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Carbon and nutrient use efficiencies optimally balance stoichiometric imbalances

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Decomposer organisms face large stoichiometric imbalances because their food is generally poor in nutrients compared to the decomposer cellular composition. The presence of excess carbon (C) requires adaptations to utilize nutrients effectively while disposing of or investing excess C. As food composition changes, these adaptations lead to variable C- and nutrient-use efficiencies (defined as the ratios of C and nutrients used for growth over the amounts consumed). For organisms to be ecologically competitive, these changes in efficiencies with resource stoichiometry have to balance advantages and disadvantages in an optimal way. We hypothesize that efficiencies are varied so that community growth rate is optimized along stoichiometric gradients of their resources. Building from previous theories, we predict that maximum growth is achieved when C and nutrients are co-limiting, so that the maximum C-use efficiency is reached, and nutrient release is minimized. This optimality principle is expected to be applicable across terrestrial-aquatic borders, to various elements, and at different trophic levels. While the growth rate maximization hypothesis has been evaluated for consumers and predators, in this contribution we test it for terrestrial and aquatic decomposers degrading resources across wide stoichiometry gradients. The optimality hypothesis predicts constant efficiencies at low substrate C:N and C:P, whereas above a stoichiometric threshold, C-use efficiency declines and nitrogen- and phosphorus-use efficiencies increase up to one. Thus, high resource C:N and C:P lead to low C-use efficiency, but effective retention of nitrogen and phosphorus. Predictions are broadly consistent with efficiency trends in decomposer communities across terrestrial and aquatic ecosystems.