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Doktorská práce s názvem Amount and transformation of phosphorus in permafrost affected soils se zabývá velmi aktuálním ekologicko-environmentálním tématem. Obecně lze konstatovat, že témata prací zahrnující globální změny jsou bezesporu více než aktuální. I tato práce napomáhá pochopení mechanismů a rozsahu dějů, které s sebou globální změny přinesou a tímto rovněž zpřesňovat odhady dopadů na globální ekosystém. Osud nutrientů bezesporu patří do této oblasti.

Práce samotná sestává z kompilace 4 manuskriptů, kdy 3 byly již publikovány, a to v časopisech s impaktním faktorem vysoko přesahující medián oboru. U třech článků je kandidát první autor.

Práce je sepsána velmi kultivovanou a srozumitelnou angličtinou bez zbytečných překlepů a formulačních nejasností.

Rád bych vyzdvihnul zejména úvodní kapitolu popisující modely dějů v permafrostu při kryoturbacích a zcela se ztotožňuji k přiklonění k metabolické teorii, zahrnující aktivní mikrobiální složku, se kterou autor dále pracuje. Je zřejmé, že problematika je značně komplexní a např. uváděné teoretické zvýšení teploty o 10°C může mít vliv na celou řadu dalších dějů, jako je vodní režim. Dále je nutné pamatovat, že při anaerobních procesech bude značnou úlohu hrát dostupnost akceptorů elektronů a rovněž i obecné parametry jako je např. pH. Nicméně jak bylo zmíněno výše, každé přispění do skládačky modelů umožňuje další upřesňování dopadů globálních změn.

Jak bylo zmíněno práce dále sestává ze 4 manuskriptů. 1. článek sleduje zejména mikrobiální transformace dusíku v různých horizontech půdy z tundry, kdy autoři popisovali složení biomasy pomocí analýzy fosfolipidických mastných kyselin. 2. článek popisuje vliv teploty na dekompozici půdních organických látek za aerobních a anaerobních podmínek v různých půdních horizontech. 3. publikovaný článek se zabývá vlivem obsahu fosforu na mikrobiální komunitu v různých ekosystémech a 4. dosud nepublikovaný článek se týká interakcí mezi rostlinami a mikroorganismy s ohledem na dostupná množství dusíku a fosforu v půdě. Témata jednotlivých článků se vhodně doplňují a umožňují autorovi vyvracet, či potvrzovat nastolené hypotézy.

Obecně hodnotím doktorskou práci velmi kladně. Práce ukazuje autorovu vyspělost a úspěšná zvládnutí náročných recenzních řízení ve špičkových časopisech dokumentují úroveň dat a jejich interpretace. Vzhledem k uvedeným okolnostem doporučuji práci k obhajobě.

Pro obhajobu mám následující dotazy:

1) Pro popis mikrobiálních společenstev používáte PLFA metodu. Pokusil jste se použít i z kvalitativního hlediska mnohem detailnější přístupy pokročilých sekvenčních metod, které jsou v poslední době lépe dostupné? Plánujete eventuelně toto ve vaší případné další práci? Eventuelně je známo z literatury, že kvalitativní struktura biomasy má dopad na transformace organické uhlíku v permafrostu? Ne alespoň popisoval někdo rozdíly ve společenstev různých permafrostů pomocí NGS?

2) Metoda PLFA používá specifické markery pro skupiny mikroorganismů. Jejich sumací se však často ztratí informace z jednotlivých mastných kyselin. Pokusil jste se statisticky zpracovat jednotlivé markery namísto sum?

2) Byl manuskript 4 odeslán do nějakého časopisu, eventuelně, do kterého ho plánujete?

V Praze 9.10.2016

Prof. RNDr. Tomáš Cajthaml, Ph.D.

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Review of PhD thesis by Petr Čapek

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Petr Čapek recently submitted his PhD thesis titled:
"Amount and transformation of phosphorus in permafrost affected soils".

He performed and wrote a great PhD thesis, with 3 publications out (2 as first author) and 1 in preparation - these are the ones presented in his PhD thesis - and further 11 publications on high latitude ecosystem performance published as a co-author. The papers represent an innovative and important original contribution to our knowledge on arctic soils, microbial stoichiometry and its coupling to biogeochemical processes, and particularly on microbial N versus P limitation. As shown above the papers were clearly of high quality and therefore have been published already (or will be so in due time), pinpointing the high quality of his work. In all papers Petr formulated substantial questions, clear hypotheses and developed and applied appropriate methodology and designed suitable experiments to test them. Methods and models are well described. Impressive is also his understanding and the application of stoichiometric, kinetic and metabolic theories and models, that go far beyond simple descriptive studies, but help to get to the mechanistic basis of soil microbial processes and even touch ecosystem nutrient limitation. Much of these models have been newly developed or adopted in his studies. This further demonstrates his great understanding and deep insights into terrestrial biogeochemistry and ecological stoichiometry. Reading his papers showed that he clearly argues along his lines of discussion and provides – as far as possible – concise answers to the questions he posed, and further demonstrates his knowledge of available literature. A meta-analysis of data on N:P fertilization experiments in the arctic moreover points to his excellent skills in searching, reading, extracting and interpreting literature.

What are his main objectives and "contributions to science"?

Objective 1: Temperature sensitivity of soil organic carbon mineralization in the arctic (paper 2)
In the arctic vast amounts of organic C are stored in permafrost affected soils, with large portion being in cryoturbated horizons. Understanding of the vulnerability of these C stores is still in its "infancy" and which conditions cause loss of SOC not fully explored. This study nicely demonstrates – with a unique set-up - how temperature and soil moisture/oxygenation interactively affect the decomposition of arctic SOC. Moreover he shows the pathways of C loss (CO2 versus CH4), and that CH4 production is only important in organic horizons and increases in absolute and relative terms with temperature. He further outlines and discusses how and why metabolic theory (related to microbial metabolism) is the better predictor of Q10 values of SOC mineralization than kinetic theory (related to C quality). A unique finding is that the Q10 was lower under anoxic conditions that under oxic conditions, a result that highlights the importance of soil oxygen availability for SOC decomposition and its temperature sensitivity, and one also prone to strong fluctuations and eventual slow but significant changes in the future. Further studies should find the mechanistic basis for the low Q10 of SOC decomposition, an unexpected finding. Interestingly Q10s were similar across soil horizons, showing that SOC quality and stabilization had a minor impact on temperature-dependence of SOC decomposition. Main drivers of SOC loss were microbial biomass and SOC contents, with temperature and

oxygen being secondary to these primary drivers. The long residence times and slow decomposition rates of cryoturbated OM was due to low microbial biomass, and this connected to energy constraints and nutrient limitation of the microbial communities in cryoturbated horizons.

Objective 2: Soil P availability in permafrost affected soils (paper 4)
The arctic is generally thought of being N limited but the possibility of N:P co-limitation or P limitation had not been thoroughly studied. In this part Olsen-P was measured as proxy for soil P availability in a wide range of arctic land ecosystems. Olsen-P was high in cryoturbated horizons indicating absence of microbial P limitation of microbes. Comparison of N:P ratios of extractable nutrients showed a trend towards P increasing relative to N with absolute longitude, implying high P relative to N in East Siberia and low P relative to N in West Siberia (and North America). This points towards major changes in N versus P limitation across the arctic, with major implications for future responses to atmospheric N deposition, and interesting but unstudied geochemical and historic causes for future studies.

Objective 3: Drivers of microbial P limitation (paper 3)
Based on ecological stoichiometry Petr here developed theory, a model and a technical approach to estimate critical C:P ratios for soil microbes. $C:P_{CRIT}$ is an important parameter as it indicates where microbes switch from C (energy) limitation towards P limitation, with strong repercussions on microbial growth, SOC decomposition, respiration, but also P cycling and mineralization. This is a highly innovative undertaking and with some changes in the methodological setup could soon provide scalable and generalizable mechanistic understanding of microbial P limitation and controls on SOC decomposition and organic P mineralization. This would provide a surge in the quality of global biogeochemical models (including P cycle). The approach can further be developed to assess controls of soil microbial C or N limitation, and provide microbial critical C:N and N:P ratios. The major limitation of the results as presented here was that the expected stoichiometric controls on $C:P_{crit}$ (e.g. C:P of microbes, available P etc) did not hold and only microbial community composition had a strong effect on $C:P_{crit}$. This makes extrapolation hard at present time given the lack of general global measurements of soil microbial community structure, which however does not disprove the approach but rather calls for measurements across wider spatial and temporal scales. Furthermore, he demonstrated that the $C:P_{crit}$ parameter is not a constant but varies between ecosystem types and depending on microbial community structure.

Objective 4: P effects on N dynamics (papers 1 and 4)
Interactive effects between P and N availability have been recently described, and based on microbial and plant mechanisms help to maintain N:P homeostasis. Most importantly in the papers Petr demonstrated that low P availability or microbial P limitation enhances net N mineralization and N availability to plants while P fertilization of P limited soil microbial communities drastically reduces N mineralization. This can cause co-existence of N limited plants and P limited microbes in the spatiotemporal dimension or when both become limited by the same nutrient, competition and decreases in productivity or decomposition. He based much of this on differences in plant and microbial critical N:P ratios, which he derived from own measurements/models and global data resources. He further adopted stoichiometric concepts and derived a ratio between N:P crit of microbes by N:P of the available nutrient pool, as indicator of microbial N or P limitation. As a co-author he further showed that at low P tundra sites microbial nitrogen use efficiency was low, meaning that more of the organic N taken up by microbes is mineralized and exuded than at high P/low N sites. At the latter microbial NUE was high and therefore N mineralization low. P therefore has strong effects on microbial N cycling in soils.

Given the quality, importance and innovative nature of the research I therefore clearly and fully recommend the PhD thesis of Petr Čapek to be accepted and defended.

Kind regards,

Wolfgang Wanek