Rijkswaterstaat
Ministry of Infrastructure and the Environment

Into Dutch Soils

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A swift overview of how the Dutch manage their soils:
a source of inspiration for your own practice

The text

This booklet provides an overview of 35 years of Dutch soil policy development, beginning with a description of how it all began: the geological and historical development of the Netherlands. It considers questions like: Why does a portion of the Dutch population live below sea level? And how have the activities of the Dutch over time affected the soil quality?

Soil legislation provides the legal framework for current land use in the Netherlands. Amongst many more, it defines liability and enables sustainable land management. It relates to a large number of other legislative fields, specifically with respect to other environmental compartments like groundwater, surface water and sediments. These matrices are only mentioned shortly in this booklet.

In addition, a large array of technical guidelines and approaches has been developed over the years. These instruments play a major role in daily practice. The key elements are introduced in this booklet.

This 2nd edition of this booklet was written for the Ministry of Infrastructure and the Environment by Frank Lamé and Linda Maring of Deltares with a contribution of Frank Swartjes of RIVM.

The photos

The photos in this booklet show the Dutch in direct contact with their soil and represent ‘everyday’ activities like agriculture, the construction of underground infrastructure, recreation, children playing, sports, soil remediation, building activities, the development of man-made environment, investigation of soil quality and archaeology.

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ATLAS
YANMAR

History of the Dutch delta

The Netherlands is a typical delta area, with two major rivers, the Rhine and the Meuse, flowing into the North Sea.
The Netherlands as we know it today developed predominantly during the Holocene, approximately the last 10,000 years, when the ice sheets of the last ice age melted and retreated to the north. As a consequence, between 10,000 and 5,000 years ago, the sea level rose by some 35 metres. For the last 5,000 years the sea level has risen by only a few metres. This rising sea level caused the western part of the Netherlands to become largely covered by the sea some 5,000 years ago.

Before focusing on the way the Dutch deal with their soil, let us first go back in history and look at the development of the Netherlands as we now know it. The rivers were able to move freely over the land, depositing clay, sand and gravel during seasonal floods within a wide floodplain. Swamps developed in the coastal area and the slightly higher-lying eastern part of the Netherlands was covered by woods and high moorlands.
Early inhabitants were hunter-gatherers, but progressively they settled and became farmers, clearing the woods for farmland.
The western part of the Netherlands gradually evolved due to deposition of sand and clay and the development of peat in the coastal area, with the sea becoming a diminishing influence on the coastal area.
The presence of the Romans in the Netherlands between 12 B.C. and 450 A.D. saw their roads and buildings bring substantial progress to the Netherlands. The River Rhine formed a natural northern border of the Roman Empire.
The late Middle Ages (1050 - 1500 A.D.) specifically saw exploitation of the peat swamps and moorlands. Ditches were dug to drain the swamps and dikes were build along the rivers and the coast. This allowed permanent occupation of the western parts of the country. Social and organisational structures started to develop, resulting in the world's very first democratically chosen form of administration, water authorities. These water authorities were responsible for the water management of the lower regions.

The extensive peat cover of the western part of the Netherlands proved to be a valuable source of energy. This was of growing importance at the end of the Middle Ages as the period known as the 'Little Ice Age' started when the Netherlands suffered long and cold winters. Having a large source of peat available for heating purposes, further economic and social development was possible, despite the climatic conditions at that time, resulting in booming economic development during the 17th century, or 'the golden century' as it became known in the Netherlands.

During this period, the Dutch fleet made the country a major military power that dominated the world trade. With demand for big sailing ships for world trade, the city of Amsterdam, with its natural harbour, started to play a major role. Until then other cities in the Netherlands, like Utrecht, had been of far greater political and economic importance. However, in contrast to Amsterdam, those cities had no direct connection to the sea. The city of Amsterdam, which had slowly developed during the centuries before, now became an important economic power as the base of Dutch trade merchants. The quickly growing population fuelled the demand for more food and energy, a need that obviously continued after the booming 17th century. Areas in the former coastal zone with rich peat deposits were excavated further and further. Where the peat was thick, this resulted in shallow lakes. In other places, natural lakes were surrounded by dikes and with the use of windmills the water was pumped out. This resulted in new land below sea level, the famous Dutch polders.

The level of the groundwater in these areas often lies just a few decimetres below the soil surface. In the past, farmers therefore welcomed (household) waste to raise the soil level of their land. In some areas, this has resulted in widely distributed diffuse contamination of the arable land and grassland.

Until less then 100 years ago, water was a major route for transportation. Boats could carry far more freight than could be transported over land. Having plenty of water in the western part of the Netherlands, the economic development in this area was given a further boost and a network of villages and cities developed, housing more and more people in the lower parts of the Netherlands.
But the density of population and industry took its toll on the soil quality, a situation that is certainly not unique to the Netherlands. Similar processes have occurred in other (densely) populated areas around the world.

Obviously, water is still a threat, not only from the sea but also from the rivers. Dunes along the North Sea coast and dikes around lakes and rivers protect the low areas of the Netherlands against the water. The last time large floods encroached upon part of the Netherlands was in 1953. A north-westerly storm coincided with a spring tide to raise the sea level to a record height, which proved too much for many of the dikes, specifically in the province of Zeeland. More than 1,800 people died and some 100,000 people became homeless as a result of this breach. This prompted a major upgrading of the Dutch sea defences, the so-called Delta Works.
The very first inhabitants of the Netherlands had to cope with the omnipresent water; this need for protection against the sea and

Some facts and figures

The **River Rhine** is 1,320 km long. From its source in the Swiss Alps, it passes through France and Germany with a catchment area of 185,000 km^2 and an average of 2,200 m^3/s of water flows through the Netherlands.

The **River Meuse** is 925 km long and originates in France, passing through Belgium before arriving in the Netherlands. Its catchment covers an area of 36,000 km^2 and the average flow rate is 230 m^3/s.

The **North Sea** is a relatively shallow coastal area of the Atlantic Ocean. It covers the area between the United Kingdom, the Netherlands, northwest Germany, Denmark and the southern part of Norway; its total area is 575,000 km^2 with an average depth of just 95 m.

The royal kingdom of **the Netherlands** covers 41,526 km^2 and is inhabited by 16.9 million people. The coastline is 451 km long. Most of the land surface is flat, except for some remnant lateral moraine of the last ice age in the central part, and a hilly area in the south east. The highest point in the Netherlands is 323 m, right on the border with Germany and Belgium. The lowest point is 6.76 m below sea level. In all some 40% of the land area lies below sea level.

The Netherlands below and above sea level

(Actueel Hoogtebestand Nederland)

rivers over the centuries has become rooted in the Dutch who, despite these risks, value the soil beneath their feet!

Nowadays, the Netherlands is a densely populated country, averaging almost 500 people per km^2, a figure that rises to almost 1,300 inhabitants per km^2 in its most densely populated province of Zuid-Holland! And although an increasing amount of agricultural land is gradually becoming urbanised, redevelopment of that urban area is inevitable if spatial development is to keep in line with growing needs. That the Dutch should be confronted with a 'soil legacy' was inescapable.

'The concept of defining soil quality with legislative reference values was so new, that it was even implemented in a number of other countries'

Dutch soil: types and quality

The description of the formation of the Netherlands during the past 10,000 years in the previous chapter provides a framework for the soil types present. These soil types are strongly related to the altitude of the soil throughout its formation.

Starting at the North Sea coast in the west, we first encounter a coastal dune area whose sands are marine in origin and deposited by onshore winds. This is a relatively narrow zone, but of great significance for sea defences. The dunes not only protect the low country from flooding, but also provide a barrier between the salt water of the North Sea and the fresh groundwater inland.
Just east of these dunes is a zone with surface marine clays that covers both the western and northern part of the Netherlands. Further inland is the former coastal swamp region. Given the significant excavation of peat deposits throughout the centuries, the peat is no longer as wide-spread as it used to be. What often remains here at the surface is the marine clay which was originally at the base of the peat.

In the central part of the Netherlands a zone with river deposits can be found. The main soil type here is river clay. Away from this central area, in the somewhat higher regions to the north, east and south, sandy soils occur, while in the northern part of the country boulder clay is found. These deposits were formed during the last few ice ages, when the climate in the Netherlands was much colder and the large northern ice sheet occasionally reached halfway into the country.

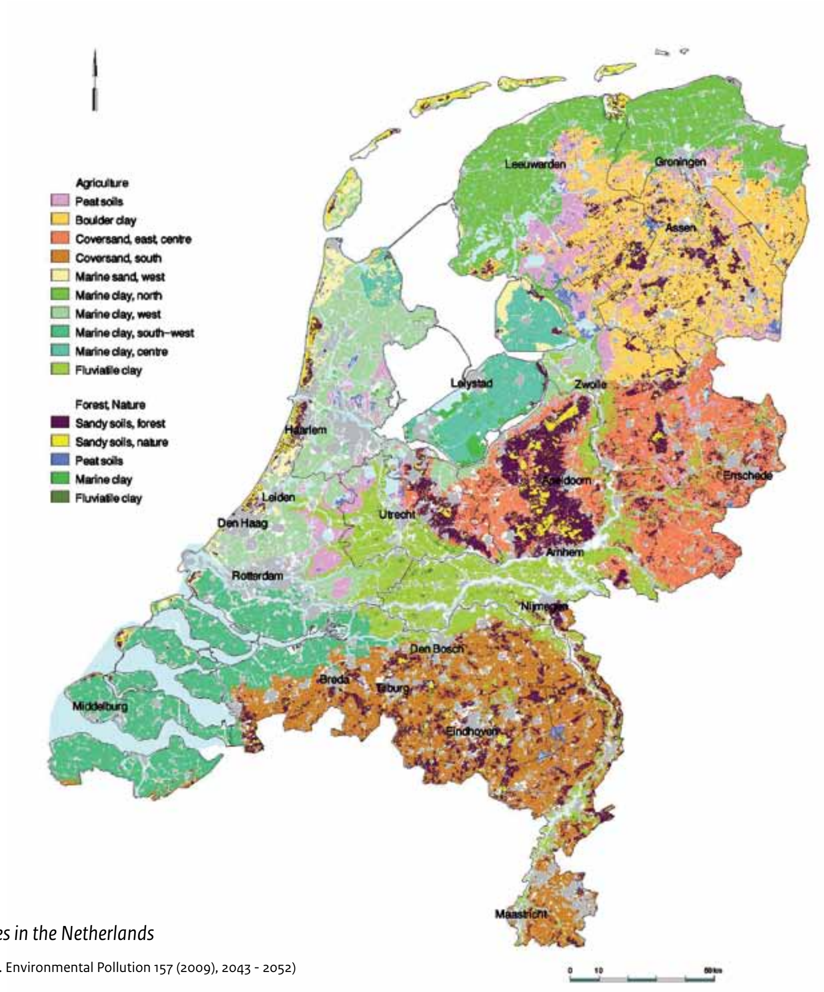
Soils in the Netherlands, specifically in the clay areas, are rich and a great source for crop production. Indeed, agriculture is an important activity in the Netherlands.

With the industrial revolution at the end of the 19^{th} century, the Netherlands changed from a predominantly agricultural to an industrialised society. As an agricultural society, the Dutch predominantly lived in harmony with the soil but industrialisation made demands on the soil with which it could not cope. The self-sustaining farmer of the past became a citizen who no longer understood the needs and capabilities of the soil and former agricultural land increasingly became urbanised and industrialised.

Public awareness of soil contamination started in 1979 after the soil in some major areas was found to be contaminated, as in the residential area of Lekkerkerk, which came as a shock to the public in the Netherlands. Given that the extent of the problem had been underestimated for quite a number of years, the government realised that legislation would be necessary to deal with it. Fortunately, the government had started to develop soil legislation some years earlier, which resulted in the first Interim Soil Remediation Act, passed in 1983.

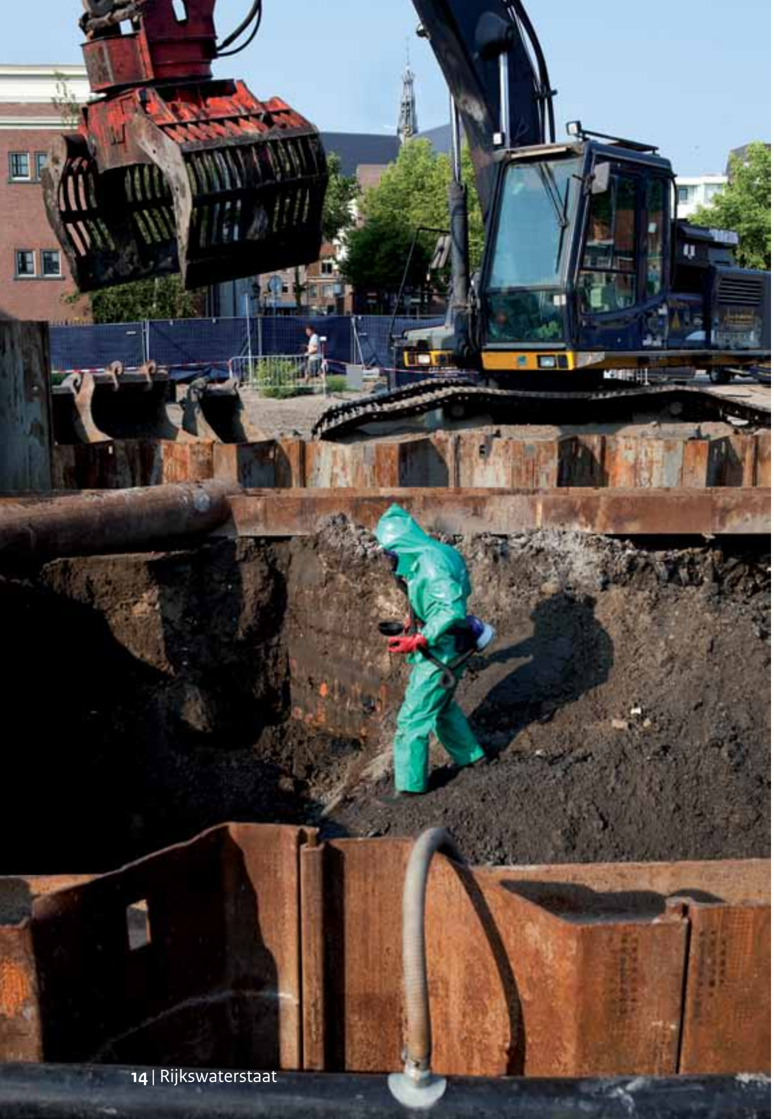
Once the first (few) chemical dump sites had been found, a broadly embraced feeling emerged among the Dutch that they had to take care of their soil. Coincidence or not, this fitted right in with a general growing environmental awareness in the Netherlands, expressed in a strong environmental movement during the 1980s and 1990s.
Expecting at first only a limited number of contaminated sites, it was assumed that these problems could be completely solved in just a decade. However, the appearance of more and more contaminated sites, mainly local pollution but occasionally also regionally found diffuse contamination, raised the fear among experts of whether any clean, unpolluted, areas were left in the Netherlands. We now know that the majority of the rural and natural areas of the Netherlands are indeed still unpolluted.

The question whether the soil is contaminated or not leads by definition to the need for a framework to establish such a judgement. For this the Dutch Ministry of the Environment developed the A, B and C values first published in 1983 as part of the Interim Soil Remediation Act.
The concept of defining soil quality with legislative reference values was so new that the list not only attracted great interest from countries all over the world, it was even implemented in a number of other countries. Since then changes have been made to both the numerical values, the terms used, and the role and function of these terms. This is considered later in this booklet (see the chapter ‘The Dutch soil quality standards’).



Soil types in the Netherlands

(Brus et.al. Environmental Pollution 157 (2009), 2043 - 2052)



Developing a soil policy

With the discovery of the first major polluted sites in the late 1970s, the Dutch government realised that it was due time to develop a soil contamination policy. Bearing in mind that at the time only a small number of contaminated sites had been expected, it was assumed that these problems could be completely solved. The initial policy approach, therefore, was that all contamination should be eliminated. Consequently, a remediated site would be fit for all possible future functions, ranging from heavy industry to a domestic vegetable garden.
Considering the urgency of dealing with serious soil pollution, such as directly under domestic housing, the first Interim Soil Remediation Act passed in 1983. It introduced the concept of a 'multifunctional' soil with the objective of allowing every kind of reuse after remediation.

In addition, the Soil Protection Act came into effect on 1 January 1987 with the aim of preventing soil contamination. For situations where new soil contamination nevertheless developed, the 'polluter pays principle' was introduced. The person or organisation that causes the soil contamination is liable for its remediation (see also the chapter 'Liability: who pays the bill?'). Since then this principle has been embraced as a funding mechanism for soil remediation in a large number of countries.

In the National Environmental Policy Plans of 1989 and 1993, the aim was still to remediate all sites with serious soil contamination before 2010. However, acknowledging the discovery of more and more polluted sites, the National Environmental Policy Plan of 1997 amended the ambitions by stating that all sites with soil pollution should be known before 2005 and that all sites with serious risks shall be controlled prior to 2030.

As for new soil contamination, the principle of a multifunctional soil remained, as it does today. However, for soil that was contaminated prior to 1 January 1987, the concept of a multifunctional soil was abandoned. In view of experiences over previous years, it was evident that the demands of the multifunctional soil concept for 'historical' soil pollution often cannot be met. Additionally, technological

developments in the remediation field introduced a whole series of new methods to deal with a contamination. Consequently, 'dig and dump' was no longer the only possible solution.
For immobile contaminants the aim was to establish a soil quality that is fit for its future land use. The new function of the soil, therefore, determines the extent to which remediation is necessary. For mobile contaminants the remediation measures should be determined by cost effectiveness, which might imply the treatment of contamination over a longer period rather than trying to solve the problem within a few weeks or months.

In 1994 the A,B and C values for the appraisal of the soil and groundwater quality were replaced by a new set of risk-based action values. The lowest level (Target values) defines the quality of unpolluted soils while the highest level (Intervention values) defines when remediation becomes necessary.

On 1 January 1995, soil remediation was included in the Soil Protection Act, thereby ending the Interim Soil Remediation Act.

In the fourth National Environmental Policy Plan, published in 2001, the Dutch government states its intention to end the transfer of environmental costs to future generations. This policy statement underlined the ambition of 1997: in 2030 all sites with serious soil pollution should be under control. In 2002 legislation actually incorporated the principles set by the National Environmental Policy Plan of 1997 with respect to specific local circumstances. These circumstances must determine the remediation measures necessary in order to obtain a cost-effective remediation. It incorporates a risk-based approach; the highest risk is given top priority.
On 1 January 2006 a new Soil Protection Act came into effect. It incorporated the amended legislation with respect to functional remediation and introduced a criterion for urgent remediation.

Finally, on 1 July 2008, the Soil Quality Decree and its accompanying Soil Quality Regulation came into effect. It was developed in light of identified problems within existing legislation. These were:
1. the quality of the actual activities,
2. the management of (slightly) polluted sites and,
3. the environmental safe use of building materials.

Consequently, the Soil Quality Decree was developed from a different perspective. No longer a strictly environmental perspective governs soil policy. Nowadays a balance is established between the protection of the soil and its use for economic and social purposes.

Therefore the Soil Quality Decree consists of three parts. The first part deals with quality assurance whereby requirements are set with respect to the registration and assurance of the activities performed by people and organisations, both in the field and in the laboratory. To put it simply, it provides an answer to the question of whether the reported activities have indeed been performed in line with regulations and the accepted work procedures (like national standards). It helps to set a balance between the costs and quality of the work in a highly competitive market.

The second part is the result of the incorporation of the Building Materials Decree which originally became effective on 1 July 1999. With the establishment of the Soil Quality Decree, the Building Materials Decree is no longer a standalone decree. Although the Soil Quality Decree brought some changes, its contents are comparable with the former Building Materials Decree. It aims to regulate the environmentally safe use and reuse of stony building materials. As such it provides an important field of application for secondary building materials like slags, that would otherwise have had to be disposed of in the absence of environmentally safe reuse regulation.
The third part deals with soil and dredged sludge. It sets soil quality criteria for different soil functions that apply both to the soil in-situ as well as to soil or dredged sludge that will be applied on land. Setting soil function criteria aims to incorporate the soil quality as a criterion in site redevelopment and spatial planning. It provides a sound basis for sustainable land management.

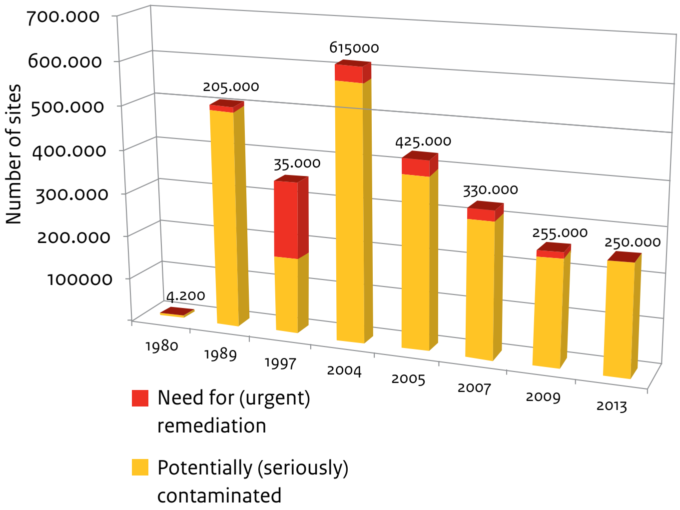
Together with the Soil Quality Decree also the financial means were made available to fulfil its policy goals.

The Soil Quality Regulation, which provides a technical and practical translation of the Soil Quality Decree, contains an entirely new system of regulatory values for soil and dredged sludge, replacing the set of Target and Intervention values published in 2000. This set is now defined from the perspective of soil (re)use. As the Soil Quality Decree does not include legislation with respect to groundwater, it does not change the Target and Intervention values for groundwater set in 2000.
Despite the fact that the Soil Quality Decree does not include Intervention values, these still exist. A partly updated set of Intervention values was published in 2013 as they continue to be the criterion for the remediation of contaminated sites.

Estimated workload

Since 1980, several investigations on the number of contaminated sites were undertaken in the Netherlands, but many uncertainties remained. In 1998, the government decided on a new thorough investigation, based on the evaluation of environmental permits, knowledge of activities that are a threat to soil quality, and aerial photographs. This resulted in a number of 615,000 potentially contaminated sites in 2004, of which a workload of 425,000 potentially seriously contaminated sites remained after first screening. Further local site investigations had to reveal the scale of contamination and the possible need for remediation.
After further evaluation and soil remediation, the workload was adjusted downwards several times. In 2013 the remaining workload of potentially seriously contaminated sites was estimated at 250,000 sites. Approximately 1,600 of these sites need urgent remediation, because of human health risks (9%), risks from transport of contaminants in groundwater (70%), ecological risks (8%) or combinations of those risks (13%).
For the remaining sites of the workload, the soil contamination is expected not to represent actual risks. Therefore, sustainable land management is sufficient and remediation can take place at a convenient moment in time, for example, when building activities or other soil-related activities take place. The number of remediated sites in The Netherlands from 1980 until 2013 is approximately 30,000.

Development of estimated workload



Sketch of the legislative framework

The previous chapter provided an overview of the developments in Dutch soil policy and the legislation that was derived from it. This legislation is not autonomous; it is embedded in more general environmental legislation. There is also legislation for closely related environmental compartments like surface water, groundwater and waste.

The overarching environmental legislation is provided in the Environmental Management Act that first came into effect in 1993. The act sets general regulations for water, air, soil and waste as well as the framework for specific legislation. Within that framework, it allows the definition of environmental quality demands, including the set of regulatory values for soil and dredged sludge as incorporated in the Soil Quality Regulation.

Furthermore, the Environmental Management Act provides the basis to enforce environmental legislation. Provinces, water authorities, municipalities and the national government along with its inspection services fulfil different tasks in enforcing the environmental legislation.

Due to the decentralisation, the municipalities have an important role in enforcing the Soil Quality Decree. The government is empowered to impose a fine or to stop activities when the rules of the Soil Quality Decree are violated.

For a lot of activities in which soil is involved, a permit is necessary. And as the municipality is the competent authority, both for providing these permits as well as for enforcing the law, a conflict of interests might occur, particularly in situations where the municipality itself develops these activities. In order to ensure the autonomy of the legislation enforcer, the Environmental Management Act demands the enforcers to adopt formal organisational autonomy.

Although in the Netherlands a major disposal route for waste is incineration, for part of the waste this is simply impossible. Consequently, partial disposal of the waste in landfills is unavoidable. If the landfill is not equipped with proper soil protection measures, the waste material might get into contact with soil and groundwater. This underlines the need for environmental legislation for waste and landfills. In this legislative field the influence of overarching

European legislation on Dutch legislation, in this case the Environmental Management Act, is clear, and the European Landfill Directive sets the conditions.

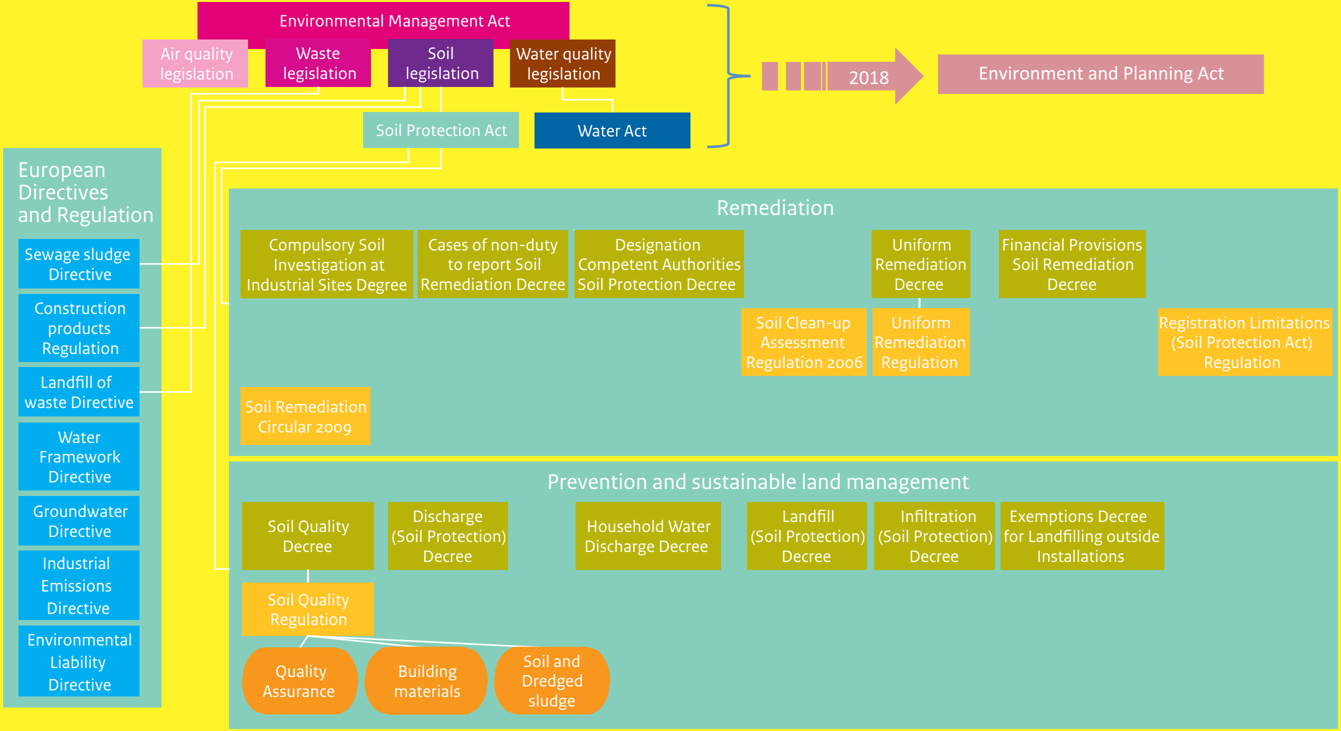
In 2006 the Thematic Strategy for Soil Protection was published by the European Commission, the focus points of which have been taken in consideration when developing the Soil Quality Decree.

Construction products might have adverse effects on soil quality through the emission of hazardous substances, something already formally recognised in Dutch legislation with the publication of the Building Materials Decree in 1999. In the European field this has also been recognised, resulting in the implementation of environmental quality criteria in the Construction Products Directive and later (2013) in the Construction Products Regulation. Again, when incorporating the Building Materials Decree in the Soil Quality Decree, account was taken of these European developments. This is important, since construction products are quite often exported and imported so they should meet the national requirements, irrespective of whether they are produced inside or outside the Netherlands. Having the same requirements throughout Europe, and using the same methods to determine the environmental impact of these products, is vital to Dutch and European industry.

It has already been mentioned that apart from the Soil Quality Decree, there is also a Soil Quality Regulation. In fact, having a regulation in addition to the decree is a general principle in Dutch Environmental legislation. For the whole legislative package, a comparison could be made with a pyramid.

On top there is the Environmental Management Act. A second layer is formed by decrees for different compartments, of which the Soil Quality Decree is one. The third layer contains a regulation for each of these decrees that provides more technical and practical rules with respect to the implementation of that decree. The regulation itself refers to a whole series of protocols, standards as well as certification and accreditation schemes. These documents can be seen as the fourth and last layer of the pyramid. The documents in this last layer are not directly published by the government but are developed and maintained by national institutes like the Netherlands Standardisation Institute (NEN) and the Foundation Infrastructure for Quality Assurance of Soil Management (SIKB). Later in this booklet the role of these bodies will be described in more detail (see the chapter 'Technical guidelines').

When it comes to remediation, the funding of the costs is a key factor. Nowadays, since the remediation of the majority of sites is due to changes in the sites' use, spatial planning has become an important factor.
However, using the possibilities that are offered by the financial provisions in the Soil Remediation Decree, the government also subsidises the soil remediation of specific industries. An important provision therein is an agreement between the government and the umbrella organisation for a specific type of industry with respect to the remediation of contaminated soils.



Overview of current Dutch soil legislation, together with related European Directives

Future developments in soil policy

At the moment the Dutch environmental regulation and legislation is being transformed with the objective to facilitate spatial development by simplifying and combining many existing acts and decrees. As a consequence most of the Environmental Management Act (in total 15 existing laws) will be integrated in the Environment and Planning Act. Expectations are that the Environment and Planning Act will be empowered in 2018.

Currently, the major responsibility for soil is being decentralised. With a covenant (2010-2015) between the state government, provinces, municipalities and water authorities, ambitions were formulated concerning remediation and sustainable use of the subsurface. Arrangements were made to reach these goals together. With the covenant, the major responsibility for soil is decentralised. A succeeding covenant is now being prepared and will be effective in 2016. One of the ambitions of the new covenant is to involve the private sector in the new arrangements.

The transition in soil regulation can be divided in two main streams:

1. **Taking charge of the remediation operation**
   In the first covenant period, many sites are investigated and remediated, including most of the urgent sites. The next step is the management phase, aimed at contaminations that cannot be excavated, and that have a risk to spread.

This phase focuses on innovative management of these sites, e.g. on the application of different in-situ techniques and area based management of contaminated groundwater. The link with spatial development is vital to the future of soil remediation in the Netherlands, as new ways of soil usage will initiate additional funding for remediation activities, especially if these can be combined with another land use, e.g. aquifer thermal energy storage (ATES). Soil remediation unrelated to spatial development is becoming redundant and is replaced by area based sustainable soil management.

2. **Using the possibilities of the subsurface**
   Objective of the amendments is to focus on the sustainable use of the subsurface. This means that the use of the subsurface cannot be seen separated from spatial developments and societal challenges such as climate change, sustainable energy, (ground)water management and economic developments. The covenant addresses different functions of the subsurface. Themes such as sustainable use of resources (eg. strategic groundwater resources) and energy (shale gas, effects of gas winning, soil energy) are topics of interest.

Because not all aspects can be arranged on the local or regional level, strategies are being prepared on the spatial planning of the subsurface. In 2012 this was done for subsurface pipes. In 2013 the national government started, in cooperation with local and regional governments, the preparation of a national strategy for the subsurface 'STRONG'. In STRONG decisions will be made with respect to spatial planning with a national interest. It also should help local or regional governments to make decisions on spatial planning, both in urban and rural areas. The STRONG is planned to be ready in 2015. A strategy for shale gas (also expected 2015) will be an integral part of STRONG.

The envisaged transitions will involve different governmental organisations as well as private parties and research organisations. This collaboration aims to come to agreement on the use of the subsurface, the generation of knowledge and the necessary financial arrangements. Final objective is the implementation of sustainable use and management of the subsurface in daily practice.

Many parties involved

During the process of identifying and remediating a contaminated site, the number of involved parties easily goes up to 16. This underlines the need of good communication. An example:

The owner of the (potentially) polluted site is obviously the first party that is involved. It might be that for a specific type of industry (e.g. drycleaners, fuel-filling stations), an umbrella association is delegated to deal with the specific soil problems of the sector. If so, it will obviously be involved.

A consultant will be contracted to perform an investigation of the site although the actual fieldwork will be delegated to sampling specialists. The resulting samples will then be transported to a specialised environmental laboratory. The results of the lab analyses will go to the consultant who will use it to write a report for the person or organisation that contracted the consultant. If there is serious soil contamination due to the extent and concentrations found, a Main Investigation will be necessary. At this stage at least the competent authority will be informed.

While the same consultancy firm may perform the Main investigation, often another consultancy firm is contracted.

The competent authority must be informed about what was found as well, to take a formal decision with respect to the remediation of the site, if necessary. For the development of a Remediation Plan a consultant will be contracted again, though this is rarely the same consultant as involved in the investigation phase. The Remediation Plan will be announced in a local news paper by the competent authority, in order to inform neighbouring residents.

The competent authority will take a formal decision with respect to how the site will be remediated. Then a contractor (or a combination of contractors) will be involved in the actual remediation. The remediation method applied will determine if groundwater needs to be treated on site and if polluted soil will be excavated. If the latter, the technical and financial feasibility of cleaning that soil will determine whether the soil is cleaned or taken to a landfill. Slightly polluted soils might be reused on

site, or are transported to a soil recycling facility for application elsewhere. Landfilling is only allowed after a check by a government agency.
During the remediation, a consultant will ensure that the environmental goals of the remediation are actually met. Certainly during the remediation phase, neighbouring residents will have to be informed about the remediation and its progress.

In order to define the final situation following remediation, an evaluation report will be produced. The result of the remediation will have to be approved by the competent authority. If any post-remediation care is necessary, this will also require a specific decision by the competent authorities.

In practice, the consultants are in charge of all practical work and consequently they bear a large degree of responsibility. This is recognised in the Soil Quality Decree in which quality assurance is an integral part.

Decisions of the competent authority

The competent authority plays a vital formal role in the appraisal and remediation of contaminated sites. The Soil Protection Act designated the larger Dutch municipalities and the provinces as competent authority. At the various stages of dealing with a contaminated site, a formalised process will lead to a formal decision of the competent authority.

Depending on the complexity of the local situation, two different processes exist.

In a complex situation, both the Main Investigation (see the chapter 'Investigating the soil quality') as well as the development of a Remediation Plan starts with a formal notification to the competent authority. Based on this, the competent authority will provide a draft decision which, for a period of six weeks, will be available for comments by people and/or organisations that have an interest in the specific site. A formal decision will be taken by the competent authority 15 weeks after receipt of the notification. Interested parties can still appeal to the State Council against the formal decision.
After the remediation is finished, the competent authority must receive the evaluation report. For post-remediation care, the same applies to the report on the post-remediation care programme. Based on the report(s), the competent authority will come to a final decision, eight weeks after an evaluation report and six months for a post-remediation care programme. Again, parties with an interest in the specific site can appeal within six weeks. If the appeal is rejected, a final appeal can still be made to the State Council.

The previous procedure takes a considerable amount of time. This is acceptable for complex situations but for less complex situations it could hinder further developments on the site. In fact, the procedure could take more time than the site investigation and remediation itself. For less complex situations, therefore, a national uniform regulation has been provided by the national government whereby the competent authority needs to be notified of the fact that remediation will follow the simplified procedure. A standard form is available for this notification.
The competent authority should decide

within five weeks if the simplified procedure can indeed be followed. There is no possibility to appeal against this decision. If the competent authority does not respond within five weeks, the simplified procedure is implicitly accepted.

After remediation is completed, a standard evaluation form is provided to the competent authority, based on which a formal decision on the acceptance of the remediation result should be made within eight weeks. Parties involved have the right to appeal to the State Council.

The competent authority not only has a role in the remediation part of the Soil Protection Act, it also has a specific role when it comes to prevention of soil pollution.
Environmental permits demand protective measures whenever activities might pose a threat to the soil quality. Obviously this relates to the European IPPC directive (integrated pollution prevention and control).

‘Although the polluter pays principle is still valid, for practical and juridical reasons this principle can’t always be followed, while stimulation of the remediation process also triggers continued governmental funding.’

Liability: who pays the bill?

As mentioned before, the 'polluter pays principle' has already been embedded in Dutch soil legislation since 1987 when liability became the key term in recovering the cost of soil remediation. Despite that, the need persists for soil remediation funding from the national government.

According to jurisprudence, it is generally assumed that before 1975 people or companies could not have been aware of the fact that activities might contaminate the soil. Consequently, all remediation costs for a contamination caused before that date are, in principle, covered by the national government. This does however not completely exclude contributions from companies in respect of contamination caused prior to 1975. If the polluter had already been aware of the severe danger of contaminating substances, and putting these substances directly or indirectly into the soil could already have been seen as a culpable act, the 'polluter pays principle' is still valid.

Generally speaking, prior to 1975, an expert working with chemicals could not have been aware of the adverse effects these chemicals could have on the soil quality. There were just too few scientific publications about soil contamination.
Since 1975, these publications started to emerge more frequently, so an expert should have taken note and measures to protect the soil. If not, a company employing such experts is regarded as liable for the soil pollution it caused.

The availability of expert information, however, still does not imply the availability of common knowledge about soil contamination. This changed with the publication of the Soil Protection Act in 1987. The presents of legislation implied that, at least in legal terms, everybody in the Netherlands should be aware of the need to protect the soil against contamination.

During the 'grey' area between 1975 and 1987, it is accepted that non-experts were still unaware of existing soil contamination. For property and premises, for example, achieved between 1975 and 1987 where the buyer was unaware of (the risk of) soil contamination, the government may still fund the remediation.

In order to stimulate the remediation of industrial sites and to achieve that all sites with serious risks are controlled prior to 2030, there are four different financial regulations under the Financial Provisions Soil Remediation Decree. Apart from stimulating the actual remediation, these also aim to prevent bankruptcy of otherwise financially sound companies due to the costs of soil remediation. The governmental financial support under these regulations can go up to 70% of the remediation costs.

What is the cost for soil remediation in the Netherlands? In recent years, the national government has spent around 150 million euros a year on soil remediation. In addition, the annual market turnover in recent years is the same as government spending, which means total annual expenditure of around 300 million euros!

Apart from soil remediation costs, there are also costs involved in the sustainable land management for clean or slightly polluted soils and sediments.

Costs related to the actual use or reuse of soil material will be covered by the party responsible for its use or reuse: the costs of the soil itself, the machinery necessary to relocate the soil material and costs related to sampling and analysis of the soil. In addition to that there are costs related to the development and use of Soil Quality Maps (see the chapter 'Knowing the soil quality').

These costs are partly covered by both municipalities and by spatial redevelopment initiatives. These costs are therefore an integral part of other processes and less well known. Nevertheless, the expenditure is probably comparable to that of soil remediation.

Soil functions and ambitions

The Soil Quality Decree generically defines what the Dutch want to achieve with respect to their soils as well as provides opportunities for local authorities to deviate from these general principles. The local authority is encouraged to formulate its own soil quality aims in a Soil Ambition that may relate to all the soil the competent authority is responsible for, or may be limited to a local spatial development. The Soil Ambition directly relates to the current and/or future function of the soil: the land use. The competent authority - the municipality, the province or the water authority - is responsible for the formal acceptance of the Soil Ambition. However, while a property developer may also take the initiative to define a local Soil Ambition for the area he is planning to (re)develop, the competent authority still has to formally accept it.

The Soil Ambition is formulated in a local Soil Management policy document which concretises the local Soil Ambition.

Apart from the 'chemical' quality, the soil is also defined in terms of its physical property and ecological properties, the geological, archaeological and culturally historic value, the soil threats (e.g. erosion, depletion, salinisation) and the use of the soil for other purposes (e.g. mining, production of drinking water, storage capacity). It is up to the competent authority to define the terms of local relevance, all of which must be taken into account when developing a local Soil Ambition. This should be done in close cooperation with responsible parties like another unit within the community's civil service, or the water authority, for example.

The current soil quality can be maintained or enhanced. Taking the option of maintaining the soil quality, local deterioration is allowed, something that might prove necessary in order to obtain sufficient flexibility in the local soil management. Otherwise the soil quality could be an obstacle for further spatial development. In fact, when defining the Soil Ambition, the competent authorities should consider future spatial developments. This makes the relationship between the soil function and the soil quality tangible - it uses the opportunities the soil presents.
When a municipality decides to implement

a Soil Ambition for all the soil within the municipal borders, it is advised to co-develop this Soil Ambition with the neighbouring municipalities, the province and the water authority. This collaborative procedure will result in more options to reuse soil and sediment simply because it allows the soil to also be reused in one of the neighbouring municipalities.

The current or future soil function (e.g. agriculture, residence, industry) determines what kind of soil quality is necessary. In its turn, the prevailing soil quality will determine which functions are possible. If the combination of soil function and soil quality does not fit, measures have to be taken. In short: the soil should be fit for its use.

It has be come possible to define the Soil Ambition due to the acquisition of a substantial amount of soil quality data over the years. The Dutch now know their local soil quality.

Knowing the soil quality

The whole concept of sustainable land management for clean and slightly polluted soils is based on an extensive knowledge about the soil quality. Dutch soil has already been investigated for three decades, not only at contaminated sites but also at uncontaminated sites. Theoretically, this implies that there is a huge amount of soil data available. In practice, however, this is misleading since older data tend not to be digitally available and soil data are considered to be valid for a period of only five years. Nevertheless, most of the soil data that are valid are indeed digitally available.

As already mentioned, all potential contaminated sites were identified in 2005. This resulted in a nationwide map that is publicly accessible through internet. It allows anyone, both the lay and professional public, to focus on a specific site in the Netherlands and obtain its contamination status. One can simply find out whether a site is suspected of soil contamination, is under investigation or has been remediated. The nationwide map does not provide actual soil quality data. For this information, one has to contact the municipal authorities. Obviously, as this map focuses exclusively on (potentially) contaminated sites, it does not provide soil quality information on the major part of the Netherlands.

More detailed information on the soil quality is contained in the Soil Quality Maps primarily produced and maintained by the municipal authorities. These Soil Quality Maps are an essential part of the local soil management aim that is part of the local Soil Ambition (see the chapter 'Soil functions and ambitions'). These Soil Quality Maps are based on the available soil data and may pertain to the whole, or part, of the municipal area. For example, agricultural land may be excluded if insufficient soil quality data are available.

The Soil Quality Maps provide generalised soil quality information for specified zones within municipal borders. These zones tend to be distinguished by the municipality's development history. Even in the absence of soil quality data, a distinction in soil quality may be expected between an area developed between 1900 and 1940 and an area developed, for instance, only in 1990.

The generalised soil quality is based on data available within each zone, excluding polluted sites within these zones.

The main role of these Soil Quality Maps is to enable the reuse of soil without the need for analysis. As such, it significantly reduces the costs associated with soil reuse and gains time as there is no need to wait for the results of analyses. The local Soil Ambition will determine the zones from which soil could be exported to other zones, and which zones can import soil. The generalised soil quality of the zone is the determining factor here. If the Soil Ambition is predominantly defined from an environmental protection perspective, the result will limit the possibilities to exchange soil between zones. This will mean that more soil investigations will be necessary than for a Soil Ambition that tries to maximise the spatial developments. So, even with a rather strict environmental protection objective, the Soil Ambition does not rule out all the soil transport between zones. It just implies that soil lots require testing (far) more often prior to reuse in order to determine whether the quality of a specific soil lot allows it to be reused at the designated location.

A national guideline is available for the development of Soil Quality Maps.

Soil quality information can also be obtained through national and provincial inventories. This information concerns the acquisition of data on a nationwide or province-wide scale for the purpose of knowing the general soil quality in the Netherlands and the changes therein over time.

Finally, information on the Dutch soil quality has been obtained from a nationwide investigation of the background concentrations. This particular study is of importance as it provides the basis for the background values that are now part of the set of legislative soil quality standards (see the chapter 'The Dutch soil quality standards'). The 100 locations throughout the Netherlands for this nationwide study were selected on the basis of information on current land use and using a statistical sampling design. Composite samples were taken at these locations to represent the soil quality of the top soil (0 - 10 cm) and on an undisturbed depth (50 - 100 cm). All composite samples were analysed for all 252 substances for which Dutch legislation provides soil quality standards (see the chapter 'The Dutch soil quality standards'). The analysis of such a large amount of substances in 200 soil samples had never been performed before in the Netherlands. For the first time, nationwide conclusions could be drawn with respect to the background concentrations.

Detailed soil quality information is obviously not available for all 252 substances. The Soil Quality Maps, in principle, only cover the substances for which the Background value is frequently exceeded. The definition of this 'standard set' of substances is based on combining:

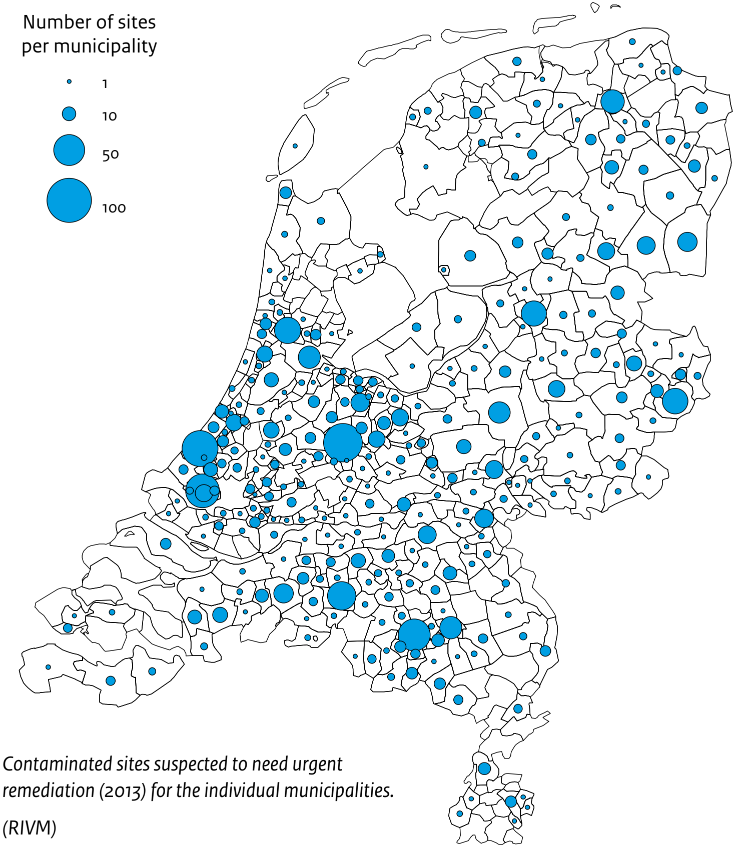
- The Background values derived from the distribution of background concentrations.
- An extensive database of soil quality measurements for non-suspect soils as performed by the environmental laboratories.
- The policy decision that no more than 5% of the routine measurements of non-suspect soils might exceed the Background values.

If there is a larger than 5% chance that a routine measurement of a non-suspect soil exceeds a Background value, routine testing of that substance is necessary.

Accordingly, the 'standard set' of substances comprises barium, cadmium, cobalt, copper, mercury, lead, molybdenum, nickel, zinc, sum-PCBs, sum-PAHs and mineral oil. In addition to these substances, the percentage clay and organic matter also needs to be determined in each sample.

Contaminated sites that need urgent remediation, 2013

Total number of sites: 1643



Contaminated sites suspected to need urgent remediation (2013) for the individual municipalities.

(RIVM)

Water and sediments

Like the close relation between soil and groundwater in the Netherlands, groundwater is an integral part of the Dutch regulations for soil.

The chemical equilibrium between soil and water implies that the quality of the soil determines the quality of the groundwater and, when present, the surface water. Specifically for the western part of the Netherlands, there is a close relationship between the groundwater and soil. Often the saturated zone is (far) less than a metre away from the soil surface, implying that where the soil is contaminated, the groundwater will also be contaminated.

Groundwater in the Netherlands is the main supply of drinking water, together with water from the rivers. Surface water is also directly used for crop irrigation and drinking water for cattle, and serves an important ecological and recreational role. To some extent the contamination of groundwater and surface water poses a bigger threat to human health than soil contamination. The risk of direct contact with contaminants, either through skin contact or ingestion, is much greater for water than for soil. Although the concentrations in water are far less than in soil, this highlights the importance of protecting the groundwater and surface water quality.

Soil quality is often defined in terms of the concentrations of chemical substances like heavy metals, mineral oil and PAHs. And depending on the solubility, these substances also govern the groundwater and surface water quality. In addition to these substances, nutrients are of specific relevance to groundwater and surface water quality.

For example in the southern part of the Netherlands, intensive cattle breeding on sandy soils has resulted in extensive nitrification of the groundwater. An overload of nutrients in the surface water causes eutrophication. Algae can make the surface water less attractive for recreational purposes, and some algae even pose a direct risk to human health. Consequently, measures have been taken to diminish the release of nutrients into groundwater and surface water.

Being a delta area, sediments are deposited in the Netherlands. In order to allow a sufficient water flow, these sediments need to be dredged on a regular basis. Substances dissolved in the surface water will often end up in the sediments. Where surface water serves to drain the surrounding land, seepage of groundwater will also influence the sediment quality, which often falls short of the desired level.

However, as long as the quality of the sediments are comparable to the quality of the soil on the adjacent land, the dredged sediments can be distributed there. This is important as the sediment then contributes to elevating the land that would otherwise sink slowly below the water level of the polder. Would it not be possible to use the sediments on the adjacent land, the water level of the polder would need to be adjusted downwards. In peat areas, the soils would then continue to settle, resulting again in the need for further adjustment of the water level. Ultimately, that would cause severe problems with the infrastructure and buildings in the polder.

Technical guidelines

In the past, prior to the Soil Quality Decree, the aims for the soil were pretty much defined by the national government. Since the early 1980s, the predominantly pioneering nature of soil remediation business has changed into a professional sector. With the development of the Soil Quality Decree this professionalism has been acknowledged. The main responsibility for maintaining soil quality shifted from national government to the municipal authorities. At the same time, the development and maintenance of technical guidelines are now primarily a responsibility of the organisations that actually use these technical guidelines. As such, the role of the consultants who operate in this field has become more dominant.

Consultants help the communities to develop their Soil Ambition (see the chapter 'Soil functions and ambitions') and take care of the development and maintenance of the standards and protocols necessary to perform the work. In developing these documents, the consultants generically define the quality that should be realised. At the same time, their day-to-day performance has to comply with the quality demands of these documents.

Obviously, the technical definition of the aspired quality is not the task of a single consultant. Here the modus operandi of the Netherlands Standardisation Institute (NEN) steps in. This implies that the development of standards, protocols and guidelines is a process that involves 'all parties concerned': the legislator, the regulator, provinces, water authorities, municipalities, industry, consultancy firms, environmental laboratories and others.

A large set of standards, protocols and guidelines is available for defining the technical quality of the work. Almost all the steps of the process are formalised by these documents, for which there are three main categories:

1. guidelines published by or on behalf of the national government;
2. standards published by the Netherlands Standardisation Institute (NEN);
3. certification and accreditation schemes published by the Foundation Infrastructure for Quality Assurance of Soil Management (SIKB).

Apart from national developments, the Netherlands Standardisation Institute also operates specifically at an international level, partly within the European Committee for Standardisation (CEN) and partly within the International Organisation for Standardisation (ISO). On both levels a Technical Committee deals with the development of standards for soil characterisation. Both committees, CEN/TC 345 and ISO/TC 190, are chaired by the Netherlands.

ISO/TC 190 has published some 160 standards, covering terminology, codification, sampling, chemical, biological and physical methods as well as soil and site assessment. These standards are available for worldwide use through the national standards institutes.

Risk assessment

Human exposure modelling is the basis of human health risk assessment in many countries. Two human exposure models have been developed in the Netherlands. The CSOIL model determines exposure to contaminated terrestrial soils, while the SEDISOIL model determines exposure to contaminated sediments. These models recognise three elements:

- contaminant distribution over the soil or sediment phases;
- contaminant transfer from (the different phases of) the soil and sediment into so-called contact media;
- direct and indirect exposure to humans.

A human exposure calculation combined with toxicological reference values results in the risk characterisation, that is, the risk appraisal of the contaminated site. It is important to define the timeframe for which the risk assessment is applicable, since factors that influence human health risks will change over time. Moreover, calculated exposure and critical exposure (toxicological reference value) should be consistent with regard to the duration and toxicologically relevant exposure period in the lifetime of the exposed population. Equations for all relevant exposure pathways have been included in the CSOIL exposure model. The main exposure pathways are:

- exposure through soil ingestion after hand - mouth contact (mainly relevant for immobile contaminants);
- exposure through crop consumption (mainly relevant for mobile contaminants);
- exposure through inhalation of indoor air (mainly relevant for volatile contaminants).

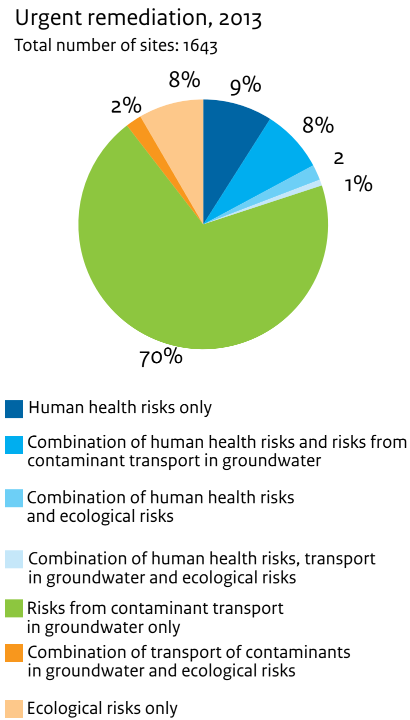
Additionally, exposure through the inhalation of soil particles, dermal uptake via soil material, groundwater consumption and inhalation of air during showering may in specific situations contribute to the exposure of particular contaminants.

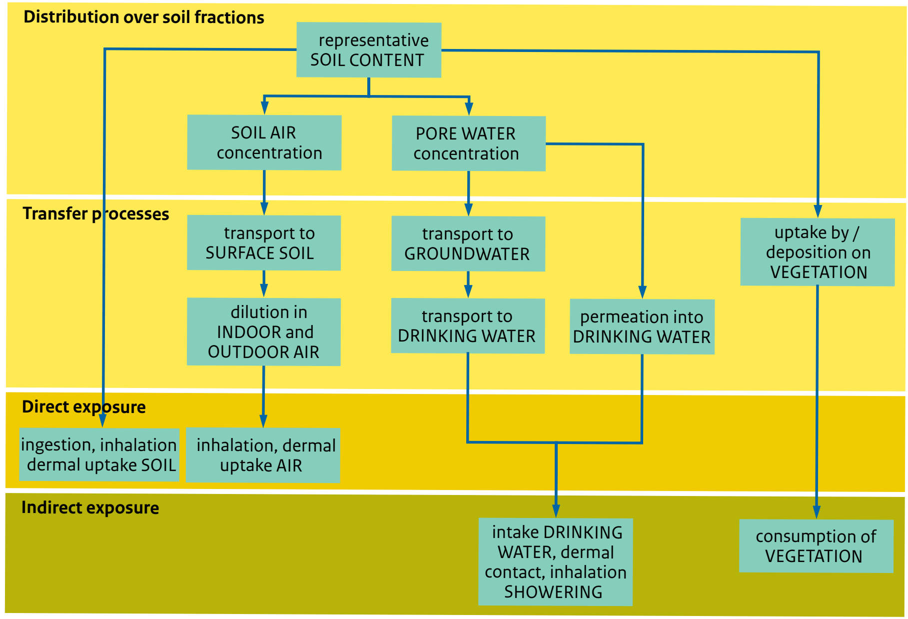
Exposure through soil ingestion is calculated according to soil ingestion intake rates for children and adults. For site-specific applications, the actual bioavailab-ility in the human body is determined in the Netherlands using the in-vitro IVD model or the Unified Barge Model. Plant-soil concentration relationships are used for assessing exposure through crop consumption. For site-specific applications a four-tiered approach is used, including calculations of the accumulation of contaminants in vegetables and a measurement protocol. The VOLASOIL model has been developed to assess the risk through vapour intrusion in case of soil or groundwater contamination with volatile contaminants. This model enables the site-specific indoor air concentration to be indicatively assessed as a function of type and positioning of the contaminants, building and soil characteristics, and groundwater depth.

The SEDISOIL exposure model includes the relevant exposure pathways for sediments such as exposure through fish consumption, dermal uptake when swimming and the ingestion of water and particulate matter during swimming.

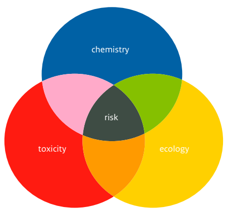
By law, the web-based Sanscrit decision support system is used in the Netherlands to decide on the urgency of remediation. The Risk Toolbox (RTB) is available to develop sustainable soil quality objectives in case of slightly contaminated soil. Both instruments support site-specific risk-based decisions and risk-based land management. Decisions are based on actual risks to human health, the soil ecosystem and food safety as well as risks arising from contaminant transport. For each of the protection targets a tiered approach is followed. In each progressive tier the assessment becomes less conservative, is based on more site-specific information and, hence, is more complex, time-consuming and often more expensive. When unacceptable risks in a specific tier cannot be excluded, an assessment in the following tier has to be performed. The underlying principle is: simple when possible and complex when necessary.

The human health risk assessment module in both decision support systems is based on the CSOIL exposure model. It is generally recognised that site-specific risk assessment requires an intelligent combination between exposure calculations and measurements in contact media. Therefore, this module offers the possibility for measurements in contact media like indoor air, vegetables and indoor dust. In specific cases, the possibility of biomonitoring exists, e.g. measuring lead in blood or arsenic in toe nails.
Soil ecosystem risks are derived using the tiered TRIAD approach that enables the site-specific assessment of ecological risks on the basis of three lines of evidence: soil chemistry, toxicity and ecology. The four-tier approach to assess the risks due to contaminant transport in groundwater is as follows: Tier 0 is a qualitative analyses of possible risk due to groundwater transport. Tier 1 involves a simple generic contaminant transport calculation based on a conservative scenario. In Tier 2, a more complex site-specific calculation is performed. Finally, in Tier 3, monitoring activities can be performed and complex numerical models can be used. Furthermore, leaching is taken into account in this tier, and special attention is given to Total Petroleum Hydrocarbons (TPH), a frequently occurring contaminant in groundwater.





CSOIL model to quantify exposure to contaminated terrestrial soils



The TRIAD approach for scientifically based and efficient site-specific ecological risk assessment

The Dutch soil quality standards

Reference has been made earlier in this booklet to the fact that Dutch soil quality standards have been developed over the years in a number of stages (see the chapter 'Developing a soil policy').
The first set of soil quality standards for soil and groundwater, published in 1983 as part of the Interim Soil Remediation Act, were the A, B and C values for soil and groundwater. Concentrations below the A value implied that there was no soil contamination. Exceeding the C value ('serious soil contamination') implied that remediation was necessary. The B value was the trigger for a Main Investigation: it suggested that if concentrations above the B value were found, serious soil contamination might be present. The A, B and C values were defined for a list of substances that were thought to be of relevance with respect to the occurrence of soil contamination and, to some extent, this mirrors the contaminated sites encountered at that time in the Netherlands. The A values related to the background concentration, while the C values were primarily derived based on 'expert judgment'.

In 1994, these three values were replaced by a set of two values, the Target value and Intervention value for soil and groundwater. The Target value had a similar function as the A value. The role of the Intervention value was comparable to the C value: exceeding means a 'serious soil contamination', for which remediation is necessary. However, exceeding the Intervention value does not imply an immediate remediation. It meant that the urgency of remediation has to be determined. In practice, remediation takes place for urgent cases of soil remediation, in particular cases that are urgent on the basis of human health risks. Other sites with serious soil contamination generally can be remediated at a convenient moment in time, for example, when building activities or other soil-related activities take place at the site.
A major difference was the scientific basis of the Target and Intervention values; they were derived applying risk assessment. The Target values are based on ecological risks and background concentrations and the Intervention values are based on human health and ecological risks. Although there was no longer a formal intermediate (B) value, in practice such an intermediate value

was still used to determine the need for a Main Investigation. For this, the average of Target and Intervention value was used.

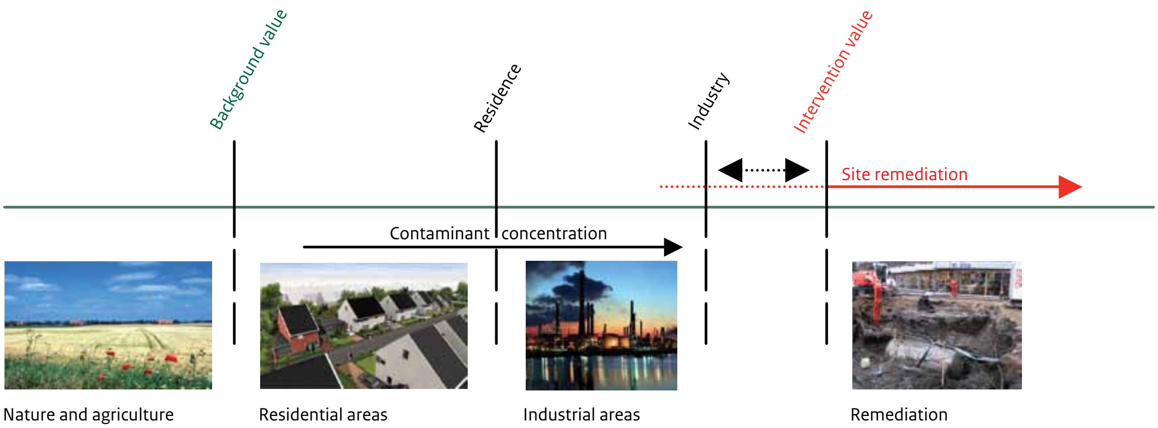
Moreover, a volume criterion was introduced in 1994. It implied that a single excess of the Intervention value in one soil sample is not sufficient to declare contamination to be serious. This requires a volume of at least 25 m^3 for soil or 100 m^3 for water-saturated soil volume for groundwater exceeding the Intervention value.

As mentioned earlier, by now the Target values have been replaced by the Background values derived from the nation wide study of the background concentrations for 252 substances. The number is the result of the sum of all individually listed substances and the substances that are part of a listed sum parameter. An example is the listed sum-PAHs (Polycyclic Aromatic Hydrocarbons), for which 10 specific PAHs compounds need to be analysed.
The list includes so-called 'indicative levels of serious risk' for 32 substances, as alternative for an Intervention value, for which a standardised measurement or analysis protocol is lacking or the ecotoxicological component of the Intervention value is missing.

The risk-based Intervention values were revised at several stages; the latest revision is from 2013. In 2008, an Intervention value for asbestos has been included in the list, solely based on human health risks. It is obvious that the exposure to asbestos in soil is quite different compared to other substances since the inhalation of asbestos fibres is the only relevant exposure pathway. Therefore, an alternative procedure was followed, using measured concentrations in soil and air at different activities and soil and weather conditions. Moreover, differences in carcinogenic potential between different types of asbestos were taken into account.

The publication of the Soil Quality Decree in 2008 resulted in a drastic change in soil quality assessment. The perspective of the new decree is different from the past as (re)use of slightly contaminated soil became an important objective. Intervention values are still used to define whether remediation is necessary. But through the Soil Quality Decree two additional soil quality standards were introduced that define whether slightly contaminated soil is fit for a specific land use. These soil quality standards, called Maximal values for residential land use and Maximal values for industrial land use, relate the acceptable quality of the soil to its function. The Maximal values, which are available for soil only (not for groundwater), have been derived based on human health risks, ecological risks and risks for agricultural production.
Maximal values have been published for 101 substances in the Dutch soil quality regulation (latest version 2012).

The Background values now in place were derived from the study of national background concentrations in the Netherlands (see the chapter 'Knowing the soil quality').
In principle, the Background values were set at the 95 percentile of the distribution of background concentrations in the top soil in 'relatively undisturbed areas'. For substances for which the Background concentrations were lower than the analytical detection limit, the Background values were set equal to the detection limit. This is applicable for a large group of organic substances.



Illustrative overview of the Dutch Soil Quality Standards

1. In addition to the concentration of these substances, the percentage of clay and organic matter should be determined.
2. Intervention values as included in the Dutch Soil Protection Act.
3. The values for barium have been withdrawn as the intervention value is lower than the natural occurring concentrations. When there is a higher value than the background value, caused by an antropogenic source, then the competent authority can assess this value using the former intervention value of 625 mg/kg d.m.
4. For inorganic and organic mercury respectively.

Substance [1)]	Background value	Maximum value for residential land use	Maximum value function class 'Industry'	Intervention value [2)]
barium[3]	-	-	-	- [3)]
cadmium	0.6	1.2	4.3	13
cobalt	15	35	190	190
copper	40	54	190	190
mercury	0.15	0.83	4.8	36 / 4 [4)]
lead	50	210	530	530
molybdenum	1.5	88	190	190
nickel	35	39	100	100
zinc	140	200	720	720
sum-PCBs	0.02	0.04	0.5	1
sum-PAHs	1.5	6.8	40	40
mineral oil	190	190	500	5000

Soil quality standards expressed for the 'standard soil' in mg/kg dry matter for the 'standard set' of substances.

As mentioned earlier, some major differences are found among the soil properties of the top soil in the Netherlands. There are large differences in the fraction of clay between sand and clay soils as well as in the organic matter content of, for example, peat and sand. Both the fine fraction and the organic matter strongly influence the availability of substances in soil. To account for these differences, the soil quality standards are normalized according to what is called the 'standard soil' with an organic matter content of 10% and 25% clay, using practical soil properties conversion equations.

Investigating the soil quality

Prior to investigating the soil quality of a site, it is important to identify the motive for the investigation. Different motives are possible and might trigger an investigation. Obvious motives for an investigation are present or past activities on the site that have a strong likelihood of causing soil contamination. (Re)development for residential purposes also triggers an investigation in the Netherlands to prevent building on a seriously contaminated site. Yet another reason could be a property transaction between two (private) parties, whereby the potential new owner wants to exclude the risk of acquiring a contaminated site. A logical decision since Dutch law prescribes that the new owner will be liable for the remediation costs in the event of contamination.

Knowing why the site requires investigation already provides important clues to the kind of soil investigation that is necessary.

Soil investigation always starts with a Preliminary Investigation. It consists of a desk study and a site inspection. The purpose of the Preliminary Investigation is to establish whether the site might be contaminated on the basis of historical information: past and present activities on the site as well as the site's geological and hydrological situation. Obviously, if the site has a long history, it might prove very hard or even impossible to obtain all the relevant information, a fact that should be taken into consideration when defining the investigation strategy.

Based on the obtained information a 'conceptual model' of the sites contamination situation is defined. For this a limited number of basic assumptions with respect to the potential contamination is used. If contamination is expected, the spatial distribution over the site is either homogeneous or heterogeneous.
If a homogeneous distribution is expected, the suspected depth will be identified. For simple situations, the contamination level will be more or less stable over the contaminated surface. However, even significant variation in contamination levels can occur. The homogeneous character in such a situation is the expected constant level of variability. For example, at sites where the soil plain has been elevated in the past using old harbour sludge, the concen-

trations can vary significantly from point to point yet the contamination level of the whole layer still appears to be predictable. A heterogeneous distribution can be expected as a result of some kind of spillage in the past. Depending on how long the site has been in use, and how many different activities have been performed, the position of the resulting 'hot spots' may be known or not.

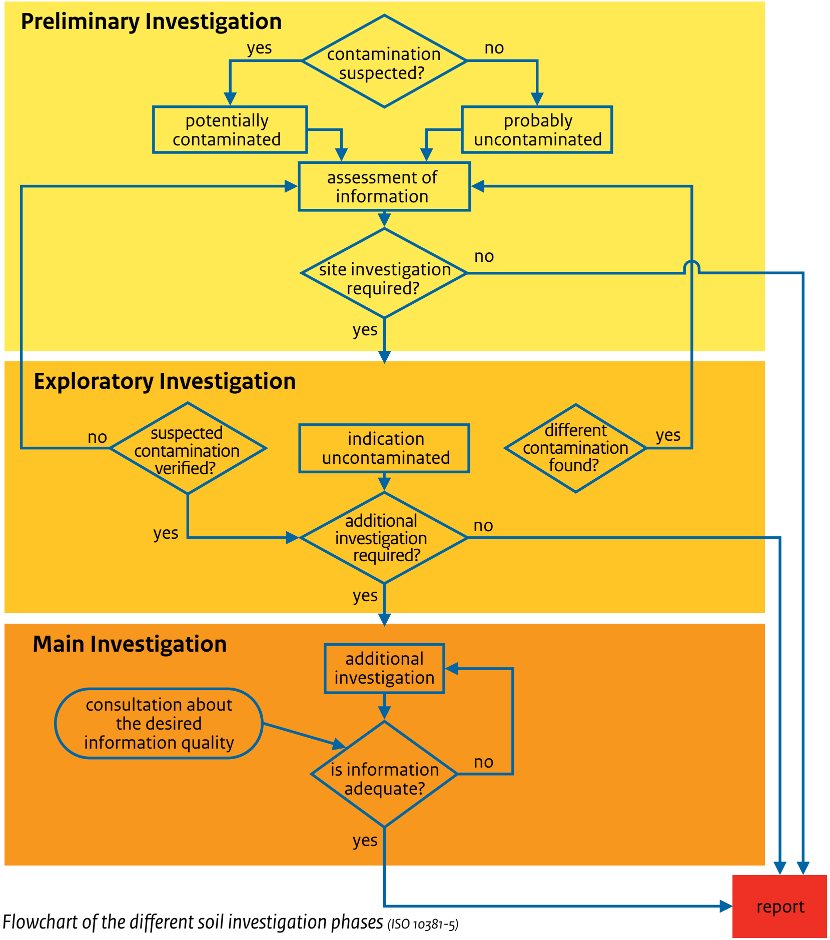
All these assumptions together result in a first version of the 'conceptual site model'. The importance of this investigation phase is widely accepted, as all subsequent investigations will, in principle, be based on these results. Consequently, a sufficient amount of effort (and thus money) should be spent on the Preliminary Investigation. The 'conceptual site model' obtained provides the input for what needs to be done in terms of site investigation in the next phase, the Exploratory Investigation. During the Exploratory Investigation the first actual sampling occurs, its main purpose being to check whether the assumptions of the conceptual site model are correct. It is a limited, cost-effective sampling exercise wherein the sampling strategy is linked to assumptions of the conceptual site model. This underlines the importance of the assumptions that are the basis for the conceptual site model. During the Exploratory Investigation of a heterogeneous contamination at a known position, the sampling will focus on that position only. If the information on the position is incorrect, the contamination may be missed.

Once the samples have been taken and the analytical results are available, it is up to the consultant to redefine the conceptual site model. Information from the Exploratory Investigation is added to that of the Preliminary Investigation to generate a somewhat more detailed conceptual site model.
The result of the Exploratory Investigation will determine if additional sampling is necessary. Where no contamination had been expected, and if, indeed, no contamination has been found, there will be no reason for further investigations. Again, this stresses the importance of well-founded assumptions obtained from a thorough Preliminary Investigation. If, despite the assumptions, contamination is found, further investigation of the site will be required. Where contamination had been expected and actually found, there will be a need for further delineation of that contamination in the Main Investigation.

To assess the risks of the contamination, apart from knowledge of the contamination itself, information must also be gathered about the geological and hydrological situation. This knowledge will also prove essential when remediation will be necessary.

In the Main Investigation the conceptual site model needs to be redefined until sufficient knowledge of the contamination situation is obtained. Sufficient knowledge will depend, amongst others, on the spatial distribution of the contaminants, the (geo) hydrology, the remediation method applied as well as the future use of the site. Given these variable boundary conditions, it is less simple to provide tangible instructions for the Main Investigation. It also implies that the Main Investigation, certainly in more complex situations, cannot be performed in a single phase. After each phase it must be judged if the conceptual site model is sufficiently defined in light of the contamination, the associated risks and its potential future remediation.

If more than 25 m³ soil or 100 m³ groundwater appears to be polluted above the Intervention value, it is referred to as serious soil pollution. This means that the functional properties of the soil for humans, plants or animals might be seriously impaired. Therefore, it must be investigated whether the risks to humans and/or the environment are acceptable or not. The site-specific risks will determine the urgency of a remediation (see the chapter 'Risk assessment').
A series of standards and protocols is available for the investigation of the soil. Apart from national standards and protocols, ISO/TC 190 has also provided a guideline for the investigation of potentially contaminated sites (ISO 10831-5). In 2015 or 2016 this standard will be replaced by new ISO-standards; ISO 18400-202 and 18400-203. Specifically for the Exploratory Investigation, detailed instructions on the sampling strategy have been defined in the Netherlands as NEN 5740 (2009).



Flowchart of the different soil investigation phases (ISO 10381-5)


MAKING YOUR LOGISTICS WORK

Solutions

Nowadays a wide variety of remediation methods is available and applied. The common characteristic of these methods is that they aim to limit human and ecosystem exposure risks as well as prohibit (further) migration of the contaminants. This implies that the local situation, the future use of the site and the contamination itself, together will determine what kind of remediation is possible.

Remediation is a broadly defined term in the Netherlands. It does not imply per se the removal of the contamination. An accepted remediation method, for example, is the geohydrological isolation of the source of the contamination. Another example of remediation where the contamination is not removed is to isolate the contaminated soil layer, for example, in combination with a new top layer of clean soil to allow future use of the site. In general terms: sustainable land management is also considered as a remediation method as it provides a solution to an existing soil contamination.
Remedial method selection should be done after the Main Investigation is finished and a Remediation Plan is developed. As already mentioned, it might be that additional site information has to be gathered in order to determine the most appropriate remediation method.

Apart from the technical definition of potential remediation methods, the costs are obviously also an important factor of the remediation phase but also, depending of the method chosen, of the post-remediation care. The remediation itself might also have direct adverse effects on the environment. If heavy machinery is needed to excavate a contaminated site, there comes a point when one might consider whether it is still worthwhile removing the contaminants from the soil. Perhaps the environmental impact is less when (part of) the soil contamination remains. So, when deciding on the remediation method, the environmental impact also has to be considered. Obviously, the decision to leave part of the contamination behind must be based on the risks associated with that residual pollution.

Removing the contamination from soil or groundwater implies that targets have to be set. When the contamination is excavated, a limit must be defined for the soil concentration that actually needs to be removed. To put it simply: how clean does it need to be? The soil quality standards can be used to determine this. Obviously, where the Intervention value indicates severe deterioration of the soil quality, concentrations above this value must be removed. Additionally, there often will be no need to remove all contaminants down to the level of the Background value. The applied value will depend on the future use of the site.

If not all contamination is removed, post-remediation care is essential. The measures taken with respect to this will depend on the position of the contamination (depth, in the soil or in the groundwater) and what kind of contaminating substances are present (mobile, immobile). In any case, where soil contamination remains, this will be formally registered in the land register together with the owner of the site and the site boundaries.

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Dutch soil on the internet

Government
www.government.nl/ministries/ienm
rwsenvironment.eu/subjects/soil/

Knowledge institutes
www.deltares.nl/en
www.rivm.nl/en/
www.alterra.wur.nl/uk

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