[1]Modeling the Measurable or Measuring the Modelable: A Hierarchical Approach to Isolating Meaningful Soil Organic Matter Fractionations

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Summary

The approaches of modeling the measurable and measuring the modelable are both valuable for advancing our understanding of soil organic matter (SOM). In the former case, we assume that the measurements we make are the best representation of nature, and that model structure should follow. While this may simplify model testing, it may not yield a particularly useful description of SOM dynamics. There is no question that most of our knowledge about SOM is derived from experimentation, but models are being increasingly used to further our understanding. In the latter case, model structure and parameters are modified in reasonable ways to obtain the best fit of simulation with observation, thus deducing the "correct" structure. In this case, it is conceivable that more than one structure can result in a good fit to the data. Good predictions may be produced, but an incorrect structure may be derived. In either case, there are no clear criteria for obtaining the "truth" except for repeatedly testing our methods/models against new information, preferably obtained from definitive experiments. A combination of approaches is best. We elaborate a particular approach which is mindful of the habitat in which microbes and their substrates reside and relate this theory to methods developed to separately isolate plant and microbially derived SOM, which may be physically protected from microbial attack in the soil.

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Introduction

Changes in soil organic matter (SOM) and its relationship to soil properties has been an area of intense scientific study over the past decade, and considerable progress has been made in developing the theory of organic matter behavior in soil, especially as it relates to soil fertility (Elliott *et al.*, 1993; Elliott *et al.*, 1994; Swift & Woomer, 1993). Many different approaches and philosophies have emerged and have become intertwined into a complex set of theory, experimental approaches and practice. One important tool that has surfaced in this study is the simulation model, which has been used to integrate various factors (e.g., soil temperature, moisture, aeration, litter chemistry) controlling decomposition processes and SOM dynamics (Bosatta & Agren, 1991; Jenkinson *et al.*, 1987; Molina *et al.*, 1983; Parton *et al.*, 1987, 1988; Paustian, 1994; Paustian *et al.*, 1992; van Veen & Paul, 1981). McGill (this volume) has reviewed a number of these models and Christensen (this volume) has discussed several models in relation to organic matter fractions.

Simulation models of SOM are useful for a number of reasons; they (1) embody multiple facets of our best understanding of SOM dynamics, (2) may be embedded within a whole ecosystem context, (3) may be used to make projections of changes in SOM under different management, climate or with changes in other factors and (4) can be used to investigate the consequences of alterations in the controls on SOM. With regard to this last consideration, there are a number of different approaches that have been used to describe SOM in models. These approaches have utilized a number of SOM pools, each with different properties. Key properties of these pools are their turnover rates, size and the differential effects that changes in the soil environment have on their turnover rates. However, current theory (and models) are weak in two areas of critical importance, (i) the relationship between soil structure and the ability of a soil to stabilize organic matter and (ii) *physical disturbance* effects on organic matter turnover. The focus of this paper will be to present a particular view of the hierarchical nature of soil structure as it relates to the relationship between pools used in simulation models and analytical measurements of SOM pools. Other approaches are presented by Christensen (this volume).

Soil Structure, Models, and Organic Matter Turnover

One of the most often cited deficiencies of current SOM/agroecosystem models is that functional, kinetically-defined pools cannot be directly related to measurable variables.