ANALYTICAL DEVELOPMENTS: NEW PERSPECTIVES FOR ISOTOPE HYDROLOGY

W. AESCHBACH-HERTIG
Institute of Environmental Physics, Heidelberg University, Heidelberg, Germany
E-mail address: aeschbach@iup.uni-heidelberg.de

Abstract: Several recent developments in the field of analytical techniques are currently transforming the research field of isotope hydrology. The first and most widespread technological revolution is the use of laser spectroscopy for the measurement of stable isotope ratios of water [1] and other important environmental compounds [2]. This approach of isotope ratio infrared spectroscopy (IRIS), especially in the form of wavelength-scanned cavity ring down spectroscopy (CRDS) has now developed into a mature technology that is challenging and partly replacing the traditional method of isotope ratio mass spectrometry (IRMS). A second, technologically similar but more challenging development concerns laser spectroscopic methods for the analysis of the rare radioisotope $^{14}$C, which may also have the potential to replace the established method of accelerator mass spectrometry (AMS) for many applications [3]. In the field of trace analysis of ultra-rare radioisotopes, a third technological breakthrough was achieved with the development of atom trap trace analysis (ATTA), again a laser-based method, derived from laser cooling systems widely used in atom physics [4]. This ongoing development brings the often praised but rarely used radioisotopes of the noble gases Ar and Kr ($^{39}$Ar, $^{81}$Kr, $^{85}$Kr) within reach of widespread applications in environmental studies [5, 6]. A fourth area of active technological development concerns the measurement of dissolved gases in water. It has been demonstrated that comparatively simple systems based on quadrupole mass spectrometry (QMS) are capable of performing precise noble gas analysis [7]. Membrane contactors as a means for gas extraction have become widely used and can be combined with QMS to build membrane-inlet mass spectrometers (MIMS), enabling fast and continuous gas tracer measurements in aquatic systems [8].

The main advantages of the new techniques are that they enable either the measurement of smaller samples or faster, sometimes even continuous, measurements. These advances open up new perspectives for applications in isotope hydrology and other fields of environmental research. For example, using CRDS systems it is now feasible to measure time series of stable isotopes in precipitation, atmospheric vapour, or aquatic systems, with high temporal resolution. Similarly, MIMS methods enable on-site, quasi-continuous gas analyses. ATTA, on the other hand, opens the path towards applications of noble gas radioisotopes in situations where sample size is critical, such as the dating of deep ocean water or polar ice cores. In the long run, ATTA may also become available for other rare radioisotopes. In summary, these new developments open up many intriguing new perspectives for isotope research in environmental sciences.

REFERENCES


