Project proposal form – 2018 entry

Project code: FOR CENTA USE ONLY

Project title: Can urban air quality be improved through the use of plant associated bacteria?
Host institution: University of Warwick (Life Sciences), RHS Wisley
Theme: Anthropogenic impacts and environmental sustainability/organisms omics and biogeochemistry
Key words: phyllosphere microbial communities, urban green spaces, green infrastructure
Supervisory team (including institution & email address):

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Project Highlights: 3 points as a bulleted list

- **Assess how plants and microbes contribute to the provision of ecosystem services in urban areas, focussing on air pollution mitigation**
- **Investigate degradation of air pollutants by plant-associated microbiota**
- **Characterise phyllosphere microbiomes using environmental genomics approaches**

Overview: Over 90% of the UK population is urban and thus facing a range of urban-specific environmental challenges (higher temperatures, increased flooding risks, reduced air quality). Green infrastructure can help mitigate some of these challenges, but the choice of planting can have significant impact on the extent of benefits[1]. Plants with certain structural and functional properties (hairy leaves, large leaf areas, high transpiration rate) tend to provide higher level of services. Of particular interest are ecosystem services related to the mitigation of air pollution. Air pollution causes millions of premature deaths and is an important issue in metropolitan areas worldwide[2]. Air pollutants include a number of volatile species, such as NO_x, SO_2, carbon monoxide and a range of volatile organic compounds. In addition, particulate matter (PM) is a major concern for air quality and public health. PM are produced from natural and anthropogenic processes, the latter including transport emissions.

The role of vegetation in maintaining and improving air quality is undisputed, but the underlying mechanisms are not fully understood at present. One such mechanism involves the trapping and removal of pollutants from the atmosphere, such as PM, but also in providing a habitat for plant associated microbial communities in the phyllosphere (above ground parts of plants); these bacteria too can act to remove and metabolise some of these gaseous pollutants. Building on previous research at RHS and Warwick, we are keen to test the potential of plants and bacteria to contribute to air quality improvement. The ability of plants to trap particulate matter is enhanced by properties such as having hairy leaves[3]. Trapped PM may remain bound to the leaf structure or can be transferred into soil by being washed off by rain water. Research at RHS has highlighted hairy-leaved plants like *Stachys* and *Salvia* species to be beneficial for PM trapping.

Bacteria inhabiting the above ground parts of plants, the so-called phyllosphere, have the potential to degrade atmospheric volatile compounds and may contribute to degradation of volatile pollutants and chemicals bound to PM. Ongoing research at Warwick has shown microbial communities associated with tree leaves to degrade para-nitrophenol (PNP; Palmer, Bending, Schäfer, unpublished), a dominant atmospheric nitrophenol[4], which is a component of particulate matter from diesel engines[5]. We have also observed phyllosphere microbiota to be capable of carbon monoxide degradation.

In this PhD project you will address fundamental aspects of plant-bacterial partnerships and their potential to mitigate air pollutants. Key questions to be addressed are how the presence of leaf hairs affects microbial colonisation of the phyllosphere and how the

microbiota interacts with the plant and atmospherically derived pollutants. This will be carried out with plants previously identified as providing a high level of ecosystem services within green infrastructure (*Stachys* and *Salvia* spp.). Interestingly, these plants also have high content of phenolic compounds, which may affect colonisation of the phyllosphere, but also prime the microbiota to degrade plant and atmosphere derived phenolic compounds. Suitable comparisons will be done with 'control' plants lacking hairy leaves/phenolic content. **Overall, you will assess whether the extent of ecosystem services delivery by these plants can be enhanced through the air pollutant degradation via partnership with specific microorganisms.**

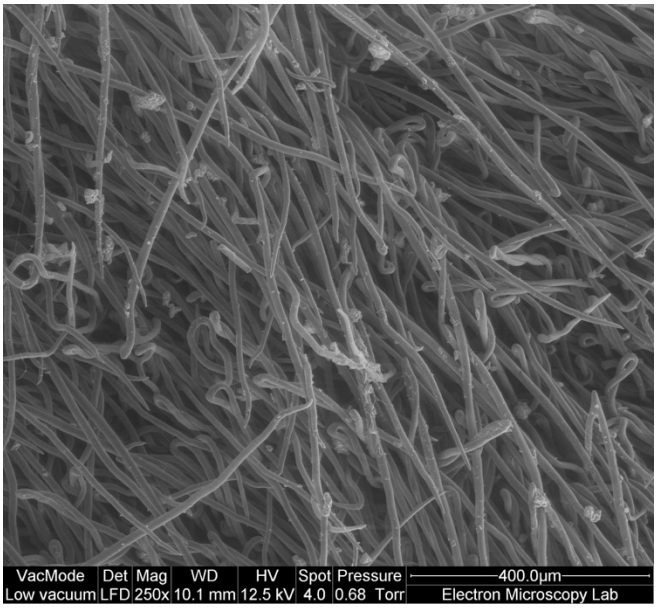

Figure 1: *Electron microscopy image of Cotoneaster leaf exposed to air pollution showing particles attached to leaf haris (copyright Tijana Blanusa, Royal Horticultural Society).*

Methodology: You will use a combination of growth experiments with specific plant species in the laboratory and environmental sampling of green infrastructure to assess diversity and activity of plant phyllosphere microbial populations and their potential to aid in ecosystem service delivery. You will use a variety of molecular approaches to characterise microbial community organisation and its ecological function. This will include DNA and RNA extraction and purification, PCR, sequencing using next generation platforms and bioinformatic analysis. Functional characterisation may include assessing processes such as trace gas/pollutant degradation using gas chromatography and liquid chromatography/mass spectrometry, or the role of microbial communities to the health status/disease resistance of host plants.

Training and skills: CENTA students are required to complete 45 days training throughout their PhD including a 10-day placement. In the first year, students will be trained as a single cohort on environmental science, research methods and core skills. Throughout the PhD, training will progress from core skills sets to master classes specific to CENTA research themes. Additional media training at the RHS will be provided in RHS media to equip the student with the skills to communicate their findings to different audiences.

Partners and collaboration (including CASE): Royal Horticultural Society (RHS) is supporting this project as a CASE partner. You will spend 3 months of the project closely working alongside RHS Principal Horticultural Scientist, who leads RHS' green infrastructure and ecosystem services research. You will gain insights into plant physiological techniques used to quantify provision of multiple services such as cooling, rainfall capture and particle pollutant capture by various landscape plants. You will also have the opportunity to work within a range of green infrastructure types (green roofs and walls, linear vegetation). There will be an annual opportunity to present at the RHS PhD student symposium where all RHS-funded students (and guests) share their progress.

Possible timeline:

Year 1: Assess microbial diversity and function associated with key infrastructure plants such as *Stachys* and *Salvia* spp. **Year 2&3:** Comparative studies in green infrastructure plantings and surrounding soil to map degradative functions and their expression.

Further reading: [1] Cameron & Blanusa, T. (2016) Annals of Botany, 118: 377-391. [2] Lelieveld et al (2015) Nature 525(7569):367-371. [3] Blanusa et al (2015) Urban Forestry & Urban Greening, 14 (4). pp. 1095-110 [4] Harrison et al. (2005) Atmos. Environ. 39(2):231-248. [5] Furuta C, et al. (2004) Biol. Reproduct. 70(5):1527-1533.

Further details:

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