Für Mensch & Umwelt

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RECOMMENDATION

Evaluation of Drinking Water Quality with Respect to the Parameters Lead, Copper and Nickel

Recommendation of the German Environment Agency after consultation of the Drinking Water Commission of the Federal Ministry of Health

1 Introduction

1.1 Scope of application

This recommendation serves to implement the requirements of the Drinking Water Ordinance (TrinkwV) Annex 5 Part II Letter b) for the sampling of drinking water for the analysis of chemical parameters. It deals in particular with the sampling procedure and the evaluation of the parametric values of lead, copper and nickel and provides guidance for sampling and evaluation of other chemical parameters that may undergo change in the domestic distribution system.

1.2 Release of metals and other substances in the domestic distribution system

Concentrations of the metals lead, copper and nickel in drinking water samples taken from consumers' taps are determined mainly by the materials used in the water supply system, in particular the domestic distribution system. Pipes made of metals such as copper, galvanized steel, lead or other installation components (i.e. fittings, pipe connectors, mountings, water meters, sampling valves made of copper alloys or other metallic materials) can significantly alter the concentrations of the listed chemicals.

The concentrations of the parameters antimony, arsenic and cadmium as well as the indicator parameters aluminium and iron may also be influenced by the metallic components of the domestic distribution system (see1.4.2).

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In recent years, organic materials (e.g. plastics, coatings, elastomers, lubricants) have been used to a greater extent for pipes and other components of domestic distribution systems. For this reason, the concentrations of organic substances (i.e. epichlorohydrin, vinyl chloride) may also be influenced by the domestic distribution system.

In addition to the materials used, the following influencing factors are relevant to the release of substances in domestic distribution systems:

- the design of the domestic distribution system (e.g. length and diameter of pipes),
- operating conditions (flow and stagnation times, consumer behaviour),
- age of the domestic distribution system as well as
- chemical and physical characteristics of the drinking water (notably regarding metallic materials).

Due to the diversity and overlapping of these influences, analysis results from samples taken from the consumer's tap can vary by orders of magnitude not only from location to location, but also over time. Therefore, when evaluating the results, local conditions at the sampling point (tap) as well as sampling conditions must be taken into account.

1.3 Directive 98/83/EC on the Quality of Water intended for Human Consumption (EC Drinking Water Directive)

Directive 98/83/EC on the quality of water intended for human consumption (EC Drinking Water Directive) takes account of the circumstances outlined above by referring the parametric values for lead, copper and nickel – in keeping with their toxicological rationale - to a sample "obtained by an adequate sampling method at the tap and taken so as to be representative of a weekly average value ingested by consumers". A random sample shall be taken and assessed for its parametric values (Directive (EU) No 2015/1787). A sample of 1 litre in volume is taken from the tap of a consumer at a random time of day without prior flushing (Random sample method). Member States may alternatively use methods with a predetermined stagnation time which more accurately reflect their own domestic situation, provided that this does not lead to fewer cases of non-compliance being detected than the random sample within the water supply zone. The Directive also requires Member States to take account of "the occurrence of peak levels that may cause adverse effects on human health" (Annex I Part B Note 3, EC Drinking Water Directive).

The Directive defines the point of compliance with the parametric values to be "the taps, within premises or an establishment, that are normally used for human consumption" (Article 6 (1) (a), EC Drinking Water Directive). In the vast majority of monitoring cases, these will be taps within the domestic distribution system (consumer's tap).

The Directive exempts the Member States from responsibility for changes in water quality in domestic distribution systems (point 22 of the Preamble to the EC Drinking Water Directive) provided that no water is made available to the public. However, they remain responsible for ensuring that appropriate countermeasures are taken where there is a risk that water from the consumer's tap would not comply with the parametric values.

1.4 Ordinance on the Quality of Water intended for Human Consumption (Drinking Water Ordinance – TrinkwV)

1.4.1 Parametric values for lead, copper and nickel

The reference of the parametric values for lead, copper and nickel to a “weekly average value ingested” as laid down in the EC Drinking Water Directive has been incorporated into the Drinking Water Ordinance (Annex 2 Part II, TrinkwV).

With regard to sampling, the following specifications for the parameters lead (serial no. 4), copper (serial no. 7) and nickel (serial no. 8) can be found in Annex 2 Part II, TrinkwV, under the relevant column "Remarks":

- “In order to comply with the reporting requirements under section 21(3) within a given supply zone, random sampling shall be carried out (Z sample) or alternatively staged stagnation sampling (S0 sample, S1 sample, S2 sample) only at the compliance point under section 8."
- “To determine whether the relevant parametric value is being exceeded from a single extraction point in a building, staged stagnation sampling" shall be “performed” pursuant to this recommendation.

When in contact with drinking water, metals form cover layers which reduce the release of the metals into drinking water. Newly constructed domestic distribution systems, can however initially have elevated concentrations. For new installations, these concentrations may be tolerated for the parameters lead, copper and nickel if the limit values are complied with within 16 weeks at the latest after commissioning and if the concentrations measured by that time do not exceed twice the respective parametric value (Section 9 (4), TrinkwV).

1.4.2 Limit values / maximum parametric values for other chemical parameters

It is advisable to take samples for chemical parameters whose concentrations in the domestic distribution system may increase, pursuant to this recommendation (Annex 5, Part II, Letter b, Sentence 4, TrinkwV).

Annex 2, Part II, TrinkwV, specifies the parameters that may change during water distribution which includes the domestic distribution system. In addition, the indicator parameters iron and aluminium of Annex 3 Part I, TrinkwV, may also change in the domestic distribution system.

Notes on individual parameters:

Antimony, **arsenic** and **cadmium** as well as the indicator parameters **aluminium** and **iron** can migrate from metallic or inorganic (e.g. cementitious) materials into drinking water. Antimony and arsenic could be components of copper alloys used in domestic distribution systems. Cadmium is an impurity found primarily in older galvanised steel pipes. Should these parameters be influenced by the domestic distribution system, then sampling and evaluation should be carried out by analogy with the parameters lead, copper and nickel.

Benzo(a)pyrene and the cumulative parameter **polycyclic aromatic hydrocarbons (PAH)** are parameters whose concentrations may increase during water distribution. The primary causes are coatings of coal tar (submerged tarred pipes) and to a lesser extent, bitumen coatings, which were partially used for components of the central water supply network. If this is confirmed, then taking samples for evaluation from the central water supply network

should be sufficient (see 3.5). However, PAHs could also migrate to drinking water if unsuitable materials are used in the domestic distribution system (e.g. hoses, seals made from unsuitable elastomers). If an increase in PAH concentrations in the domestic distribution system is suspected, then sampling and evaluation must be carried out by analogy with the parameters lead, copper and nickel.

Epichlorohydrin and **vinyl chloride** are organic material contaminants, as they are used, inter alia, as starting substances for the production of epoxy resins or PVC and can contaminate drinking water in the form of residual monomers. The Drinking Water Ordinance stipulates that compliance with the limit values of the two parameters can be calculated from the maximum release. If the two parameters are analysed in the domestic distribution system as organic material contaminants of drinking water, then the sampling and evaluation must be carried out by analogy with the parameters lead, copper and nickel.

The concentration of the parameter **nitrite** can also change in the domestic distribution system. During long stagnation times - especially in galvanized steel pipes - total oxygen depletion may occur due to the reaction with the metal pipe materials. The next oxidizing agent to be reduced to nitrite is nitrate, resulting in an increased nitrite concentration. However, the change in nitrite concentration over time differs from that for material born contaminants (e.g. lead, copper, nickel). For this reason, staged stagnation sampling (see 2.2) is not suitable for evaluation.

The presence of chlorine as a disinfectant may also increase the concentration of **trihalomethanes (THM)** in the domestic distribution system. This increase in concentration, however, is not comparable to the release of material born contaminants. Therefore, staged stagnation sampling (see 2.2) is not suitable for evaluation in this case either.

The German Environment Agency's recommendation "Evaluation of material born contaminants in contact with drinking water" (https://www.umweltbundesamt.de/dokument/beurteilung-materialbuertiger-kontaminationen-des) provides further information on the evaluation of material born contaminants in contact with drinking water (only available in German).

1.4.3 Monitoring by the Federal Ministry of Health

Lead, copper and nickel are crucial parameters when monitoring drinking water at standard tapping points. This applies in particular to the following monitoring activities performed by the Ministry of Health:

- dutiful monitoring of the domestic distribution system (water supply systems within the meaning of Section 3 No. 2 Letter e, TrinkwV), to the extent that water is supplied from these installations as part of a public service (Section 18 (1) Sentence 2 No. 2 TrinkwV),
- dutiful monitoring of small installations for private supply (water supply installations within the meaning of Section 3 No. 2 Letter c, TrinkwV), whereby samples for the parameters lead, copper and nickel must be taken from a representative tapping point in a building (Section 18 (1) Sentence 1, TrinkwV),
- dutiful monitoring of mobile supply facilities (water supply facilities within the meaning of Section 3 No. 2 Letter d, TrinkwV), to the extent that water is supplied from them as part of a commercial or public activity (Section 18 Paragraph 1 Sentence 2 No. 1, TrinkwV),

- dutiful monitoring of installations for temporary water distribution (water supply installations within the meaning of Section 3 No. 2 Letter f ,TrinkwV) (Section 18 Paragraph 1 Sentence 1, TrinkwV) and
- Monitoring of domestic distribution systems or mobile supply systems which are also implicated in the protection of human health or to ensure the proper quality of drinking water (Section) 18 (1) Sentence 3, TrinkwV)

The parameters lead, copper and nickel will have to be measured as part of these monitoring activities. As a rule, an analysis of the parameter copper can be dispensed with if the pH value of the drinking water in the supply zone is ≥ 7.8 (see comment to Annex 2 Part II No. 7, TrinkwV). If several samples are taken from the same domestic distribution system, measurement of the parameters lead, copper and nickel may be dispensed with if no abnormalities have occurred to date and the installation and its end fittings have not been altered. For mobile supply systems, the decision on whether to examine these parameters is made by the Federal Ministry of Health.

For parameters whose concentrations may have changed during distribution - notably lead, copper and nickel - in order to comply with the reporting obligations pursuant to Section 21 (3) TrinkwV, the sampling plan of the Federal Ministry of Health in accordance with Section 19 (2), TrinkwV, may only use sampling points in the domestic distribution systems (compliance point pursuant to Section 8, TrinkwV) (Section 19 (2c) TrinkwV). Accordingly, the Federal Ministry of Health must obtain these samples at random (see 2.1) or as staged stagnation sampling (see 2.2) as part of its monitoring activities pursuant to Section 18 (1) Sentence 2 No. 2 TrinkwV. In order to comply with the reporting obligations under Section 21 (3), TrinkwV, the Federal Ministry of Health can only consider analyses performed by the central water supply company if these were taken at random from consumers' taps of domestic distribution systems (see 2.1) or as staged stagnation sampling (see 2.2) and the sampling was agreed beforehand by the Federal Ministry of Health. The Federal Ministry of Health must ensure that representative sampling points are selected for the water supply zone.

The Federal Ministry of Health shall decide which parameters in addition to lead, copper and nickel are to be evaluated as part of the monitoring activities and for compliance with the reporting obligations in the domestic distribution system and which sampling method is to be used for this purpose.

2 Sampling method

2.1 Random sampling (Z-sample)

A sample shall be taken from the tap where the consumer normally draws water for consumption, **without prior flushing** of the drinking water. A sample of 1 litre in volume is taken from the tap of a consumer **at a random time of day** without prior flushing.

Explanation

The parametric values for lead, copper and nickel found in random samples do not indicate whether a limit value has been exceeded at a single sampling point (tap). However, a higher number (n > 10) of random samples in a water supply zone enables conclusions to be drawn about any possible generic problems of lead, copper and nickel released in the water supply

zone. For this reason, the random sample is suitable for fulfilling the obligations under Article 7 of the EC Drinking Water Directive.

2.2 Sampling after drainage and stagnation (staged stagnation sampling)

At the tap from which water is usually drawn for consumption, water is to be run until it leaves the tap in the quality delivered by the water supplier (e.g., at constant temperature).

Before taking a sample, the temperature of the running water (e.g. in an overflowing receptacle) must be measured and recorded. The sample 1 litre in volume, taken from the running water (**sample S0**), is representative of the drinking water quality delivered by the water supplier.

After completion of this flushing, the tap is shut for a period t (stagnation time in hours) of 4 hours, but not less than 2 hours. This is to ensure that care is taken to ensure that no water is drawn from the tap during this time. Consumption in other parts of the building is not influenced. After this stagnation period, 2 further samples, each 1 litre in volume, are drawn consecutively without any additional prior flushing (**samples S1 and S2**). The tap used for the sampling must not be closed between the sampling of the S1 sample and the S2 sample. Care must be taken to ensure that no water is run between samples S1 and S2. The concentration in sample S1 reflects the influence of the domestic distribution system including the tap (important in the case of nickel and lead, for example) whilst S2 only covers the influence of the other components of the domestic distribution system.

The concentrations of lead, copper and nickel are determined in all three samples.

Normalisation

If the stagnation period is less than 4 hours but not less than 2 hours, the measured concentration is extrapolated to the concentration after four hours by multiplication with a factor of 4/t (measured concentration * 4/t = normalised concentration).

If the stagnation time is more than 4 hours, no normalisation can be performed. In the test report the discrepancy is reported and only the measured concentrations are indicated.

The normalised concentration is compared with the parametric value and used to determine whether the relevant parametric value is being exceeded. If the normalised concentration exceeds the parametric value, a sample shall be taken after a stagnation period of precisely 4 hours and used as assessment basis as regards orders of the health office pursuant to Article 20 (3), TrinkwV.

Explanation

A variable stagnation period of between 2 and 4 hours was chosen for reasons of practicability.

An indication of a precise stagnation period of 4 hours, for example, would considerably reduce flexibility in the organisation of sampling and would compromise the ability of a sampler to take several samples over a day.

The assumption of a linear increase of concentrations with the stagnation time leads to an overestimation of results from shorter stagnation periods as compared to those of samples with a stagnation period of 4 hours.
However, in most cases this will not significantly change the assessment. If the calculated 4-

hour concentration exceeds the parametric value, however, another sample has to be taken after exactly four hours of stagnation for validation.

Recommendation

Taking the S0 sample after stagnation samples S1 / S2 is not permitted.

3 Choice of sampling method

3.1 Sampling carried out as part of the Federal Ministry of Health's monitoring activities

If the Federal Ministry of Health should take samples for the evaluation of drinking water with respect to the parameters lead, copper and nickel in a building or from a single tapping point during its monitoring activity (see 1.4.3), a staged stagnation sampling must be performed.

If additional samples are taken in buildings supplied by central waterworks (water supply facilities as defined in Article 3 No. 2 Letter a, TrinkwV) in order to fulfil the reporting obligations under Article 21 Paragraph 3, TrinkwV, a random sample may also be taken in accordance with this recommendation.

If further chemical parameters as material born contaminants originating from the domestic distribution system (see 1.4.2) cannot be excluded, random sampling is useful to detect any influences caused by the domestic distribution system.

3.2 Investigations of the owner or operator of a domestic distribution system / a mobile supply system / a temporary water distribution system

In some cases (e.g. if the materials used are unknown) it may make sense for the owner or operator of a domestic distribution system, a mobile installation or a temporary water distribution system to have the drinking water analysed for the parameters lead, copper and nickel or other material born contaminants. A staged stagnation sampling should be used for such cases.

3.3 Sampling from new installations[1]

The German Environment Agency has established evaluation criteria for metallic materials. These contain a positive list of metals approved for use in drinking water. For the new construction or maintenance of installations for the production, treatment or distribution of drinking water, only metals listed on this positive list may be used (Article 17 (3), TrinkwV).

It is ensured that the requirements of the Drinking Water Ordinance are met for the listed materials, taking into account the areas of application (e.g. bare copper pipes cannot be used for all drinking water). Taking samples of drinking water from new installations to determine the concentrations of lead, copper and nickel is therefore not absolutely necessary. It is accepted that there will be increased release during the first weeks after commissioning. However, the concentration may not be more than twice the limit values (Article 9 (4) Sentence 3, TrinkwV). This is due to the fact that a protective layer is only just beginning to

[1] New domestic distribution systems or the installation of new components in a domestic distribution system

form. The limit values must be met no later than 16 weeks after commissioning. In this case, sampling shall be carried out in the form of a staged stagnation sample.

3.4 Cold / warm water sampling

Normally the sampling is performed on cold water. Should hot water sampling be carried out, the type of hot water supply (e.g. central hot water storage tank with circulation pipe, decentralised hot water storage tank, instantaneous water heater) shall be taken into account and the sampling adapted accordingly.

For a centrally located DHW cylinder with circulation pipe, a Z-sample is useful for evaluation. In contrast to the Z-sample (see2.1) however, the water should be allowed to run off until hot water is actually obtained.

3.5 Sampling within the distribution network of the central water supply or after treatment

The samples for monitoring the parameters lead, copper and nickel are to be taken, according to Section 19 Paragraph 2c, TrinkwV, at the compliance point under Section 8, TrinkwV. If sampling in the distribution network of the central water supply or downstream of a central treatment plant is nevertheless required, this shall be carried out pursuant to DIN ISO 5667-5 (in accordance with Annex 5 Part II Letter b Sentence 5, TrinkwV).

To identify lead pipes in the water supplier's network, which as a rule is incumbent on the central water supply company, it is recommended that staged stagnation sampling according to 2.2 be performed at a sampling point near the transfer point from the water supply company to the domestic distribution system (i.e. the water meter).

4 Evaluation of the results

4.1 Evaluation of the results from the random sample

The results from the random sample are not suitable for determining whether the parametric value, defined as weekly average value, is being exceeded for any individual installation or individual consumer. They are in principle suitable only for indicating whether there is a risk of parametric values being exceeded.

If a random sample indicates that a parametric value has been exceeded, sampling should be repeated in the form of a staged stagnation sampling to assess whether a limit value has been exceeded at each sampling point (tap). Irrespective of the result of the staged stagnation sampling, the sample shall be deemed to exceed the limit value when there is a reporting obligation pursuant to Article 21 (3), TrinkwV.

4.2 Evaluation of the results of staged stagnation sampling

The concentration in a sample, representative of a weekly average value ingested by consumers, depends on the average residence time of the water in the domestic distribution system for a given water quality and types of materials used. The reference value is a stagnation time of 4 hours. If the concentration in the sample after precisely 4 hours of stagnation does not exceed the relevant parametric value, it is unlikely that it will exceed the weekly average value.

Evaluation of the different samples

The limit value of the relevant parameter is deemed to be exceeded if the concentration

detected in one of the three samples S0, S1 or S2 exceeds the limit value.

According to Section 21 (3), TrinkwV 2001, the Federal Ministry of Health must treat these as exceeding limit values if a reporting obligation exists.

Pursuant to Section 9 (7), TrinkwV 2001, the Federal Ministry of Health is required to order the owner or operator of a domestic distribution system to undertake appropriate remedial measures and to inform consumers thereof. Conversely, the Federal Ministry of Health also has the authority to issue orders to privately operated domestic distribution systems.

Information on the causes of the limit value being exceeded and remedial action

1. If the normalised concentrations (see section 2.2) of the three parameters specified comply with the relevant parametric values in either of the samples S0, S1 and S2, no further action is required.
2. If non-compliance with the relevant parametric value is found in the first sample after stagnation (S1), but not in the second sample after stagnation (S2) and not in the reference sample after flushing (S0), as a remedial measure, the consumer should be advised to allow the first litre to run off before drawing the water for consumption or personal hygiene (the latter holds for the parameter nickel). This is deemed a suitable remedial measure and may be ordered by the Federal Ministry of Health pursuant to Section 20, Paragraph 1, No. 5, TrinkwV.

   Non-compliance with the parametric value for nickel is particularly likely in cases where nickel-plated components have been installed or where chrome-plated end fittings are present.
3. If non-compliance with the relevant parametric value is found in the second sample after stagnation (S2), a differentiated evaluation is required. For this purpose, the design of the distribution system (configuration and types of material) must be taken into account in this evaluation. Technical remedial measures might need to be taken, e.g. additional installation of a supply pipe of a size appropriate to the consumption, or the exchange of fittings containing nickel. The water supplier could also be responsible for the cause, i.e. a service pipe made of unsuitable material such as lead.

   Whether compliance with a parametric value is possible simply through a change in consumer behaviour (prior flushing) must be determined on a case-by-case basis.

   Pregnant women and infants should not drink tap water or eat food prepared with this water in buildings where lead pipes are still in use.
   If the normalised concentration in the second sample after stagnation (S2) exceeds twice the relevant parametric value, the consumer will not be able to ensure the maintenance of drinking water quality with sufficient certainty through behaviour change alone. In such cases, the implementation of technical measures by the owner or operator is required.
   The reason for the non-compliance with the relevant parametric value in the S2 sample must be determined. This requires the performance of an on-site technical inspection to evaluate the domestic distribution system and its compliance with the generally acknowledged technical standards. Further sampling may also be necessary to determine the cause.

4. If non-compliance with the parametric value is found in the sample drawn after flushing (S0), the water supplier could be responsible for the cause, i.e. a service pipe made of unsuitable material such as lead.

   The cause of the non-compliance with the parametric value must be determined. This requires the performance of an on-site technical inspection to evaluate the domestic distribution system and the service pipe and their compliance with the generally acknowledged technical standards. Further sampling may also be necessary to determine the cause.