Investing in Opportunities

This project has received European Regional Development Funding through INTERREG IV B.

INTERREG IVB

CityChlor

An integrated approach to tackle pollution of soil and groundwater in the cities

Foreword

Land and soil are the basis for much of our development and prosperity. Soil provides us with a wide range of benefits that are vital for our well-being, like food production and the cleaning of water which replenishes the aquifers. When we contaminate our soils, we diminish their capacity to provide these essential services thus increasing environmental problems.

Along with other important threats such as soil erosion and the loss of soil organic matter, soil contamination affects the amount of land available, e.g. for agriculture and contributes to the loss of rural landscapes. Land planners and investors often prefer to utilise new land rather than abandoned sites, partly because they fear high remediation costs.

Europe is the world's most urbanised continent. More than 100,000 hectares (an area larger than the city of Berlin) of mainly agricultural land are taken annually for urbanisation purposes in the 27 Member States. The continued spread of urban areas is ultimately unsustainable. This is why, while infrastructure development is needed in some parts of Europe, there is a strong case for a more rational use of land and to maintain as many soil functions as possible.

We will need to use our soils more wisely if we are to safeguard their use by future generations. The European Commission's proposal for a Soil Framework Directive seeks to prevent further soil degradation, and to repair damage due to past neglect.

Site redevelopment can make a significant contribution to achieving the zero net land take objective set in the Commission's 2011 Roadmap to a Resource Efficient Europe. Currently there are wide variations between Member States, reflecting the presence or absence of national legislation.

In this context, new innovative in-situ techniques as suggested by the CityChlor project, can offer sound and practical solutions to renewing contaminated sites. These techniques are particularly suitable for urban environments, as the pollution of groundwater and soil with chlorinated solvents is a complex issue posing a serious problem for many European cities.

CityChlor is a good example of fruitful co-operation between European regions from four Member States and between experts from different disciplines, meeting the demands of regional planners and urban developers. Last but not least, I am pleased that the project work has been made possible through the support of the EU's Cohesion Policy and I trust that the results of this work will help contribute to a better management of soil resources throughout Europe.

Janez Potočnik
Commissioner for Environment European Commission

Introduction

Many North-West Europe cities are confronted with large scale contamination with chlorinated solvents used by dry cleaners, metal processing plants or printing companies as just a few examples. It is an extensive problem throughout the territory as the contaminated zones are difficult to detect and treat. The solvents challenge spatial planning and indirectly affect urban redevelopment decisions.

The traditional approach to soil and groundwater remediation is technically possible, but expensive due to the scale of contamination. The solution must be sustainable and facilitate urban development to allow the adaptation of space for working and living purposes.

The INTERREG IVB North-West Europe Programme tackles sustainable development and takes necessary precautions to reduce the vulnerability of the area. It builds on the territorial assets and addresses challenges in a collective, transnational manner to ensure that problems relevant to the entire territory are dealt with in a comprehensive way. To prevent further air, water and land pollution and diminish the effects of the already existing environmental problems, the Programme calls for a broad range of actions.

The remediation of contamination is a challenge, but it is also an opportunity gathering actors such as the CityChlor partners to increase spatial integration of the Programme territory. To turn a threat into a chance, the 9 organisations from 4 countries enabled the change from the traditional soil and groundwater remediation to an area-oriented and integrated approach. In this way, the project not only combats the soil and groundwater pollution, but also lifts the restraints to the economic growth of the territory covered. CityChlor has tested new techniques and trialled its approach, implementing innovative ideas and achieving sustainability objectives like CO2 reduction and the use of sustainable energy. Through active participation in policy making, CityChlor has also had a positive influence on the European Commission proposal of the new Soil Framework Directive applicable to all EU Member States.

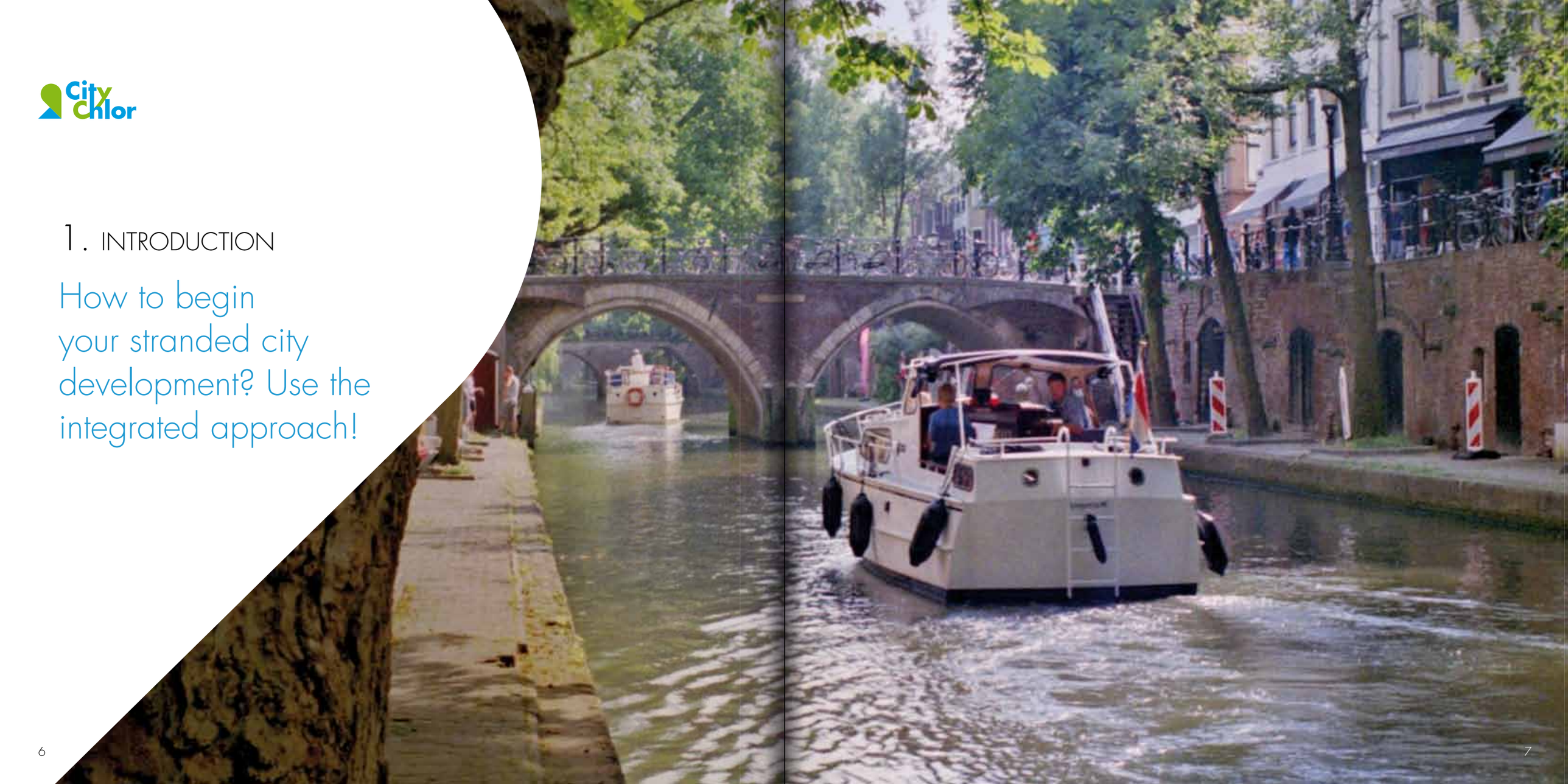
This booklet contains a selection of the project results. I wish you enjoyable reading and look forward to the project model being duplicated beyond the North-West Europe territory.

Ruut Louwers
Programme Director Interreg IVB

Content

1. INTRODUCTION

How to begin your stranded city development? Use the integrated approach!



You are a mayor, project developer or architect who is planning to redevelop part of a town centre. You can already envision the new shops, houses, offices, streets and parks. There's just one small problem. Or to be honest, a very big problem. The soil and the groundwater are contaminated. And you can not build on contaminated ground. To make matters worse, remediation is expensive, complex and costs a lot of time. What are you going to do? How can you develop your city on a sustainable way?

As many European towns and cities face the same problems, nine partners from Germany, France, the Netherlands and Flanders joined forces. In the CityChlor project they collected solutions which must ensure that contaminated soil forms less of a barrier to development. In fact, you can use the pollution as part of the solution start on your stranded city development. Even on a sustainable way. That seems counter-intuitive but the following parts will show that a polluted subsurface is not the end of the world. It is just a new begin.

This all sounds a little vague, almost like magic. Is there a catch? What's the trick? How can we use pollution to develop our city centres? If you ask a CityChlor-specialist, he or she will say: 'You have to use an area-oriented and integrated approach.' Simple as that.

Use an area-oriented and integrated approach

But what does that mean, area-oriented and integrated? Area oriented means that you look at an entire area and not just at a small plot of contaminated ground. And integrated means that you have to involve all stakeholders at once and look beyond the technical aspects. Because the socio-economic issues have a major impact to a smart solution.

The CityChlor project has illustrated that this integrated, area-oriented approach can work. The next chapters will go further in detail and deliver building blocks for the innovative approach. But if you want to stop reading now, which we do not hope of course, just remember these four words: area-oriented and integrated approach.

Faster, smarter, more effective

CityChlor has brought European experts together to find solutions to the complex problems of a polluted subsurface in the inner city. Experts looked into the transition from a local, technical approach to an area-oriented and integrated approach. Because

Facts & figures

- Definitions
- Chlorinated solvents: what, how, why?
- CityChlor: a transnational cooperation

that is what everybody agrees on: the solution for chlorinated pollution in the town lies in a broader perspective on the problem. It is better to treat different polluted sources together. And from an organisational viewpoint it is wiser to involve all of the stakeholders in the project at once. This is faster, smarter and more effective. Or as one of the stakeholders put it: 'pollution is part of the solution'.

Build with the tools of CityChlor

CityChlor was not just a theoretical exercise. The project also put the theory into practice. New techniques have been tested and integrated approaches have been tried out. For example pilot projects took place in the German city of Stuttgart, the Dutch city of Utrecht, the Flemish towns of Kortrijk and Herk-de-Stad and near the French capital Paris. These pilots illustrated that the new approach can work. It was also clear that each type of pollution with chlorinated solvents requires its own specific solution. There is not a ready-made solution that the mayor, architect or project developer can simply pluck off the shelf. Therefore CityChlor provides many examples of good practices and many proofs of concept. So you, urban developer, mayor, architect and expert can use the proven approaches to build further.

From single case to integrated approach

This booklet contains a selection of the outcomes from the CityChlor project. It covers characterisation technologies, new methods for remediating soils and groundwater, ways of reducing costs, overcoming legal obstacles, and manners of cooperating with all of the parties involved. The aim of the booklet is to inspire the reader and to provide a framework for everyone involved in inner-city redevelopment. Because together we can move from a case-by-case method to an integrated and area-oriented approach.

Facts & figures

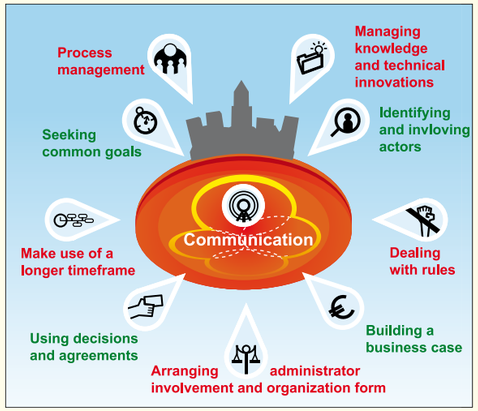
Definitions

Area oriented approach
A technical approach which makes it possible to remediate, monitor and control multiple soil and groundwater sources and plumes within a fixed area:

- Area can be extended to the border around the plumes
- Area can be location based
- Area can be in a city, brownfield or even natural area
- Area is all compartments, i.e. soil, groundwater, soil gas and indoor air

Integrated approach
An approach that combines all aspects that are relevant to tackle the problems that chlorinated solvents in urban environment cause.

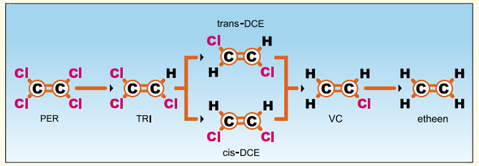
- Combines: depending on area, site, context you can use different aspects together or parallel to each other.
- All aspects: socio-economical aspects (like urban development, communication, financial and legal aspects), techniques, time, space, environment, actors (active & passive) and contexts.



Success factors for an integrated approach

Chlorinated solvents: what, how, why?

CityChlor is investigating how towns can best deal with contamination due to chlorinated solvents.
Yet, what are chlorinated solvents? Why are these dangerous? And how do we get rid of them? Ten things everyone should know about chlorinated solvents.



Degradation route tetrachlorethene

1. Family: chlorinated solvents, also sometimes called Volatile OrganoChlorine Compounds VOC's
2. Names of some chlorinated molecules: perchlorethylene, trichlorethylene, cis- and trans-dichlorethylene, vinylchloride
3. Up until the 1990s they were used a lot by: dry cleaners, printing works, metal processing factories and garages
4. Uses: solvent, degreasing agent, cleansing agent
5. Disadvantages: toxic, difficult to break down, spread heterogeneously and deep in the soil, contaminate ground water and indoor air
6. Where: on industrial sites, but also in towns under buildings and houses
7. Remediation solutions: excavate, pump and treat, venting, biological, chemical or thermal treatment and many other methods
8. Problems: historic pollutions, polluter often is no longer known, expensive remediation because of complex spreading, difficult accessibility, conventional methods for remediation take years, legislation lags behind
9. Stakeholders: polluters, residents, municipality, planners, remediators, project developers, administration, legislators
10. Best approach: look at an entire area and not just a small plot of contaminated subsurface (technical term: area-oriented approach), involve all stakeholders at once (technical term: integrated approach)

CityChlor: a transnational cooperation

CityChlor was a transnational cooperation project that intended to improve the quality and to minimize the pollution of soil and groundwater. The project developed an integrated approach to tackle the threats caused by contamination with chlorinated solvents in urban areas. Project partners from Belgium, France, Germany and The Netherlands formed the necessary complementary team to achieve this goal.

CityChlor examined contamination from a far broader perspective. We were not only looking at the contaminated location but also the area around this. And besides soil remediation companies we are also working with policy specialists and spatial planners. Thanks to the project we are creating a small paradigm shift.

The total research budget amounts to 5,2 M € of which 50% is financed by the INTERREG IV B programme for North West Europe. The project started at the end of 2009 and the final conference took place in Ghent on 16 and 17 May 2013.

CityChlor has shared specialised knowledge and developed new insights from studies and pilot tests. The results were discussed at several workshops and dissemination seminars with regional experts. Knowledge and practices were exchanged between the different countries and between different actors. CityChlor added value for all partners and experts.

2. INTEGRATED APPROACH

The integrated approach: building blocks

The traditional way of dealing with polluted soil and groundwater does not work in all cases. In urban environments with complex contaminations of chlorinated solvents an integrated approach is needed to tackle the problems. Yet where should you start? The CityChlor project provides building blocks. If you use these building blocks your chances of success are much greater. And by working together right from the start you can influence the process and turn problems into solutions for a sustainable city development.

CityChlor has demonstrated that remediation and sustainable re-development can evolve on a parallel timescale. It is also clear that public and private partnerships are important for guaranteeing the success of the process over a period of several decades. Moreover, the project has shown that an integrated approach can fit into European and local legislation. Finally, CityChlor has created tools for risk perception and community involvement and, of course, the project has reviewed and selected new techniques for characterisation and remediation.

So CityChlor has delivered the building blocks for stranded city development. But what building block must be added when and by whom? To provide an answer to such questions, CityChlor developed a plan that takes you through the different steps of an integrated approach and takes the interests of stakeholders into account. The complete, interactive step-by-step plan can be found on **www.citychlor.eu** Here we explain a few points.

The four phases of a re-development project

Producing a standard approach might seem an impossible task. Each pollution and every urban development task is different. Furthermore, the legislation differs per country and there are different stakeholders involved in each situation. Nevertheless, several common threads can be identified. For example, we can always divide a re-development project and a remediation project into four phases:

1. initiation
2. feasibility
3. realisation
4. management/maintenance

The stakeholders

For each phase we can consider the stakeholders and their interests:

- inhabitants, residents, neighbours, association for protection of the environment
- investors and their profit, owners, site operators
- governance, administration, state institutions, national agencies, health organisations
- cityplanners, land developers, contractors, real estate developers
- legal advisors
- environmental experts, advisers for contractors, engineering consultants, remediation operators

For each phase, and for many of the stakeholders and interests, the CityChlor project has compiled a list of do's and don'ts with links to manuals. This can concern complex issues but also quite simple things. A concrete example? You are a project developer and the project is in the initiation phase. Then one of the do's is: 'List the stakeholders. An obvious stakeholder is the alderman or the head of the city council, but the environmental department should not be forgotten either.' Another example? You are the same project developer, but now you are in the feasibility phase. A tip is: 'Are you experiencing difficulties in completing the business case? Then remember that other stakeholders can contribute to the financing. For example, energy consumers or producers can invest in thermal pumps.'

Is it really that simple? Just follow the steps and you are done? No, the feasibility phase, for example, is a cyclical phase. Sometimes you must repeat a step in order to achieve a better design. However this step-by-step plan does help you to check you have not forgotten anything and it can provide new insights. Moreover, sustainable urban development and remediation continue to be a human effort and therefore no two cases are the same. There are always unexpected issues. And in the future it will become less of a step-by-step (serial) process as there will be a growing need and tendency to consider and discuss things in parallel. Sustainability simply demands this. This will give rise to new challenges. For example, the need for all stakeholders to have easy access to reliable information is becoming increasingly important.

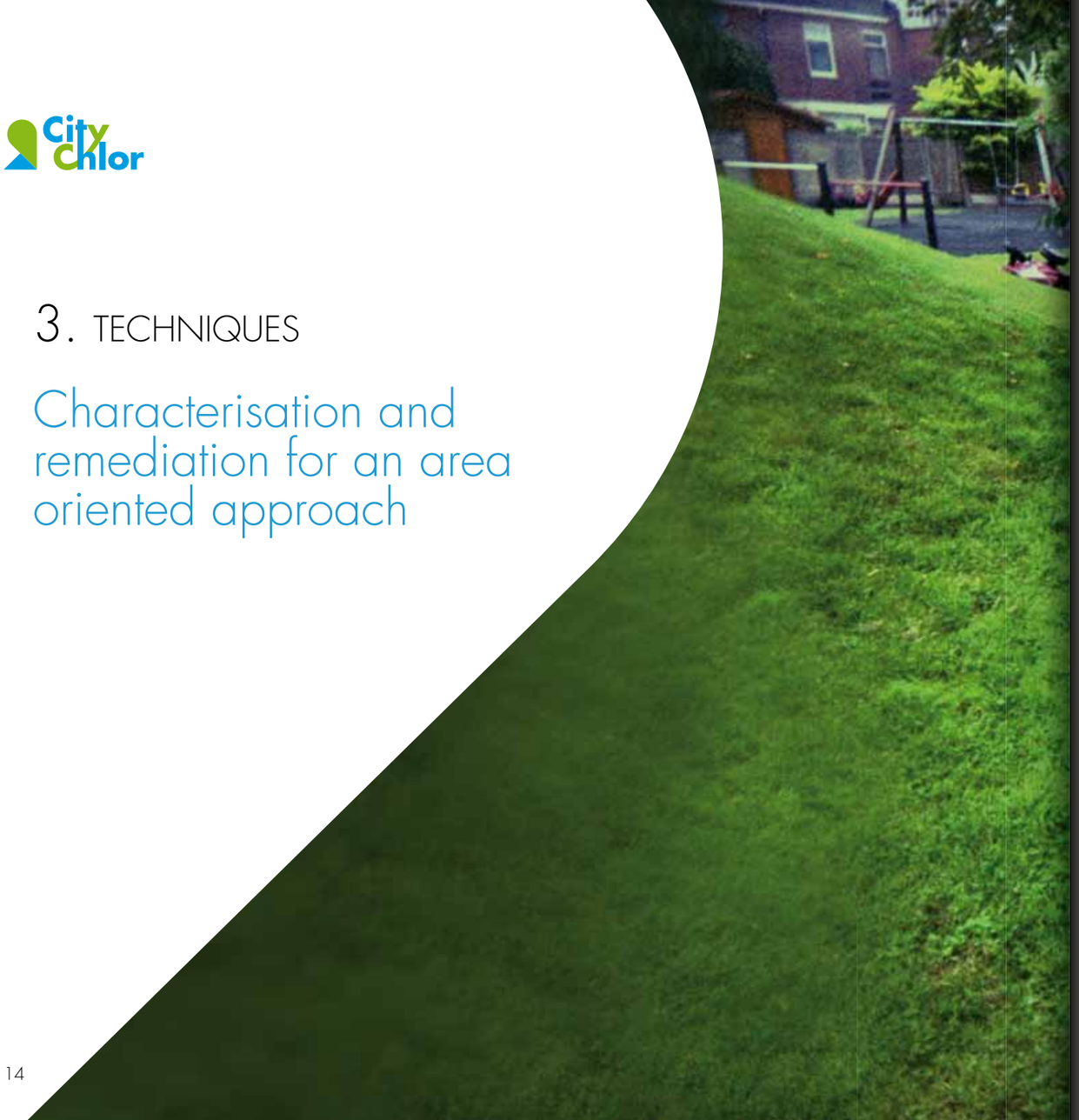
What's next?

So, these are the building blocks. Now you have to align right from the start: knowledge of communication, economic aspects, governance, urban planning, rules and legislation and the expert views on soil and groundwater, risk assessment, remediation measures and energy challenges. More about these topics can be found in the next chapters and on the website.

Video
Technical reports
Additional information

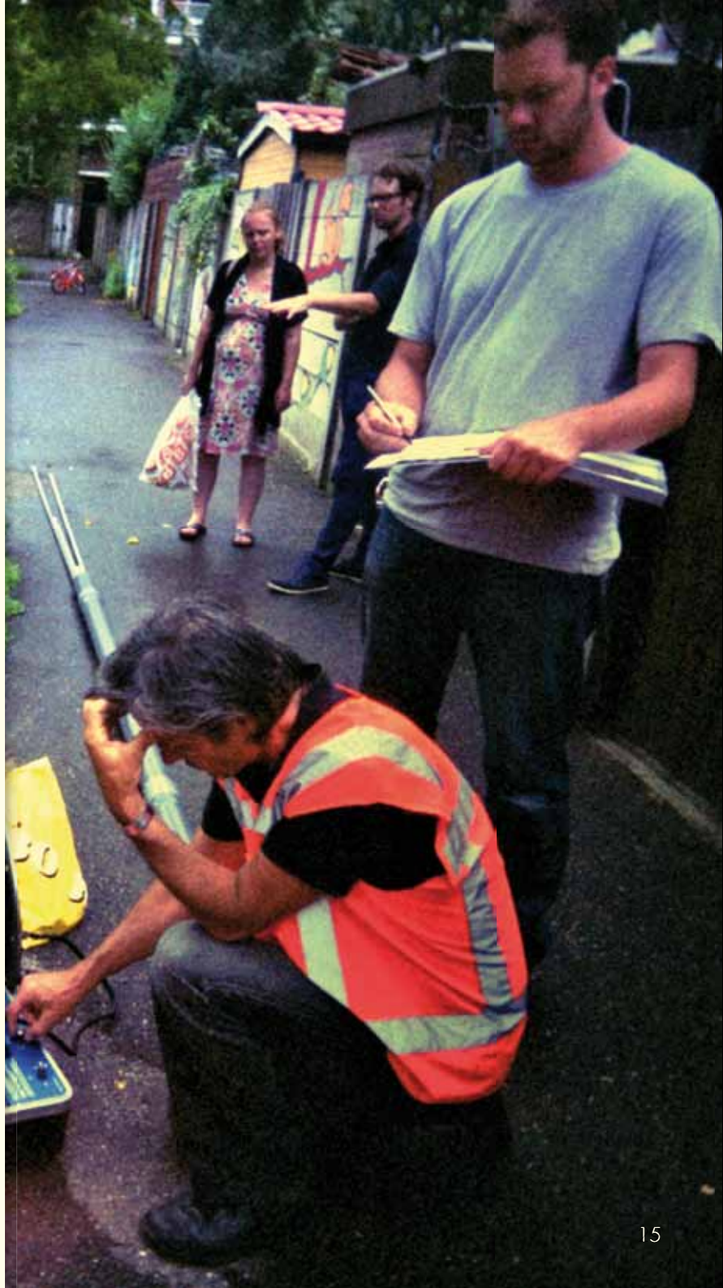
3. TECHNIQUES

Characterisation and remediation for an area oriented approach



Facts & figures

- FRANCE
  New methods for characterisation: passive sampling and direct push technology
- GERMANY
  The Stuttgart project: look beyond your own backyard



Facts & figures

FRANCE

New methods for characterisation: passive sampling and direct push technology

It is essential: you have to characterise before, during and after remediation. But how? Near the French capital Paris the researchers of the CityChlor project studied some relatively new characterisation techniques.

Passive sampling

One of the techniques is passive sampling. Unlike conventional sampling (purging the well and then taking a sample with a pump), passive samplers allow to sample pollutants in monitoring wells without creating active transport of groundwater and without any external energy sources. Identification and quantification of the pollutants is done by chemical analysis after retrieval of the sampler. They are simple to use and they do not hinder the neighbourhood. A survey amongst French consultants showed that passive samplers were not widely used in France because there was a need to provide feedback and guidelines to consultants to promote the use of passive samplers in a regulatory context. CityChlor tested passive samplers to measure groundwater quality at a site contaminated with chlorinated solvents. Four passive samplers were tested: polyethylene diffusion bags, ceramic dosimeters, Gore Sorber Modules and cellulose-regenerated dialysis membranes. Chlorinated solvent concentrations in groundwater given by the tested passive samplers were consistent with the ones obtained from the conventional sampling method. The results showed that passive samplers were very interesting to measure groundwater quality at a contaminated site. In addition, they were generally more cost effective than the conventional sampling method and cross-contamination was avoided. They could as well offer complementary information compared with traditional sampling methods because they allowed depth discrete and multi-level sampling in a well. Consequently, they seem to be very promising tools for groundwater quality measurement on contaminated sites.

Direct push technology

Direct-push Technology (DPT) refers to a group of techniques used for subsurface investigation by driving, pushing and/or vibrating small-diameter rods into the ground. By attaching tools to the end of the rods, they can be used for in-situ measurements or for the collection of samples from soil, groundwater or soil air. DPT holds a group of a versatile techniques that aid in cost-efficient and flexible soil investigation.

DPT probings are faster and more flexible than conventional drilling techniques. Due to the smaller diameter of DPT probes, the technique is less invasive. This reduces the time needed for sampling or measurements and increases the density of collected data. The number of sampling points can be higher than with conventional techniques within the same time and budget. As soil material is only pushed sidewards with the propulsion of the probe, there is no waste material. This reduces costs as there is no need for removal of (polluted) material.

DPT can be used for a wide range of research questions. Different techniques can be combined in a single probe. The use of DPT allows to react in a flexible way on results and to adapt the programme of the investigation to these. DPT will can therefore contribute to cost efficient investigation.

Direct push rig for nano-iron injection

GERMANY

The Stuttgart project: look beyond your own backyard

CityChlor strived for an integrated approach towards soil remediation. At several locations trial projects were taking place. One of these was in the centre of Feuerbach, a district of the German city of Stuttgart.

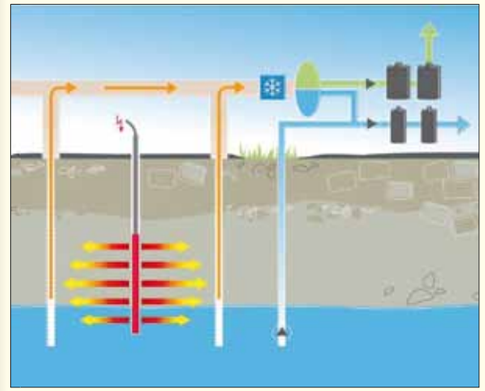
The Stuttgart project focuses on a plot 20 by 40 metres with buildings on it. For decades a metal processing company was located there. They stored chlorinated solvents and processed waste in their courtyard. These leaked into the soil and groundwater and spread to the neighbouring built-up area. The city has already been remediating the soil and groundwater for 20 years by a 'classical' pump and treat system without real success and without reaching the threshold values. Continuing like this would last for years or decades. And demolishing the buildings and excavating the soil to several meters is too expensive. Now the city uses a different technique to clean the soil.

Technique: heating up the soil

Stuttgart heats up the soil and so mobilises the contaminants by evaporation. The contaminated soil vapour is extracted via a soil vapour extraction system and subsequently cleaned. The technique is not completely new but it is scarcely used in hydrogeological conditions like in the site of Stuttgart. It should be suitable for high-density soils, such as clay and loam. A critical issue is soil shrinking, which can occur in these geological surroundings. Information gained with this pilot test will enable others to use this approach for other urban sites as well. This pilot project is therefore a sort of showcase.

Tips for other problem owners of contaminated soil

Peter von Schnakenburg, one of the project leaders has some tips for others with contaminated soil: 'Look beyond your own backyard. Not just literally but also figuratively. We are now using a technique that we have not previously used. Our aim is to bring sites back into use and to the real estate market, therefore we need a short remediation time.'



Thermal heater wells and soil vapor extraction

In urban areas, pollution does not only pose a direct risk by exposure to contaminants, it also indirectly restrains economic and urban development and harms the quality of life due to the slow processes of site investigation and remediation. Therefore, as part of the integrated approach, CityChlor investigated some innovative techniques that have a positive impact on social economics: more cost efficient, faster and less inconvenient for the neighbours than traditional techniques.

Up until now project development of polluted areas was often viewed as a step-by-step plan. First characterisation, second remediation and third building. That approach does not work when the pollution is complex. Besides that, how do you know when the remediation has been successful? That is why you have to keep on monitoring the pollution during and after the remediation.

Don't waste time: characterise

Characterisation of a polluted site is generally done by drilling to collect soil, soil gas and groundwater samples. Wells are placed to monitor groundwater and soil gas. When buildings are present above volatile contaminants, indoor air is as well characterized. Yet if you need to deal with a polluted subsurface in between buildings then extensive drilling could be a difficult task. Furthermore, the pollution often extends under buildings and, of course, you simply cannot go and break open a neighbour's floor to drill. CityChlor dealt with these types of characterisation problems, tested some solutions and evaluated the outcomes.

Risk management is a crucial aspect in polluted sites. Risk models are used and therefore the characterization step needs to be reliable in order to provide consistent input data for the models for a correct risk assessment.. You have to work with risk models in order to know if the use of the site (industrial, housing, et cetera) is compatible with the pollution level. If not, you have to remove the pollution or change the use.

Facts & figures

Remediation? Combination!

Remediation in urban areas must not hinder economic and social activities. In most cases remediation must therefore be realised 'in-situ'. This means treating the pollution without excavation. There are countless highly promising remediation techniques but most of these are not widely used. The CityChlor project revealed that the specific characteristics of the site play a crucial and often limiting role. Different types of pollution are frequently mixed up. This means that a straightforward remediation is not enough. Also a contaminated subsurface with chlorinated solvents usually requires the treatment of a relatively small source zone of high contamination that is frequently accompanied by a large plume of contaminated groundwater. All possible means of eliminating the sources of pollution must be sought. A cost-effective remediation must differentiate between the source zones and the plumes.

Complete restoration can be difficult and so a combination of techniques is the smartest approach. The trick is making sure you use the right techniques at the right place and time. Researchers from CityChlor tested techniques for the characterisation and remediation of soils, groundwater, soil gas and indoor air at pilot sites. The tests revealed that the smartest approach often involves a combination of several techniques. Which combination depends on a wide range of factors. The researchers have written up the various test results in codes of best practice, reports and manuals. This meets the need of soil remediators for new tools whose effectiveness has been evaluated.

Videos

Characterisation
- Technical reports
- Pilot Cases

Remediation
- Technical reports
- Additional information
- Pilot Cases

Facts & figures

FLANDERS

Characterisation and remediation in Flanders

In Kortrijk and Herk-de-Stad researchers of CityChlor tested promising characterisation and remediation techniques.

Characterisation with EnISSA-MIP in Kortrijk

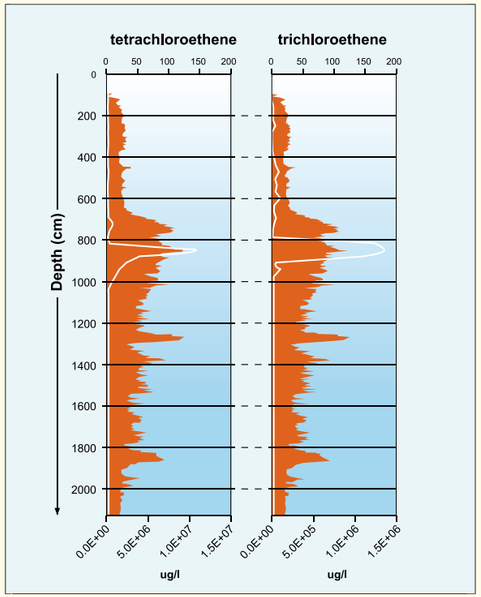
'On site' soil screening direct-push technologies such as the Membrane Interface Probe (MIP) are already frequently used in addition to traditional sampling methods. They are used to provide detailed screening of (semi)volatiles and make on-site, real-time decision making possible. However, classical MIP has limitations: it has relatively high detection limits compared to typical risk or clean-up values and does not differentiate between individual chemical compounds. EnISSA-MIP connects gas chromatography and mass spectroscopy to a direct push MIP. Cost comparisons indicate that the EnISSA strategy achieved cost savings over conventional approaches, and also delivers a much higher density of information about contaminant distributions in the subsurface.

On the site of a former warehouse in the city of Kortrijk where opportunities are being examined for remediation in combination. EnISSA was compared with traditional sampling methods. An EnISSA-MIP profile is quasi continuous (1 measurement of up to 12 (semi-)volatile components every 30 cm) while a sampling well only screens a part of the soil profile (usually 1 or 2 meter), which can in some cases be somewhat arbitrarily chosen. Consequently EnISSA found unidentified contaminations in soil profiles next to 'clean' neighboring sampling wells. EnISSA was also superior to sampling wells in detecting pure product zones, which are frequently present in narrow soil horizons. Correlation between contaminant concentrations from sampling wells and EnISSA measurements on comparable depths were good. Demonstration work indicated that it is possible to qualify and quantify pollutant mixtures every 30 cm within the time frame of conventional MIP application. Taken in account the different sampling methods, the EnISSA MIP-results correspond well with the soil samples and the groundwater samples. Moreover, this demonstration project illustrates how the EnISSA-method can contribute to the creation of an enhanced conceptual site model by providing accurate spatial data.

Remediation with iron particles in Herk-de-Stad

CityChlor tested a remediation technique in which nanoparticles or microparticles of iron are injected into the soil. The location was the site of a former printer in the Belgian town of Herk-de-Stad. So far, the technique has scarcely been tested in Europe. The principle of zerovalent iron is already being used in permeable reactive barriers (PRB) to control a plume. The difficulty in the tackling of source zones of pollution by using this facilitator, is bringing the iron in contact with the pollution.

Our labtests showed better results on reactivity and injectivity for the nano-iron. But the field tests showed a different result. The micro-iron was improved by a glycerol substrate for improvement of the injectivity and this combination showed a better breakdown of VOC than the 20 times more expensive nano-iron but mainly through biodegradation. The conclusion of these tests is that the iron injection can work in combination with other remediation techniques, but in that case you don't need the expensive nano-iron.



Output of Enissa MIP on-line measurement

THE NETHERLANDS

Utrecht: cleaning up contamination gives you energy

A unique result of the CityChlor project is the integrated approach at several levels of risk management that involves different aspects of urban development. For example, sometimes not one pollution but an entire area was investigated. Or the pollution was always viewed in relation to what would be built on the ground. Or throughout the entire process all of the actors were informed and involved separately. In the Dutch city of Utrecht all of these different aspects were integrated and a new combination of sustainable energy was also used as a remediation technique. This is the Utrecht case.

Problem: more than 900 hectares of contaminated urban subsoil

Utrecht is an expanding city in the centre of the Netherlands with more than 300,000 residents. The problem with the subsoil in Utrecht is that several types of pollution from different sources have become mixed up over the course of time. A total of 180 million m^3 groundwater is polluted with chlorinated solvents and some 900 hectares of subsoil is polluted: that is roughly an area of 3 km by 3 km. An area of about 90 ha close to the central train station is now being redeveloped with lots of new buildings, offices, and underground parking spaces as well as many ATES systems (aquifer thermal energy storage). Most of the historic buildings will not be demolished. Due to the mixing of the historic pollutions a single-case remediation approach is impossible and from a legal perspective each ATES system requires a separate remediation approach.

Solution: aquifer thermal energy storage

The chlorinated solvents biodegrade naturally due to the conditions present in the subsoil. However that is happening slowly, too slowly. Utrecht City Council decided to combine the problems and solve these with an integrated approach. Instead of standard remediation techniques like the pump-and-treat method, the polluted soil in Utrecht is now being pumped via the ATES systems of different developers. The groundwater pumping by the energy storage systems will result in a better mixing of the polluted groundwater, bacteria and nutrients. This will lead to a more rapid breakdown of the pollution than under the natural conditions. The groundwater flows through a heat pump, which warms up the buildings in the winter and cools them in the summer. This leads to energy savings and a reduction in CO2 emissions. This integrated approach is a good example of the integration of redevelopment, groundwater remediation, and energy storage and reduction of CO2.

Role of the city council: facilitate

Utrecht City Council has mainly played a facilitating role. For example, it investigated how the law could be interpreted in such a way that the approach would become possible. Later the Dutch government even modified the law to make this approach easier for the entire country. The council has now also started an information point for parties who want to purchase ATES systems in the complex urban subsoil areas of Utrecht. Finally, the council has put a lot of time and effort into communicating with involved private parties and nearby residents.

Future/tips: collaboration is the key to success

The multiple integrated approach will be used more often in the future: pollutions in a larger area are tackled above and below ground with all of the parties involved. Or as Utrecht puts it 'we clean up the mess together and gain energy from the process'. Utrecht's approach is a success which can also work in other urban areas of Europe. During the CityChlor project Utrecht exchanged its experience with Flanders, for example, where opportunities are being examined for remediation in combination with aquifer thermal heat storage. Utrecht's approach has also attracted interest from outside of Europe.

Illustration of biowashing machine

4. SOCIAL-ECONOMIC ASPECTS

Remediation is also communication, legislation and financing

Remediation is also a matter of communication, legislation and financing. And with an area-oriented (more polluted sites at once) and integrated approach (all stakeholders together) those aspects are more important than ever. To put it straight: without good communication, legislation and financing the area-oriented and integrated approach will not work. Or, to turn it around: with good communication, legislation and financing you can make your urban redevelopment even more successful.

There are some interesting developments concerning the legislation of remediation. Until recently, Flanders, Germany, France and the Netherlands have always focused on single-case remediation. The legislation was based on individual cases. The polluter or the owner of a plot of land had to ensure that it was clean or that it became clean. Frequently, however, a case of pollution extends beyond the boundary of a plot and becomes mixed up with other sources of pollution. The Netherlands amended its legislation in 2012 so that a large areas containing several contaminations can now be tackled as a single entity, the area-oriented approach. Flanders, that had widened its law already in 2001, extended it more recently from sites to areas. And also Germany and France do have opportunities in the law to use an area-oriented approach.

Finance: spread the costs

Also in the area of finance things are changing. Urban developing projects are spreading the costs in time and across all of the parties involved in the area. Future users are turned in co-investors. That is possible because after redevelopment the plots will rise in value. It is really a win-win situation. The government has to pay less. Investors and developers share the costs. And on top of that, because every one works together, the procedures for planning, development and remediation run parallel. And that saves time, money and miscommunication. CityChlor has made a model to calculate the financial benefits for an area-oriented approach.

Communication: communicate throughout the entire project

An integrated approach takes more than a few days to complete; such projects may run for over 30 years. Good communication is therefore essential.
For example, soil remediation companies have made short information films that municipalities can place on their website to explain what those 'weird machines' are doing. Also more and more the neighbourhood is already involved in the planning phase for the redevelopment of an area.
And developers can use a phased plan which shows who must be involved in the project at each stage.

However, one thing is apparent from all of the projects: ensure that your communication is clear throughout the entire project. That will prevent unnecessarily long delays, rising costs, dissatisfied stakeholders and negative public opinions.
The CityChlor project provided tools to communicate with all stakeholders.

Now: adopt an integrated approach

What does the future look like? Ideally you would have a clear phased plan about how to synchronise spatial redevelopments with underground remediations, which you could work your way through. Everyday practice, however, is often tougher than the theory, especially as we are dealing with complex projects that can run over several decades. Experience from the CityChlor projects reveals the importance of pursuing an open and flexible approach. You must be willing to adjust your plans during the process and to bear in mind that remediation and sustainable redevelopment can evolve on a parallel time scale. The pilot projects have demonstrated that.

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Additional information

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Additional information

Communication
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Additional information

Pilot Cases

CityChlor: new solutions for complex pollutions

The densely populated areas of North West Europe face similar difficulties with the presence of chlorinated solvent pollution. Up until now, regions have partly developed their own solutions. Within CityChlor nine partners from France, Germany, the Netherlands and Flanders have developped a new solution for complex pollutions.

Remediation of a pollution with chlorinated solvents is complex, especially within city centres. This is why redevelopments of, for instance old historical city centres, are often hindered. The CityChlor Approach is to integrate both the technical and socio-economic aspects.

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project partners