Mitigating greenhouse gas releases from contaminated urban re-development sites.

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Background: The construction industry is a major contributor to global carbon emissions and urgently needs to address this to reduce its carbon emissions. The release of the greenhouse gases, methane and carbon dioxide, from building site soils has not been properly investigated. These emissions are potentially harmful to the occupants of the new buildings as well as to the climate.

Developing brownfield sites (sites that have previously been used for industrial purposes) is more sustainable and environmentally responsible than building on greenfield or other undeveloped sites. Unfortunately, the soils at such sites are more likely to emit the greenhouse gas, carbon dioxide (as well as other gases, such as methane) and initial excavations may exacerbate these emissions. Assessing the gas emissions at such sites is evaluated through the planning process and effective site remediation is required for such residential developments to prevent harm to the new occupants.

Existing remediation processes are costly and not optimised for achieving sustainability targets: the focus is on minimizing cost and time over material re-use and reduction of greenhouse gas emissions. Brownfield remediation typically involves removal of the contaminated material to a pre-defined depth and placing a marker layer (plastic membrane) in the ground. Aggregate (crushed concrete) is then placed over the membrane and the site is finally covered with topsoil. Where high gas levels occur, an additional barrier membrane is also used to prevent dangerous accumulations of gases in the new buildings. Inevitably the plastic membranes will deteriorate over time releasing harmful microplastics into the environment, hence these cover systems cannot be considered sustainable. Alternative solutions which do not utilize plastics but still deliver appropriate capping for contaminated land are needed, Figures 1a & b.

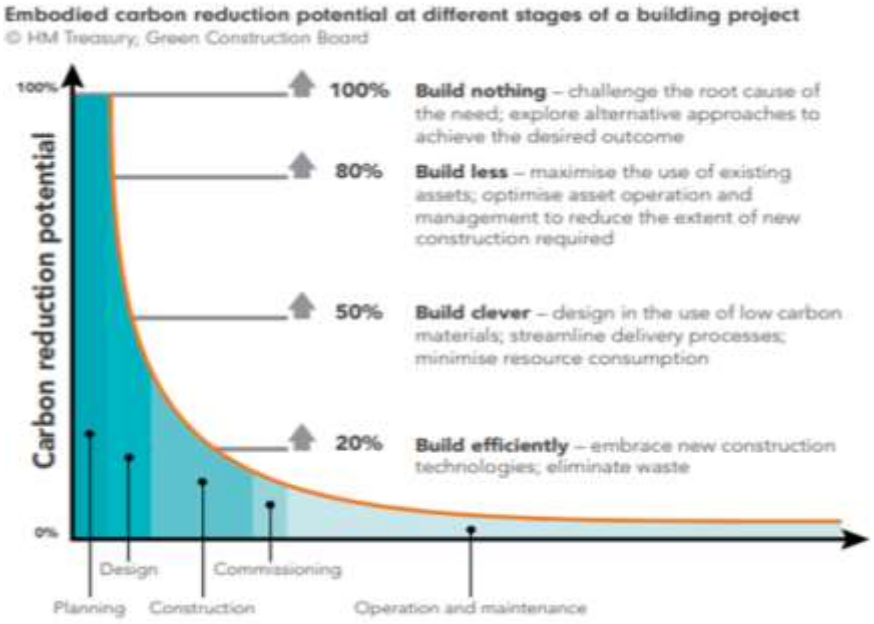

Figure 1a

Clever and efficient build to reduce carbon

Figure 1b

Plastic membrane used on sites

Project Description: The challenge in this PhD is to better understand the mechanisms of gas release from soil, the activities that contribute to this and thus explore how to minimise their emissions in remediation processes through better overall remediation design. Existing analysis and mitigation measures are based upon building a physical barrier: issues such as gas emissions and the influence of water on this are neglected.

This project investigates the hypothesis that moisture in soils may trap harmful gases via capillary forces or at least limit the rate of emissions. If so, we can potentially reduce/slow the release of these gases in earthwork activities and by developing covers using layers of soils with different grain sizes, ideally taken from top-soils of other building sites. This would mitigate the environmental impact through 1) reducing greenhouse gas emissions, 2) avoiding microplastics entering the environment and 3) reducing building waste.

You will investigate the following open-ended research questions:

- How does soil moisture content and grain size affect brownfield gas emissions?
- Is it possible to design an alternative, safe, more environmentally friendly capping by re-using soils from the existing site or from other building sites?

There will be 2 interconnected phases with flexibility to focus towards either phase based on your interests. Phase 1 will apply on-going research into the capillary trapping of carbon dioxide in the rock of deep underground aquifers and depleted hydrocarbon reservoirs. You will investigate the reverse of this process and develop appropriate numerical modelling or mathematical analysis tools, potentially validated by experiments. The aims are to determine i) how much gas will be released when partially saturated soil are disturbed during building excavations, ii) the sensitivity to the soil properties (grain size, layering, moisture content).

Phase 2 will use the tools developed in phase 1 to identify natural materials and layering strategies that

can be used to reduce gaseous emissions on site. The work will also focus on preserving topsoil and on-site materials, thus addressing the sustainability element of these valuable resources The challenge lies in identifying which materials are available or easily accessible on-site and determining the optimum layering and depth of each material in order achieve the most robust solution for minimizing gaseous releases, taking into account seasonally changing moisture contents.

Training opportunities:

You will undertake a placement with the industrial partner, LEAP Environmental to gain onsite site experience of brownfield/geotechnical site investigation and remediation design. In addition, you will be trained in

- Carbon calculation of earthworks and brownfield remediation
- CO_2 and methane gas measurement on development sites .

The project will be predominantly desktop-based with opportunities for field work/investigations. Existing commercial software can be used or the student can develop their own toolkit. Subject to your research interests, you may also perform scaled sandpack experiments in the laboratory or larger scale studies at a brownfield site. You would be trained in the use of the commercial or existing research software for numerical modelling of multiphase flow in porous media.

Student profile:

The student will need:

- A solid grounding (First or 2:1 Degree) in mathematics, engineering, physics or a physical science. Some knowledge of statistics would be beneficial.
- Ability to understand and develop software for scientific experimentation and data analysis.
- Familiarity with GIS modelling would be an advantage.
- An organised approach to work with strong problem-solving skills.
- Good oral and written communication skills.

Funding particulars: CASE funding through the SCENARIO DTP (https://research.reading.ac.uk/scenario/) supported by LEAP Environmental.

Home Department: School of Sustainability, Civil and Environmental Engineering, University of Surrey with regular visits to Imperial College to meet with your Imperial co-supervisors. This will enable you to meet with other PhD students at Imperial, working in related areas and to participate in activities in the sister DTP “Science and Solutions for a Changing Planet” https://www.imperial.ac.uk/grantham/education/science-and-solutions-for-a-changing-planet-dtp/