

ISO 18400-104:2018 (E)

Soil quality — Sampling — Part 104: Strategies

Contents

	Foreword
	Introduction
1	Scope
2	Normative references
3	Terms and definitions
4	Overall investigation strategy
4.1	General
4.2	Zoning
4.3	Types of investigation
4.3.1	General
4.3.2	Preliminary investigation
4.3.3	Exploratory investigation
4.3.4	Detailed investigation
4.3.5	Supplementary investigations
4.4	Conceptual site model
4.5	Preliminary risk assessment
5	Sampling strategies — General aspects
5.1	Sampling objectives
5.2	Scope of the sampling strategy
5.3	Designing the sampling strategy
5.4	Principal sampling situations
5.5	Representative and sufficiently representative samples
5.6	Characteristics of the spatial distribution
5.7	Statistical aspects
5.8	Uncertainty of measurements caused by sampling and analysis
5.9	Safety and environmental protection
5.10	Barriers to sampling
5.11	Timing of investigations
6	Sampling strategies — Key aspects and concepts
6.1	Statistics and geostatistics
6.1.1	General
6.1.2	Statistics
6.1.3	Geostatistics
6.2	Approaches to sampling
6.2.1	General
6.2.2	Judgemental sampling
6.2.3	Systematic sampling
6.2.4	Convenience sampling
6.3	Average properties
6.4	Types of samples
6.4.1	General
6.4.2	Disturbed and undisturbed samples
6.4.3	Spot (single) samples
6.4.4	Cluster samples
6.4.5	Spatial (composite) samples
6.4.5.1	Characteristics
6.4.5.2	Advantages, disadvantages, limitations
6.4.5.3	Recommendations for application

6.4.6	Selective samples
6.5	Number of samples
6.5.1	General
6.5.2	Number of samples at discrete sampling points
6.5.3	Number of cluster samples
6.5.4	Number of composite samples
6.6	Sample sizes
6.6.1	General
6.6.2	Practical considerations
7	Deciding how many samples to take
7.1	General
7.2	Basic situations
7.3	Determining average concentrations
7.3.1	General
7.3.2	Using spatial composite samples
7.3.3	Using spot samples
7.3.4	Determining relation to threshold limit
7.4	Finding (hot spots and) areas of interest of a specified minimum size
7.5	Sampling for particular purposes
7.5.1	Determination of background values
7.5.2	Waste classification
7.5.3	Supplementary investigations for remediation
7.5.4	Validation of remediation and other works
8	Sampling strategies for in-ground sampling
8.1	Approach to sampling
8.2	Sampling patterns
8.2.1	General
8.2.2	Potentially contaminated sites
8.2.3	Hot spot detection, site investigation design and sampling
8.3	Types of samples
8.4	Sampling depths
8.4.1	General
8.4.2	Potentially contaminated sites
8.4.3	Sampling in relation to the groundwater profile and aquifer
8.5	Size of samples
8.6	Number of samples
8.6.1	General
8.6.2	Number of samples at individual sampling points
8.6.3	Number of composite samples
9	Sampling of above-ground deposits
9.1	General
9.2	Sampling patterns
9.3	Types of sample
9.3.1	General
9.3.2	Convenience sampling
9.4	Sampling depths
9.5	Size of samples
9.6	Number of samples
Annex A	(informative) Basic statistical concepts
A.1	General
A.2	Population and subpopulation
A.2.1	General
A.2.2	Population
A.2.3	Subpopulation
A.2.4	Population parameters
A.2.5	Dependence on sample scale
A.2.6	Dispersion variance
A.3	Variability
A.3.1	General
A.3.2	Types of variability

- A.3.3 Fundamental variability
- A.3.4 Spatial variability
- A.3.5 Variability between soil units
- A.4 Estimation error
- A.5 Reliability
- A.5.1 General
- A.5.2 Bias
- A.5.3 Precision and confidence
- A.5.4 Estimation of statistical parameters

Annex B (informative) Sampling patterns

- B.1 General
- B.1.1 Overview
- B.1.2 Bayesian approaches to investigation and sampling
- B.1.3 Sampling in three-dimensions
- B.2 Patterns for spatial composite sampling
- B.3 Sampling patterns for permanent monitoring sites
- B.4 Circular grids
- B.5 Simple random sampling
- B.6 Stratified random sampling
- B.7 Regular grids
- B.8 Systematic unaligned sampling
- B.9 Herringbone pattern
- B.10 Systematic sampling on a triangular grid
- B.11 Sampling along a linear source
- B.12 Sampling in three dimensions
- B.12.1 Simple random sampling in 3 dimensions
- B.12.2 Stratified random sampling in 3 dimensions
- B.12.3 Systematic regular sampling
- B.12.4 Sampling the surface of above-ground deposits
- B.12.5 Directional sampling

Annex C (informative) Assessment and modification of sampling uncertainty

- C.1 General
- C.2 Example of estimation of uncertainty and improvement in fitness-for-purpose

Annex D (informative) Examples of sampling for particular purposes

- D.1 General
- D.2 Example 1: Determination of the compliance of a soil stockpile with national limit values for re-usability
- D.2.1 Purpose of sampling
- D.2.2 Definition of sampling objectives
- D.3 Example 2: Verification of physical characteristics of supplied soil
- D.3.1 Purpose of sampling
- D.3.2 Definition of sampling objectives
- D.4 Example 3: Detailed characterization of a stockpiled soil
- D.4.1 Purpose of sampling
- D.4.2 Definition of sampling objectives

Annex E (informative) Scale of sampling

- E.1 Spatial variability and scale
- E.2 Three specific situations for which the scale is defined
- E.2.1 Situation 1
- E.2.2 Situation 2
- E.2.3 Situation 3
- E.3 Effects of different definitions of the scale on sampling results
- E.4 Choices about the scale of sampling

Annex F (informative) Determination of size and number of samples and increments

- F.1 General
- F.2 Background to the determination of the minimum increment size
- F.3 Background to determination of the minimum sample size
- F.4 Use of the equation for the minimum sample size
- F.4.1 General

- F.4.2 Particle size distribution, factors D05, D95 and g
- F.4.3 Density of the particle
- F.4.4 Fraction of the particles with the characteristic to be determined, factor w
- F.4.5 Coefficient of variation from the fundamental error, factor σ_{rel}
- F.4.6 Commonly used assumptions
- F.5 Determination of the maximum particle size, factor D95
- F.5.1 General
- F.5.2 Step 1: Sampling
- F.5.3 Step 2: Sieving the sample
- F.6 Calculation of the actual increment and sample size
- F.6.1 Spot sampling
- F.6.2 Composite sampling

Annex G (informative) Statistical methods for estimating soil parameters

- G.1 General
- G.2 Estimation of statistical parameters from n available samples
- G.2.1 Symbols and abbreviated terms
- G.2.2 Mean
- G.2.3 Standard deviation
- G.2.4 Coefficient of variation
- G.2.5 Percentiles
- G.2.5.1 General
- G.2.5.2 Percentiles assuming normality
- G.2.5.3 Percentiles assuming log-normality
- G.2.5.4 Percentiles — Non parametric approach
- G.2.6 Maximum
- G.2.7 Percentage compliance with a given limit
- G.2.7.1 General
- G.2.7.2 Percentage compliance — Parametric approach
- G.2.7.3 Percentage compliance — Non-parametric approach
- G.3 Calculating the number of samples required to achieve a desired precision
- G.3.1 Symbols and abbreviated terms
- G.3.2 Estimating a mean concentration
- G.3.2.1 Using composite sampling
- G.3.2.2 Using individual samples
- G.3.3 Estimating a standard deviation
- G.3.4 Estimating a percentile
- G.3.4.1 Assuming normality
- G.3.4.2 Non-parametric approach
- G.3.5 Estimating a percentage compliance with a given limit

Annex H (informative) Geostatistical methods for sampling design and evaluation of soil quality

- H.1 General
- H.2 Characterization of spatial variability
- H.2.1 General
- H.2.2 Exploratory data analysis (EDA)
- H.2.2.1 General
- H.2.2.2 Information on the site and its sampling
- H.2.2.3 Presentation of the data
- H.2.2.4 Simple statistics
- H.2.2.5 Variogram cloud
- H.2.2.6 Sample variogram
- H.2.3 Variogram fitting
- H.3 Geostatistical interpolation and simulation methods
- H.3.1 Kriging and related techniques
- H.3.1.1 Mapping the concentration: Kriging
- H.3.1.2 Confidence intervals
- H.3.1.3 Estimation of the probability to remain below a given threshold
- H.3.2 Geostatistical simulations
- H.3.3 Integration of auxiliary information
- H.4 Sampling design
- H.4.1 Methodology
- H.4.2 Examples
- H.4.2.1 General

- H.4.2.2 Global estimation variance for basic sampling patterns
- H.4.2.3 Minimizing the global uncertainty on the concentration
- H.4.2.4 Minimizing the local uncertainty on the concentration
- H.4.2.5 Improving the delimitation of contaminated areas
- H.4.2.6 Meet a compromise between uncertainty reduction and cost increase
- H.4.2.7 Reducing the uncertainty on the variogram
- H.4.3 Production of results for decision making

Annex I (informative) Sampling strategies for risk assessment

- I.1 Overview
- I.2 General
- I.3 Soil concentrations and risk assessment
- I.4 Hot spots
- I.5 Efficiency of sampling patterns for identifying hot spots, etc.
- I.6 Guidance on sampling strategies
- I.7 Suggested statistical approach to the use of generic assessment criteria in risk assessment
 - I.7.1 General
 - I.7.2 Sample numbers

Page count: 131