Measuring Specific Surface of Soil with the WP4

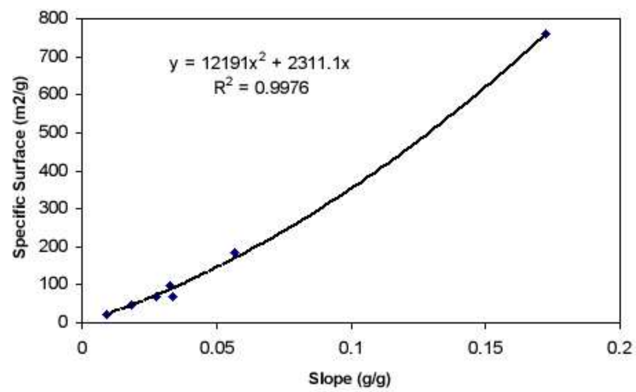
The specific surface area of a soil sample is the total surface area contained in a unit mass of soil. Soils with high specific surface areas have high water holding capacities, more adsorption of contaminants, and greater swell potentials.

Specific surface is therefore an important parameter. Specific surface is closely tied to particle size distribution. This can be seen with a simple thought experiment. A cube, 1 cm on a side, with a density of 1 g/cm^3 has a surface area of 6 cm^2/g. If the cube were divided into smaller cubes 1 mm on a side, the resulting 1000 cubes would have the same mass of material, but a surface area ten times that of the single cube, or 60 cm^2/g. If the cube were divided into 10^{12} cubes 1 um on a side, the surface area would be 6 x 10^4 cm^2/g. Thus, the smaller the particles, the greater the surface area per unitmass of soil.

Various approaches have been used to measure specific surface area, including adsorption of nitrogen and other gases on the soil. The most commonly method at present uses the adsorption of ethylene glycol monoethyl ether (EGME). This involves saturating prepared soil samples, equilibrating them in a vacuum over a CaCl2-EGME solvate, and weighing to find the point when equilibrium is reached. The specific surface is then determined from the mass of retained EGME in comparison to the amount retained by pure montmorillonite clay, which is assumed to have a surface area of 810 m^2/g (Carter et al. 1986). The measurement typically takes around 2 days to complete.

Soil is typically in a hydrated state, and surface area measurements should apply to that state. It would therefore be ideal if water could be used as the probe to determine the specific surface area. Quirk (1955) reviewed such measurements and concluded that water clusters around cation sites, and can therefore lead to errors in the measurements. Recent work, however, using more modern methods for measuring the energy state of the water in the soil, show promise as simple methods for determining specific surface of soil samples. Campbell and Shiozawa (1992) correlated specific surface of six soils with measurements of the slope of a moisture release curve and found excellent correlation.

Figure 1 shows the data for the six soils, along with an additional point for Ca-montmorillonite. The slope (x axis value) is equal to the water content of the sample at a water potential of -123 MPa, and is the inverse of the slope used by McKeen (1992) to quantify expansive soils, so it is clear that all these properties are closely linked.



A recent paper by Tuller and Or (2005) obtained the following equation relating surface area and the moisture characteristic:

$$w = \left[\frac{k}{6\pi(\rho_w \psi)} \right]^{1/3} \rho_w S$$

Where *w* is water content (g/g), ρ_w is the density of water (1000 kg/m^3), is the water potential (J/kg), S is the specific surface (m^2/kg), and k is the Hamaker constant, which they took as -6 x 10-^{20} J. They used the WP4 to obtain water potentials for samples at low water content. These, along with the measured water contents, were used to estimate surface area for the same samples shown in Fig. 1 plus one additional soil. The results are shown in Table 1.

	Hygrometric surface area (m^2/g)	EMGE surface area (m^2/g)
L-soil	24	25
Royal	58	45
Walla Walla	71	70
Milville	72	73
Salkum	84	51
Palouse B	181	203
Ca - montmorillonite	597	760

Table 1 Tuller and Or (2005) specific surface calculations compared to EGME

The agreement between the two methods is generally good. The low point here, as well is in Fig. 1 is the Salkum soil. Its area may have been underestimated by the EGME method due to the pretreatment. The montmorillonite area is also low, but that value was taken from the literature, and not re-measured in this study. These results are preliminary, but indicate that the WP4 may be a useful instrument for determining specific surface of soils.

References

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