Mg isotope fractionation in organisms: why fractionation factors depend on Mg uptake

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Contrary to most metal stable isotope systems, Mg isotopes in microorganisms or higher plants are commonly isotopically heavier compared to the Mg source by up to 1.5 ‰ in the $^{26}Mg/^{24}Mg$ ratio. Yet for some species the isotope fractionation factor is zero. A general trend in all published data indicates that the isotopic difference relative to the Mg source becomes smaller with increasing Mg concentration in an organism or the organ of a plant.

We developed a model to explain the mechanism behind this dependance based on two isotope studies on Mg uptake from growth solutions into model organisms [1, 2]. Uptake into the rock-inhabiting fungus *Knufia petricola* strain A95 results in a pH-dependent fractionation between 0.65 and 1.1 ‰. The cyanobacterium *Nostoc punctiforme* yields a fractionation factor of -0.3 ‰. We explain this difference with intra-cellular mechanisms: the fungus locks a fraction of the Mg taken up into strong ^{26}Mg-enriched bonds like in ATP and ribosomes whilst passing the residual light cytosolic Mg back into solution, resulting in an isotopically heavy organism. In contrast, due to its higher demand, the cyanobacterium locks most of the Mg into strong bonds like in chlorophyll, ATP and ribosomes, with little efflux from the cell. Hence, its isotope ratio is similar to the growth solution with minor preference for light Mg during uptake.

We assume the same principal cellular mechanisms apply to all plants and microorganisms studied so far: the more Mg is taken up, the more is locked into Mg-compounds and the smaller the apparent isotope fractionation relative to the Mg source. This mechanism also explains the successively decreasing $^{26}Mg/^{24}Mg$ ratio from root through stem into foliage, as most of the Mg is in the leaf's chlorophyll.

In consequence, isotope-based forest ecosystem budgets of Mg fluxes need to consider Mg amounts and isotope ratios of all organs of a plant, and the species-dependent isotope fractionation.

[1] Pokharel et al, 2017, Environ Sci Technol. 51

[2] Pokharel et al, 2018, Environ Sci Technol. 52