



Portable mass spectrometer allows on-site gas analysis

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Topics: Pollutants | Drinking Water

Analyses of environmental gases which previously required months of laboratory work can now be carried out rapidly in the field. A group of Eawag scientists have developed a portable mass spectrometer allowing on-site measurements – and a spin-off has been created to commercialize the new system.

What are the effects of volcanic gases accumulating in Lake Kivu in central Africa? How does the Rhine's groundwater system function near Pratteln? What is the best way of controlling greenhouse gas emissions from a landfill in northeastern Switzerland? Answers to questions like these can be provided by a newly developed portable mass spectrometer – by the researchers named “miniRuedi” – which allows gas and water samples to be analysed on site and in real time. For example, the concentrations of different gases were determined at a landfill during a one-day measurement campaign. This study supports the optimisation measures to aerate the landfill in order to reduce the formation of methane, a strong greenhouse gas.

System in a suitcase

Eawag environmental physicist Matthias Brennwald, who developed the portable mass spectrometer, explains: “Our instrument, weighing 13 kilograms and mounted in a wheeled suitcase, can be taken to the most remote locations. Once it's been installed on site, the Mini-Ruedi can immediately and efficiently measure gases using very small samples, so it doesn't interfere with the natural dynamics of the environment.” The system, which can operate autonomously, provides continuous measurements of a wide range of gases. The most suitable sites and times for sampling can thus be identified immediately. Long-term operation is also possible. As Brennwald points out, “Analyses which in the

past would have been inconceivable – partly for financial reasons, as they'd have involved months of laboratory work – are now suddenly possible.”

Two weeks instead of six years

For example, using the Mini-Ruedi, the Eawag team only needed two weeks to complete a groundwater analysis project in Australia. With conventional methods and instruments, Brennwald estimates, the team would have required about six years in the lab. Nonetheless, the precision of the new system's measurements is remarkable, with an analytical uncertainty of one to three per cent (versus one to one-and-a-half per cent for a much more expensive, laboratory-based spectrometer). Other advantages offered by the system are its low power consumption (50 watts, no more than a traditional light bulb) and maintenance-free operation. Brennwald emphasizes that “for people used to working with measurement instruments, it only takes a day to learn how to handle the portable system.”

Off-the-shelf components

Although the portable mass spectrometer may look complex at first glance, it actually consists of just four main elements (Fig. 1). The incoming gas passes slowly through a ten-metre-long capillary tube, reminiscent of an elephant's trunk (hence the system's name, “Ruedi Rüssel” being a well-known chain of petrol stations in Switzerland). Two pumps generate the requisite vacuum in the chamber where the composition of the gas mixture and the abundances of the various gases are measured. The system's electronic “brain” is controlled by software developed by Brennwald himself. From here, the results are transferred to a computer.

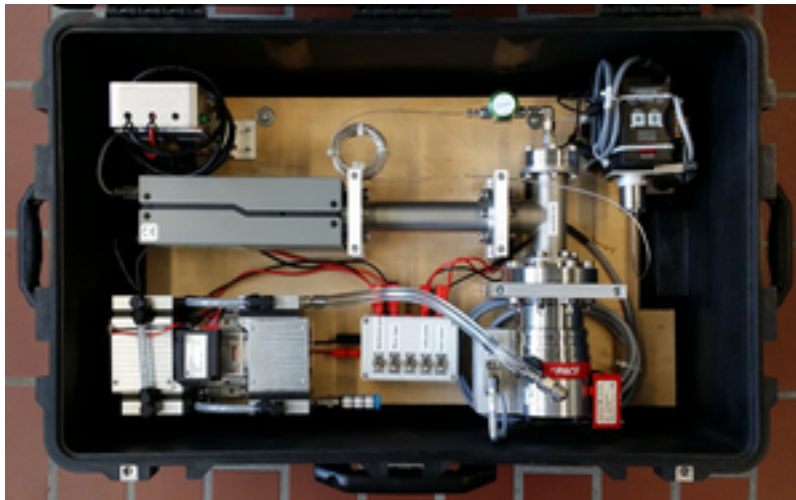
If gases are to be analysed in water samples (e.g. from lakes), a membrane is used to separate the gases from the water, so the system's delicate components are not exposed to moisture.

Gasometrix spin-off established

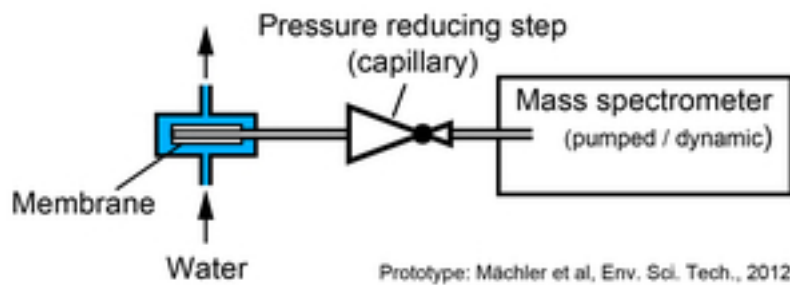
Just two years after the Mini-Ruedi was first deployed in a project, another eight instruments are now in use – a total of five at Eawag and four at the Universities of Geneva and Tübingen and the Mont Terri rock laboratory. As Matthias Brennwald has received numerous enquiries (not connected with Eawag projects) about purchasing the system, he decided – in consultation with Eawag – to establish a spin-off. Since April, he has been developing the portable systems under the name of Gasometrix; as a loyal Eawag employee, he adds, this is merely a sideline. The first client acquired for his own company is the University of Oxford.

Mini-Ruedi applications all over the world

The Mini-Ruedi can quantify numerous gases – currently including helium, argon, krypton, nitrogen, oxygen, carbon dioxide and methane – in environmental systems. Measurements of specific gases can help researchers to understand the underlying processes of gas formation. As this compact system (60 cm x 40 cm x 14 cm; 13 kg) can analyse various gases in less than a minute and can be deployed at remote locations, it is already widely used (for examples of applications in Eawag research projects around the world, see: <http://gasometrix.com/map/>). It has been used, for example, for water analyses to assess groundwater systems or to investigate anthropogenic effects on waterbodies. In a recent project in the Czech Republic, soil samples were analysed to study gas exhalations from springs. Also planned are analyses to be conducted for an oil and gas company in Norway: here, gas flows are to be monitored so that methane or carbon dioxide leaks can be detected.



The portable mass spectrometer in a wheeled suitcase. The coiled “trunk” through which the incoming gas passes can be seen in the middle at the top.



The principle of gas sampling via a membrane inlet.



The Mini-Ruedi deployed in the



field - in Australia, Oman and on



Soppensee (Canton Lucerne)

Publication

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Interview with Matthias Brennwald

It all began with a PhD thesis ...



What role did you play in the development of the portable mass spectrometer?

An earlier version was the result of doctoral research which I co-supervised. The aim of that project was to create an alternative to the elaborate gas analyses conducted at our large laboratory – in other words, an instrument that could be deployed on site and produce continuous measurements of gas concentrations. It was fascinating for me to see how the then-doctoral student Lars Mächler modified an existing atmospheric analyser and mounted it on a wheelbarrow. As I enjoy solving technical problems, I was motivated to optimize this instrument – in terms of required sample volume, size, weight and power consumption.

Who were your supporters?

My Eawag colleague Rolf Kipfer was the supervisor of Lars Mächlers Ph.D and he has a broad insight in analytical technics. So I could count on his know how and colleagues at ETH. They have a lot of expertise in vacuum technology and software development.

What were the biggest challenges?

Commercially available instruments require quite a lot of gas for an analysis. Their pumps, which generate the vacuum, are like a small vacuum cleaner. They draw 20 to 50 millilitres of gas per minute through the tube, which alters the sample. So the challenge for us was to reduce the amount of gas required so that, after analysis, the samples contain virtually the same amount of gas as before. The Mini-Ruedi requires just a tenth of a millilitre of gas per minute. To operate the system, I also needed dedicated software, as it wasn't possible to adapt existing programs. So I wrote new software from scratch – which is now available as open-source.

How would you explain the portable mass spectrometer in lay language?

Put simply, it's a gas sniffer, which sniffs at a gas or water sample with its trunk and can determine what gases the sample contains and in what concentrations. This means we no longer have to collect samples in the field and then analyse them laboriously and at great expense in the lab, only obtaining the results months later. With the Mini-Ruedi, we can "see" what gases are present directly on site.

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Contact



Matthias Brennwald

Tel. +41 58 765 5305

matthias.brennwald@eawag.ch



Andri Bryner

Media officer

Tel. +41 58 765 5104

andri.bryner@eawag.ch

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