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'Dryland' mechanisms of decay – an array of emerging mechanisms that degrade organic matter when the climate gets warmer and drier

José Grünzweig and Daniel Gliksman

Hebrew University of Jerusalem, Institute of Plant Sciences and Genetics in Agriculture, Faculty of Agriculture, Food and Environment, Rehovot, Israel (jose.gruenzweig@mail.huji.ac.il)

Decomposition of organic matter is a key process in the cycling of carbon and nutrients in ecosystems, and in the exchange of carbon and nutrients between the biosphere and the atmosphere. Decomposition is generally considered to be the direct consequence of microbial activity, as regulated by temperature, moisture and the chemical composition of the organic material. However, as the climate gets warmer and drier, with a higher frequency of extreme events, such as prolonged droughts, new mechanisms, and their driving factors and feedbacks, become dominant. Such new mechanisms have recently been described for carbon and nutrient cycling in drylands, but they are expected to explain responses to a changed climate in dry as well as humid regions. Photochemical degradation (photodegradation) is a major abiotic mechanism of decomposition of dead plant material (litter) and surface soil organic matter. High flux densities of ultraviolet and shortwave visible (blue-green) radiation induce photochemical processes, which degrade any organic material exposed to solar radiation. In certain ecosystems, photodegradation accounted for a major part of annual litter mass loss and mineralized a sizable fraction of net primary production. Photodegradation commonly co-occurs with thermal degradation, an additional abiotic mechanism that operates at temperatures above 30°C, which are common conditions at and near the soil surface in many regions of the world. In addition to abiotic mechanisms, biotic degradation can operate in the absence of precipitation. Such humidity-enhanced microbial degradation (in contrast to precipitation-enhanced microbial degradation) is enabled by moisture from non-rainfall water sources, such as water vapor, dew and fog that is absorbed by plant litter, predominantly at night. Those emerging mechanisms of decomposition do not only affect organic materials directly, but can modify mass loss and nutrient dynamics beyond periods of their operation. For instance, photodegradation during daytime facilitated humidity-enhanced microbial degradation at night, and vice versa. Moreover, combined biotic and abiotic degradation in dry seasons facilitated precipitation-driven microbial degradation and associated nitrogen dynamics in wet seasons. Some of these emerging 'dryland' mechanisms have already been observed in humid environments, and they can be added to biogeochemical models to better understand and predict the impact of climate change on carbon and nutrient cycling in humid climatic zones.