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Water quality — Sampling —

Part 12:
Guidance on sampling of bottom sediments from rivers, lakes and estuarine areas

Qualité de l'eau — Échantillonnage —

Partie 12: Recommandations concernant l'échantillonnage des sédiments dans les rivières, les lacs et les estuaires

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Contents

Page

Foreword

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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).

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For an explanation on 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 the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 147, *Water quality*, Subcommittee SC 6, *Sampling (general methods)*.

This second edition cancels and replaces the first edition (ISO 5667-12:1995), which has been technically revised.

A list of all parts in the ISO 5667 series can be found on the ISO website.

Introduction

This document should be read in conjunction with ISO 5667-1 and ISO 5667-15.

The general terminology used is in accordance with the various parts of ISO 6107, and more particularly, with the terminology on sampling given in ISO 6107-2.

Water quality — Sampling —

Part 12: Guidance on sampling of bottom sediments from rivers, lakes and estuarine areas

1 Scope

This document provides guidance on the sampling of unconsolidated sediments for the determination of their geological, physical and chemical properties, as well as the determination of biological, microbiological and chemical properties at the water and sediment interface. Guidance on achieving sediment cores is given specifically for the measurement of rates of deposition and detailed strata delineation. The main emphasis of this document is to provide methods that achieve sediment samples.

The environments considered are

— limnic (rivers, streams and lakes, natural and man-made), and

— estuarine, including harbours.

Industrial and sewage works for sludges, paleolimnological sampling and sampling of open ocean sediments are specifically excluded from this document (and are addressed in ISO 5667-15), although some techniques may apply to these situations. Sampling of suspended solids is outside the scope of this document and reference can be made to ISO 5667-17 for such guidance.

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 5667-1, *Water quality — Sampling — Part 1: Guidance on the design of sampling programmes and sampling techniques*

ISO 5667-15, *Water quality — Sampling — Part 15: Guidance on the preservation and handling of sludge and sediment samples*

3 Terms and definitions

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

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

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

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

3.1
composite sample
two or more samples or subsamples mixed together in appropriate known proportions, from which the average result of a designed characteristic may be obtained

Note 1 to entry: The individual portions may be derived from the same unit (stratum) or at the same sediment depth below a certain interface. The use of subsamples from the same stratum is limited to situations where a natural mixing of strata is unlikely to have occurred or where the depth of the sediment stratum is sufficient to allow subsampling without artificial mixing during sample operations. Therefore, subsampling from different strata is allowed in relation to the objective of the investigation.

3.2
pile-working core compression
blockage
phenomenon which occurs when the sample rising up the inside of a piston corer meets a resistance due to its own friction, a blockage by a large piece of stone, or the tube being full

3.3
descriptive mapping
description of the *sediment* (3.5) present in terms of its nature, variation and extent

Note 1 to entry: The exercise is carried out by precise marking of sample location and general recording of site conditions. Pre-established conditions may be a requirement of the exercise.

3.4
monitoring
establishment of variation of the *sediment* (3.5) characteristics with time and location

3.5
sediment
solid material, both mineral and organic, deposited in the bottom of a water body

3.6
sediment quality
chemical nature, as well as the physical properties of the *sediment* (3.5) being sampled, e.g. in relation to assessment of harbour sediment due to be dredged to determine disposal process

3.7
sampling site
sampling station
well-delimited area, where sampling operations take place

3.8
sampling point
precise position within a *sampling site* (3.7) from which samples are taken

3.9
uncertainty arising from sampling
part of the total uncertainty of a measured value attributable to sampling

3.10
unconsolidated sediments
sediments (3.5) that are loose so that individual particles are able to move easily relative to each other

4 Sampling strategy

4.1 General

Sampling of sediments from estuarine and inland water bodies can be completed to address the following:

— temporal and spatial monitoring of the environment;

— as part of environmental impact assessment informing future construction developments (e.g. increasing of harbour depth so that vessels can access harbours, and installation of renewable energy applications such as wind farms);

— sediment distribution mapping of an area to enable, for example, sediment transport or intrusion of fine inorganic particles and organic material to be determined;

— examining the sediment quality (physical and chemical) so, for example, sediment disposal method can be determined prior to dredging of harbours or rivers;

— spatial and temporal patterns of sediment-dwelling organisms;

— fundamental research.

4.2 Type of investigation

4.2.1 General

The sampling strategy will vary depending on the aims of the work being completed. Three common types of investigation can be distinguished:

a) chemical investigation;

b) physical investigation;

c) biological and microbiological investigation.

4.2.2 Chemical investigation

In this type of investigation, the nature and amounts of the substances which are bound to the sediment or are associated with pore water may be determined. Some chemical species become bonded in preference to small mineral particles and organic matter while some are incorporated in residual pore water. It should be noted that where the sampling device is made of metal then abrasion and chemical action, for example from sulfides and phosphates, may lead to specific contamination. In cases where sample equipment made from plastics are used, chemical residues may leach from the material into the sample, for example dispersants, or chemicals from the sediment may adsorb into the plastics. Quality control measures should be undertaken in full consultation with the receiving laboratory in order to establish the degree of influence of such effects on the survey results. Some study parameters (e.g. sulfides) may require to be maintained in an oxygen-free atmosphere. In such circumstances, storage and handling under an inert gas atmosphere may be needed. If it is necessary to maintain anaerobic conditions while handling samples, tools such as a glove box should be used. For samples whose measurements can be affected by exposure to oxygen, analysis should be performed as quickly as possible.

4.2.3 Physical investigation

In this type of investigation, the structure, texture, particle size and layer formation of the sediment bed are determined and the strata delineation is important for geographical, morphological and, in some cases, geotechnical investigations.

4.2.4 Biological and microbiological investigation

A biological investigation generally involves classifying the species and numbers of flora and/or fauna present on and in the sediment bed. In many cases, sampling is carried out in the habitat layer, with most species present in the top 10 cm. However, this might extend to several decimetres. For specific details regarding biological investigations, references should be made to specific ISO standards already in existence or under development, including ISO 16665 for methods involving quantitative sampling and sample processing of marine sub-bottom macrofauna and ISO 10870 for selection of sampling methods and devices for benthic macroinvertebrates in fresh waters. In some cases, microbial processes may also be of interest, such as denitrification, phosphate release, methylation of metals such as mercury or tin.

4.3 Choice of sampling site

In choosing the exact point from which samples are required, two aspects are generally involved:

a) the selection of the sampling site (e.g. the location of the sampling cross-section on the base of the seabed);

b) the identification of the precise point at the sampling site.

The purpose of sampling is often at a precisely defined sampling site (as is the case when studying deposition from a particular discharge point), but sometimes the purpose is only to lead to a general definition of the sampling site as in the characterization of the quality and type of material.

The choice of sampling sites for a single sampling station is usually relatively easy. For example, a monitoring station for a baseline record of sediment quality may be chosen to permit the use of a convenient bridge or to allow an upstream effluent discharge or tributary to be well mixed laterally before the station.

Remote sensing methods, such as use of echosounders, including multibeam, or side scan sonars, should be considered to assist in checking sediment bed status for rock, or other obstacles such as protected wrecks and unexploded ordnance, prior to sampling. Refer to EN 16260 for advice regarding completion of visual seabed surveys using remotely operated and/or towed observation gear for collection of environmental data.

To establish locations for sediment sampling, and to register the exact sampling point locations, it is recommended to use Global Positioning System (GPS) technology.

The criteria for sample site choice can include:

— the presence of good sedimentation conditions (e.g. reduced flow rate);

— ease of repeated access to the location, for example a tidal influence;

— seasonal accessibility;

— the influence of marine traffic;

— heterogeneity of the stream bed (roughness, particle size, etc.) across a river transect or within an area of interest.

4.4 Choice of sampling point

This will be influenced by physical constraints such as boat size or water depth but the precise point will largely depend upon the purpose of the investigation. For example, if descriptive sediment mapping is the sole purpose then choice may be the function of flow and current conditions only, whereas if chemical contamination is being studied, the sampling point will depend largely on the conditions present at the sediment bed.

NOTE For instance, it would not be expected to find contamination caused by anthropogenic metal inputs in a riffle area of a stream compared with a pool area.

Consideration of local conditions and features in the monitoring of harbours, such as proximity to outfalls, the influence of stream mixing and other factors such as plant growth, may be important. Further guidance is given in 4.7 and ISO 5667-1.

The choice of sampling point will be a desirable pre-qualification for the programme, but exact locations will inevitably be revised in the field. The number of sampling points required needs to be statistically representative relevant to address the purpose of the investigation. In rivers and estuaries, it needs to be considered that the sediments are turned over in several deposition and re-suspension cycles. Thus, the sediment layers may not be representative for historical deposition scenarios. In this case, age determination by radiological or limnological analysis is recommended. Statistical guidance is given in ISO 5667-1. Composite samples may be produced to reduce analysis costs and assist deriving average regional concentrations as indicated in 6.2. Because of the often patchy distribution of organisms, for biological samples, it could be necessary to choose multiple random sample sites or to conduct stratified random sampling[23].

4.5 Choice of sampling method

4.5.1 General

The choice of sampling method will largely be restricted by the two following factors:

a) the requirement for a largely undisturbed sample for delineation and the preservation of water and sediment interface (further details are given in Clause 5);

b) the acceptance of a disturbed sample taken near the bed surface for a general morphological or chemical examination.

Certain types of chemical parameter may necessitate the use of inert liners in piston or tube type recovery devices, for example polytetrafluoroethylene linings if low-level pesticides are being examined. Reference should be made to ISO 5667-15 for guidance on the preservation and handling of sediment samples.

The remaining factor affecting the choice of sampling method will be the applicability of the proposed device to the sediment bed conditions. Ideally, consistent sampling methods are used throughout the survey, although if sediment bed conditions vary within the area being sampled, this may not be possible. Sampling regimes are summarized in Table 1. More detail about samplers is given in Clause 5.

Table 1 — Sediment type and recommended sampler

Sediment type	Sampler[a]
Gravel	Grab systems; large particle size may require heavier grabs.
Sand	Both grab and corer systems can be used. A sand bed can be hard to penetrate and thus prove difficult for lightweight grabs and manually operated corer systems. Grabs of larger mass and heavy mechanical corers may be required.
Clay	It may be necessary to use a corer because grab systems often cannot penetrate easily into the clay.
Mud	Both grab and corer systems can be used but care should be taken to avoid over penetration (see 4.5.3).
Peat	A difficult medium to sample but it is sometimes possible to use a manually operated corer system or a special peat borer.

[a] Sampler type versus sediment type may have to be determined by experimentation.

4.5.2 Consolidated bottom sediment

For consolidated bottom sediment, both grab and corer systems can be used. If a grab is used, it may be difficult to determine the penetration depth of the sampling.

4.5.3 Unconsolidated bottom sediment

For unconsolidated bottom sediment, grab systems are not suitable as they are prone to sinking through the soft layer. Corer systems are better but, when a frame is used at greater depth, care is essential to prevent the frame from sinking through the soft layer. More support can usually be given to prevent this by adding large plates to the feet of the frame. Samplers which depend on the free-fall principle are not suitable for this bed type.

4.6 Frequency and time of sampling

Results from a sampling programme need to provide data with an acceptable uncertainty defined in the objectives of the programme. If the objectives do not include a definition of the tolerable error, a statistically-based sampling programme is impossible. It should be remembered that changes with time of sediment composition may require a much longer period of observation to detect than changes observed for water. For example, diurnal variation in concentration of metals may be detected in estuarine water but the respective sediments may only show fluctuation over a much longer sampling period. When using systematic sampling, it is essential to ensure that the frequency of sampling does not coincide with a natural cycle present in the system. In the case of sediments, this may be seasonal variation, yet it should also be considered that flow extremes, especially flooding, result in bed transport and altered sediment structure and lead to intrusion or washout of inorganic and organic fine material. It may be necessary to increase the sampling frequency in order to observe any variation in some cases, for example when monitoring pore water nutrients. The frequency of sediment sampling is only likely to have a major influence on the interpretation of results when rapid deposition rates are expected, for example weekly sampling of a river bed downstream of a discharge point is not likely to reveal any data that is different from that demonstrated from sampling at half yearly intervals other than the inherent variability of the sediment. The reasons for sampling are constrained by the needs of a particular project which will themselves define the frequency of sampling. For details of the application of statistics to sampling frequency, refer to ISO 5667-1.

4.7 Site conditions

4.7.1 General

Conditions at the sampling position are of vital importance to achieve correct sampling. A number of these conditions will usually be known before sampling takes place and should be taken into account when preparing the operation and also when choosing the apparatus to be employed.

The following conditions are important:

— meteorological and climatic (e.g. temperature, precipitation, solar radiation);

— hydrological (e.g. discharge, water depth, current, velocity);

— geological (e.g. characteristics/composition/stratification of sediments, erosion);

— nautical;

— biological (e.g. with reference to macrophyte accumulation).

4.7.2 Meteorological and climatic conditions

Temperature, wind direction and force can be restricting factors when carrying out sampling. For example, if the sampling location is situated in an area which is strongly affected by wave movements, then this should be taken into account when planning the operation and when using the apparatus. The restrictions related to climates are covered specifically for each type of instrument in the annexes.

In countries with cold climates, it may be practical to work on ice surfaces of lakes. However, safety should always be a priority and local regulations should apply. Equipment and samples can be protected from freezing in heated tents.

The need for sampling should be judged against the safety factors influenced by climatic conditions. In addition, storm conditions may disturb sediment beds so that sampling can become impractical or meaningless.

4.7.3 Hydrological conditions

4.7.3.1 Tidal areas

In tidal areas, attention should be paid to variations in the depth of water, current speeds and directions. Variable currents, in particular, are often a restrictive factor in the choice of apparatus to be used. Many instruments cannot be used where fast currents are present. Sampling using these instruments should be restricted, due to the effect on the sampling vessel, to periods of low flow rates.

Since the depth of water in tidal areas varies, it is often advisable to carry out sampling at low tide, for example on dried-out sandbanks, where manual sampling using conventional spades and similar tools is possible, giving due regard to relevant safety precautions. Each sampling occasion should be judged against local conditions and experience of local tides. With a budget supported sufficiently onboard, sampling at high tide could be considered at the expense of precise location and site observation in order to guarantee the safe field operation. In this case, sampling equipment should be adjusted with grab systems or a corer of heavier weight.

The sampling of tidal river beds and mud flats may be approached in a similar manner to that employed for the sampling of soil. Refer to ISO 18400-102.

4.7.3.2 Rivers

Account should be taken of high flow rates in rivers. If the project allows, it may be advisable to restrict sampling to periods of low water level with low flow rates, where sampling equipment is less likely to be affected. Other local hydrographical conditions may occur, for example the operation of locks, which will require investigation before sampling.

4.7.3.3 Standing bodies of water

In lakes, harbour areas and some sedimentation ponds, the currents are often negligible so that the hydrographical conditions have very little effect on the choice of sampling equipment. When choosing the equipment to be used, the water depth at the sampling point is important in all three water systems mentioned here. If the depth is less than 4 m, then manually operated equipment is advisable. At depths of greater than 4 m, sampling systems operated by lifting or guidance mechanisms are recommended because of possible vessel disturbance of the sediment surface layer. In the case of the grab systems, the size of the equipment will determine whether this can be manually operated or not. Further guidance is given in Table 2.

4.7.3.4 Geological conditions

The general nature of the sediment layer is important when choosing the apparatus to be employed. If no prior knowledge is available then it is advisable to carry out a preliminary investigation using geological maps, coastal charts, visual investigations, as well as remote sensing techniques, or even an inspection via diving, thus preventing many problems arising during the actual sampling. Recommendations for various combinations of sampler type and sediment bed material are summarized in Table 2 and Table 3.

4.7.3.5 Nautical conditions

Due to certain nautical conditions, it is not usually possible to carry out sediment sampling from an anchored vessel in harbour entrances or busy waterways. In these cases, the sampling equipment should be able to be used quickly to compensate for these conditions and hand-operated systems are preferable. In all cases, compliance with local safety regulations is essential.

4.7.3.6 Biological conditions

The use of all types of sampling device may be severely hindered by heavy macrophyte growth; on-site decisions will be constrained by the conditions found. Clearing an area with a dragline is worth trying before sampling, but it is not successful for all types of plant growth and it limits the sample to physical examination. Clearing stands of rooted macrophytes will cause disturbance of the sediment and water interface as well as the upper centimetres of the sediment. This may influence, for example, measurements of sediment pore water nutrient concentrations or sediment phosphorus fractions.

4.7.3.7 Statistical considerations

The design of sediment sampling programmes is project-specific and generalizations cannot be made. Some guidance is given in ISO 5667-1 and it is essential to consider prior to completion of programme to ensure results are robust and fit for purpose desired. The statistical interpretation of data obtained can be dealt with using the principles detailed in ISO 2602 and ISO 2854.

5 Sampling equipment

5.1 General

Sampling of bottom sediments can be broadly split into two methods: grab devices (see Table 2) and coring systems (see Table 3). Samplers presented focus on obtaining undisturbed sediment sample, mainly in finer sediment types. In the case of small depths, where an operator can enter directly on foot into the water, it is possible to use a scoop to collect sediment. If a scoop is used, care should be taken not to mix different layers of sediment.

When a grab system is not used, the criteria for selection of sampling apparatus may also be required to meet the following conditions:

— storage of the sediment in order to minimize changes from *in situ* conditions;

— allow the selection of a layer;

— allow sampling at the required water depth.

5.2 Grab systems

Many samples are collected using bed grabbers. The most well-known is the scissor grab, sometimes known as the van Veen type grab sampler. There are, however, a large number of variations. In general, grab systems consist of one or more hinged buckets which close as it is raised. During closing, sediment is enclosed by the buckets providing disturbed samples, especially for the van Veen grabber type. This can be avoided by using other grab systems, such as the Ekman type, which provides relatively undisturbed samples compared with van Veen type. Probe depths vary from 5 cm to several decimetres, depending upon the size and mass of the sampler and the structure of the bed material. Due to the grab construction, there is a large chance of losing part of the finer fraction and/or the top layer, although Ekman grab systems have shown to be less prone to such losses. Generally, grab systems are not suitable for sampling peat, clays or gravel beds in fast-flowing areas. Grabs are available in a variety of designs and examples are given in Table 2. Since generally all grab systems have the same sampling characteristics, only the van Veen type is described in detail in Annex A. Detailed operating instructions of grab systems are provided by the manufacturer.

Table 2 — Grab samplers

Type	Examples	Sampler penetration depth	Pore water sampling	Water depth (guide)	Accuracy of sample	Sediment type (geological conditions)	Nautical conditions
Manually operated grab (smaller versions of bucket grabs)	Hand-held van Veen grab, petite Ponar grab sampler, mini-Shipek sampler, Sediment snapper, Telescopic sample with stainless beaker	0 cm to 10 cm	No	0 m to 20 m	Need to make sure sampler is sampling perpendicular to the bed. Inaccuracies arise because of washing away of fine fractions.	Unconsolidated sediments (muds and sands); petite Ponar grab is good for sampling coarse and consolidated bottom sediments.	Both shallow and deep water and in areas of slow and fast currents. However, the construction and mass should be adapted to suit the conditions. For mechanical devices, it is recommended, that a secondary line carrying a marker float be attached as a security measure, in case the main line needs to be abandoned for safety reasons.
Mechanical bucket grab – hinged bucket/s that shut together when reaching sediment surface	van Veen (scissor grab) – see Annex A, Clamshell, Day grab, Smith MacIntyre grab, Birge-Ekman sampler, Ponar grab, Lafond and Deitz mud snapper grab	0 cm to 30 cm		5 m to 200 m	Relatively undisturbed sediments. Inaccuracies arise because of washing away of fine fractions.	Unconsolidated sediments (muds and sands); Ponar grab is good for sampling coarse and consolidated bottom sediments.	
Mechanical grab – bucket rotates under spring-loaded mechanism into the sediment upon reaching the sediment surface	Shipek grab	0 cm to 10 cm		5 m to 200 m		Unconsolidated sediments (muds; sands and gravels). Sensitive trigger mechanism – never pull out trapped particles directly.	

NOTE Additional equipment, which emulates or compliments the advantages of that discussed in this document, may also be available commercially. The scope for inclusion in future revisions will be considered at the appropriate time.