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Soil quality — Characterization of soil with respect to human exposure

Qualité du sol — Caractérisation des sols en lien avec l'évaluation de l'exposition des personnes

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

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This document was prepared by Technical Committee ISO/TC 190, *Soil quality*, Subcommittee SC 7, *Impact assessment*.

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This second edition cancels and replaces the first edition (ISO 15800:2003), which has been technically revised. The main changes compared to the previous edition are as follows:

— the feedback on contaminated soil management for 15 years has been taken into account;

— the analysis results have been updated.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

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Introduction

Characterizations of soils and sites relating to human exposure are performed all over the world. They are often planned and conducted by consultancies and expert organizations. Information from these characterizations is used to assess human exposure. Furthermore, these characterizations are used for decision-making by companies, individuals and local and national authorities as well as a basis for recommendations and regulations issued by national and international authorities.

The assessment of potential human health effects from exposure can be used for:

— the classification of contaminated sites;

— recommendations regarding the remediation of sites, soils and soil materials, e.g. priority of remediation;

— decisions regarding the future/planned use of contaminated sites;

— decisions regarding the disposal/treatment/re-use of contaminated or remediated soil and/or soil material.

The information needed for evaluations of human exposure is, to some extent, dependent on the way in which the exposure is assessed, e.g. calculations can be based on different scenarios, each requiring different information.

The extent of investigations necessary for the assessment of human exposure varies depending on the level of contamination and the investigated area. In some cases, the assessment of potential human health exposure can be based solely on information on the substances present in the soil and their concentrations and the relevant soil parameters. In other cases, it is necessary to know the "availability" of the substance (i.e. the proportion biologically active). This information will depend on the type and concentration of the substance, the relevant soil parameters and the type of exposure relevant for the area investigated, represented in the conceptual site model (CSM). Furthermore, the sampling method and strategies can depend on the use of the project area and the possible exposure patterns.

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Soil quality — Characterization of soil with respect to human exposure

1 Scope

This document provides guidance on the type and extent of soil characterization necessary for the evaluation of human exposure to substances present in possibly leading to adverse effects.

It does not provide guidance on:

— the design or selection of numerical models that can be used to estimate exposure;

— potential exposure to radioactivity, pathogens or asbestos in soil.

Background information is provided on human health related to exposure to soil and the influence on exposure via different pathways.

NOTE 1 For convenience "soil" in this document also includes "soil material" unless stated otherwise.

NOTE 2 Overall exposure can be due to potentially harmful substances (PHSs) in soil, groundwater and air. Exposure to those in soil can be direct (e.g. through inhalation, ingestion, cutaneous contact), or indirect (through the consumption of plants or animals that have taken up substances of concern).

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NOTE 3 The evaluation of the possible impact on human health of potentially harmful substances is most commonly required when these are present as a result of human activity (e.g. on old industrial sites) but can sometimes be required when they are present naturally.

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NOTE 4 Soil characterization precedes the assessment of the compatibility between soil and its use (i.e. soil quality assessment). Tools such as a conceptual site model (CSM) and health risk assessment can be used to aid this assessment.

NOTE 5 Soil characterization can be used to develop an overview of population exposure to soil. Other International Standards are available that can aid the characterization of other media (e.g. surface and groundwater), in terms of their possible adverse effects on humans.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 11074, *Soil quality — Vocabulary*

ISO 25177, *Soil quality — Field soil description*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 11074, ISO 25177 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

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3.1
analytical data quality objectives
statement of the required detection limits, accuracy, reproducibility and repeatability of the required analytical and other data

Note 1 to entry: Generic data quality objectives might sometimes be set at national level. Data quality objectives can also embrace the amount of data required for an area of land [or part of a *site* (3.21)] to enable a sound comparison with generic guidelines or standards or for a site-specific or material-specific estimation of *risk* (3.17).

3.2
bioaccessibility
fraction of a substance in *soil* (3.23) or *soil material* (3.25) that is liberated in (human) gastrointestinal juices and thus available for absorption

[SOURCE: ISO 17924:2018, 3.2]

3.3
bioavailability
fraction of a substance present in ingested *soil* (3.23) that reaches the systemic circulation (blood stream)

[SOURCE: ISO 17924:2018, 3.3]

3.4
contaminant
substance or agent present in the *soil* (3.23) as a result of human activity

Note 1 to entry: There is no assumption in this definition that harms results from the presence of the contaminant. See also *pollutant* (3.14).

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[SOURCE: ISO 11074:2015, 3.4.6, modified — Term number in Note 1 to entry has been adapted to the numbering of this document.]

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3.5
deep soil
soil (3.23) that is generally deeper than 90 cm and that is not accessible in normal situations but can become accessible in case of construction site for example

Note 1 to entry: Examples include construction of foundations and basements, installation of services, planting pits for trees and shrubs.

3.6
exposure assessment
process of establishing whether, and how much, exposure occurs between a *receptor* (3.16) and a contaminated *source* (3.26)

[SOURCE: ISO 11074:2015, 5.2.11]

3.7
exposure pathway
path a chemical takes from a *source* (3.26) to a *receptor* (3.16)

EXAMPLE Ingestion, *inhalation* (3.11) or cutaneous contact.

[SOURCE: ISO 11074:2015, 5.2.12, modified — Note 1 to entry has been replaced by the example, accepted term "exposure routes" not included.]

3.8
groundwater
water which is being held in and can be recovered from an underground formation, except capillary water

Note 1 to entry: Groundwater is usually taken to include any water, beneath the surface of the land or beneath the bed of any stream, lake, reservoir, or other body of *surface water* (3.29), whatever the geological formation or structure in which such water occurs; but water within the beds of streams, etc. is often excluded.

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[SOURCE: ISO 11074:2015, 3.2.3]

3.9
hazard
property of a substance or material or situation that in particular circumstances could lead to harm or pollution

[SOURCE: ISO 11074:2015, 5.2.15]

3.10
ingestion
exposure pathway (3.7) of substances reaching the body by oral intake, such as from contaminated food or direct *soil* (3.23) intake, in particular by children

3.11
inhalation
exposure pathway (3.7) of airborne particles and gases reaching the body during breathing

Note 1 to entry: The inhalation exposure covers alveolar exposure as well as bronchial exposure; and this bronchial mucus can subsequently be ingested.

3.12
non–threshold effect substance
substance for which there is considered to be some *risk* (3.17) at any level

3.13
pathway
mechanism or route by which substance or agent could come into contact with, or otherwise affect, a *receptor* (3.16)

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Note 1 to entry: Examples can be migration pathway, transfer pathway and *exposure pathway* (3.7).

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[SOURCE: ISO 11074:2015, 5.2.21, modified — Note 1 to entry added.]

3.14
pollutant
substance or agent present in the *soil* (3.23) [or *groundwater* (3.8)] which, due to its properties amount or concentration, causes adverse impacts on soil functions or on human health or other *receptors* (3.16)

[SOURCE: ISO 11074:2015, 3.4.18, modified — The phrase "or on human health or other receptors" was added.]

3.15
potentially harmful substance
PHS
substance or agent present in the *soil* (3.23) [or *groundwater* (3.8)] which, due to its properties, amount or concentration can cause adverse impacts on soil functions or human health or *receptors* (3.16)

3.16
receptor
defined entity that is vulnerable to the adverse effect(s) of a hazardous substance or agent

EXAMPLE Human, animal, water, vegetation, building services, etc.

[SOURCE: ISO 11074:2015, 3.3.29]

3.17
risk
combination of the probability or frequency of occurrence of a defined *hazard* (3.9) and the magnitude of the consequences of the occurrence

[SOURCE: ISO 11074:2015, 5.2.24]

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3.18
risk assessment
assessment performed with the data and other information from the *site* (3.21) investigations using databases and numerical models for assessment of the release of *contaminants* (3.4) and naturally occurring *potentially harmful substances* (3.15), environmental fate analysis, *exposure assessment* (3.6), environmental impact analysis, environmental impact analysis and an uncertainty analysis

3.19
risk characterization
evaluation and conclusion based on the hazard identification and the exposure and effect assessment

3.20
scenario
quantitative risk assessment
set of conditions or assumptions about *sources* (3.26), *exposure pathways* (3.7), amounts or concentrations of agent(s)involved, and exposed organism, system, or (sub)population (i.e. numbers, characteristics, habits) used to aid in the evaluation and quantification of exposure(s) in a given situation

3.21
site
scope covered by the study

Note 1 to entry: It could be a site in the property sense (plot with defined boundaries) or a more extended area affected by the same contamination.

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3.22
site characterization
collection of appropriate information including analytical data, etc. for the assessment in question

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Note 1 to entry: In connection with *risk assessment* (3.18), specifically the *source* (3.26) identification and characterization element of the *exposure assessment* (3.6).

[SOURCE: ISO 11074:2015, 2.3.12, modified — The phrase "of data connected to a site providing" was deleted and "including analytical data, etc." was added.]

3.23
soil
upper layer of the Earth's crust transformed by weathering and physical/chemical and biological processes and composed of mineral particles, organic matter, water, air, and living organisms organized in generic soil horizons

Note 1 to entry: In a broader sense, soil includes *topsoil* (3.31) and *subsoil* (3.27), deposits such as clays, silts, sands, gravels, cobbles, boulders, and organic matter and deposits such as peat; materials of human origin such as wastes; ground gas and moisture; and living organisms.

[SOURCE: ISO 11074:2015, 2.1.11, modified — Note 1 to entry "civil engineering" was deleted.]

3.24
soil characterization
determination of relevant physical, chemical and biological properties of the *soil* (3.23) in case of human *exposure assessment* (3.6)

[SOURCE: ISO 11074:2015, 2.1.12, modified — The phrase "in case of human exposure assessment" was added.]

3.25
soil material
material composed of excavated *soil* (3.23), dredged materials, manufactured soils, treated soils and fill materials

[SOURCE: ISO 11074:2015, 7.4.16]

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3.26
source
place from which a substance or agent is released giving rise to potential exposure of one or more *receptor* (3.16)

[SOURCE: ISO 11074:2015, 3.3.35]

3.27
subsoil
natural *soil material* (3.25) below the *topsoil* (3.31) and overlying the parent material

[SOURCE: ISO 11074:2015, 2.1.20, modified — Note 1 to entry was deleted.]

3.28
surface soil
soil (3.23) exposed at the surface

Note 1 to entry: Sometimes referred to as accessible soil or superficial soil.

3.29
surface water
water on the surface of the planet such as in a river, lake, wetland, or ocean

Note 1 to entry: It can be contrasted with *groundwater* (3.8) and atmospheric water.

3.30
threshold effect substance
substance where the critical effect is considered to have dose or exposure below which a significant adverse effect is not expected

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Note 1 to entry: An adverse effect is a change in morphology, physiology, growth, development or life span of an organism which results in impairment of functional capacity or impairment of capacity to compensate for additional stress or increase in susceptibility to the harmful effects of other environmental influences. Decisions on whether or not any effect is adverse require expert judgement.

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3.31
topsoil
upper part of a natural *soil* (3.23) that is generally dark coloured and has a higher content of organic matter and nutrients when compared to the (mineral) horizons below, excluding the humus layer

[SOURCE: ISO 11074:2015, 2.1.21, modified — Note 1 to entry has been removed.]

4 Use of this document

The purpose of characterizing soil (or other media) as suggested in this document is primarily to perform risk assessments with respect to human exposure. These assessments can be performed by referring to published international or national standards that set out physical, chemical or other criteria that shall be complied with, or according to criteria set on a site-specific basis. In many jurisdictions, formal guidance on such assessments has been published and should be considered. Guidance has also been provided by professional organizations and some standardization bodies.

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

To provide context to this guidance, a general, non-normative account of human risk assessment, with particular emphasis on when humans are exposed to soil is provided in Clause 5. Clause 6 considers the relationship between soil and particular exposure pathways. Guidance on characterization of the soil,

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for example in terms of physical properties is provided in Clause 7, and in terms of what substances to look for and how to measure them in Clause 8. Clause 9 provides information on how the results of characterization can be used and Clause 10 provides guidance on how to ensure that information collected including analytical data are sufficient for the investigation in hand in terms of quality, quantity and type. How to achieve the last is the principal purpose of Clauses 7 and 8.

This document refers in places to substance, potentially harmful substances (PHSs) and to contaminants. The latter applies strictly only when a substance or agent is present due to human activity but unless indicated otherwise or by the context can be assumed to also include substances that are present naturally as well as those present due to human activity. The term pollutant is not used in this document (see Note).

As indicated by the note below, those preparing human health risk assessments should always be careful to define the terms and concepts they are employing in reports. Terms are not used consistently by people with different backgrounds and experience, and there can be subtle differences in how terms are used and understood. It is also important to remember that reports will often be read by those without specific training or education in risk assessment.

NOTE It is important when carrying out human health risk assessment to carefully define the terms that are being used, especially for example "contaminant/contamination" and "pollutant/pollution" because they might not be understood to have the same meaning by people with different backgrounds and experience. This document follows the established convention for documents published by ISO Technical Committee 190 (TC190) in distinguishing between "contaminant" ("substance or agent present in an environmental medium as a result of human activity – see 3.4) and "pollutant" ("substance or agent present in the soil (or groundwater) which, due to its properties, amount or concentration, causes adverse impacts on soil functions" – see 3.14 and ISO 11074:2015, 3.4.18). Hence, "contamination" and "pollution" are not considered to be the same thing. However, it is recognised that this distinction is not always made at "official" level in all jurisdictions. Even in those jurisdictions where it is recognised, it might be for some purposes but not others and the definitions of "contamination" and "pollution" used in legislation and regulations for different purposes can differ. In addition, the use of the terms is not necessarily consistent between and even within guidance documents produced by government and professional bodies.

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5 Background

5.1 Characterization of soil and sites with respect to human exposure

Characterizations of soils and sites with respect to human exposure are usually performed as a part of a risk assessment.

In most countries, industrial activities have had adverse effects on soil and groundwater quality. Similarly, soil and groundwater quality is often adversely affected by agricultural and similar activities. Elevated concentrations of potentially harmful substances (PHSs) can also be present naturally.

The accumulation of substances in soil, groundwater and other media (food, air) should be taken into account when quantifying human exposure to PHSs to assess potential effects on humans.

PHSs often have acute and/or chronic effects on human health. The risks usually addressed in formal human health risk assessments (for example, of old industrial sites) are chronic.

In the event of an incidental discovery of contamination during excavation, potential effects on, for example, human health and safety, should be identified, measured and monitored, and assessed

The toxic action of a substance can be divided into acute effects and chronic effects:

— acute health effects are quickly seen, usually after exposures to fairly high levels or concentrations of potentially harmful substances (such exposures often cause severe symptoms in animals or humans which develop rapidly);

— chronic (long-lasting) health effects usually develop more slowly and can be the result of either a short-term exposure or due to a long and continuous exposure to low concentrations of a potentially

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harmful substance which in some cases (e.g. cadmium) accumulates in the body over time until a harmful concentration is reached.

NOTE 1 Care is required when using the terms “short-term” and “long-term” and “acute” and “chronic” and to be clear whether an “exposure” or “effect” is being described. For example, in terms of occupational exposure, some conventions ascribe “short-term” to only a few minutes exposure, whereas “long-term” might assume exposure lasting up to about 8 h (i.e. a working day). The adverse effect being guarded against, might be “acute”, i.e. manifest immediately or shortly after exposure, or might only become manifest in the longer term. For example, a single exposure to asbestos might be the cause of cancer 30 or 40 years later. In contrast, short-term exposure might result in a chronic (long-lasting) effect that first becomes manifest shortly after exposure.

Acute risks and chronic risks should always be considered and appropriate risk assessments carried out (these are often required by regulations relating to occupational health and safety, etc.).

Chronic risks are generally considered using health risk assessment based on long-term exposure (between one year and life-time). Models can be used to predict exposure and can incorporate case-specific and realistic assumptions. The expected effects are either localised or systemic. These effects can be carcinogenic, teratogenic or thresholded, depending on the toxicological properties of the substance.

NOTE 2 Duration of exposure is not taken into account in risk calculations for substances with threshold effects, see Reference [61]. For a substance of concern due to its toxicity (i.e. with threshold effects) but which does not accumulate in the body, the length of exposure is irrelevant in classical model equations.

A risk assessment comprises the following elements:

— hazard identification,

— dose-response assessment,

— exposure assessment, and

— based on the above, risk characterization.

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Risk and exposure assessments are usually performed on the basis of one or more defined scenarios, see Reference [60], e.g. to establish general criteria related to the scenario, or on the basis of the data associated with a specific site.

An exposure assessment is the process wherein the intensity, frequency, and duration of human exposure to a substance are estimated. It comprises:

— source identification and characterization,

— identification of exposure pathways,

— identification of relevant receptors groups with relevant exposure scenarios, and

— based on the above, the exposure assessment itself.

The development of a conceptual site model (CSM) can be used to identify exposure pathways relevant to the assessment of a site and hence the type of soil characterization to be carried out. In this context, a (potentially) contaminated site is an area defined, for example, by property boundaries and contaminated by past or present human activities. It might be an area of natural, near natural or agricultural land or an artisanal or industrial site. In many countries, contaminated sites are registered publicly as a consequence of specific legislation.

The CSM first relies on an inventory of sources, transfer pathways and receptors (current or future). In the context of potentially contaminated sites, this CSM in turn leads to the formulation of contamination-related hypotheses that the investigation at the site examines through the collection of relevant information. The term “contaminant linkage” is used to describe a particular combination of contaminant source, exposure pathway, and receptor. It is site-specific and it facilitates the decision-making process relating to a potentially contaminated site. It is used to develop appropriate sampling

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