Member Submitted Articles

Saturated Hydraulic Conductivity (K_s) expressed as pK_s

Peter Zund and Bernhard Buchter

Saturated hydraulic conductivity is a key factor in soils together with the water characteristic curve. Values of the latter such moisture content and matric potential are easily understood however saturated hydraulic conductivity values are not so easily understood. This is partly due to the large range of values that saturated hydraulic conductivity can have, for example K_s is between 10^{-3} and 10^{-7} m/s in most soils, and 10^{-2} m/s in packed gravel and 10^{-9} m/s in landfill liners. Also, contributing to the confusion is the wide variety of units used to report hydraulic conductivity. While SI units are the standard (for example m/s), units such as cm/s, mm/h, mm/day, cm/day, m/day are routinely used and sometimes inch/h and feet/day. Hence the need for conversion tables in some texts. Due to the heterogeneity of soils and a myriad of soil attributes that can affect hydraulic conductivity, is it accurate to report specific hydraulic conductivity values instead of a range of values? Scale at which hydraulic conductivity is measured at and the scale at which the value is used at also needs to be considered. Is it right to use laboratory determined saturated hydraulic conductivity values for a small soil core in a landscape-wide simulation model?

Because of the aforementioned we would like to suggest to the soil science community that saturated hydraulic conductivity (K_s) be expressed as a *negative* log and called pKs.

$pK_s = -\log_{10} (K_s[m/s])$

This is similar to expressing the concentration range of H_3O^+ ions in chemistry between 10^{-1} – 10^{-14} mol/L or as pH 1– 14. For pK_s, SI Units (m/s) would need to be used. The range of expected values for pK_s in soil would commonly be between 3 and 7. This range is far more straightforward to comprehend than other non-logarithmic ranges.

For example the classes of saturated hydraulic conductivity in the Yellow Book, from Very Slow corresponding to K_s < 5 mm/day to Very High corresponding to K_s > 500 mm/day can be converted to SI Units as follows: $K_s < 5.8*10^{-8}$ m/s for Very Slow to $K_s > 5.8*10^{-6}$ m/s for Very High or simply: Very Slow: $pK_s > 7.2$ to Very High $pK_s < 5.2$. An additional benefit is that the arithmetic mean of a range of pK_s values can easily be calculated and is more appropriate than the arithmetic mean of K_s itself, because Saturated Hydraulic Conductivity is log-normally distributed. Considering the error in measurement of K_s due to the method used, often quite constant if expressed relative to the measured value as well as the variability of soils in the landscape, the adoption of pK_s would introduce more appropriate classes of values to use, compare and discuss soil hydraulic conductivity. For example the division of pK_s into steps of 1, corresponding to steps of 1 order of magnitude for K_s. The problem of units will also disappear and thus simplify the discussion of hydraulic conductivity among soil scientists allowing more time to focus on solving the many problems encountered and as yet unresolved when measuring hydraulic conductivity.

Further discussion and analysis of the rational of using pK_s can be found at www.alberta.ch/Dokumente/pKsat_14.pdf.