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Towards a more explicit representation of soil microbial community in soil carbon and nitrogen dynamics models: a review

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The need to understand and predict the soil carbon and nitrogen dynamics has led to an increase of models development in the last century. Both concept and accuracy of these models have been largely studied. One of the most influent debates in model development is about the place of soil microorganisms in these models. Difficulties in linking microbial communities with soil carbon and nitrogen dynamics have participated to a largely non-explicit representation of the role of microbial communities in these models.

The objective of this work was to get a state of the art overview of studies which have worked in linking soil microbial diversity and community composition to carbon and nitrogen dynamics helping by last advances in molecular biology. How recent models represent these microbial characteristics is then reviewed and some directions for future research in carbon and nitrogen dynamics modelling are proposed.

Last advances of molecular biology have permitted to better apprehend the role of microorganisms. Review of microbial communities – soil carbon and nitrogen dynamics relations studies shows that even if a lot of unknown is still to be unravelled, there is a great interest of taking into account more explicitly the role of microbial communities in carbon and nitrogen dynamics. Last studies on diversity erosion impact in soil carbon and nitrogen dynamics show that the microbial diversity is non neutral. Moreover, microbial communities' composition could also have a relative importance. As microbial communities characteristics are largely driven both by pedoclimatic factors and agricultural management and their interactions, these characteristics constitute a link between interactions of pedoclimatic factors and agricultural management and soil carbon and nitrogen dynamics. Explicitly including these characteristics could improve models quality, especially for models devoted to realistic predictions of these dynamics in numerous agricultural contexts.

Despite the obvious interest of explicitly representing microbial communities' characteristics in models, literature is largely dominated by models with either non explicit representation or representation of only one compartment of microbial biomass eluding the soil microbial diversity or community's composition. Few recent models incorporate several compartments of microbial biomass with different functional traits and/or different biochemical characteristics in order to represent the microbial diversity. Among these around fifty reviewed models, most of them are largely theoretical without confrontation to real data and efforts are needed to combine the different approaches in order to go further towards predictive models that integrate microbial diversity.

To conclude, some guidance is proposed in terms of experiments, model development and model evaluation to meet these needs in future research. In particular, it appears interesting to statistically link some parameters of these models to microbial communities' characteristics following what it is classically done with pedological factors. As well as explicitly integrating these characteristics into models, this method would avoid to add more and more compartments to represent the microbial diversity which drastically complicates the models. Strong assessment of these models, through sensitivity and uncertainties analyses, is needed to validate this method.