High-precision stream gauging with a field fluorometer

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ID 849494

ABSTRACT

Probably the best method in terms of quality-price ratio in stream flow measurements (gauging) is the so-called global method of fluorescent tracer dilution. This technique is the most effective for gauging boisterous flows. In this method, a given mass of tracer is thrown into the stream (global injection) while a field fluorometer measures the tracer concentration at 2 second interval some hundreds of meters downstream. For optimal precision we carry out a local calibration a few minutes prior to injecting the tracer. The fluorometer is immersed during 2 minutes into 5 liters of a fresh solution of tracer of known concentration prepared with the stream water. This method allows for discarding all influences on the tracer, such as variations of the water temperature, the pH and possible presence of bleaching chemicals (such as chlorine). The large water volume of 5 liters prevents a quick warm-up. We observe that simultaneous measurements at the same place produce results within 0.2% variation.

THE METHOD

We use a GGUN-FL30 field fluorometer (Schnegg 2003) for continuous measurement of a tracer concentration. Any kind of dye tracer can be employed. Uranine (fluoresceine) is not advisable under high sunshine conditions. Naphtionate was the tracer used in this example. It has the interesting property of being invisible. But usually, this is not a concern since the method gives very good results at 10 ppb peak, which is below the sensitivity of the eyes. The process is described in 4 steps on the right.

Sometimes a similar gauging method is used: The continuous injection method. Because this method requires the installation of a constant-flow source (Mariotte bottle) the global injection method must be preferred for its shorter setup time. Any stream can be measured regardless of its flow rate. For example Iguazu River, with its 1500 m^3/s would require 50 kg tracer to achieve a useful half-peak concentration of 5 ppb.

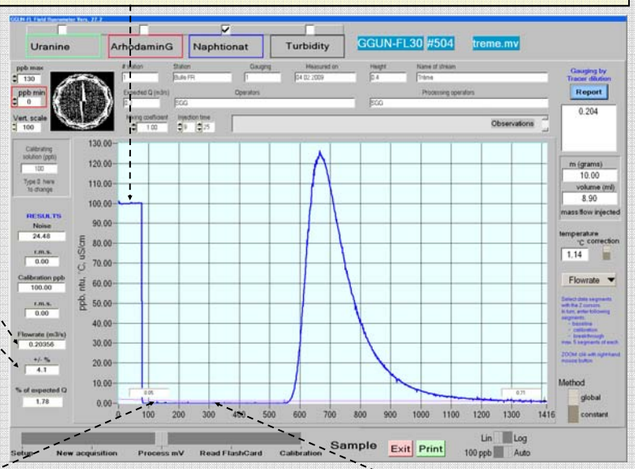
Schnegg, P.-A., 2003.

A new field fluorometer for multi-tracer tests and turbidity measurement applied to hydro-geological problems. Proceedings of the Eighth International Congress of the Brazilian Geophysical Society, Rio de Janeiro.

Other application of the field fluorometer: Investigating dam leakage with fluorescent tracers. Photo by Samuel Hernández, Honduras.

1st step : Local calibration of the fluorometer with steam water
A ready-to-use volume (50 ml) of a solution of tracer at 10'000 ppb is mixed with water from the stream to make 5 liters of calibrating solution at 100 ppb concentration. The fluorometer is immersed in this solution, switched on and set for 2-second sampling rate. It is kept running all the time till the end of the measurement. This allows for the display of the calibration and breakthrough curves on the same screen.

4th step : Data processing
When the tracer signal has returned to its background value, the data is downloaded and displayed on a personal computer. Three signal segments are selected in turn with the two screen cursors (background signal, calibration step, break-through curve). The flow rate is computed and displayed. The error is computed as the contribution of the volumetric errors from the used vessel (injection and calibration volumes). If the curve is not given enough time to return to zero, the program can extrapolate the missing tail with a decreasing exponential function.



2nd step : Installation in the stream
Without stopping the data acquisition, the fluorometer is installed in the stream. The background signal is recorded during a few minutes. Note that this background signal can be particularly high at the excitation wavelength used for naphtionate, due to the presence of DOC. For uranine or rhodamine, this level is below 1 ppb. Since the background is subtracted from the tracer signal, the only requirement is that the background signal remains stable.

3rd step : Tracer injection
The tracer is injected a good distance upstream (here: 10 g naphtionate diluted in 1 liter). The success of the method relies on the perfect mixing on a cross-section of the stream at the measurement point.