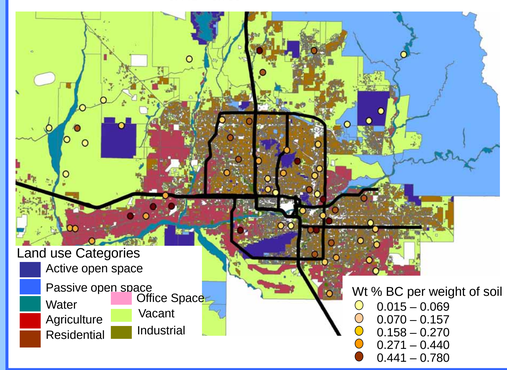
Wt % OC (g OC/g soil)	1.1 ± 0.9
Wt % BC (g BC/g soil)	0.2 ± 0.2
BC/OC (g BC/g OC * 100)	26 ± 24
Avg. Black Carbon d^{13}C (‰)	-17 ± 3

Central Arizona soil
1.1 % avg. organic carbon

Central Arizona organic carbon
Variable amounts of black carbon

Distribution of BC in CAP research area





Sources (Biomass burning and Fossil Fuel)	62 to 284 Tg yr^{-1}
Sinks (Sedimentary BC)	10 Tg yr^{-1}
Imbalance **:**	52 to 274 Tg yr^{-1}

Inputs do not equal outputs!

This imbalance suggests a dynamic role for BC in which it is somewhat reactive in the environment

Acknowledgements: Stevan Earl, Nancy Grimm, Sharon Hall, Natasha Zolatova, Ken Mossman Student Machine Shop, CAP-LTER

Structure Relates to Reactivity

Structure → Via chemical *Functional groups → Reactivity

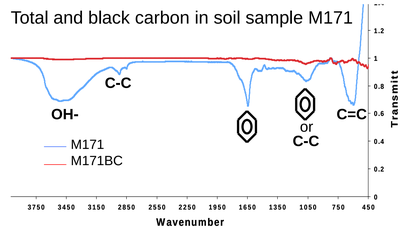
*Functional groups are small groups of atoms that display characteristic reactivity.

Fourier Transform Infrared (FTIR) Spectroscopy

- Instrumentation used to aid in the identification of chemical structures by detecting the bending and stretching of chemical bonds that absorb IR radiation.
- Chemical functional groups present in a sample are indicated by peaks located at different frequencies in the spectrum.
- Small amounts (<1mg) of sample are homogenized with potassium bromide (KBr; 3-4mg) and pressed to make 4mm KBr pellets.
- The transmittance of IR radiation is measured through the transparent pellet.

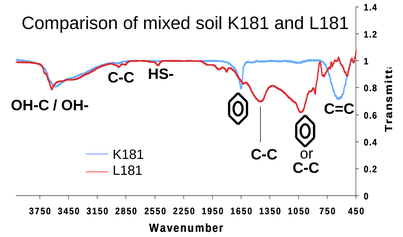
FTIR spectra of selected Survey 200 soils

Total and black carbon in soil sample M171



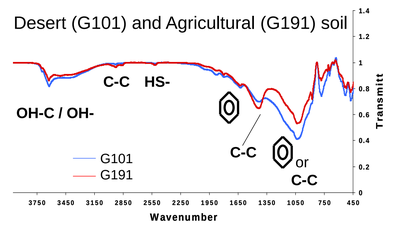
- Presence of aromatic (1031cm^{-1} and 1639cm^{-1}) and alkene carbon (586cm^{-1}) is evident from spectrum. OH- group presence indicated by broad peak at 3477cm^{-1}.
- M171BC: CTO375 treated. Spectrum is representative of black carbon in sample. Small peak at 1031cm^{-1} indicates remaining aromatic carbon.

Comparison of mixed soil K181 and L181



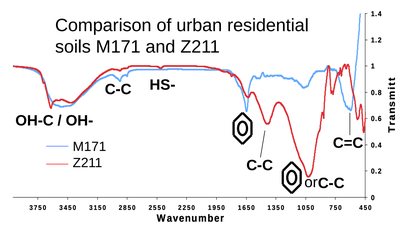
- Both contain OH- group, sharp peak (3614cm^{-1}) in L181 indicates tertiary alcohol.
- Both spectra show evidence of aromatic carbon. L181 spectrum indicates alkane groups and K181 spectrum indicates alkene groups.
- Aromatic peak more prevalent in K181 possibly because of a higher conc. of BC in that sample.

Desert (G101) and Agricultural (G191) soil



- Both have peaks indicating OH- and tertiary-OH, sulfur, aromatic, and alkane groups. Both sites are located on far west side of the CAP area, about 15 mi. apart.

Comparison of urban residential soils M171 and Z211



- Both contain OH- group, sharp peak (3612cm^{-1}) indicates tertiary alcohol.
- Both spectra indicate the presence of aromatic carbon. M171 spectrum indicates alkene groups and Z211 spectrum indicates alkane groups.
- Aromatic peak more prevalent in M171 possibly because of a higher conc. Of BC in that sample.

Preliminary Functional Group Assignment

Land Use	Functional Group: Aromatic	Alcohol OH-	Alkane C-C	Alkene C=C	Sulfur HS-
Agriculture					
G191	x	x	x		x
Desert					
G101	x	x	x		x
Urban Res					
M171	x	x	x	x	
Z211	x	x	x		x
Mixed					
K181	x	x		x	
L181		x	x		x
Urban Res BC					
M171 BC	x		x		

Structure and Reactivity

- The chemical structure of an organic molecule can indicate its reactivity based on the presence of various functional groups.
- Functional groups are specific groups of atoms within molecules that are responsible for the chemical reactions that take place in that molecule.
- Aromatic and alkane functional groups have low reactivity because the bonds are stable. OH-, C-OH, and C=C functional groups are typically more reactive.
- OH- functional groups are more reactive because of the weaker hydrogen bond between H and O.
- C=C functional groups are more reactive because of the pi electrons in the double bond.
- Desert microbial communities need a carbon source in order to carry out their metabolism. Since BC is a significant portion (>20%) of the organic carbon pool, it could be possible that BC is metabolized by microorganisms.

Future Work

- Further FTIR analysis will be completed on both bulk and BC samples. Changes in the FTIR spectrum will be studied over time and temperature. Solid-state NMR will also be used to compliment FTIR data.
- Investigation of the changes in carbon composition when charred samples are exposed to microbial communities are also being planned.