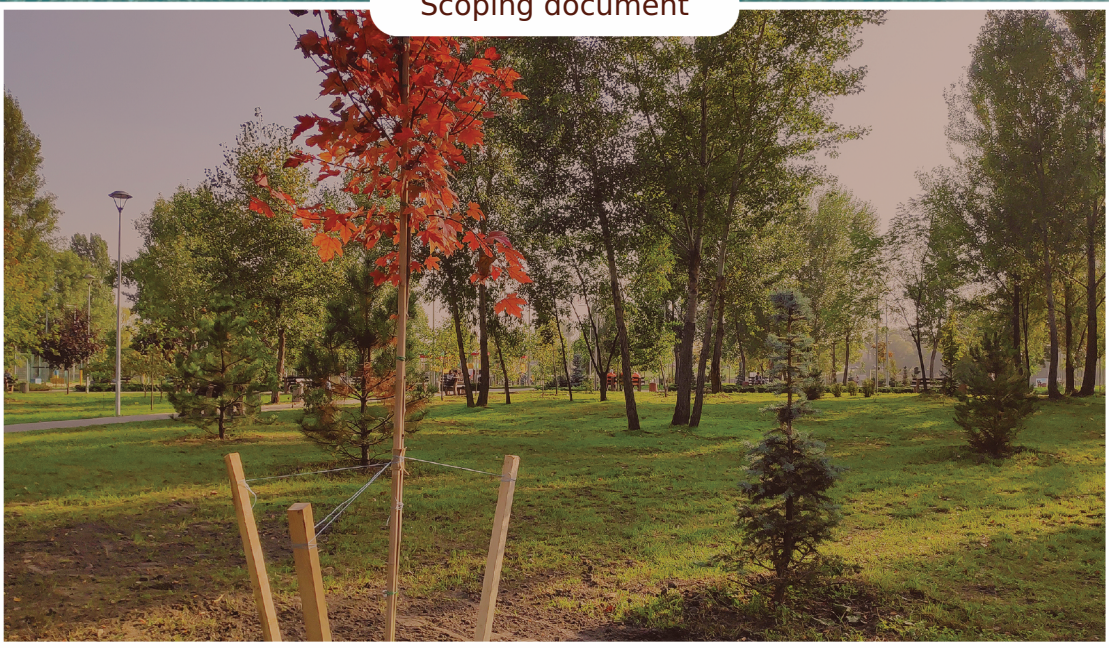
Soils for Europe 1: e119055
doi: 10.3897/soils4europe.e119055

SOILS FOR EUROPE
Soil sealing and urban soils

Scoping document



Preliminary assessment of the knowledge gaps to reduce soil sealing and increase the reuse of urban soil

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Funded by the European Union

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Preliminary assessment of the knowledge gaps to reduce soil sealing and increase the reuse of urban soil

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Academic editor: Nikolay Mehandzhiyski

Received: 18 Jan 2024 | Accepted: 29 Apr 2024 | Published: 30 May 2024

Citation: Cortinovis C, Frezzi S, Geneletti D (2024) Preliminary assessment of the knowledge gaps to reduce soil sealing and increase the reuse of urban soil. Soils for Europe 1: e119055. https://doi.org/10.3897/soils4europe.e119055

List of abbreviations

EC - European Commission

EEA - European Environment Agency

EU - European Union

SOLO - Soils for Europe Project

TT - Think Tanks

Introduction

To achieve the ambitious goal of 100% healthy soils in 2050, in the last few years the European Union has set up a complex policy framework for soil protection. The framework includes the Soil Strategy, the Directive on Soil Monitoring and Resilience (Soil Monitoring Law, European Commission 2023), the European Soil Observatory, and the Mission “A soil deal for Europe” (European Commission, Directorate-General for Research and Innovation 2022), as well as relevant sectoral policies (e.g., carbon policies). The EU Soil Strategy for

2030 (European Commission 2021b), approved in November 2021, is a key deliverable of the EU Biodiversity Strategy (European Commission, Directorate-General for Environment 2021) and aims to ensure that, by 2050,

- all EU soil ecosystems are healthy and more resilient and can therefore continue to provide their crucial services;
- there is no net land take and soil pollution is reduced to levels that are no longer harmful to people's health or ecosystems; and
- protecting soils, managing them sustainably and restoring degraded soils is a common standard.

The Mission "A Soil Deal for Europe", or EU Soil Mission (European Commission, Directorate-General for Research and Innovation 2022), supports the implementation of the strategy by finding solutions to protect and restore soil health. The mission defines eight specific objectives that future research and innovation activities should address. The third specific objective is to achieve *no net soil sealing and increase the reuse of urban soil*. Soil sealing is the main process that causes land degradation in urban areas (EEA European Environment Agency et al. 2022). When soil is sealed, an impermeable layer interrupts the connection between the soil and the atmosphere, which leads to a loss of soil resources, biodiversity, and ecosystem services. The process of soil sealing is strictly linked to that of land take (see definitions in the next Section). The reuse of urban soil instead refers to the use of excavated soil from construction sites for other purposes, instead of considering it as waste (Reicosky and Wilts 2005).

Beside the Soil Mission, another key action of the Soil Strategy is the proposal of a Soil Monitoring Law drafted in 2023, aiming to specify the conditions for healthy soils and lay out rules conducive to sustainable soil use and restoration. The proposal includes a mandatory monitoring of land take and soil sealing by Member States, to be conducted according to a common framework defining indicators and minimum methodological criteria (European Commission 2023). The indicators defined by the Soil Monitoring Law are: total artificial land; land take, including reverse land take (i.e., the renaturalization of previously developed land) and net land take (i.e., total minus reverse land take); and soil sealing. Member States may also measure optional indicators such as land fragmentation, land taken for specific uses, and impact on ecosystem services. According to the proposal, the values of soil sealing and land take indicators should be updated at least every year.

The third specific objective of the Soil Mission (*no net soil sealing and increase the reuse of urban soils*) is linked to several other strategies, goals, and targets of the EU, including those expressed in the Roadmap to a Resource Efficient Europe (European Commission 2011) (especially the target of "no net land take" by 2050), the EU Biodiversity Strategy to 2030 (European Commission, Directorate-General for Environment 2021), the proposal of a Nature Restoration Law (European Commission, Directorate-General for Environment 2022), and the EU Action Plan "Towards Zero Pollution for Air, Water and Soil" (European Commission 2021a). Achieving no net soil sealing and increasing the reuse of urban soils would also contribute to other EU Missions and related policy areas, such as *Oceans,*

Seas and Waters (management of water quality and quantity in urban areas), *Adaptation to Climate Change* (flood mitigation), and *Climate Neutral and Smart Cities* (climate mitigation and resource efficiency). In addition, the specific objective is directly linked to several targets of SDG 11 - Make cities and human settlements inclusive, safe, resilient and sustainable.

The aim of this document is to provide an initial overview of the topics addressed by the mission objective of *no net soil sealing and increase the reuse of urban soils* and a preliminary list of associated knowledge gaps. The contents have been progressively integrated and refined during two online and one in-person meetings where the members of the dedicated Think Tank set up by the project SOLO shared their views and opinions. In an effort to gather different perspectives, the fourteen contributors to this first version come from eleven countries and include academics and researchers, consultants, and representatives of public agencies and institutes of different Member States.

State-of-the-art

While the third specific objective of the Soil Mission puts together the issues of soil sealing and urban soil reuse, the two topics are usually addressed in separate ways by different scientific disciplines and stakeholders groups. For this reason, the following short description of the state-of-the-art -focused on the EU- is divided into two sub-chapters. The Think Tank discussed the existing boundaries between the two groups of experts but at the same time identified a potential innovation in the connection proposed by the Soil Mission. A key first step to link the two communities is to build a common ground for discussion based on agreed-upon definitions (Table 1).

Soil sealing

Despite being among the human activities with the greatest impacts on soil, data on sealing at the European level have been missing for a long time. In the past three decades, the extent of soil sealing has been estimated based on land take data, also reflecting the greater policy attention dedicated to the latter process, for which the “no net” target had been proposed already in 2011 (European Commission 2011). The same Soil Mission implementation plan estimates that the area with poor soil health due to soil sealing is probably <1% of EU land, but can be as high as 2.5%. These figures are based on the assumption that sealed areas represent around 50% of artificial areas, which cover 4.2% of the EU (European Commission, Directorate-General for Research and Innovation 2022).

As a consequence of this lack of direct data, soil sealing at the EU level could only be monitored indirectly by looking at changes in the size of artificial areas. Every six years, the European Environment Agency (EEA) reports on changes in artificial areas and net land take over the whole Europe based on Corine Land Cover maps. Available data cover the period between 2000 and 2018, during which artificial areas increased by 7.1%. Despite a reduction in the last decade, land take in EU28 between 2012-2018 still amounted to 539 km^2/year, of which 440 km^2/year are net land take (EEA European Environment Agency

2019a). Between 2000 and 2018, 78% of land take affected agricultural areas, consuming 0.6% of all arable lands and permanent crops, 0.5% of all pastures and mosaic farmlands, and 0.3% of all grasslands. Critical trends emerged in specific countries, such as Cyprus, the Netherlands, and Albania, which showed the highest rates of land take in the 18-years period (EEA European Environment Agency 2019b).

Table 1.

Definitions

Soil is the upper layer of the earth in which plants grow (Nougues and Brils 2023).
Land is the ground, including the soil covering and any associated surface water, over which ownership rights are enforced (Nougues and Brils 2023).
Soil sealing is the loss of soil resources (nutrients and moisture) due to the covering of the soil surface with impervious materials, as a result of urban development and infrastructure construction (https://esdac.jrc.ec.europa.eu/themes/soil-sealing).
Land take is the conversion of natural and semi-natural land into artificial land (Soil Monitoring Law - Article 3 (*European Commission 2023*). Land take is a process that transforms natural and semi-natural areas (including agricultural and forestry land, gardens and parks) into artificial land, using soil as a platform for constructions and infrastructure, as a direct source of raw material, or as archive for historic patrimony. This transformation may cause the loss, often irreversibly, of the capacity of soils to provide other ecosystem services (provision of food and biomass, water and nutrients cycling, basis for biodiversity and carbon storage). (Soil Monitoring Law - Preamble (30), European Commission 2023).
Soil reuse involves the repurposing of excavated soil from construction sites, which may be reused on-site or off-site, taking into account its characteristics and ensuring that they are compatible with the new soil application (Hale et al. 2021).
Land recycling is defined as the reuse of abandoned, vacant or underused land for redevelopment (EEA European Environment Agency 2021).

The main drivers of land take during 2000-2018 were industrial and commercial land use, as well as extension of low-density residential areas and construction sites (EEA European Environment Agency 2019b). These findings could also give some hints on the main drivers of soil sealing, although the resolution of Corine Land Cover data is not suitable to capture small-scale urbanisation processes such as “small sealing” interventions that affect the open spaces around and associated with residential properties (Cameron 2023). More detailed data on land take and net land take are available at the level of single cities and commuting zones, based on the Urban Atlas database that provides high-resolution land use land cover maps of 788 Functional Urban Areas (FUA), i.e. cities and related commuting zones, across Europe (EEA European Environment Agency 2023). On the other hand, the fact that this database does not cover the whole territory of the EU limits its application for large scale (national and continental) monitoring.

In 2018, the Copernicus Land Monitoring Service released the first version of the Imperviousness Density (IMD) high-resolution layer. The product captures the spatial distribution and change over time of artificially sealed areas by storing in a raster map at 10m resolution information about the density of impervious areas in each cell, expressed in a range from 0% to 100%. The maps cover the whole EEA-38 (members and cooperating countries of the European Environment Agency) area and the United Kingdom, thus

providing a homogeneous dataset to assess soil sealing at the EU level. Updated maps are resealed every three years and those currently available cover the period between 2006 and 2018, although resolution and technical details are not fully aligned across the different versions. Besides these limitations in terms of spatial and temporal resolution, it should be noted that the IMD layer estimates sealing based on remote-sensing data, which do not capture underground structures, such as basements and parking garages. These structures are common in urban areas and reduce the supply of soil ecosystem services, such as water infiltration and water purification (Tobias et al. 2018).

Besides soil sealing, the third Soil Mission specific objective (*no net soil sealing and increase the reuse of urban soils*) also addresses the increase of land recycling activities (EEA European Environment Agency 2016). The term "land recycling" refers to one of the indicators developed by the EEA to monitor specific processes linked to land take. The land recycling indicator includes three components: "green recycling", "grey recycling", and "densification" which were assessed for the first time by the EEA in 2018 based on Urban Atlas data (EEA European Environment Agency 2021). Densification, i.e., land development within existing urban areas that makes maximum use of the existing infrastructure, accounted for the largest proportion of land recycling (9% of total land consumption). Grey recycling, i.e., the internal conversions between residential and/or non-residential land cover types, was secondary to densification (3.2% of total land consumption), with country rates ranging from 14% of total land consumption in Latvia to less than 1% in Slovakia, Slovenia, Luxembourg, and Lithuania. Green recycling, i.e., the development of green urban areas on previously built-up areas, was a marginal process in all countries and, on average, accounted for only 0.2% of total land consumption. The monitoring of these indicators by the EEA was discontinued, so more recent figures are not available. The Soil Mission has set a target of exceeding the limit of 13% for land recycling. This figure refers to the period of 2006-2012, when land recycling contributed only 13% towards the total land use changes involving urbanized areas in European Functional Urban Areas.

Urban soil reuse

The objective of *no net soil sealing and increase the reuse of urban soils* also addresses the reuse of urban soils, although no specific target has been set for this part of the objective. In most countries, soils excavated from construction sites are currently considered as waste and disposed on in landfills, which makes them the biggest source of waste in the EU (more than 520 million tonnes only in 2018) (Scialpi and Perrotti 2022). To reduce this trend, the Soil Strategy aims to investigate the streams of excavated soils and considers proposing a "soil passport", on the model of existing digital tools to track soil reuse in some EU countries (e.g., in Belgium and under development in France) (SOILveR (Soil and land research funding platform for Europe), 2022). These tools are sometimes also called or linked to 'soil banks', whose aim is to reconcile supply and demand of surplus soil from construction sites.

Indeed, the legal framework around excavated soils and their potential reuse is very different across Member States. In some countries, reuse is encouraged and even enforced for certain soils of high agricultural value. In other countries, reuse is allowed under certain conditions that usually refer to the quality of the soil and sometimes set temporal and spatial boundaries for the new application (e.g., in Sweden, only on-site and within a reasonable period of time) (Hale et al. 2021). Often, additional permits or licences are required, which impose a burden on reuse activities (Hale et al. 2021).

The management of excavated soils and their potential reuse is strictly linked to the issue of pollution (addressed by the fourth specific objective of the Soil Mission), although only part of excavated soil is polluted. While potentially contaminated sites in EEA-39 amount to 2.8 million, diffuse pollution -including pollution due to microplastic- could be a major problem in urban soils, whose impacts are still largely unknown. Beyond these general issues, other local issues may emerge in specific contexts as an effect of the high levels of soil sealing and associated anthropic activities and management practices, including compaction, erosion, and other types of concentrated pollution, which may affect urban soils in different ways compared to natural soils.

A detailed knowledge of the quality of soils, not only in terms of contamination levels but also in terms of geotechnical properties, is a prerequisite for safe reuse (Hale et al. 2021). The current level of knowledge on urban soils is generally poor, also due to the high spatial variability of their properties (Pouyat et al. 2020). However, more and more databases of urban soil quality are being developed at regional level (e.g., the GeoBaPa in the Regions Ile de France and in Normandy, or similar examples in various Länder in Germany) and even at the national level (e.g., BDSolU in France).

Knowledge Gaps

The H2020 project Soil Mission Support (SMS) completed in 2022 and the Soil Mission Implementation Plan had already identified some knowledge needs associated with the Soil Mission specific objective of *no net soil sealing and increase the reuse of urban soils.* Those initial lists were integrated through a fast screening of relevant literature and then complemented by the outcomes of the discussions within the Think Tank.

Knowledge gaps to achieve no net soil sealing

1. Link between soil sealing and land take
    1. What is the degree of soil sealing associated with different land take processes? How does it vary in different contexts (e.g., for the same land use class across different countries)?
    2. To which extent do the “no net soil sealing” and “no net land take” targets overlap?
2. Methods, data and indicators to monitor soil sealing
    1. What approaches are more suitable to monitor soil sealing and land take processes at different scales?

2. What methods and data are suitable to capture small sealing interventions at the local scale?
3. What indicators should be adopted to assess the impacts of soil sealing and land take?

3. Scientific basis and applicability of non-binary classifications of soil sealing
   1. Would it be possible and desirable to move away from binary classifications of sealed vs. unsealed soils towards a more shaded picture based on soil properties and the impacts of sealing activities on soil health and functions?
   2. To which extent could a non-binary assessment of soil sealing be included or support the development of innovative policies to achieve “no net soil sealing”?
   3. How can underground soil sealing and other forms of degradation with similar impacts (e.g., compaction) be assessed properly and effectively?
4. Differences across Member States
   1. How are land take and soil sealing currently assessed in different countries (data sources, methods, indicators and reporting units, evaluation frequency)?
   2. Are there indicators related to soil sealing and land take currently monitored and reported on across other EU level initiatives?
   3. What common procedures can be established to monitor soil sealing and land take in EU Member States?
   4. What would be the reporting mechanisms of these indicators? And how will the monitored data be analysed and compiled to assess soil sealing and land take at EU level?
5. Effectiveness of actions to counteract soil sealing
   1. How effective are de-sealing/unsealing actions in restoring lost soils functions?
   2. What is the potential of de-sealing interventions and how does it vary across different contexts (urban vs. non-urban areas, different types of settlements)?
   3. How to identify suitable areas for de-sealing interventions and to prioritise them?
6. Legal dimension of soil sealing
   1. How does the legal dimension of soil sealing and land take vary across Member States and what are the opportunities to integrate the “no net soil sealing” objective?
   2. How do property rights and property regimes affect soil sealing in urban areas?
7. Societal dimension of soil sealing
   1. How does society perceive the relevance and need for the “no net soil sealing” and “no net land take” targets?
   2. What is the level of awareness of the functions of soils across different categories of actors?
   3. What social, economic, and cultural factors drive the decisions of landowners and land managers about soil sealing?

4. What actors are likely to oppose policies and actions to achieve no net soil sealing the most? Why

8. Fairness and legitimacy of “no net soil sealing” policies
    1. How to minimise the negative impacts of “no net soil sealing” and “no net land take” policies on housing affordability and other material benefits?
    2. How to ensure that policies aimed at halting land take and soil sealing have fair impacts and do not exacerbate inequalities?
    3. What actions can be taken to enhance the legitimacy of reducing new land take and soil sealing against the demand of people?
    4. What tangible benefits of soil sealing reduction strategies can be stressed to enhance their legitimacy in the eyes of the urban and non-urban population?
9. Consideration of soil sealing in existing policies
    1. To what extent are the concept of "healthy soils" and the importance and diversity of soil functions included in spatial planning?
    2. To what extent have different policy instruments proven to be effective in supporting the “no net soil sealing” target?
    3. What policies have an indirect impact on soil sealing and land take? How to ensure that this impact is considered in their evaluation?
10. New approaches and instruments to reduce soil sealing
    1. What is the potential impact of different strategies for sustainable urban development (e.g., densification, regeneration, greening through nature-based solutions, integrated water management) on soil sealing and land take?
    2. How to design effective policies making use of innovative tools such as compensation mechanisms and incentive mechanisms that integrate both push (costs of inaction) and pull factors (benefits from sustainable soil use)?

Knowledge gaps to increase the reuse of urban soils

1. Quality of (urban) soils
    1. What is the quality of urban soils in Europe?
    2. What indicators and protocols can be used to assess the quality of urban soil for their reuse?
    3. What (cost-)effective methods and tools exist for the analysis?
2. Regulations on Maximum Limit Values
    1. What are existing regulations on threshold values for different reuse purposes (road and transportation projects, agriculture, urban development)?
    2. How to implement Maximum Limit Values at EU-level for the assessment of urban soil quality for different reuse purposes, considering the differences in terms of quality of local soils and existing legislation?

3. Remediation and improvement techniques
    1. What are the most cost-effective remediation techniques for urban soils that do not meet reuse standards?
    2. How to select the most suitable remediation technique depending on the purpose of the reuse?
    3. How to prove the quality of improved soil with an acceptable level of certainty?
4. Best practices to promote the reuse of urban soils
    1. What are existing best practices of certifying soil quality and tracking soil transportation ("soil passport")? How could they be scaled at the EU level?
    2. What are the most effective policy instruments to promote the reuse of urban soils?
5. Social acceptance of soil reuse
    1. What is the level of social acceptance of soil reuse? How can it be improved?
6. Barriers to soil reuse
    1. What are the most important barriers that currently limit the reuse of urban soils?
    2. How do barriers to soil reuse vary across different EU contexts?

Acknowledgements

This document received substantial contributions from the SOLO (Soils for Europe) Think Tank 3 members: Martin Bocquet (Centre for Studies on Risks, the Environment, Mobility and Urban Planning - CEREMA), Christel Carlsson (Swedish Geotechnical Institute – SGI), Samuel Coussy (French National Geological Service – BRGM), Antoine Decoville (Luxembourg Institute of Socio-Economic Research – LISER), Kristina Flexman (WSP), Jean-Marie Halleux (Université de Liège), Karen Naciph Mora (ICLEI), Michele Munafò (Istituto Superiore per la Protezione e la Ricerca Ambientale - ISPRA), Rita Nicolau (Direção-Geral do Território), Gundula Prokop (Austrian Environment Agency - Umweltbundesamt), Stefan Siedentop (TU Dortmund), Jaroslava Sobocká (Soil Science and Conservation Research Institute - SSCRI), Roger Roca Vallejo (ICLEI), Eliška Vejchodská (Charles University in Prague).

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