

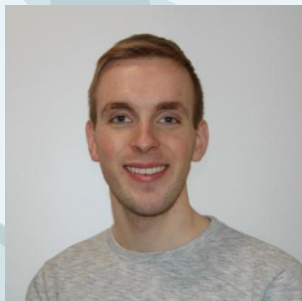
Testing the ability of submersible spectrophotometers to trace suspended sediment sources at high-temporal frequency

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1. SEDIMENT FINGERPRINTING: CURRENT LIMITATIONS FOR HIGH-FREQUENCY OBSERVATIONS

- **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?

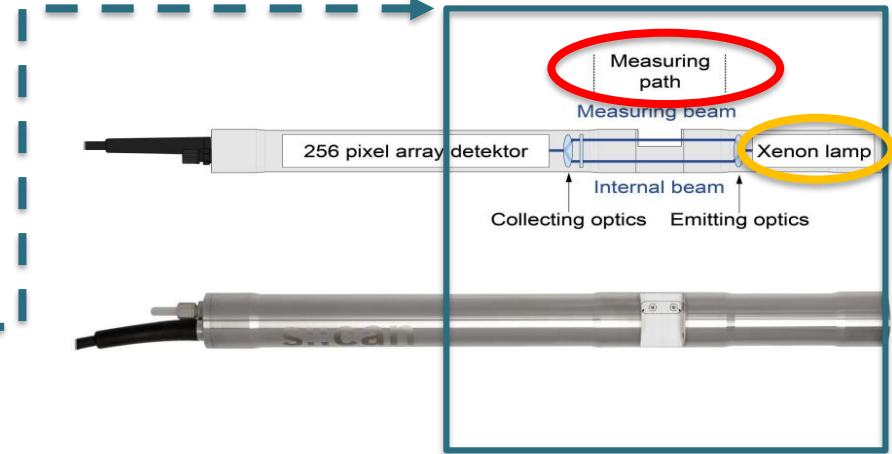
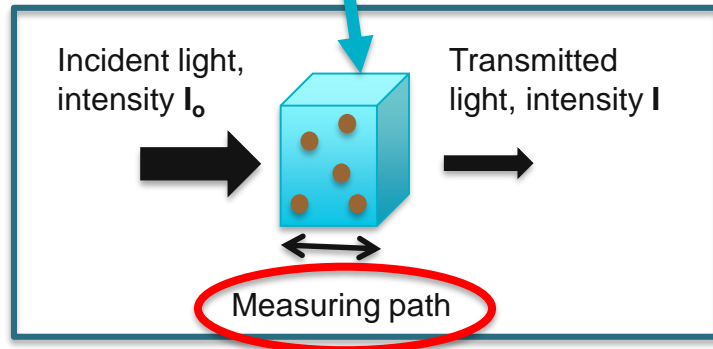


Some methods for collecting SS; Autosampler and Philips sediment trap

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).



Spectrophotometer used in this research experiment, with details on internal structure. Water & sediments are detected while passing through the measuring path.

Source: <http://www.s-can.at/>

CAN A SPECTROPHOTOMETER INDICATE SS PROPERTIES?

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

Measuring:

- Absorbance UV-VIS range.
- TSS, Turbidity, $\text{NO}_3\text{-N}$, COD, BOD, TOC, DOC, UV254, colour, O_3 , H_2S , assimilable organic carbon.

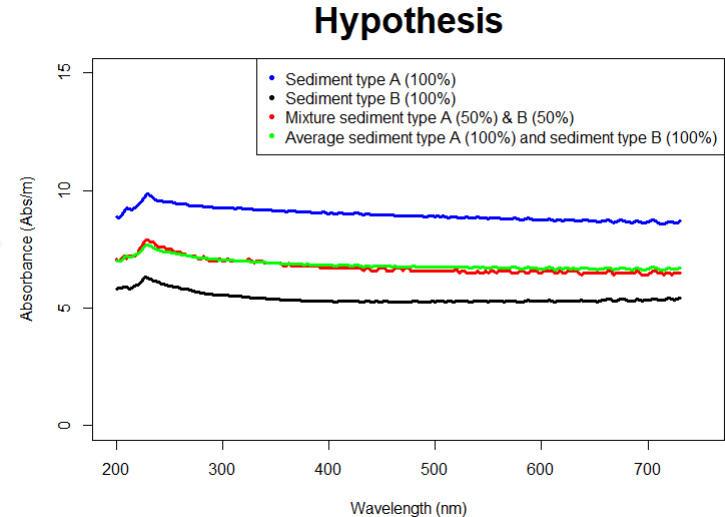
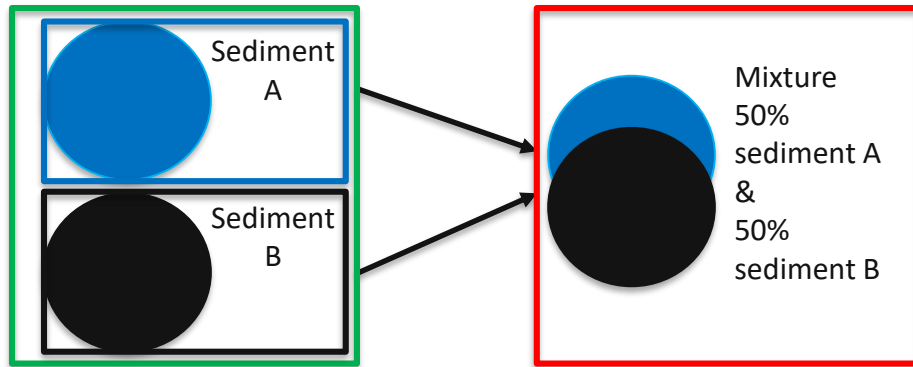
→ **Suitable for detecting SS properties?**

- 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

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.



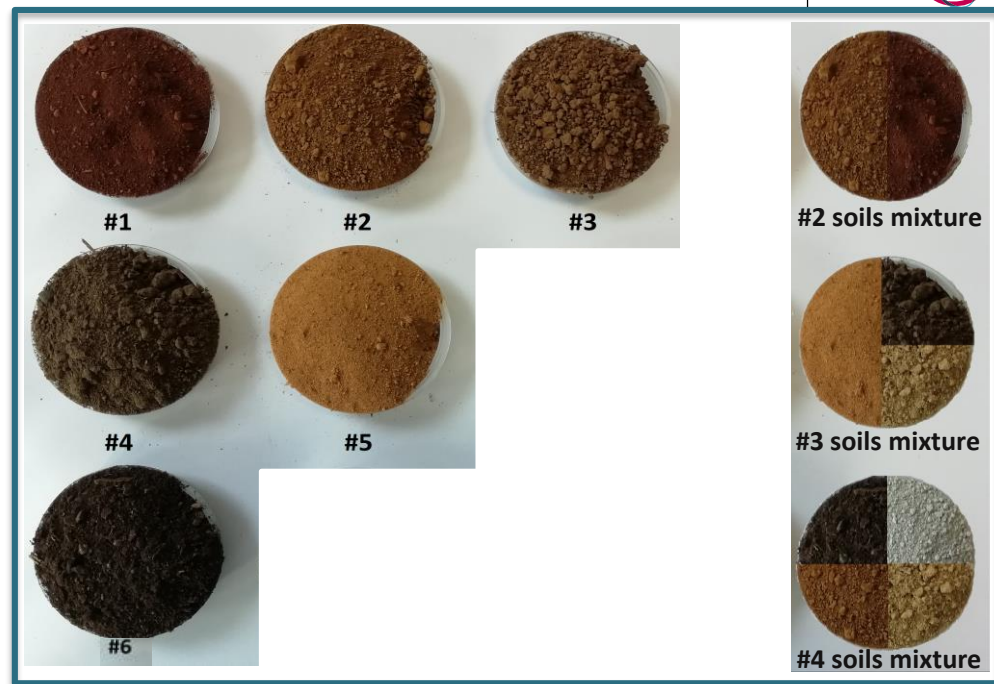
The blue, black and red lines are directly measured by the spectrophotometer.

The green line is calculated by taking $0.5 \times \text{blue line} + 0.5 \times \text{black line}$ (expected absorbance signal mixture)

HOW DO WE TEST THE HYPOTHESIS?

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:
[$>32\ \mu\text{m}$, $32-63\ \mu\text{m}$, $63-125\ \mu\text{m}$])
- 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?

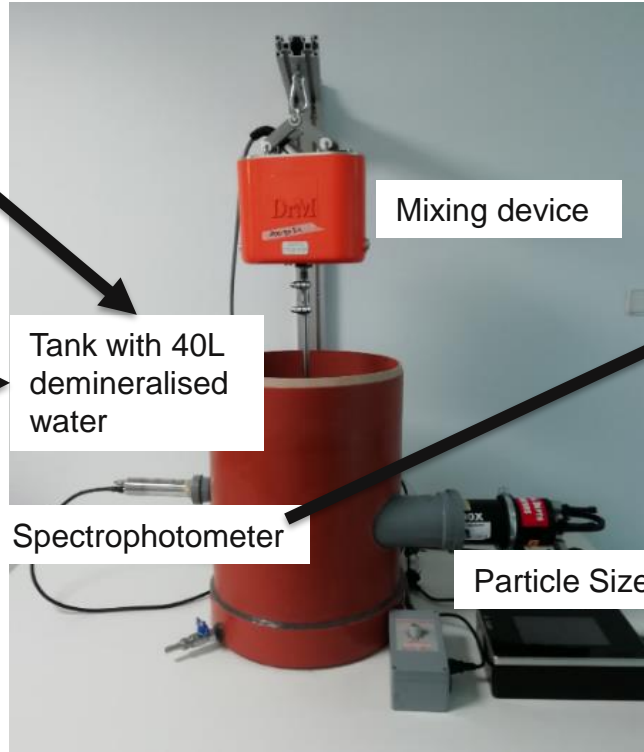


Soil A

Soil B



Mixture 50% soil A, 50% Soil B

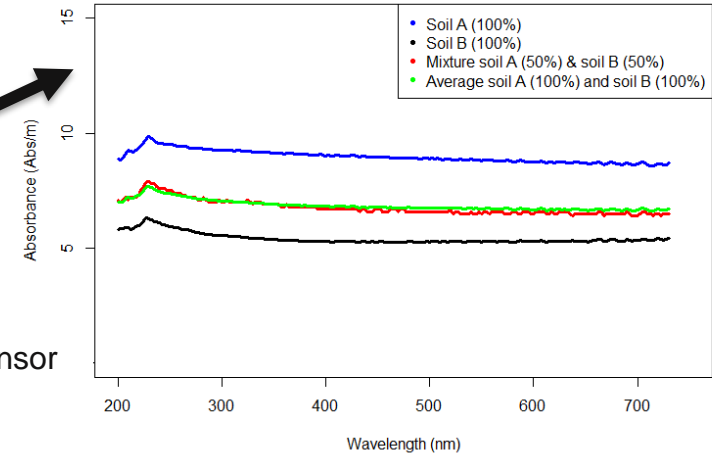


Mixing device

Tank with 40L
demineralised
water

Spectrophotometer

Particle Size sensor



Input: soils & mixtures

Test in laboratory tank set-up

(Expected) output spectrophotometer

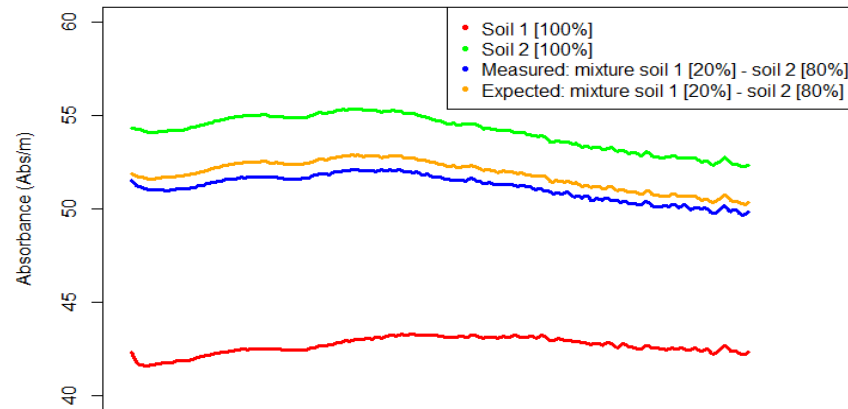
4. PRELIMINARY RESULTS

Overall impressions:

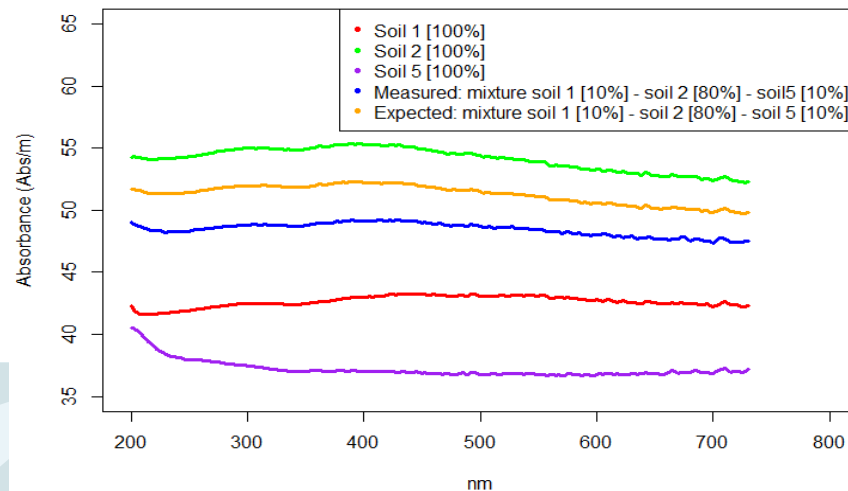
- Mixture line measured (blue) and mixture line expected (orange) show same pattern
- Deviations between mixture line measured and mixture line expected range from **+/- 0% to +/-20%**
 - For **12** tested two-soil mixtures (110 values):
 - * 38% of values <5% deviation
 - * 61% of values <10% deviation
 - * 2 values >20% deviation [21.72 & 24.29%]
 - 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)).

Mixture soil 1 & soil 2 (<32 μ m) - 1000 mg/L



Mixture soil 1, soil 2 & soil 5 (<32 μ m) - 1000 mg/L



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.

