
International Standard



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Water quality — Sampling — Part 1 : Guidance on the design of sampling programmes

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Foreword

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Water quality — Sampling — Part 1 : Guidance on the design of sampling programmes

0 Introduction

This International Standard is the first of a group of three standards intended to be used in conjunction with each other. ISO 5667/2 and ISO 5667/3 deal respectively with sampling techniques and with the preservation and handling of samples. The general terminology used is in accordance with that established in ISO/TC 147, *Water quality*, and, more particularly, with the terminology on sampling given in ISO 6107/2.

1 Scope and field of application

This International Standard sets out the general principles to be applied in the design of sampling programmes for the purposes of quality control, quality characterization, and identification of sources of pollution of water, including bottom deposits and sludges. Detailed instructions for specific sampling situations will be given in subsequent International Standards.

2 References

ISO 2602, *Statistical interpretation of test results — Estimation of the mean — Confidence interval*.

ISO 3534, *Statistics — Vocabulary and symbols*.

ISO 5667/2, *Water quality — Sampling — Part 2 : General guidelines to sampling techniques*.¹⁾

ISO 5667/3, *Water quality — Sampling — Part 3 : General recommendations for the preservation and handling of samples*.¹⁾

ISO 6107/1, *Water quality — Vocabulary — Part 1*.

ISO 6107/2, *Water quality — Vocabulary — Part 2*.¹⁾

1) At present at the stage of draft.

Section one : Definition of objectives

3 Introduction

The purpose of this section is to emphasise the more important factors which have to be considered when devising a sampling programme in relation to water, bottom deposits and sludges. More detailed information is given in subsequent sections. Samples are collected and examined primarily to determine associated physical, chemical, biological and radiological parameters.

Whenever a volume of water, bottom deposit or sludge is to be characterized, it is generally impossible to examine the whole and it is therefore necessary to take samples. The samples collected should be as fully representative as possible of the whole to be characterized, and all precautions should be taken to ensure that, as far as possible, the samples do not undergo any changes in the interval between sampling and analysis. The sampling of multiphase systems, such as water containing suspended solids or immiscible organic liquids, can present special problems.

Before any sampling programme is devised, it is very important that the objectives be established since they are the major factors in determining the position of sampling sites, frequency of sampling, duration of sampling, sampling procedures, subsequent treatment of samples, and analytical requirements. Some consideration should also be given to the degree of detail and precision that will be adequate, and also the manner in which the results are to be expressed and presented, for example concentrations or loads, maximum and minimum values, arithmetic means, median values etc. Additionally, a list of parameters of interest should be compiled and the relevant analytical procedures consulted since these will usually give guidance on precautions to be observed during sampling and subsequent handling. (General guidance on the latter aspects is given in Parts 2 and 3 of this International Standard respectively.)

It may often be necessary to carry out a preliminary sampling and analysis programme before the final objectives can be defined. It is important to take into account all relevant data from previous programmes at the same or similar locations and other information on local conditions. Previous personal experience can also be very valuable. Time and money allocated to the design of a proper sampling programme is usually well justified by ensuring that the required information is obtained efficiently and economically.

Three main objectives may be distinguished as follows (for details, see clause 15) :

- a) quality control measurements used by local management to decide when short-term process corrections are required;
- b) quality characterization measurements used to indicate quality, perhaps as part of a research project, for long-term control purposes, or to indicate long-term trends;
- c) identification of sources of pollution.

The purpose of the programme may change from quality characterization to quality control and vice-versa. For example,

a longer term programme for nitrate characterization may become a short-term quality control programme requiring increased frequency of sampling as the nitrate concentration approaches a critical value.

4 Requirements

Without attempting to list all the specific reasons for requiring sampling and analysis programmes, they may be grouped as follows.

4.1 General requirements

To establish the order of concentration levels or loads of specific parameters at selected positions (for example at the surface of, or in, a body of water) or, with bottom deposits, to obtain a visual indication of their nature.

4.2 Specific requirements

To establish in detail the concentration levels or load distributions of physical or chemical parameters and biological species of interest throughout the whole or part of a body of water. This will normally be linked to a study of changes with time, flow rates, operating plant conditions, weather conditions etc.

These reasons for sampling may be further sub-divided into more specific objectives such as the following.

- a) To determine the suitability of water for an intended use and, if necessary, to assess any treatment or control requirements, for example to examine borehole water for cooling, boiler feed or process purposes, or, if a natural spring, as a possible source of drinking water.
- b) To study the effect of waste discharges, including accidental spillages, on a receiving water. Apart from contributing to the pollution load, such discharges may produce other reactions such as chemical precipitation or evolution of gases.
- c) To assess the performance and control of water, sewage and industrial effluent plants — for example : to assess the variations and long-term changes in load entering a treatment works; to determine the efficiency of each stage in a treatment process; to provide evidence of quality of treated water; to control the concentration of treated substances including those which may constitute a health hazard or which may inhibit a bacteriological process; to control substances which may damage the fabric of plant or equipment.
- d) To study the effects of fresh and saline water flows on estuarine conditions in order to provide information on mixing patterns and associated stratification with variations in tides and freshwater flow.
- e) To identify and quantify products lost from industrial processes. This information is required when product

balances across the plant are to be assessed and when effluent discharges are to be measured.

f) To establish the quality of boiler water, steam condensate and other reclaimed water. This enables the suitability of the water for an intended purpose to be assessed.

g) To control the operation of industrial cooling water systems. This enables the use of water to be optimized and, at the same time, the problems associated with scale formation and corrosion to be minimized.

h) To study the effects of atmospheric pollutants on the quality of rainwater. This provides useful information on air quality and also indicates if problems are likely to arise, for example, on exposed electrical contacts.

j) To assess the effect of inputs from the land on water quality. There may be contributions from naturally occurring materials, or contamination by fertilizers, pesticides and chemicals used in agriculture, or both.

k) To assess the effect of the accumulation and release of substances by bottom deposits on the aquatic biota in the water mass or bottom deposit.

m) To study the effect of abstraction, river regulation and river-to-river transfers on natural water-courses. For example, varying proportions of waters of different quality may be involved in river regulation and the quality of the resulting blend may fluctuate.

n) To assess changes in water quality which occur in distribution systems. These changes can occur for a number of reasons, for example contamination, introduction of water from a new source, biological growths, deposition of scale or dissolution of metal.

On some occasions the conditions may be sufficiently stable for the required information to be obtained from a simple sampling programme, but in most locations quality characteristics are subject to continuous variations and, ideally, assessment should also be continuous. However, this is often very costly and in many situations impossible to achieve. When considering sampling programmes, the special considerations given in clause 5 should be borne in mind.

5 Special considerations in relation to variability

5.1 Sampling programmes may be complex in situations where wide and rapid variations occur in the concentrations of determinands of interest. These variations may be caused by such factors as extreme changes in temperature, flow patterns or plant operating conditions. Sampling should be avoided at or near boundaries of systems unless conditions are of special interest.

5.2 Even when concentration changes are slow and not very marked, the assessment of a large catchment area, such as a river basin, is a complex exercise.

5.3 Care should be taken to eliminate or minimize any changes in the concentration of determinands of interest that may be produced by the sampling process itself, and to ensure that changes during the period between sampling and analysis are avoided or minimized.

5.4 Composite samples give the best indication of the average composition over a period of time provided that the determinand is stable during the period between sampling and examination, but they are of little value in determining transient peak conditions.

Section two : Identification of sampling situations

6 Introduction

This section deals with the various situations that may be encountered in sampling practice and the extent to which these situations affect the choice of a sampling site. Attention is drawn to the safety precautions necessary in various situations which, in view of their importance and general character, are set out in clause 7.

7 General safety precautions

7.1 The enormously wide range of conditions encountered in sampling waters and bottom deposits can subject personnel to a variety of safety and health risks. Apart from physical injury, precautions must be taken to avoid inhalation of toxic gases and ingestion of toxic materials through the mouth and skin.

Personnel responsible for the design of sampling programmes and for carrying out sampling operations must ensure that the requirements of relevant safety regulations are taken into account and that sampling personnel are informed of the necessary precautions to be taken in sampling operations.

NOTE — Insurance against accidents may need to be considered.

More specific situations are discussed below.

7.2 Weather conditions should be considered in order to ensure the safety of personnel and equipment. Life-jackets and life-lines should be worn when sampling large masses of water. Before sampling from ice-covered waters, the location and extent of weak ice should be carefully checked. If self-contained underwater breathing apparatus or other diving equipment is used, it should always be checked and maintained to ensure reliability.

7.3 Stability is an important property of any boat used for sampling purposes. In all waters, precautions should be taken in relation to commercial ships and fishing vessels; for example, the correct signal flags should be flown, to indicate the nature of the work being undertaken.

7.4 Sampling from unsafe sites, such as unsafe banks, should be avoided if possible. If this is unavoidable, the operation should be conducted by a team using appropriate precautions rather than one operator. Sampling from bridges should be used when appropriate.

7.5 Reasonable access in all weather is important and it is essential for frequent routine sampling. In some situations, consideration should be given to additional natural hazards such as poisonous foliage, animals and reptiles.

7.6 If instruments or other items of equipment are installed on a river bank, situations susceptible to flooding or vandalism should be avoided, or appropriate precautions taken.

7.7 Many other situations arise during the sampling of water when special precautions have to be taken to avoid accidents.

For example, some industrial effluents may be corrosive or may contain toxic or flammable materials. The dangers associated with sewage should also not be overlooked; these may be gaseous, microbiological, virological or zoological, such as from amoebae or helminths.

7.8 Gas protection equipment, breathing apparatus, resuscitation apparatus and other safety equipment should be available when personnel have to enter hazardous atmospheres. In addition, the concentration of oxygen and of any toxic vapour or gas likely to be present should be measured before personnel enter enclosed spaces.

7.9 In the sampling of steam and hot discharges, special care is necessary and recognised techniques should be applied.

7.10 The handling of radioactive samples requires special care and the special techniques required should be applied.

7.11 The use of electrically operated sampling equipment in or near water can present special electrocution hazards. Work procedures, site design and equipment maintenance should be planned so as to minimize these hazards.

8 Special considerations in sampling

8.1 Design of sampling programmes

Depending on the objectives to be achieved (see clause 6), the sampling network may be anything from a single site to an entire river catchment. A basic river network may comprise sampling sites at the tidal limit, major tributaries at their confluence, and major discharges of sewage or industrial effluent.

In designing quality sampling networks it is usual to make provision for the measurement of flow at key stations (see section 4).

8.2 Identifying the sampling location

Identifying the sampling location enables comparative samples to be taken at other times. In most river situations, sampling locations can readily be fixed by reference to features on the river bank.

On uncovered estuarine and coastal shores, sampling locations may similarly be related to an easily recognizable static object. For sampling from a boat in these situations, instrumental methods for location identification should be used. Map references or other standard forms of reference may be valuable.

8.3 Character of flow

Ideally, samples should be taken from turbulent, well-mixed liquids and, whenever possible, turbulence should be induced in flows that are streamlined. This does not apply to the collec-

tion of samples for the determination of dissolved gases and volatile materials, the concentration of which may be altered by induced turbulence.

8.4 Change in flow characteristics with time

Flow may change from streamlined to turbulent and vice-versa. "Reverse flow" from other parts of the system may occur which could produce contamination at the sampling point.

8.5 Change of liquid composition with time

Discrete "slugs" of material may occur at any time, for example, dissolved contaminants, solids, volatile materials or oily surface layers.

8.6 Sampling from pipes

Liquids should be pumped through pipes of adequate size (for example, when sampling heterogeneous liquids, of minimum nominal bore 25 mm) at linear velocities high enough to maintain turbulent flow characteristics. Horizontal pipe runs should be avoided.

8.7 Nature of the liquid

The liquid may be corrosive or abrasive. Resistance to these conditions should be considered. It should be borne in mind that the cheapest course is not necessarily to use expensive chemically-resistant equipment for short-term sampling if the equipment can readily be replaced and contamination of the sample by corrosion products is not likely to be important.

8.8 Temperature changes occurring in sampling systems

Temperature variation over long or short periods may cause changes in the nature of the sample that may affect the equipment used for sampling.

8.9 Sampling for determination of suspended solids

Solids may be distributed anywhere throughout the depth of a liquid. Adequate mixing should be carried out, if possible, by maintaining turbulent conditions. Ideally, the linear velocity should be sufficient to induce turbulence and samples should be taken under isokinetic conditions (see ISO 6107/2). If this is not possible, a series of samples should be taken across a full cross-section of the flow. It should be remembered that the size distribution of suspended solids may change during the time necessary to complete the sampling.

8.10 Sampling for volatile compounds content

Material being sampled should be pumped with minimum suction lift. All pipework should be kept full and the sample bled from a pressurized pipe after running some of the material to waste to ensure that the sample collected is representative.

8.11 Mixtures of waters of different densities

These can cause layering in a streamlined flow, for example the production of a layer of warm water over cold water or of fresh water over saline water.

8.12 Hazardous liquids

It is necessary to consider the possibility of the presence of toxic liquids or fumes, or both, and the possible build-up of explosive vapours.

8.13 Effect of meteorological conditions

Changes in meteorological conditions may induce marked variations in water quality; such changes should be noted and allowance made for them when interpreting results.

9 Individual sampling situations — Natural waters

9.1 Precipitation

When samples of precipitation are collected for chemical analysis, the sampling site should be selected to avoid contamination by extraneous matter, for example dust, fertilizers, pesticides, etc. The sampling apparatus should preferably be placed in a lawn.

If the sample is frozen or consists of snow or hail, the funnel should preferably be kept warm by, for example, an electric heating element. Where this is not possible, the entire apparatus should be removed and thawed at low temperatures.

9.2 Estuaries, coastal waters, seas and oceans

9.2.1 Extent and depth

The boundaries of the area under investigation should be clearly defined and consideration given to the relation of the area to adjacent areas of water. Selection of sampling sites and positions should take into account the fact that tidal currents and their modification by wind, density, bottom roughness, shore line proximity and shipping can all produce considerable disturbance within the water and variation in water quality at the designated sampling site. In addition, the effect upon sampling of any local discharges should be carefully considered.

9.2.2 Use of boats

Boats, when used, should be capable of reaching all sampling positions within the time-limits of the survey in suitable weather conditions.

9.2.3 Ice cover

In water under ice cover, a restricted inverse thermal stratification develops with a thin layer (about 5 mm) of cold water at 0 to 3 °C on top of the main mass of water at 4 °C. Steep

thermal concentration gradients may be associated with this thermal stratification and biological communities may also be stratified.

9.3 Rivers and streams

9.3.1 Mixing

If significant streaming or stratification exists at the sampling point, a series of transverse and depth samples should be collected to determine the nature and extent of any streaming or stratification.

9.3.2 Selection of sites

Sites should be selected so as to provide representative samples, preferably where marked quality changes are likely to occur or where there are important river uses, for example confluences, major discharges or abstractions. Weirs or small discharges which are only very local in effect should generally be avoided.

Sites should preferably be chosen where flow data are available. River gauging huts are frequently used for the installation of water-monitoring equipment.

If sampling is intended to monitor the effects of a discharge, sampling both upstream and downstream should be carried out, but careful consideration should be given to the mixing of the discharge and receiving water and its effects on the downstream samples. Sampling should extend for an appropriate distance downstream to assess the effects on the river.

9.4 Canals

In general, the considerations for rivers and streams apply, but the following factors need special attention.

9.4.1 Flow

The direction of flow may be changeable. The flow rate may vary considerably and be more dependent upon the amount of navigational use (i.e. the number of locking operations) than upon prevailing weather conditions.

9.4.2 Stratification and streaming

These will tend to be more pronounced than in rivers under the quiescent conditions found in canals. The passage of boats may have a very marked short-term effect on the quality of water in a canal, especially on the suspended solids concentration.

9.5 Storage reservoirs and lakes

Sampling should be carried out at all available draw-off points and draw-off depths in addition to inputs. The water body may be thermally stratified and very significant quality differences may develop between different depths. Ecological investigations may require a more detailed sampling programme; flow data and meteorological data may be required.

In large water masses, sampling from a boat is normally necessary.

9.6 Groundwaters

9.6.1 Abstracted groundwater

Samples are required to assess the suitability of an abstracted groundwater for a particular use. Samples may be taken at the abstraction point, although these samples may not be representative of the general quality of the water in the aquifer.

9.6.2 Water in an aquifer

When sampling is carried out to assess the quality of water in an aquifer, the well or borehole should, whenever possible, be pumped prior to sampling to ensure that new water is drawn from the aquifer. Even in these circumstances, the water in the well or borehole may be stratified and additional sampling may be required to assess the degree of stratification. The depth below ground level at which the sample is taken should always be recorded.

Wells or boreholes lined with materials liable to corrosion should always be pumped thoroughly prior to sampling in order to clear all accumulated corrosion products from the system.

Where representative samples are required from predetermined depths in the aquifer, sampling tubes to each depth in the borehole, or separate boreholes to each depth, should be employed.

9.7 Bottom deposits in rivers, estuaries and the sea, lakes and reservoirs

Sampling patterns should be established to take account of variations of composition in both vertical and horizontal directions. It may be necessary to obtain information on the depth of a bottom deposit or on its composition at different depths.

Many factors important in sampling waters, such as the use of boats, also apply to the sampling of bottom deposits.

Substrata are usually heterogeneous and special care should be taken to ensure that a sufficient number of samples is taken to provide a representative assessment of the parameter(s) under consideration.

9.8 Drinking water

9.8.1 Water being pumped into supply

The sampling point should be selected so as to permit monitoring of residual disinfecting agents before any loss occurs but after all reactions are completed, for example, monitoring of residual chlorine after complete reaction of sulphur dioxide with excess chlorine. Sampling for routine bacteriological examination is also required and suitable precautions, including any national safety regulations, should be observed.

The usual sampling point is a tap connected directly to the pumping main. The sampling tap should have no attachments

and should be suitable for sterilization by flaming. The material of the sample pipe shall be carefully chosen in relation to the test requirements, for example, copper pipe may lead to an increase in the copper concentration in the water and a decrease in bacterial count. In order to make sure that the sample is drawn directly from the tap into the container, the sample container should be placed immediately below the tap but not connected to it, nor in direct contact with it.

9.8.2 Service reservoirs

Samples should be taken from a tap fitted to the outlet main as close as possible to the reservoir. Many service reservoirs are designed so that they fill and empty through the same main, and therefore care is needed to ensure that the reservoir is emptying at the time of taking the sample.

9.8.3 Water in the distribution system

Taps at consumers' premises provide the most satisfactory means of sampling water from the general distribution system. Anti-splash or similar devices should be removed before sampling; mixer taps are not recommended for sampling. Samples from extensions to the main distribution system are usually obtained from hydrants and washouts. Again, special precautions are necessary for sampling for bacteriological examination.

9.8.4 Sludges derived from drinking water treatment

Some treatment plants produce lime-softening sludges or biological sludges. Most sludges produced in drinking water treatment, however, are of aluminium hydroxide or iron hydroxide. They may need to be sampled within coagulation or settling tanks at different depths and also in thickening tanks. It is often important to examine sludge samples with a minimum of delay and agitation, as the characteristics can change significantly within minutes.

9.9 Bathing places

In naturally formed bathing places, sampling should be carried out as for storage reservoirs and lakes (see 9.5). In swimming pools with recirculating systems, samples should be taken at the inlet, the outlet and from the body of the water.

10 Sampling situations in industry

10.1 Inlet water

Drinking water, river water and borehole water are included and are usually homogeneous in composition at any given time, although they can vary in quality with time. The water usually enters the factory through a conventional system of pipes and no special sampling situations arise.

If separate non-potable industrial supplies are available, special care is needed to ensure that the various distribution systems are clearly identified and that there is no uncertainty at the sampling points. To check that a water is suitable for drinking purposes, facilities should be available for sampling.

If information on the quality of the final blend of a mixture of

waters is required, it is necessary to ensure that adequate mixing has occurred before sampling.

10.2 Boiler system waters

10.2.1 Water from a treatment plant

At the design stage of the treatment plant, the positioning of sampling points should be carefully considered and it is usually necessary to include facilities for removing samples at various treatment stages as well as at the inlet and outlet of filters. When suspended solids are present, the sample lines should be thoroughly flushed before the sample is taken.

Special sampling techniques are necessary to avoid losses when taking samples for the determination of dissolved gases, for example oxygen or carbon dioxide. If a degassing tower is included for the removal of carbon dioxide, subsequent sample handling should avoid loss or pick-up of carbon dioxide. The sample tube should normally dip well into the body of the water to avoid anomalous surface conditions.

10.2.2 Boiler feedwater and boiler water

The water from many sampling points in the steam/condensate/water circuit will contain only trace concentrations of the impurities of interest; special care should therefore be taken to avoid contamination of the samples in the interval between sampling and analysis.

Sampling systems should normally be made of stainless steel and of sufficient structural integrity to withstand the operating pressures to which they may be subjected.

Water fed to a boiler is often a mixture of treated boiler feedwater and returned condensate and the sampling point should be positioned after adequate mixing has occurred. If boiler feedwater at high temperature and pressure has to be sampled through long sampling lines, it is highly desirable, in the interests of safety, to cool the sample in the sampling line as near as possible to the sampling point. Additionally, such cooling avoids errors due to loss of flash steam and minimizes the risk of loss of oxygen resulting from reaction at, or with, the walls of the sampling line.

When both physical and chemical de-aeration processes are used, two sampling points are normally required; one to check the efficiency of physical de-aeration before chemicals are added, and a second to check the overall efficiency of the de-aeration.

Sampling points should be so positioned on the boiler as to ensure representative sampling of the boiler water. For some analyses, such as for trace metals, which may be partly or wholly in particulate form, isokinetic sampling probes should be used.

10.2.3 Steam and steam condensate

In industry, it is important to control the quality of steam and it is normally necessary to sample both steam condensate return lines and superheated or wet steam under pressure. Isokinetic sampling probes, in conjunction with a suitable cooler-

condenser made of stainless steel, should be used for sampling steam and special care should be taken to avoid contamination in the interval between sampling and analysis.

10.2.4 Water from cooling systems

There are three main types of cooling system :

- a) open evaporative;
- b) once-through;
- c) closed circuit.

Normally, in open evaporative systems, the inlet (make-up) water and the circulating water are sampled. One sampling point is normally provided on the inlet line but, on the cooling system itself, it may be necessary, in order to obtain the information required, to sample at a number of points such as at the inlet to the circulating pump, immediately prior to the cooling tower if a biocidal treatment has been used and possibly at the basin of the cooling tower if water with a high suspended solids content is in use. Ideally, isokinetic sampling systems should be used.

Sampling points are normally provided in the once-through and closed circuit systems, for example at inlet and outlet for a once-through system and at a low point in a closed system.

11 Trade effluents

11.1 Sites

The sampling of industrial effluents has to be considered in relation to the nature and location of each individual effluent.

In general, industrial effluent discharge points may be pipe discharges or open ducts at remote locations where physical access is difficult and no services are available. Alternatively, the discharge points may be readily accessible within the factory premises. It may on occasion be necessary to sample from deep manholes and, in such cases, specially designed equipment is required. With manhole sampling, it is preferable, for safety reasons, that the manhole should be designed so as to permit sampling to take place without entry.

The possibility of domestic sewage from the factory being contained in the sample should also be considered and the site should be chosen to exclude such wastes, if necessary.

If the effluent discharge is to a lagoon or holding tank, then the sampling situation becomes similar to that for lakes.

11.2 Nature of the effluent

In some industrial situations (for example discharges from individual plants before further dilution), concentrations of certain constituents may present special difficulties requiring individual consideration. Examples are the presence of oil or grease, high suspended solids, highly acidic effluents and flammable liquids or gases.

When effluents from a variety of processes discharge into a common main, adequate mixing is required in order to obtain a satisfactory sample.

11.3 Industrial water and effluent treatment sludges

A wide range of chemical sludges can be produced in industrial water treatment, for example sludges may contain toxic metals or radioactive materials, and biological sludges from effluent treatment plants may also need to be sampled (see 12.1.2). When sampling such sludges, suitable safety precautions, including relevant national safety regulations, should be applied.

12 Sewage and sewage effluents

Samples may be required both when sewage enters a treatment plant and also after various stages of treatment, including samples of the treated effluent.

12.1 Selection of sampling sites

12.1.1 Liquid effluents

The choice of sampling site at each stage in the process should be made carefully, particularly in the case of crude sewage, the composition of which can show considerable variation with time. The sewage may be contained in culverts of large cross-section and its composition may vary with depth and across the diameter of the culvert. Incomplete mixing of sewages from different sources may also occur and at low flow rates suspended material may settle. Before selecting a site, a preliminary sampling programme to establish these variations should be conducted and the location of the routine sampling point determined from the information obtained. In many cases, it will be necessary to take two or three routine samples at different points and to mix these to give a composite sample.

Floating material, such as oil or grease, cannot be sampled representatively on a routine basis and samples should, generally, be taken from below the surface.

Crude sewage samples are frequently taken after the preliminary screening and comminution processes so that adventitious inclusion of large particles in the sample is avoided. However, where automatic samplers are used, these can be sited upstream of the preliminary processes, provided that a screen or a small macerator is fitted to the sampler inlet to prevent blockages.

In selecting a sampling site for crude sewage at the treatment plant, the inclusion of recirculated liquors within the plant should be considered. Ideally two samples, one including all liquors representing the total load on the plant, and one excluding recirculated liquor to give a measure of the loading from external sources, may be necessary. If collection of either of these samples is not practicable, it may be possible to calculate the composition of the sewage by separate sampling and analysis of the liquors.

12.1.2 Sewage treatment sludges

Sludges may need to be sampled in certain tanks, such as sedimentation tanks or digestion tanks, lagoons, or drying beds.

If both primary and digested sludges are to be sampled, considerable difficulty may be experienced due to lack of homogeneity and also to the presence of large particles.

If sampling is to be from a pipeline, the sampling line should be at least 50 mm in diameter in order to ensure minimum occurrence of blockages, and samples should be taken at frequent time intervals. When sampling from tanks, lagoons, or drying beds, a large number of samples from various depths and positions may be necessary. Accessibility to the sampling points may be difficult and may need special structures.

In all these situations, a statistical approach to determining sampling frequency is desirable. An example of such an approach is included in clause 16.

13 Storm sewage and surface run-off

The discharge of such waters normally occurs when flows in

the receiving water courses are high and the dilution available is correspondingly large. However, for a variety of reasons, storm sewage overflows may operate at other times and surface run-off may become contaminated to such an extent that the overflows may represent a serious threat to the quality of a watercourse even under high flow conditions.

The sampling of such discharges presents special problems because of their intermittent nature and because the quality can change markedly throughout the period of discharge. The quality is worse in the first flush of the discharge as a result of the initial cleansing of sewers and impermeable areas. Automatic sampling devices that collect samples at regular intervals and which start at a prescribed flow offer many advantages. This equipment should be installed in a permanent state of readiness. In many instances, flow-proportional sampling will be desirable. The usually highly heterogeneous nature of unmacerated or unsettled storm sewage gives rise to difficulties in obtaining a representative sample and to blocking of equipment. This heterogeneity should be taken into account when sampling techniques and equipment are being selected.

Relevant precipitation and air temperature data should be collected throughout the period of investigation.

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Section three : Time and frequency of sampling

14 Introduction

Information is normally required over a period of time during which the water quality may vary; thus, samples should be taken at times which will adequately represent the quality and its variations with minimum effort. This approach contrasts with the choice of sampling frequency based on either subjective considerations or the amount of effort available for sampling and analysis. Both these latter methods may lead either to totally inadequate sampling or to unnecessarily frequent sampling.

15 Types of sampling programme

Three main types of programme exist. These may be described as quality control, quality characterization, and identification of sources of pollution (see clause 3). Measurements made for quality control purposes may be used for quality characterization and vice-versa.

15.1 Quality control programmes

These usually involve the control of concentration of one or more determinands within defined limits. The results are required in order to decide whether immediate action is needed. The sampling frequency should therefore be chosen so that there is more than an acceptable probability of important deviations outside the control limits occurring between successive measurements. There are two primary factors which fix this frequency :

- a) the magnitude and duration of deviations from the desired conditions;
- b) the probabilities of occurrence of deviations from the desired conditions.

Often, only approximate definitions of these factors will be possible, but reasonable estimates will enable a working value for the sampling frequency to be deduced.

15.2 Quality characterization programmes

These programmes aim to estimate one or more statistical parameters that characterize the concentration or its variability during a defined period, or both. For example, the mean or median indicate the central tendency of results and the standard deviation indicates the variability. The results may be required as part of a research investigation, or for characterization of determinands which do not currently need to be controlled, or for long-term control purposes.

15.3 Programmes for investigation of causes of pollution

These programmes should be designed to determine the characterization of polluting discharges of unknown origin.

They are generally based on a knowledge of the nature or natures of the pollutants, and the coincidence of the periodicity of the appearance of pollution and of sampling.

These criteria necessitate that the sampling, in contrast with that carried out for quality control and quality characterization, should be carried out with a fairly high frequency in relation to the frequency of appearance of pollution.

The establishment of the frequency can be very useful.

16 Statistical considerations

16.1 Establishment of sampling programmes

The times and frequencies of sampling in any programme can be properly decided only after detailed preliminary work, in which a high sampling frequency is necessary to provide the information to which statistical techniques may be applied. If quality is subject to variations, either random or systematic, the values obtained for statistical parameters, such as mean, standard deviation, maximum, are only estimates of the true parameters and generally differ from them.

In the case of purely random variations, the differences between these estimates and the true values can be calculated statistically; they decrease as the number of sample increases. Once the frequency of sampling has been decided, the data obtained should be reviewed regularly so that changes can be made as required.

The treatment in 16.2 to 16.5 is an example of the above approach, using one statistical method applied to one statistical parameter, the mean, and assumes that the normal distribution applies. The terminology used is in accordance with ISO 3534 to which reference should be made for definitions of the terms used.

For a full treatment of calculation of the mean in terms of confidence interval, reference should be made to ISO 2602.

16.2 Confidence interval

In practice, the confidence interval L of the mean of n results, defines the range in which the true mean lies at a given confidence level.

16.3 Confidence level

The confidence level is the probability that the true mean will be included within the calculated confidence interval L . A confidence interval for the mean value $\bar{x}$ of a concentration, calculated on the basis of a sample with n results, and at a 95 % confidence level, means that there are 95 chances out of 100 that the interval will contain the true mean $\bar{X}$. For the case in which a large series of samples are effectively taken, the frequency of cases in which the interval will include $\bar{X}$ will be close to 95 %.