Highway Exhaust Aerosols and Their Effects on Alpine Lichen Populations

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Abstract

The aim of this study was to investigate the particle inventory of airborne particles in the region of the Bluntau-Valley near Golting / Salzburg to find correlations between the existence of alpine lichen communities, particularly their vitality, and the exposure to exhaust emissions of the nearby Motorway E55 (Tauernautobahn). This motorway has been fitted with 4 m tall sound-shielding barriers to reduce noise levels of nearby residential areas. The U-shaped Salzach-Valley is strongly influenced by oscillatory motions of air masses due to solar radiation and characteristic wind directions. This leads to a translocation of aerosol particles from vehicle exhaust across the sound-protection barriers and into the Bluntau-Valley. The examination of epiphytic lichen populations in this valley confirms the negative effect of vehicle exhaust emissions, displaying a strongly reduced diversity and a change in lichen communities.

Introduction

The Bluntau-Valley was chosen for these investigations because it was found that lichen population density and diversity have decreased under the influence of airborne pollutants (Christ & Türk, 1981). Hence it was the aim of this study to correlate particle exhaust load originating from this highway to verify the assumption that highway exhaust strongly affect lichen diversity in the Bluntau-Valley area in close proximity to the motorway E55 (Ellenberg, 1992; Kasperowski & Frank, 1989).

Results

Particle concentrations decrease with increasing distance to the source, i.e. the highway E55. Figure 3 reveals the characteristic dilution gradient within the Bluntau-Valley. This observation was consistent through the sampling campaign for all of the inbound wind conditions. However, it was observed that during inbound wind directions, the half-way site (BH) yielded lower aerosol particle counts than the remotest site (FFK). This is not a surprise as the FFK-site is approx. 90 m higher in elevation and hence much more exposed to particle loads originating from the highway than the BH-site – the latter being well protected within a coniferous forest, whereas the FFK-site is an open location with direct view to the motorway. This correlates nicely with the species diversity found at the various locations, in that a higher diversity was documented at the BH-site and a slightly lowered one of the FFK-site.

In addition it was found that days with reversed wind conditions (outbound of the Bluntau-Valley), the average particle inventory was comparable to “purified” mountain air (FFK-site; approx. 1200 particles/cm³) compared to particle loaded Salzach-Valley air measured during inbound wind conditions (FFK-site approx. 2600 particles/cm³). During the half-year measurement campaign (from July till December 2006), we further documented a 30% decrease in particle inventory on all sites due to a reduced vehicle frequency on the motorway especially in the colder months – i.e., particle number concentration is almost twice as high in summer and correlates with the peak travelling time of major EU countries. It was also noted that characteristic and yet pollutant-sensitive lichen species of this climatic zone are displaced by mainly nitrophilous species (KRDL, 2007).

Conclusions

The area of the Bluntau-Valley is predetermined to be influenced by solar radiation and changing wind conditions due to meso-climatical processes and the topographical setting of the valley. Measurement days in summer showed higher particle concentrations, which correlates with the peak vehicle frequencies during the summer-holiday season.

Measurement sites closer to the highway produced higher concentrations as a result of the constant mixing of exhaust particles and resuspension of larger aerosol-clusters and elevated vehicle density (Hofmann, 2005). Consequently, particles are easily relocated by wind and transported over the sound-protective barriers to finally settle in neighbouring land strips. As expected, sampling sites further away and deeper within the Bluntau-Valley yielded lower particle concentrations. However, particle loads originating from the motorway does regularly occur, as lichen-populations on exposed sites such as the remotest site surveyed (FFK-site) do reveal a suppressed species diversity. This observation correlates with other works by those other authors that associate these ecological changes to excess eutrophication and an elevated pollutant load (Masuch, 1993).

In particular, higher aerosol concentration results in lower species diversity by damaging the thallus of the lichens (Nemis, 2002). Therefore, measurement sites in close proximity to the E55 display a distinctive absence of species otherwise found in more pristine areas of similar geologic character (Masuch, 1993).

Additionally, lichen associations near the highway tend to change to more nitrophilous lichen associations because of a higher amount of nitrogen available due to vehicle exhaust and being in a rural setting, the prevailing agricultural activities near the motorway along with the associated wind-related relocation of fertilizer. The dramatic reduction of lichen diversity observed at all measurement sites – with none to just a few in close proximity to the motorway – backs up the hypothesis that certain particle sizes are able to form the lichen thallus through pores of the polysaccharide layer of the epiphytes thereby negatively affecting the fungi and in turn the symbiotic association between the mycobiont and the photobiont (Masuch, 1993).

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References


