Testing the ability of submersible spectrophotometers to trace suspended sediment sources at high-temporal frequency

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Suspended Sediment (SS) sampling at the catchment outlet: limited by *workload*, automatic sampling equipment, and the need for *sufficient quantities of SS* for analysis.

Laboratory analysis: analysis of SS properties involves *high workload*.

Sample preservation: SS properties might *change* during sampling and transport to the lab.

Use of spectrophotometer?
2. WHAT IS SPECTROPHOTOMETRY?

Working principles:

→ The xenon lamp, the light emitting source, emits light (photons). These photons contain different energy levels (wavelengths). Depending on properties of the water & sediments, these photons get absorbed. The spectrophotometer here measures over the UV-VIS wavelength range (200-730nm).

Source: http://www.s-can.at/
CAN A SPECTROPHOTOMETER INDICATE SS PROPERTIES?

→ Current application focuses on (drinking/waste) water quality parameters

Measuring:

• Absorbance UV-VIS range.
• TSS, Turbidity, NO$_3$-N, COD, BOD, TOC, DOC, UV254, colour, O$_3$, H$_2$S, assimilable organic carbon.

→ Suitable for detecting SS properties?

• Bass et al. (2011) & Martínez-Carreras et al. (2016) estimated SS properties (Particulate Organic Matter, Loss-on-ignition) by calibrating the spectrophotometer readings using SS samples.

Measuring on high-frequency (e.g. minutes) & Direct in-stream observations

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3. HYPOTHESIS

The absorbance values (200-730nm) measured by the submersible spectrophotometer, influenced by SS properties, can be used as tracers to un-mix sediment samples, assigning relative contributions to their individual sources.

The blue, black and red lines are directly measured by the spectrophotometer. The green line is calculated by taking 0.5*blue line + 0.5*black line (expected absorbance signal mixture)
Using selected soil material as input for a water tank set-up, to test:

How the spectrophotometer readings react to the different selected soils? (6 soils, sieved to 3 fractions: [>32 μm, 32-63 μm, 63-125 μm])

How differences in readings from the selected soils can be used to un-mix artificial created mixtures comprising of these soils? (using 2, 3 and 4 soil sample mixtures; with known contributions)

Selected soils and examples of mixtures (mixture contributions depicted here are for example purpose only and differ from real contributions used)
HOW DO WE TEST THE HYPOTHESIS?

Input: soils & mixtures
Test in laboratory tank set-up
(Expected) output spectrophotometer

Soil A  Soil B

Spectrophotometer

Tank with 40L demineralised water

Mixing device

Particle Size sensor

Mixture 50% soil A, 50% soil B

#2 soils mixture
4. PRELIMINARY RESULTS

Overall impressions:
- Mixture line measured (blue) and mixture line expected (orange) show same pattern

- Deviations between mixture line measured and mixture line expected range from \( \pm 0\% \) to \( \pm 20\% \)
  \( \Rightarrow \) For 12 tested two-soil mixtures (110 values):
  * 38% of values <5% deviation
  * 61% of values <10% deviation
  * 2 values >20% deviation [21.72 & 24.29%]

  \( \Rightarrow \) For 6 tested three-soil mixtures (59 values):
  * 22% of values <5% deviation
  * 58% of values <10% deviation
  * Highest deviation: 15%

Example of a two-soil sample mixture (upper figure) and a three-soil sample mixture (lower figure). The orange line (expected mixture absorbance signal) is calculated using the relative contributions of the single soil lines (e.g., upper figure, orange line is composed of 20% line soil 1 (red) and 80% line soil 2 (green).
WHAT ISSUES IN THE SEDIMENT FINGERPRINTING APPROACH COULD IN-SITU SPECTROPHOTOMETRY POTENTIALLY TACKLE?

1. The possibility to predict SS source contributions at **high-frequency** (frequency intervals up to 2 minutes).

2. The possibility to investigate changes in SS source contributions over **longer time scales** (e.g. different seasons).

Supported by the advantage that when sources are identified and spectrophotometer spectra are calibrated, **limited SS sampling** (and thus laboratory analysis) is needed.
5. FUTURE RESEARCH DIRECTIONS

• How to deal with influences of concentration and particle size on the absorbance spectra?

• Can we use absorbance data to “see” specific sediment properties (e.g. colour, mineralogical composition) by looking at specific wavelengths/wavelength ranges?

• Testing the approach in a “real-life” situation
  ➔ e.g. small catchment with distinctive SS sources.