Stable Isotopes

For every element of the periodic table, there exists an atom with the same number of protons but a different number of neutrons. As a result, an element may present atoms of different mass, called isotopes. These different isotopes can be stable or not. For example, in nature most of the carbon has a mass of 12 (98.89%), but some of the carbon has a mass of 13 (1.11%) and other of 14 (10^{-12}%). Carbon 14 (^{14}C) is not stable and disintegrates into nitrogen; however, carbon 13 (^{13}C) is stable. Thus, during natural chemical and biological processes, both stable carbon (^{12}C & ^{13}C) participate to reactions. However, since ^{12}C is lighter than ^{13}C, it is preferentially used during natural chemical and biological transformation processes. This preferential use of ^{12}C is due to the fact that ^{13}C (heavier) require more energy to be processed in the different natural chemical and biological reactions. This preferential use is called fractionation. Consequently, the different natural materials show distinct isotopic signatures. That is, the $^{13}C/^{12}C$ ratio will not be the same in corn than in maple or in an aquatic plant. It is thus possible to trace the origin of organic matter at any point of any given ecosystem. The mass spectrometer (figure 1&2) is the instrument used to measure the amount of ^{12}C and ^{13}C in a sample. Since it is technically difficult, even impossible, to measure the absolute amount of ^{12}C and ^{13}C in a given sample, mass spectrometers actually measure ^{13}C /^{12}C ratios and compares them to an international reference material (for which we know the ^{13}C /^{12}C). Even though almost every element of the periodic table has one or many stable isotopes, the most commonly studied are hydrogen (2H/1H), carbon ($^{13}C/^{12}C$), nitrogen ($^{15}N/^{14}N$), oxygen ($^{18}O/^{16}O$) and sulphur ($^{34}S/^{32}S$). The isotopic composition of oxygen and hydrogen are generally used to study the hydrological cycle, mostly for evaporative processes in lakes and rivers. Carbon and nitrogen isotopic compositions are typically used to study food chain processes (for both humans and animals). Sulphur isotopic composition is mostly used to study bacteria as well as in geological studies on rock samples. In the precise case of greenhouse gas studies, we use carbon stable isotopes to trace CO_2 sources and processes in the reservoir and as a tool to estimate CO_2 fluxes across the water air interface at the surface of the reservoir.

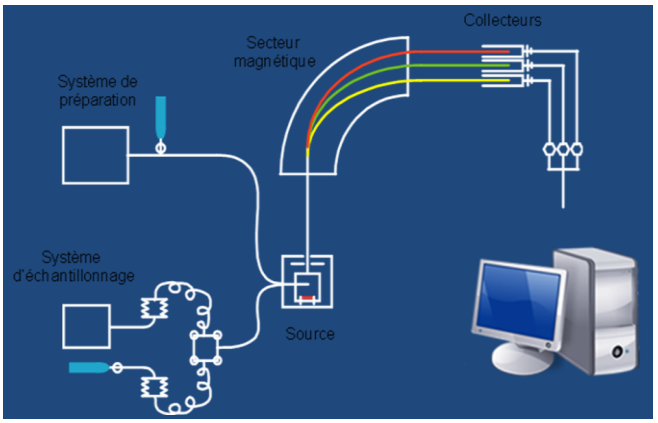

Figure 1 : *Schematics of a gas source isotope ratio mass spectrometer.*

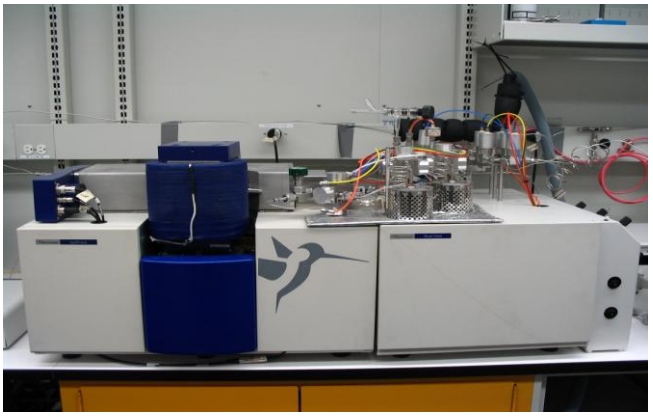

Figure 2 : *Picture of a gas source isotope ratio mass spectrometer.*

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