Comment on Chain Method for Measuring Soil Roughness

It is common knowledge among those who study wind erosion and develop plans for controlling it that soil ridges and surface random roughness have a major influence on wind erosion. My colleague, Saleh (1993, 1994), has proposed a chain method to measure both random and oriented roughness. A roughness $R$ is calculated from

$$ R = (1 - \frac{L2}{L1})100 \tag{1} $$

where $L1$ is the length of chain required to span roughness element(s) for a horizontal distance $L2$.

At first glance, the procedure has appeal. It is simple to use and inexpensive and appears to give reasonable results. As ridge height increases without changing ridge spacing ($L2$), the length of chain needed to span the ridge will increase; thus, it can be seen from Eq. [1] that the calculated roughness also will increase. Similarly, if ridge height is held constant and ridge spacing is increased, roughness as calculated by Eq. [1] will decrease. However, a problem occurs when ridge height and ridge spacing vary together. When $L2$ and $L1$ vary but the ratio remains constant, Eq. [1] produces unrealistic results.

For well-defined ridges, like the constructed wooden isosceles triangular ridges used by Saleh (1994), $L1$ can be computed directly based on the geometry of the ridges. Thus, to estimate the length of chain required to span one ridge cycle, let $s$ be ridge spacing, which is equal to $L2$ for one ridge, and $h$ be ridge height for isosceles triangular ridges (Fig. 1), then

$$ L1 = s/cos[arctan(2h/s)] \tag{2} $$

Substitution of Eq. [2] into Eq. [1] for $L1$ gives:

$$ R = [1 - \cos[arctan(2h/s)]]100 \tag{3} $$

Table 1 shows the results of the calculated roughness $R$ from Eq. [3] for four ridges (1, 2, 3, and 4) under column heading R2. Column R1 of Table 1 is from Saleh’s (1994, Table 1) chain method measurement. The agreement between measured and calculated values is as good as would be expected. However, when other ridge configurations (5, 6, and 7 of Table 1) with the same $L2/L1$ ratio are considered, Saleh’s (1994) chain method, Eq. [1], would give each of them the same roughness (Table 1, heading R2). Obviously, these three ridges, depicted in Fig. 1, are not the same.

Consider the different effects that the ridges of Fig. 1 have on the wind speed profile parameters. The familiar logarithmic law for wind speed profile is given by

$$ u = u_0/k \ln[(z - d)/z_0] \tag{4} $$

where $u$ is the wind speed at height $z$, $u_0$ is the friction velocity, $k$ is the von Karman constant (0.4), $d$ is the displacement height, and $z_0$ is the aerodynamic roughness parameter. The displacement height was estimated by multiplying the ridge height by 0.5, and the roughness parameter $z_0$ by multiplying the ridge height by 0.065 (Abtew et al., 1989). Then the friction velocity was calculated with wind speed of 10 m/s at 10 m height. These friction velocities show that aerodynamically the ridges are very different.

A ridge-roughness factor ($K_r$) based on height of ridges has been used in the wind erosion equation to estimate the reduction of wind erosion caused by nonerodible ridges. The traditional equation (Saleh, 1993) is

$$ K_r = 4h^2/s $$

and the equation proposed by Saleh (1993, 1994) is

$$ K_r = C_r0.02118/N $$

where $N$ is the number of ridges covered under $L2$ length. Table 1, heading R2, shows that the number of ridges covered under $L2$ length $N$ was always one. Suppose I had let $N$ be

\begin{table}[h]
\begin{tabular}{|c|c|c|c|c|}
\hline
Ridge & Ridge Height, m & \multicolumn{3}{c|}{Horizontal Distance, m} \\
\hline
1 & 0.10 & 0.02 & 0.10 & 0.283 \\
2 & 0.25 & 0.33 & 0.25 & 0.21 \\
3 & 0.50 & 0.50 & 0.50 & 1.42 \\
4 & 1.00 & 0.83 & 0.83 & 1.41 \\
\hline
\end{tabular}
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