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Density fractions versus size separates: Does physical fractionation isolate functional soil compartments?

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Physical fractionation is a widely used methodology to study soil organic matter (SOM) dynamics, but concerns have been raised that the available fractionation methods do not well describe functional SOM pools. In the present communication we explore whether physical fractionation techniques isolate soil compartments meaningful and functionally relevant for the investigation of litter-derived nitrogen dynamics at the decadal time scale. We do so by performing aggregate density fractionation (ADF) and particle size-density fractionation (PSDF) on mineral soil samples from two European beech forests a decade after application of 15N labelled litter. Our approach consisted in representing the results of both fractionation procedures on a condensed scheme. First, principle component analysis (PCA) was used to reduce the set of organic matter related data (including C and N contents, C/N ratio, δ13C) to two independent variables or principal components (PC) that accounted for the majority of the data variability. The second step consisted of resolving the plane defined by the two principal components into contour maps of 15N label incorporation among physical fractions from both fractionation procedures. By doing this, dynamics of litter derived N transformation can be visualized as trajectories in the PCA plane. Both density and size-based fractionation methods suggested that litter-derived nitrogen became increasingly associated with the mineral phase as decomposition progressed, within aggregates and onto mineral surfaces. However, scientists investigating specific aspects of litter-derived nitrogen dynamics are pointed towards ADF when adsorption and aggregation processes are of interest, whereas PSDF is the superior tool to research the fate of particulate organic matter (POM). Some methodological caveats were observed mainly for the PSDF procedure, the most important one being that fine fractions isolated after sonication can not be linked to any defined decomposition pathway or protective mechanism. This also implies that historical assumptions about the "adsorbed" state of carbon associated with fine fractions need to be re-evaluated. Finally, this work demonstrates that establishing a comprehensive picture of whole soil OM dynamics requires a combination of both methodologies and we offer a suggestion for an efficient combination of the density and size-based approaches.