An Automated System for the Quasi-Continuous Measurement of the Particle-Size Distribution

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Introduction

Soil texture is an important parameter for many soil and land-related studies, among others for soil hydraulic and transport transfer functions (PTTs). Common soil particle-size classes are required to be able to uniformly determine the texture of the soils. However, it is not always possible – due to the different national classification systems (see figure) – and much valuable information is disregarded while either deriving or applying PTTs.

One way to get common particle-size information is to interpolate the particle-size distribution (PSD) curve. Advanced interpolation solutions are becoming available, but there is always uncertainty associated with these techniques. Another possibility is to measure all PSD curves in such a way that it is compatible to the commonly used classification systems.

A new automated measurement technique is introduced, that can easily provide PSD data compatible to any (and all) of the existing national and international classification systems at the same time. A computerized measurement system has been developed to record density changes in a settling-tube system in arbitrary small time steps. This in turn allows the derivation of a quasi-continuous PSD curve. The measurement is based on anemometry (Stokes-law), thus the system is compatible to the most commonly applied settling-tube type measurement systems.

![Scheme of equipment](image)

**Physical model**

\[ \Delta G = \frac{1}{2} \cdot A \cdot g \cdot (\rho_p - \rho_a) \cdot \sum_{i=1}^{n} \left[ \left( l - v_i \cdot t \right) + \left( l - v_i \cdot t \right) \right] \]

- $A$: cross-section of floating cylinder, m$^2$
- $g$: gravity acceleration, 9.81 m/s$^2$
- $\rho_p$: density of suspended particles, kg/m$^3$
- $\rho_a$: density of air, kg/m$^3$
- $l$: height of floating cylinder, m
- $\Delta G$: change of weight, kg.m.s$^{-2}$
- $v_i$: deposition speed of $i^{th}$ fraction m/s
- $n$: number of fractions

**Calculation method**

Multiple linear regression is performed in each required particle-size range. Particle-size distribution can be calculated from the normalized integral concentration of every particle size fraction.

![Calculated particle size distribution](image)

**Features**

- The new evaluation method of measured values takes the density changes along the anemometer body into consideration, so it avoids the problem of reference point determination.
- Initial comparative measurements show excellent correspondence with conventional settling-tube results for various soil materials.
- Reproducibility of the measurement shows to be very high.
- Using this technique does not require more sample preparation than past methods.
- The automated reading requires less manpower to perform the measurement, which reduces risks of human errors.
- It reveals multi-gradability and fine-scale details of particle-size distribution.

**Conclusion**

The presented particle-size measurement system makes the unification of soil texture description possible while keeping compatibility with the systems commonly used nationally and internationally. The provided quasi-continuous particle-size distribution curve could be useful as standard for the description of PSD. Using such a curve, current limitations in soil texture comparisons could be overcome, errors associated with particle-size interpolations could be disregarded. Background for further international co-operation may be improved, advancing the creation of further international databases and maps, and allowing the deduction of more reliable conclusions than currently possible.