Sustainable Urban Carbon Capture: Engineering Soils for Climate Change

Newcastle University

EPSRC Pioneering research and skills

SUCCESS Stakeholder Meeting took place 12th October, 2015

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Special points of interest:

- SUCCESS stakeholder meeting (top) took place on Monday 12th October, 2015
- Dr Ehsan Jorat oversaw construction of Carbon Capture plots (Below left)
- Dr Mark Goddard set up Pot trial experiments (Below right) to determine which plants grow best in urban soils
- Dr Ben Kolosz performed a preliminary Lifecycle Assessment on trial plots to estimate when the experiment becomes carbon neutral

Prof David Manning (PI) and Dr Saran Sohi (Co-I)

SUCCESS seeks new ways to design carbon capture function into engineered soils: green space around infrastructure, development sites, or in land remediation and restoration. Our aim is to define a process able to remove millions of tonnes of CO_2 from the UK atmosphere annually. This is an ambitious target, but direct measurement has already shown that 1 hectare of urban land can remove 85t CO_2 annually under ideal conditions. A piece of land the size of a premier league football pitch would remove 50t CO_2 annually. Our goal now is to establish how this can be practically achieved at the necessary scale.

The project has now been running for one full year, using a combination of experimental plots at Newcastle University's Cockle Park Farm in Northumberland and various brownfield sites in Newcastle and Gateshead. In parallel a broader picture has been investigated through "life cycle analysis", a desk-based effort considering sites across the north of England and southern Scotland. As well as the core team of researchers, Mark Goddard, Ehsan Jorat and Ben Kolosz, the project has benefited tremendously from the involvement of Pete Manning, Jon Aumônier and four MSc students: Dom Bradley, Sarah Broadbent, Sam Ngeow and Fei Wang. The field experiments now established provide a foundation for the project: data coming in from several different fronts is shaping our vision for the next phase, which focuses on implementation.

Now we have set up the key experiments (which will continue), we want to develop implementation of the concept. During 2016, we will examine with a number of interested landowners and other stakeholders how our findings can be integrated into their activities so that carbon capture can be added to a range of desired ecosystem services. Additions to our list of contacts are very welcome.

"Can urban soils be designed for carbon capture?

Dr Ehsan Jorat
Geotechnical Engineering

A research/demonstration site was constructed using artificial cement-based and quarried natural dolerite materials crushed down to <4mm as a source for Ca^{+}. The materials were separately mixed with yellow sand (having particle size <2mm) or placed in separate strata into the 14 trial plots of 3m x 4m x 1m in various proportions. For the last stage of the construction, plots were covered with <4 cm of compost to encourage vegetation on the plots. Since the construction of the demonstration site, monitoring of the trial plots' geotechnical properties have been conducted every six month using Cone Penetration Test (CPT) and undisturbed soil samples were also collected for comprehensive laboratory analysis. Cement and dolerite based live sites suitable for investigation of the carbonation process have been identified for geotechnical and ecological investigation. For Cement based sites, five brownfield sites in Newcastle and Gateshead were identified and ecological and geotechnical investigation were conducted. For dolerite based sites, an experimental site at Turners Quarry, Northumberland was identified for geotechnical and ecological investigation. 13 trial plots are present at the Turners Quarry site with various substrates mainly consisting of dolerite rocks of <50mm. Comprehensive physical, chemical and mechanical properties measurements were conducted on the samples collected from the experimental plots at the Turners Quarry to evaluate the effect of carbonation on the properties of the samples.

"Will plants grow on harsh soils for carbon capture?"

Dr Mark Goddard
Urban Ecology

A new experiment was established at Newcastle University's Cockle Park Farm. Over 200 pots have been planted with 25 different plant species from a range of plant functional groups, such as grasses, trees and herbaceous plants, as well as some species that are grown as energy crops. The plant growth experiment makes use of two main substrates – crushed concrete and dolerite quarry fines – which are known to have great potential for capturing carbon inorganically as calcium carbonate. The experiment runs for 18 months and soil samples will be collected to examine the amount of carbon that has been captured in the different experimental treatments. At the end of the experiment we will also look at the total growth of the plants in each pot as a measure of their performance over the course of the experiment. We hope that this work will be a forerunner to recommending designer plant communities as part of 'carbon capture gardens' in new urban developments or construction projects. Such carbon capture gardens will have the potential to be multifunctional, delivering other ecosystem services such as biodiversity conservation, recreation or bioenergy production. In addition to the experimental work at Cockle Park Farm, surveys across a variety of brownfield sites in Newcastle and Gateshead have been carried to address two main research questions:

What explains variation in carbon capture within and between brownfield sites (e.g. soil properties, vegetation cover, plant type)?

What are the trade-offs and synergies between carbon capture and other ecosystem services (i.e. flood regulation, pollination and cultural services)?

"Are our experiments carbon neutral?"

Dr Ben Kolosz
Urban Sustainability

We have been conducting some early analyses of the carbon capture trial plots to determine when they will become carbon neutral. This is important, as when we built the plots, it involved several processes which consume energy and in turn produce embedded emissions. Examples of this include the grinding, milling, transportation, mixing and the eventual delivery and excavation of the engineered soil to the site. Through our early estimations of the predicted rate of absorption, it will take roughly 2 years for the experiments to become carbon neutral in the sense that they offset the work that was carried out to implement them. There are a few unknowns still left to discover, such as the capacity and rate of the soil to absorb carbon and this is one of the things we need to find out. We will also be using cost benefit analysis in order to ascertain whether the soil product is viable as a commercial solution. If so, nationwide adoption may become a reality, provided that the land is available.