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The use of the isotope systems of alkaline earth elements (Mg, Ca, Sr) to determine plant origin and their potential to study plant metabolism and environmental fluxes

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The determination of the origin of plant material becomes increasingly important as a result of fraudulent practices and consumer protection when agricultural products are used as food or raw material (e.g. wood, sugar cane).
Besides the commonly applied isotopes of the (light) 'bioelements' (H, C, N, O, S), new isotopic systems have been increasingly used to monitor provenance (e.g. Sr, Mg, Ca). Still, an understanding of isotope effects during uptake and metabolism is necessary to use isotopes for provenancing. At the same time, the knowledge of the effects of plant metabolism can be utilized in order to determine elemental fluxes in ecosystems.
In this work, the Sr system will be highlighted as a promising tool. Sr is known to show no significant fractionation in plant metabolism. Natural weathering processes dominate the mobilization of Sr from geological sources. Consequently, bioavailable Sr reflects the local geochemical composition and differing weathering rates. Therefore, the assessed isotopic information of bioavailable Sr can be converted into isoscapes (maps which link a distinct isotopic composition to a geographical location), which can be further used to track provenance of plants or monitor animal migration. Exemplarily, this aspect will be demonstrated for provenance studies of agricultural products.
The investigations are necessarily linked to the study of biogeochemical cycles. In addition to the underlying geology, growing conditions (e.g. groundwater fluxes, wet and dry precipitation) influence the availability of Sr to plants. Therefore, the Sr isotopic composition can be used to determine water sources and fluxes in an ecosystem. We have demonstrated that the Sr isotopic composition can be used as a proxy for the depth of the nutrition sources of a tree in a soil. In geologically heterogeneous soils, surface and ground water fluxes have to be taken into account and usually result in a distinct Sr isotopic composition. This understanding is crucial for using the Sr isotopic system in provenance studies. In contrast to Sr, Ca and Mg are thought to show metabolic fractionation, which needs to be taken into account when using these isotopes for provenance and flux studies. The potential use of Ca and Mg in addition to the Sr system will be discussed as these elements can be applied to study the plant metabolism under varying environmental conditions, which opens a new field of applications for environmental monitoring.