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Comment on 'Soil organic stocks are systematically overestimated by misuse of the parameters bulk density and rock fragment content' (Poeplau *et al.*, 2017, SOIL, 3(1), 61-66).

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Poeplau et al [2017] recently outlined the systematic overestimation of soil organic carbon (SOC) stocks due to incorrect application of bulk density and rock fragment content in calculation of SOC stocks. Unfortunately, the method they propose to rectify this is associated with a greater error (due to assumption of rock density, extra calculation steps and propagation of errors) than the simpler mass balanced derived equation for SOC stock calculations, outlined below. Using a mass balance approach to C stocks we define:

$$C_{Stock} = Mass\ Proportion_C \cdot \rho \cdot d \quad \text{(i)}$$

Where C_{stock} is the amount of carbon stored in a given soil area (kg m^{-2}) and depth, d (cm); Mass $Proportion_C$ is the carbon content of the whole soil (g kg^{-1}) and ρ is the bulk density of the whole soil (g cm^{-3}).

Using a mass balance approach on the Mass Proportion of C in the whole soil, we obtain:

$$MassProportion_C = C_{Content,\ fine} \cdot Mass\ Proportion_{fine} + C_{Content,\ coarse} \cdot Mass\ Proportion_{coarse} \quad \text{(ii)}$$

Where $C_{Content,fine}$ is the mass proportion of C in the fine soil fraction (g kg^{-1}), Mass $Proportion_{fine}$ is the mass proportion of the fine soil to the whole soil sample (g kg^{-1}) and $C_{Content,\ coarse}$ is the mass proportion of C in the coarse soil fraction (g kg^{-1}), Mass $Proportion_{Coarse}$ is the mass proportion of the coarse soil to the whole soil sample (g kg^{-1}), generally referred to as the rock content. $C_{Content,\ coarse}$ is assumed to be negligible (i.e. = 0) in all methods, so that the equation (2) simplifies to:

$$MassProportion_C = C_{Content,\ fine} \cdot Mass\ Proportion_{fine} \quad \text{(iii)}$$

The Mass $Proportion_{fine}$ is

$$MassProportion_{fine} = \frac{Mass_{fine}}{Mass_{Total}} = \frac{Mass_{fine}}{Mass_{fine} + Mass_{coarse}} \quad \text{(iv)}$$

$$= \frac{Mass_{fine} + Mass_{coarse} - Mass_{coarse}}{Mass_{fine} + Mass_{coarse}} \quad \text{(v)}$$

$$= 1 - Mass\ Proportion_{coarse} \quad \text{(vi)}$$

Substituting equation (vi) into equation (iii) we obtain:

$$MassProportion_{C} = C_{Content,\ fine} \cdot (1 - Mass\ Proportion_{coarse}) \quad \text{(vii)}$$

Substituting equation (vii) into (i) we obtain:

$$C_{Stock} = C_{Content,\ fine} \cdot (1 - Mass\ Proportion_{coarse}) \cdot \rho \cdot d \quad \text{(viii)}$$

This looks similar to equation (5) in Poeplau *et al.* [2017]. However, they use the volumetric proportion, not the mass proportion of rock fragments, which is mathematically incorrect. They also state that their equation (6) 'resembles' equation (viii). However, their M4 is actually a more convoluted and obtuse equivalent to the commonly known and applied equation (viii) (Ellert and Bettany 1995; Goidts et al. 2009, Mikha et al. 2013; Orgill et al. 2013). This can be shown by combining equations (3) and (6) from Poeplau *et al*, which illustrates the redundancy of using the rock density to calculate SOC stocks.

Equation (viii) is also mathematically equivalent to calculations according to equations (7) and (8) in Poeplau *et al*. However, the recommended use of the mass of fine fraction for the calculations by Poeplau *et al*. also has a greater potential error than using the mass proportion of rocks according to equation (viii). The advantage of using the rock mass to correct the stocks is that rocks are (nearly) entirely conserved during sieving, whereas fine soil mass is lost as dust during sieving, increasing uncertainty in the calculations. In contrast, M4 (equations (3) and (6)) of Poeplau *et al*. requires an estimation of rock density (they recommend assuming a rock density of 2.63 g cm^{-3}) to calculate the bulk density of the fine soil sample as well as to adjust for rock content. Unfortunately, the additional calculations required also increase the uncertainty of the estimate due to error propagation. Although mathematically equivalent, calculations according to their M4 are therefore less precise due to extra sources of error (derived from either analytical or assumed rock density as well as error propagation). As such, using equation (viii) above, based on the C content of the fine soil, mass proportion of rocks and bulk density in the whole sample will yield the most precise estimate of C stocks.

With regards to eliminating the depth, d, from the calculations (equation (9) in Poeplau *et al.*), this is only applicable to samples taken as a whole which are then not subdivided further. Samples are frequently cut into smaller depth increments for depth explicit sampling, e.g. to investigate the depth distribution of SOC, so that equation (9) in Poeplau *et al*. is only of use in a limited number of cases. In order to avoid possible errors due to the application of equation (9) for samples which have been subdivided into discrete depth increments, it seems more appropriate to retain the universally applicable equation (viii).

In summary, Poeplau *et al*. have clearly demonstrated the need to adjust for coarse fragments >2 mm in SOC stock calculations. Unfortunately, their recommendation has added some confusion to the correct method of calculation of SOC stocks via the introduction of unfamiliar formulas. Whilst mathematically correct, their formulas are associated with larger errors than the standard equation and are not universally applicable, so present no clear advantage. As such, we recommend the use of equation (viii) for SOC stock calculations.

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