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RECARE
Preventing and Remediating degradation of soils in Europe through Land Care

POLICY BRIEF
REMEDIATING HISTORICAL SOIL CONTAMINATION – EFFECTIVE MEASURES AND POLICY SOLUTIONS

SUMMARY

Soil contamination is a major soil threat in Europe with a high potential risk for human and environmental health. RECARE project tested and evaluated remediation measures in two historic sites affected by contamination from industrial and mining activities. The findings show that immobilization of contaminants in roots and soil (phytostabilization) is an effective measure to reduce the impact of contamination in large contaminated areas. Phytostabilization, however, requires careful and systematic monitoring. Moreover, a number of barriers limit the extent to which remediation measures can be applied more broadly to remediate sites at a faster pace.

Several steps can be taken at EU and national level to increase the pace of remediating contaminated sites. Whereas prevention and limiting of polluting activities leading to new contamination are addressed in several European policy instruments with room for improving implementation and enforcement, the problem of historical contamination remains an important gap in European policymaking on soils. Political commitment is required to address the issue of historical contamination systematically by providing a common EU framework to guide and facilitate activities at the national level, where in turn establishing and implementing national strategies for managing soil contamination is important. Finally, improving knowledge, sharing and availability of existing information, and engaging stakeholders in the process of remediating soil contamination is recommended.

Fig. 1 | Soil polluted by a mine-spill in 1998 (on the left) and the same location in 2015 after soil was remediated and afforested (on the right).

INTRODUCTION

Soil contamination represents a significant environmental problem in Europe. A recent review by the European Commission estimates that there are 2.8 million potentially contaminated sites and 650, 000 (23%) are already registered contaminated sites in Europe.[1] The scale of the problem is significant, with the cost of remediating and managing contaminated sites estimated at 46 billion over 25 years.[2]

Activities related to industry, mining, and industrial waste disposal and treatment are responsible for two thirds of the ongoing soil contamination in Europe, with mineral oils, heavy metals and metalloids as the most frequent soil contaminants.[3] Today, almost 30% of the total surface area of the EU exceeds an established threshold concentration of heavy metals.[4]

Soil contamination reduces the quality of the soil, has a negative impact on natural soil functions and ecosystem services, and can endanger human and environmental health.

Soil contamination is the chemical degradation of soils, e.g. the presence of a chemical or substance out of place and/or present at a higher than normal concentration, which affects human health and the environment and reduces the ability of soils to provide soils ecosystems services.[1,5]

Currently, several EU directives provide the framework for national policies to prevent current or future contamination. Of particular importance are:

- Waste Framework Directive, which sets the basic concepts and definitions related to waste management
- Industrial Emissions Directive (IED), which is the main EU instrument regulating pollutant emissions from industrial installations covering environmental damages occurring after 2007
- Environmental Liability Directive (ELD), which sets up the “polluter pays principle”

Fig. 2 | Industrial emissions have historically accounted for a large share of soil contamination in Europe

Historical contamination represents a widespread problem not addressed by these instruments because they manage pollution only from the date of entry of the law into force, whereby the exact entry into force also varies from one Member State to another. Historical sites are those sites that existed before specific soil-contamination laws were adopted by Member States since the 1980s[1] and most certainly before IED became binding in 2007.[6]

At present, no clear goals are set in relation to historical soil contamination, and there is no EU legal requirement to identify historical sites nor a common framework for how to manage these sites. Criteria that Member States have established for historical contamination are often less stringent than for new contamination.[1]

Historical contamination is often linked to the issue of orphan sites, sites that have been contaminated and where it is not possible to identify the polluter so that the ‘polluter pays’ principle cannot be applied.[1]

RECARE PROJECT

Two RECARE case study sites focused on investigating measures for remediating soil contamination – Guadiamar Valley in Spain and Copşa Mică in Romania. Both areas contain historic sites contaminated with inorganic pollutants (heavy metals). The characteristics and focus of these two case studies is given below.

	Copşa Mică (RO)
Context	Copşa Mică is a city developed around two industrial areas, both with high pollutant sources. The main pollutants identified in this area were cadmium, copper, lead and zinc. The primary source of historical pollution was a metallurgical plant, first built in 1939 and in operation until 2010. Air emissions and waste deposited on the land were the sources of pollutants. The particularities of the Case Study (large polluted area, historical pollution, large number of landowners, agricultural use of land, etc.), require the development of a long term management plan of land use in order to reduce the effects of heavy metal pollution and to increase the quality of life in this area. Affected area: 20,000ha, estimated cost of remediation for site not available; for all Romanian sites, the value is at 8,4 billion €.[7]
RECARE Research	RECARE project tested the effectiveness of different soil amendments to reduce the heavy metals mobility in soil and the uptake by plants. Stakeholders were involved in selecting the measures to be tested, participated in setting-up the field experiments and demonstration activities. Stakeholder involvement helped to strengthen the confidence and interest in selected measures.

Fig. 3 | RECARE experimental site in Copşa Mică with the metallurgical plant, the source of pollution, in the background

RECARE PROJECT

	Guadiamar valley (ES)
Context	After a mine spill occurred in 1998, about four hm^3 of acid waters and two hm^3 of mud, rich in heavy metals and trace elements (mainly As, Cd, Cu, Pb, Tl and Zn), were released into the Agrio and Guadiamar rivers. Since the spill various remediation activities have taken place, providing a rich basis to evaluate longer-term effects of remediation measures. The contaminated land was purchased by the regional government, remediated and converted in a forested park, then legally protected (in 2003) as the Guadiamar Green Corridor. Affected area: 4,939ha, estimated cost of remediation at 165 million €.[8]
RECARE Research	RECARE project tested and evaluated long-term effectiveness of applying soil amendments and tree planting to reduce mobility of contaminants. Stakeholders were involved in selecting remediation measures for testing and evaluation, and in assessing the impact of these measures on ecosystem services. Because the contaminated and remediated land has been converted in a forested and conservation area, most of the discussion with stakeholders focused on the impact on ecosystem services of regulation (improvement of air, water and soil quality, soil conservation, mitigation of climate change) and cultural (recreation, nature observation, aesthetics values).

Fig. 4 | Experimental site in Guadiamar valley

RECARE MESSAGES ON EFFECTIVE REMEDIATION MEASURES

Traditional decontamination measures such as physical separation exist but their cost is prohibitive for extensive contaminated areas, and implies soil physical, chemical and biological deterioration.

An alternative approach for decontamination is phytoremediation. This approach involves two options: phytoextraction and phytostabilisation. With phytoextraction plants and associated microorganisms bioaccumulate and remove trace elements,* in this case heavy metals. Accumulator plants suitable for phytoextraction, for example, include acacia, willow, and hornbeam. Phytostabilisation, on the other hand, involves immobilising contaminants in soil and roots of plants, including grasses and trees which retain metals in their roots. In large contaminated areas and in particular in semi-arid zones the time needed to extract the heavy metals would be too long (>100 years) and the cost too high. Therefore, in the case of RECARE contaminated sites, research has focused on phytostabilization. While phytostabilisation is slower than traditional methods, it is overall also cheaper, it has the benefit of preserving soil functions, and is particularly suitable for agricultural land.

RECARE RESEARCH IN ROMANIA AND SPAIN HAS SHOWN THAT:

- Addition of soil amendments (ES, RO) and planting of trees (ES) are effective in reducing mobility and bioavailability of heavy metals in contaminated soils. Amendments need to be selected for the trace element target. The most effective amendments in RECARE sites include sugar beet lime and biosolid compost (ES), and Dolomite and Na-Bentonite (RO).[9]

- Where the level of contamination is high, this effect may not be sufficient to produce healthy feed for animals and avoid the transfer of heavy metals into the food chain. In Copsa Mica, fodder still contained heavy metals in concentrations beyond thresholds allowed for fodder.

- In areas with high contamination levels, it may be necessary to change the land use to produce alternative crops, such as biomass for energy or industrial crops. In those cases, it is important to select crops with low rate of translocation to seeds (e.g. rapeseed) and monitor the use of biomass. Some crops are not appropriate for such use (e.g. Mischantus). If selected species are able to produce high biomass, phytoremediation can also be used to generate added value from degraded land through biomass / biofuel production. Alternative use may also mean converting the contaminated and remediated land to forest and conservation area for public use, as was the case in the Guadiamar site.

- Reducing the metal toxicity and improving soil fertility led to development of a consistent vegetation cover with positive effects on soil erosion and soil biodiversity (RO, ES).

- Long-term evaluation of remediation in Guadiamar area has shown that following the initial remediation with removal of sludge and topsoil (to remove the highest concentrations of heavy metals), amendments and tree planting measures stabilized contaminants over a period of 15 - 20 years, preventing them from moving to water and through the ecosystem.[10] The combination of soil amendments and native non-accumulator plant species is a feasible and cost-efficient option for the management of large areas contaminated with trace elements.

- Measures related to the control of erosion and landslides are of great significance to minimise negative impacts on contiguous ecosystems.

- It is recommended to sequence the remediation of soils contaminated with trace elements as a three-stage process, including 1) addition of soil amendments, 2) selection and planting of most suitable trees, and 3) a systematic monitoring scheme to detect changes in the mobility of trace elements in the system.[11]

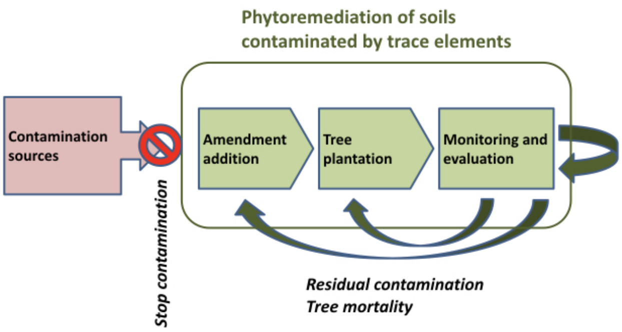

Fig. 5 | Three stages in phytoremediation of soils contaminated with trace elements[11]

* Trace elements are chemical elements which are present in very small concentrations. For soil contamination both organic and inorganic trace elements are important, with the focus in RECARE studies on heavy metals (in particular, Cd, Pb, Cu and Zn).

BARRIERS TO REMEDIATION OF SOIL CONTAMINATION

RECARE research has identified effective remediation measure to address soil contamination by trace elements. However, several barriers exist to implementing these measures in practice.

Political	• Lack of political commitment and initiative to address historical contamination and earmark sufficient funds (ES, RO) • No regulations that clearly and coherently define indicators for monitoring and evaluating the necessarily remedial measures (RO) • Lack of an action plan with appropriate measures for soil protection (RO) • Poor implementation of an existing national strategy for management of contaminated sites (RO)
Financial	• Lack of financial resources: soil remediation measures are expensive and must be maintained long term (ES, RO)
Institutional	• Absence of a suitable institutional framework and of qualified personnel (RO) • Lack of communication or information transfer among administrations and/or different users (ES)
Information	• Research and knowledge on soil science often lacks direct applicability for soil remediation (ES) • Low dissemination of remediation project results and soil protection actions at local level (RO,ES) • Lack of information and data related to potential and contaminated sites and remediation actions (RO) • Lack of information about risk of agricultural use and suitable crops for contaminated land (RO)
Socio-economic	• Lack of social pressure for factory owners to invest in the new technologies and remediation projects - majority of employees lived in the contaminated area and their income depends on company’s profitability (RO)

Fig. 6 | Stakeholder workshop in Copşa Mică

RECOMMENDATIONS

ESTABLISH A COMMON EU FRAMEWORK TO GUIDE REMEDIATION OF HISTORICAL CONTAMINATION AT NATIONAL LEVEL

The findings emerging from RECARE case studies in Romania and Spain underline a key message from previous studies on the need to establish a common EU framework to guide remediation of historical contamination at national level.[1, 6] Given the transboundary character of soil contamination, a common framework is needed so as to: 1) define guidelines, screening values and thresholds that trigger investigation of potentially contaminated sites, 2) standardise definitions, methods of sampling and monitoring indicators, as well as develop a common language and comparability of information, 3) define liability and responsibilities for remediation, and 4) define monitoring requirements to measure progress.

This common framework for historical soil contamination needs to be placed within a set of coherent EU rules that define the role of soil, targets and priorities on soil contamination.[6] Without such a framework, there is limited ability to integrate soil contamination concerns in wider policies, including EU funding instruments, as well as limited incentive to act in countries where there is a lack of political will to address soil protection in a coordinated way. Legally binding framework for soil protection more broadly, and soil contamination more specifically, would lead to a more systematic identification and remediation of historical contaminated sites, as well as coordination and exchange of experiences around most effective remediation measures in terms of impacts on soil ecosystem services as well as cost-effectiveness. It would also enable increase in available funding for remediation in EU funds, such as the Cohesion Fund, European Regional Development Programme, or LIFE+ Programme.

The challenge is to find a workable and legally binding framework on which Member States with different biophysical and institutional contexts, as well as different stages in the development of soil protection policies, can agree.

In the short term, exchange of experiences around the implementation and reporting on Sustainable Development Goals may be beneficial (including on SDG target 3.9 to substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination by 2030 and SDG target 15.3 on land degradation neutrality).

ESTABLISH AND IMPLEMENT NATIONAL STRATEGIES FOR SOIL CONTAMINATION

In many Member States, a national strategy on soil contamination is already in place. A recent review by the Commission indicates that a number of Member States have official policy targets for soil contamination (17 of 28 reported such objectives).[1] Therefore, there is room for improvement in many Member States in terms of establishing a strategy, developing a national inventory system, and setting up a framework for funding and which determines responsible authorities to coordinate activities around soil contamination.

IMPROVE KNOWLEDGE, SHARING AND AVAILABILITY OF INFORMATION, AND ENGAGE STAKEHOLDERS IN THE PROCESS OF REMEDIATING SOIL CONTAMINATION

There is a need to improve the applicability of research and knowledge for soil remediation, improve dissemination of remediation project results and sustainable soil management action among local and wider communities. Information on cost-effective remediation measures that have a positive impact on soil ecosystem services needs to be better disseminated.

Knowledge gaps would be best addressed within a coordinated framework on soil contamination. At EU level a platform to share and exchange experiences and projects could be established for soil contamination and soil management more broadly (for example, by extending the existing DG Environment Soil Wiki Platform in the direction of the European Climate Adaptation Platform).

RECARE project shows that involving stakeholders from early on in research and remediation activities increases their trust and acceptance of remediation measures, thus overall also increasing the acceptability of remediation projects.

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RECARE PUBLICATIONS

References 9, 10 and 11 are publications directly derived from RECARE research.

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Further information about the soil contamination case studies:
www.recare-hub.eu/case-studies/guadiamar-spain
www.recare-hub.eu/case-studies/copsa-mica-romania

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