INTERNATIONAL STANDARD

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Soil quality — Characterization of excavated soil and other soil materials intended for re-use

Qualité du sol — Caractérisation de la terre excavée et d'autres matériaux du sol destinés à la réutilisation

Reference number
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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 15176 was prepared by Technical Committee ISO/TC 190, *Soil quality*, Subcommittee SC 7, *Soil and site assessment*.

Annexes A, B, C, D and E of this International Standard are for information only.

Introduction

This International Standard is one of a series providing guidance on the assessment of soils and soil materials in relation to certain functions and uses. It should be read in conjunction with these other International Standards, some of which give more specific guidance in relation to some of the uses listed in the Scope or particular aspects of assessments. For example, ISO 15800 gives guidance on assessments relating to human exposure to potentially harmful substances and ISO 15175 gives guidance on characterization of soil related to groundwater.

Soils are the dynamic product of chemical, physical and biological processes. They are the result of interactions between the inherent nature of the parent material, the prevailing environmental conditions and human activities. They are a valuable natural resource which should be conserved wherever possible. When construction, mining or other activities require soils to be excavated and moved from their natural situation, they should as far as possible be reused in a manner consistent with their natural properties and the intended use of the receiving location. Soils intended for re-use are usually required to have certain chemical, leaching, geotechnical, physical, biological and radiochemical attributes consistent with this future use. Particular attention must be paid in situations where there is reason to believe that the surplus soil may be contaminated.

Soils that are to be excavated should be investigated to determine how they may be re-used so as to minimize the quantities to be disposed of as waste and to determine environmental impacts that might arise during re-use. Treatment of soils and soil materials to remove or destroy contaminants or to reduce their availability to the environment may alter soil properties. These properties should therefore be determined before re-use. For manufactured soils, the characteristics of both the components and of the manufactured product may need to be determined.

The purpose of characterizing soil (or other media) as suggested in this International Standard is usually to enable judgements to be made about its suitability for a defined use (e.g. arable farming, domestic gardens). These judgements may be made by reference to published international or national guidance that sets out physical, chemical or other generic criteria that must be met, or against criteria set on a site-specific basis. When substances are present that might be harmful to human health or the environment, the judgement may also be made on the basis of a site-specific qualitative, semi-quantitative or fully quantitative risk assessment. In many jurisdictions, formal guidance on such assessments has been published. In some cases this guidance fits within a legislative framework. Guidance has also been provided by professional organizations and some standardization bodies.

When deciding whether to re-use soil material, other possibly competing or overriding objectives such as protection of soil, nature, water and air; physical planning requirements and national legislative requirements may have to be met.

Assessment of soil material for re-use may require the measurement of the chemical, physical, biological, geotechnical and radiochemical characteristics of soil material and of the source and target sites. The assessor should identify those parameters that are appropriate to the task in hand.

This International Standard identifies the functions and properties of soil materials at the source (point of origin) and also the properties of the target (receiving) site which may be relevant to the potential uses listed in the Scope, and indicates for which parameters or procedures there are International Standards available. Radiochemical and geotechnical aspects are not covered. For guidance on the geotechnical aspects of the use of soil materials as construction material, reference should be made to other relevant International Standards (e.g. those produced by ISO/TC 182, *Geotechnics in the field of civil engineering*) or national standards.

The way the soil is handled after excavation may affect soil properties. Some suggestions regarding good practice in soil handling and related practice and monitoring after placement are provided in annex B.

Soil quality — Characterization of excavated soil and other soil materials intended for re-use

1 Scope

This International Standard provides guidance on the range of tests that may be necessary to characterize soil materials intended to be excavated and re-used, with or without preliminary treatment. Soil materials include excavated soil, dredged materials, fill materials, manufactured soils and soil treated to remove or destroy contaminants.

It takes into account the different requirements of top soil, sub-soil and other soil materials such as sediments or treated soils. International Standard methods are listed where available.

The test methods are intended to cover a range of possible end uses, such as:

— play areas for small children, including nursery schools, kindergardens, etc.,

— schools,

— gardens and other residential areas,

— allotments,

— horticulture,

— agriculture,

— forestry,

— recreational areas, e.g. parks, sport fields,

— restoration of damaged ecosystems,

— construction sites.

It is intended to be of use in determining the suitability of soil materials for re-use, and the assessment of the environmental impacts that might arise from re-use.

This International Standard is not applicable to the placement of soil materials in an aqueous environment or to restore underground workings. It does not address geotechnical requirements when soil materials are to be used as construction material.

2 Normative reference

The following normative document contains provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 11259, *Soil quality — Simplified soil description*

3 Terms and definitions

For the purposes of this International Standard, the following terms and definitions apply.

3.1 Types of soil and other soil materials

3.1.1
soil
upper layer of the earth's crust composed of mineral parts, organic substance, water, air and living matter

[ISO 11074-1]

3.1.2
top soil
upper part of a natural soil which is generally dark-coloured and has a higher humus and nutrient content when compared to the subsoil below

[ISO 11074-4]

3.1.3
sub-soil
material underlying the topsoil and overlying the solid (parent) rock beneath

NOTE All or much of the original rock structure has usually been obliterated by pedogenic processes.

3.1.4
soil material
excavated soil, dredged materials, manufactured soils, treated soils and fill materials

3.1.5
excavated soil
any natural material excavated from the ground, including top soil, sub soil, altered parent rock and parent rock itself

NOTE Excavated soil typically arises during construction works.

3.1.6
manufactured soil
manufactured soil material
manufactured product intended to perform specified soil functions produced by blending combinations of natural, waste or manufactured materials with the addition of nutrients or other additives when necessary

3.1.7
treated soil
soil that has been subjected to a process-based treatment method

3.1.8
dredged material
material excavated during maintenance, construction, reconstruction and extension measures from waters

NOTE Dredged material may consist of:

— sediments or subhydric soils,

— soils and their parent material beneath the surface water body.

3.1.9
fill material
made ground
mixed natural (often displaced or disturbed) soil materials and other materials characteristic of urban and industrial sites

EXAMPLES Building rubble, timber and other wastes.

3.2 Soil characteristics

3.2.1
soil function
use of soil which is significant to man and the environment

NOTE Important soil functions are:

- control of substance and energy cycles as compartments of ecosystems;
- basis for the production of agricultural products;
- basis for the life of plants, animals and man;
- carrier of genetic reservoir;
- basis for the stability of buildings;
- buffer inhibiting movement of water, contaminents or other agents into the groundwater;
- reservoir of archeological remains;
- reservoir of paleoecological remains.

NOTE Adapted from ISO 11074-4.

3.2.2
background concentration
concentration of a substance characteristic of a soil type in an area or region arising from both natural sources and non-natural diffuse sources such as atmospheric deposition

cf. **natural background concentration** (3.2.4)

NOTE It is commonly expressed in terms of an average, median, a range of values, or a background value (3.2.3).

3.2.3
background value
expression of the upper limit of the range of the background concentration

NOTE It is commonly expressed as the percentile value.

3.2.4
natural background concentration
concentration of a substance that is derived solely from natural sources

NOTE 1 It is of geogenic origin.

NOTE 2 It is commonly expressed in terms of average, a range of values, or a natural-background value (3.2.5).

3.2.5
natural background value
expression of the upper limit of the range of the natural background concentration

NOTE It is commonly expressed as percentile value.

3.2.6
contaminant
substance or agent present in soil as a result of human activity

cf. **pollutant** (3.2.7), **potentially harmful substance** (3.2.8)

NOTE There is no assumption in this definition that harm results from the presence of the contaminant.

3.2.7
pollutant
substance or agent present in the soil which due to its properties, amount or concentration causes adverse impact on soil functions or soil use

cf. **contaminant** (3.2.6), **potentially harmful substance** (3.2.8)

NOTE See Introduction in ISO 11074-1:1996.

3.2.8
potentially harmful substance
substance which, when present in sufficient concentration or amount, may be harmful to humans or the environment

NOTE It may be present as a result of human activity [**contaminant** (3.2.6)] or naturally.

3.2.9
residual contamination
amount or concentration of contaminants remaining in specific media following remediation

[ISO 11074-4]

3.2.10
trace element
element present in low concentration in soil material

NOTE A trace element may be essential at low concentration but harmful at higher concentration.

3.2.11
essential trace element
element essential at low concentrations for plant or animal (including human) metabolism

NOTE An element may be essential at low concentrations but become harmful at higher concentrations.

3.3 Land and sites

3.3.1
damaged or degraded land
land which, due to natural processes or human activity, is no longer able to properly sustain an economic function and/or its original natural, or near-natural ecological function

3.3.2
target site
site at which soil is to be re-used

3.4 Utilization, reclamation and treatment

3.4.1
re-use of soil materials
useful and harmless utilization of soil materials

NOTE In the context of this International Standard, re-use means transfer of soil materials to another location for use in agriculture, horticulture, forestry, gardens, recreational areas and construction sites.

3.4.2
construction works
soil application including earthworks and embankments, landscape engineering, road construction, construction of waste disposal sites, and backfilling of excavated sites or mines

NOTE Construction works are applications where soil materials are not required to have a direct productive use, although they may support other layers intended to have productive use.

3.4.3
reclamation
restoration
rehabilitation
⟨of land⟩ return of damaged, degraded or derelict land to beneficial use

NOTE The term **remediation** is commonly restricted to the process of dealing with contaminated/polluted sites.

3.4.4
soil rehabilitation
actions taken to improve the capability of damaged or degraded soil to perform specified functions

NOTE An example of such action is the addition of organic matter and nutrients to promote plant growth.

NOTE Adapted from ISO 11074-4.

3.4.5
remediation strategy
combination of remedial techniques and associated work programmes that will meet specified contamination-related remediation objectives and other objectives, and overcome possible restraints

NOTE 1 Adapted from ISO 11074-4.

NOTE 2 Examples of objectives are residual-contaminant concentrations, and engineering-related objectives.

3.4.6
process-based treatment method
application of physical, chemical or biological processes either to remove or destroy contaminants, or to reduce their availability to the environment

[ISO 11074-4]

NOTE Different treatment methods, e.g. biotreatment, are defined in ISO 11074-4.

3.4.7
stockpile
temporary deposit of soil material for later use

3.4.8
investigation for compliance or performance
investigation, or programme of on-going inspection, testing or monitoring, to confirm that a remediation strategy has been properly implemented and/or when a containment approach has been adopted, that this continues to perform to the specified level

EXAMPLE Testing to confirm that all contaminated material has been removed.

[ISO 11074-4]

3.5 Assessment

3.5.1
hazard
property of a substance or material, or any action, which may have an adverse effect on soil functions

NOTE A hazard has the potential to cause harm.

3.5.2
risk
expression of the probability that an adverse effect on soil functions will occur under defined conditions, and the magnitude of the consequences of the effect occurring

3.5.3
harmlessness
condition in which the application of a soil material does not result in damage to the present functions of the soil already existing at the target site

3.5.4
data quality objectives
required detection limits, accuracy, reproducibility and repeatability of the required analytical and other data

NOTE 1 The objectives are often presented in a statement.

NOTE 2 Generic data quality objectives may sometimes be set at national level.

NOTE 3 The objectives may also include the amount of data required for an area of land (or part of a site) to enable a sound comparison with generic guidelines or standards or for a site-specific or material-specific estimation of risk.

4 Characterization of soil materials and sites

4.1 General

The purpose of characterizing soil and soil materials as suggested in this International Standard is usually to enable judgements to be made about its suitability for a defined use (e.g. arable farming, domestic gardens). Before any judgement can be made about suitability, the right type, quantity and quality of data must be available (see annex A). It is likely to be necessary to determine the relevant chemical, physical, biological and other characteristics as appropriate. This requires the development of an overall investigation strategy which needs to include, in particular:

— sampling strategies, and

— analytical and testing strategies

for each location and/or medium that is to be assessed.

The first step, therefore in the assessment of soil materials which have been, or may be, excavated or treated is to review the already available information and data to determine whether they are sufficient to enable an assessment to be made. If the data are not, then an appropriate investigation should be carried out. Subclause 4.2 discusses the situation when there is prior knowledge that excavation is to take place. Obviously the approach described needs to be adjusted for other situations (e.g. when the soil material of interest is a manufactured soil).

Sometimes investigations are required for the sole purpose of deciding whether soil and other soil material such as fill materials are suitable for re-use (the situation envisaged in Figure 1) but often this is only one of a number of objectives of a more comprehensive investigation of a suspect potentially contaminated site. In this latter case, the initial task becomes to ensure that the overall sampling, analytical and testing strategies for the investigation properly address the needs of this specific objective. In practice, investigations are commonly phased for both technical and cost reasons and it may therefore be preferable to carry out at least part of the characterization, particularly for example of the nutrient and trace element status, physical and biological soil properties, through a supplementary investigation (see Figure 2). The real need to assess the soil material for re-use may only arise during the development of a remediation strategy, and the need to gather supplementary information at this stage is no different than that for other components of the remediation strategy (e.g. the need for geotechnical data relevant to installation of a cut-off wall may become apparent, the need for gas-permeability data for application of soil vapour extraction may become apparent).

The discussion below focuses on soil materials that are to be excavated. This International Standard covers a number of other situations including for example dredged materials, treated soil materials and manufactured soils. Comparable appropriate investigation is required to be sure that there is a good understanding of the source of the material and its components so that appropriate analytical and testing strategies can be developed.

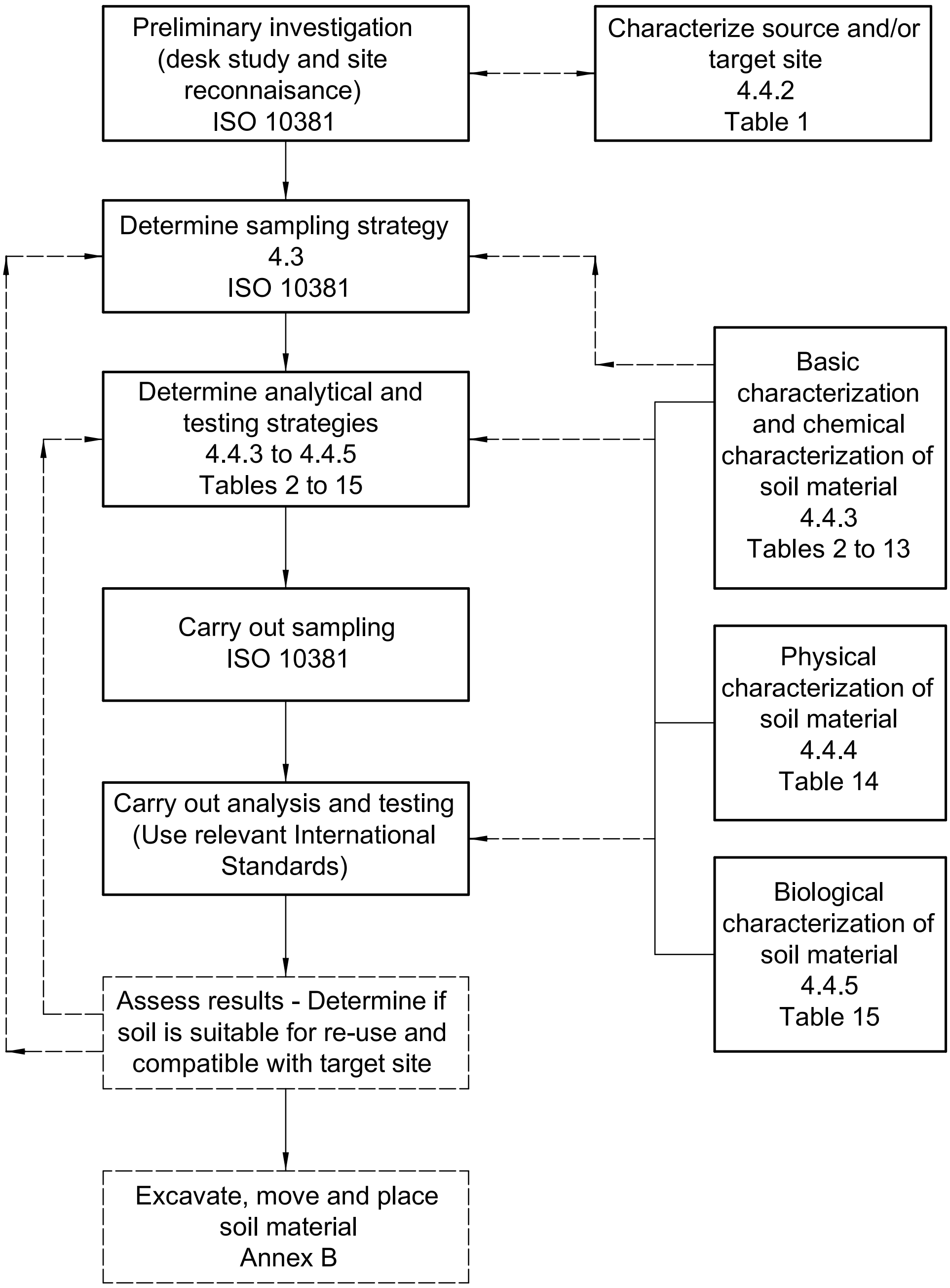

Figure 1 — Overall flow chart for characterization of soil materials for re-use

4.2 Investigation strategies

The typical overall investigation strategy for a potentially contaminated site (i.e. one where it is suspected potentially harmful substances may be present as a result of human activity) is to:

— carry out a preliminary investigation comprising a desk-top study and a site reconnaissance (walk over-survey). The aim is to build up as comprehensive a picture as possible of the history of the site, its geology and hydrogeology, environmental setting, and current condition;

and, on the basis of the resulting conceptual model, to:

— develop a strategy for intrusive investigation which properly takes into account the health and safety of the investigation team and the general public, and which avoids harm to the environment.

Often, but not always, the intrusive investigation will be phased (see Figure 2). An initial exploratory investigation (Phase 2) may be carried out first to attempt to confirm hypotheses drawn from the preliminary investigation (Phase 1) and to provide initial information to be better able to design the subsequent main investigation (Phase 3). In the light of the results of these early phases, it may be necessary to carry out supplementary investigations (Phase 4) to determine, for example the suitability of soil for re-use, or to gather information relevant to the application of a process-based treatment method.

It is important that the information and data required to assess excavated soil material for re-use be identified as far as possible before the investigation starts. In this way appropriate sampling, analytical and testing strategies can be developed at the outset. If this is not done, there may be significant gaps in the information available, necessitating further costly intrusive investigation. As suggested in 4.1, however, some aspects of characterization may often be better addressed through a supplementary investigation.

The approach outlined above should be adapted for other sources of soil materials, for example when soil material is being manufactured it would be appropriate to enquire into the source and history of each of the ingredients. In the case of soil material from a process-based treatment method, it would be appropriate to enquire into the history of the source site. Exploratory sampling programmes could then be carried out before designing and embarking on a programme for continuous monitoring of feed and output materials.

4.3 Sampling strategies

4.3.1 General considerations

Investigation may be required (as appropriate)

— *in situ* at the point of excavation,

— following excavation,

— following treatment,

— following manufacture of manufactured soil,

— *in situ* at the source or target site.

The sampling strategies and the measurements to be made (analytical and testing strategy) should be determined on the basis of

— the history of the site from which the soil material is excavated or dredged,

— the quantity of soil material to be assessed,

— available data or results of previous investigations,

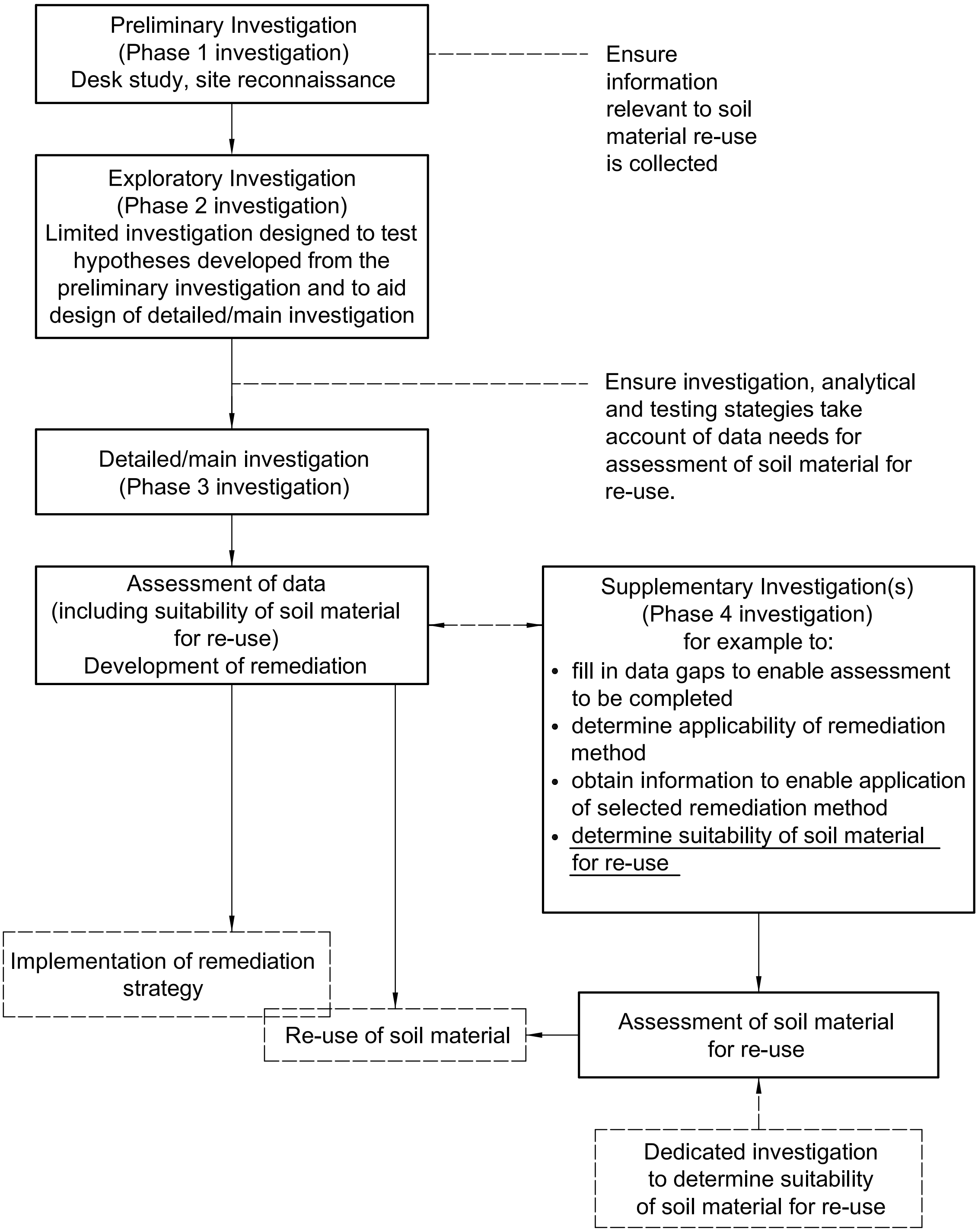

Figure 2 — Diagram showing how assessment of excavated soil material might fit into investigation of a suspect potentially contaminated site (as opposed to the alternative of a dedicated investigation with this sole objective)

- the nature and type of material to be characterized,
- the nature of any process based treatment methods that has been applied to the soil material,
- the intended use of the soil material,
- the planned way of handling the soil material from excavation to target site, e.g. transport and stockpiling,
- the history and present condition of the target site,
- the intended use of the target site,
- data quality objectives (see annex A).

When deciding on investigation, sampling, analytical and testing strategies, reference should be made to any relevant statutory (i.e. legally binding) requirements or other relevant guidance applicable in the jurisdiction where the soil is to be excavated and/or re-used.

Before commencing any investigation it is essential to define the objectives of the investigation and to prepare a sampling strategy consistent with those objectives. Reference should be made to relevant International Standards and to the guidance attached to any national guidelines or standards relating to soil quality that are to be used in the assessment of the results of the investigation. In some jurisdictions, there may be a legal requirement to follow certain procedures if published criteria are to be used as the basis of the assessment.

Within the scope of this International Standard, sampling may be required of *in situ* or excavated (*ex situ*) soil, fill materials, dredged materials, manufactured soils and their components, and treated soils. For example:

- *in situ* soils and other materials intended for excavation;
- *in situ* soils at the intended location of use;
- groundwater at the point of excavation or at the point of re-deposition;
- sediments *in situ* in ponds, lakes, canals, estuaries etc.;
- stockpiles of excavated soils and other soil materials;
- stockpiles of excavated sediments;
- soil materials arising from a process-based remediation method;
- *in situ* soil, etc., after emplacement, to ensure compliance and performance.

International Standards should be applied for sampling soils in various contexts; these are published as parts of ISO 10381. International Standards are also available for sampling surface water (ISO 5667-4, 5667-6), groundwater (ISO 5667-11), and sediments (ISO 5667-12). Otherwise appropriate national or equivalent standards should be used.

In general, soil materials should be sampled *in situ* rather than after placement in stockpiles. This enables potential environmental impacts arising from handling and storage to be determined, and may enable potential damage to the soil that may arise during storage to be avoided (see annex B).

Whilst the testing of soils for geotechnical properties is outside of the scope of this International Standard, the guidance available for description, sampling and investigation design may sometimes be helpful. In particular, attention is drawn to ISO 14688-1 and to ISO 14689. These International Standards include definitions (e.g. of soil and rock) specific to geotechnical applications.

4.3.2 Sampling *in situ* soil materials

If sufficient data are not already available (see 4.3 and annex A), it will be necessary to sample soil materials at the point of excavation and/or at the target site. Relevant International Standards on sampling soils in relation to soil quality are listed in clause 2 and in the Bibliography.

4.3.3 Sampling sediments

Guidance on sampling of sediments is given in ISO 5667-12.

4.3.4 Sampling materials arising from a process-based remediation method

Assessment of materials arising from a process-based treatment method usually requires sampling in a statistically sound way in order to confirm compliance with pre-determined chemical, physical or biological criteria (for example residual concentrations of pollutants).

NOTE At the time of publication of this International Standard, no directly relevant International Standards have been published which deal with this item. However, an International Standard on sampling of stockpiles is in preparation.

4.3.5 Sampling manufactured soil materials

Assessment of manufactured soil materials usually requires sampling in a statistically sound way in order to confirm compliance with pre-determined chemical, physical or biological criteria.

The materials used in manufacture usually require characterization before blending.

NOTE At the time of publication of this International Standard, no directly relevant International Standards have been published which deal with this item. However, an International Standard on sampling of stockpiles is in preparation.

4.3.6 Sampling stockpiles of untreated or treated soil materials

Soil materials may be stockpiled after excavation or dredging. Treated materials may also be stockpiled before re-use. Special sampling methods are required for such stockpiles. Samples from different stockpiles should not be mixed.

NOTE At the time of publication of this International Standard, no directly relevant International Standards have been published which deal with this item. However, an International Standard on sampling of stockpiles is in preparation.

4.3.7 Sampling soil materials after placement at the target site

It may be necessary to sample soil materials after placement at the target site for compliance and performance assessment. This may be required shortly after placement or some years afterward, to see, for example, if a desired improvement in a soil function has been achieved. In general, sampling methods applicable to *in situ* soil materials are appropriate.

4.3.8 Sampling the water environment

It may sometimes be necessary to sample groundwater or surface waters at the location from which soil materials are to be excavated or dredged, or at the target site. In this case ISO 5667-4, ISO 5667-6 and ISO 5667-11 shall be observed.

4.4 Characterization of soil materials

4.4.1 General

Depending on the intended use, characterization of soil materials require determination of basic characteristics (for example pH, mineralogy), chemical, physical (including texture), geotechnical, biological and radiochemical properties. It is often also necessary to determine or describe certain aspects of the site from which the soil material is to be excavated from (source site) and/or at which the soil material is to be used (target site). Figure 1 indicates the broad areas in which measurement or description may be required. The figure assumes that a dedicated investigation is being carried out for the specific purpose of assessing soil material for re-use. However, as discussed in 4.1 and 4.2 and illustrated in Figure 2, investigation related to re-use of soil material may be simply one aspect of a wider investigation and assessment programme.

Certain parameters require determination in almost all situations; others only require measurement depending on the intended use of the soil material.

4.4.2 Characterization of source and target sites

Suggestions about the characteristics of the source and target sites that might be determined are listed in Table 1. In general, the parameters to be determined at the source site are those relevant to the extraction process itself and subsequent intermediate storage and handling, and direct observations that can be made on-site (e.g. in inspection pits) that are relevant to the intended use of the excavated soil material. At the target site, the parameters of concern are primarily those that are relevant to the placement process and the properties of the existing top soil and subsoil which are relevant to determination of whether imported soil material can be used without harm (see annex B for discussion of the concept of "harmlessness").

4.4.3 Physical and chemical characterization, including basic characteristics

4.4.3.1 General

It may be necessary to measure chemical parameters in the following broad groups:

— basic characteristic parameters (e.g. pH, cation exchange capacity, petrographic features);

— nutrients;

— trace elements;

— potentially harmful substances.

Certain parameters require measurement in almost all situations; others only require measurement for some intended uses of the soil material. A judgement should, however, be made on a case-by-case basis.

Some elements may be regarded as essential trace elements at low concentrations, but at higher concentrations may be harmful to some biota. For example, copper is listed in Table 5 as an essential trace element but is also included in subsequent tables dealing with potentially harmful substances.

In order to estimate the availability of inorganic substances to different environmental compartments, it may be necessary to distinguish between different fractions of an analyte, e.g. soluble in strong acid, weak extractants, or water. Although the extractants may be different, it is often possible to use the same methods to analyse the extractant. Guidance on available International Standard methods and their applicability to different extractants is given in Table 2.

Whereas the inorganic analyst is primarily concerned with the analysis of a defined number of elements and anions, the organic analyst is often interested in looking for any chemical which may be present. In practice, organic analyses take two forms:

a) determination of what is present (qualitative analysis), and

b) determination of how much of a specific compound or class of compounds is present (quantitative analysis).

The detection of "adventitious" or unexpected substances, particularly when complex mixtures of organic chemical species are present, requires the use of analytical screening methods such as gas chromatography/mass spectometry. It is also customary to employ analytical methods that purport to give total concentrations of classes of compounds such as phenols, polycyclic aromatic hydrocarbons (PAHs), total petrol hydrocarbons (TPH) and chlorinated hydrocarbons. Care is required in both the use and interpretation of the results of such methods.

Table 1 — Characterization of source and target sites

Parameters	Source site		Target site		International Standard
	Soil to be used for natural (productive) function	Soil to be used for construction (e.g. earth works)	Soil to be used for natural (productive) function	Soil to be used for construction (e.g. earth works)	
Land use:					
Vegetation, buildings, etc.	X	X	X	X	–
Topography:	X	X	X	X	ISO 11259
Surface characteristic:					
Rock outcrops, erosion, cracks, etc.	X	X	X	X	ISO 11259
Hydrology:					
Surface water balance	–	–	X	X	–
Rainfall	–	–	X	X	–
Evapotranspiration	–	–	X	X	–
Groundwater recharge	X	X	X	X	–
Depth to groundwater table	X	X	X	X	–
Soil geometry:					
Stratigraphy	X	X	X	X	ISO 11259
Inhomogeneities	X	X	X	X	ISO 11259
Fracturing	X	X	X	X	ISO 11259
Geology:					
Type of parent material	X	X	X	X	ISO 11259
Effective soil depth	X	X	X	X	ISO 11259
Soil type/soil:					
Soil type and sequence of horizons	X	X	X	X	ISO 11259
Description:					
Thickness of horizons	X	X	X	X	ISO 11259
Colour of the horizon matrix	X	–	X	–	ISO 11259
Texture:					
Mottles	X	–	X	–	ISO 11259
Moisture status	X	–	X	–	ISO 11259
Structure	X	–	X	–	ISO 11259
Compactness	X	–	X	–	ISO 11259
Total estimated porosity	X	–	X	–	ISO 11259
Roots	X	X	X	X	ISO 11259
Worm channels, biological activity	X	–	X	–	ISO 11259
Other characteristics:					
Presence of non-soil material	X	X	X	X	–
Presence of biodegradable material	X	X	X	X	–
Presence of buildings, etc.	X	X	–	–	–
Present plant:	X	–	X	–	–
Engineering qualities:	X	X	X	X	–

NOTE "X" indicates that the information or chararacteristic may be relevant. However, decisions about relevance should always be made on a case-by-case basis.

Qualitative analysis is frequently carried out prior to quantitative analysis. Class analyses frequently precede specific compound analyses.

"Total" applied to organic compounds (e.g. phenols) usually means that an analytical technique has been employed that cannot distinguish between similar compounds: in the case of phenols say between monohydric, dihydric and trihydric compounds (i.e. compounds with one, two and three hydroxyl groups attached to the benzene ring). However, the term "total" may be misleading: not all phenols may be detected by the method employed (e.g. there may be limitations in terms of molecular weight or the number and size of other functional groups present on the benzene ring) and different methods may give different results.

Analyses of soil materials for volatile organic compounds (e.g. benzene, chlorinated solvents) present particular analytical difficulties. Research suggests that even under ideal conditions of sampling, transport and sample preparation, etc., substantial losses may occur (one study suggested that 50 % retention was the best that could be achieved). Under less than ideal conditions, almost all may be lost. Thus, use of *in situ* methods such as soil vapour analysis, are likely to give a more reliable indication of distribution and relative concentrations of the substances of concern. In addition, it should be noted that different laboratory methods (e.g. purge-and-trap and head-space analysis) may give substantially different results.

It is important to recognize that organic compounds may be extracted from naturally occurring organic materials (e.g. humus, decaying vegetation, peat, coal) and that non-specific analyses, in particular, may therefore give misleading results.

Guidance on the applicability of various chemical measurements in relation to the intended use of the soil material is given in Tables 3 to 13 below. Figure 3 indicates how the tables should be used.

Before any laboratory analysis, samples should be subjected to pretreatment (e.g. ground, sub-sampled) compatible with the method(s) of analysis to be employed. Methods for pretreatment are described in ISO 11464 (pretreatment of samples for physico-chemical analysis) and ISO 14507 (pretreatment for determination of organic contaminants). Some methods for extraction or analysis include their own requirements regarding pretreatment of samples and these should always be followed unless there are sound technical reasons not to do so, in which case those reasons should be reported with the analytical results.

Table 2 — International Standard methods for extraction of metals and metalloids

Fraction	Extraction method	Determination method (example)
Total	Digestion with hydrofluoric and perchloric acids in accordance with ISO 14869-1	ISO 11047
Pseudo-total	Trace metals soluble in aqua regia in accordance with ISO 11466	
Extracted with weak extractant	e.g. NH_4NO_3 $NaNO_3$ $CaCl_2$	ISO 11047
Water extracts	e.g. soil:water ratio using batch tests Soluble in column leaching tests	ISO 11047

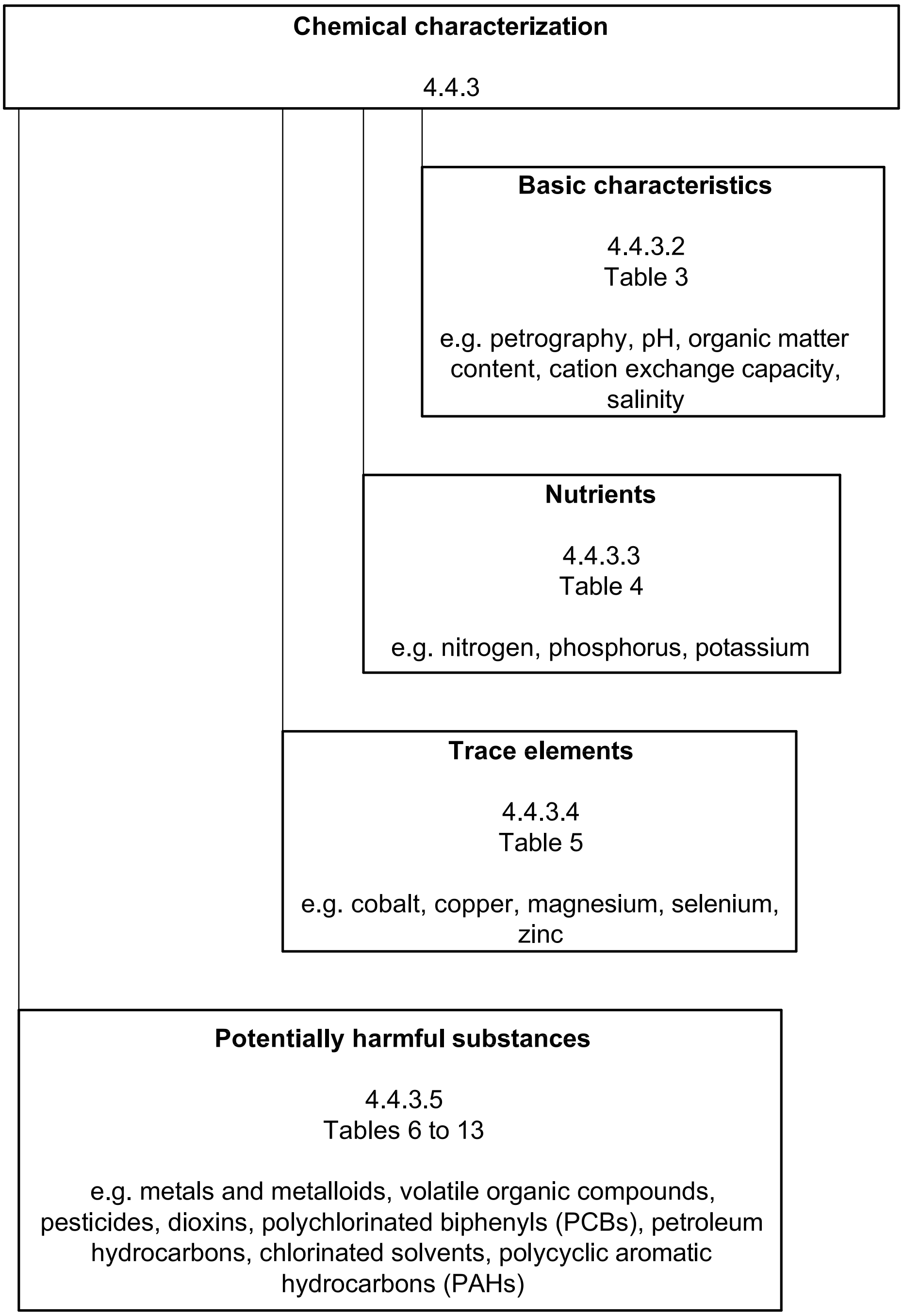

Figure 3 — Determination of basic characteristics and chemical characterization of soil materials

4.4.3.2 Basic characteristics

Basic characteristics of soil materials that might be desirable to measure are listed in Table 3. As with all the similar tables, the assessors must decide which of the parameters listed are relevant in the particular circumstances in which they are working. Some, such as pH, are likely to be relevant in most cases, whereas others, such as exchangeable acidity, are less frequently required.

Table 3 — Basic characteristics

Parameter	**Use of soil material**		**International Standard**
	Natural (productive) function	**Construction** (e.g. earth works)	
Petrographic characteristics	X	X	–
Mineralogy	X	X	–
Nature of parent material	X	X	–
pH	X	X	ISO 10390
Redox potential	X	X	ISO 11271
Salinity	X	X	–
Sodium	X	–	–
Total organic carbon (TOC)	X	X	ISO 10694
Organic carbon	X	–	ISO 14235
Loss on ignition at specified temperature(s)	X	X	–
Cation exchange capacity	X	–	ISO 11260 ISO 13536
Water content	X	X	ISO 11465 ISO 11461
Dry matter content	X	X	ISO 11465
Carbonate content	X	–	ISO 10693
Specific electrical conductivity	X	X	ISO 11265
Exchangeable acidity	X	–	ISO 14254
Potential acidity	X	X	

NOTE “X” indicates that the information or characteristic may be relevant. However, decisions about relevance should always be made on a case-by-case basis.

4.4.3.3 Nutrients

Nutrient parameters that it might be desirable to measure are listed in Table 4. These are not usually relevant when a soil material is to be used for non-productive applications such as earthworks. However, care may be required to ensure that excess nutrients do not leach into surface or ground waters when soil materials are used in construction.

Table 4 — Nutrients

Parameters	Speciation	Use of soil material		International Standard
		Natural (productive) function	Construction (e.g. earthworks)	
Calcium		X	–	–
Magnesium		X	–	–
Sodium		X	–	–
Potassium	total	X	–	–
	water-soluble	X	X	–
	weak extractant	–	–	–
Nitrogen	total	X	X	ISO 11261 ISO 13878
	nitrite	X	–	TS 14256-1 ISO 14256-2
	nitrate	X	–	TS 14256-1 ISO 14256-2
	ammonium	X	–	TS 14256-1 ISO 14256-2
	water-soluble	X	X	ISO 14255
Phosphorus	total	X	–	–
	weak extractants	X	–	ISO 11263
	water-soluble	X	–	–
Sulfur	elemental	–	–	–
	total	X	X	ISO 15178
	water-soluble sulfate	X	X	ISO 11048
	dilute acid-soluble sulfate	X	X	ISO 11048
NOTE “X” indicates that the information or chararacteristic may be relevant. However, decisions about relevance should always be made on a case-by-case basis.				

4.4.3.4 Essential trace elements

Essential trace elements that it may be desirable to determine when soil material is to have a productive use, are listed in Table 5. Note that at concentrations above a certain level, some of these elements may be harmful to a range of biota (the level often depends on the type, species and race). Essential trace elements are by definition not relevant when the soil material is to be used for non-productive uses such as earthworks.

Table 5 — Essential trace elements

Element	Form	International Standard	
		Extraction method	Determination method
Boron		*	–
Cobalt	weak extractant	*	*
	strong acid	ISO 11466	ISO 11047
Copper	weak extractant	*	– *
	strong acid	ISO 11466	ISO 11047
Iron	weak extractant	**	– *
	strong acid	*	– **
Manganese	weak extractant	*	– *
	strong acid	ISO 11466	ISO 11047
Molybdenum		**	– **
Selenium		**	– **
Zinc	weak extractant	*	– *
	strong acid	ISO 11466	ISO 11047

NOTE Essential trace elements are only relevant where the soil or other soil material is to have a productive function.

* Weak extractant methods for productive purpose need to be developed.

** Strong acid methods need to be developed.

4.4.3.5 Potentially harmful substances

The potentially harmful substances likely to be present depend on the history of the site (e.g. current and past uses, whether subject to diffuse sources of contamination). Contaminants typically associated with a number of site types are listed in annex C. It is stressed that these suggestions are not exhaustive and should be regarded as indicative only. The assessor should decide what substances may be present on a site-by-site basis. Further guidance on site use/contaminant linkages is provided in ISO 10381-1. The arrangement of the Tables in this subclause is indicated in Figure 4. Inorganic substances are listed in Tables 6 to 10. Organic substances are listed in Tables 11 to 13.

Total concentrations of potentially harmful elements are dealt with in Table 6, i.e. the total of the element present in all chemical forms and irrespective of its location in the soil material, including that incorporated into silicate minerals. Determination of these “true” total concentrations requires use of an instrumental technique such as X-ray fluorescence analysis or a powerful solvent combination, such as a mixture of hydrofluoric and perchloric acids. The use of this solvent presents many practical problems and for many purposes in environmental assessment, pseudo-total concentrations suffice (see Table 7). These are determined using a strong acid or combination of acids, but they typically leave a small insoluble residue with some soil materials. Depending on the element and the matrix, these typically yield about 70 % to 90 % of the “true” total concentration (it can be lower for those elements which are present predominately bound in silicate or aluminate lattices). When comparisons with guideline values are required for particular soil uses, it is essential to determine whether “pseudo-total” or “total” concentrations are required.

Concentrations extractable with complexing agents such as diethylenetriaminepentaacetic acid (DTPA) (see Table 8) and weak extractants (Table 9) such as calcium chloride solution are employed when “availability” to plants are to be assessed.

Finally, concentrations extractable in water (see Table 10) are relevant to an assessment of potential leachability into the environment. It is important to recognize that when compounds of limited solubility are present (e.g. gypsum), the apparent amount soluble depends on the soil:water ratio employed in the tests. A detailed discussion of soil leaching and extraction tests is provided in ISO 15175. Qualitative methods for assessing potential leaching risks from non-reactive contaminants (e.g. nitrate and chloride), heavy metals (e.g. cadmium) and organic compounds are described in ISO 15175.

The range of organic chemicals that might be present is very wide. Thus only a few are listed in Tables 11 to 13: essentially those for which International Standard methods of analysis exist or are in preparation. A classification of organic substances, in terms for example of volatility and whether they contain halogens, is provided in annex E. For a general discussion about analyses for organic substances, see 4.4.3.1.

It should be noted that it is very difficult to obtain representative samples of soil materials for determination of volatile organic compounds. Various studies have shown that almost all may be lost if samples are not handled correctly. Consequently, concentrations of volatile organic compounds in soil gas are commonly determined directly. A variety of techniques are used to make measurements *in situ* or to obtain samples of vapour for on- or off-site laboratory analysis (e.g. using absorption tubes).

NOTE There are at present no International Standards available for the *in situ* sampling or testing for volatile inorganic compounds, although ISO 10381-7 when published will provide relevant guidance.

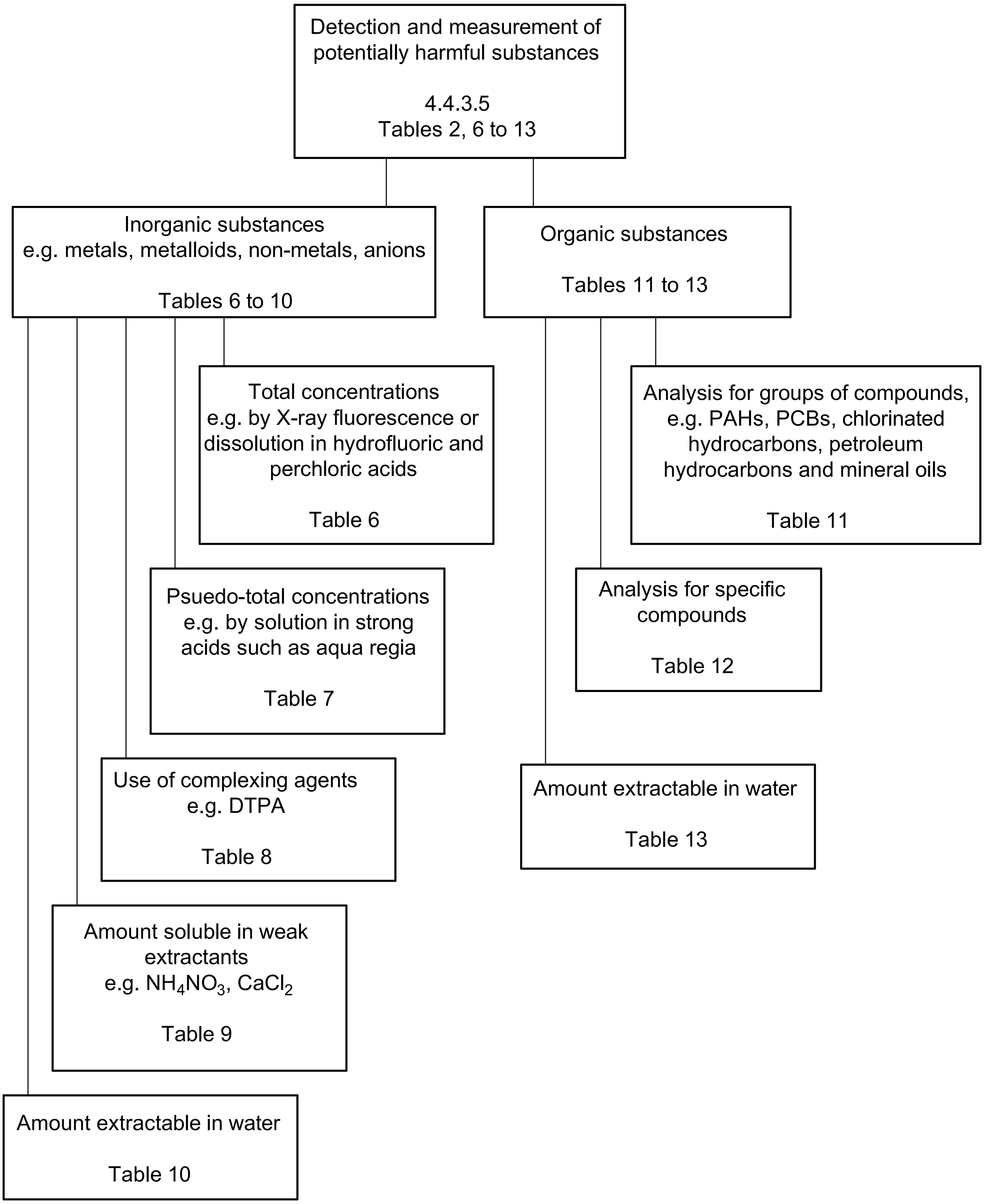

Figure 4 — Detection and measurement of potentially harmful substances

Table 6 — Total concentrations of potentially harmful inorganic substances

Substance group	Element /form	Use of soil material		Extraction/preparation method		Determination method
		Natural (productive) function	Construction (e.g. earthworks)			
Metals and metalloids	Arsenic	X	X	X-ray fluorescence $HF+HClO_4$	ISO 14869-1 ISO 14869-2	ISO 14869-1
	Barium	X	X	X-ray fluorescence $HF+HClO_4$	ISO 14869-1 ISO 14869-2	ISO 14869-1
	Cadmium	X	X	X-ray fluorescence $HF+HClO_4$	ISO 14869-1 ISO 14869-2	ISO 14869-1 ISO 11047
	Chromium	X	X	X-ray fluorescence $HF+HClO_4$	ISO 14869-1 ISO 14869-2	ISO 14869-1 ISO 11047
	Cobalt	X	X	X-ray fluorescence $HF+HClO_4$	ISO 14869-1 ISO 14869-2	ISO 14869-1 ISO 11047
	Copper	X	X	X-ray fluorescence $HF+HClO_4$	ISO 14869-1 ISO 14869-2	ISO 14869-1 ISO 11047
	Lead	X	X	X-ray fluorescence $HF+HClO_4$	ISO 14869-1 ISO 14869-2	ISO 14869-1 ISO 11047
	Manganese	X	X	X-ray fluorescence $HF+HClO_4$	ISO 14869-1 ISO 14869-2	ISO 14869-1 ISO 11047
	Mercury	X	X	X-ray fluorescence $HF+HClO_4$	ISO 14869-1 ISO 14869-2	–
	Nickel	X	X	X-ray fluorescence $HF+HClO_4$	ISO 14869-1 ISO 14869-2	–
	Selenium	X	X	X-ray fluorescence $HF+HClO_4$	ISO 14869-1 ISO 14869-2	–
	Silver	X	X	–		–
	Thallium	X	X	–		–
	Zinc	X	X	X-ray fluorescence $HF+HClO_4$	ISO 14869-1 ISO 14869-2	ISO 14869-1 ISO 11047
Nonmetals	Boron	X	–	–		–
	Phosphorus	X	–	–		–
	Sulfur	X	X	X-ray fluorescence Dry combustion	ISO 14869-1	ISO 14869-1 ISO 15178
Anions	Cyanide	X	X	–		–
	Chloride	X	X	–		–
	Sulfate	X	X	–		–

NOTE "X" indicates that the information or characteristic may be relevant. However, decisions about relevance should always be made on a case-by-case basis.

Table 7 — Pseudo-total concentrations of potentially harmful inorganic substances

Substance group	Element/form	Use of soil material		Extraction/preparation method	Determination method
		Natural (productive) function	Construction (e.g. earthworks)		
Metals and metalloids	Arsenic	X	X	–	–
	Barium	X	X	–	–
	Boron	X	X	–	–
	Cadmium	X	X	Aqua regia ISO 11466	ISO 11047
	Chromium	X	X	Aqua regia ISO 11466	ISO 11047
	Cobalt	X	X	Aqua regia ISO 11466	ISO 11047
	Copper	X	X	Aqua regia ISO 11466	ISO 11047
	Lead	X	X	Aqua regia ISO 11466	ISO 11047
	Manganese	X	X	Aqua regia ISO 11466	ISO 11047
	Mercury	X	X	–	–
	Molybdenum	X	X	–	–
	Nickel	X	X	–	–
	Selenium	X	X	–	–
	Silver	X	X	–	–
	Thallium	X	X	–	–
	Zinc	X	X	Aqua regia ISO 11466	ISO 11047
Nonmetals	Boron	X	X	–	–
	Carbon	–	–	–	–
	Phosphorus	X	–	–	–
Anions	Cyanide	X	X	–	–
	Sulfate	X	X	Dilute acid ISO 11048	ISO 11048

NOTE 1 "X" indicates that the information or characteristic may be relevant. However, decisions about relevance should always be made on a case-by-case basis.

NOTE 2 For some purposes, an alternative to extraction with aqua regia (ISO 11466) might be extraction with boiling 2 mol/l nitric acid. However, there is no International Standard for this method.

Table 8 — Potentially harmful inorganic substances extracted with complexing agents

Substance group	Element/form	Use of soil material		Extraction/preparation method	Determination method
		Natural (productive) function	Construction (e.g. earthworks)		
Metals and metalloids	Aluminium	X	not relevant	–	–
	Arsenic	X		–	–
	Barium	X		–	–
	Cadmium	X		DTPA ISO 14870	ISO 11047
	Chromium	X		DTPA ISO 14870	ISO 11047
	Cobalt	X		–	ISO 11047
	Copper	X		DTPA ISO 14870	ISO 11047
	Iron	X		DTPA ISO 14870	–
	Lead	X		DTPA ISO 14870	ISO 11047
	Manganese	X		DTPA ISO 14870	ISO 11047
	Mercury	X		–	–
	Nickel	X		DTPA ISO 14870	–
	Selenium	X		–	–
	Silver	X		–	–
	Thallium	X		–	–
	Zinc	X		DTPA ISO 14870	ISO 11047

NOTE ”X” indicates that the information or characteristic may be relevant. However, decisions about relevance should always be made on a case-by-case basis.

Table 9 — Potentially harmful inorganic substances extracted with weak extractants

Substance group	Element/ form	Use of soil material: Natural productive function	Use of soil material: Construction (e.g. earthworks)	Extraction/preparation method	Determination method
Metals and metalloids	Aluminium	X	not relevant	e.g. NH_4NO_3, $NaNO_3$, $CaCl_2$, KCl	–
	Arsenic	X		e.g. NH_4NO_3, $NaNO_3$, $CaCl_2$, KCl	–
	Barium	X		e.g. NH_4NO_3, $NaNO_3$, $CaCl_2$, KCl	–
	Cadmium	X		e.g. NH_4NO_3, $NaNO_3$, $CaCl_2$, KCl	ISO 11047
	Chromium	X		e.g. NH_4NO_3, $NaNO_3$, $CaCl_2$, KCl	ISO 11047
	Cobalt	X		e.g. NH_4NO_3, $NaNO_3$, $CaCl_2$, KCl	ISO 11047
	Copper	X		e.g. NH_4NO_3, $NaNO_3$, $CaCl_2$, KCl	ISO 11047
	Iron	X		e.g. NH_4NO_3, $NaNO_3$, $CaCl_2$, KCl	–
	Lead	X		e.g. NH_4NO_3, $NaNO_3$, $CaCl_2$, KCl	ISO 11047
	Manganese	X		e.g. NH_4NO_3, $NaNO_3$, $CaCl_2$, KCl	ISO 11047
	Mercury	X		e.g. NH_4NO_3, $NaNO_3$, $CaCl_2$, KCl	–
	Nickel	X		e.g. NH_4NO_3, $NaNO_3$, $CaCl_2$, KCl	–
	Selenium	X		e.g. NH_4NO_3, $NaNO_3$, $CaCl_2$, KCl	–
	Silver	X		e.g. NH_4NO_3, $NaNO_3$, $CaCl_2$, KCl	–
	Thallium	X		e.g. NH_4NO_3, $NaNO_3$, $CaCl_2$, KCl	–
	Zinc	X		e.g. NH_4NO_3, $NaNO_3$, $CaCl_2$, KCl	ISO 11047

NOTE "X" indicates that the information or characteristic may be relevant. However, decisions about relevance should always be made on a case-by-case basis.

Table 10 — Potentially harmful inorganic substances extracted with water

Substance class	Element/ species	Use of soil material		Extraction method see Notes	International Standard
		Natural (productive) function	Construction (e.g. earthworks)		
Metals and metalloids	Aluminium	X	X		–
	Arsenic	X	X		–
	Barium	X	X		–
	Cadmium	X	X		ISO 11047
	Chromium	X	X		ISO 11047
	Cobalt	X	X		ISO 11047
	Copper	X	X		ISO 11047
	Iron	X	X		–
	Lead	X	X		ISO 11047
	Manganese	X	X		ISO 11047
	Mercury	X	X		–
	Nickel	X	X		–
	Selenium	X	X		–
	Silver	X	X		–
	Thallium	X	X		–
	Zinc	X	X		ISO 11047
Nonmetals	Phosphorus	X	X		–
	Sulfur	–	–		–
	Boron	X	–		–
Anions	Cyanides	X	X	–	–
	Sulfate	X	X	ISO 11048	ISO 11048
	Chloride	X	X		

NOTE 1 "X" indicates that the characteristic may be relevant. However, decisions about relevance should always be made on a case-by-case basis.

NOTE 2 There are many different extraction methods based on batch processes (e.g. shaking with fixed amount of water, sequential extractions, or columns). For a detailed discussion of methods see annex E of ISO 15175:—[1].

NOTE 3 There are a variety of analytical methods for water available as International Standards which may be applicable. However it is important to confirm that they will work with the extracts obtained from a particular (contaminated) soil material.

1) To be published.

Table 11 — Methods for groups of potentially harmful organic substances

Substance group	Use of soil material		International Standard
	Natural (productive) function	**Construction** (e.g. earthworks)	
Volatile aromatic hydrocarbons	X	X	ISO 15009
Petroleum hydrocarbons	X	X	–
Mineral oil content	X	X	TR 11046
Polycyclic aromatic hydrocarbons (PAHs) - "total"	X	X	ISO 13877
Halogenated hydrocarbons	X	X	ISO 15009
Phenols	X	X	–
Chlorinated phenols	X	X	ISO 14154
Phthalates	X	X	–
Polychlorinated biphenyls (PCBs)	X	X	ISO 10382
Persistent herbicides	X	X	ISO 11264
Triazines and phenyl urea herbicides	X	X	–
NOTE "X" indicates that the characteristic may be relevant. However, decisions about relevance should always be made on a case-by-case basis.			

Table 12 — Methods for specific potentially harmful organic substances

Substance(s)	Use of soil material		International Standard
	Natural (productive) function	**Construction** (e.g. earthworks)	
Benzene	X	X	–
Ethylbenzene	X	X	–
Toluene	X	X	–
Xylenes	X	X	–
Methyl *t*-butyl ether (MTBE)	X	X	–
Individual polycyclic aromatic hydrocarbons (PAHs)	X	X	–
Individual polychlorinated biphenyls	X	X	–
Pentachlorophenol	X	X	ISO 14154
NOTE "X" indicates that the characteristic may be relevant. However, decisions about relevance should always be made on a case-by-case basis.			

Table 13 — Potentially harmful organic substances and groups of substances soluble in water

Substance group	Use of soil material		International Standard	
	Natural (productive) function	Construction (e.g. earthworks)	Extraction method	Determination method
Groups of compounds:			see Note 2	see Note 3
Volatile aromatic hydrocarbons	X	X		
Petroleum hydrocarbons	X	X		
Mineral oil content	X	X		
Polycyclic aromatic hydrocarbons (PAHs)	X	X		
Halogenated hydrocarbons	X	X		
Phenols	X	X		
Chlorinated phenols	X	X		
Polychlorinated biphenyls (PCBs)	X	X		
Persistent herbicides	X	X		
Triazines and phenyl urea herbicides	X	X		
Specific compounds:				
Benzene	X	X		
Ethylbenzene	X	X		
Toluene	X	X		
Xylenes	X	X		
Methyl *t*-butyl ether (MTBE)	X	X		
Individual PAHs	X	X		
Individual PCBs	X	X		
Phenol	X	X		
Pentachlorophenol	X	X		

NOTE 1 "X" indicates that the characteristic may be relevant. However, decisions about relevance should always be made on a case-by-case basis.

NOTE 2 There are many different extraction methods based on batch processes (e.g. shaking with fixed amount of water, sequential extractions, or columns). For a detailed discussion see annex E of ISO 15175:—[1)]

NOTE 3 There are a variety of analytical methods for water available as International Standards which may be applicable. However it is important to confirm that they will work with the extracts obtained from a particular (contaminated) soil material.

4.4.4 Physical characteristics

Physical characteristics that it may be desirable to determine when soil materials are to be re-used are listed in Table 14. Measurements on the soil material of interest may be made before placement or after placement. In the case of soil and other soil materials that are to be excavated, some before-placement measurements are necessarily made *in situ* and some *ex situ*. In some cases, similar properties may be measured either *in situ* or *ex situ*. The assessor must determine which is most appropriate in each case. In the case of treated soil materials and manufactured soils, only *ex situ* measurements are possible.

Some of the characteristics to be measured influence the geotechnical and handling properties of the soil material. International Standards and guidance on geotechnics in civil engineering, e.g. ISO 14688-1 and ISO 14689, may also be of relevance.

At the target site, it may be desirable to measure some characteristics before the imported soil material is placed, in order to ensure that the application is suitable (again if the depth of soil material to be placed is particularly high, some geotechnical measurements may be desirable). Other measurements to be made concern, for example, the “health” of the soil material as a growth medium. If the soil material is being used in earthworks, then appropriate geotechnical measurements on the placed soil may be required, depending on the precise function(s) it is required to perform.

Table 14 — Physical parameters

	Parameter	Source site		Target site				International Standard
		Before placement		Before placement		After placement		
		Natural (productive) function	**Construction** (e.g. earth works)	**Natural (productive) function**	**Construction** (e.g. earthworks)	**Natural (productive) function**	**Construction** (e.g. earthworks)	
In situ	Soil profile description	X	X	X	X	–	–	–
	Texture	X	–	X	–	–	–	–
	Coarse material	X	–	X	–	–	–	–
	Electrical conductivity	X	–	X	–	–	–	–
	Redox potential	X	–	X	–	–	–	ISO 11271
	Water content	X	X	X	–	–	–	ISO 10573
	Presence of roots etc.	X	X	X	–	–	–	–
	Bulk density	X	X	–	–	–	–	ISO 11272
	Hydraulic conductivity	–	–	X	–	–	–	–
	Pore water pressure	–	–	X	–	–	–	ISO 11276
	Plasticity index	X	X	X	X	–	–	–
	Consistence	X	–	X	–	–	–	–
	Structure stability	X	–	X	–	–	–	–
	Infiltration rate	–	–	X	X	X	X	–
Ex situ	Particle size distribution	–	–	X	X	–	X	ISO 11277
	Aggregate stability	–	–	X	X	–	–	–
	Coarse material	–	–	X	X	–	X	–
	Bulk density	–	–	X	X	–	–	ISO 11272
	Water content	–	–	X	X	–	–	ISO 11461
	Particle density	–	–	X	X	–	–	ISO 11508
	Water-retention characteristics	–	–	X	X	–	–	ISO 11274

4.4.5 Biological characteristics

Some biological characteristics that it might be desirable to measure when soil is to have a productive use are listed in Table 15. It is assumed that these are not relevant when soil is to be used for a non-productive use (e.g. earthworks), but note that such fill may underlie more productive layers and that some biological characteristics might then be relevant.

It is unlikely that biological measurements will be made on a routine basis when soil materials are to be re-used. However, biological measurements which determine toxicity directly or indirectly can be particularly valuable, for example:

- when there are complex mixtures of potentially harmful substances present in soil materials and it is difficult to determine from simple analytical measurements what additive or synergistic effects there might be on living organisms;
- effects, such as the phytotoxic effects of zinc, nickel and copper, alone and in combination, may be mitigated by pH and the presence of organic matter or clay minerals, and consequently it is difficult to predict what effects there will be in practice. Direct measurements can avoid costly conservative assumptions;
- treatment has resulted in the presence of residual concentrations of substances (e.g. hydrocarbons) above limiting concentrations; it may be possible to demonstrate that nevertheless there is no residual toxicity;
- treatment may have resulted in formation of difficult to identify intermediates and final products;
- it is necessary to demonstrate that mitigating measures, e.g. addition of lime or organic matter to soil, have had their desired effect;
- to demonstrate that a manufactured soil (which may in some cases include industrial by-products as components) provides a “healthy” and “productive” growth medium.

Of course, measurements before and after any treatment or amendment of soil are often desirable in order to demonstrate any beneficial effect.

It should be noted that:

- conditions can change over time. For example degradation of organic matter and changing pH can alter the availability of substances to biological systems and thus toxicity might increase with time. In contrast, other natural mechanisms such as biodegradation might reduce concentrations of toxic substances, leading to an overall lowering of toxicity. Thus, repeat measurements after a number of years may be desirable.
- an absence of toxicity to plants does not necessarily mean that the soil is “healthy”. Toxicity to soil micro-organisms may occur at concentrations below those that affect plants directly, and this may adversely affect the overall “health” of the soil, thus lowering productivity.

Table 15 — Biological measurements on productive soil materials

General characteristic	Specific measurement/example	Relevant International Standard
Microbial activity	Respiration	–
	Mineralization of organic chemicals	ISO 14239
	Rate of decomposition of organic matter	–
	Soil microbial mass	ISO 14240-1, ISO 14240-2
	Biodegradation under anaerobic conditions	ISO 15473
	Biodegradation under aerobic conditions	ISO 11266
	Nitrogen mineralization	ISO 14238
Toxicity to plants	Inhibition of root growth	ISO 11269-1
	Effects on emergence and growth of higher plants	ISO 11269-2
	Germination	–
	Field tests on higher plants	–
Toxicity to micro-organisms	Inhibition of microbial activity Change of population diversity	ISO 14238 ISO 16072 ISO 17155
Presence of pests	Nematodes	–
	Fungi	–
Microbial biomass	Induced respiration method Fumigation-extraction method	ISO 14240-1 ISO 14240-2
Toxicity to macro-fauna	Acute toxicity to earthworms (*Eisenia fetida*) Effects on reproduction of earthworms (*Eisenia fetida*) Effects on earthworms (*Eisenia fetida*) — Field testing Inhibition of reproduction of Collembola	ISO 11268-1 ISO 11268-2 ISO 11268-3 ISO 11267

5 Data quality, handling and evaluation

The purpose of characterizing soil (or other media) as suggested in this International Standard is usually to enable judgements to be made about its suitability for a defined use (e.g. arable farming, domestic gardens). This International Standard provides guidance on the types of data that might be required in an assessment and indicates for which parameters or procedures there are International Standards available. The assessor should choose those parameters that are appropriate to the task in hand. Suggestions on how to handle and evaluate the data arising from an assessment is provided in annex A.

6 Using this International Standard

Some examples of assessment using the principles of this International Standard are provided in annex C.

Annex A
(informative)

Data quality, handling and evaluation

The purpose of characterizing soil (or other media) as suggested in this International Standard is usually to enable judgements to be made about its suitability for a defined use (e.g. arable farming, domestic gardens). These judgements may be made by reference to published international or national standards that set out physical, chemical or other criteria that shall be met, or against criteria set on a site-specific basis. When contaminants are present that might be harmful to human health or the environment, it may also be made on the basis of a site-specific qualitative, semi-quantitative or fully quantitative risk assessment. In many jurisdictions, formal guidance on such assessments has been published. In some cases this guidance fits within a legislative framework. Guidance has also been provided by professional organizations and some standardization bodies.

Before any judgement can be made about the suitability of the soil material for use, the sufficiency of data to be used should be evaluated. The data should be sufficient in terms of

— type (e.g. if chemical: total, pseudo-total, water-soluble, as appropriate),

— quantity (e.g. number of sampling locations and number of samples from each location),

— quality of tests, analysis and assessment.

These requirements apply equally to “information” such as that obtained from desk studies and to numerical data from measurement programmes. The sufficiency of the information and database on which the assessment is to be made is best guaranteed by careful planning of the necessary investigations and the use of appropriate quality control and quality assurance procedures.

This International Standard provides guidance on the types of data that might be required in an assessment and indicates for which parameters or procedures there are International Standards available. The assessor should choose those parameters that are appropriate to the task in hand. The assessor should bear in mind the disproportionate costs and time delays that may result if it is necessary to carry out an additional sampling exercise if, for example, a particular parameter is not determined when the opportunity is available.

Before investigation of the soil or other material is started, it is essential to

— define the objectives of the investigation,

— establish a sampling strategy in terms of types of samples to be obtained, sampling locations, and how samples are to be handled consistent with these objectives (more detailed guidance on sampling is provided in 4.3),

— establish an analytical and testing strategy taking into account the guidance in this and other relevant International Standards,

— set data quality objectives consistent with the assessment procedure to be used.

It is essential to have sufficient data. The confidence that can be attached to any judgements made, for example through comparison with the requirements of a published standard (the requirements in such standards regarding sampling should always be followed) or a site-specific risk assessment, is no greater than the confidence there is in the representativeness of the data. This applies equally to soil that is being assessed *in situ* before excavation and to the stream of treated material arising from a process-based treatment method. For example, if because of the limited amount of sampling carried out, there is only 25 % confidence that a “hot spot” of contamination occupying 5 % of the volume of material has been identified, then comparisons with published criteria may be unsound. In the case of material arising from a process-based treatment method, a statistically sound basis for sampling should be agreed before treatment starts.

Care should be taken in deciding what statistical expression(s) of the data is to be used in the assessment, as this can affect the choice of sampling procedures. For example, for agricultural purposes average compositions may be appropriate, and thus a composite sampling method that gives a good estimate of this "property" may be appropriate.

For human health assessments, a statistic such as the "95 % upper confidence level of the mean" or the "maximum observed value" is more likely to be required and thus a different sampling procedure will be required.

The quality of the data to be used can be assured by

— setting formal data quality objectives (e.g. for accuracy, reproducibility, etc.),

— using standardized analytical and testing methods such as those listed in this International Standard or, where International Standard methods are not available, those published by national standardization or equivalent bodies,

— using laboratories with accreditation meeting the requirements of ISO/IEC 17025,

— using laboratories that take part in relevant proficiency testing schemes,

— the commissioning agent employing its own quality assurance procedures.

Often, the reports presenting the results of assessments are scrutinized by regulators and other interested parties, including the general public. It is important, therefore, that such reports be of a high technical standard but also take account of the diverse, and often non-technical, readership. Use should therefore be made of tabular summaries, graphical and other means to present the data in ways that make the data as easy as is practicable to assimilate and assess.

Annex B
(informative)

Good practice in the re-use of soil materials

B.1 General

This annex highlights key technical factors influencing the satisfactory re-use of soils and other soil materials. Suggestions are also made regarding the requirements for continued surveillance once soil materials have been placed at the receiving (target) site to ensure that the objectives of re-use are achieved over the longer term.

The guidance provided is primarily applicable to natural soils, but should be applied to other soil materials as appropriate. It is based on practice and experience in temperate climates; however, due regard should be paid to local climatic conditions. The guidance is not exhaustive; for more details, reference should be made to authoritative guidance on the use of top soils and the reclamation of degraded or derelict land.

It is essential that due regard be given to national regulations, codes of practice and other general requirements. In addition, it is essential that adequate site supervision be provided to ensure that all planned procedures and activities are put into place.

B.2 General guidance for re-use

B.2.1 The principles

Whenever possible, the following general principles should apply when soils and other soil materials are to be re-used:

- usefulness;
- harmlessness;
- avoidance of excavation or removal from site;
- avoidance of damage during handling, storage or placement.

B.2.2 Usefulness

Whenever possible, the use of the soil material should provide benefits at the target site. For example, restoration of degraded land, reclamation of mining areas, earthworks, soil improvement especially for agricultural use (e.g. increasing water-holding capacity, increasing depth of rooting zone, improving workability).

B.2.3 Harmlessness

When there is to be no change in intended land use at the target site, imported soil materials should not lead to a permanent reduction in performance of relevant soil functions.

When there is to be a change of use, the soil should be suitable for the new use. This may permit some change in performance of some soil functions.

The chemical, physical, biological and “basic” characteristics of the soil material should be used in evaluation of harmlessness. The concentrations of potentially hazardous substances are usually decisive for harmless re-use. The concentration should not normally be adjusted by mixing with less contaminated material.

The concept of harmlessness is illustrated in the examples described in annex D.

B.2.4 Avoidance of excavation or removal from site

Removal of soil from the excavated site should be avoided whenever possible. Use of excavated material within the construction site (mass balancing) reduces environmental impacts, for example from waste disposal and traffic movements.

B.2.5 Avoidance of damage to soil material during handling, storage and placement

Impairment of soil functions can be caused, for example, by

- poor excavation practice,
- poor stockpiling practice,
- compaction by heavy machinery.

The ability of the soil structure to regenerate is limited. Detrimental structural changes, in particular of subsoil, can hence be irreversible. Therefore, soil intended to have a productive function should be handled in a way that as far as possible limits the extent and intensity of compaction.

B.3 Handling and storing excavated soil and other soil materials

When soil or soil material is to be excavated, any plants growing on the area to be excavated should first be removed.

Topsoil, subsoil and other soil layers with distinct properties [for example, soils belonging to different suitability classes (see Annex D)] should be excavated, stored and re-used separately. To limit compaction, the subsoil should be excavated in a single operation without intermediate trafficking.

During excavation works the consistency of the soil, which is largely governed by the moisture content, should be compatible with the planned handling, transport and placement procedures. Soil should not be handled when it is wetter than the lower plastic limit. After wet weather, neither topsoils nor subsoils should be allowed to dry out.

Intermediate storage of soil material always increases the risk of quality deterioration and should be avoided if possible. If intermediate storage of soil material is required, it should be protected from compaction and waterlogging by limiting the height of the stockpile (to a maximum of 2 m in the case of humic soil), adopting a profile that limits infiltration and erosion and by limiting storage duration. In cases of prolonged storage (e.g. more than 6 months), the stack should be planted with deep rooting, frost-resistant (where relevant) and water-consuming plants, and weed growth should be controlled to prevent a build-up of seeds in the stored material. The latter should be achieved by mechanical means rather than by use of herbicides, with a balance being drawn between the risks of pollution and mechanical damage to the soil.

B.4 Placement at the target site

The success of soil movement and re-use is mainly determined by the chemical and physical properties of the newly deposited soil layer. A pedologically well-founded selection of appropriate soil material to be added, and the sound handling of it and of the soil materials on the target site, are the essential keys to success.

Mechanical effects during redeposition can cause changes in the soil structure, depending on the structure's stability (dependent for example on soil type, soil structure, soil moisture) and on the soil at the target site. There can be a reduction in pore volume, a change in pore size distribution and an interrupted continuity of pores. The water and air balance as well as the rooting capability can be impaired, soil pores clogged and the erodability increased. Since newly deposited soils often have a poor infiltration ability, there can be an increased risk of run-off and consequently increased erosion in heavy rain.

Soil material used for reclamation should usually be suitable to restore the native soil quality of target site, at least in the long run. However, note that in some reclamations of degraded land or in creation of particular ecosystems this may not be a requirement.

Soil materials should be handled and placed in a way that avoids compaction on the target site. In addition, care should be taken to avoid introduction of unnecessary nutrient inputs that might lead to polluting run-off or promote nutrient-hungry plants at the expense of the desired, less nutrient-dependent species.

The probability of success of the re-use is generally enhanced if the following criteria are observed:

- large amelioration and recultivation areas are subdivided into sectors of a maximum of one hectare and plant cover established;
- soil material is **not** applied by hydraulic fill or as a suspension;
- the characteristics of the soil material to be applied are similar to those of the soil at the target site;
- reclamation works are performed only in dry weather and only when both the topsoil and subsoil are dry;
- soil material is placed in layers no more than about 0,2 m thick at a time;
- if a total depth of more than about 0,2 m is to be applied, any topsoil already present is first removed (soil excavation should be carried out as a single action) and, if necessary, the subsoil broken up prior to applying the soil material;
- removed topsoil is replaced afterwards;
- care is taken when soil is placed on slopes to avoid risks of erosion and run-off;
- avoidance of compaction by heavy vehicles (this may require use of large tyres or other techniques);
- following soil application the area is levelled periodically, whilst taking care not to promote erosion where the soil is placed on a slope;
- if necessary, soil pH and base saturation are adjusted with either lime or gypsum, respectively.

B.5 After-care of the target site

Good and lasting productivity from the placed soil requires that appropriate nutrient and trace element concentrations and physical characteristics of the soil be first established and then maintained. The structure, mechanical loading capacity, erosion resistance and pore continuity of the improved and recultivated soil can be optimized and maintained by adhering to the following principles in successive years of land utilisation:

- adjustment of the organic matter content of the topsoil to a level appropriate to the end use via suitable crop rotations, organic manures and other soil improvers. Rates of manure addition should be such that the risk of nutrient leaching is minimized. The site drainage should be designed to minimize the potential for pollution to occur;
- choice of plants that promote development of soil structure and drainage;
- use of legumes and other plants that promote nutrient production and retention;
- conducting land utilisation and maintenance measures only on appropriately dry soil;
- remedying soil compaction and waterlogging by mechanical loosening and/or partial appropriate draining.

B.6 Use of soil materials in construction works

Good engineering practice as set out in international, national or professional codes of practice and standards should be followed.

Annex C
(informative)

Guidance on determination of the scope of investigation needed before excavation of soil materials

C.1 General

This annex describes a possible approach to the determination of the need for, and scope of, an investigation of soil materials which may require excavation in connection with a building or other construction project (the materials to be excavated may be natural soils or fill comprising relocated soils and/or previously deposited waste materials).

General guidance on the investigation and assessment of soil materials that are to be excavated is given in clause 5. Care should be taken, when following the approach suggested here, to adhere to relevant national requirements for site investigation and assessment, to make use of relevant international and national standards [for example ISO 10381 (all parts)], and to take account of any site-specific requirements of local regulatory authorities (e.g. physical planning, public health, environmental protection).

C.2 Determining the need for investigation

Before excavating soil or other soil material in connection with a building or other construction project, it is necessary to decide whether it is likely to contain substances potentially harmful to human health or the environment (these might take the form of contaminants (anthropogenic origin) or be naturally occurring (geogenic origin). This decision should be based on a thorough review of the documentation available on the site itself and on neighbouring sites (migration of contaminants may have occurred). Based on the desk study and site reconnaissance, hypotheses about the probability of the presence of potentially harmful substances (see for example the discussion in C.3 regarding linkages between site history and probable contaminants) and their likely distribution can be developed. These hypotheses can be first tested by limited targeted (judgemental) sampling and subsequently by a more detailed investigation if required, following, as appropriate, the guidance on sampling in the appropriate part of ISO 10381.

If the preliminary and exploratory investigations give reason to believe or demonstrate that potentially harmful substances are present, chemical investigation is required. The investigation should take into account the history of the site and surrounding areas, and the clues that this can provide about the contaminants likely to be present.

Subject to the views of local regulators and legislative requirements, detailed investigations are generally not required if there is no indication of anthropogenic changes or geogenic substance accumulations, for example, when establishing building sites on areas which have not been used by industry or trade, for waste disposal or as military sites. However, it should be noted that some agricultural and horticultural sites may be contaminated and that there is a degree of contamination of surface soils in old residential areas.

In some jurisdictions it may also be unnecessary to carry out extensive assessments (subject to local regulations) if

— soil excavated from areas with anthropogenically increased background loads is placed at the same depth within the soil profile and re-used on the site from which it was removed or on comparable sites in the region,

— soil excavated from areas with geogenically increased contents of inorganic pollutants is involved, provided it is used in areas where there are soils derived from the same parent rock,

— topsoil from family and house gardens is re-used within the same property,

— topsoil material from forestry areas is re-used for similar purposes.

C.3 Development of analytical strategies

Samples of soil materials should normally be analysed for their pseudo-total concentrations [e.g. metals soluble in strong acids such as aqua regia (ISO 11466)], availability to plants (concentrations soluble in weak extractants) or the environment (e.g. concentrations extractable in water) and in respect of the soil parameters that might influence their behaviour (e.g. pH value, percentage of organic material, clay content).

Some suggestions regarding where investigation is required and the range of analyses required are listed in Table C.1.

Care should be used in following all such listings, including those given here. They do not obviate the need for the assessor to think about what might be present on the site to be investigated, taking all available information into account.

It should be noted that “biological contaminants” in the form of vermin, vermin-carried pathogens [e.g. Weil’s disease (Leptospirosis)] and infected needles may be present in old derelict buildings.

Some recommendations on when soils and other soil materials should be investigated are listed in Table C.2.

When soil material is re-used for soil improvement or recultivation, the nutrients in the soil material should be considered. In some cases, use of organic soils (for example half-bog soils, low moor soils) may involve a risk of a high rate of nitrogen mineralization and of consequent leaching of nitrate into surface water or groundwaters.

In addition to the contents of potentially harmful substance, other characteristics governing the water, air and substance regime (e.g. field capacity, infiltration ability, air capacity, exchange capacity) as well as the ability of the soil to be cultivated (e.g. rock content) should be taken into account for soil material used for soil improvement or recultivation. This includes pH value, clay content (soil type), parent material and organic matter (humus) content.

Deposition of soil material containing proportions of e.g. sulfate rock (gypsum, anhydrite) or pyritic clay mineral can result in impairment of surface or groundwater quality at the target site.

Table C.1 — Types of contaminated sites and related compounds

Type of industry	Typical contaminants
Petrol stations and other sites for storage, treatment and handling of oil and petroleum	Volatile aromatics [benzene, toluene, xylene, ethylbenzene, methyl t-butyl ether (MTBE)]; alkanes C_5 to C_{20}; methyl ethyl ketone (MEK); organolead.
Manufacture of paint, lacquer and enamel	Solvents (petrol, turpentine, volatile aromatics, alcohols, ketones, esters, glycoethers and esters, chlorinated hydrocarbons, acrylamides); metals, etc. (arsenic, chromium, copper, cadmium, lead, zinc).
Asphalt and tar production plants	Volatile aromatics [benzene, toluene, xylenes; phenols; naphthalenes, polycyclic aromatic hydrocarbons (PAHs)]; other hydrocarbons.
Gasworks	Phenols and alicyclic phenols, PAHs, volatile aromatics, cyanides, thiocyanates, ammonia, sulfur compounds.
Timber treatment	Phenols, PAHs, creosote, chlorophenols, pesticides, dinitrophenol, arsenic, chromium, copper, tin, zinc, fluorides.
Tanneries	Solvents, sulfides and sulfates, chlorophenols, cyanides, acids, alcohols, esters, ketones, xylenes, aluminium, arsenic, boron, chromium, cadmium, cobalt, lead, anthrax spores.
Plating works (galvanic industry)	Chlorinated solvents, other solvents, cyanides, hydocarbons, arsenic, chromium, cadmium, chromium, copper, lead, nickel, silver, zinc.
Auto repair	Aliphatic hydrocarbons, volatile aromatices, PAHs, styrene, chlorinated hydrocarbons, other solvents, amines, isocyanates, MTBE, glycols, toluene di-isocyanate (TDI), copper, lead, aluminium.
Foundries, metal works, etc.	Aluminium, arsenic, cadmium, copper, chromium, lead, manganese, nickel, zinc, antimony, sulfides, phenols, formaldehyde, acids, cyanates, carbamides, amines.
Metal industry	Cadmium, copper, chromium, nickel, lead, zinc, aluminium, manganese, iron, tin, boron, fluorides, polychlorinated biphenyls (PCBs), polychlorinated triphenyls, hydrocarbons, chlorinated hydrocarbons, solvents, glycols, turpentine, alkanes, cyanides, phosphorus, acids, ethers, silicates, PAHs.
Petrol industries	Volatile aromatics (benzene, toluene, xylene, ethylbenzene, MTBE); alkanes C_5 to C_{20}; MEK; organolead compounds; PAHs; acid tars and other processing residues.
Rubber and synthetics industries	Volatile aromatics (benzene, toluene, xylene, ethylbenzene; chlorinated solvents); other solvents.
Wood, wood fibre and laminate industries	Toluene, xylenes, trichloroethene, methyl methacrylate, other solvents.
Chemical laundries and dry cleaners.	Trichloroethene, tetrachloroethene.
Printing industries	Chlorinated solvents, benzene, toluene, xylene, acetone, isopropanol, other solvents, lead, antimony.
NOTE This and any similar listings should be used with care. The listing of potential contaminants is not necessarily complete; what is present depends on the actual processes used. Not all contaminants listed will be present on a particular site.	

Table C.2 — Guidelines on when to investigate soil and soil materials

Situation	Recommended investigative action
Soils in industrial areas and in areas used for military purposes	Determine analytical strategy on the basis of site history - see Table C.1.
Topsoil (for disturbed soils also deeper layers) in the centre of urban and industrial areas (e.g. city centres)	Determine analytical strategy on the basis of site history.
Possible hazardous waste sites, abandoned hazardous waste sites and their surroundings	Determine analytical strategy on the basis of site history.
Topsoil alongside roads including verges	As, Pb, Zn, Cd, Ni, PAHs - the extent of contamination will vary with the age of the road and the amount of traffic. A minimum distance of 10 m from the edge of the road is recommended.
Topsoil around buildings and structures with anticorrosive coatings (e.g. treated power supply pylons, bridges)	Pb, Zn, Cd, Cu.
Dredged material if the nature of the catchment area of the water gives rise to the suspicion that the sediments may be contaminated	Heavy metals and arsenic, mineral oil hydrocarbons, PAHs, PCBs.
Topsoil in the surroundings of relevant emitting sources, e.g. cement industry, crematory, metal smelters	Determine analytical strategy on the basis of site history (e.g mercury from crematoria, fluoride from brickworks). Dioxins may be relevant to some sources.
Areas subject to flooding (also flood-control reservoirs) if the catchment area of the waters gives rise to the suspicion of sediment contamination	Heavy metals and arsenic, PAHs, PCBs.
Waste materials (spoil) from metalliferous mining areas and their surroundings	Heavy metals and arsenic, sulfides, cyanide, salts.
Soil (up to 0,3 m deep or to the cultivation depth) from areas where compost and sewage sludge have been spread	Heavy metals and arsenic, PAH, PCB, PCDD/F.
Soil (up to 0,3 m deep or to the cultivation depth) from areas where industrial or commercial wastes have been spread	Determine analytical strategy on the basis of site history.
Soils from areas on which untreated wastewater has been percolated over many years	Heavy metals and arsenic, PCBs, PAHs, PCDD/F.
Top soil from areas used for family and house gardens	Heavy metals and arsenic, organochlorine pesticides, PAHs.
Top soil from permanent cropping areas such as vineyards, land used for hop cultivation, tea plantations Soil of small areas, outside farmyards, mainly in farm sheds where fluid fuels and chemicals are kept and distributed.	Cu, As, Hg, organochlorine pesticides, organic fungicides.
Soil in old orchards	As, Pb, organic pesticides.
Soil in forestry areas where there is reason to suspect (e.g. because of timber treatment activities) accumulation of potentially hazardous substances	Heavy metals and arsenic, pentachlorophenol, organochlorine pesticides, PAHs.
Areas where the soil is suspected of being contaminated due to atmospheric deposition or other area-wide mechanisms (e.g. flooding with contaminated river water)	Heavy metals and arsenic.

Annex D
(informative)

Example of classification and evaluation of soils and other soil materials

D.1 General

This annex is provided solely as an example of how data obtained following the principles outlined in this International Standard can be applied in temperate zones. It should be noted that it may conflict in parts with legislative requirements or codes of practice applicable in some jurisdictions.

D.2 The concept of suitability classes

Soils and other soil materials can be broadly classified in terms of their suitability for particular uses on the basis of their physical characteristics, contents of potentially harmful substances and nutrients, and the type and composition of the parent material.

D.3 Suitability classes depending on harmful substance content

D.3.1 Test criteria and suggested suitability classes

Test criteria comprise the pseudo-total contents of potentially harmful substances. For the evaluation of inorganic substances, pH values and soil type, and for organic pollutants, the organic matter content should also be determined. When the pH of the soil material is low, the mobile heavy metal contents (neutral salt extraction) should also be used in the evaluation.

Possible suitability classes are suggested in Table D.1. The scope of the suitability classes is described in D.3.2 to D.3.4 below.

Table D.1 — Suitability classes depending on the potentially harmful substance content

Suitability class	Maximum permitted concentration of potentially harmful substance
I Unrestricted re-use	Background value (but see Note)
II Restricted re-use	Generic requirements for potential use(s)
III Restricted re-use subject to specified technical safety measures being employed	Generic requirements for the protection of surface or ground water resources
IV Re-use not permitted; treat as waste	Limits applicable to waste disposal
NOTE In some jurisdictions, generic guideline values (to be applied with professional judgement) or standards [legally binding value (ISO 11074-1)] may have been set somewhat above natural background values but at a level judged to pose minimal risks to defined potential human and ecological targets. In some jurisdictions these are known as soil screening values.	

D.3.2 Unrestricted re-use

Depending on the circumstances, the limiting concentrations of potentially harmful substances for unrestricted use of a soil material might be set on the basis that concentrations arising from anthropogenic sources (i.e. contaminants):

— should not exceed the substrate-specific background values for soils, or

— should not exceed the most restrictive generic guideline or standard value applicable in the jurisdiction (see Note to Table D.1).

When complying with these values, it can be assumed that there will be no (unacceptable) impacts on the assets worthy of protection, such as humans, animals, plants or waters.

Soil materials with geogenically increased contents of potentially harmful substances constitute an exception. These materials may be applied to soils of the same parent material if, in view of their proposed subsequent use, precautionary values with regard to human health are not exceeded.

If there are any doubts about how "clean" the soil material is, it should not be considered suitable for unlimited use.

D.3.3 Restricted re-use

Restricted re-use of soil materials may be permitted when the concentrations of potentially harmful substances exceed the background values of soils (or the generic value permitting unlimited use) but are below a specified higher value. This upper limit is typically established on the basis of the specific requirements for the potential possible uses and protected assets affected (e.g. on the basis of applicable national or regional, etc. guidelines or standards, or site-specific values).

Regard should be paid when depositing the soil material to a possible need to keep a minimum distance between the base of the deposited material and the highest groundwater level, taking into account local geology and hydrogeology and any local regulations, etc.

Soils in this class should only be used when it is proven safe to do so. They should not normally be used

— on soils with contents of potential harmful substances below the background value,

— in areas subject to flooding (e.g. flood-control reservoirs, diked areas),

— in nature reserves,

— in biosphere reserves,

— on particularly sensitive areas, such as

  — any area where there may be close contact between the material and humans, especially children, for example domestic gardens, kindergartens, school playing fields and sports fields (areas used for informal recreation, e.g. parklands, are usually less sensitive but may contain areas subject to more sensitive uses),

  — areas to be used for horticulture or agriculture,

  — established or proposed drinking water or medicinal spring protection areas.

D.3.4 Restricted re-use including technical safety measures

Re-use of soil material may sometimes be permitted even though the concentrations of potentially harmful substances can exceed the upper limits set for restricted re-use, provided certain mitigating measures are employed. Potential adverse affects on water quality are often the basis for setting concentration limits for this re-use category.

Soil materials of this suitability class may be used for certain building measures, including those listed below, when the technical safety measures indicated are observed:

a) in earthworks in hydrogeologically favourable areas (aquifers overlain by widespread layers sufficiently thick to provide protection against migrating contaminants);

b) in road construction, paved areas in industrial and commercial areas (parking or storage places) and other traffic areas (e.g. airports, harbours, goods traffic centres) as

   - base courses below a low-permeability covering layer (concrete, asphalt, pavement), and

   - bound base courses below a covering layer less permeable to water (pavement, plates).

For uses in category b) above, established good practice for the design and construction of the road, etc., should be followed.

Neither category a) nor category b) uses are appropriate in areas likely to be frequently disturbed (e.g. for repair works on supply lines and wastewater pipelines).

For other construction purposes not mentioned under a) and b), suitability for re-use should be established by agreement with the competent authorities.

Soil material of this re-use category may also be used on waste disposal sites, e.g. as a compensating layer between waste and surface sealing or as intermediate cover between layers of waste.

Regard should be paid, when depositing the soil material, to a possible need to keep a minimum distance between the base of the deposited material and the highest groundwater level, taking into account local geology and hydrogeology and any local regulations, etc.

Soil material of this re-use category should not be used for soil and site improvement, reclamation or landscape management. Nor should it be used

- in established or proposed drinking water protection areas, medicinal spring protection areas, or areas subjected to flooding (e.g. diked areas, flood-control reservoirs),

- in water reservoir areas identified in the interest of safeguarding future water supply by regional planning,

- in karst areas without sufficient low permeability covering layers and in border areas which drain in karst as well as in areas with heavily fissured and especially water conducting geological strata,

- in especially sensitive areas such as children's playgrounds, recreation grounds, sports grounds and schoolyards (see D.3),

- in drainage layers.

D.4 Soil unsuitable for re-use

Soil regarded as unsuitable for re-use should be dealt with in line with local regulatory requirements regarding storage, treatment, transport and disposal.

D.5 Additional suitability classes for soil improvement and reclamation

In addition to the content of potentially harmful substances, additional properties of the soil material (e.g. field capacity, infiltration ability, air capacity, exchange ability and its ability to be cultivated) should be taken into account for soil material to be re-used for soil improvement and reclamation.

The following test criteria are required in this connection:

- organic matter (topsoil and subsoil), e.g. according to ISO 10694;

- soil type (sand, silt, clay), e.g. according to ISO 11277;

— coarse soil fraction (gravel, grit, rock), e.g. according to ISO 11277;

— non-soil components of soil (e.g. building rubble);

— waterlogging characteristics (mottling as well as rising of groundwater and backwater).

In some cases it may be necessary to consider additional criteria (e.g. storage density during excavation from compacted soils of building roads).

For examination of the corresponding plans, a comprehensive presentation of the suitability of the soil material (classification) will be helpful. Three main suitability classes are distinguished depending on the soil type and the coarse soil fraction which serve as decisive criteria in this respect (see Table D.2).

Table D.2 — Suitability classes depending on soil type and coarse soil fraction

Suitability class[a]		**Fine soil fraction** category	**Coarse soil fraction**[b] vol. fraction, %
A	especially suitable	silts, loams	—
B	suitable	sands	—
C	limited suitability	clays	—
a	especially suitable		< 1 %
b	suitable		1 % to 10 %
c	limited suitability		10 % to 30 %

[a] The test criteria for organic matter content and waterlogging characteristics in particular may lead to another suitability classification. Reference is made to the positive influence of the humus content and the water-holding capacity of sandy soils as well as to the structure of clay soils.

[b] In this example, soil materials with grain sizes of diameter > 2 mm are characterized as coarse-textured soils. If the maximum grain diameter is less than 20 mm, the soil may be placed in a higher class. Soil particles with a grain diameter of greater than 200 mm are not suitable. Soil material with more than 10 % of foreign mineral components or with a maximum coarse-grain volume fraction of more than 30 % should not be re-used for soil improvement or recultivation.

D.6 Suitability of soils and soil materials for combining

Soil materials to be used for soil improvement or recultivation should be investigated for their suitability. For this purpose, the composition of soils should be determined as described in D.3 and D.4 on the basis of available documents or investigations (see also annex C) and placed in suitability classes according to Table D.1 and Table D.2.

In principle, only excavated soil and soil for cultivation with a similar substance and physical composition should be combined. Lowering the suitability class of receiving soils (i.e. soil at the target site) by applying excavated soil or other soil material of a lower suitability class should not normally be permitted (the concept of harmlessness). However, it is permitted to improve the site in question by application of soil material of a higher suitability class.

Based on this principle, it can be determined from the Table D.3 whether the proposed combination of soil material and receiving soil with regard to the test criteria "content of potentially harmful substances", soil type and coarse soil fraction will be permissible.

Table D.3 — Possible combinations of soils and soil materials

Suitability class of the soil material to be re-used		Suitability class of the soil at the target site							
		Content of potentially harmful substances see Table D.1		**Fine soil type** see Table D.2			**Content of coarse fraction** see Table D.2		
		I	II	A	B	C	a	b	c
Content of potentially harmful substances	I	x	x						
	II		x						
Fine soil type	A			x	x	x			
	B				x	x[a]			
	C					x			
Content of coarse fraction	a						x	x	x
	b							x	x
	c								x

x - admissible combination

[a] To ensure effective mixing and/or not to cause major changes in soil properties at the receiving site, it may be necessary to limit the depth of “sand” or “clay” applied, perhaps to no more than about 0,2 m.

If possible, soil material derived from the same substrate should be applied for soil improvement or recultivation. Changing soil properties within one area of consideration (a farm for example) may hamper management in terms of good agricultural practice.

Application of soil material on soils resulting in a rootable layer of greater than 2 m of thickness does not necessarily constitute an improvement of the soil. With special forestry cultures (deep-rooting plants), the characteristic rooting depth should be used to evaluate soil improvement. In cases of recultivation, application of soil material can be greater than 2 m thick for several reasons, e.g. filling of residual mining holes or for landscaping measures, but in these cases a combination of subsoil (or equivalent material) should ordinarily constitute the bulk of the fill material.

Annex E
(informative)

Examples of elements and compounds belonging to different contaminant groups

This annex is intended to be of use in the development of the guidance on what contaminants to look for, particularly where this refers to groups of contaminants such as "volatile organic compounds".

It is based on a US Environmental Protection Agency classification.

ORGANICS

Halogenated volatiles

Bromodichloromethane
Bromoform
Bromomethane
Carbon tetrachloride
Chlorodibromomethane
Chlorobenzene
Chloroethane
Chloroform
Chloromethane
Chloropropane
Dibromomethane
Cis-1,3-dichloropropene
1,1-Dichloroethane
1,2-Dichloroethane
1,1-Dichloroethene
1,2-Dichloroethene
1,2-Dichloropropane
Fluorotrichloromethane
Methylene chloride
1,1,2,2-tetrachloroethane
Tetrachloroethene
1,1,1-trichloroethane
1,1,2-trichloroethane
1,2-*trans*-dichloropropene
Trichloroethene
Vinyl chloride
Total chlorinated hydrocarbons
Hexachloroethane
Dichloromethane

Halogenated semivolatiles

2-chlorophenol
2,4-dichlorophenol
Hexachlorocyclopentadiene
p-chloro-*m*-cresol
Pentachlorophenol
Tetrachlorophenol
2,4,5-trichlorophenol
2,4,6-trichlorophenol
Bis(2-chloroethoxy)methane
Bis(2-chloroethyl) ether
Bis(2-chloroisopropyl) ether
4-bromophenyl phenyl ether
4-chloroaniline
2-chloronaphthalene
4-chlorophenyl phenyl ether
1,2-dichlorobenzene
1,3-dichlorobenzene
1,4-dichlorobenzene
3,3-dichlorobenzidine
Hexachlorobenzene
Hexachlorobutadiene
1,2,4-trichlorobenzene
Bis(2-chloroethoxy) phthalate
Bis(2-chloroethoxy) ether
1,2-bis(2-chloroethoxy)ethane

Non-halogenated volatiles

Acetone
Acrolein
Acrylonitrile
Benzene
2-butanone
Carbon disulfide
Cyclohexanone
Ethyl acetate
Ethyl ether
Ethyl benzene
2-hexanone
Isobutanol
Methanol
Methyl isobutyl ketone
4-methyl-2-pentanone
n-butanol
Styrene
Toluene
Trimethylbenzene
Vinyl acetate
Xylenes

Non-halogenated semivolatiles
Benzoic acid
Cresols
2,4-dimethylphenol
2,4-dinitrophenol
2-methylphenol
4-methylphenol
2-nitrophenol
4-nitrophenol
Phenol
Acenaphthene
Acenaphthylene
Anthracene
Benzidine
Benzo[*a*]anthracene
Benzo[*b*]fluoranthene
Benzo[*k*]fluoranthene
Benzo[*a*]pyrene
Benzo[*g,h,i*]perylene
Benzyl alcohol
Bis(2-ethylhexyl) phthalate
Bisphthalate
Butyl benzyl phthalate
Chrysene
Dibenzo[*a,h*]anthracene
Dibenzofuran
Diethyl phthalate
Dimethyl phthalate
Di-*n*-butyl phthalate
4,6-dinitro-2-methylphenol
2,4-dinitrotoluene
2,6-dinitrotoluene
Di-*n*-octyl phthalate
1,2-diphenylhydrazine
Fluoranthene
Fluorene
Indeno[1,2,3-*cd*]pyrene
Isophorone
2-methylnaphthalene
Naphthalene
2-nitroaniline
3-nitroaniline
4-nitroaniline
Nitrobenzene
N-nitrosodimethylamine
N-nitrosodi-*n*-propylamine
N-nitrosodiphenylamine
Phenanthrene
Phenylnaphthalene
Pyrene
Pyridine

PCBs
PCB (Arochlor)-1016
PCB (Arochlor)-1221
PCB (Arochlor)-1232
PCB (Arochlor)-1242
PCB (Arochlor)-1248
PCB (Arochlor)-1254
PCB (Arochlor)-1260
PCB (not otherwise specified)

Pesticides
Aldrin
a-Benzene hexachloride
b-Benzene hexachloride
d-Benzene hexachloride
g-Benzene hexachloride
Chlordane
4,4'-DDD
4,4'-DDE
4,4'-DDT
Dieldrin
Endosulfan I
Endosulfan II
Endosulfan sulfate
Endrin
Endrin aldehyde
Ethion
Ethyl parathion
Heptachlor
Heptachlor epoxide
Malathion
Methylparathion
Parathion
Toxaphene

Dioxins/furans
2,3,7,8-tetrachlorodibenzo-*p*-dioxin
1,2,3,7,8-pentachlorodibenzo-*p*-dioxin
2,3,7,8-tetrachlorodibenzofuran

Other organics
Cyanides

Organonitriles

Corrosives
Acetic acid
Acetyl chloride
Aniline
Aromatic sulfonic acids
Cresylic acid
Formic acid

INORGANICS

Lead
Mercury
Tin

Aluminium
Antimony
Arsenic
Barium
Beryllium
Bismuth
Cadmium
Calcium
Chromium
Copper
Cobalt
Iron
Magnesium
Manganese
Nickel
Potassium
Selenium
Sodium
Vanadium
Zinc

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