This is the age of RAIN

Paul Shand/BGS

Daren Gooddy and George Darling explain how scientists make the most of man-made emissions.

Thomas Midgley, an inventive industrial chemist in the United States, came up with solutions to two early 20th century problems: 'knocking' in petrol engines, and the dangerous nature of the ammonia and sulphur dioxide then being used in refrigeration. The solutions, tetraethyl-lead and chlorofluorocarbons respectively, may both have proved problematic in the longer term, but the latter at least have provided a boon to oceanographers and hydrogeologists in more recent times.

Chlorofluorocarbons, or CFCs, have been building up in the atmosphere at a known rate since the late 1930s. In the 1970s this was recognised by far-sighted geochemists such as John Hayes at the University of Indiana as an opportunity to put a date on particular events in the water cycle, provided these occurred since roughly 1950. As CFCs, like all gases, have a characteristic solubility in water, their dissolved concentrations in rainfall maintain a unique signature of the atmosphere at that particular time, thereby providing a date for the event. This could be applied, for example, to understanding ocean currents, or to replenishing groundwater by rainfall. Although first widely used by oceanographers, the CFC-dating technique is now becoming popular with hydrogeologists, who want to know more about how long water spends underground.

Why is this important? There are two basic reasons: quality and resources. If, (for example), a particular well or borehole yields water containing no trace of CFCs, it is likely to have fallen as rain well before the year 1950. Thus not only may it have contained less pollution in the first place, but it has also had plenty of time to be filtered through the rock. If CFCs are present, however, it implies rapid circulation of industrial-age rainfall, and the possible presence of contaminants.

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As far as water resources are concerned, groundwater movements can be complex, and comparing CFC concentrations in waters from different boreholes in the same aquifer can provide vital clues about the different directions it is flowing in, and where its sources are. It is this kind of information that hydrogeologists in the Environment Agency and the water companies need so they can manage our groundwater resources sustainably.

There is, however, a cloud on the horizon, even if it is a small one. When the hole in the ozone layer was discovered, countries agreed to reduce CFC emissions by signing the Montreal Protocol in 1987. So although the ozone layer will, in time, regain its pre-industrial thickness, to the world's ultimate benefit, atmospheric CFCs are starting to decline, and in a few years there will no longer be a 'unique' date to fit the measurements we make.

What can we do about this? The obvious answer is to find another trace gas that is building up in the atmosphere. Fortunately there is one: sulphur hexafluoride (SF_6). This is associated with making products such as high-voltage switchgear, double-glazing and training-shoe soles. It is also used in testing airflow in buildings. Its atmospheric concentration is increasing rapidly, but because at present it is only about one-hundredth the concentration of the CFCs, there are no moves to ban emissions. The low concentration makes it more difficult to measure in groundwater, but at least hydrogeologists and others have a 'guaranteed' water-dating tool for years to come.

The British Geological Survey is the only UK organisation specialising in the CFC and SF_6 age tracers in groundwater and uses them widely in its hydrogeological research and survey work. However, we feel the technique will have wider application to UK environmental studies in the future.

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