Soil detritivore functioning in heterogeneously contaminated soils

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2009

document version
Publisher's PDF, also known as Version of record

Summary

The soil is a dynamic and heterogeneous environment with a great diversity of soil dwelling fauna. The diversity of soil species and the relationship to soil processes has become a major area of research as global species diversity is declining by human influences. One of these human influences is soil contamination which can have a direct negative effect on the functioning and behaviour of soil organisms and, by consequence, affect the functioning of soil ecosystems. The effect of a contaminant on organisms depends, among other things, on its bioavailability in the soil. The heterogeneous nature of the physico-chemical constituents of soils affects the bioavailability directly. Furthermore, the contamination can be heterogeneously situated in the soil profile and thereby affect different groups of soil dwelling species. Vertical heterogeneous contamination can affect different species as species are known to prefer specific soil depths for their habitat. The heterogeneous contamination creates the potential for species to avoid contaminated patches and might thereby disrupt important ecological interactions between species. Therefore in this thesis, the central hypotheses tested are 'that exposure to contaminants affects (i) vertical stratification of detritivore annelids, (ii) species composition of the detritivore community and, (iii) facilitative interactions of soil detritivore species and microorganisms, thereby affecting soil process rates'.

The study was situated in a river floodplain, the Afferdense and Deestse Waarden, of the Dutch river Waal (contributory of the river Rhine). Dutch river floodplains show high spatial heterogeneity in contamination and are therefore very suitable to test these hypotheses. The river floodplain soil showed high zinc concentrations which exceeded the Dutch risk assessment level 4, which stands for high ecological risk (*Chapter 2 and 3*). Zinc concentration showed a rather homogeneous pattern on a horizontal scale in the northern half of the field, while the southern part was more heterogeneous. Zinc concentrations did not show any correlations with soil fauna distribution. Vegetation and soil moisture content explained most of the variation found in the distribution of soil fauna.

Vertical heterogeneity of contamination was also observed in the river floodplain. A field monitoring study assessed the effect of vertically heterogeneous soil contamination on soil fauna and soil functioning in

which four locations with four distinct contamination profiles in the field were monitored for three years (*Chapter 3*). The results showed that the earthworm species *Aporrectodea caliginosa* had higher biomass in clean locations, whereas *Allolobophora chlorotica* showed higher biomass in more humid and more contaminated soils. It is more likely that the higher biomass of *Aporrectodea chlorotica* at the higher contaminated soils were due to the high humidity of the soil as the species prefers humid conditions. Therefore, no effects of contamination on soil fauna were found which was probably due to the low availability of the contamination.

In addition, laboratory tests were performed to address specific hypotheses of this thesis in a more controlled environment. One microcosm experiment studied the effect of vertically heterogeneous contamination on detritivore behaviour and their interactions with microbes (*Chapter 4*). The soil columns in the microcosms were constructed using floodplain soils and reflected the vertical heterogeneity of contamination found in the river floodplain. Burrowing intensity and soil organic matter content changes indicated that the behaviour of earthworms was not affected and therefore the earthworms did not seem to avoid the contaminated layer. Contamination did affect the microbial functioning itself as soil respiration was low in the contaminated soil. However, direct negative effects of soil contaminations on microbial functioning were indirectly compensated for by soil fauna stimulating the microorganisms. Therefore, these results show the importance of soil fauna in stimulating microbes in contaminated soils.

The second microcosm experiment studied the effect of detritivore species diversity on soil process rates (*Chapter 5 and 6*). Soil processes (litter fragmentation, soil respiration, gross NO_3^- production and litter mass loss) showed an asymptotic relationship with species diversity, which indicates that there is functional redundancy within the group of detritivores. To assess if interactions between species were occurring, a net diversity effect was calculated based on individual effects of the species. Net diversity effects showed the importance of the functional identity of the species. Species which were similar showed neutral and negative interactions. However, net diversity effect of soil respiration and litter mass loss increased with functional dissimilarity of species. Litter mass loss had a key species, the earthworm *Lumbricus rubellus*, whose performance was facilitated by other macrodetritivore species.