Proposal for 2010-2011
Northwest Columbia Plateau PM_{10} Project

Objective #2: **Measurement and Prediction of Wind Erosion and Dust Emissions**

Title: ***Particle sizing and the $PM_{2.5}$ to PM_{10} emission ratio of eroded sediment***

Personnel: Principal Investigator: **Brenton Sharratt, USDA-ARS;**
Co-investigator: **Vankat Vandella, WSU;**
Support staff: **Guanglong Feng, WSU; Bob Barry, USDA-ARS.**

Project Objectives

Saltation is often thought to be the driving mechanism for the emission of fine soil particles from agricultural soils during high winds. Indeed, the common method employed in simulating wind erosion and dust emissions from agricultural soils requires knowledge of the saltation activity at the soil surface. Saltation activity results in the direct emission of fine soil particles ($PM_{2.5}$ and PM_{10}) from the soil surface or abrading larger soil particles from which emanates the ejection of $PM_{2.5}$ and PM_{10}. Soils across the Columbia Plateau, however, are very unique compared to other regions of the United States where erosion occurs due to high winds. Soils of the Columbia Plateau are derived from loess and are predominately comprised of silt-size particles. To aid in simulating wind erosion processes in regions dominated by loess, knowledge must be acquired concerning the size of particles eroded from soils.

The Wind Erosion Prediction System has the capability to simulate PM_{10} emissions, but lacks the ability to simulate $PM_{2.5}$ emissions from agricultural soils. Estimating the emission of both $PM_{2.5}$ and PM_{10} is necessary for regional air quality modeling of these pollutants. An initial strategy to simulate $PM_{2.5}$ emissions from soil requires knowledge of the $PM_{2.5}$ to PM_{10} emission ratio. Indeed, knowing the fraction of PM_{10} that is comprised of $PM_{2.5}$ can simplify the algorithm used for estimating $PM_{2.5}$ emissions. However, no studies have examined the $PM_{2.5}$ to PM_{10} emission ratio for agricultural soil or whether this ratio will vary across soil types common to the Columbia Plateau.

The objectives of this research are to:

1. examine the particle size of sediment eroded from agricultural fields during high wind events.
2. ascertain the $PM_{2.5}$ to PM_{10} emission ratio for the major soil types found across the Columbia Plateau.

Recent Accomplishments

Five major soil types common to the Columbia Plateau were collected and prepared to assess threshold friction velocity, under varying conditions of soil water content and crust cover, in a portable wind tunnel. Constraints in using the wind tunnel necessitated delaying measuring the threshold velocity until 2010.

Soil hydraulic properties of long term cropping systems that promote less soil disturbance and more residue cover to control wind erosion were investigated at Ralston, WA. Infiltration, saturated hydraulic conductivity, and in-situ soil water retention were measured in no-tillage spring barley / spring wheat, winter wheat / summer fallow, and spring wheat / chemical fallow rotations after sowing spring wheat in the spring and after sowing winter wheat in late summer. Infiltration and saturated hydraulic conductivity in spring and late summer were greater for no tillage spring barley / spring wheat than for winter wheat / summer fallow and spring wheat / chemical fallow. Larger or more continuous pores in no tillage spring barley / spring wheat likely contributed to more rapid soil water flow in spring and late summer as compared with the other cropping systems.

Sediment transport and PM_{10} emissions were examined under different tillage intensities during the summer fallow phase of a winter wheat / summer fallow rotation at Lind, WA. Tillage treatments imposed during summer fallow included conventional tillage (cultivated and chiseled in autumn, cultivated in spring, and rodweeded during summer), reduced tillage (undercut in autumn and spring and rodweeded during summer), delayed-minimum tillage (undercut in spring and rodweeded during summer), and no tillage (undisturbed throughout the fallow period). Sediment transport and PM_{10} emissions were respectively measured with an iso-kinetic sampler and aerosol sampler inside a portable wind tunnel. Horizontal sediment flux and PM_{10} flux during summer fallow tended to increase for each subsequent tillage operation. After each tillage or sowing operation, sediment and PM_{10} flux generally ranked from highest to lowest as follows: conventional tillage, reduced tillage, delayed-minimum tillage, no tillage.

Planned Research

An objective of our research is to examine the particle size of sediment eroded from agricultural fields during major high wind events. Sediment has been collected from eroding field sites since about 1993. These samples have been archived, but supporting information about the weather or field characteristics at the time of the erosion event are often difficult to locate. We will examine particle size of eroded sediment from five major dust storms that have occurred over the past 10 years. Dust storms will be screened for amount of eroded sediment and availability of weather and field information. Sediment from these storms will be analyzed using a sonic sieve to fractionate the sediment into sizes >100µm, 100-60µm, 60-30µm, 30-10µm, and <10µm. Two subsamples from each BSNE sampler located in the field during the dust storm will be screened through the sonic sieve. Although the number of BSNE samplers deployed in the field during a dust storm varied across years, BSNE samplers were installed at 0.05, 0.1, 0.2, 0.5, and 1.5 m heights above the soil surface and at a minimum of six locations at the leeward side of an eroding field. Trends in the size of eroded sediment with height will be identified from plots of size fraction with height. Results will be compared with those found for sandy and clayey soils in other regions of the United States (Zobeck and Fryrear, 1986; Weinan and Fryrear, 1996).

Another objective of our research is to ascertain the $PM_{2.5}$ to PM_{10} emission ratio for the major soil types found across the Columbia Plateau. The five major soil types have been collected and sieved through a 2 mm screen. Soil types that will be examined in this study include Athena silt loam, Palouse silt loam, Ritzville silt loam, Walla Walla silt loam, and Warden silt loam. Samples were collected from the upper 3 cm of the soil profile. Aluminum trays (2 m long, 0.5 m wide, and 0.02 m deep) will be filled with the air-dried soil. Immediately prior to placing the tray in the wind tunnel, soil samples will be extracted from the tray and processed using a dewpoint potentiometer to determine matric potential. The trays will be placed in the wind tunnel so that the soil surface is flush with the tunnel floor (tray is recessed into the floor of the tunnel which is of wood construction). Wind speed, sediment flux, and $PM_{2.5}$ and PM_{10} concentration will be measured downwind and at various heights above the soil tray. These measurements will be repeated at free stream wind speeds of 5, 10, and 18 m s^{-1}. Wind speed will be measured using pitot tubes, sediment flux using an iso-kinetic sampler, and $PM_{2.5}$and PM_{10} concentrations using DustTrak Aerosol Monitors. Wind speed and $PM_{2.5}$ and PM_{10} concentration will be measured at 1 HZ over a 300 s sampling period; measurements will be replicated four times. $PM_{2.5}$ and PM_{10} flux will be computed over the duration of each sampling period. Results from our wind tunnel investigation will be compared with a limited number of studies that have observed the $PM_{2.5}$ to PM_{10} emission ratio for agricultural soils during high winds (Sharratt and Lauer, 2006).

References cited

Sharratt, B.S. and D. Lauer. 2006. Particulate matter concentration and air quality affected by windblown dust in the Columbia Plateau. *J. Environ. Quality* 35:2011-2016.

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