



**International
Standard**

ISO 24212

**Remediation techniques applied at
contaminated sites**

Techniques de dépollution appliquées aux sites pollués

**First edition
2024-09**

iTeh Standards
(<https://standards.iteh.ai>)
Document Preview

[ISO 24212:2024](https://standards.iteh.ai/catalog/standards/iso/b736d5aa-d26c-47fa-bf2f-403e07edc55e/iso-24212-2024)

<https://standards.iteh.ai/catalog/standards/iso/b736d5aa-d26c-47fa-bf2f-403e07edc55e/iso-24212-2024>

iTeh Standards
(<https://standards.itih.ai>)
Document Preview

[ISO 24212:2024](https://standards.itih.ai/catalog/standards/iso/b736d5aa-d26c-47fa-bf2f-403e07edc55e/iso-24212-2024)

<https://standards.itih.ai/catalog/standards/iso/b736d5aa-d26c-47fa-bf2f-403e07edc55e/iso-24212-2024>



COPYRIGHT PROTECTED DOCUMENT

© ISO 2024

All rights reserved. Unless otherwise specified, or required in the context of its implementation, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

	Page
Foreword	viii
Introduction	ix
1 Scope	1
2 Normative references	1
3 Terms and definitions	1
4 Abbreviated terms	3
5 Overview	5
5.1 Structure of this document.....	5
5.2 Generic concepts associated with remediation.....	6
6 Good practice for carrying out a strategies appraisal prior to implementing remediation strategy	8
6.1 General.....	8
6.2 Identifying feasible remediation strategies.....	9
6.3 Detailed evaluation of strategies appraisal.....	9
6.4 Selecting the final remediation strategy.....	11
7 Generic recommendations for the selection of remediation techniques	11
7.1 General.....	11
7.2 Considering the site's context.....	12
7.3 Remediation set up on-site.....	13
7.4 Techniques prerequisites.....	13
7.5 Techniques collateral effects.....	14
7.6 Laboratory testing and pilot tests.....	14
8 Generic recommendations for managing hazards and risks during remediation	14
8.1 General.....	14
8.2 Risk management process.....	15
8.2.1 General.....	15
8.2.2 Hazards and controls associated with contaminated soil and groundwater.....	15
8.2.3 Asbestos.....	16
8.2.4 Dust.....	16
8.2.5 Offensive or noxious odours.....	16
8.2.6 Contaminated waste.....	16
8.2.7 Remediation equipment.....	16
8.2.8 Unexpected finds.....	17
8.2.9 Long-term monitoring.....	17
8.2.10 Outdoor work.....	17
8.2.11 Remote or isolated working.....	17
8.2.12 Underground services and pipelines.....	17
8.2.13 Ground stability.....	18
8.2.14 Excavations.....	18
8.2.15 Unexploded ordnance (UXO).....	18
8.2.16 Confined space.....	18
8.2.17 Hazardous chemicals and dangerous goods.....	18
8.2.18 Hazardous manual tasks.....	19
8.2.19 Slips, trips and falls.....	19
8.2.20 Plant and equipment.....	19
8.2.21 Noise.....	19
9 Remediation techniques description	20
9.1 In situ chemical oxidation (ISCO).....	20
9.1.1 Technique principle.....	20
9.1.2 Scope and applicability of the technique (operating window).....	20
9.1.3 Technology description.....	20

ISO 24212:2024(en)

9.1.4	Design considerations and dimensioning	20
9.1.5	Key monitoring parameters	21
9.1.6	Advantages and limitations	21
9.1.7	Specific EHS aspects	21
9.1.8	Other techniques or containment approaches that can be combined with the technique	22
9.2	In situ chemical reduction (ISCR)	22
9.2.1	Technique principle	22
9.2.2	Scope and applicability of the technique	22
9.2.3	Technology description	22
9.2.4	Design considerations and dimensioning	22
9.2.5	Key monitoring parameters	22
9.2.6	Advantages and limitations	23
9.2.7	Specific EHS aspects	23
9.2.8	Other techniques that can be combined with the technique	23
9.3	Enhanced in situ bioremediation (EISB)	23
9.3.1	Technique principle	23
9.3.2	Scope and applicability of the technique (operating window)	23
9.3.3	Description of technology	24
9.3.4	Design considerations and dimensioning	24
9.3.5	Key monitoring parameters	24
9.3.6	Advantages and limitations	24
9.3.7	Specific EHS aspects	25
9.3.8	Other techniques or containment approaches that can be combined with the technique	25
9.4	Monitored natural attenuation (MNA)	25
9.4.1	Technique principle	25
9.4.2	Scope and applicability of the technique (operating window)	25
9.4.3	Description of technology	25
9.4.4	Design considerations and dimensioning	25
9.4.5	Key monitoring parameters	25
9.4.6	Advantages and limitations	26
9.4.7	Specific EHS aspects	26
9.4.8	Other techniques or containment approaches that can be combined with the technique	26
9.5	Incineration	26
9.5.1	Technique principle	26
9.5.2	Scope and applicability of the technique	26
9.5.3	Technology description	26
9.5.4	Design considerations and dimensioning	27
9.5.5	Key monitoring parameters	27
9.5.6	Advantages and limitations	27
9.5.7	Specific EHS aspects	28
9.5.8	Other techniques or containment approaches that can be combined with the technique	28
9.6	In situ thermal remediation (ISTR)	28
9.6.1	Technique principle	28
9.6.2	Scope and applicability of the technique (operating window)	28
9.6.3	Description of technology	28
9.6.4	Design consideration and dimensioning	29
9.6.5	Key monitoring parameters	29
9.6.6	Advantages and limits	29
9.6.7	Specific EHS aspects	30
9.6.8	Other techniques or containment approaches that can be combined with the technique	30
9.7	On-site thermal desorption	30
9.7.1	Technique principle	30
9.7.2	Scope and applicability of the technique (operating window)	30
9.7.3	Technology description	30

9.7.4	Design considerations and dimensioning	30
9.7.5	Key monitoring parameters	31
9.7.6	Advantages and limits	31
9.7.7	Specific EHS aspects	31
9.7.8	Other techniques or containment approaches that can be combined with the technique	31
9.8	Soil vapour extraction (SVE)	31
9.8.1	Technique principle	31
9.8.2	Scope and applicability of the technique (operating window)	32
9.8.3	Technology description	32
9.8.4	Design and dimensioning considerations	32
9.8.5	Key monitoring parameters	32
9.8.6	Advantages and limits	33
9.8.7	Specific EHS aspects	33
9.8.8	Other techniques or containment approaches that can be combined with the technique	33
9.9	Air-sparging	33
9.9.1	Technique principle	33
9.9.2	Scope and applicability of the technique (operating window)	33
9.9.3	Technology description	34
9.9.4	Design considerations and dimensioning	34
9.9.5	Key monitoring parameters	34
9.9.6	Advantages and limits	34
9.9.7	Specific EHS aspects	34
9.9.8	Other techniques or containment approaches that can be combined with the technique	34
9.10	Multi-phase extraction (MPE)	35
9.10.1	Technique principle	35
9.10.2	Scope and applicability of the technique (operating window)	35
9.10.3	Technology description	35
9.10.4	Design considerations and dimensioning	35
9.10.5	Key monitoring parameters	35
9.10.6	Advantages and limitations	36
9.10.7	Specific EHS aspects	36
9.10.8	Other techniques or containment approaches that can be combined with the technique	36
9.11	Dual pump liquid extraction (DPLE)	36
9.11.1	Technique principle	36
9.11.2	Scope and applicability of the technique (operating window)	36
9.11.3	Technology description	37
9.11.4	Design considerations and dimensioning	37
9.11.5	Key monitoring parameters	37
9.11.6	Advantages and limitations	37
9.11.7	Specific EHS aspects	37
9.11.8	Other techniques or containment approaches that can be combined with the technique	37
9.12	Hydraulic techniques for groundwater remediation	38
9.12.1	Technique principle	38
9.12.2	Scope and applicability of the technique (operating window)	38
9.12.3	Technology description	38
9.12.4	Design considerations and dimensioning	38
9.12.5	Key monitoring parameters	39
9.12.6	Advantages and limitations	39
9.12.7	Specific EHS aspects	39
9.12.8	Other techniques or containment approaches that can be combined with the technique	39
9.13	Soil washing	39
9.13.1	Technique principle	39
9.13.2	Scope and applicability of the technique (operating window)	39

ISO 24212:2024(en)

9.13.3	Technology description.....	40
9.13.4	Design and dimensioning considerations.....	40
9.13.5	Key monitoring parameters.....	40
9.13.6	Advantages and limitations.....	40
9.13.7	Specific EHS aspects.....	40
9.13.8	Other techniques or containment approaches that can be combined with the technique.....	41
9.14	Biopiling.....	41
9.14.1	Technique principle.....	41
9.14.2	Scope and applicability of the technique (operating window).....	41
9.14.3	Technology description.....	41
9.14.4	Design considerations and dimensioning.....	41
9.14.5	Advantages and limitations.....	42
9.14.6	Key monitoring parameters.....	42
9.14.7	Specific EHS aspect.....	42
9.14.8	Other techniques or containment approaches that can be combined with the technique.....	42
9.15	Landfarming.....	43
9.15.1	Technique principle.....	43
9.15.2	Scope and applicability of the technique (operating window).....	43
9.15.3	Technology description.....	43
9.15.4	Design considerations and dimensioning.....	43
9.15.5	Key monitoring parameters.....	44
9.15.6	Advantages and limitations.....	44
9.15.7	Specific EHS aspects.....	44
9.15.8	Other techniques or containment approaches that can be combined with the technique.....	44
9.16	Vertical barrier technologies (VBT).....	44
9.16.1	Technique principle.....	44
9.16.2	Scope and applicability of the technique.....	45
9.16.3	Technology description.....	45
9.16.4	Design considerations and dimensioning.....	45
9.16.5	Key monitoring parameters.....	45
9.16.6	Advantages and limitations.....	45
9.16.7	Specific EHS aspects.....	46
9.16.8	Other techniques or containment approaches that can be combined with the technique.....	46
9.17	Cover systems.....	46
9.17.1	Technique principle.....	46
9.17.2	Scope and applicability of the technique.....	46
9.17.3	Technology description.....	47
9.17.4	Design considerations and dimensioning.....	47
9.17.5	Key monitoring parameters.....	48
9.17.6	Avantages and limitations.....	48
9.17.7	Specific EHS aspects.....	48
9.18	Permeable reactive barrier (PRB) systems.....	49
9.18.1	Technique principle.....	49
9.18.2	Scope and applicability of the technique (operating window).....	49
9.18.3	Technology description.....	49
9.18.4	Design considerations and dimensioning.....	49
9.18.5	Key monitoring parameters.....	49
9.18.6	Advantages and limits.....	50
9.18.7	Specific EHS aspects.....	50
9.18.8	Possible combination with other techniques and technique variations.....	50
9.19	Immobilisation techniques for soil and solid materials.....	50
9.19.1	Technique principle.....	50
9.19.2	Scope and applicability of the technique (operating window).....	50
9.19.3	Technology description.....	51
9.19.4	Design and dimensioning considerations.....	51

ISO 24212:2024(en)

9.19.5	Key monitoring parameters	52
9.19.6	Advantages and limitations	52
9.19.7	Specific EHS aspects	53
9.19.8	Other techniques or containment approaches that can be combined with the technique	53
9.20	Excavation	53
9.20.1	Technique principle	53
9.20.2	Scope and applicability of the technique (operating window)	53
9.20.3	Description of technology	53
9.20.4	Design considerations and dimensioning	53
9.20.5	Key monitoring parameters	54
9.20.6	Advantages and limitations	54
9.20.7	Specific EHS aspects	54
9.20.8	Other techniques or containment approaches that can be combined with the technique	54
9.21	Off-gas treatment technologies and wastewater treatment technologies	54
9.21.1	General	54
9.21.2	Carbon adsorption	55
9.21.3	Off-gas treatment technologies	55
9.21.4	Wastewater treatment technologies	56
Annex A	(informative) Remediation techniques, characteristics and conditions of implementation	59
Annex B	(informative) Remediation techniques suitability for contaminants	63
Annex C	(informative) Examples of illustrative diagrams of remediation techniques	71
Bibliography		99

<https://standards.iteh.ai>
Document Preview

[ISO 24212:2024](https://standards.iteh.ai/catalog/standards/iso/b736d5aa-d26c-47fa-bf2f-403e07edc55e/iso-24212-2024)

<https://standards.iteh.ai/catalog/standards/iso/b736d5aa-d26c-47fa-bf2f-403e07edc55e/iso-24212-2024>

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 document 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).

ISO draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). ISO takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, ISO had not received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at www.iso.org/patents. ISO shall not be held responsible for identifying any or all such patent rights.

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.

This document was prepared by Technical Committee ISO/TC 190, *Soil quality*, Subcommittee SC 7, *Impact assessment*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 444, *Environmental characterization of solid matrices*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

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.

<https://standards.iteh.ai/catalog/standards/iso/b736d5aa-d26c-47fa-bf2f-403e07edc55e/iso-24212-2024>

Introduction

In the context of contaminated land, if unacceptable risks associated with a site are identified following a risk assessment and should be managed, remedial actions are required to prevent, minimise, remedy or mitigate the effects of the unacceptable risks. The choice, implementation and verification of remediation techniques require detailed site characterization and risk assessment.

A remediation strategy should be set up encompassing these actions by implementing technical and organisational actions on contaminant source(s), transport and exposure pathways and/or receptors, aiming to control the unacceptable impacts and associated risks that have been established following the investigations and risk assessment. Amongst these actions are the implementation of individual, or combinations of, remediation techniques aiming to address contaminants that can be present within the soil, water, soil gas or ambient air, including non-aqueous phase liquids (NAPL).

This document provides requirements and guidance on key aspects for effective implementation of individual or combinations of in situ and on-site remediation techniques. It was developed in response to demand for minimum specifications for the selection and verification of remediation strategies to manage the risks from contaminated sites.

It is intended to inform practitioners and stakeholders about the main characteristics of commonly used remediation techniques. It can also help practitioners to select technically feasible approaches within the options appraisal phase, based on the state of the art of remediation technologies.

NOTE 1 Some of the on-site techniques presented in the document can also be used within off-site treatment facilities but the latter are not covered (e.g. this document covers incineration on-site, but not incineration at a permanent off-site installation).

NOTE 2 There is a continuous development of remediation techniques. It is possible that this document does not reflect all knowledge that is gained as techniques are improved.

NOTE 3 Not all available techniques are covered. Those not covered include: electrokinetic methods to remove contaminants or to improve the effectiveness of other methods (e.g. electrokinetic enhanced bioremediation), and phytoremediation.

[ISO 24212:2024](https://standards.iteh.ai/standards/iso/b736d5aa-d26c-47fa-bf2f-403e07edc55e/iso-24212-2024)

<https://standards.iteh.ai/catalog/standards/iso/b736d5aa-d26c-47fa-bf2f-403e07edc55e/iso-24212-2024>

Remediation techniques applied at contaminated sites

1 Scope

This document provides requirements and guidance on key aspects of remediation techniques. It describes the principles, main characteristics, advantages and limitations to be considered in the selection within an option appraisal of individual or combinations of in situ and on-site remediation techniques, including:

- the type of contaminants to be dealt with;
- current and/or intended site use;
- local legal, policy, socio-economic and environmental contexts.

This document is applicable to the remediation of contaminated sites, i.e. where soil, or soil gas, ambient air or groundwater are contaminated. It identifies which phase/matrix can be targeted by a technique, e.g. fluid (groundwater, gas, non-aqueous phase liquid) or solid, and which contaminant it can be applied to. This document also provides information on hazards that can be associated with the implementation of remediation.

This document does not provide:

- an exhaustive list of remediation techniques;
- guidance on sites contaminated with radioactive substances, pathogenic or infectious agents, or “pyrotechnic devices” (e.g. unexploded ordnances);
- guidance on ex situ techniques that are set up off-site;
- a framework that covers all individual situations, or prescribes which technique(s) to use in a specific context.

<https://standards.iteh.ai/catalog/standards/iso/b736d5aa-d26c-47fa-bf2f-403e07edc55e/iso-24212-2024>

2 Normative references

There are no normative references in this document.

3 Terms and definitions

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

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

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

3.1

contaminant linkage

presence and relationship established between contaminants, preferential pathways and receptors

3.2

engineering-based technique

civil engineering technique (e.g. excavation, containment, hydraulic control) used to remove the contaminant source or soil material or to modify pathways without necessarily removing, destroying, or modifying the source

Note 1 to entry: Some of these techniques can be considered when implementing protective measures.

[SOURCE: ISO 11074:2015, 6.2.1, modified — in the term, “methods” has been changed to “technique”; Note 1 to entry has been added.]

3.3

environmental medium

soil, underlying material, sediments, surface water, groundwater, soil gas, and ambient air that can contain contaminants

[SOURCE: ISO 21365:2019, 3.4, modified — “ambient” has been added before “air”.]

3.4

ex situ treatment technique

treatment technique applied to medium to be treated (e.g. soil, groundwater) after extraction from the ground

[SOURCE: ISO 11074:2015, 6.2.2, modified — in the term and the definition, “method” has been replaced by “technique”.]

3.5

hazard

property of a substance or material or situation that in particular circumstances can lead to harm or pollution

[SOURCE: ISO 11074:2015 5.2.15]

3.6

in situ treatment technique

treatment technique applied to medium to be treated (e.g. soil, groundwater) without extraction from the ground

Note 1 to entry: The remediation installation is built on-site and the treatment of the contaminants is applied directly to the subsurface.

[SOURCE: ISO 11074:2015, 6.2.3, modified — in the term and the definition, “method” has been replaced by “technique”; Note 1 to entry has been added.]

3.7

off-site treatment

treatment applied away from the site to be remediated

[SOURCE: ISO 11074:2015, 6.2.4]

3.8

on-site treatment

treatment applied on the site being remediated

Note 1 to entry: In the case of contaminated ground, treatment is applied after extraction of *environmental medium* (3.3) material from the ground.

[SOURCE: ISO 11074:2015, 6.2.5, modified — Note 1 to entry has been added.]

3.9

remediation

process of dealing with contaminated soil, groundwater, or site to eliminate, reduce or control *risks* (3.12) to human health or the environment

Note 1 to entry: A remediation can rely on an individual remediation technique or a combination of remediation techniques.

[SOURCE: ISO 11074:2015, 6.1.17, modified — “reduce” has been added after “to eliminate”; Note 1 to entry has been added.]

**3.10
remediation strategy**

remedial design

one or more *remediation* (3.9) technologies and associated works that meets specified contamination-related *risk* (3.12) reduction objectives

Note 1 to entry: The choice of methods can be constrained by a variety of site-specific factors such as topography, geology, hydrogeology, underground services, propensity to flood and climate.

[SOURCE: ISO 18504:2017, 3.5, modified — the admitted term “remedial design” and Note 1 to entry have been added.]

**3.11
sustainable remediation**

elimination, reduction and/or control of unacceptable risks in a safe and timely manner whilst optimising the environmental, social and economic value of the work

[SOURCE: ISO 18504:2017, 3.10, modified — “reduction” was added after “elimination”.]

**3.12
risk**

combination of the probability or frequency of occurrence of a defined *hazard* (3.5) and the magnitude of the consequences of the occurrence

[SOURCE: ISO 11074:2015, 5.2.24]

**3.13
unacceptable risk**

level of *risk* (3.12) that requires *remediation* (3.9)

Note 1 to entry: The level of risk may be evaluated by comparison to a relevant numeric threshold or by benchmarking against a narrative definition. Different levels of risk are deemed unacceptable in different countries or even by different laws within a country.

ISO 24212:2024

[SOURCE: ISO 11074:2015/Amd 1:2020, 6.5.10]

4 Abbreviated terms

BTEX	benzene toluene ethylbenzene xylene-isomers
COD	chemical oxygen demand
DNAPL	dense non-aqueous phase liquid
DPLE	dual pump liquid extraction
ECH	electric conduction heating
EHS	environment health and safety
EISB	enhanced in situ bioremediation
ENA	enhanced natural attenuation
FAG	funnel and gate
GAC	granular activated carbon

HDPE	high density polyethylene
HRC®	hydrogen release compound
ISC	in situ combustion
ISCO	in situ chemical oxidation
ISCR	in situ chemical reduction
ISTD	in situ thermal desorption
ISTR	in situ thermal remediation
LCA	life cycle assessment
LNAPL	light non-aqueous phase liquid
MNA	monitored natural attenuation
MPE	multi phase extraction
MTBE	methyl ter-butylether
NOD	natural oxidant demand
NSZD	natural source zone depletion
ORC®	oxygen release compound
ORP	oxydation reduction potential
P&T	pump-and-treat
PAH	polyaromatic hydrocarbon
PBDD	polybrominated dibenzo-p-dioxin
PBDF	polybrominated dibenzo furan
PCDD	polychlorodibenzodioxines
PCDF	polychlorodibenzofuranes
PCBs	polychlorobiphenyls
PCE	perchloroethylene or tetrachloroethylene
PFAS	per-and polyfluoroalkyl substances
PRB	permeable reactive barrier
PVC	polyvinyl chloride
POPs	persistent organic pollutants
ROC	return on capital
RoC	radius of capture
ROI	return on investment