Particulate Emissions from Biochar-Amended Soils: A Potential Health Hazard?

Stuart Olshevski[1], Sujith Ravi[1], Junran Li[2], and Brenton Sharratt[3]

[1] Department of Earth & Environmental Sciences, Temple University, Philadelphia, PA 19122. E: stuart.olshevski@temple.edu [2]Department of Geosciences, University of Tulsa, Tulsa, OK 74104.
[3]Northwest Sustainable Agroecosystems Research, USDA-ARS, Pullman, WA 99164

TEMPLE UNIVERSITY

Introduction

Large-scale biochar application may provide sustainable pathways to improve productivity and carbon storage of agricultural soils or remediate contaminated lands. However the environmental impacts of large-scale biochar application needs to be investigated to evaluate the tradeoffs and synergies. In this preliminary research we used wind tunnel studies to investigate the dust emission potential of biochar-amended soils. The increase in airborne dust can impact human health, particularly since biochar particles can sorb bioavailable contaminants.

Concepts

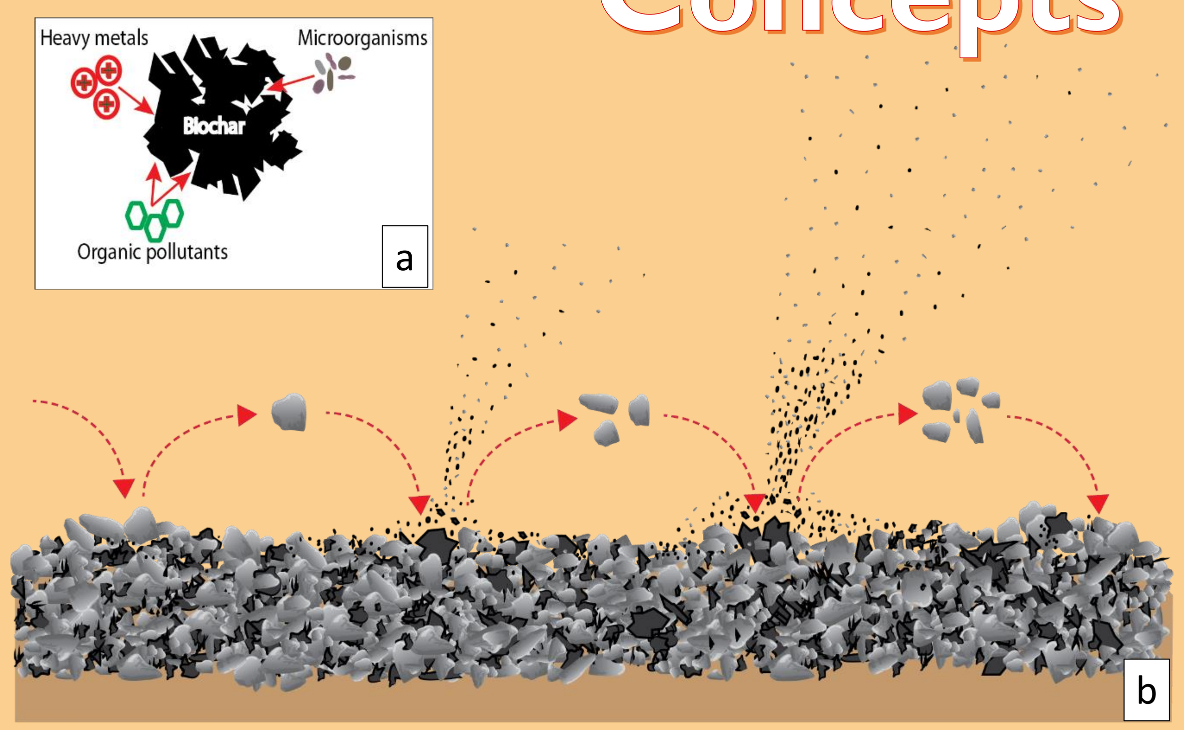

Fig. 1 (a) High surface areas and micropores allow biochar particles to trap contaminants and microbes within.
(b) Mechanism of saltation and abrasion of biochar leading to particulate dust emission

Methods

Wind tunnel experiments were set-up as follows: tray of soil sample (100x20x1.5 cm) located downwind subjected to ~7 minutes of wind. Wind speed, Particulate Matter ≤ 10µm aerodynamic diameter (PM_{10}) dust concentration, and Total Suspended Particulates (TSP) were measured using pitot tubes, TSI DustTrak aerosol monitoring tubes, and E-Sampler tubes respectively, all vertically positioned at 6 incremental heights from 0.5 to10 cm. The ambient air quality was also measured.

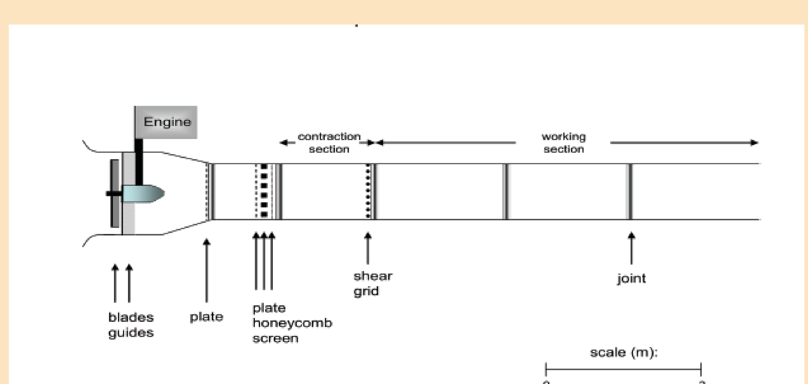

Fig. 2. Set-up of wind tunnel experiment

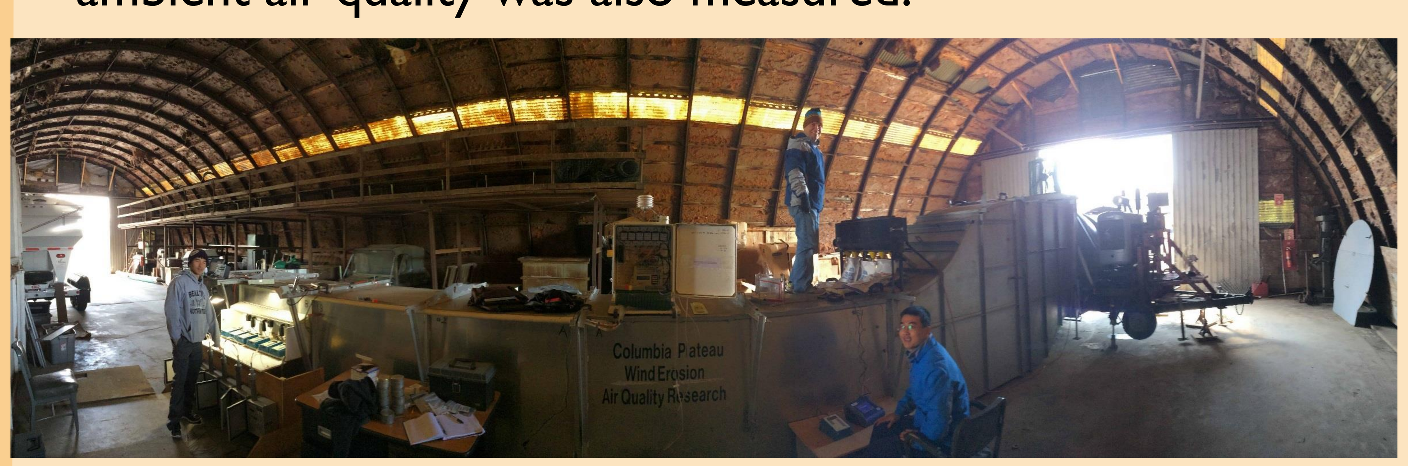

Fig. 3. Photograph of outside wind tunnel set-up

Table 1. Biochar Amendment Tests Performed in Wind Tunnel
-Concentrations in % biochar by volume
-Unsieved (U) or Sieved (S)

Soil Type		
Soil Type	Ritzville Silt Loam	C, 5U, 10U, 10S, 20U
	Warden Sandy Loam	C, 5U, 10U, 10S, 20U
	Ottawa Sand	C, 5U, 5S, 10U, 10S, 20U, 20S *all Ottawa tests also subjected to shorter test with Quartz abrader

PM_{10} Flux with Biochar

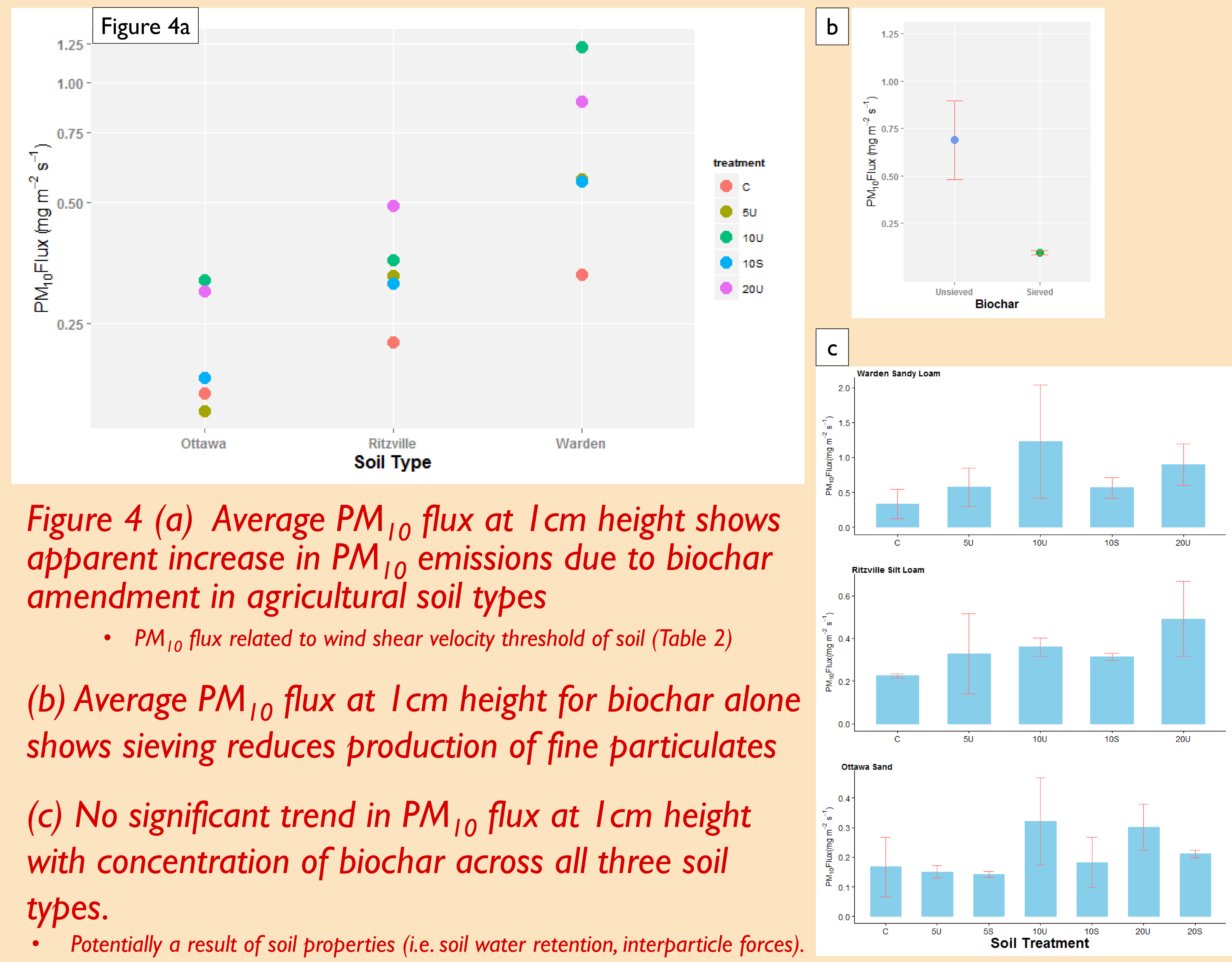

Figure 4 (a) Average PM_{10} flux at 1cm height shows apparent increase in PM_{10} emissions due to biochar amendment in agricultural soil types

- *PM_{10} flux related to wind shear velocity threshold of soil (Table 2)*

(b) Average PM_{10} flux at 1cm height for biochar alone shows sieving reduces production of fine particulates

(c) No significant trend in PM_{10} flux at 1cm height with concentration of biochar across all three soil types.

- *Potentially a result of soil properties (i.e. soil water retention, interparticle forces).*

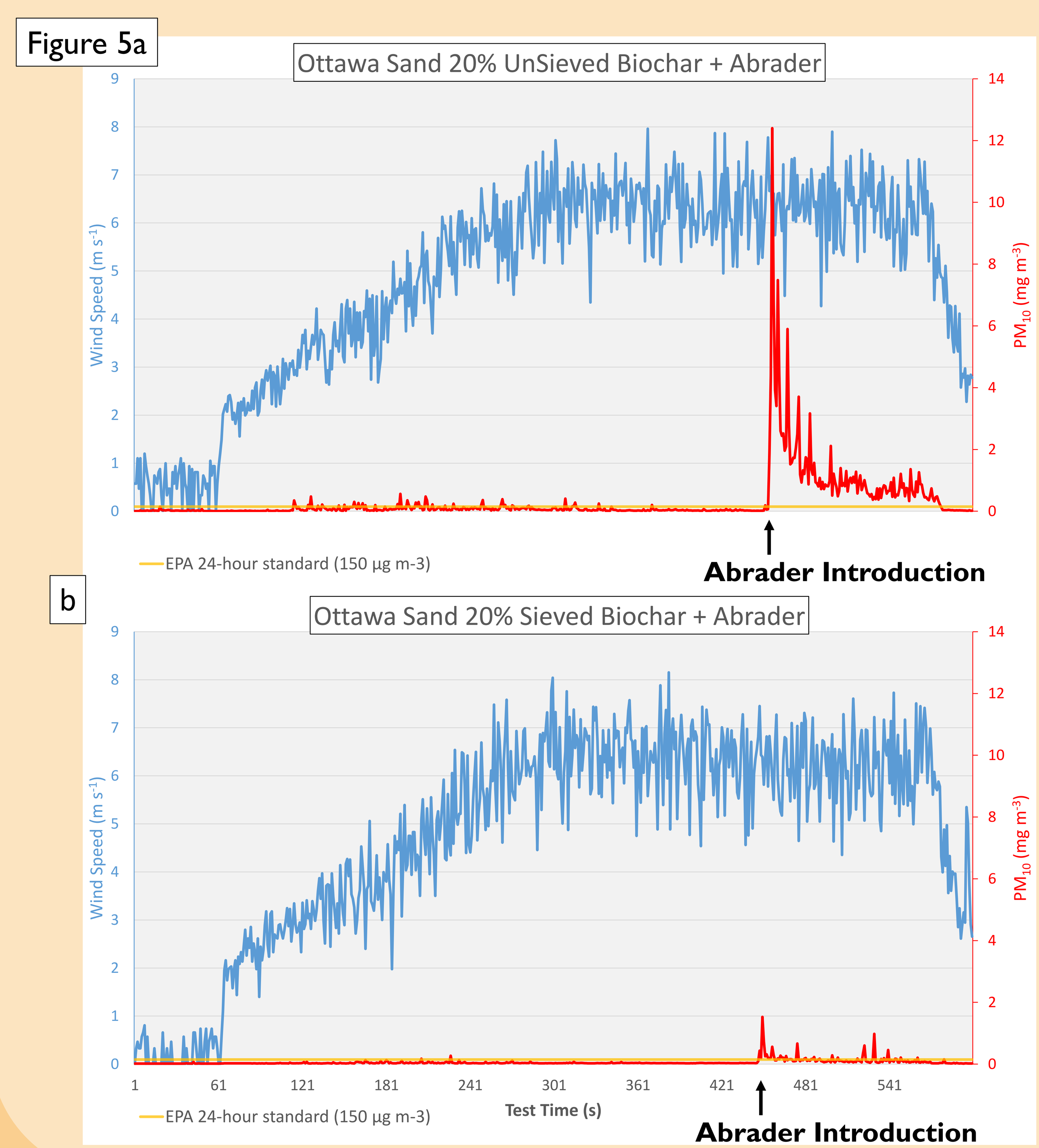

Fig. 5. Examples of Ottawa 20U Test (a) and Ottawa 20S Test (b) show increase in PM_{10} concentration due to quartz sand abrader introduction occurring at ~7:30 minutes. First 7-minute PM_{10} flux due to threshold eroding loose, fine particles.

- *The average PM_{10} concentration (320 µg/m^{-3}) for 20% Unsieved Biochar over 10-minute simulation of a wind event exceeded the EPA 24-hour standard of 150 µg/m^{-3}.*

Emission Threshold

Soil Type	Shear Velocity Threshold (ms^{-1})
Ritzville Silt Loam	0.18
Warden Sandy Loam	0.15
Ottawa Sand	0.35
Biochar UnSieved	0.15
Biochar Sieved	0.24

Table 2. Soil types' shear velocity thresholds differ in comparison to that of biochar (Warden<Biochar<Ottawa), and therefore the effect of saltation mechanism in creating greater emissions can be determined by soil properties.

Soil Moisture

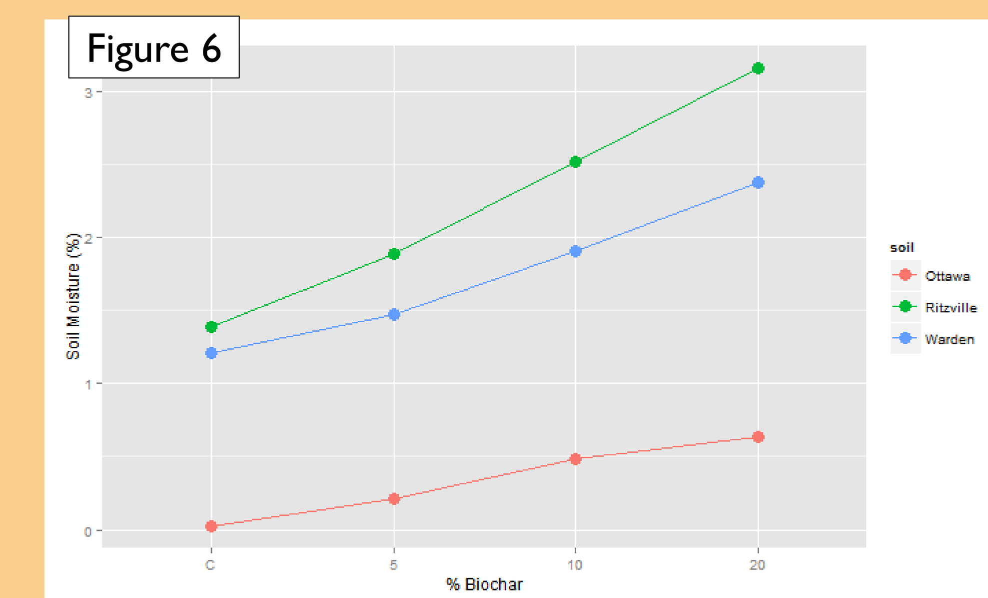

Fig 6. Positive relationship between concentration of biochar and near-surface soil moisture

Biochar addition reduced the shear velocity thresholds for erosion, but no difference between treatments

Conclusions

While no significant trend was observed with concentrations of biochar in the three different soil types, measurements of higher particulate emissions were typically observed with increasing biochar concentrations. Furthermore, we demonstrated that abrasion by sand grains can significantly contribute to biochar-amended soils' particulate emission. This preliminary research suggests further investigation into the effects of wind erosion on biochar-amended soils in order to effectively determine the impact on human health. More specifically, identify soil properties that could influence biochar susceptibility to erosion (i.e. soil water retention, interparticle forces) with large-scale applications of biochar.

References:
"The National Ambient Air Quality Standards for Particle Pollution". *Environmental Protection Agency.* 14 December 2012. Web.
Shackley, S., Sohi, S., Ibarrola, R., Hammond, J., Masek, O., Brownsort, P., Cross, A., Prendergast-Miller, M., Haszeldine, S. "Biochar, Tool for Climate Change Mitigation and soil Management". *Encyclopedia of Sustainability Science and Technology* . Ed. Robert Myers. Springer, 2011. 73-140.
Sharratt, B. S. & Vaddella, V. K. "Threshold friction velocity of soils within the Columbia Plateau". *Aeolian Research* 6 (2012): 13-20.
Tang, J., Zhu, W., Kookana, R., Katayama, A. "Characteristics of biochar and its application in remediation of contaminated soil". *Journal of Bioscience and Bioengineering* 116 (2013): 653-659.