Comment on “Predicting event soil loss from bare plots at two Italian sites” by Bagarello et al. 2013 (DOI: 10.1016/j.catena.2013.04.010)

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A B S T R A C T

The USLE-MM event erosivity factor is given by the power of the product of the runoff ratio (QR), total storm energy (E) and the maximum 30-min intensity (I30). Bagarello et al. (2013) develop equations to provide common values of this power at Messe and Sparacia experiment stations in Italy. The approach produced a false perception that the erodibility of the soils at the two experiment stations in Italy was the same when QREI30 is greater than 6 – 9 MJ mm ha\(^{-1}\) h\(^{-1}\) while below this critical level, the soil at Messe has a greater erodibility than the soil at Sparacia.

Bagarello et al. (2013) analysed data from bare runoff and soil loss plots of various lengths (11 m to 44 m) at two locations in Italy to determine relationships between event soil loss and the QREI30 index to a power greater than 1.0. For the data collected at the Messe experimental station south of Perugia in central Italy, they obtained

\[
A_{eUP} = 0.0847(QREI_{30})^{1.164}
\]

where \(A_{eUP}\) is the soil loss (t ha\(^{-1}\)) adjusted to the loss that would occur on the “unit” plot (22.1 m long bare fallow area on a 9% slope gradient) and \(QREI_{30}\) is the product of the runoff ratio (QR), total storm energy (E) and the maximum 30-min rainfall intensity (I30). The \(QREI_{30}\) index was proposed by Kinnell and Risse (1998) as the erosivity index in the USLE-M, a modification of the USLE shown to predict event soil loss better than the USLE when event runoff is known or predicted well. For the data collected at the Sparacia experiment station, they obtained

\[
A_{eUP} = 0.0306(QREI_{30})^{1.469}
\]

When plotted on log scales, they perceived that the two equations converged when \(QREI_{30}\) was higher than about 6 MJ mm ha\(^{-1}\) h\(^{-1}\). Consequently, they proposed that a common equation should be used when \(QREI_{30}\) was above 6 MJ mm ha\(^{-1}\) h\(^{-1}\);

\[
A_{eUP} = 0.058(QREI_{30})^{1.278}
\]

Below that critical value of \(QREI_{30}\), they concluded that, for Messe,

\[
A_{eUP} = 0.087(QREI_{30})^{1.335}
\]

and for Sparacia,

\[
A_{eUP} = 0.030(QREI_{30})^{1.335}
\]

Fig. 1 shows the curves for these 5 equations plotted on logarithmic scales and it would seem that, as claimed by Bagarello et al., Eqs. (3) – (5) do not produce significantly different predictions of event soil loss to those produced by Eqs. (1) and (2).

As noted above, the values of \(A_{eUP}\) used to develop Eqs. (1) – (5) resulted from an often used practice of rescaling the soil loss data from bare runoff and soil loss plots of various lengths and gradients using recognised equations for predicting the effects of slope length and gradient to generate values for the unit plot situation (22.1 m long bare fallow area on a 9% slope gradient). This approach is
questionable when, as at Sparacia, the runoff ratio decreases with slope length. Consequently, Bagarello et al. also analysed the data for only plots that were 22 m long and observed that above QREI30 = 9 MJ mm h⁻¹ h⁻¹,

\[ A_{UP} = 0.062(Q_{REI30})^{1.253} \]  

(6)

Below that critical value of QREI30, they concluded that, for Messe,

\[ A_{UP} = 0.106(Q_{REI30})^{1.308} \]  

(7)

and for Sparacia,

\[ A_{UP} = 0.0319(Q_{REI30})^{1.308} \]  

(8)

However, they observed that there was no appreciable difference between the three equations developed for all plot lengths (Eqs. (3), (4), and (5)) and Eqs. (6), (7), and (8).

The USLE-MM, a modification of the USLE-M (Kinnell and Risse, 1998) proposed by Bagarello et al. (2010), is based on the assumption that

\[ A_{UP} = b_1(Q_{REI30})^{c_1} \]  

(9)

where \( b_1 \) represents soil erodibility if \( c_1 \) does not vary between soils or geographic locations. The approach adopted by Bagarello et al. (2013) focuses on the development of equations which have common values of \( c_1 \) at Messe and Sparacia so that differences between the two locations can be perceived to be simply taken into account through variations in USLE-MM soil erodibility factor (\( b_1 \)). Given Eqs. (3), (4), and (5), and Eqs. (6), (7), and (8), Bagarello et al. suggest that, for the USLE-MM model, the erodibilities of the soils at the two locations are the same when QREI30 is greater than 6 – 9 MJ mm h⁻¹ h⁻¹ but they differ appreciably when QREI30 is less than 6 – 9 MJ mm h⁻¹ h⁻¹. However, Bagarello et al. did not (a) show that Eqs. (3), (4), and (5) and (6), (7), and (8) account significantly more of the variation event soil loss than that accounted for by Eqs. (1) and (2), and (b) provide a physical explanation for the change in the power of QREI30, and the step change in the regression coefficient at about 6 – 9 MJ mm h⁻¹ h⁻¹. Arguably, the power values for the data below and above 6 – 9 MJ mm h⁻¹ h⁻¹ are not significantly different from each other but three erodibility values exist at the two locations when the model represented by Eqs. (3), (4), and (5) and (6), (7), and (8) is used. While it could be argued that there could be an increase in erodibility at Sparacia if rilling only occurred when QREI30 exceeds 6 – 9 MJ mm h⁻¹ h⁻¹, the association of the critical value of QREI30 with the onset of rilling would not account for the drop in erodibility when QREI30 exceeds 6 – 9 MJ mm h⁻¹ h⁻¹ at Messe.

There is no doubt that Eq. (9) is appropriate at Messe and Sparacia but, as noted by Bagarello et al. (2013) in the introduction to their paper,

\[ b_0(Q_{REI30}) = Ve \left[ b_2P_e^{r_e} \right] \]  

(10)

where \( V_e \) is runoff amount, \( P_e \) is rainfall amount, \( b_0 \) is soil erodibility when soil loss is from the unit plot when the QREI30 index is used, and the term in the squared bracket is sediment concentration, the mass of soil lost per unit of runoff. Consequently, for the USLE-MM

\[ b_1(Q_{REI30})^{c_1} = Ve \left[ b_1 \left( E_{30}P_e^{-r_e} \right)^{c_1} \right] \]  

(11)

In Bagarello et al. (2011), it was observed that the value of \( A_{UP} P_e (EI30)^{-1} \) increased with \( V_e \) to a power of about 1.48 on 22 m long plots at Sparacia so that runoff had a significant effect on sediment concentration at that location. Arguably, the value of \( c_1 = 1.164 \) in Eq. (1) indicates that variations in runoff had less effect on sediment concentration at Messe than Sparacia but the value of \( b_1 = 0.0847 \) generates a false perception that the soil at Messe is inherently more erodible than the soil at Sparacia. It is difficult to justify the approach adopted by Bagarello et al. on physical grounds and the perception that a realistic common power equation exists at the two locations when QREI30 exceeds 6 – 9 MJ mm h⁻¹ h⁻¹ is less credible when Eqs. (1), (2), (3), (4) and (5) are plots using linear scales (Fig. 2).

References


