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Water quality — Guidelines for the selection of sampling methods and devices for benthic macroinvertebrates in fresh waters

Qualité de l'eau — Lignes directrices pour la sélection des méthodes et des dispositifs d'échantillonnage des macro-invertébrés benthiques dans les eaux douces

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Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

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.

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ISO 10870 was prepared by Technical Committee ISO/TC 147, *Water quality*, Subcommittee SC 5, *Biological methods*.

This first edition of ISO 10870 cancels and replaces ISO 7828:1985, ISO 8265:1988, and ISO 9391:1993, which have been technically revised.

Introduction

Macroinvertebrates are an important component of fresh-water ecosystems and are the most widely used biological group to monitor aquatic ecological status (Reference [6]). A wide range of sampling and survey methodologies has been developed for a variety of specific applications as well as ecological assessment including: conservation status, biodiversity assessment, pollution control, and habitat enhancement (Reference [7]).

This International Standard gives guidelines on the selection, design, operation, and performance characteristics of sampling devices for the evaluation of benthic macroinvertebrate taxonomic composition, abundance, and diversity in fresh waters, which can all be components of the applications given in the first parargraph.

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WARNING — Working in or around water is inherently dangerous. This International Standard does not purport to address the safety problems associated with its use. It is the responsibility of the user to establish appropriate health and safety practices and to ensure compliance with any national regulatory conditions.

1 Scope

This International Standard specifies criteria for the selection of sampling methods and devices (operation and performance characteristics) used to evaluate benthic macroinvertebrate populations in fresh waters (rivers, canals, lakes, and reservoirs). The methods and devices considered in this International Standard are suitable for sampling all major components of the benthic assemblage. They are not suitable for sampling meiofauna.

2 Terms and definitions

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

2.1
abundance
total number of individuals in a taxon, per sampling unit or estimated per unit area

2.2
benthic
dwelling at the bottom of an aquatic environment

2.3
canal
artificial watercourse constructed, usually, to join rivers, lakes or seas, and often of a size suitable for navigation

[SOURCE: ISO 6107-2:2006,[2] 15]

2.4
deep water
water from 1 m below the water surface to the limiting depth for efficient sampling

2.5
diversity
species richness of a community and the distribution of individuals across those species

2.6
habitat
area of the environment in which a particular organism or population lives, including its characteristic assemblages of plants and animals

2.7
lake
inland body of water of considerable area

[SOURCE: ISO 6107-2:2006,[2] 57]

2.8
macroinvertebrate
invertebrate that is easily visible without magnification (>0,5 mm)

2.9
meio-fauna
small benthic invertebrates that pass unharmed through a 0,5 mm mesh

2.10
qualitative observation
observation that does not involve measurement or numbers

2.11
quantitative observation
observation that involves measurement or numbers

2.12
reservoir
construction, partially or wholly man-made, for storage and/or regulation and control of water

[SOURCE: ISO 6107-2:2006,[2] 107]

2.13
river
natural body of water flowing continuously or intermittently along a well-defined course into an ocean, sea, lake, inland depression, marsh or other watercourse

[SOURCE: ISO 6107-2:2006,[2] 109]

2.14
semi-quantitative observation
observation on a sample where the relative abundance of taxa can be estimated, but not numerically related to a specific area or volume of habitat

2.15
species/taxa composition
species/taxa list from the sampled habitat which can include the relative dominance (number of benthic macroinvertebrates of a species/taxon divided by the total number of benthic macroinvertebrates of all species/taxa, expressed as a percentage)

3 Principle

3.1 General

In order to evaluate benthic macroinvertebrate population parameters such as taxonomic composition, abundance, and diversity in fresh waters, appropriate sampling devices are required. The choice of the appropriate sampling device depends on the objective of the study itself as well as on the water type and the benthic macroinvertebrate population being studied (Reference [6]).

Sampling methods are described in this International Standard to cover the broad variety of fresh waters and the diversity of macroinvertebrate taxa and these habitats. The performance characteristics of the devices should be taken into account in order to achieve the best evaluation in the context of the objectives of the survey.

3.2 Objectives

The methods given in this International Standard are suitable for a wide variety of objectives. These objectives include: assessment of ecological status, detection of change in surveillance, operational and investigational monitoring programmes, diagnosis of environmental stress, and the assessment of both acute and chronic stressors (pollution control). The methods are also suitable for conservation and biodiversity assessments with measurement of both community parameters and appraisal of rare species status. Many of the methods are used both routinely and in research studies (References [6][11]–[14]). Guidance on the analysis of results from benthic macroinvertebrate surveys is given in ISO 8689-1[3] and ISO 8689-2.[4]

3.3 Sampling programmes

The design of a sampling programme depends on the aims of the survey and the required power of discrimination of the data. The programme should be developed with regard to the local topographical and hydrological conditions in the survey area, information on local environmental stressors, and knowledge from previous surveys (if any). The number of sampling stations, their positions, season or seasons of sampling, and the numbers of replicate samples to be taken at each station should be established prior to the initiation of the survey, or through a pilot survey (Reference [6]). The design of the programme determines the options for data treatment and statistical analyses that can be performed; therefore, prior consideration should be accorded to the reporting requirements. Quality assurance of sampling and analysis should also be considered at this stage. Further general guidance on survey design is given in ISO 5667-1.[1]

During the design of the sampling programme, consideration should be given to the possibility of transferring diseases (e.g. crayfish plague) and the dispersal of non-native invasive species. Appropriate precautionary measures should be included in the operation of any of the devices to prevent such transfers.

3.4 Device and method selection

The methods and devices given in this International Standard have been chosen to achieve a good evaluation for the broad variety of inland waters and the diversity of macroinvertebrate taxa. The methods and devices are suitable for routine monitoring and for some research purposes. Methods and devices suitable only for research purposes have been excluded. Detailed guidance on the design of sampling equipment, the mode of operation and the scope of characteristics can be found in Clause 4. Three main selection criteria have been evaluated in recommending suitable methods/devices for sampling different habitats. The three criteria are:

— suitability for operation in flowing or standing fresh waters;

— suitability for operation in shallow or deep fresh waters;

— the ability to provide results that are qualitative, quantitative or semi-quantitative.

Table 1 indicates which devices are appropriate for each habitat and in which section each device can be found.

4 Benthic macroinvertebrates sampling methods and devices

4.1 General

Benthic macroinvertebrates may be caught by active sampling or passive sampling (colonization samplers). For all sampling methods, seasonal aspects of macroinvertebrate life cycles should be considered and taken into account. The efficiency of active and passive sampling may also vary depending on the time (day/night) of use; therefore the details of these aspects of use should be recorded. For those sampling devices that use nets, it is important to consider mesh size in relation to the objectives of the survey. General comments about mesh sizes applicable to all devices using nets are given in Table 2. The performance characteristics of each sampling device can be found at the end of each section.

4.2 Handnet

4.2.1 General

No sampling technique is appropriate to all types of water and it is necessary to specify a number of sampling procedures to meet different requirements. Sampling effort should be appropriate to the objectives of the study and consideration of the physical characteristics of the site, and hence be based on suitable distance, area or time (Reference [15]).

Sampling during and immediately after spates should be avoided (unless investigating the impacts of floods). Samples collected at these times are not comparable with samples collected during periods of normal flow and it is possible that they do not reflect the underlying environmental quality of the site accurately.

Table 1 — Selection of devices for specific environments

Equipment	Clause	Water				Sample type		
		Still	Flowing	Deep	Shallow	Qualitative	Semi-quantitative	Quantitative
Handnet	4.2	✓	✓	✓[a]	✓	✓	✓	—
Surber	4.3	—	✓	—	✓	✓	✓	✓
Box	4.4	—	✓	—	✓	✓	✓	✓
Cylinder	4.5	—	✓	—	✓	✓	✓	✓
Naturalist's dredge	4.6	✓	✓	✓	—	✓	✓	—
Eckman–Birge	4.7	✓	✓	✓	✓	✓	✓	✓
Ponar grab	4.8	✓	✓	✓	—	✓	✓	✓
Van Veen grab	4.9	✓	✓	✓	—	✓	✓	✓
Polyp grab	4.10	✓	✓	✓	—	✓	✓	✓
Air lift sampler	4.11	✓	✓	✓	—	✓	✓	✓
Core and tube samplers	4.12	✓	✓	✓	—	✓	✓	✓
Colonization samplers	4.13	✓	✓	✓	✓	✓	✓	—

✓ ≡ suitable — ≡ not suitable [a] Maximum 4 m.

4.2.2 Frame design

A handnet consists of a handle and a frame, which holds a net in which organisms are collected. The handles are usually made of metal, wood or reinforced plastic and the frames are usually constructed in metal. A rectangular frame (see Figure 1) is preferred so the flat edge can be placed in close contact with the bed during use. The vertical sides permit a larger cross-sectional area of water to enter the net than a triangular shape does.

The handnet frame should be large enough to allow a reasonable sample to be taken, but not so large that the net offers too much resistance to the flow of water, which could make sampling difficult in fast flows. The length of the net can be varied depending on the objective of the study. Suitable rectangular handnets currently in use have evolved in the light of experience and have frame dimensions in the ranges listed in Table 2.

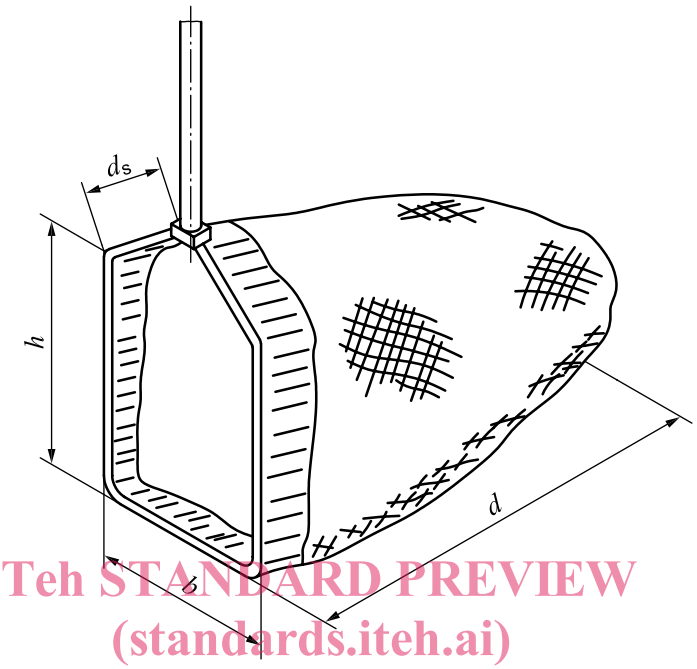
Table 2 — Handnet frame dimensions

Dimension	mm
Width, b	200 to 400
Depth, d	400 to 500
Shoulder, d_s	100 to 200
Height, h	200 to 300

4.2.3 Net design

In choosing an appropriate net, two interrelated factors have to be considered; the dimensions and shape of the net; and the mesh size of the net material. Finer mesh sizes increase the risk of clogging with organisms and debris. This reduces net efficiency as it increases the tendency of water and organisms to flow around the net rather than into it. This effect can be minimized by increasing the depth of the net (see Figure 1, depth d), or by frequently emptying it. For guidance, Table 3 gives examples of the most suitable depths of nets as a function of their size of openings. The shape of the net is not particularly important from a sampling point of view but can be determined by practical considerations in manufacture. The net material is normally sewn to strong canvas, which is attached to an inner frame. This material is more resistant to abrasion. Methods of joining the inner and main frames, which facilitate replacement in the field, are clearly advantageous. Net

material may be of a monofilament weave or knitted. However, monofilament is preferred due to its increased strength. Synthetic fibre is preferable since it is stronger and less liable to decompose, but should be selected to ensure sufficient flexibility. The mesh size should be appropriate for the objectives of the study. Increasing the net mesh size decreases estimates of abundance and taxa richness. The maximum recommended mesh opening sizes are given in Table 3.



Key

b width
d depth
d_S shoulder
h height

Figure 1 — A rectangular handnet

4.2.4 Handnet operation

4.2.4.1 General comments

When it is intended to collect as many taxa as possible, take a sample by a combination of the methods. It is customary to explore thoroughly all the types of substratum by this method to assess ecological status, including sweeps through weed patches and between the roots of overhanging trees.

Examine and wash the collecting net before and after samples are taken. Take care to ensure that the net is not damaged or contaminated with animals from previous samples.

4.2.4.2 Kick sampling

The net should be held vertically on the riverbed downstream of the operator's feet with the lower edge held against the substrate. The substratum should be disturbed forcefully with the toe or heel of the boot and the released material should be caught in the net. By working across the river, different habitats can be sampled. This method is somewhat selective, because it is possible that fewer of the attached animals are taken than unattached fauna, therefore some of the stones should be lifted and examined by hand where practical. To allow semi-quantitative results to be calculated, the kick sample needs to be based on an agreed time or an agreed area. Recommended times are between 2 min and 5 min to achieve a reasonable sample for routine ecological status assessment (EN 16150[5]). EN 16150[5] gives guidance on replicate sampling with

the handnet. Conservation and biodiversity studies designed to catch maximum numbers of taxa can require longer sampling times.

The removal of the catch can be facilitated by using the flowing water to wash it into a corner of the net and then shaking the net gently while removing it from the water. The net can then be turned inside out to aid the transfer of the sample to a container of water. Animals which cling to the net can be removed by hand and then added to the sample. It is recommended that the net be thoroughly washed between taking samples. Further sample treatment, such as the decanting of surplus water (to minimize predation by carnivores), the reduction of sample bulk by removing sticks, stones, leaves, and other debris as well as the addition of preservatives, depend upon operator preference and the objective of the sampling programme. A sieve, of the same mesh size as the net, can be used to reduce sample bulk.

Table 3 — Recommended handnet mesh sizes and nets depths

Survey objective	Maximum size of mesh opening mm	Recommended minimum depth mm	Comments
General/routine Biological monitoring: data for surveys using biotic scores or indices	0,5 to 1,0	400	Danger that small stages of most benthos are not captured
For surveillance with more complete records of taxa present, diversity indices	0,5	450	Danger that early instar stages of many insects are not captured
For special surveys requiring complete taxa lists including rare taxa for conservation evaluation	0,25	550	Ensures capture of first instar stages and very small organisms which may prove of value in water quality determination

4.2.4.3 Sampling in very shallow flowing water by hand

Hold the lower edge of the handnet against the streambed while turning over the stones immediately upstream by hand in the flowing water. Dislodged animals are carried into the net by the current. Examine the stones, remove any attached or clinging species and add them to the sample. Disturb the finer lower deposits to dislodge any further organisms.

4.2.4.4 Sampling in slow-flowing or still waters

In still water, it is possible that the handnet is not the most appropriate method for sampling because of the requirement for flow to sweep the macroinvertebrates into the net. Consideration should be given to the use of other methods and devices (Table 1). Some habitats, such as stony lake shores, can be sampled by the hand-picking method, but this can cause collecting efficiency to be lower. The best procedure is to remove stones carefully and agitate them vigorously in the net, after which any remaining animals can be picked off by hand and added to the sample. When sampling other slow-flowing or still-water habitats, the absence or reduction of water movement necessitates a different procedure from that used in flowing water where the current is used in order to sweep dislodged animals into the net. In still water, it is necessary for the operator to supply the relative motion of the fauna and net. The substratum should be disturbed with the feet and the dislodged fauna caught by repeatedly sweeping the net through the water in the disturbed area.

4.2.4.5 Sampling in deep waters

In deep-flowing and still water, where the substratum consists of mud or silt, the handnet should be drawn or pushed through the surface layer of the substratum, preferably over a predetermined area or distance. The limit of deep-water sampling relates to the length of the handle: 2 m is most often used and 4 m is probably the practical limit.