

Real-time dye tracer detection in waters of high DOM content

ABSTRACT

In tracer tests carried out in the karst, it is not uncommon to encounter difficulties in detecting ppb concentrations of dye tracers due to a strong spectral background of dissolved organic matter (DOM). We propose a field technique based on a multi-spectral flow-through field fluorometer in which one optical channel is dedicated to DOM concentration measurement. After appropriate signal treatment, the true concentration of the injected tracer (uranine) can be safely recovered.

1. INTRODUCTION

It may prove difficult to reconcile the high analytical resolving level achieved in the laboratory with samples collected by mechanical samplers and the high temporal resolution of field fluorometers. This resolution is often required. Sometimes also, the inconvenience of collecting discrete water samples speaks in favour of using a field fluorometer. However, waters with high DOM content (dissolved organic matter) that occur mostly in groundwater of karst origin are particularly difficult to trace correctly with fluorometers due to the spectral interference of the tracer with the DOM. This is particularly the case for uranine. We show here that this difficulty can be overcome by carefully measuring the DOM concentration during a period of time before the tracer test. Then, a correction can be applied to the uranine detection channel, allowing to remove the background signal originating from natural fluorescence.

2. THE FLOW-THROUGH FIELD FLUOROMETERS

Flow-through field fluorometers have almost completely replaced mechanical samplers in tracer test experiments. Mechanical water samplers have serious limitations such as time resolution, sample ageing and contamination. Because field fluorometers feature high sampling rate and sensitivity, they are suitable for measuring the discharge of a stream or river. Furthermore they are not prone to contamination or to sample ageing. In the device used for this research, as many as four optical channels are working simultaneously, allowing detection of virtually all dye tracers. Provided that they are conveniently selected, three tracers can be separated from a cocktail, allowing multitracing capability. Water turbidity is measured with the fourth optical channel in the red part of the spectrum. Other useful water parameters such as electrical conductivity, temperature and water depth are also measured by the fluorometer probe. The blue light source used for detection of uranine is not absolutely selective, since the fluorescence of the DOM present in the water is also excited by this wavelength (470 nm). Fortunately, the UV source (365 nm) foreseen for the detection of tracers such as Tinopal does not excite the fluorescence of uranine. Thus, the signal from this source results only from DOM concentration, since dissolved organic matter has its maximum extinction wavelength in the UV. This observation allows us to correct the signal.

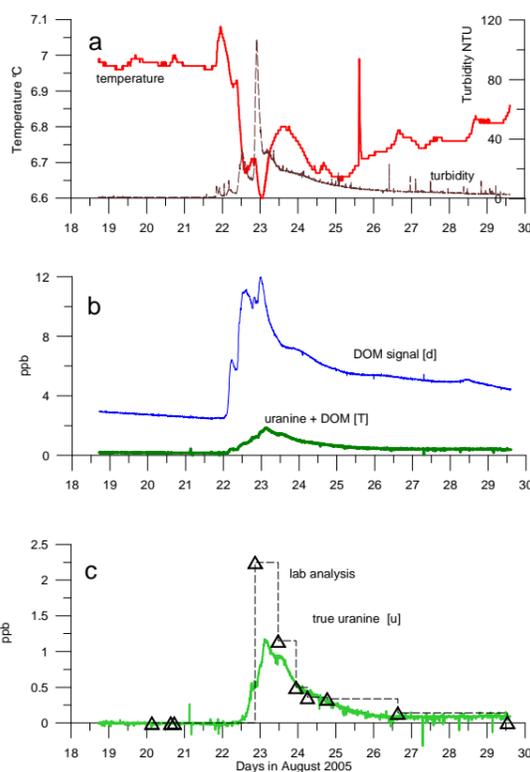
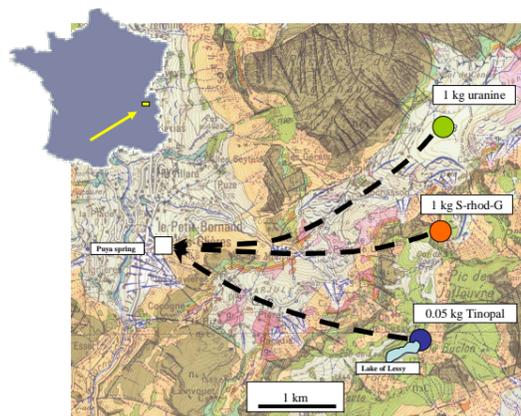


Figure 2

4. CONCLUSION

DOM fluorescent signals can be misleading while interpreting the breakthrough curves from a tracer test carried out with a simple flow-through field fluorometer. We have shown that this concern could be brushed aside if the DOM concentration is measured independently from the tracer. The sensitivity improvement brought by our method may permit the carrying out of tracer tests over longer distances in places such as karst areas where the DOM background might otherwise prevent the use of this technique.

3. APPLICATION TO A DIFFICULT ISSUE : TRACER TEST IN PRESENCE OF DOM

An example of tracer test carried out in the karst of the French Alps shows the ability of the field fluorometer to detect part-per-billion (ppb) concentrations of uranine (fluorescein) in spite of strong fluorescence signal produced by naturally-occurring dissolved organic matter released during the precipitation event of August 2005. The aim of the tracer test was to locate leaking spots of karst origin in the bottom of a small lake used for domestic freshwater supply of a village. Uranine (1 kg) was injected on August 11, 2005. After eleven days and the occurrence of strong precipitations, both DOM and uranine signals showed up, accompanied by strong turbidity signals and water temperature variation. We use an empirical formula to compute the true uranine signal, after removal of the DOM background :

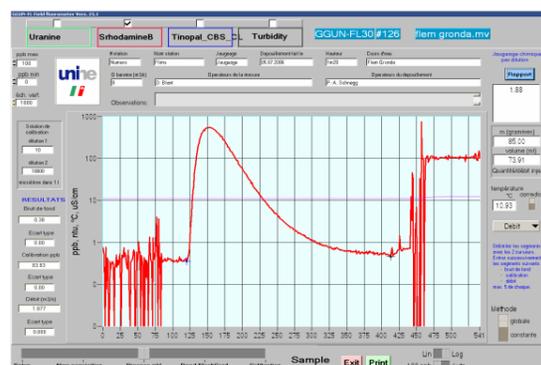
$$[u] = [T] - 0.066 [d] - 0.002 [d]^2$$

where [u], [T] and [d] are the concentrations of the corrected uranine (ppb), the measured uranine and the DOM signal. The numeric coefficient is obtained from the water signal before arrival of the tracer plume by requiring [u]=0. Fig 1a shows the temperature (thick line) and turbidity between the 18th and the 29th of August 2005. Figure 1b shows the raw fluorometer signals [T] and [d], whereas figure 1c shows the signal of uranine [u] cleared up from the DOM signal. To check this result, the uranine concentration was measured with a Perkin Elmer spectro-fluorometer from discrete samples. This comparison shows that the signal measured by the fluorometer is really that of uranine. The misfit of the data taken the 22 August at 21h is understood as a local concentration fluctuation.

Other applications of the GGUN fluorometers at <http://www-geol.unine.ch/geomagnetisme/tract.html>



Dam leakage detection (Honduras)



Stream discharge gauging



Optional water conductivity measurement



Autonomous suspended fluorometer for tracer tests in submarine aquifers