Particulate pollution capture by plants on living walls: the impact of rainfall

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Particulate Matter (PM$_{10}$, PM$_{2.5}$ and PM$_{0.1}$) comprises a considerable fraction of urban air pollution, is directly associated with severe health effects (Laden et al., 2006), and much of it is generated by traffic (Anon., 2011). Air quality in many large cities in England and Wales does not comply with the European air quality standards (Pugh et al., 2012). Vegetation is known to capture particulates and urban greening is a potential method of removing them (Dover, 2015). However, the value of living wall systems (Fig 1) in the reduction of traffic-generated particulate air pollution has received scant attention (Cheetham et al., 2012).

Validation of sampling protocol

The distribution of particulates on leaves was analysed using four plant species commonly used in living walls with different morphology (Fig 2) to develop and validate a sampling protocol.

As shown in Fig 4 particulate distributions on the leaf-blade resulted in lower levels of variation for all four species compared to other leaf areas and the leaf-blade was thus selected as the best area to sample leaf sections throughout the study.

Particulate remobilisation by rainfall

Particulate remobilisation due to rainfall is currently being studied by simulating rainfall using an environmental chamber equipped with spray nozzles. Leaves were sampled from the roadside, cut in two down the mid-rib, and one half exposed to rainfall. Particulates on both halves of the leaf were then quantified using the ESEM and differences in pollution density compared using paired t-test (n=20). The procedure was repeated for different rainfall durations.

A significant reduction of particulates was observed (Fig 6) on leaves of Hedera helix at all exposure times (p<0.05). Particulate wash-off from the underside of leaves was significantly less (p<0.05) than that from the upper-side of leaves in all size fractions. A significant proportion of captured particulates is washed-off by rain, therefore leaf surfaces become available to capture more particulates. A total of five plant species will be studied to draw more accurate conclusions on the impact of rainfall on particulate remobilisation.

The inter-species variation of particulate

PM$_{10}$, PM$_{2.5}$ and PM$_{0.1}$ captured on leaves of twenty plant species representing different morphological types will be quantified and size-ranged using an ESEM (Environmental Scanning Electron Microscope) and image analysis software (imageJ). Some example micrographs of particulates captured on leaves are given in Fig 5. Inter-species variation in particulate capture will be evaluated using GLM (General Linear Model). The elemental composition of captured particulates will be determined using the Energy Dispersive X-ray analysis unit of the ESEM.

Best species composition to trap particulates

The variation in capture levels with different plant combinations, different planting designs, and micro-topographical variations will be evaluated and the optimisation of species composition for particulate capture by living walls explored.

Rationale

The optimal species composition for particulate capture, fate of the captured particulates under different weather conditions and the best planting designs for living walls to act as Particulate Matter (PM) traps are not yet understood. This study will employ an experimentally manipulated living wall system and existing living wall systems to explore the impact of living wall systems on the reduction of traffic-generated particulate pollution.

References