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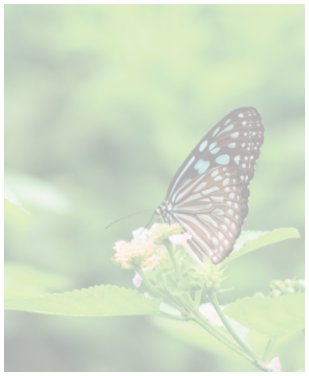


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Wednesday, October 5, 2022

08h30
Attendees's welcoming

09h15
Introduction
Saïd El Fadili, Head of Soils sub-division - Brussels Environment

09h30
European vision
Bavo Peeters, Policy Officer Soil - European Commission

10h00
Flemish Region
Ann Cuyckens, Head of Soil Division - Public Waste Agency of Flanders (OVAM)

10h30
Wallonia Region
Esther Goidts, Senior Advisor, Soil and Waste Department, Soil Protection Directorate - SPW

11h00
Coffee break

11h30
Brussels-Capital Region
Saïd El Fadili, Head of Soils sub-division - Brussels Environment

12h00
Discussions - Panel moderated by Bernard Deltour, Partner - Industrious Law Firm

12h30
Lunch

Zero soil artificialization

13h30
Soil ecosystem services in belgian urban planning: the first pilots - Brussels, Antwerp and Ghent
Kristel Lauryssen, Expert - Antea Group (Belgium)

13h50
Urban recycling and optimal use of built stock and artificial land
Sébastien Hendrickx, Searcher - Lepur-Uliège

14h10
Organization of participatory worksites in the public space of Brussels, in order to demineralize the soil and regenerate/vegetate it
Laëtitia Cloostermans, Coordinator - Less Béton ASBL

14h30
Dewatering urban soils: Where? How ? Introduction to the tools being developed as part of the DésiVille project
Cécile Le Guern, Senior project manager - BRGM (France)

What practices for sustainable soil management?

14h50
Re-design of cropping routes by farmers based on a diagnosis of soil life: CONSOL project
Pierre Mulliez, Head of Agronomy Department, Agricultural Engineer, Soil Scientist - Pays de Loire Regional Chamber of Agriculture (France)

15h10
Engineered soils from natural mineral additives and industrial waste for restoration of degraded areas
Vesna Zupanc, Researcher - University of Ljubljana, Biotechnical Faculty (Slovenia)

15h30
NWE-REGENERATIS Workshop
Valorization of soils and polluted materials from metallurgical sites: current challenges and new tools developed in the framework of the NWE-REGENERATIS project

Description: *The recovery of materials is one of the major axes in the framework of the climate transition and the economic reconversion of polluted sites. This workshop is organized in the framework of the NWE-REGENERATIS project which aims to provide a solution, based on data collected from demonstration sites, to recover aggregate materials (ferrous metals, white and black slag, other streams, ...) by urban mining techniques.*
This workshop will be an excellent opportunity to explore urban mining from different aspects and will allow the identification of the main barriers and solutions for the implementation of future projects focused on resource recovery.

15h30
Presentation of the NWE-REGENERATIS project
Claudia Neculau, Head of R&D and Innovation Department - SPAQuE

15h45
Resource recovery from construction waste: Barriers and solutions in the Walloon context
David Lamy, General Manager - Tradecowall

16h05
Evaluation of the use of historical pocket slag deposits in road construction as an alternative to LD and EAF slag
Stéphane Neirynck, General Manager - CTP

16h25
New economic model for the development of the projects on the former metallurgical sites
Iqra Aziz, Project Manager NWE-REGENERATIS - SPAQuE

16h35
Coffee break

16h50
Synthesis of bio-sourced catalysts from ryegrass produced on the metallurgical sites for the synthesis of therapeutic molecules: a possible option? Feedback from the NWE-REGENERATIS project
• *Adeline Janus, Researcher - Polluted Sites and Soils Department - Ixsane*
• *Alina Ghinet, Sustainable Chemistry Team Leader & Christophe Waterlot, Environment Team Leader - Health & Environment Department - Junia*

17h05
The NWE-REGENERATIS project: an open access platform to boost the rehabilitation of metallurgical wastelands
Sébastien Moreaux, Project Manager - Atrasol

17h15
Debate / Discussion: Identification of the barriers and solutions to prepare recommendations for the implementation of the projects focused on resource recovery

17h30
Conclusion of the day by *Mr. Alain Maron, Minister of the Environment of the Brussels-Capital Region*

17h45
Cocktail & Networking

19h00
End of the 1st day

La nouvelle stratégie de gestion des sols en Région de Bruxelles-Capitale

Saïd El Fadili, Chef de sous division – Bruxelles Environnement
Sous-division Sols
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1. Importance de la gestion intégrée et durable des sols à Bruxelles

Les sols sont une ressource non renouvelable et limitée, dont la formation de quelques centimètres requiert plusieurs milliers d'années. Ils sont de ce fait particulièrement précieux et constituent un écosystème vivant essentiel, complexe, multifonctionnel et indispensable au niveau environnemental et socio-économique. Ils rendent des services écosystémiques essentiels aux populations locales et au niveau mondial, tels que la fourniture de ressources alimentaires et de matières premières, la régulation du climat grâce à la séquestration du carbone, la purification de l'eau, la régulation des nutriments ou la lutte contre les organismes nuisibles. En outre, ils servent de plateforme aux activités humaines et limitent les risques d'inondation et de sécheresse. Ces services sont cruciaux pour la vie humaine et la survie des écosystèmes, afin que les générations actuelles et futures puissent subvenir à leurs propres besoins.

Or, la législation bruxelloise actuelle se limite à la prise en charge des pollutions chimiques des sols, en vue de les décontaminer et de les réserver presque uniquement aux seules fonctions de support pour des bâtiments et autres infrastructures. Cette approche néglige la prise en considération des sols dans leurs dimensions physique et biologique et, par conséquent, ne prend pas (ou insuffisamment) en compte la valeur des services écosystémiques qu'ils fournissent. La nouvelle stratégie de gestion des sols bruxellois consiste en une gestion intégrée et durable et a pour objectif d'intégrer, en plus des composantes chimiques, les propriétés physiques et biologiques des sols et de traiter l'ensemble des dégradations qu'ils subissent (compaction, érosion, pertes en matière organique, en nutriments et en micro-organismes,…).

Les différentes campagnes d'analyse, réalisées par Bruxelles Environnement en 2021 et 2022, montrent que 50% de sols bruxellois sont dégradés et la Région ne peut négliger le risque qu'entraîne l'aggravation de cette situation. La Région a besoin d'intégrer la politique de protection, de gestion durable et de restauration des sols dans le modèle socio-économique proposé par la Commission européenne.

L'absence de cadre juridique bruxellois en matière de gestion intégrée et durable des sols, adapté et cohérent, est identifiée par les parties prenantes interrogées lors des enquêtes de 2021, comme la principale cause favorisant la poursuite de la dégradation des sols bruxellois.

Investir pour éviter la dégradation des sols et pour restaurer les sols dégradés est économiquement cohérent, car en règle générale les bénéfices excèdent largement les coûts et selon la stratégie 2030 sur les sols de la Commission européenne les coûts de la restauration sont dix fois plus élevés que les coûts de prévention.

La protection des sols, leur utilisation durable dans le contexte d'une économie circulaire, ainsi que leur restauration doivent être intégrées dans toutes les politiques sectorielles pertinentes et cohérentes afin de prévenir toutes nouvelles dégradations, de garantir un niveau uniformément élevé de protection (et, le cas échéant, de restauration) et d'éviter les chevauchements, les incohérences et les contradictions au sein de la législation et des politiques de la Région.

2. Gestion intégrée et durable des sols pour lutter contre les changements climatiques

La dégradation des sols entrave la capacité de la Région à atteindre ses objectifs en matière d'environnement, de développement durable et de climat. Ainsi, par exemple, en l'absence de mesures supplémentaires pour améliorer la qualité des sols bruxellois, il sera difficile, voire impossible, d'atteindre les objectifs de neutralité carbone et d'adaptation aux changements climatiques en 2050 comme en atteste la Commission européenne dans sa stratégie 2030.

Les sols vivants renforceront la résilience de la Région et réduiront sa vulnérabilité aux changements climatiques. Les sols de la planète constituent le plus grand réservoir terrestre de carbone (3 à 4 fois plus que la végétation et l'atmosphère réunies). Les sols sains sont essentiels à l'atténuation du changement climatique car ils absorbent environ 25 % de l'équivalent carbone issu chaque année de l'utilisation des combustibles fossiles au niveau mondial ([1]). Les espaces verts, l'agriculture, les bois et les forêts contribuent de façon essentielle à l'absorption du carbone de l'atmosphère grâce au captage et au stockage du carbone dans les sols et dans la biomasse.

La Commission européenne déclare qu'on ne peut réussir les stratégies relatives à la biodiversité, l'alimentation et surtout la neutralité carbone en 2050 que si nous avons d'ici là 100% de sols sains ([2]). Plus concrètement, la Commission estime que pour parvenir à la neutralité carbone en 2050, il faudra non seulement mettre un terme à la destruction des sols riches en carbone mais aussi enrichir les sols en carbone ([3]). La Région pourra soutenir l'initiative mondiale « 4 pour 1000 » afin d'augmenter la teneur en carbone organique des sols (agricoles, forestiers et des espaces verts) ([4]). Compte tenu de leur rôle crucial dans le cycle de l'eau, les sols constituent également un allié indispensable pour l'adaptation au changement climatique. Une forte capacité de rétention d'eau des sols limite les effets des inondations et diminue l'impact négatif des sécheresses.

Enfin, des bonnes pratiques concernant le stockage du carbone et le maintien de l'eau dans les sols (agroécologie, agroforesterie, agriculture de conservation, gestion des paysages, gestion des déchets verts, paillage, etc.) seront mises en place.

3. Gestion intégrée et durable des sols pour lutter contre le déclin de la biodiversité

Les sols vivants abritent 25% de la biodiversité mondiale et tous ces micro-organismes jouent un rôle essentiel pour assurer l'ensemble des services écosystémiques. La présence d'une faune dans les sols augmente significativement le rendement, la biomasse et la diversité des plantes. Plus généralement, l'impact de la faune du sol sur la production primaire peut être vu au travers de ses effets sur les fonctions de recyclage des nutriments, d'entretien de la stabilité/structure du sol, de contrôle des parasites et de support de biodiversité. Un sol vivant favorisant une biodiversité riche et variée ne doit pas être forcément un sol riche en nutriments et en matière organique car l'objectif est d'avoir une diversité des sols pour assurer une diversité des plantes. Par exemple, un sol vivant riche dans une zone humide permet le développement d'espèces végétales telles que la reine des prés qui est extrêmement utile aux insectes butineurs, tandis qu'un sol pauvre favorise l'apparition d'orchidées sauvages, etc.

La faune du sol représente donc un atout pour la croissance et la diversité des plantes. Pourtant, cette faune s'appauvrit en raison de pratiques de gestion des sols non durables et de la fragmentation des habitats naturels. Cet appauvrissement agit sur les interactions biologiques et

[1] Avis du Comité des régions sur la « Mise en œuvre de la stratégie thématique en faveur de la protection des sols » (2013/C 17/08)
[2] Stratégie UE, p. 3.
[3] *Idem*, p. 4.
[4] www.4p1000.org.

induit un plus faible niveau de services rendus, notamment concernant la pollinisation ou le contrôle des ravageurs, la disponibilité en nutriments ou la stabilité des sols. Les pratiques de gestion durables des sols devraient aider à maintenir, voire améliorer, la faune du sol et par conséquent la diversité des plantes.

La présente ordonnance vise dès lors à restaurer la faune du sol, à surveiller son évolution et son étendue.

4. Gestion intégrée et durable des sols en faveur de l'économie circulaire

Enfin, la gestion circulaire des sols déjà scellés (entre 17.000 et 26.000 bâtiments abandonnés) pourrait aider à freiner l'imperméabilisation des sols et ainsi à mieux lutter contre les inondations et le déclin de la biodiversité. La Stratégie UE projette, à ce titre, « zéro artificialisation nette » en 2050 ([5]). A l'échelle de la Région, 65 hectares de sols sont imperméabilisés par an. Sans mesures contraignantes destinées à limiter l'occupation de nouvelles terres et à favoriser leur restauration, leur remise en culture et leur recyclage, il sera impossible d'atteindre l'objectif consistant à mettre fin à l'augmentation nette de l'artificialisation des terres d'ici 2050.

5. Mise en place concrète de la gestion intégrée et durable des sols

Pour passer à l'action, il est nécessaire de connaitre la qualité des sols bruxellois et le présent projet d'ordonnance poursuit cet objectif car seule une information complète peut aider à identifier et restaurer les dégradations et à gérer durablement les sols bruxellois.

Le présent projet d'ordonnance vise à mettre en place une procédure d'identification et de traitement des sols dégradés et à aider les propriétaires et les exploitants à mieux choisir les usages pour leurs sols en fonction des services écosystémiques qu'ils sont susceptibles de fournir. Par exemple, un sol vivant sera, dans la mesure du possible, réservé à l'agriculture, la biodiversité et la régulation des cycles de l'eau et du carbone, tandis qu'un sol non vivant sera destiné aux constructions.

En outre, le présent projet vise à encourager les utilisateurs des terres à prendre des mesures de prévention afin d'empêcher la dégradation des sols, de préserver les sols et de les gérer de manière durable pour les générations futures.

Pour ce faire, le présent projet d'ordonnance prévoit des mesures de soutien et d'incitation financières suffisantes en faveur de la protection, de la gestion durable, de la préservation et de la restauration des sols.

De même, des guides techniques verront le jour afin d'aider les acteurs concernés à gérer de façon intégrée et durable les sols bruxellois.

Des partenariats seront renforcés avec des acteurs tels que Urban, les communes, les opérateurs publics, les experts ou les entrepreneurs en gestion ainsi qu'avec les notaires et les fédérations sectorielles.

Enfin, il est utile et nécessaire de mettre en place des initiatives qui visent à améliorer la sensibilisation et la compréhension du public en ce qui concerne l'incidence positive des fonctions des sols et de la protection et la de restauration des sols, ainsi qu'en matière de santé publique et de durabilité environnementale. La sensibilisation du public à l'égard des fonctions des sols et sa compréhension du sujet sont fondamentales pour garantir le succès du présent projet d'ordonnance. La participation des citoyens, et en premier lieu des propriétaires et gestionnaires terriens, des

[5] Stratégie UE, p. 4.

agriculteurs et des forestiers, en tant qu'acteurs principaux de la gestion des sols est aussi un enjeu fondamental. Pour ce faire, il est préconisé de renforcer le dialogue avec le grand public en ce qui concerne la santé des sols et l'urgence environnementale, de soutenir les initiatives locales sur la protection et l'utilisation durable des sols.

Soil Ecosystem Services in Belgian Urban Planning: The first pilots – Brussels, Antwerp and Ghent

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Given the extremely high degree of urbanization in Belgium, the sustainable provision of urban ecosystem services becomes increasingly important. Soils in particular, play a fundamental role in providing cities with vital resources and services by regulating various processes such as water production, pollution mitigation and carbon sequestration. Because of those benefits, it would be strongly advisable to include them more prominently earlier on into climate adaptation strategies and the urban development decision making process.

Antea Group is playing an active role in the introduction of soil related ecosystem services in urban planning via several pilot projects.

Brussels, like any other major city in Europe, has the challenge of satisfying the simultaneous increase in housing demand, provisioning services and open (blue-green) spaces in the changing climate. To avoid the constant conversion of open space for urban development, Antea Group and her partners are constructing a comprehensive vision of the open space network based an ecosystem-service oriented cartographic framework. Soil ecosystem services play a leading role in this exercise. Based on parameters such as soil state, pollution and permeability, optimal routes for green-blue connections are be determined. This way urban development in Brussels becomes data driven starting from upper level policy making. The vision document aims to stimulate the creation of an optimal, uniform and multifunctional open space network that supports a healthy and robust living environment.

A second example is the creation of a green open space network around the ring road of Antwerp. The goal is to create a healthy living environment before covering the highway with an above ground tunnel system. Besides the infrastructural design, Antea group is responsible for the durable management of soil and biodiversity, with the inclusion of soil-water management and climate adaptation measures. First steps included the creation of tactical infrastructure elements whereby an important fraction of soil was translocated. At the moment, it is assessed how rare vegetation can be preserved as well as how the soil seed banks can be displaced.

Antea Group has also developed robust ‘water-smart ecosystems’ in the core area of Ghent , countering draught and tackling water provisioning issues. The digital soil database of the Flemish soil agency (OVAM) was accessed and visualized in a GIS based platform. Uninvestigated parcels with a high potential for soil contamination were identified. Interference was evaluated between the (potential) soil contamination and proposed measures aimed for the improvement of the water-smart ecosystems, resulting in a win-win situation where the reinforcement of soil- and water related ecosystem services

provides an improved soil quality. This study will also be used in an improvement of governmental data management for use in urban planning projects.

***Fig 1**: New green corridors in the open space network of Brussels, where SESS are evaluated (Antea group – Buur, 2019)*

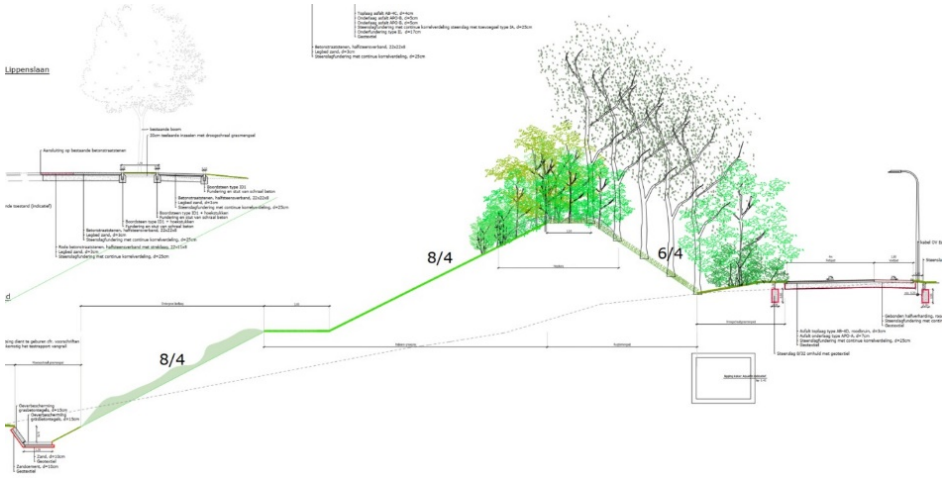

***Figure 2**: Redevelopment scheme for the ring road of Antwerp (Antea Group et. al., 2019)*

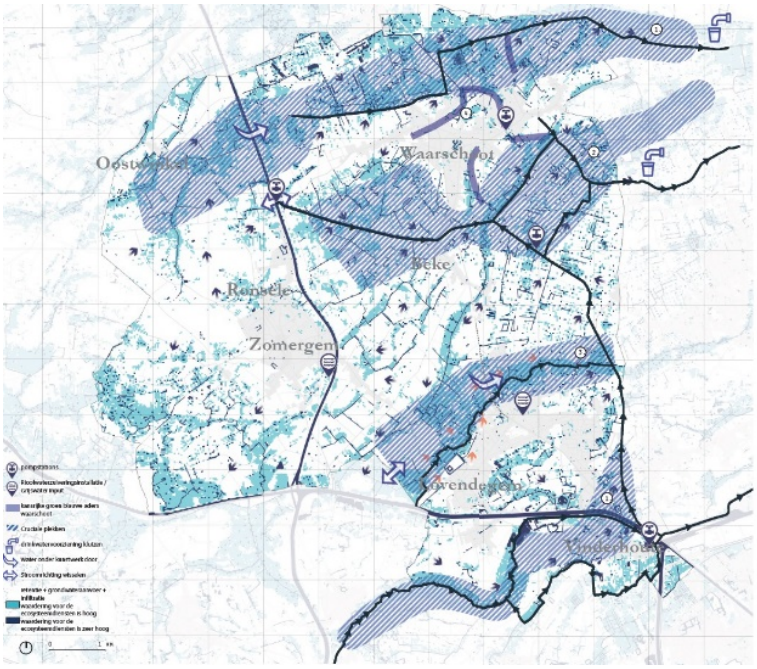

Fig 3: *Crucial meso-scale areas in the water-smart ecosystem for evaluation of soilquality .(Antea group – PT Architects)*

Urban recycling and optimal use of built stock and artificial land

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In the context of the *Conférence Permanente du Développement Territorial* (CPDT) in Wallonia (Belgium), the research "Intensification and requalification of centralities to reduce urban sprawl and car dependency" is in line with the Walloon government's desire to limit urban sprawl and, finally, to put an end to it by 2050.

Achieving this objective means optimising the use of artificial land and the existing stock of buildings. Urban recycling is based on the densification or intensification of some urban areas, on the re-use of wasteland (brownfields) and on the rehabilitation of old urban areas.

It is also a question of improving the monitoring of urban sprawl through better observation of urban recycling processes and the potential for housing production through these (Coszach et al., 2019). In the context of this research, we propose to verify whether the available data sources make it possible to quantify and spatialise precisely the importance of the different forms of urban recycling in housing production and the potential of residential built-up areas to increase the number of housing units within them (Hendrickx et al., 2021).

Part of urban recycling in current housing production

Some previous analyses have tried to quantify the production of housing through urban recycling (Charlier et al., 2014; Jungers et al., 2015). Mainly based on data from the issuing of permits (*ex-ante* data), these analyses do not take into account all forms of housing production on artificialised land. The method we propose is complementary and relies on property data, more commonly referred to as 'cadastre' (*ex-post* data). These data are used in a diachronic analysis of the evolution of the number of housing units at the cadastral parcel level.

The property situations on the 1st of January 2010 and 2016 were compared in order to identify three types of operations: construction of new buildings, modification of existing buildings and demolition of buildings. For each type of operation, the analysis consists of quantifying the change in the number of housing units (positive or negative) and characterising it through changes in land use (cadastral nature) or building morphology.

Compared to previous analyses, this method makes it possible to distinguish between the construction of buildings on greenfield and those that take place on land that was previously artificialised. It also allows to associate the production of some housing units with modifications of the building structure involving an increase in the built-up area as well as with changes in land use, such as the transformation of land used for non-residential purposes into land used for residential

purposes. Finally, it allows spatialization on the scale of cadastral parcels, whereas the data from the issuing of permits easily allows only an approach on the communal scale.

The result of this analysis is that 63% of net housing production in Wallonia is linked to new construction on virgin land, in other words to artificialisation. Urban recycling represents 37% of housing production, including 15% of new constructions on artificialised land and 22% of modifications to existing buildings. The results also show that in certain municipalities, the part of urban recycling represents more than 60% and sometimes up to 80% of the development of the residential housing stock.

These elements are important to be considered in the light of the fact that the objectives of limiting artificialisation are to aim for an urban recycling rate of 100%.

Potential for residential densification

Demographic forecasts show that the question of housing production must be asked both in quantitative terms (how many housing units should be produced?), in qualitative terms (what size of housing unit should be produced?) and in spatial terms (where should housing production be privileged?). In this perspective, the research proposes an analysis aimed at quantifying and spatialising the potential for residential densification on the Walloon territory through five soft densification modes:

- Mode 1: new constructions on already developed land (bimby);
- Mode 2: horizontal extension of an existing building;
- Mode 3: vertical extension of an existing building;
- Mode 4: demolition-reconstruction;
- Mode 5: division of existing housing units.

For each mode, requirements have been defined on the basis of two criteria:

- Spatial availability at the property level (available surface areas, available volumes, access to the road);
- The situation of neighbouring properties or the built environment (proximity to neighbouring houses, height or depth of buildings on neighbouring properties, land use efficiency within a certain radius).

The potential is identified in terms of available land or floor surface and converted into a number of potential housing units according to realistic density criteria, established according to the surrounding context.

Finally, the results have been declined according to the proximity of the identified potential to basic services and to public transport provision with a view to the intensification of centralities.

The analysis identifies a residential densification potential equivalent to 300,000 additional housing units that could be produced within one kilometre of two basic services or a major public transport station. This potential, which is impressive to say the least, although it remains theoretical, is quite demonstrative of the fact that housing needs should be able to be met without difficulty despite the objectives of a gradual reduction in land take, including by limiting urban recycling to parts of the territory located close to services and a public transport station. Moreover, they show that these objectives can be achieved by relying on a scenario of soft residential and/or built-up densification, taking care not to denature the existing urban environment. There is no need to build towers in the middle of villages...

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Organization of participatory worksites in the public space of Brussels, in order to demineralize the soil and regenerate/vegetate it

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Less Béton is a Brussels-based project that aims to enable citizens to actively participate in the resilience of their city and to increase their own resilience through the re-appropriation and transformation of public space.
To this end, the association accompanies groups of citizens in a collective and active process aimed at demineralizing (semi) public space, in order to proceed together with developments that fight against the effects of climate change and the collapse of biodiversity.

Throughout the process, Less Béton acts as an intermediary between the municipal/regional entities that manage the public space and the citizen who wants to get involved in the evolution of the latter, in order to reach a final consensus.
The aim is to apply a permaculture vision to the city, i.e. a systemic vision inspired by nature, and thus to train 'ambassador' citizens.

ECOLOGICAL & SYMBOLIC AIM
In freeing up soils, which sometimes have been buried under concrete for decades, by hand, to regenerate them so that they can once again provide a maximum of ecosystem services (living soil, vegetation, water infiltration, shelter and cover for biodiversity) and impact on the local and global climate (cool areas, carbon sinks).

SOCIAL & SOCIETAL OBJECTIVES
The project is intended to be inclusive (attracting people who are less concerned at first sight) and aims to reappropriate public space by citizens and by nature.

The aim is also to participate in a change of perspective on this nature and especially on nature in the city. By working on the mineralized interstices, we allow nature to be present almost everywhere and therefore city dwellers to reconnect with it and no longer see it simply as urban furniture or confined to well-defined spaces like parks.

PEDAGOGICAL AIM
While clearing the ground is a goal in itself, it also becomes a pretext, a means of taking a different look at one's city, its inhabitants (human and non-human), and its street, and of reconnecting with the cycles of life (the cycle of water, organic matter, etc.). But also to reappropriate buried knowledge such as working the land or planting a tree, which today is often delegated to experts.

Less Béton invites us to look at the immense potential for resilience that lies under our feet, under the asphalt, under the paving stones!

Desealing urban soils: Where? How?
Introduction to the tools being developed within the DésiVille project

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Desealing appears as an option to reduce the amount of artificial soils. The main associated issues are water management, adaptation to climate change, the well-being of inhabitants and biodiversity. In practice, many desealing operations are carried out. The areas to be desealed are most often linked to opportunities such as development projects. There are in fact few potential maps to support desealing strategies. Existing methods systematically take certain criteria into account (e.g. water infiltration). Environmental criteria are however more or less taken into account.

The DésiVille project (2021-2023) aims to provide decision-making tools to support desealing strategies. On the one hand, it is preparing a methodological guide to map the potential for desealing, in order to propose a harmonized and concerted framework. The methodology takes into account various criteria including sealed surfaces, urban heat islands, soil pollution, flooding by rising water tables, amenities and the multifunctionality of soils.

It is also developing a catalog of desealing solutions. There are already many operational ones. Two types of solutions are considered: grey solutions and nature-based solutions. The latter mainly include the revegetation of soil. Environmental constraints (soil pollution, rising water tables in particular) are put into perspective for the different solutions considered.

La désimperméabilisation apparaît comme une option pour réduire la part de sols artificialisés. Les principaux enjeux associés sont la gestion de l'eau, l'adaptation au changement climatique, le bien-être des habitants et la biodiversité. En pratique, de nombreuses opérations de désimperméabilisation sont déjà conduites. Les zones à désimperméabiliser sont le plus souvent choisies en fonction d'opportunités liées par exemple à des projets d'aménagement. Il existe en fait peu de cartographies de potentiel pour appuyer les stratégies de désimperméabilisation. Les méthodes existantes prennent en compte certains critères de manière systématique (ex. infiltration de l'eau). Les critères environnementaux sont en revanche plus ou moins pris en compte.

Le projet DésiVille (2021-2023) vise à apporter des outils d'aide à la décision pour appuyer les stratégies de désimperméabilisation. Il prépare d'une part un guide méthodologique pour cartographier le potentiel de désimperméabilisation, afin de proposer un cadre harmonisé et concerté. La méthodologie prend en compte différents critères dont les surfaces imperméabilisées,

les îlots de chaleur urbains, la pollution des sols, les inondations par remontée de nappe, les aménités et la multifonctionnalité des sols.

Il élabore d'autre part un catalogue de solutions de désimperméabilisation. Il existe déjà de nombreuses solutions opérationnelles. Deux types de solutions sont considérées : les solutions grises et les solutions fondées sur la nature. Ces dernières intègrent pour l'essentiel une végétalisation des sols. Les contraintes environnementales (pollution des sols, remontées de nappe notamment) sont mises en perspective pour les différentes solutions considérées.

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Re-design of cropping routes by farmers based on a soil life diagnosis: CONSOL project

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In a growing context of taking into account the preservation of agricultural soils, the AgrInnov program (Casdar 2011/2015) led by the OFSV (Observatoire Français des Sol Vivants) has validated a dashboard of indicators of good soil life between scientists and farmers, which can be used as an innovative diagnostic tool for diagnosing the impact of practices on soils.

The choice of the 6 bio-indicators selected for this project (test-beak, LEVABag, microbial abundance and diversity, nematode abundance and diversity, earthworm abundance and diversity, physico-chemical) had as main criteria robustness, the operationality and existence of a specific interpretative framework. They make it possible to assess the fertility of the soil (production potential in the short term) and its heritage value (potential for long-term sustainability).

In the Pays de la Loire, the Chamber of Agriculture, accompanied by ESA, OFSV and IFVV, has set up an action research project (CONSOL) based on 3 groups of voluntary farmers to design, test and evaluate crop systems and innovative routes to improve the biological quality of soils in the context of ecological and economic multi-performance.

Two groups of 10 farmers in mixed-stock farming and a group of 9 winegrowers, gathered in ECOPHYTO 30 000 collectives, embarked on the adventure.

The first phase of the project in 2018 was based on two complementary diagnostics: AGRINNOV and DIAGAGROECO diagnostics and made it possible to identify the strengths and weaknesses of each of the crop systems, both on the soil aspects of the sampled plot and from a global point of view on the holding. This diagnostic phase was accompanied by training to enable farmers to interpret the results and formulate hypotheses on the links between their practices and soil quality indicators.
Based on this diagnosis and the objectives of each farmer, different co-design workshops were organised within each group. These workshops have made it possible to open the field of possibilities and to bring about innovations in crop systems, meeting the objectives set by farmers.

As an example, one of the workshops was devoted to the re-design of a system of Large Crops-Mixed Livestock Farming in Tillage simplified . Although the results of the soil biological quality analyses showed green indicators, the main objective of the re-design of this system was to reduce the system's dependence on glyphosate to cope with regulatory changes, while maintaining limited working time to maintain balance between the various workshops of the holding. Collective reflection and exchanges between farmers have made it possible to build a system mobilizing new levers to meet the challenges. These include the following: rotation (integration of alfalfa to facilitate grass management at the rotation scale), direct seeding in an existing canopy or crop, cover management (integration of double canopy in long interculture), etc…

After a phase of adjustments to transform the results of the co-design workshop into an action plan, each farmer has worked for 3 years to implement his action plan, thanks to individual and collective support (within the framework of group 30000).

The results were re-evaluated in 2021 with a second test campaign of biological indicators of good soil life.

Farmers and grape growers, for many, were already well advanced in innovative cropping systems. Instead, they wanted to reassure themselves by considering the indicators as a dashboard of good behaviour and verify that their practices were moving in the right direction.

The CONSOL project, coordinated by the Chamber of Agriculture of the Pays de la Loire and in partnership with the OFSV (Observatoire Français des Sols Vivants), the Ecole Supérieure d'Agriculture d'Angers and the Institut Français de la Vigne et du Vin, was supported by the Pays de la Loire Region, the OFB, ADEME and the French State.

Engineered soils from natural mineral additives and industrial waste for restoration of degraded areas

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Innovative nature: creating fertile soils from industrial waste

Keywords: circular economy, degraded areas, agricultural land, engineered fertile soils, natural mineral additives

Objective: Create engineered, fertile soils for restoration of degraded areas with the purpose of creating functioning ecosystem for agricultural production and other ecosystem services

With increasingly limited land areas, restoring degraded land into functioning ecosystems is of extreme importance. Polluted and/or abandoned industrial or urban areas sites can be restored as part of sustainable land management. For that, technogenic soils with suitable physical and chemical properties must be engineered with mineral- and humus-rich soil materials. In order to protect fertile soils of agricultural land, mineral soil horizons can be used, which are a by-product of construction works. Mineral soil horizons are very often of low fertility; in addition to an unfavourable soil texture, an acid pH and a low cation exchange capacity also limit their use. The unfavourable properties can be improved by different amendments of natural or artificial origin.

In this study, different natural additives such as limestone and zeolite, and industrial wastes, namely Syporex and gypsum boards, were tested as means to improve low fertile, highly acidic (pH=3.8) silty clay loam (SCL) soil material excavated during construction works. Additives were added at three dosages (3, 25, and 50 mass percent). In addition to the chemical and physical properties of the soil, the effect on plant growth was also tested using Chinese cabbage (*Brassica rapa* subsp. *pekinensis* L.). Soil acidity was significantly reduced by the addition of Siporex and limestone. At a dose of 25%, the addition of gypsum board and Siporex (silty loam) improved soil texture better than the addition of limestone and zeolite (clay loam). All types of additives had a positive effect on cabbage yield. For practical use, the addition of Siporex would be recommended, but for extended use we suggest further investigations to determine state of engineered soils long-term.

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Presentation of the NWE-REGENERATIS project

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The NWE-REGENERATIS (REGENERATIon and Rehabilitation of past-metallurgical Sites through resource recovery) project is being developed within the framework of the European Interreg North-West Europe program. In collaboration with Belgian, German, French and British public and private partners, NWE - REGENERATIS aims to recover the materials and metals from the Past Metallurgical Sites and Deposits (PMSD) through project methodology called REMICRRAM, which favors the reduction of rehabilitation costs. The final goal is the reintegration of raw materials and land into the regional economy.

Resource recovery from construction waste: Barriers and solutions in the Walloon context

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After understanding the contextual aspects of waste management in the construction sector, the evolution of the regulatory framework and its application in the field, concrete cases of 'waste/resource' valorization will be presented.

Do construction projects fit into a circular economy and sustainability dynamic?

Based on the current findings, what is the future evolution? With what constraints and opportunities?

Evaluation of the use of historical pocket slag deposits in road construction as an alternative to LD and EAF slag

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CTP's participation in the NWE-REGENERATIS project consists of evaluating the potential for recovery and valorization of materials present on the Duferco site in La Louvière through mineral processing techniques.

The valorization of a historical deposit of ladle slag in the field of civil engineering was especially taken into account within the framework of the project because it contributes to the economy of natural resources while avoiding the dumping of these materials.

Although EAF (Electric Arc Furnace) and BOF (Basic Oxygen Furnace) slag can be used for soil stabilization and are included for this purpose in “Qualiroutes” (regional regulation for the quality of materials for the construction of roads); there is no use today for ladle slag. In this context, the research carried out by the CTP aims at demonstrating the potential of ladle slag as a treatment agent for the improvement of the quality of soil quality before it is used as backfill, or even as a sub-base, and should ultimately lead to the realization of an experimental plot on the DUFERCO site.

New economic model for the development of the projects on the former metallurgical sites

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The NWE-REGENERATIS project partners have developed a transparent, evidence-based economic model framework that will help decision-makers, stakeholders, brownfield owners/managers, municipalities, the public/private sector or any other relevant authority to analyze the economic, technical and social viability of an urban mining project before its launch. It is a realistic analysis of costs and benefits, with a detailed study of associated risks and influencing factors. It is a record of the return on investment from a financial perspective and summarizes all the benefits delivered directly and indirectly to the beneficiaries.

Synthesis of bio-sourced catalysts from ryegrass produced on the metallurgical sites for the synthesis of therapeutic molecules: a possible option?

Feedback from the NWE-REGENERATIS project

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IXSANE & JUNIA have conducted a series of laboratory and brownfield tests to evaluate the possibility of using metal-rich brownfield soils for the cultivation of ryegrass, which will then be transformed into bio-sourced catalysts.

The work carried out within the framework of this project has enabled the JUNIA/IXSANE team to produce a significant amount of data and to develop specific expertise, opening up new avenues for the potential future use of brownfield soil. The main results obtained up to this point in the project will be presented.

The NWE-REGENERATIS project:
an open access platform to boost the rehabilitation of metallurgical wastelands

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In order to boost the market, and as a complement to the SMARTIX process simulation expert system (a tool under development within the framework of the project), a digital platform is being developed by the project partners. Its purpose is to allow owners to register their sites after a "quick scan" evaluation, civil engineering companies active in the sector to make themselves known and metallurgists to indicate their interest in the recovery of certain metals. This platform will allow interested parties to meet to develop projects whose economic and environmental interests are well established.

HAVET &
VANHUFFEL
ASSOCIATION
D'AVOCATS

Thursday, October 6, 2022

08h30
Attendees's welcoming

Soils and Circular Economy

Treatments, characterization and circularity

09h00
PFASafe® - Next level analysis
Fabio Galeazzi, Account Manager - SGS

09h20
Monitoring the ecological functions of rehabilitated soils: the contributions of biological indicators
Jennifer Hellal, Researcher - BRGM (France)

09h40
Thermoreact® - Un produit de remédiation innovant pour la neutralisation in situ des halogènes, soufre, phosphore et mercure lors de la désorption thermique
Jan Haemers, Managing Director - Haemers Technologies

Recycling and circularity

10h00
Study of the potential for the recovery of excavated soil, quarry soil, sediments or co/mineral by-products
Marielle Fassier, Research Engineer - CTMNC (France)

10h20
Coffee break

10h50
Agromining cropping systems a sustainable alternative for metals in mineralized soils? - Case study in Albania
Aida Bani, Professor - Agricultural University of Tirana, Faculty of Agriculture and Environment (Albania)

11h10
Material recycling of excavated soils from the Grand Paris Express site
Audrey Godia, Land Development Project Manager - Société du Grand Paris (France)

11h30
Circular floor: or how to go from polluted soil to a low CO2 emission finishing product used in the building sector
- *Wouter Vermin, Treatment and Valorization Director - Group De Cloedt - Bioterra*
- *Stéphane Verstraete, Director - Envirobouw, DC Environment*

11h50
Round table (Brownfield Academy)
Policy, legislation and practices in the recycling of degraded land: how to remove the obstacles to the circularity of such sites?

Participants:

- *Saïd El Fadili, Director Soils sub-division - Brussels Environment*
- *Philippe Scauflaire, Remediation and Valorization of Polluted Soils - SPAQuE*
- *Pascal Seret, Co-Manager - DCI Monaco & Partner - Tubize Outlet Mall*
- *Kim Eric Möric, Lawyer partner - Parresia Avocats*
- *Olivier Waleffe, Managing Director - Duferco*
- *Eddy Wille, Negociator/Facilitator of the "Brownfieldconvenant" program - Flemish Region Ministry*

12h30
Lunch

Soils and digital management

13h30
Landfill data management at OVAM: prospecting redevelopment opportunities with the Cedalion tool
- *Cuinera Isenborghs, Project Assistant Dynamic Landfill Management - Public Waste Agency of Flanders (OVAM)*
- *Eddy Wille, Senior advisor - Public Waste Agency of Flanders (OVAM)*

13h50
TREX: a software to ensure the traceability for 45 millions of tons of excavated rocks
Guillaume Gérard, Spoil project manager - Société du Grand Paris (France)

14h10
The non-profit organization Walterre - presentation of the digital management of land traceability in the Walloon Region
Isabelle Laurent, General Manager - Walterre asbl

14h30
Digitization and automation of the traceability and environmental assessment of earth movements: feedback on two worksites
Thierry Dumas, Senior Business Development Partner - Altaroad (France)

14h50
Method for mapping soils suitable for agricultural use of dredged sediments
Julie Paciello, Circular Economy Project Manager - Cerema (France)

15h10
Coffee break

Soils and Biodiversity

15h30
EMPOCHA project: Evaluation of the impact of the application of fungicides on the microbial populations of the soil in potato cultivation according to different cultivation methods (Organic, conventional, reasoned)
John Rivière, Research Officer - HEPH-Condorcet/CARAH/Hainaut Analyzes

15h50
Circular conversion of wasteland in Wallonia, the Waste2Bio initiative
Cécile Nouet, Project Coordinator - University of Liège

16h10
Integrating the importance of Ecosystem Services in the selection of soil remediation - methodology in Flanders
Karen Van Geert, Project Manager & Dorien Gorteman, Project Manager - Arcadis Belgium

Soil and Climate

16h30
GHG emissions (CO_2 & N_2O) from an acid soil after adding liming products, observed at 2 experimental scales (in situ and undisturbed cylinders)
Camille Rousset, Postdoc - INRAE (France)

16h50
Biochar as a method of CO_2 sequestration in the soil and a sustainable agricultural solution
Stéphane Ledentu, Director - Terra Fertilis (France)

17h10
Multi-scale spatialization of N2O emissions by soils and their abatement potential in the Bourgogne Franche-Comté Region: interests, limits and valuation paths for decision support in the context of ecological transition at loco-scale regional
Catherine Hénault, Research Director - INRAE - AGROECOLOGY (France)

17h30
Conclusions

17h45
End of the conference

PFASafe® - Next Level analysis

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Context:

PFAS are known as Poly and Per Fluorinated Alkyl Substances. Poly Fluorinated compounds are subject to degradation phenomena which will lead in the long run to “new” degradation products being the Per Fluorinated who are that stable that nature cannot degrade them anymore. A large group of estimated 4000 – 6000 compounds from which only a few are well studied (type PFOA/PFOS). At present both legislators as well as consultants and laboratories are focusing on only +/- 40 – 50 compounds. Risk is underestimation of the actual PFAS presence in the environment as they are not covered from an analytical point of view.

Target:

Contribute from an analytical point of view to the PFAS subject being a combined technical approach for a complete PFAS presence in the environment. Supply all stakeholders involved in this business (consultants, problem owners, remediation companies but as well as the authorities) with the correct global PFAS information present in the environment.

Innovation to be presented:

By means of a combination of (new) existing analytical techniques allowing to have a complete picture on the presence of PFAS presence for the majority of the estimated 4000 – 6000 compounds and not only on a nowadays identified +/- 40 – 50 compounds. This means that both actual presence of known compounds style PFOA/PFOS are being identified and quantified as well as future deploying contaminations (due to degradation of actual long and unknown Poly Fluorinated Alkyl Substances.

Monitoring the ecological functions of rehabilitated soils: the contributions of biological indicators

Jennifer Hellal[1*], Camille Chauvin[2], Marie-Paule Norini[1], Oliver Taugourdeau[3], Cécile Grand[4], Catherine Joulian[1], Hélène Cérémonie[2], Caroline Michel[1], Hassan Boukcim[3] et Cécile Villenave[2]

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Soil is recognized as a major component of the functioning of terrestrial ecosystems and a key element for the provision of Ecosystem Services (ES). In a context of tensions over their use, the ecological rehabilitation of abandoned sites (industrial, urban or agricultural wasteland) is an opportunity to make territories more resilient to the consequences of climate change (Climate and Resilience Law, 2021) and to meet the objectives of preserving and restoring biodiversity (Biodiversity Plan, 2018). The question then arises of the reversibility of this soil degradation via refunctionalization, i.e. the restoration of ecological processes that should ultimately lead to the provision of ecosystem services adapted to these new uses. One of the obstacles to the success of ecological rehabilitation projects is linked to the difficulty of recreating functional ecosystems starting from degraded soil (compacted, sterile, impermeable).

As part of the BioTubes project (https://expertises.ademe.fr/content/biotubes-bio-technosols-urbains-faveur-biodiversite-services-ecosystemiques), a urban wasteland was rehabilitated (Figure 1) using different ecological engineering paths including, soil decompaction or importation, controlled inoculation by microorganisms and sowing & planting of local plant species. The functioning of these soils, from which stems their ability to provide ES, is based on their physico-chemical but also biological parameters, in particular those of microbial communities and nematodes, which play a fundamental role in bio-geochemical cycles. For 3 years, monitoring of activity, biomass and microbial and nematofauna diversity were carried out in parallel with physico-chemical parameters and plant diversity in order to identify (bio)indicators that are witnesses of effective rehabilitation. In particular, this work has focused on integrating indicator measurements to reflect the state of soil ecological functions (Figure 2, carbon storage and dynamics, nutrient supply, habitat for biodiversity).

Keywords: soils, microbial communities, nematofauna, bioindicators, ecological functions, rehabilitation, wastelands

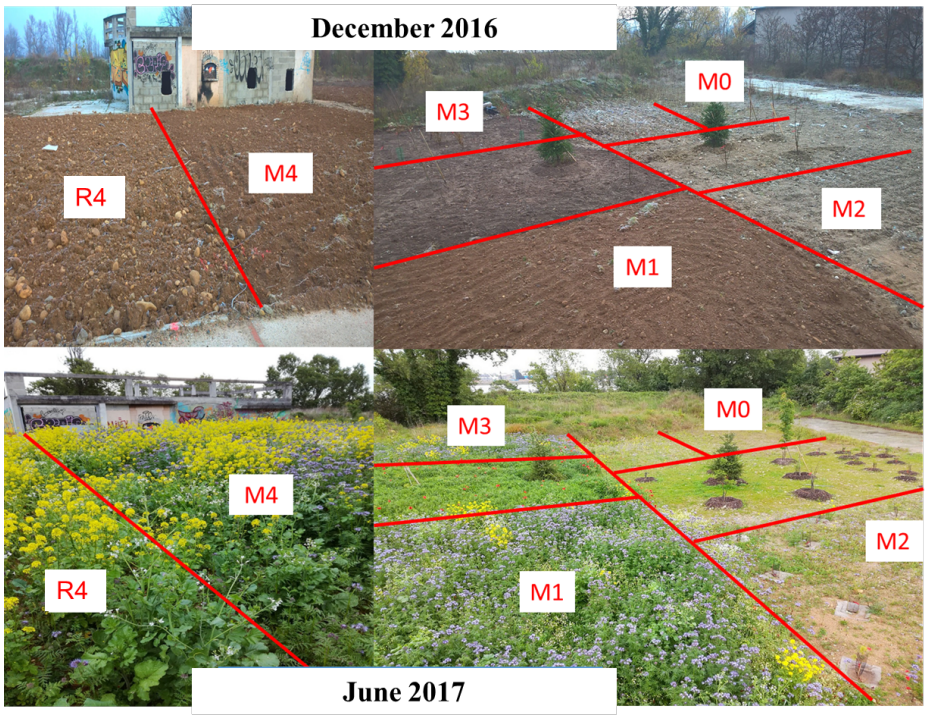

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Figure 1. Study site after soil ecological rehabilitation (december 2016) and the following spring (june 2017). M0 to M4 and R4 are codes given for the different experiments.

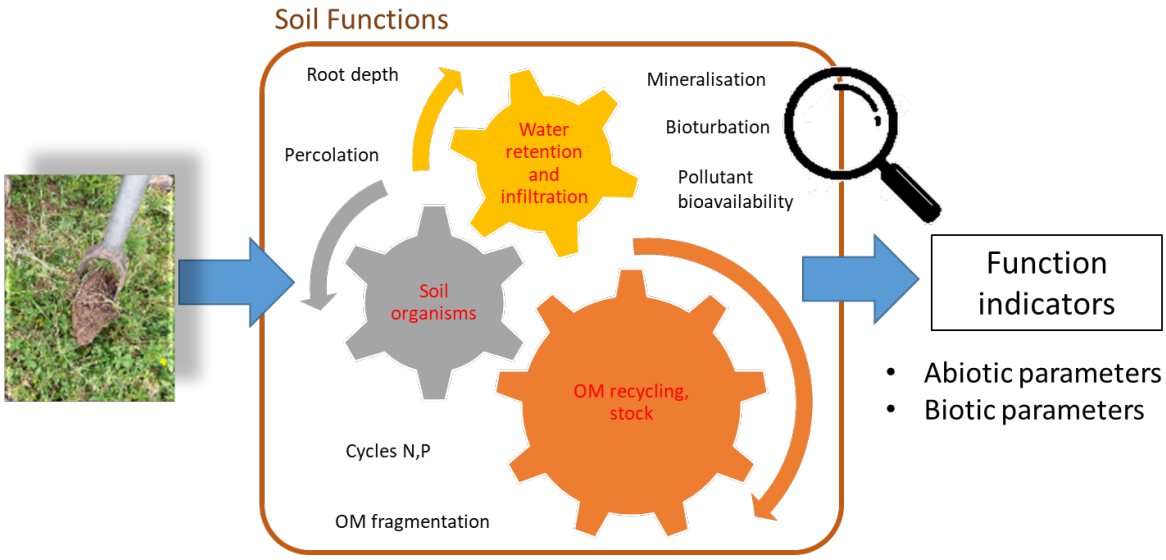

Figure 2. Soil ecological function result from the interactions between biotic and abiotic compartments.

Thermoreact® - Un produit de remédiation innovant pour la neutralisation in situ des halogènes, soufre, phosphore et mercure lors de la désorption thermique

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During In Situ Thermal Desorption, polluted soil (generally with TPH, PAH, Mercury, chlorinated solvents, etc.) is heated until vaporization of target contaminants is reached out of the soil. This results in the vaporisation of those pollutants, which are then drawn through perforated steel tubes, called vapor tubes, surrounded by gravel acting as a draining medium preventing the clogging of the tube perforations (by fine particles, sludge, etc). These recovered vapours are then either treated in a vapour treatment unit or re-injected into the flame (in case of hydrocarbon pollution and heating with smart burners).

In many cases, the pollutants to be treated in the soil are accompanied by other process-disturbing elements (such as phosphorus, sulphur or halogenated compounds like chlorine). The heat causes the vaporization of many chemical compounds, including those disruptive compounds that are conducted through the porous medium to the extraction wells. The problem with these disruptive compounds is that in some cases they become very corrosive and therefore tend to destroy equipment and render the remediation technology less effectively. Additionally, if not treated, they can cause non compliant air emissions as well.

Thermoreact® is an innovative product that replaces the conventional gravel around vapour tubes. The product allows for in-situ neutralization of the vapors before exiting the soil pack, reducing the treatment requirements and saving substantial treatment costs overall.

Its composition varies in function of the pollutants present in the soil in order to always obtain the best neutralization reaction while keeping permeability at the required level for proper vapor extraction.

The producs of said neutralization are inert minerals that can be left in the soil, making In Situ Thermal Desorption a truly zero-waste treatment for many more contaminants than is currently the case.

The paper presents the results of various tests and cases where In Situ Thermal Desorption has been adapted to use Thermoreact® instead of conventional gravel. Before and after results are compared (example below of In Situ sulphur captation)

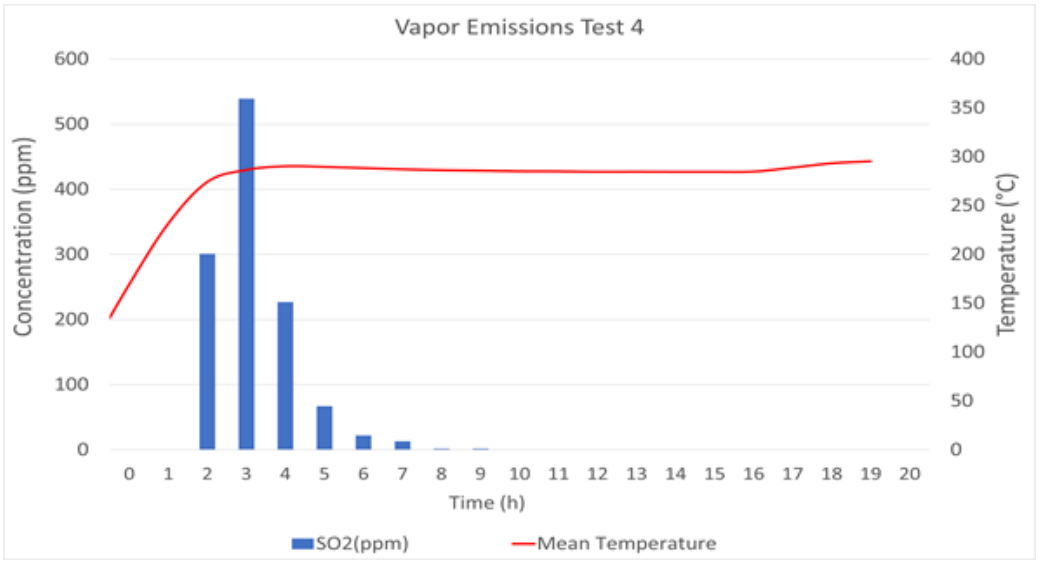

Figure 1: Vapor analysis with conventional gravel

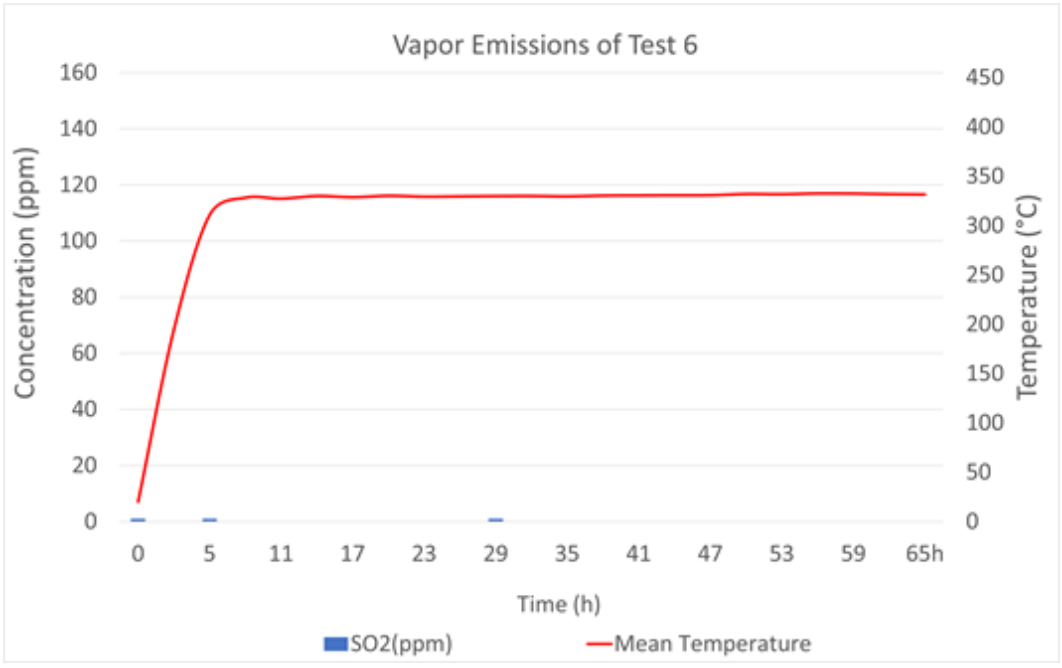

Figure 2: Vapor analysis with Thermoreacts®

Study of the potential for recoverin ex-excavated soil

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Urban construction sites, the creation of traffic or communication routes as well as the expansion of the number of buildings constructed lead to a need to valorize excavated earth in industrial production as a raw material or constituent of a manufacturing mixture.

Excavated earth, depending on its nature and geographical origin, can be used in the manufacture of construction production such as fired clay products, raw earth, expanded clay, concrete and cement, but also in sectors of activity such as tableware, tiling, refractories, street furniture or as mineral fillers.

With regard to the fired clay products sector, in addition to being able to constitute a raw material for manufacturing or substitute elements for components of industrial manufacturing mixtures, the use of excavated earth, having characteristics and properties consistent with the manufacturing of fired clay products, can make it possible to sustain or extend the life of quarries. The contribution of excavated earth, in the local production of fired clay products, can allow on the other hand, the mix of materials or composition in the realization of works, a reinforcement of the exercise of circular economy and a maintaining committed sustainable development in terms of production and properties of clay products.

To do this, the CTMNC has developed a process and its associated flowchart to qualify, characterize and estimate the potential for recovery and use of clay and/or sandy minerals in the manufacture of fired clay products.

This approach, which takes place in several phases, makes it possible to validate the feasibility of valorization in order to lead to an optimal use of the minerals considered. Clay and/or sandy minerals that may be mined, excavated, co- or by-product or be in the form of sediment.

The first steps related to the characterization of the deposit and the earth as well as its behavior during the shaping process of the fired clay products make it possible to define whether the latter can be used alone as a manufacturing mixture or whether it will have to be adjuvanted to become it or if, conversely, it can be used as a substitution or complement in a current production mixture.

The entire process being carried out by the CTMNC, it makes it possible, during the first stages, to characterize the earth or the deposit in order to define its elementary chemical composition and its mineralogical composition, to determine its content of soluble salts in order to prevent possible surface and structural defects and efflorescence as well as possible emissions during the cooking phase in anticipation of environmental discharges of sulphur, fluorine and chlorine as well as the levels of total and organic carbon as well as carbonates in the context of the declaration CO_2 quotas of the European ETS directive.

In addition, elemental analyzes are carried out on the soil or the deposit such as the determination of the particle size distribution, the water content, the apparent density or the lower and higher calorific values making it possible to detect the presence of organic matter and the needs or energy inputs during the various stages of the manufacturing cycle.

In parallel with the analysis of the earth or the deposit, a study is carried out in order to determine and evaluate the shaping criteria and the behavior of the shaped earth during the manufacturing cycle of the terracotta products. As a result, extrudability criteria such as forming humidity are evaluated as well as possible forming defects. Following this, drying and firing phases are carried out by following industrial cycles specific to the different families and uses of fired clay products in order to determine the shrinkage during the drying and firing phases, the loss on ignition or mass during drying, the apparent density and the structural or surface defects that may appear during these phases of the manufacturing process as well as the residual water after drying, the transformations generated during these two phases and the dimensional expansion.

Before orienting the earth or the deposit towards a possible use, according to the criteria defined previously, elementary physical characteristics are validated such as the absolute density, the rate of open porosity, the absorption of water and the mechanical resistance in bending and in compression, on dry products and on products fired at the temperatures specific to the different families of fired clay products.

Agromining cropping systems a sustainable alternative for metals in mineralized soils? Case study in Albania

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Metalliferous soils (ultramafic) cover large areas in the Balkans, more than in any other part of Europe. The total surface of mineralized area in Albania is 11.05% and the larger areas are located in the south-east covering until 28% of the surface. In this part of Albania there is also a high density of abandoned or active mining sites as well as metal smelters. Ex-mining ultramafic areas are often almost completely devoid of vegetation due to toxic levels of trace metals and other unfavorable edaphic physico-chemical conditions. Recently, accumulators or hyperaccumulators plants are widely used in phytomining to decontaminate soils by phytoextraction of heav meals. Previous studies have shown that nickel bioavailability is high in these soils. Consequently, there is the possibility of its passage into the food chain. The Ni hyperaccumulator O. chalcidica has real potential to become acash crop. Agromining technology, which is a NBS and 'green technology' that extracts valuable products, including high-purity metal salts useful for the battery industry, from selected plants known as 'metal crops'.

Farming for nickel offers a sustainable approach to economically recover battery-grade materials from unconventional sources, thus, producing 'green technologies' from 'green sources'. Consistently, by extracting metals from contaminated soils, phytomining enables the reuse of metals otherwise not utilized (wasted) and adversely impacting ecosystems.

Albania is a potential target for phytomining/agromining activities and also has the highest diversity in Ni hyperaccumulator plants in Europe and one of the highest globally.

The ultramafic surface area in Albania with 10–43% MgO covers 313 300 ha or 11.05% of the total surface of the country (Lekaj et al. 2019). Agricultural areas, an important land cover category of the ultramafics in Albania, were estimated to be 20 907 ha and included Mg-rich arable Vertisols covering about 10 000 ha in 2018 (Lekaj et al. 2019). Vertisols were selected among all candidates as the target soil type for agromining in these regions, namely in Albania, because of their high Ni phytoavailability and position in the landscape (downslope soils and alluvial

In Albania there is also a high density of abandoned or active mining sites as well as metal smelters. Ex-mining ultramafic areas are often almost completely devoid of vegetation due to toxic levels of trace metals and other unfavorable edaphic physico-chemical conditions. The plants growing on metal-loaded soils respond by exclusion, indication or accumulation of metals. Recently, accumulators or hyperaccumulators plants are widely used in phytomining to decontaminate soils by phytoextraction.

The Ni hyperaccumulator *Odontarrhena chalcidica (synonym Alyssum murale)* cultivated on ultramafic and contaminated plots in south-east and north of Albania under different agronomic practices (organic and mineral fertilization, co-cropping systemes, irrigation, wild control, etc. reached high biomass production and Ni yields.

Experiments were undertaken for years on *in situ* experimental plots. Field experiments (Bani et al. 2015a, b; Bani 2019; Bani et al unpublished data) were aimed at studying (i) the distribution of Ni and

other elements in plant organs, (ii) plant nutrition and fertilization practices, (iii) weed control, (iv) the crop establishment technique (natural cover *vs.* sown crop) and (v) planting density, Co-cropping.

Results for this species demonstrate that it is necessary to transplant *O. chalcidica* at a density of 4 plants m^{-2} on well-structured (ploughed) soils, under conditions of non-limiting Ni availability on ultramafic soil in South (Bani et al., 2021) and North of Albania. Harvests can be carried out at the mid-flowering stage, when the nickel concentration is higher, in plant. The fertilization patterns have been improved throughout the years for these soils. Our cropping system; soil tillage-4 plant m2-fertilization with organic manure (South of Albania) results much more effective, with a biomass production 9.96 t ha-1 and nickel yield 145 kg ha-1. In the north of Albania our cropping system; soil tillage-4 plant m2-fertilization with mineral fertilizer that contain Ca results with the biomass 5.6 t and nickel yield 73 kg/ha.

Phytomining field plots operated also in Prenjas serpentine quarries and Elbasan (contaminated by industrial activities). Consequently, cropping systems have been designed. Ni hyperaccumulator *Odontarrhena chalcidica* cultivated on contaminated plots of Prenjas and Elbasan under organic and mineral fertilization reached the Ni yields from 8.5 to 12 kg ha^{-1} (Osmani et al. 2018a, 2018b).

The Ni hyperaccumulator *O. chalcidica* has real potential to become a cash crop. Our study showed us that we can obtained ammonium nickel sulfate hexahydrate (ANSH) with 99% purity by applying the hyperaccumulator *Odontarrhena chalcidica* on ultramafic and contaminated soils in Albania and for more we obtained 5–13% of Ni in the ash from incinerating nickel (Ni) hyperaccumulator plants, significantly higher than the Ni-concentrations in common (primary) ores (3%) (Barbaroux et al. 2011, 2012).

Key words: Agromining, NBS, Mineralized soils, contaminated, soils, metal recovery, Ni hyperaccumulators

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Material recycling of excavated soils from the Grand Paris Express site

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Dealing with the production of 47 million tons of excavated soils overall the *Grand Paris Express* project over ten years, the *Société du Grand Paris* has studied innovative solutions to improve excavated soils management on a large scale. To reach the objective of reusing and recycling 70% of excavated soils, the *Société du Grand Paris* entered in a proactive approach of circular economy with the support of stakeholders sharing the same ambitions. The *Société du Grand Paris* developed an operational material recycling methodology.

This approach started with the study of recycling potential of excavated soils issued from the *Grand Paris Express* project to improve the knowledge of these materials and their recyclability.

A multi-criteria soil sampling and characterization campaign began in 2018 with the recovery of samples from a panel of geological layers met on the path of the future subway. Tested materials represent over 80% by volume of geological strata that are crossed during earthworks.

The campaign aimed to determine which types of excavated soils could be recycled and to define eco-materials and eco-products. For this purpose, soils were chemically, minerally, and mechanically characterized allowing to define the best recycling channel.

Following these characterizations, eco-materials and eco-products formulations were developed in laboratory using part of these excavated soils in substitution of quarry products. Prior to formulation most of excavated soils samples from the *Grand Paris Express* project were prepared by soaking, screening, deagglomeration or calcination depending on aimed recycling channel. All formulations were performed with mechanical monitoring to obtain products of similar performance compared to market standards. The compliance with expected technical specifications determined the maximum incorporation rate of secondary products.

Finally, release of chemical species in the environment under simulated weather conditions was monitored to ensure product environmental compatibility. The test conditions enabled accelerated aging process of the eco-material/eco-product with open environment.

A total of 80 different formulations will be developed until 2023 by the *Société du Grand Paris*, incorporating soils from tunnels and stations digging, with various chemical qualities.

Today, many recycling opportunities were confirmed thanks to these tests and formulations. Studies conclude that excavated soils can be used in replacement of natural resources in industrial processes like cement, plaster and brick production, road and dykes construction, sealing materials, grouting injection, recycled aggregates, etc. For example, 145 000 tons of excavated soils were already used in Ile-de-France for cement production. These materials were then used on the same site for station construction.

With this approach, in 2019 the *Société du Grand Paris* initiated a call for applications towards recycling industrial actors. This first call, reconducted by then, allowed to conclude agreements between the *Société du Grand Paris* and these partners to develop new recycling processes. More than thirty companies were sourced representing more than a hundred sites, able to use excavated soils to produce construction materials.

To encourage a market more favourable to recycling, the *Société du Grand Paris* reassessed its own technical specifications to promote the use of recycling materials and provides support to other public construction owners sharing the same ambition in terms of material recycling. Goals for use of reused and recycled excavated soils were contractually set and new construction works offers are now assessed partly based on materials and waste circularity criteria to complete the approach.

Circular soil: how to move from a polluted soil to a finished product with low CO2 emissions used In the building sector

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Until a few years ago, Belgian soil treatment facilities were satisfied when they could reduce the pollution degree of contaminated soils in order to recover it as backfill in road works or in the development of anti-noise walls. Worse still, is that even today in some European countries the treatment of polluted soils is limited to a declassification of the pollution degree rather than really treating the soils. This means that soil treatment facilities consider mainly the disposal of polluted soils in landfills upon reduction of the pollution degree, either in landfills authorized for non-hazardous waste when the soils had been initially categorised as hazardous waste or at best to landfills authorized for inert waste when the soils had been initially characterised as non-hazardous waste. Hence the idea of declassification as mentioned above.

Reading the above, it is easier to understand the extraordinary evolution represented by the transition from the concept of waste declassification to the real treatment & valorisation of the waste into a secondary raw material as finishing application for the building sector, and all this with a reduced CO_2 footprint. One can truly speak of a Copernican revolution inspired by the precepts of circular economics.

This has been achieved by Group De Cloedt and more particularly its subsidiary Bioterra based in Genk (Belgium).

Bioterra's primary activity consists in treating soil that is sometimes heavily impacted by both organic pollutants (mineral oils, PAHs, BTEX, etc.) and minerals (mainly heavy metals). The technique used to do this is called a wet particle size separation (also known as physico-chemical treatment or washing). The result of this treatment is a separation of the large particles (sand) from the small ones (fine silt and clay) that make up the soil. As the pollution tends to bind to the small particles, the latter unfortunately ends up in landfills while the sand can be recovered & valorised. And that's precisely where the innovation lies. As mentioned earlier, previously, or still in some European countries, this washed sand is reused as backfill or ends up in a landfill of lower category. Bioterra, for its part, is using it, no longer, as it was until a few months ago, exclusively in structural work applications (concrete), but now also in finishing applications for the construction sector.

These sands from the treatment of polluted soils are used in screed applications. Various formulations have been developed and tested in real conditions.

The formulations consist of a 0/4 mm fraction composed of 100% secondary raw material (from Bioterra's treatment facilities), an Eco-binder or binder with low CO_2 impact and natural fibres. It is essential to point out that these formulations are completely cement-free.

This screed is as easy to lay as traditional screed, and no loss of quality has so far been detected in the finished product.

Whilst the first tests were limited to the installation of screeds on small areas of approximately 100 m², Bioterra and its screed laying partner are now applying screed volumes 10 times larger on a single site with the same success.

Landfill data management at OVAM:
Prospecting redevelopment opportunities with the Cedalion tool

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Dealing with the past and preparing the future

Today, only a limited share of the produced waste is landfilled in Flanders (<2%). However, this positive observation overlooks the many landfill sites that remind us of the linear economy. In view of the dispersed data collection over various data sources, the **inventory** of these landfill locations **in the past proved not to be evident**. The files were not systematically saved by the then licensing authority, let alone stored digitally to enable specific consultations. A systematic data collection was therefore necessary. Not so much because the current landfill content was seen as a problem, as investigations on environmental risks pointed out that no urgent intervention was required[1]. Actually, the position of former landfills in the circular economy was questioned. Moreover , **doubts** arose about the robustness of these static landfills in a **strongly changing and dynamic environment**.

The roadmap to mining

The **basis for a data structure** was provided in the *Enhanced Landfill Mining* (ELFM) program[2] that ran at OVAM from 2011 to 2015. The focus was mainly on locating landfill sites in view on **potential mining**. In a first phase, 'mapping', the aim was to make the landfill inventory as comprehensive as possible. The second phase focused on 'surveying', in which the focus was on the description of **the content**: the landfill volume, waste characteristics and surface area, crucial data necessary for decision-making in view of the third phase: mining of landfills. However, landfill mining seemed not (yet) profitable for the majority of the landfill sites.

Transition is needed

Providing better long-term management of landfills as our objective, we shifted the focus to **sustainable interim uses** and **other redevelopment processes.** Landfill mining was extended from the traditional valorization of the content to a broader concept of site revitalization. Think of recreation, a solar panel park, a 'hard' destination or (partial) mining/disposal of waste to enable water storage. In order to support motivated decisions about this, the data management must be sufficiently extensive and we also need information about **the context** of the landfill. This overall concept[3] is described as Dynamic Landfill Management and was approved by the Flemish Government on October 16, 2015.

From Landfill mining to Dynamic Management

The shift from Landfill Mining to Dynamic Landfill Management resulted in a demand for a wider range of data, inside and outside the landfill area. In the first phase, data mining was crucial, followed by data processing, analysis and assessment. The latter included the development of

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[1] A general overview in 'Cedalion and Orion: a two-step decision support tool (…)', E. Wille, C. Isenborghs, et.al., in Detritus / Volume 18 - 2022 / pages 85-94, https://doi.org/10.31025/2611-4135/2022.15165

[2] **Final report on ELFM in Flanders (ENG)**

[3] **Concept note Sustainable stock management of landfills (NL), Memorandum on Dynamic Landfill Management (ENG)**

decision support tools[4] in order to achieve a sustainable long-term management of landfills. When developing such tool, we relied on the expertise of the Interreg projects COCOON[5] and RAWFILL[6] were. This resulted in the decision support model **Cedalion**. Cedalion forms the basic system in which all landfills are included and on which simple queries can be carried out. The link with the GIS environment allows specific spatial explorations and analyses. This type of prospection translates into **opportunity maps** for afforestation, green energy, extraction of raw materials, opportunities for sustainable water management, etc. During the live presentation concrete examples of GIS analysis with accompanying maps will be shown in addition to the history of data management that is briefly explained in this text.

Challenges and opportunities

We are facing many environmental, social and economic challenges and seldom one-fits-all solutions are available. Regarding our broader vision on landfills and their future use, OVAM shares their data to support match making and tackle those different challenges. Recently, we have published our landfill inventory with approximately 2700 landfills (Figure 1). This is the first phase of sharing our information on landfills with the broader public. By mapping old landfills, we are taking an important first step towards reusing this space. By 2028, all historic landfills must be investigated . Where necessary, the soil will be remediated. More than 100 km² of space in Flanders can be rehabilitated in this way.

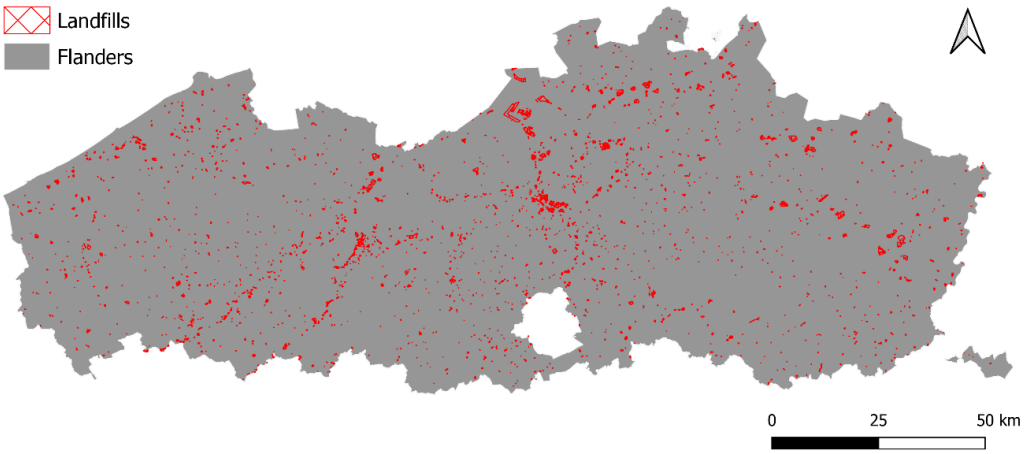

Figure 1 Landfills in Flanders

[4] **Decision support tools (vlaanderen.be) (NL)**
[5] **COCOON | Interreg Europe (ENG) or COCOON | OVAM (ENG)**
[6] **RAWFILL | Interreg NWE (ENG) or RAWFILL |OVAM (ENG)**

TREX: a software to ensure the traceability for 45 millions of tons of excavated rocks

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One the first software designed for excavated rocks traceability in France
Key words : digital information, wastes traceability documents, Grand Paris Express

The « Grand Paris Express » is the transportation network project of in the capital region that will double the size of the existing one. The construction of additional 200 km tracks, whom 180 km will be underground, requires the excavation of around 49 million tons of rocks.

In accordance with French law, these rocks are classified as waste as soon as they leave the construction site. The « Société du Grand Paris » is fully responsible until the final wastes disposal or recycling and sought to set up their traceability. This traceability consists in registering every stage of waste management and needs several millions of transport documents to fill-in, control, process and archive. Moreover, in order to detect any abnormality and ensure an efficient tracking, the « Société du Grand Paris » has to recover all information in real time for a given batch. A classical paper-based system would require several days, even weeks, to return information to the client.

Hence, in 2017, a software of waste traceability was developed and imposed to every operator. It relies on weighing and digital information. After 5 years of use, this software deals with the increase of data, new regulations and it is time to assess its strengths, its limits, and the necessary updates. This software provides a complete database to the Société du Grand Paris that allows monitoring of the company objectives and is a useful security for its reputation. However, new environmental laws require the use of similar softwares causing an increase in workload for the operators. Also, some operational processes cause rigidity and may be improved. Therefore, new evolutions are planned such as allowing interaction with other companies and state softwares or use of data analysis solutions.

Presentation of the digital management of land traceability in Wallonia

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The non-profit organization Walterre has software developed on existing CRM functionalities of the Salesforce platform (account management, financial aspects, etc.) and on custom development in order to meet the specific needs of the implementation of the land traceability.

The software was created from the 3 key elements on which the concept of traceability is based:

- **Accounts**: the actors concerned by earth movements (contracting authorities, approved experts, navvies and contractors, platforms, earth receivers, etc.)
- **Location** (original site, receiving site, platform, etc.)
- **Land plots / Land quality report**: The "land plot" element plays a central role. The tool makes it possible at any time to locate each lot of land whether it is part of a construction site, whether it is stored on an approved installation, … and to retrace its route (history). Everything is easy and intuitive. Different data can be assigned to the lots such as the types of admissible uses, possible restrictions, the possible presence of invasive non-native plant species or asbestos fibers, etc.

On the basis of these constituent elements, the user can make his requests and notifications and WALTERRE will draft the land quality report certificates and the transport documents. Traceability is guaranteed at all times regardless of the journeys or operations: transport to the final destination, or via a grouping platform. Throughout the process – the link is maintained between the origin, the destination, the characteristics, the parties concerned (in the case of grouping), the volume(s), the intermediate storage centers, and the treatments (grouping / treatment of polluted soil / sieving).

The software offers internal and external users an extensive range of features to manage all their projects, land lots, documents, etc.,

The use of the software is supported through a series of tools:

- Appearance of pop-up windows accompanying the user step by step during each request, notification, etc.
- Intuitive progression following a tree structure that leads the user to the desired screen, depending on the type of request or service desired.
- Adapted search functions.

L'ASBL Walterre dispose d'un logiciel développé sur des fonctionnalités CRM existantes de la plateforme Salesforce (gestion de comptes, aspects financiers, ...) et sur le développement sur mesure afin de répondre aux besoins spécifiques de la mise en oeuvre de la traçabilité des terres.
Le logiciel a été créé à partir des 3 éléments-clés sur lesquels repose le concept de la traçabilité :

- **Comptes :** les acteurs concernés par les mouvements des terres (maîtres d'ouvrages, experts agréés, terrassiers et entrepreneurs, plateformes, récepteur de terres, …)
- **Localisation** (chantier d'origine, terrain receveur, plateforme,…).
- **Lots de terres / Rapport de qualité de terres** : L'élément « lot de terres » joue un rôle central. L'outil permet à tout moment de localiser chaque lot de terres qu'il fasse partie d'un chantier, qu'il soit stocké sur une installation agréée, …et de retracer son trajet (historique). Le tout se passe aisément et de manière intuitive. Différentes données peuvent être assignées aux lots telles que les types d'usages admissibles, d'éventuelles restrictions, la présence éventuelle d'espèces végétales non indigènes envahissantes ou de fibres d'amiante, …

Sur base de ces éléments constitutifs, l'utilisateur peut faire ses demandes et notifications et WALTERRE rédigera les certificats de rapport de qualité de terres et les documents de transports. La traçabilité est à tout moment garantie quels que soient les trajets ou les opérations : transport vers la destination finale, ou par l'intermédiaire d'une plateforme de regroupement. Pendant tout le parcours – le lien est conservé entre la provenance, la destination, les caractéristiques, les parties concernées (dans le cas de regroupement), le(s) volume(s), les centres de stockage intermédiaires, et les traitements (regroupement / traitement de terres polluées / tamisage).

Le logiciel offre aux utilisateurs internes et externes un éventail étendu de fonctionnalités pour gérer tous leurs projets, leurs lots de terres, leurs documents, etc...,

L'utilisation **du logiciel** est soutenue par l'intermédiaire d'une série d'outils :
- Apparition de fenêtres contextuelles accompagnement l'utilisateur pas à pas lors de chaque demande, notification, ….
- Progression intuitive suivant une structure en arborescence qui conduit l'utilisateur jusqu'à l'écran voulu, en fonction du type de demande ou de service souhaité.
- Fonctions de recherche adaptées.

Digitalization and automation of traceability and environmental assessment of earth movements on construction sites: feedback on two sites

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The regulation changes put recently in place in France in terms of traceability of all construction wastes respond to European directives that are gradually becoming widespread in the various EU countries.

Altaroad is an independent private company, supported by the European community, and specialized in the traceability of construction wastes. Its position as an independent actor in relation with all stakeholders has made it possible to observe the difficulties encountered when developing such a monitoring process and to develop solutions. The purpose of this presntation is to illustrate these points with the feedbacks of two construction sites.

Difficulties observed when implementing an end-to-end traceability approach

A primary difficulty is to ensure that the waste traceability system is adopted and applied correctly by all levels of the chain from extraction to final destination.
A second critical point is that the monitoring system is at the same time unique, to allow a common language between all parties, and covers all cases to permit having a global vision over several construction sites. For example, it is often problematic for managing teams and operational staff to follow easily the traceability of a material batches that undergo stages of massification and transformation, involving different partners, each with its own data management system. Last, it needs to be digitized and automatized as much as possible to avoid double entries, errors and associated paperworks. This becomes even more critical during peak periods when systems and teams are dealing with a massive number of simultaneous operations.

Example of Feedback: the construction sites of Line 18 Lot 1 of Greater Paris

The context: Line 18 is part of the Grand Paris Express transport infrastructure extension projects. The lot 1 corresponds to a 11.8 km long drilled tunnel between Orly Airport and Massy-Palaiseau, with the creation of 3 underground stations, 13 ancillary works, and 10 connecting branches. The cuttings of tunnel boring machines and the earthworks specific to the creation of the stations constitute a total of 950,000 m3. The Project Owner is the Société du Grand Paris (SGP), the Prime Contractor is a consortium of Ingerop, Artelia and Arcadis (ICARE) and the main contractor is VINCI Construction Grands Projets in joint venture with partners. The traceability of all flows-in and -out is imposed by the project owner and requires the entry of the information for each truck from the extraction to the final outlet in a specific register (T_REX tool). The weighing of the vehicles is not imposed at the exit of the working sites.

The request of the main contractor in this context was twofold: 1) To find a solution easily accessible to all the operators concerned and simplifying as much as possible the management of this traceability on a daily basis, and 2) to optimize the trucks loads, considering that transporting 1 tonne less than targeted represents a 4% increase on transport costs and on the number of trucks put on the road.

The solution implemented was a platform with relevant interface (DigiTrack) throughout the project to manage real-time data entry and data processing, and connected to the regulatory registers. The sites with a higher volume, are equipped with a mobile weigh-in-motion system (TopTrack) using artificial intelligence and machine learning to estimate the loads in real time, and with plate

recognition cameras (CamTrack) to identify automatically the vehicles. An alert system is set up to report in real time all weight deviations from the objective.

The direct results observed by the contracting company are reflected in the expected reduction in transport costs and number of trucks on the road, as well as significant HR savings related to data handling. The indirect result is a gain in comfort, efficiency and responsiveness in the control of operations, allowing to implement corrective actions in real time. This system is being extended to other projects and completed by on-time monitoring of CO2 balance..

Example of Feedback: The extension of tramway site T10

The context: The project corresponds to the extension of the T10 Tramway line between Anthony and Clamart (Grand Paris area, France). The project was co-financed by the Region of Ile de France, the Hauts de Seine department and the Prefect of the Ile de France region. The objective for the various stakeholders of the site was to commit to the circular economy and ensuring the detailed traceability of waste. The Hauts de Seine Department also committed to reduce significantly its environmental footprint.

The solution implemented is a digital platform, a camera that automatically identifies the trucks and a weigh-in-motion system fixed on the driving path measuring the weight of all trucks in and out, permitting to visualize at anytime the tare weight of the truck, its load weight, the type of waste, its origin and its destination.

The direct results observed by the company are threefold: Automatizing the processes made it possible to simplify the work, to avoid input errors, and in the end to free up 2 employees who could be assigned to other tasks. Fuel savings were achieved thanks to real-time weight alerts and reduced number of truck rotations. Finally, the implementation and regular monitoring of progress indicators gave a higher credibility to the contractor in front of project owners regarding the reality of the circular economy options promoted.

The results observed by the project Owner are the benefit of reliable and clear summary tables that make it possible to monitor in detail the site's waste recovery rates and to validate that these rates are in line with expectations, as well as tools to better communicate with the contractor and external parties.

Conclusion

An important challenge for the construction industry is the appropriation of end-tot-end traceability approaches to the benefit of all stakeholders. The experience developed by Altaroad together with its clients shows that it is possible to make it a real tool to reach better economic and environmental performance, with solutions that simplify the data handling, speed up the processing of the information, permitting to monitor the projects with real-time information.

Altaroad's experience has enabled to extend this approach to very distinct contexts and to develop additional functionalities already in use such as, among others, image recognition and real-time management of the carbon footprint, whether it comes to excavation, soil depollution, deconstruction, waste handling or material recycling.

Méthode de cartographie des sols aptes à la valorisation agricole des sédiments de dragage

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En France, chaque année sur le domaine fluvial, en moyenne 6 millions de m^3 de sédiments, dont 1,6 millions de m^3 provenant du domanial, sont extraits des 525 000 kilomètres de cours d'eau et canaux, à l'occasion de travaux d'aménagements ou de maintenance. L'extraction de ces sédiments représente une opération de restauration du milieu ou d'entretien indispensable à la prévention des risques d'inondation, au rétablissement du tirant d'eau pour la navigation et à la restauration du milieu naturel. Compte tenu de l'importance des gisements produits chaque année, les sédiments de dragage constituent une véritable ressource naturelle à caractère renouvelable. Dans ce contexte, des expérimentations sont menées depuis quelques années pour la mise en place de filières de valorisation agricole des sédiments de dragage, notamment avec VNF et EDF. Particulièrement, le projet VASC (Valorisation Agricole des Sédiments du Cours d'eau de la Charente) propose, par l'apport de sédiments, de reconstituer des sols supports de cultures agricoles. Les expérimentations menées ont montré l'intérêt de l'apport de sédiments pour améliorer les propriétés des sols : réduction du stress hydrique, amélioration de l'activité microbienne, augmentation du rôle d'autoépuration, augmentation du rendement, etc.

Le développement de cette filière passe par l'identification de sols présentant des carences, ou un contexte défavorable, pour lesquels l'apport de sédiments s'avère bénéfique. Ainsi, une méthode cartographique est développée pour identifier les potentialités théoriques de valorisation de sédiments. Cette méthode tient compte de plusieurs critères pédologiques (texture, pH) et hydriques (réserve utile) qui rendent compatible et désirable l'apport de sédiments. Ces paramètres sont tirés de datasets globaux articulés via la plateforme Google Earth Engine.

Dans le cadre de cette présentation, la méthode est déclinée sur le territoire français. Cette méthode est reproductible et, du fait de l'origine des données, transposable ailleurs dans le monde. Elle peut par ailleurs être enrichie par d'autres paramètres agro-pédologiques susceptibles de mettre en évidence le besoin de reconstitution en agriculture de certains sols. Également, la cartographie produite par l'application de cette méthode offre au producteur de sédiments (gestionnaire de cours d'eau naturels et artificiels) la possibilité d'identifier les terrains agricoles susceptibles de recevoir des sédiments à proximité des futures zones de dragages. Dans un deuxième temps, la compatibilité sol-sédiments devra être confirmée et étudiée à l'échelle de la parcelle.

* * *

In France, every year, an average of 6 million m^3 of sediments are extracted from the 525,000 kilometers of rivers and channels, during development or maintenance works. The dredged sediment represent an operation of restoration of the environment or maintenance essential to the prevention of flood risks, to the restoration of the draught for navigation and to the restoration of the natural environment. Considering the quantity produced each year, the dredged sediment constitute a renewable natural resource. In this context, experiments have been carried out for several years for the beneficial reuse of sediment in agricultur, in particular with the partners VNF and EDF. In particular, the VASC project proposes, through the contribution of sediment, to reconstitute soils that support agricultural crops. The experiments carried out have shown the interest of adding sediment to improve soil properties : reduction of water stress, improvement of microbial activity, increase in the role of self-purification, increase in yield, etc.

The development of this sector requires the identification of soils with deficiencies, or an unfavorable context, for which the supply of sediment proves to be beneficial. Thus, a cartographic method is developed to identify the theoretical potentialities of reused sediments. This method aims at analyzing several topographical (slope), pedological (texture, pH) and hydric (useful reserve) criteria that make the contribution of sediments compatible and desirable. These parameters are taken from global datasets articulated via the Google Earth Engine platform.

In this presentation, the method is declined on the French territory. This method is reproducible and, because of the origin of the data, transposable elsewhere in the world. It can also be enriched with other agro-pedological parameters that can highlight the need to reconstitute certain soils in agriculture. Also, the mapping produced by the application of this method offers the producer of sediments (manager of natural and artificial rivers) the possibility of identifying the agricultural plots likely to receive sediments near future dredging areas. Secondly, the soil-sediment compatibility must be confirmed and studied at the scale of the plot.

Evaluation of the impact of fungicide application on microbial populations in potato crop depending on different crop method (biological, conventional)

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Abstract :

This presentation is part of the international project EMPOCHA (IMPROVING SOIL, POTATO CROPS, HUMAN HEALTH AND FORAGE QUALITY IN A CLIMATE CHANGE CONTEXT), which is financed by BELSPO (Belgian Science Policy Office) and involve researchers from China, South-Africa and Belgium for 3 years (July 2021 – June 2024).

The project focuses on the potato crop, which is an economically and agronomically important crop in the project partner countries. This is structured according to the 3 axes of the 2020 BELSPO Call, namely: health, biodiversity, and climate change. The objective of the biodiversity component is to study the impact of agricultural practices on the soil microbiome, especially bacterial and fungal populations. The analysis of these populations is based on an innovative method of high-throughput DNA sequencing of the target microorganisms. The sequences obtained by this method allow us to evaluate the composition of the soils and to compare them with each other to evaluate notably the impact of the use of fungicides as well as cultural practices, in the three concerned countries.

During cropping season 2022, the CARAH experimentation department and the biotechnology and applied biology laboratory collected soil samples from 9 plots representing contrasting agricultural practices. Namely 6 plots in conventional culture with organic matter inputs and an elevated level of protection of potato crops and 3 in organic culture. This field experiment aims to study the dynamics of bacterial and fungal populations according to cultural practices and in particular the use of fungicides against potato blight. The collection of soil samples was carried out on each plot at the rate of 15 takes, at 0-15cm depth, and mixed to form a composite sample of approximately 500g.

9 samples were taken (8 for organic farmers) to cover the entire potato growing season and were taken at the start of cultivation as well as at harvest and during cultivation, systematically after application of a fungicide treatment. DNA extraction was performed directly after collecting soil samples to avoid any alteration of the microbiome. For this, fresh soil samples are sieved at 2 mm before proceeding with DNA extractions from a specific kit. The last step consists of analyzing DNA samples by high-throughput sequencing (NGS) on an Illumina Miseq platform, targeting bacterial (16S rDNA) and fungal (ITS2) populations. The reads obtained were then processed using a home-made bioinformatics pipeline to perform taxonomic assignment. Bacterial and fungal populations were examined and compared to identify the impact of fungicide treatments and cultivation method on population dynamics and their relative distribution within the microbiome. The Funguild (Nguyen et al., 2016) and Faprotax (Louca et

al., 2016) functional databases were also used to explore the functional aspects of the populations identified for the different soils.

The analysis of taxonomy data offers the possibility to see the effect of fungicides and cultural methods. Concerning bacterial populations, taxonomy results see low difference between collection dates. We find same conclusion for conventional and organic agriculture.

We observed more effects in fungal populations. For the taxonomy, the principal component analysis (PCA) makes it possible to identify a clustering between the cultivation methods (Bio – Conventional), highlighted by increases or decreases of some's genera (*e.g.Tricharina sp., Penicillium sp., Trichocladium sp., Fusarium sp., Podospora sp.*). The functional analysis (Funguild) of fungal populations confirmed the observation above. Indeed, soil and wood saprotroph and animal pathogen fungus are responsible for the clustering on PCA analysis.

However, we do not see significant difference in fungal populations depending on sampling dates.

In conclusion, fungicide treatments do not appear to significantly change the microbial populations during the potato crop. But the cultural method shows different fungal population between conventional and organic methods. The bacterial population is not really affected by fungicide application neither by cultural methods.

Towards an environmental and economic revalorization of brownfields in Wallonia, the Waste2Bio initiative

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Innovative character: public-private consortium promoting economic and environmental revalorization of brownfields through phytomanagement solutions ensuring ecological functions and exploitation of plant biomass.

Key words: brownfields, temporary use, nature-based solutions, bio-based products, circular production mode.

The Waste2Bio initiative is coordinated by ULiège in close collaboration with Spaque, Valbiom, Brownfield Academy and the Greenwin and Wagralim competitiveness clusters. It relies on a consortium of more than 100 partners, Walloon actors of brownfields redevelopment, biobased economy and ecology intervening at all levels of the value chain: land managers, public authorities, companies (soil and landscape engineering firms, urban planners, architects, biomass producers and users), non-profit organizations, education and research organizations.

Objectives and strategy

The presence of numerous brownfields in Wallonia (40,000 potentially polluted hectares, i.e. 2.3% of the territory) is the starting point of our Initiative. In a context of climate change, decline of biodiversity, no net land take strategy and increasing competition for the allocation of land to different uses, these abandoned sites represent an undeniable reservoir of land to install a vegetation cover providing multiple ecosystem services.

Waste2Bio proposes an integrated approach to rehabilitate these lands in an economically viable manner with a positive impact on the environment. In concrete terms, Waste2Bio aims to create by 2027 an operational platform deploying innovative phytomanagement solutions to restore value to brownfields on a temporary or permanent basis.

The actions envisaged are in line with several strategic innovation domains (SIDs) identified by the Walloon region:

- The improvement of the inventory and mapping of sites suitable for phytomanagement applications;

- The development of original crops based on species assemblages according to uses;

- The development of local production channels of valuable biomass (energy, construction, hygiene, health) SID1-SA1, SID4-SA1;

- The environmental valorization of brownfields: green infrastructures to reinforce biodiversity, improve the quality of water and soil resources, prevent flooding, improve the quality of life of citizens, SID5-SA3;

- The development of intelligent systems of above ground plant production (Plant Factories) on brownfields with buildings, SID2-SA2;

- The development of *phytovoltaics* (combination of phytomanagement and photovoltaic panels);

- The reinforcement of training courses for these new modes of production and renaturation of brownfields.

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Integrating the importance of Ecosystem Services in the selection of soil remediation Methodology in Flanders

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Soil remediation concerns an activity carried out by man to improve his living environment and human wellbeing, his surroundings and the ecosystem. This activity can have an impact on the ecosystem functions and directly or indirectly on the services provided by the ecosystem for the benefit of mankind.

A healthy soil delivers several important soil functions, and consequently ecosystem services, to humans and their environment, such as soil fertility (primary production of food, energy crops), regulation of water quantity and quality, carbon storage in soils, habitat for functional and intrinsic biodiversity, nutrient cycling and processing, cultural services, etc.

The services that soil provides for people and the environment deserve our attention. Moreover, various future challenges, such as climate change and changes in land use, make such attention and concern urgent. In this context, a methodology was developed to integrate the assessment of ecosystem services into the multi-criteria analysis used for the selection of a soil remediation approach.

Initially, a matrix was drawn up with an overview of the impacts that the various soil remediation techniques could have on ecosystem functions. The possible impacts of the various soil remediation techniques on the ecosystem services and functions were then translated into a score.

This is a simple assessment method that is currently applied in the context of drawing up soil remediation projects in Flanders (Belgium). It simplifies the concept of ecosystem services, with the aim of making it easy for the soil expert to use and hence providing a basis for comparing soil remediation techniques. In addition, this methodology creates awareness of the effects of different soil remediation techniques on the capacity of soil to deliver ecosystem services.

This methodology also proposes mitigation measures that can be applied to reduce the potential negative impact of remediation works on the soil.

The presentation will further explain the methodology and will illustrate it with cases.

Greenhouse gas emissions (CO_2 & N_2O) of an acid soil after adding liming products, observed at 2 experimental scales (*in situ* and undisturbed cylinders)

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Keywords: Acid soils, Greenhouse gas, N_2O, CO_2, pH, Calcium carbonate

With its known interest in agricultural production, the use of liming products on acid soils can also be considered as a lever for mitigating soil N_2O emissions. Several studies have shown that liming acid soils reduces their N_2O emissions [1-3]. This decrease is explained by an increased reduction of N_2O to N_2 during the process of denitrification in these soils whose pH has been raised [4]. An optimum pH of 6.8 has been observed, below which the N_2O reduction path is progressively inhibited [4]. Nevertheless, the interest of liming to reduce GHG emissions from soils is also conditioned by the carbon evolution from the carbonates brought into the soil, in this case their release in the form of CO_2. The Tier 1 methodology proposed by the IPCC considers that all the carbon brought by carbonate liming products is emitted into the atmosphere in the form of CO_2. However, this 1:1 ratio is discussed in some studies [5-6]. Often analysed separately, too few studies have simultaneously analysed the effect of carbonate liming product inputs on CO_2 and N_2O emissions. Thus, the objective of our project is to consolidate knowledge on the effect of carbonate liming product inputs on the cumulative emissions of two GHGs, CO_2 and N_2O.

This study was conducted on the soil of a cultivated plot located in the Morvan region (France). The soil of this plot has a sandy-clay-silt profile with an initial acid pH (5.6). The study includes measurements on undisturbed soil cylinders (height 20 cm, diameter 10 cm) with controlled moisture conditions, as well as *in situ* measurements. The soil cylinders were sampled in March 2021 and incubated at 20°C for 63 days and were divided into 2 batches. All cylinders in the 1st batch (called MC treatment) received (a) 1.45 g of a marine calcium carbonate – $CaCO_3$ with a neutralising value (VN) equal to 40 (marketed as Calcimer®) on the exposed soil surface to achieve a pH of 6.8 and (b) 0.08 g nitrate nitrogen (0.032 mg N g^{-1} soil) and those in the 2nd batch received a single addition of 0.08 g nitrate nitrogen (control). These cylinders were regularly closed for 3 hours to determine the intensity of their N_2O and CO_2 emissions.
In situ, emissions were monitored during the rye cultivation period until harvest (October 2021 – July 2022), using the static chamber method (55cm x 55cm). The chambers were placed on the plot before sowing the crop and randomised by treatments: control (no liming product input) and two limed treatments (SC = synthetic calcium carbonate - VN = 54 and MC) incorporated into the soil surface in order to also reach a pH of 6.8. N_2O fluxes are expressed in g N ha^{-1} d^{-1} and converted to CO_2 equivalents considering the global warming potential of the gases (N_2O and CO_2 for our study).

On undisturbed soil cylinders, we observed both lower N_2O and CO_2 emissions from the limed soil treatment (MC) compared to the control soil treatment, with a reduction of more than 10% in cumulative GHG emissions (Figure 1). *In situ*, the N_2O emissions were particularly low for each treatment (< 25 g N_2O-N ha^{-1} d^{-1}) which could be explained both by the unusual environmental conditions of this year (dry conditions) and the low bulk density of the soil, being well aerated all along the experimental period. Globally, no effect of the limed treatment was observed on the soil N_2O emission *in situ*. Conversely and consistent with results obtained on the undisturbed soil cylinders, the CO_2 emissions *in situ* were highly and significantly lower in the two limed treatments (MC and SC) compared to the control treatment (Figure 1) with a reduction of more than 37% in cumulative GHG emissions. Calcium carbonate being a source of carbon, this unexpected latter result now requires to be understood in a mechanistic point of view. Currently, we can suggest a possible stabilisation of soil organic carbon (SOC) after liming application.

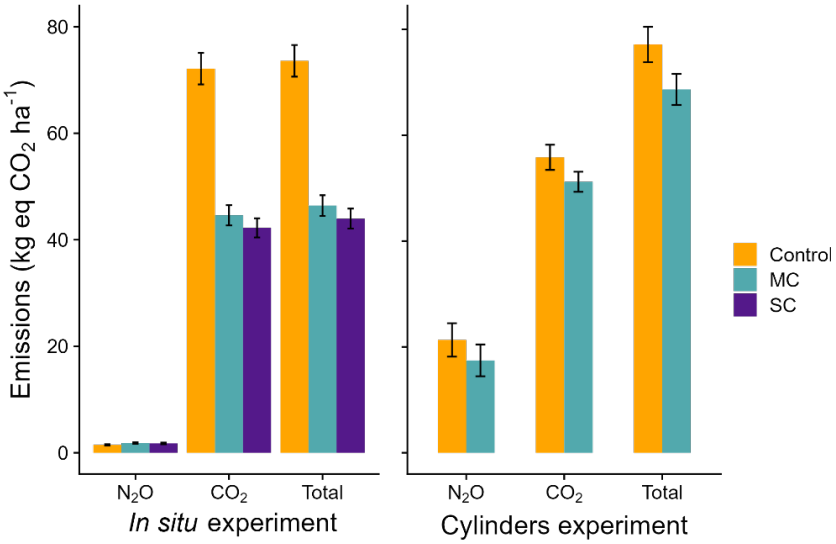

Figure 1: The average emissions measured throughout the experimental period in situ (left) and on cylinders (right). For both gases, N_2O and CO_2, the emissions are expressed in kilogram of CO_2 equivalent per hectare. Total refers to the addition of N_2O and CO_2 emissions. Error bars = s.e.m. n=9 (in situ) and n=8 (cylinders). MC stands for Marine $CaCO_3$ and SC for Synthetic $CaCO_3$.

Overall, our results show that the liming strategy for acid agricultural soils to mitigate GHG emissions, adopted in the methodology of the low-carbon label for field crops in France[7], could be refined with respect to the CO_2 emissions component. Beforehand, future studies need to ensure that those results are sufficiently generic and the acquisition of in-depth knowledge of the evolution of the C brought to the soil by carbonate liming products would be necessary.

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Biochar as a method of CO2 sequestration in the soil and a sustainable agricultural technique

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- The origin of biochar and its main characteristics
  - Discovery of Terra Preta and its properties
  - Pyrolysis: the biochar manufacturing process
  - Main characteristics

- Its effects on the physical, chemical and biological properties of soils
  - Water retention and resistance to drought
  - Retention of nutrients and stimulation of plant growth
  - Stimulation of microbiological life
  - Properties supported by studies conducted around the world

- CO2 sequestration
  - How it works
    - Photosynthesis
    - Pyrolysis
  - Carbon credits from biochar
    - One of the few carbon sequestration technologies available
    - High cost of credits: a sustainable sequestration

- Regulation, as a means of spreading the use of biochar
  - Including biochar in soil quality and regenerative agriculture policies and programs
  - Making capitalization /amortization possible for farmers
  - Creating subsidies for biochar users and producers?

- TERRA FERTILIS premium biochar
  - Its characterisitics
    - High carbon content
    - High specific surface area
  - Marketing
    - Market Authorization
    - BtoB and BtoC targets
    - Exports

- Biochar is a great example of a circular economy, and no doubt has other beneficial uses
  - Circular economy:
    - Product from biomass
    - Destination: Soil amendment
  - Other beneficial uses:

        - Water filtering
        - Soil remediation

- Foresight and prospects: a product gaining momentum
    - Al Gore (2009)
    - Paul Hawken and Drawdown project
    - IPPC climate reports.

Stéphane LEDENTU

Stéphane LEDENTU founded SLB in 1991 as a wood trading company. Following a trip to Asia, he became aware of the aberration of cutting down hundred-year-old trees to make cheap furniture. His passion for nature led him to invest in the field of **"econology"** to meet the growing needs of the wood industry while avoiding the use of native species. Thus, in 2008, he created ECONOLOGIC PROGRAM®, innovative and ecological afforestation programs in Brazil, based on a vision combining economy and ecology. In 2016, after discovering the *terra preta* in Brazil, he decided to develop a biochar production site in France and to promote its use.

SYLVA FERTILIS FRANCE manufactures and markets **TERRA FERTILIS® biochar,** a product essentially made up of carbon and obtained by wood pyrolysis, used as a soil amendment. Biochar is still little known in Europe. Thanks to its porous structure, it retains water and nutrients. It aerates and structures the soil and stimulates its microbiological activity, thus making it livelier and more fertile.
In the years to come, it will also play an important role in carbon sequestration, which is so crucial in the climate issue.

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Multi-scale spatialisation of N_2O emissions by soils and their mitigation potential in the Bourgogne Franche-Comté Region: advantages, limits and paths of exploitation for aiding decisions in the framework of ecological transition at local-regional scales

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The French inventory of anthropic greenhouse gas (GHG) emissions estimates that emissions by fertilised soils contribute 42% of the N_2O (nitrous oxide) emitted by the agricultural sector, i.e., 8% of total national emissions *[1]*. As N_2O has a global warming potential about 300 times that of carbon dioxide (CO_2), the assessment of emission potentials and/or reduction of this gas seems essential when defining and implementing policies aimed at reaching the reduction objectives set at international, national and regional levels.

To estimate N_2O emissions by soils, three inventory methods, with increasing requirements (Tier 1, 2 or 3), are now used according to the recommendations of the IPCC. The method of level 1 takes into account only the quantity of nitrogen (mineral and organic) contributed to the field to which is applied one *[2]* or more emission coefficients *[3]*, as proposed in the methodology of *Label Bas Carbone en Grandes Cultures en France* (Low Carbon Label of Major Crops in France) *[4]*. The methods of level 2 adapt emission factors by country on the basis of local references. The method of level 3 employs mechanistic emission models. Furthermore, recent works have highlighted the predominant role of soil pH in the intensity of soil N_2O emissions. They have therefore opened the path to reducing N_2O emissions by managing soil pH, associated with calculations of mitigation potentials by utilising this lever *[5]*.

To quantify N_2O emissions by soils in Bourgogne Franche-Comté, and their mitigation potential, we applied the Tier 1 methodology *sensu stricto*, the Low Carbon Label in Major Crops in France methodology and two models of Tier 2 (*[6]*; *[7]*), using different sources of spatial data dealing with soil, climate and crop. In particular, we compared 3 sources of data for the soil properties available on the study area; BDAT, LUCAS maps and IGCS *[8,9,10,11,12]*. We therefore estimated an average value of N_2O emissions by soils receiving an annual rainfall less than 950 mm in Bourgogne of 2150 t N-N_2O year^{-1}, between 1800 and 5000 t N-N_2O year^{-1}, according to the databases and calculation methods used (figure 1). Although the Tier 1 methodology applied strictly did not allow forecasting a reduction of N_2O emissions by acid soils following the input of liming materials, the other calculations performed permitted estimating on average a mitigation of N_2O emissions of 20% in the region of study, ranging from 6 to 40% (figure 1).

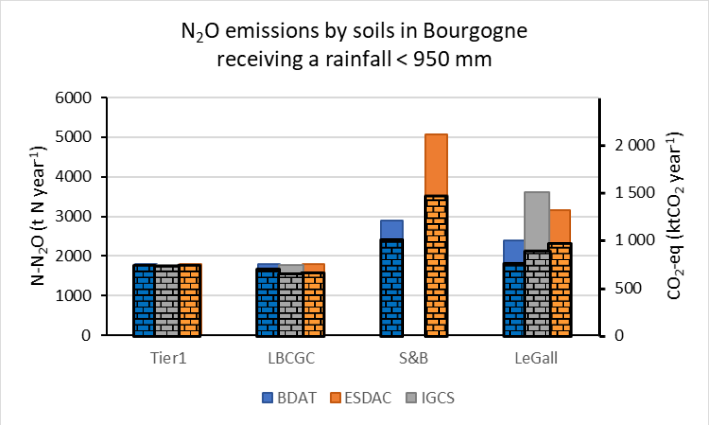

Figure 1: Estimation of N_2O emissions by soils in Bourgogne receiving a rainfall < 950 mm under the conditions of 2018 and after theoretical liming of acid soils .

These estimations were performed with different sources of soil data (BDAT, Lucas Soil, IGCS) and different calculation methodologies.

Tier 1: calculations performed according to the Tier 1

LBLGC: calculations performed according to the methodology proposed by the Low Carbon Label of Major Crops in France Methodology.

S&B: calculations performed according to *[7].*

Le Gall: calculations according to *[6].*

Since the calculations were performed spatially, they permit identifying areas of interest in relation to the use of liming acid soils to reduce soil N_2O emissions. In our case study, these areas are mainly Morvan, the Bresse depression and the Yonne valley. In these areas, the mitigation potential can exceed 50%.

In addition to their formatting for a scientific publication, we are working on the dissemination of these results to political decision-makers so that they are taken into account for the development of a National Low Carbon Strategy in France *[13]*. To achieve this, we are currently developing the "agriculture" sheet of the regional observation, analysis and air-energy-climate platform, Opteer *[14]*, to facilitate the implantation of quantifiable biotechnical solutions to reduce GHG emissions that can be used by political decision-makers. This entire approach can be transferred to other regions in France and abroad.

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