ENVIRONMENT AGENCY

The determination of taste and odour in drinking waters (2010)

Methods for the Examination of Waters and Associated Materials

The determination of taste and odour in drinking waters (2010)

Methods for the Examination of Waters and Associated Materials

This booklet contains methods for the qualitative and quantitative determination of taste and odour in drinking waters. A method is also described where the assessment is required to be carried out following de-chlorination of the sample. An on-site method is also described for continuous odour monitoring.

No performance data are available for the methods described in this booklet.

This bluebook updates and complements the earlier version published in 1994 and may be read in conjunction with “The assessment of taste, odour and related aesthetic problems in drinking waters 1998”, “The Microbiology of Drinking Water (2004) - Part 11 - Taste, odour and related aesthetic problems” and “The Microbiology of Drinking Water (2004) - Part 12 - Methods for the isolation and enumeration of micro-organisms associated with taste, odour and related aesthetic problems”.

Whilst specific commercial products may be referred to in this document, this does not constitute an endorsement of these products but serves only as illustrative examples of the types of products available. Equivalent products may be available and it should be understood that the performance of the method might differ when other materials are used and all should be confirmed by validation of the method.

Contents

About this series

Introduction

This booklet is part of a series intended to provide authoritative guidance on recommended methods of sampling and analysis for determining the quality of drinking water, ground water, river water and sea water, waste water and effluents as well as sewage sludges, sediments and biota.

Performance of methods

Ideally, all methods should be fully evaluated with results from performance tests. These methods should be capable of establishing, within specified or pre-determined and acceptable limits of deviation and detection, whether or not any sample contains concentrations of parameters above those of interest.

In the procedures described in each method any reference to the tolerances to be adopted with respect to, for example the amount or volume of reagents to be used is left to the discretion of the laboratory. These tolerances should be as low as possible in order to satisfy stringent performance criteria. Tolerances of between 1 - 5 % have been shown to be satisfactory for most purposes. Lower tolerances should result in improved precision.

In the methods described, for example for wavelengths, storage conditions, concentrations of the same or similar reagents, etc, differences may be noted. This information is provided by individual laboratories operating under their own management systems and is dependent on specific conditions pertaining to each laboratory. It is assumed this information is supported by sufficient data to justify its inclusion. Users intending to use or vary the quoted wavelengths, storage conditions, concentrations, etc, should ensure they are appropriate to their own laboratory and verify their application to demonstrate appropriate performance of the method. In addition, good laboratory practice and analytical quality control are essential if satisfactory results are to be achieved.

Standing Committee of Analysts

The preparation of booklets within the series "Methods for the Examination of Waters and Associated Materials" and their continuing revision is the responsibility of the Standing Committee of Analysts. This committee was established in 1972 by the Department of the Environment and is now managed by the Environment Agency.

Methods are produced by panels of experts in the appropriate field, often in co-operation with working groups and the main committee. The names of those members principally associated with these methods are listed at the back of this booklet. A report describing all SCA activities for the period 1 July to 30 June is produced annually and is available from the Agency's web-page (www.environment-agency.gov.uk/nls).

Users should ensure they are aware of the most recent version of the draft they seek. If users wish to receive copies or advance notice of forthcoming publications, or obtain details of the index of methods then contact the Secretary on the Agency's internet web-page or by post, see address listed at the back of this booklet.

Great efforts are made to avoid errors appearing in the published text. If, however, any are found, please notify the Secretary.

Dr D Westwood
Secretary
February 2010

Warning to users

The analytical procedures described in this booklet should only be carried out under the proper supervision of competent, trained analysts in properly equipped laboratories.

All possible safety precautions should be followed and appropriate regulatory requirements complied with. This should include compliance with the Health and Safety at Work etc Act 1974 and all regulations made under the Act, and the Control of Substances Hazardous to Health Regulations 2002 (SI 2002/2677). Where particular or exceptional hazards exist in carrying out the procedures described in this booklet, then specific attention is noted.

Numerous publications are available giving practical details on first aid and laboratory safety. These should be consulted and be readily accessible to all analysts. Amongst such publications are; "Safe Practices in Chemical Laboratories" and "Hazards in the Chemical Laboratory", 1992, produced by the Royal Society of Chemistry; "Guidelines for Microbiological Safety", 1986, Portland Press, Colchester, produced by Member Societies of the Microbiological Consultative Committee; and "Safety Precautions, Notes for Guidance" produced by the Public Health Laboratory Service. Another useful publication is "Good Laboratory Practice" produced by the Department of Health.

A Taste and odour in drinking waters

Introduction

The determination of taste and/or odour in water using the methods set out in this booklet rely on the subjective judgement of a limited number of individuals. Four methods are included in this booklet.

Method A1 describes procedures whereby an undiluted sample is smelled and tasted by a group of people in order to provide a qualitative description of the taste and odour, if present, in the sample. In addition, an indication of the intensity of the taste/odour is recorded. If the assessment of the original undiluted sample satisfies the criteria and is deemed taste- and odour-free, then no further action is required. The sample is assigned a taste/odour threshold number of one, i.e. a taste/odour dilution number of zero, and the sample is deemed to be acceptable to consumers.

If a chlorinous taste or odour is detected in the original undiluted sample, procedures are described in method A2 to assess the taste and odour on a de-chlorinated portion of the original undiluted sample. If the assessment of the de-chlorinated original undiluted sample satisfies the criteria and is deemed taste- and odour-free, then no further action is required. The sample is assigned a taste/odour threshold number of one, i.e. a taste/odour dilution number of zero, and an additional assessment is carried out to assess whether the chlorinous taste or odour in the original undiluted sample is acceptable to consumers and if an abnormal change has occurred.

Method A3 describes techniques whereby, if a non-chlorinous taste and/or odour is detected in the original undiluted sample using the procedures described in method A1, or a non-chlorinous taste and/or odour is detected in a de-chlorinated portion of the original undiluted sample using the procedures described in method A2, a quantitative determination of the taste/odour threshold number is undertaken on a portion of the sample diluted with blank water. The intensity of the taste/odour in this diluted sample is determined by a group of people, and a single numerical value, expressed as a taste/odour threshold number is determined from the geometric mean of the taste/odour threshold number results obtained by the group. Once the taste/odour threshold number is known, a taste/odour dilution number is calculated, and a further assessment should be undertaken to ascertain whether the sample is deemed to be acceptable to consumers and whether abnormal changes have occurred in the sample over a period of time.

Method A4 describes techniques where a continuous on-line odour monitor is used in water treatment works for monitoring odours in waters. The intensity of the odour is amplified by raising the temperature of the sample when the determination is carried out.

Methods A1 - A3 are primarily directed towards assessing compliance with the taste and odour requirements of new UK legislation. See Figure 1. Previous requirements relied on a statutory limit of 3 taste/odour dilution number. New requirements are based on the acceptability to consumers, of the taste and odour present in drinking water, and whether the taste and odour originates from an abnormal change. Comparable data to that previously obtained for drinking water compliance purposes for the previous taste and odour requirements can be obtained, but additional work is now required in order to ascertain if a taste and/or odour detected is acceptable to consumers, and whether the taste and odour originates from an abnormal change, rather than rely on the use of a prescribed statutory limit for taste and odour.

When water possesses an odour it may possess a taste. However, a distinct taste may arise from a sample that possesses no odour. Several dissolved metal ions, such as iron, manganese, potassium, sodium and zinc can be detected by taste whilst not giving rise to any perceptible odour.

Many complaints received from consumers are specifically concerned with poor taste, and the rapid identification of such tastes often assists in the elucidation of the cause. Several tastes can be correlated with specific water treatment problems and a person who has a particularly sensitive palate may be able to assess a sample to provide an early indication of the presence of a taste in a raw or treated water before it comes to the notice of consumers. (These people should however not be used for the routine assessment of taste and odour in drinking water). As a consequence, remedial measures may be applied at the treatment works in order to prevent, or reduce, problems associated with taste (and odour) occurring in the distribution system.

Taste tests should only be performed on samples known to be safe. The panellist should, as a precaution, be instructed not to swallow any of the sample. Consideration should be given to the potential hazards that panellists may face when carrying out the assessments of taste and odour.

Table 1 lists a number of compounds capable of causing odours (and possibly tastes) in water, together (in some cases) with typically reported odour threshold concentrations. The actual odour threshold concentration may vary for different people, depending on their differing olfactory sensitivities. These variations may range between up to 2 - 3 orders of magnitude, and the values quoted are given solely to indicate their relative odour-causing potentials.

Threshold numbers

The taste/odour threshold number (T/O TN) of a sample is that dilution of the sample with blank (reference) water where no taste or odour is detected.

Expressed mathematically, the taste/odour threshold number (T/O TN) is given by

$$\text{T/O TN} = (A+B) / A$$

Where A = volume of sample, and
B = volume of blank (reference) water used to dilute the sample.

The T/O TN of each panellist used in the test procedure is used to calculate a geometric mean T/O TN. At the final stage of the assessment, this geometric mean T/O TN is converted to a taste/odour dilution number (T/O DN).

Thus

$$\text{T/O DN} = \text{T/O TN} - 1$$

For the original (undiluted) sample, where the taste/odour is deemed taste- and odour-free,

$$\text{T/O TN} = 1 \quad \text{and}$$

T/O DN = 0

In the UK, the assessment of tastes and odours for samples taken for statutory drinking water compliance purposes, where

- non-chlorinous tastes or odours have been detected in the original, undiluted samples (method A1) or

- non-chlorinous tastes or odours have been detected in de-chlorinated portions of the original, undiluted samples (method A2)

then it is a requirement that results are expressed in units of taste/odour dilution numbers, T/O DN, for assessments carried out at 25 °C.

In method A3, the diluted sample is subjected to an ascending/descending triangle test to evaluate the T/O TN. Using these procedures enables a measure of the taste/odour intensity to be determined in a diluted sample at 25 °C.

Sampling and sample preservation

Collect the sample (with no headspace) in an appropriate clean sample bottle. The sample should be kept cool (about 5 °C) and tested as soon as possible after collection. Do not store the sample for more than 72 hours before commencement of analysis. The sample should not be de-chlorinated at the time of collection.

Panellists

For assessing the taste and odour of samples, the testing panel should, ideally, be composed of people familiar with the taste/odour of the source to be analysed. Realistically, this may not be possible where samples from many sources are evaluated in any one particular laboratory. The number of panellists within the group should consist of an odd number. This number should ensure a confirmed decision can be made with regard to the presence or absence of taste/odour in the sample.

The pool of panellists capable of undertaking the test should consist of as many people as possible. These panellists may or may not be laboratory staff. At least three panellists should be available to perform the assessment of taste and odour. If two panellists (from a group of three) completely agree in their qualitative assessment of taste and odour it may not be necessary for the third panellist to carry out these tests. Persons with high or low taste/odour sensitivities will probably cause bias in the recorded results. All potential panellists should, therefore, be screened to eliminate those persons possessing high or low taste/odour sensitivities. Procedures should exist for the retrospective assessment of potential panellists in order to ascertain the suitability of those persons considered for panel membership (see Appendix 2). Increasing the number of appropriate persons in the panel carrying out the assessment of taste and odour will enhance the precision of the assessment and hence the reliability of the results reported.

Panellists should be free from colds or allergies that affect taste/odour response, should not eat or smoke for a minimum period (for example up to 1 hour) prior to the test. Ideally, on the day of, and the day prior to, the assessment, panellists should avoid the use of perfumes or cosmetic preparations, including scented soap for hand washing.

A panellist should not assess the taste and odour of more than ten samples, together with associated blank waters, in any one session without a short break. If any of the samples has a pronounced taste or odour, a short rest period or break may be required before continuing with the tests. It has been found that ingesting a plain tasting biscuit and/or drinking a dilute sucrose solution, followed by a short break can speed recovery of the panellists' ability to continue.

In addition to the panellists, a person (sometimes referred to as a co-ordinator or panel leader) is required to prepare the samples, to offer them to the panellists and to record and collate the results. It is essential that this person carries out the manipulations with respect to samples and blank waters without revealing to the panellists the identities of the samples and blank waters. This person should not be used as one of the taste/odour assessors for the batches of samples he or she has prepared for the panellists.

Accommodation

The room in which the determinations are carried out should be free from interferences that may affect the taste/odour determinations (for example odours caused by cooking, or the use of chemicals, paints, polishes, air fresheners, room de-odorizers, etc) and other factors (such as drafts, noise, the presence of on-lookers, etc) that may cause a distraction to the testing panel.

Apparatus

General. Glassware should be reserved solely for taste and odour determinations and, when not in use, should be stored in a clean condition so that accidental contamination is avoided.

Cleaning of apparatus. Sample bottles should be cleaned before use by soaking them thoroughly overnight in a dilute solution of a strong detergent and then rinsing thoroughly with water. Detergents containing phosphates should not be used. Alternatively, an automatic dishwasher supplied with water at a temperature of not less than 60 °C and a detergent (for example as described above) may be suitable.

Water bath or incubator capable of maintaining a temperature of 25 °C throughout the bath.

Sample bottles. Wide-mouthed glass-stoppered bottles or food grade polyethyleneterephthalate (PET) bottles of at least 500 ml capacity should be used. If non-glass bottles are used then these should be thoroughly tested before use to ensure that no taste or odour is imparted to, or removed from, the sample under investigation.

Wine glasses. Typical wine glasses where the opening or mouth of the glass is smaller in diameter than the bulb or convex part of the glass. The glasses are so designed to restrict volatile components from escaping. Alternative containers may also be suitable and should be thoroughly tested before use to ensure they do not reduce or increase the intensity of the taste/odour of the sample or blank water, or remove from or impart to the sample or blank water a taste/odour .

UK legislation

The Water Supply (Water Quality) Regulations 2000 (Statutory Instrument 2000:3184) as amended in The Water Supply (Water Quality) Regulations 2000 (Amendment) Regulations 2007, Statutory Instrument 2007:2734.

See also The Water Supply Regulations 2010, Statutory Instrument 2010:991 and The Water Supply (Miscellaneous Amendments) (England and Wales) Regulations 2010, Statutory Instrument 2010:996.

Similar legislation applies to Wales: The Water Supply (Water Quality) Regulations 2001 (Statutory Instrument 2001:3911) as amended in The Water Supply (Water Quality) Regulations 2001 (Amendment) Regulations 2007 (Statutory Instrument 2007:3374) (W299). See also The Water Supply (Water Quality) Regulations 2010, Statutory Instrument 2010:994 (W.99).

Similar legislation applies to Scotland : The Water Supply (Water Quality) (Scotland) Regulations 2001, Scottish Statutory Instrument 2001:207. At the time of publication of this booklet, the requirements of these regulations include the statutory limit for taste and odour of 3 DN. (See the 1994 booklet in this series).

Similar legislation applies to Northern Ireland: The Water Supply (Water Quality) Regulations (Northern Ireland) 2007, Statutory Instrument 2007:147. The Water Supply (Water Quality) Amendment Regulations (Northern Ireland) 2009, Statutory Instrument 2009:246.

At the time of publication of this booklet, legislation in the UK is currently under revision and further guidance is being prepared elsewhere, see (http://www.dwi.gov.uk/stakeholders/legislation/index.htm).

A1 Qualitative method for the determination of taste and odour

A1.1 Principle

The original undiluted sample is smelled and then tasted at 25 °C and any taste and odour is assessed in terms of its intensity and nature, see Tables 2 and 3 respectively.

A1.2 Field of application and interferences

In treated waters which have been chlorinated, a chlorinous taste or odour may interfere in the detection of other tastes and odours by masking or enhancing their presence in the sample. If a chlorinous taste or odour is detected in the original undiluted sample, the sample should be de-chlorinated after the taste/odour assessment has been carried out, and then re-assessed in the absence of chlorine, see method A2.

A1.3 Reagents

Use analytical reagent grade chemicals unless otherwise indicated. Water for the preparation of reagents should be distilled, deionised or of similar grade quality.

A1.3.1 Blank water. Blank water used for rinsing glassware, and as a reference water, should be water appropriate to the area, and where possible, should be similar in composition to the type of water sample being tested. It should be water which has been judged by a group of people, i.e. a testing panel, to possess no taste and odour at 25 °C.

Reference water meeting this criterion can be prepared as follows. Pass distilled water at a flow rate not exceeding 10 litres per hour through a glass column (for example 20 mm in diameter and 200 mm in length) filled with fresh technical grade activated carbon (5 to 20 mesh). Collect the water in a suitable container. This water should be prepared on the day of use and judged independently by a testing panel to possess no taste and odour at 25 °C.

Activated carbon may act as a potential growth medium for bacteria. Unless changed frequently, bacteria may collect in the activated carbon and may ultimately gain access to, and contaminate the water so prepared.

The reference water should be collected in clean glass-stoppered glass containers, or food grade polyethyleneterephthalate (PET) bottles, reserved solely for this purpose. Collected water should be used or discarded within 12 hours of preparation. If non-glass containers are used, they should be thoroughly tested before use to ensure no taste or odour is imparted to, or removed from, the blank water or water under investigation.

A1.4 Analytical procedure

Step	Procedure	Notes
	Preparation of undiluted samples	
A1.4.1	Invert the sample bottle in an attempt to mix the contents. Remove the stopper from the sample bottle and discard a	

portion of sample. Replace the stopper. Allow the contents of the bottle to reach 25 °C.

A1.4.2 Shake the bottle and its contents. Remove the stopper and pour a quantity of the undiluted sample into a wine glass. Replace the stopper (see note a) and immediately cover the top of the glass with a watch-glass. Repeat this process for each panellist to be used in the assessment of taste and odour. See note b.

(a) In case a taste or odour is subsequently detected in the original undiluted sample it may be appropriate to return the bottle to cool storage.

(b) Different panellists should not smell or taste from the same container. Portions of the original undiluted sample should be decanted from the sample bottle into individual wine glasses so that each panellist is able to assess the taste and odour independently.

A1.4.3 Prepare up to ten undiluted samples in a similar way as described in steps A1.4.1 and A1.4.2. In addition, in a similar way, prepare a minimum of at least two blank (reference) water samples (A1.3.1). See notes c and d. Arrange the glasses in a random, but known order. Ensure the contents of the wine glass remain at 25 °C during the assessment.

(c) The samples and blank waters should not be identifiable to individual panellists, either by means of appearance or wine glass. If samples are turbid or coloured, consideration should be given to covering all glasses with, for example aluminium foil before they are presented to individual panellists.

(d) If 3 panellists carry out the assessment at the same time and ten samples and two blank waters are assessed, a total of 36 glasses will be required for the determinations.

A1.4.4 For each prepared individual blank water and sample, gently, so as not to spill any of the contents, shake or swirl the wine glass and its contents, remove the watch glass, smell the contents and replace the watch glass (see note e). Classify the odour immediately according to its intensity and nature (see Tables 2 and 3 respectively, and also Table 1).

(e) The contents should be smelled by holding each wine glass at its base and immediately applying the nose to the opening of the glass.

A1.4.5 Remove the watch glass. Gently, so as not to spill any of the contents, shake or

(f) The contents should be tasted by holding each wine glass at its

swirl the glass and its contents again, and taste the contents (see note f). Classify the taste immediately according to its intensity and nature (see Tables 2 and 3 respectively, and also Table 1).

base and taking into the mouth whatever volume of sample or blank water is comfortable, holding the contents in the mouth for several seconds and then discharging the contents to waste without swallowing any.

A1.4.6 The assessment of any taste and odour should be made as quickly as possible after smelling and tasting the contents, and recorded immediately. See note g.

(g) To ensure panellists do not become de-sensitised, no more than ten undiluted samples should be assessed by each panellist at any single occasion.

A1.4.7 At the same time that samples are assessed, the assessment of appropriate AQC samples should also be undertaken. See Appendix 3.

Assessment of results

A1.4.8 The results of each batch of test results for any individual panellist will be valid only if at least 60 % of the blank (reference) waters are identified as being taste- and odour-free, see Table 4 and note h.

(h) If blank (reference) waters are persistently identified by several panellists as not being taste- and odour-free, then the blank water (A1.3.1) may not be of adequate quality and a further quantity should be prepared.

A1.4.9 If a set of results is found to be invalid then additional samples and blank waters should be prepared for each additional panellist and steps A1.4.4 - A1.4.7 should be carried out using additional panellists (see notes b and i).

(i) If a single panellist persistently identifies the blank water (A1.3.1) as not being taste- and odour-free then consideration should be given to removing the panellist from the panel (see Appendix 2).

A1.4.10 If a sample is identified as being taste- and odour-free by at least 60 % of those panellists with valid results, then no further action is required and the original undiluted sample is reported to be taste- and odour-free (see Table 5 and note j).

(j) Where the taste/odour assessment on the original, undiluted sample satisfies the criteria and indicates that the sample is taste- and odour-free, it is assigned a taste/odour threshold number of 1 (i.e. a taste/odour dilution number of 0). In these cases, the original undiluted sample is deemed to be acceptable to consumers.

A1.4.11 If a sample is identified as possessing a chlorinous taste and/or odour by at least 60 % of those panellists with valid

results, then the sample should be further tested using the procedures described in method A2.

A1.4.12 If a sample is identified as possessing a non-chlorinous taste and/or odour by at least 60 % of those panellists with valid results, then the sample should be further tested using the quantitative procedures described in method A3.

A2 The qualitative determination of taste and odour following de-chlorination

Where a chlorinous taste or odour is detected in the original undiluted sample (method A1) the sample should be de-chlorinated and a further assessment carried out to ascertain if another (non-chlorinous) taste or odour has been masked by the presence of the chlorine.

In certain cases depending on the nature of the sample, sodium thiosulphate can give rise to sulphurous tastes/odours when used as a de-chlorinating agent. An alternative de-chlorinating agent, for example ascorbic acid may therefore need be used. However, ascorbic acid may also cause interfering tastes/odours, for example where waters have been chloraminated. Other de-chlorinating agents may be used provided tastes/odours are not imparted to or removed from the sample.

Where a sample has been de-chlorinated and assessed for taste and/or odour the report should contain a statement indicating the assessment has been carried out on a de-chlorinated sample.

A2.1 Reagents

Use analytical reagent grade chemicals unless otherwise indicated. Water for the preparation of reagents should be distilled, deionised or of similar grade quality.

A2.1.1 Blank water. Blank water used for rinsing glassware, and as a reference water, should be water appropriate to the area, and where possible, should be similar in composition to the type of water sample being tested. It should be water which has been judged by a group of people, i.e. a testing panel, to possess no taste and odour at 25 °C.

Reference water meeting this criterion can be prepared as follows. Pass distilled water at a flow rate not exceeding 10 litres per hour through a glass column (for example 20 mm in diameter and 200 mm in length) filled with fresh technical grade activated carbon (5 to 20 mesh). Collect the water in a suitable container. This water should be prepared on the day of use and judged independently by a testing panel to possess no taste and odour at 25 °C.

Activated carbon may act as a potential growth medium for bacteria. Unless changed frequently, bacteria may collect in the activated carbon and may ultimately gain access to, and contaminate the water so prepared.

The reference water should be collected in clean glass-stoppered glass containers, or food grade polyethyleneterephthalate (PET) bottles, reserved solely for this purpose. Collected water should be used or discarded within 12 hours of preparation. If non-glass containers are used, they should be thoroughly tested before use to ensure no taste or odour is imparted to, or removed from, the blank water or water under investigation.

A2.1.2 De-chlorinating agent. Sodium thiosulphate solution (approximately 0.0125M). Dissolve 3.5 g of sodium thiosulphate pentahydrate ($Na_2S_2O_3.5H_2O$) in water and make to 1000 ml with water. Mix well. This reagent may be stored in an amber glass bottle at a temperature about 5 °C for up to 7 days. The addition of 1 ml of this reagent will neutralise up to approximately 1 mg/l of residual chlorine in 500 ml of sample.

Alternatively, dissolve 5 g of L-ascorbic acid in water and make to 1000 ml with water. Mix well. This reagent may be stored in an amber glass bottle at a temperature about 5 °C for

up to 7 days. The addition of 1 ml of this reagent will neutralise up to approximately 1 mg/l of residual chlorine in 500 ml of sample. If ascorbic acid is used, add the acid solution to the water and allow the water to stand for approximately 5 minutes before the taste or odour is assessed. Whilst ascorbic acid may be used as an alternative to sodium thiosulphate (which may lead, in some cases, to inferring odours) it should not be used, for example where the water is chloraminated, as ammonia may be released, interfering with the taste/odour assessment. Other de-chlorinating agents may be used provided tastes/odours are not imparted to or removed from the sample.

A2.2 Analytical procedure

Step	Procedure	Notes
	Preparation of de-chlorinated sample	
A2.2.1	If method A1 has already been carried out, shake the sample bottle and its contents, and remove the stopper from the sample bottle. Pour a portion of the original undiluted sample into a suitable container so as to avoid subsequent loss of odour. Replace the stopper. Allow the contents of the container to reach 25 °C. See note a. If method A1 has not been used, invert the sample bottle in an attempt to mix the contents. Remove the stopper from the sample bottle and discard a portion of sample. Replace the stopper. Shake the bottle and its contents. Remove the stopper and pour a quantity of the undiluted sample into a suitable container so as to avoid subsequent loss of odour. Replace the stopper (see note a). Allow the contents of the container to reach 25 °C. Add a volume of de-chlorinating agent (A2.1.2) to the container and mix to completely de-chlorinate the portion of sample removed. See note b.	(a) In case a non-chlorinous taste or odour is subsequently detected in the de-chlorinated sample it may be appropriate to return the bottle to cool storage. (b) A large excess of de-chlorinating agent should be avoided, to ensure the affect of the de-chlorinating agent itself is not assessed.
A2.2.2	Pour a portion of the de-chlorinated sample into a wine glass and cover with a watch glass. Repeat this process for each panellist to be used in the assessment of taste and odour. See note c.	(c) Different panellists should not smell or taste from the same wine glass. Each panellist should be able to assess the taste and odour independently.
A2.2.3	Prepare up to ten undiluted de-chlorinated samples in a similar way as described in	(d) The samples and blank waters should not be identifiable

	steps A2.2.1 and A2.2.2. In addition, in a similar way, prepare a minimum of at least two blank (reference) water samples (A2.1.1). See notes d and e. Arrange the glasses in a random, but known order. Ensure the contents of the wine glass remain at 25 °C during the assessment.	to individual panellists, either by means of appearance or wine glass. If samples are turbid or coloured, consideration should be given to covering all glasses with, for example aluminium foil before they are presented to individual panellists. (e) If 3 panellists carry out the assessment at the same time and ten samples and two blank waters are assessed, a total of 36 glasses will be required for the determinations.
A2.2.4	For each prepared individual blank water and de-chlorinated portion, gently, so as not to spill any of the contents, shake or swirl the wine glass and its contents, remove the watch glass, smell the contents and replace the watch glass (see note f). Classify the odour immediately according to its intensity and nature (see Tables 2 and 3 respectively, and also Table 1).	(f) The contents should be smelled by holding each container at its base and immediately applying the nose to the mouth of the glass.
A2.2.5	Remove the watch glass. Gently, so as not to spill any of the contents, shake or swirl the glass and its contents again, and taste the contents (see note g). Classify the taste immediately according to its intensity and nature (see Tables 2 and 3 respectively, and also Table 1).	(g) The contents should be tasted by taking into the mouth whatever volume of de-chlorinated sample or blank water is comfortable, holding the contents in the mouth for several seconds and then discharging the contents without swallowing any.
A2.2.6	The assessment of any taste and odour should be made as quickly as possible after smelling and tasting the contents, and recorded immediately. See note h.	(h) To ensure panellists do not become de-sensitised, no more than ten de-chlorinated samples should be assessed by each panellist at any single occasion.
A2.2.7	At the same time that samples are assessed, the assessment of appropriate AQC samples should also be undertaken. See Appendix 3.	
	Assessment of results	
A2.2.8	The results of each batch of test results for any individual panellist will be valid only if at	(i) If blank waters are persistently identified by several panellists as

	least 60 % of the blank waters are identified as being taste- and odour-free (see Table 4 and note i).	not being taste- and odour-free, then the blank water may not be of adequate quality and a further quantity should be prepared.
A2.2.9	If a set of results is found to be invalid then additional de-chlorinated samples should be prepared for each additional panellist and steps A2.2.4 - A2.2.7 should be carried out using additional panellists (see notes c and j).	(j) If a single panellist persistently identifies the blank water as not being taste- and odour-free then consideration should be given to removing the panellist from the panel (see Appendix 2).
A2.2.10	If a de-chlorinated sample is identified as being taste- and odour-free by at least 60 % of panellists with valid results then no further action is required by panellists. See note k and Figure 1.	(k) The report should indicate that the sample has been de-chlorinated and that the original undiluted sample possessed a chlorinous taste/odour.
A2.2.11	If a de-chlorinated sample is identified as possessing a non-chlorinous taste/odour by at least 60 % of those panellists with valid results, then the sample should be further tested using the quantitative procedures described in method A3.	

A2.3 Acceptability

If a de-chlorinated sample is identified as being taste- and odour-free, then additional work should be undertaken to ascertain whether the chlorinous taste/odour of the original undiluted sample is or is not acceptable to consumers. For example, ascertaining whether the residual disinfectant levels are typical for the water under investigation.

Irrespective of whether the chlorinous taste/odour of the original undiluted sample is or is not acceptable to consumers, the sample is assigned a T/O TN of 1, i.e. a T/O DN of 0, and a comment should be made that the original undiluted sample possessed a chlorinous taste/odour. No further work is necessary to ascertain the actual dilution number of the chlorinous taste/odour of the sample.

A3 Quantitative method for the determination of taste/odour threshold number

This method should be used to quantify the result where the qualitative assessment described in method A1 indicates that the original undiluted sample is deemed to posses a non-chlorinous taste or odour, or the qualitative assessment described in method A2 indicates that the de-chlorinated sample is deemed to posses a non-chlorinous taste or odour.

Where the taste/odour assessment on the original, undiluted sample has shown the sample to be taste- and odour-free, or the taste/odour assessment on the de-chlorinated sample has shown the sample to be taste- and odour-free, i.e. is assigned a threshold number of 1 (a taste/odour dilution number of 0) this method may not need to be carried out.

A3.1 Performance characteristics of the method

A3.1.1	Determinand	Taste and odour.
A3.1.2	Type of sample	Drinking waters.
A3.1.3	Basis of method	A series of diluted samples is prepared with blank (reference) water (A3.2.1). These diluted samples are smelled and tasted at 25 °C and the dilution at which no taste or odour is detected is recorded.
A3.1.4	Range of application	A taste/odour threshold number (T/O TN) of 2 to 10, equivalent to taste/odour dilution number (T/O DN) 1 to 9, respectively. Higher taste/odour threshold numbers or dilution numbers can be determined using an alternative (more dilute) series of consecutive or geometric dilutions.
A3.1.5	Lower reporting limit	Taste/odour threshold number of 2, with corresponding taste/odour dilution number of 1.
A3.1.6	Sensitivity	Depends on the combined subjective sensitivities of the panellists.
A3.1.7	Bias	Depends on the combined subjective sensitivities of the panellists and the range of the diluted samples used in the test.
A3.1.8	Time required for analysis	For one sample; coordinator - 60 minutes, panellist - 10 minutes.
A3.1.9	Expression of results	The taste/odour threshold number is

used throughout the procedure. This value is converted to a dilution number in the final stage of the determination.

A3.2 Reagents

Use analytical reagent grade chemicals unless otherwise indicated. Water for the preparation of reagents should be distilled, deionised or of similar grade quality.

A3.2.1 Blank (reference) water. Blank water used for rinsing glassware and as a reference water should be water appropriate to the area and, where possible, similar in composition to the type of water being tested. It should be water which has been judged, by a group of people, i.e. a testing panel, to possess no taste and odour at 25 °C.

Reference water meeting these criteria can be prepared as follows. Pass distilled water at a flow rate not exceeding 10 litres per hour through a glass column (for example 20 mm in diameter and 200 mm in length) filled with fresh technical grade activated carbon (5 to 20 mesh). Collect the water in a suitable container. This water should be prepared on the day of use and judged independently by a testing panel to possess no taste and odour at 25 °C.

Activated carbon may act as a potential growth medium for bacteria. Unless changed frequently, bacteria may collect in the activated carbon and may ultimately gain access to, and contaminate the water so prepared.

The reference water should be collected in clean glass-stoppered glass containers, or food grade polyethyleneterephthalate (PET) bottles, reserved solely for this purpose. Collected water should be used or discarded within 12 hours of preparation. If non-glass containers are used, they should be thoroughly tested before use to ensure no taste or odour is imparted to, or removed from, the blank water or water under investigation.

A3.3 Analytical procedure

Step	Procedure	Notes
	Ascending and descending triangle test	
A3.3.1	The original undiluted sample or de-chlorinated sample should be brought to 25 °C. See note a. Shake the sample bottle and remove the stopper. Quickly transfer suitable volumes (see Table 6) of original undiluted sample or de-chlorinated sample to separate containers and replace the stopper. Immediately, add to the containers the appropriate volume of blank (reference) water (A3.2.1) at 25 °C and seal or stopper the containers. Mix well. See note b.	(a) This may take up to several hours. (b) An alternative (more dilute) consecutive or geometric series may need to be prepared if the taste or odour of the sample is extremely intense. If the taste or odour of the sample is less intense, only a few (consecutive) dilutions may need to be prepared (for example solutions C to F in Table 6).

A3.3.2	For each panellist used in the assessment (see note c) place portions of each diluted sample prepared in step A3.3.1 into separate wine glasses. Cover each glass with a watch glass. For each wine glass of diluted sample prepare two wine glasses containing blank (reference) water only. See note d.	(c) Different panellists should not smell or taste from the same wine glass. Each panellist should be able to assess the taste and odour independently. (d) For each sample to be tested, if 3 panellists carry out the assessment at the same time and four dilutions (for example C, D, E and F) are prepared, a total of 36 glasses will be required for the determinations.
A3.3.3	Present in random order (to each panellist) three glasses containing respectively two blank (reference) waters (A3.2.1) and one diluted sample, for example solution E (see Table 6 and Figure 2, and notes e and f). Ensure the contents of the wine glass remain at 25 °C during the assessment.	(e) The diluted samples and blank waters should not be identifiable to individual panellists, either by means of appearance or glass. If diluted samples are turbid or coloured, consideration should be given to covering all glasses with, for example aluminium foil before they are presented to individual panellists. (f) Since the original, undiluted sample has been assessed and found to possess a non-chlorinous taste and/or odour using the procedures described in method A1, and the de-chlorinated sample has been assessed and found to possess a non-chlorinous taste and/or odour using the procedures described in method A2, the assessment begins with a diluted sample, for example solution E. The sequence may be started with an alternative dilution series, if the sample possesses a very strong taste/odour.
A3.3.4	For each of the blank waters and diluted sample, gently, so as not to spill any of the contents, shake or swirl the glass and its contents. Remove the watch glass and request the panellist to smell the contents	(g) The contents of the wine glasses should be smelled by holding the glass at its base and immediately applying the nose to the opening of the

and replace the watch glass (note g). The panellist is to immediately record whether any of the three solutions possess an odour. If the panellist opines that any of the contents of the three glasses possesses an odour, then those glasses and their contents should be identified. Immediately, record the observations made.

A3.3.5 Remove the watch glass. Gently, so as not to spill any of the contents, shake or swirl the glass and its contents again, and taste the contents (see note h). The panellist is to immediately record whether any of the three solutions possess a taste. If the panellist opines that any of the contents of the three glasses possesses a taste, then those glasses and their contents should be identified. Immediately, record the observations made.

A3.3.6 The assessment of any taste and odour should be made as quickly as possible after smelling and tasting the contents, and recorded immediately. See note i.

A3.3.7 The results are recorded as either

(i) Taste/odour detected in the diluted sample but the blank waters assessed as being taste- and odour-free. - Proceed to step A3.3.8

(ii) Diluted sample and the blank waters assessed as being taste- and odour-free. Proceed to step A3.3.10.

(iii) Taste/odour detected in the blank water. - Repeat steps A3.3.3 - A3.3.5. If the blank water (A3.2.1) is still identified as possessing taste/odour (see notes j and k).

A3.3.8 Repeat steps A3.3.3 - A3.3.5 proceeding along the dilution series with the next more diluted sample. In the example given as described in step A3.3.3, the next dilution would be solution F (see Table 6 and Figure 2).

glass.

(h) The contents of the wine glasses should be tasted by holding the glass at its base and taking into the mouth whatever volume of diluted sample or blank (reference) water is comfortable, holding the contents in the mouth for several seconds and then discharging the contents to waste without swallowing any.

(i) To ensure panellists do not become de-sensitised, each panellist should be allowed to take a short break between assessments. See method A1, note g.

(j) If blank waters are persistently identified by several panellists as possessing a taste/odour, then the blank water (A3.2.1) may not be of adequate quality and a further quantity should be prepared.

(k) If a single panellist persistently identifies the blank water (A3.2.1) as possessing taste/odour then consideration should be given to removing that person from the panel (see Appendix 2).

A3.3.9 The process is repeated until the panellist records the diluted sample and blank waters as being taste- and odour-free. At this point, re-assess the next more concentrated diluted sample to confirm the previous assessment of this solution (as possessing a taste and/or odour). If this re-assessment is confirmed, then the threshold number is the relevant calculation value of the more dilute diluted sample. See Table 6. If however, the re-assessment is not confirmed (and is now assessed as being taste- and odour-free) then go to section A3.3.10 and assess the next more concentrated diluted sample. See also note l.

(l) If the end of the dilution series is reached and the diluted sample is still recorded as possessing taste/odour, then a further, more dilute consecutive or geometric series will need to be prepared.

A3.3.10 If the panellist records the diluted sample and blank waters as being taste- and odour-free, repeat steps A3.3.3 - A3.3.5 proceeding along the dilution series with the next more concentrated sample. In the example given as described in step A3.3.3, the next dilution would be solution D (see Table 6 and Figure 2).

A3.3.11 This process is repeated until the panellist records a taste/odour in the diluted sample but that the blank waters are taste- and odour-free. At this point, re-assess the next more dilute diluted sample to confirm the previous assessment of this solution (as being taste- and odour-free). If this re-assessment is confirmed, then the threshold number is the relevant calculation value of the diluted sample assessed as taste- and odour-free. See Table 6. If however, the re-assessment is not confirmed (and is now assessed as possessing a taste and/or odour) then go to section A3.3.8 and assess the next more dilute diluted sample. See also note m.

(m) If the diluted sample at the most concentrated level, i.e. solution C, is assessed to be taste- and odour-free then the sample is deemed to posses a taste/odour threshold number of 2.

A3.3.12 This iterative procedure is undertaken to establish a confirmed threshold number for each individual panellist.

A3.3.13 At the same time that samples are assessed, the assessment of appropriate AQC samples should also be undertaken. See Appendix 3.

A3.3.14 Repeat steps A3.3.3 - A3.3.13 for at least two more panellists.

Calculation of T/O DN

A3.3.15 The overall T/O TN for the sample is calculated as the geometric mean of the individual panellists' results. i.e.

$$T/O\ TN_y = (T_1 \times T_2 \times T_3 \ldots\ldots \times T_y)^{1/Y}$$

where

T_1 to T_y are the individual panellist's T/O TNs

Y is the number of panellists and

$T/O\ TN_y$ is the T/O TN of the sample.

The result is rounded to the nearest whole number (see note n).

(n) If the individual panellists' results for a given sample are 2, 3 and 4 respectively then the overall T/O TN for the sample would be $(2 \times 3 \times 4)^{1/3} = 2.8845$ which is rounded to 3 (see Table 7).

A3.3.16 Subtract one from the overall T/O TN (i.e. $T/O\ TN_y$) to obtain the taste/odour dilution number, T/O DN for that sample (see note o).

(o) The result should be quoted as a taste/odour dilution number.

A3.4 Acceptability

Following the determination of the T/O DN of the sample, a further assessment should be carried out to ascertain whether the taste and odour of the sample is deemed acceptable to consumers and whether an abnormal change has occurred.

A4 Determination of odour (on-site) by a continuous odour monitor

A4.1 Principle

The method describes a qualitative on-line procedure for determining odour, where the early detection of potential problems may be required. The method is applicable to raw, partially-treated and treated waters.

The water under test is heated to an elevated temperature, for example at 60 °C, for at least 30 seconds, after which, it is sprayed in a continuous stream into a bell-jar. Any odour thus collected and amplified in intensity is detected at the neck of the bell-jar and classified according to Tables 2 and 3. See also Table 1.

A4.2 Reagents

A4.2.1 Cleaning of apparatus. Sample bottles should be cleaned before use by soaking them thoroughly overnight in a dilute solution of a strong detergent and then rinsing thoroughly with water. Detergents containing phosphates should not be used.

Alternatively, an automatic dishwasher supplied with water at a temperature of not less than 60 °C and a detergent (for example as described above) may be suitable.

A4.2.2 De-chlorinating agent. Sodium thiosulphate solution (approximately 0.0125M). Dissolve 3.5 g of sodium thiosulphate pentahydrate ($Na_2S_2O_3.5H_2O$) in water and make to 1000 ml with water. Mix well. This reagent may be stored in an amber glass bottle at a temperature of about 5 °C for up to 7 days. The addition of 1 ml of this reagent will neutralise up to approximately 1 mg/l of residual chlorine in 500 ml of sample.

Alternatively, dissolve 5 g of L-ascorbic acid in water and make to 1000 ml with water. Mix well. This reagent may be stored in an amber glass bottle at a temperature at about 5 °C for up to 7 days. The addition of 1 ml of this reagent will neutralise up to approximately 1 mg/l of residual chlorine in 500 ml of sample. If ascorbic acid is used, add the acid solution to the water and allow the water to stand for approximately 5 minutes before the taste or odour is assessed. Whilst ascorbic acid may be used as an alternative to sodium thiosulphate (which may lead, in some cases, to inferring odours) it should not be used, for example where the water is chloraminated, as ammonia may be released, interfering with the taste/odour assessment.

In certain cases depending on the nature of the sample, sodium thiosulphate can give rise to sulphurous odours when used as a de-chlorinating agent. An alternative de-chlorinating agent, for example ascorbic acid may therefore need be used. However, ascorbic acid may also cause interfering odours, for example where waters have been chloraminated. Other de-chlorinating agents may be used provided tastes/odours are not imparted to or removed from the sample.

A4.3 Apparatus

The apparatus is described in Figure A4.1 and requires, for example a water pressure of 70 - 80 kPa (10 - 12 psi) and a 3 kw heater.

The apparatus should be constructed so that the constituent parts can easily be dismantled

for cleaning purposes (see section A4.2.1) to prevent the build up of pathogenic organisms in the system.

A4.4 Installation and operation of continuous odour monitors (smell bells)

In order to minimise the possible risk of operators being exposed to pathogenic organisms etc, and potential problems caused by inadequate instrumentation the following should be considered.

(i) The use of short direct runs of pipe work from the water intake to the heater, and from the heater to the bell-jar.

(ii) Dead legs and over-sized pipe-work should be avoided.

(iii) Approved materials and fittings should be used.

(iv) The intake pipe work should be insulated in order to keep the water cold prior to heating if necessary.

(v) The water should be uniformly heated to an elevated temperature, for example 60 °C for not less than 30 seconds in a suitable unit which can easily be dismantled for cleaning.

(vi) The water temperature probe should be located near the outlet of the heater chamber, it should be periodically checked for accuracy.

(vii) The water should be sprayed onto the inner surface of the bell-jar as an unbroken stream, for example in a fan shape. Jets which produce fine mists should be avoided.

(viii) The smell bell water jet, bell-jar and base should be cleaned regularly, but the heater unit may require dismantling and cleaning less frequently.

(ix) If smell bells have not been used for a period exceeding 1 month, the apparatus and its associated pipe work should be disinfected and thoroughly flushed out prior to use.

(x) The use of an in-line ultra violet disinfection unit to allay concerns over the potential risks of inhaling aerosols of raw water.

(xi) The use of large bore pipe work for the supply of raw water, possibly through a by-pass system, in order to reduce potential problems caused by algae, weed and other debris, blocking the system.

(xii) The use of flow sensors for hard water monitoring, offering protection to heating elements where cessation of flow causes the element to burn out.

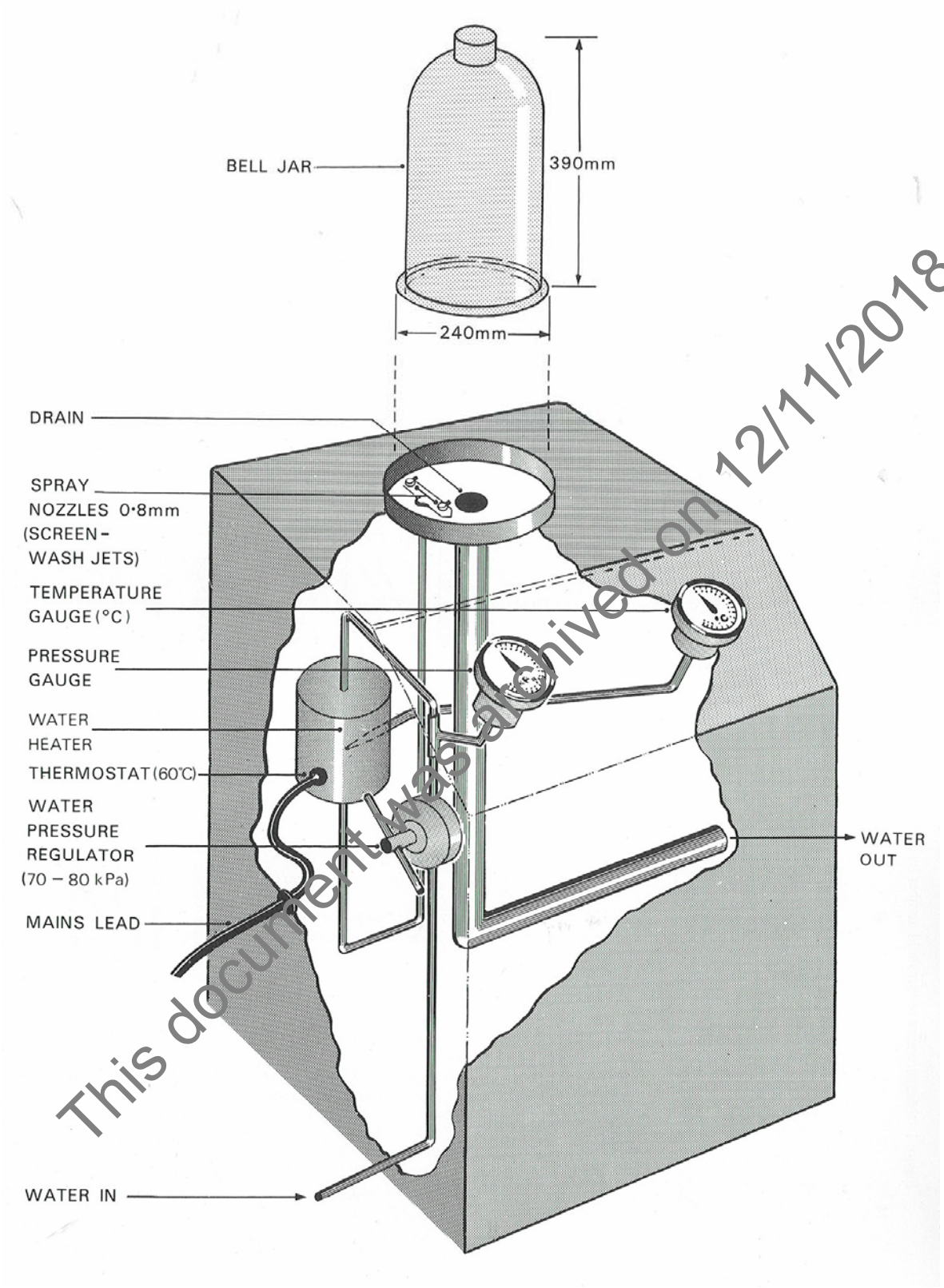
A4.5 Analytical procedure

Step	Procedure	Notes
A4.5.1	The "smell bell" should be plumbed into the system, the odour of which is required to be monitored (see section	(a) If this method is to be applied to waterworks control, the influence of terminal chlorination on the odour

	A4.4 and note a).	may be significant and a decision should be taken on whether the measurement is carried out on water supplied to the consumer. The chlorinous odour of treated water may mask other odours which may become apparent after distribution. The odour of de-chlorinated water may be assessed by de-chlorinating the water by in-line injection of de-chlorinating agent (A4.2.2).
A4.5.2	The thermostat should be set at an elevated temperature, for example at 60 °C, in order to maintain the temperature of the water for a minimum of 30 seconds.	(b) The intensity of volatile odours is increased as the temperature is raised.
A4.5.3	Any odour present in the water should be detected by removing the seal from the mouth of the bell-jar and smelling the contents of the jar. An immediate subjective assessment of the odour should be recorded.	
A4.5.4	At the same time that samples are assessed, the assessment of appropriate AQC samples should also be undertaken. See Appendix 3.	
A4.5.5	The result should be expressed as an intensity and description according to Tables 2 and 3 respectively. See also Table 1.	

Figure A4.1 Typical apparatus for the assessment of odour - smell-bell

Figure A4.2 Cutaway view of an apparatus for the assessment of odour - smell-bell



Appendix 1 Tables and Figures for use with methods A1 - A4

Table 1 Odour- (and possibly taste-) causing compounds

Compound	Odour description	Approximate odour threshold concentration (µg/l)	Possible sources
ammonia	sharp / pungent	40	fertilizers and sewage
pentylethanoate	pear drops	5	industrial waste
2-ethyl-5,5-dimethyl-1,3-dioxane	musty / nutty / sweet	0.01	industrial waste
2 ethyl 4 methyl 1,3 dioxolane	musty / nutty / sweet	0.01	industrial waste
phenol	carbolic	300	decomposition of vegetation or industrial waste
2-methylisoborneol	musty / camphor	0.02	Actinomycetes, cyanobacteria, micro-fungi
4-methylphenol	creosote	45	disinfectant and solvent
3-methylphenol	creosote	330	disinfectant and solvent
2-methylphenol	creosote	70	disinfectant and solvent
menthol	camphorus / minty	2	
linalool	woody / aromatic	60	Cleaning agents
geosmin	musty / earthy	0.015	Actinomycetes, cyanobacteria, micro-fungi
dimethyl sulphide	rotting vegetables	10	*Pseudomonas* species
diethyl sulphide	garlic	0.25	
butanoic acid	sweaty	50	
2,4,6-trichlorophenol	medicinal	0.1	chlorination of phenol during water treatment
2,6-dichlorophenol	medicinal	3**	chlorination of phenol during water treatment
2,4-dichlorophenol	medicinal	2**	chlorination of phenol during water treatment
4-chlorophenol	phenolic	250**	chlorination of phenol during water treatment
2-chlorophenol	phenolic	2**	chlorination of phenol during water treatment
chlorine	chlorinous	100 - 500*	disinfection of water
biphenyl	musty	0.5	industrial waste
benzothiazole	rubber	80	industrial waste
benzaldehyde	sharp / almonds	35	industrial waste
acetophenone	sweet / almonds	65	industrial waste
2-isopropyl-3-methoxypyrazine	mouldy / musty	-	Actinomycetes
cadin-4-ene-1-ol	woody, earthy	-	Actinomycetes
cis-3-hexen1-ol	grassy	-	green algae
diphenyl ether, trichloramine	geranium-like	-	diatoms
trans-2- and cis-6-nonadienal	cucumber	-	green algae
aldehydes (C_7 and above)	fruity, fragrant	-	ozonation
hydrocarbons; 1,3-pentadiene	solvent-like	-	permeation of petrol, diesel etc through plastic pipes
n-hexanal; n-heptanal	fishy	-	green algae, diatoms
decadienal	cod liver oil	-	green algae
hepta- and deca-dienals	fishy	-	*Dinobryon* (algae)
mercaptan	malodourous sulphur	-	decomposing cyanobacteria
hydrogen sulphide	rotten eggs	-	sulphate-reducing bacteria, clostridia
aldehydes of low molecular weight	swampy, swimming pool	-	chlorination of amino acids
iodinated trihalomethanes	medicinal		chloramination
phenolic anti-oxidants	plastic, burnt plastic		plastic, burnt plastic
ozone (in solution)	ozonous		disinfection of water
dichloramine	swimming pool		disinfection of water

* Dependent on pH.

** Produced during water treatment chlorination when phenol is present in the water.

Table 2 Intensity of tastes/odours

no taste/odour
very mild
mild
strong
very strong

Table 3 Description of tastes/odours

Odours	**Tastes**
no odour	no taste
ammoniacal	astringent
bad eggs (sulphide)	bitter
chlorine (bleach)	bituminous
earthy	chemical
farm like	chlorinous
fruity	chlorophenol
medicinal (for example “TCP”)	cucumber
milky	decayed vegetable
musty	earthy
oily	fishy
organic solvent	flat
phenolic	geranium
soapy	inky
sweet	metallic
yeasty	mouldy
other (this should be specified)	musty
	oily
	rubber
	saline
	sharp
	sour
	spirit
	sweet
	weedy
	other (this should be specified)

Table 4 Identification of blank (reference) waters

Number of blank waters in series	Minimum number of blank waters that should be identified as being taste- and odour-free by each panellist	Minimum percentage value
2	2	100
3	2	66.7
4	3	75
5	3	60
6	4	66.7
7	5	71.4
8	5	62.5

It is recognised that in the majority of cases, only 2, or possibly 3, blank waters will be used.

Table 5 Identification of samples and diluted samples

Number of panellists with valid results	Number of panellists who should identify a given sample or diluted sample as being taste- and odour-free by each panellist	Minimum percentage value
3	2	66.7
4	3	75
5	3	60
6	4	66.7
7	5	71.4
8	5	62.5

It is recognised that in the majority of cases, whilst a minimum of 3 panellists are required, additional panellists may need to be used.

To ensure a confirmed decision can be made with regard to the presence or absence of taste/odour in the sample, an odd number of panellists should be used.

Table 6 Sample dilution series

Solution	Relevant calculation value	Volume of sample (ml)	Volume of blank water (ml)	Total volume (ml)
A	-	-	200	200
B	1	200	0	200
C	2	100	100	200
D	3	70	140	210
E	4	50	150	200
F	5	40	160	200
G	6	35	175	210
H	7	30	180	210
I	8	25	175	200
J	9	20	160	180
K	10	20	180	200

Solution B is the original undiluted sample

Table 7 Rounding off geometric mean values

Value of overall T/O TN	Reported T/O TN
1.415 - 2.449	2
2.450 - 3.464	3
3.465 - 4.472	4
4.473 - 5.477	5
5.478 - 6.481	6
6.482 - 7.483	7
7.484 - 8.485	8
8.486 - 9.487	9
9.488 - 10.3	10

Figure 1 Flowchart indicating actions for qualitative and quantitative determinations of taste and odour

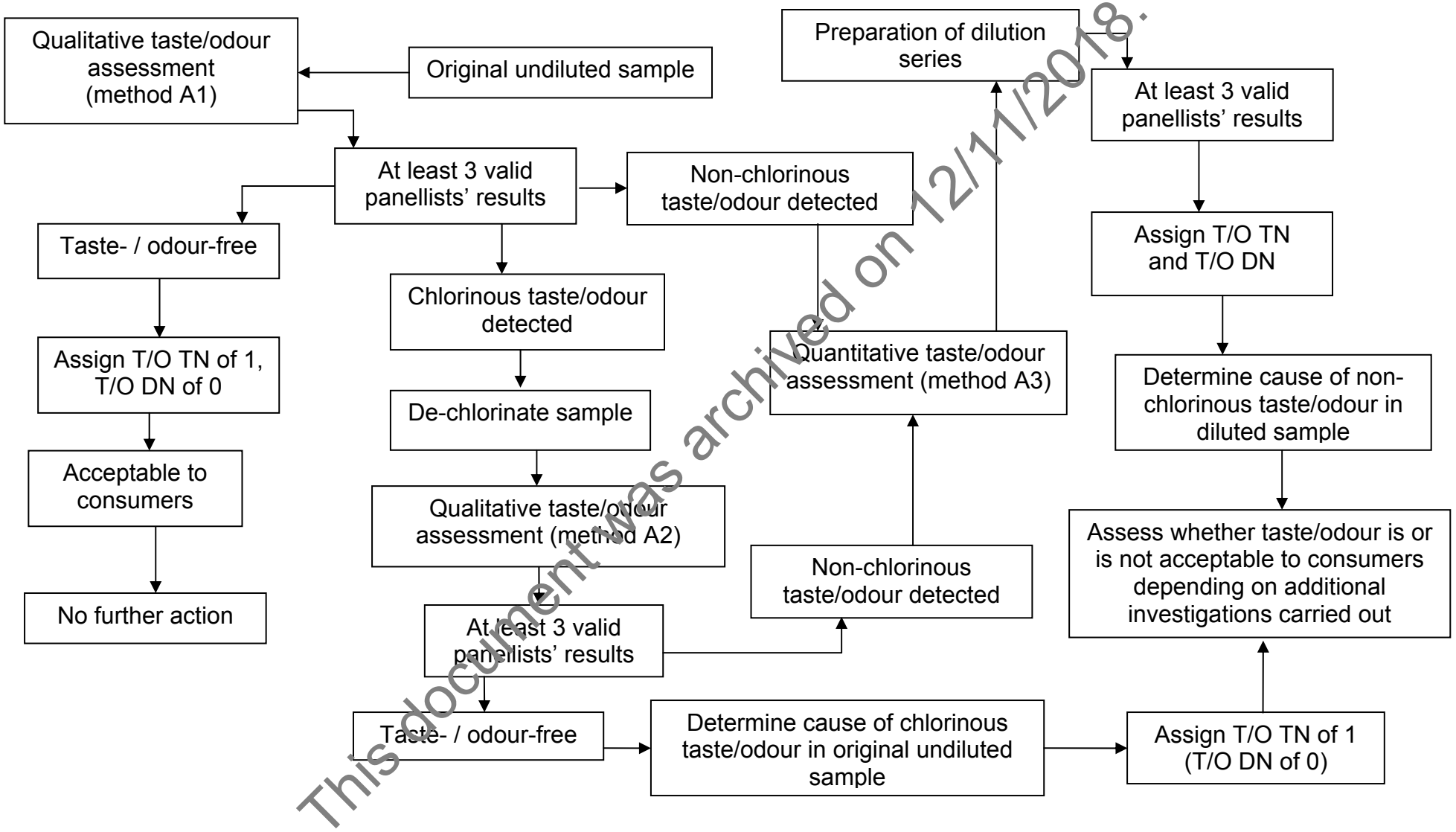
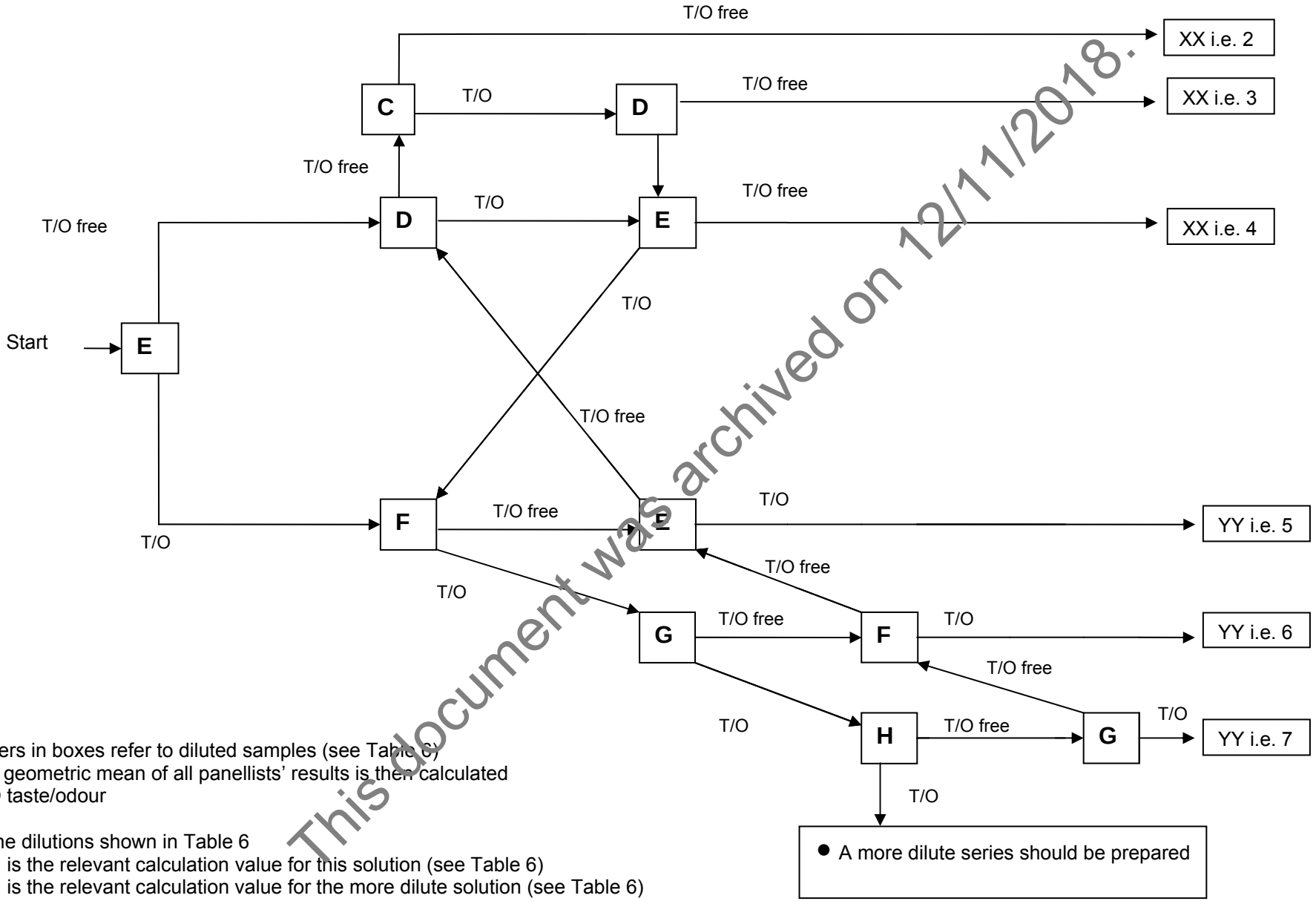


Figure 2 Assessment of T/O TN by an individual panellist using method A3



Notes
i) Letters in boxes refer to diluted samples (see Table 6)
ii) The geometric mean of all panellists' results is then calculated
iii) T/O taste/odour

Using the dilutions shown in Table 6
XX TN is the relevant calculation value for this solution (see Table 6)
YY TN is the relevant calculation value for the more dilute solution (see Table 6)

Appendix 2 Selection of panellists for taste and odour evaluation

1 Introduction

An example of a two stage screening procedure is outlined which is designed to produce a list of candidates considered suitable as panellists for taste and odour evaluations. A system should be developed for monitoring the performance of panellists, for example using real samples and comparing the results obtained from individual panellists.

2 Self-evaluation

A list of candidates for consideration as panellists can be completed and kept as a record, (for example see Form 1). Candidates are asked, for example whether they have any allergies or possess extreme sensitivity to taste or smell, and other similar questions to determine whether they can be considered suitable. Potential candidates who appear suitable are identified (which can dated) and those unsuitable are declined. Candidates considered unsuitable should not be used as panellists.

Typical example of form 1

Name	Self evaluation	Date	Screened	Date

(i) Clearly identify in the "self evaluation" column if a candidate does not suffer from allergies and has not admitted lack of, or excessive, sensitivity to taste and odour (i.e. candidate is suitable, see 2 above).

(ii) If circumstances indicate that a person is unsuitable as a panellist, clearly identify, this person in the relevant column and do not consider for use as a panellist.

(iii) In the "screened" column clearly identify if a candidate passed the screening procedure) or failed the screening procedure (see 1 above).

3 Daily check

All candidates who are considered suitable as panellists on a long term basis should be further questioned on the day the tests are to be carried out, to determine whether they remain suitable on the day; for example whether any person considered is suffering from a cold, thus affecting their potential suitability.

A check-list, for example see Form 2 should be completed on the day the tests are to be carried out for any person proposed as a panellist. The person should be used only if the responses to the questions posed indicate that the candidate is suitable.

Typical example of form 2

Date	Enter “yes”or “no”			Comments
Name	Q1	Q2	Q3	

Prospective panellists should be asked, for example, the following questions.

(Q1) Do you have a cold or sore throat?
(Q2) Is there any other reason why you might be unsuitable for use in taste and odour evaluations?
(Q3) Just prior to testing, have you eaten, drunk (for example alcohol) or smoked in the last hour.

Other relevant questions may also be asked.

Any person confirming their unsuitability for the test should not be used as a panellist.

Appendix 3 Analytical Quality Control

Many laboratories now employ the use of standard flavour solutions as quality control samples for the assessment of qualitative and quantitative tastes and odours in drinking waters. In order to avoid panellists becoming too familiar with recognisable flavours, a variety of different flavours (for example vanilla, mint, geosmin, trichlorophenol, etc) and possibly different concentrations should be used. This may require these solutions to be independently assessed for their intensity, description and taste and odour threshold numbers respectively.

An example, described below, gives some of the AQC procedures adopted for the assessment of taste and odour threshold numbers.

Blank (reference) water should be prepared and assessed as described in method A3.

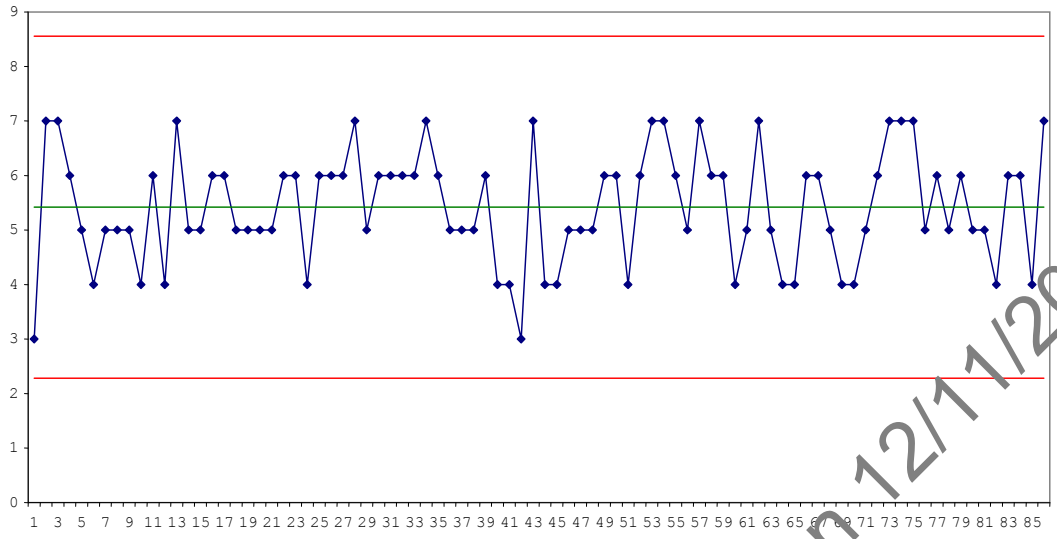
Add 0.70 ml of commercially available food grade vanilla flavouring to 500 ml of blank water. Mix well. Add 25 ml of this solution to blank water and make to 1000 ml with blank water. Mix well. This solution has been found to possess a taste dilution number of approximately 5 - 6 and an odour dilution number of approximately 3 - 4.

Use this solution (as an original undiluted sample) to prepare a range of diluted samples in accordance with procedures described in method A3. It may be necessary to prepare different dilution ranges on different occasions and present them to the panellists. Assess the dilution series for taste and odour as described in method A3. Record the T/O TN. Plot respective T/O TNs on Shewhart control charts with upper and lower action levels, set at appropriate target values, for example ± 3 standard deviations.

Typical AQC charts for T/O DN respectively are shown in Figures 3 and 4. The associated raw data are given in Table 8. Control charts may also be used to assess an individual panellist's suitability.

Figure 3 AQC chart for taste determination

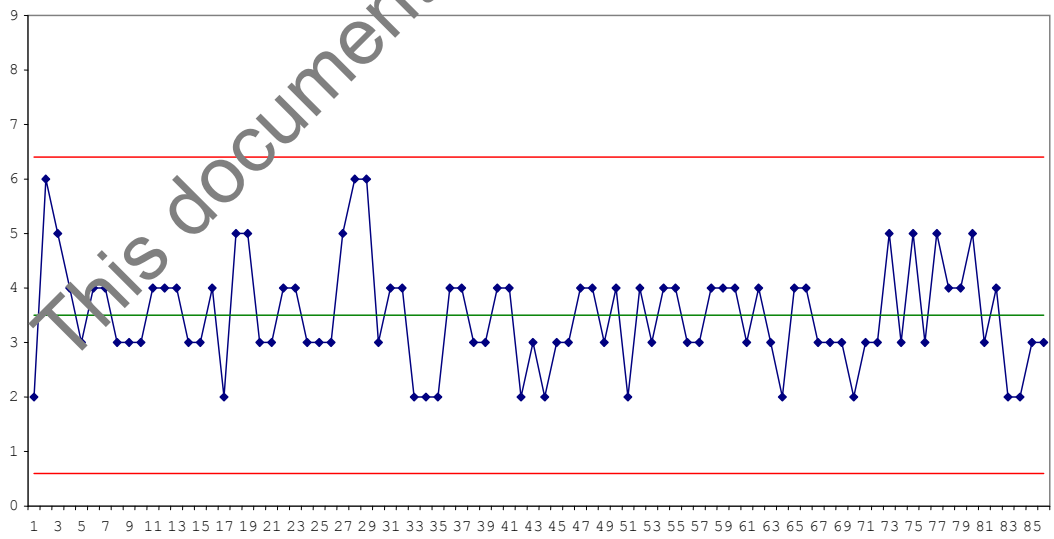
Dilution number



Analysis period (days)

Figure 4 AQC chart for odour determination

Dilution number



Analysis period (days)

Table 8 Raw data for AQC charts shown in Figures 3 and 4

Day	Taste (DN)	Odour (DN)	Day	Taste (DN)	Odour (DN)
1	3	2	44	4	2
2	7	6	45	4	3
3	7	5	46	5	3
4	6	4	47	5	4
5	5	3	48	5	4
6	4	4	49	6	3
7	5	4	50	6	4
8	5	3	51	4	2
9	5	3	52	6	4
10	4	3	53	7	3
11	6	4	54	7	4
12	4	4	55	6	4
13	7	4	56	5	3
14	5	3	57	7	3
15	5	3	58	6	4
16	6	4	59	6	4
17	6	2	60	4	4
18	5	5	61	5	3
19	5	5	62	7	4
20	5	3	63	5	3
21	5	3	64	4	2
22	6	4	65	4	4
23	6	4	66	6	4
24	4	3	67	6	3
25	6	3	68	5	3
26	6	3	69	4	3
27	6	5	70	4	2
28	7	6	71	5	3
29	5	6	72	6	3
30	6	3	73	7	5
31	6	4	74	7	3
32	6	4	75	7	5
33	6	2	76	5	3
34	7	2	77	6	5
35	6	2	78	5	4
36	5	4	79	6	4
37	5	4	80	5	5
38	5	3	81	5	3
39	6	3	82	4	4
40	4	4	83	6	2
41	4	4	84	6	2
42	3	2	85	4	3
43	7	3	86	7	3

Address for correspondence

However well procedures may be tested, there is always the possibility of discovering hitherto unknown problems. Analysts with such information are requested to contact the Secretary of the Standing Committee of Analysts at the address given below. In addition, if users wish to receive advanced notice of forthcoming publications, please contact the Secretary.

Secretary
Standing Committee of Analysts
Environment Agency (National Laboratory Service)
56 Town Green Street
Rothley
Leicestershire
LE7 7NW
www.environment-agency.gov.uk/nls

Environment Agency
Standing Committee of Analysts

Members assisting with these methods

Without the good will and support given by these individuals and their respective organisations SCA would not be able to continue and produce the highly valued and respected blue book methods.

S Clancy	Severn Trent Services - Analytical Services
S Cole	Wessex Water
K Holt	South West Water
N Hudson	South East Water
S Jones	Drinking Water Inspectorate
R Lawson	Wessex Water
J Mace	Alcontrol Laboratories
M Morgan	Drinking Water Inspectorate
J Robinson	Alcontrol Laboratories / Severn Trent Services - Analytical Services
N Roddam	Northumbrian Water Scientific Services
K Smith	Drinking Water Inspectorate
A Turner	Northumbrian Water Ltd
P Whittle	Peter Whittle Environmental Services Ltd

Grateful acknowledgement is also made to Keith Smith for the provision of colour photographs within the main body of the text.

CONTACTS:

ENVIRONMENT AGENCY HEAD OFFICE

Rio House, Waterside Drive, Aztec West, Almondsbury, Bristol BS32 4UD

www.environment-agency.gov.uk
www.environment-agency.wales.gov.uk

ENVIRONMENT AGENCY REGIONAL OFFICES

ANGLIAN
Kingfisher House
Goldhay Way
Orton Goldhay
Peterborough PE2 5ZR

MIDLANDS
Sapphire East
550 Streetsbrook Road
Solihull B91 1QT

NORTH EAST
Rivers House
21 Park Square South
Leeds LS1 2QG

NORTH WEST
PO Box 12
Richard Fairclough House
Knutsford Road
Warrington WA4 1HG

SOUTHERN
Guildbourne House
Chatsworth Road
Worthing
West Sussex BN11 1LD

SOUTH WEST
Manley House
Kestrel Way
Exeter EX2 7LQ

THAMES
Kings Meadow House
Kings Meadow Road
Reading RG1 8DQ

WALES
Cambria House
29 Newport Road
Cardiff CF24 0TP

ENVIRONMENT AGENCY
GENERAL ENQUIRY LINE
08708 506 506

ENVIRONMENT AGENCY
FLOODLINE
0845 988 1188

ENVIRONMENT AGENCY
EMERGENCY HOTLINE
0800 80 70 60

ENVIRONMENT AGENCY