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Viruses in soil and phages for microorganisms

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Viruses are ubiquitous in any environment and have various ecological functions. Despite very high abundance of viruses in soil, their importance for soil life remains completely disregarded, and just few studied started descriptive investigations. With this review we focus on the functioning of viruses in soil and the consequences for microbial life and cycling, carbon (C) and nutrient turnover, as well as related mechanisms of long-term C stabilization.
After a very short introduction to virus morphology and life cycle, we focus on their importance for microbial life in soil. Considering the viral infection of soil bacteria close to 100%, and fast lysis of infected cells, we introduced three concepts: 1) Viral microbial loop, 2) 'Forever young', and 3) C sequestration by necromass stabilization.
The traditional 'Microbial loop' assumes fast release of C and nutrients from bacteria and fungi by predation through soil animals (nematoda, protozoa etc.). We showed that the abundance, the size and the localization of micro-, meso- and macrofauna are not sufficient to explain the C and nutrient fluxes by bacterial and fungal death. The 'Viral microbial loop' raises the importance of viruses for bacterial life cycles and shows that viruses alone (without soil animals) can explain completely the bacterial death rates and the release of easily available C and nutrients, consequently accelerating cycles in soil – the common outcome of microbial loop. The concept 'Forever young' shows that viral infection maintains young age of bacterial population in soil: the aging cells will be lysed leading to the short life expectance of the most soil bacteria. We controversially discussed this concept with the contrasting facts such as 1) the most microorganisms in soil are in dormant stage, 2) low energy consumption by soil microorganisms for maintenance, and 3) high carbon use efficiency common for soil microorganisms. The recently developing concept of 'C sequestration by necromass stabilization' – that the main C sequestered in soil is produced from microbial necromass (not from the initial plant residues) – we discussed from the new view angle of consequences of viral infection. The necromass will not be microbially reutilized only if no living microorganisms are present in direct accessible distance. This is impossible because the most microorganisms in soil are located in colonies, but it is very likely if the whole microbial colony dies nearly at the same time – e.g. if it is infected by viruses. The necromass remains in the nanopores without soil animal access and will be stabilized on the clay surfaces.
Considering only very few studies to viruses in soil, we stated that actually all research directions are open and important, but the most urgent are necessary for understanding of the virus functioning, consequences for microbial life and their ecological relevance especially to prove the suggested concepts.