Ammonia in drinking-water is not of immediate health relevance, and therefore no health-based guideline value is proposed. However, ammonia can compromise disinfection efficiency, result in nitrite formation in distribution systems, cause the failure of filters for the removal of manganese and cause taste and odour problems (see also chapter 10).

Anatoxins **(cyanobacterial toxins)**[1]

Anatoxin-a, homoanatoxin-a and their dihydro derivatives (ATXs) are naturally occurring alkaloids produced by strains of various species of cyanobacteria, primarily in freshwater environments.[2] ATXs have been found in many countries but generally have been reported less often than MCs or CYNs. They have been reported from a number of cyanobacterial genera, including *Anabaena*, *Dolichospermum*, *Aphanizomenon* and *Cuspidothrix*, many of which are primarily benthic (i.e. grow on sediments or other submerged surfaces) (see also section 11.5). ATXs, like MCs and STXs, usually occur bound to cyanobacterial cells.

Drinking-water is the most likely route of exposure to ATXs where surface water with cyanobacterial blooms is the drinking-water source. Recreational activities in lakes with cyanobacterial blooms may also be a relevant exposure pathway, potentially to high concentrations (see WHO *Guidelines on recreational water quality*, 2021).

Reason for not establishing a guideline value	Available data inadequate to permit derivation of health-based guideline value
Provisional reference value (short-term)*	*Total ATXs (sum of all congeners, free plus cell-bound)*: 0.03 mg/l The reference value is based on data for anatoxin-a only
Occurrence	Concentrations reported usually range well below 1 mg/l; outside of scum areas, they rarely exceed several µg/l. ATXs largely occur cell-bound unless cell damage causes release.
TDI	A formal TDI could not be derived because of database limitations. However, 98 µg/kg bw per day, based on a 28-day study in mice, was selected as a NOAEL. An uncertainty factor of 100 (10 each for inter- and intra-species variability) was applied. An uncertainty factor for database limitations was not applied because of the conservative assumptions used to select the NOAEL (see text following the table for further detail).
Limit of detection	0.05 µg/L by LC-MS/MS and <30 µg/L by HPLC coupled with post-derivatization fluorescence. LC-MS/MS requires quantitative reference standards, which are available for anatoxin-a and for dihydro-anatoxin-a. A receptor-binding assay that is commercially available circumvents this problem and provides more reliable results than HPLC. Prior extraction of cells with freeze–thaw cycles and acidified water or acidified mixtures of methanol/water is necessary for cell-bound ATX; neglecting extraction from cells will lead to dramatic underestimation of concentrations.

[1] As cyanobacteria and their toxins are a concern in many areas and considering the complexities in their management, this chemical fact sheet has been expanded.

[2] ATXs do not include anatoxin-a(S), a naturally occurring organophosphate with a different mode of neurotoxicity.

	0.15 μg/L for anatoxin-a and 10 μg/L for homoanatoxin-a by commercially available immunoassay kits (ELISA); although these are less precise than LC with the above-mentioned detection methods, they probably capture all anatoxin-a congeners and thus are useful for most monitoring purposes.
Monitoring	The likelihood of blooms can be assessed by understanding water body conditions (in particular, nutrient concentrations, water body depth, water retention time, patterns of mixing and stratification; see section 11.5). Where conditions render blooms likely, visual monitoring of source water (including microscopy for potentially ATX-containing genera) for evidence of increasing cyanobacterial biomass (blooms) is important because biomass can increase rapidly. Exceeding alert values of biomass indicators or ATX concentrations should trigger management responses to prevent exposure to elevated toxin concentrations (see the alert level framework in section 11.5). Analysis of cyanotoxins is particularly useful for validating and optimizing the efficacy of control measures such as riverbank filtration or treatment.
Prevention and treatment	Actions to decrease the probability of bloom occurrence include catchment and source water management, such as reducing nutrient loading or changing reservoir stratification and mixing. Filtration is effective for removing intact cyanobacterial cells, but some dissolved ATX may be present. For this dissolved fraction, oxidation with ozone at sufficient concentrations and contact times, as well as GAC and some PAC applications, are effective. Chlorination is not reliably effective for oxidation of ATXs (see chapters 7–10 of *Toxic cyanobacteria in water*; Annex 1).
Reference value derivation	
• allocation to water	100%
• weight	60 kg adult
• consumption	2 litres/day
Additional comments	Total ATXs as gravimetric or molar equivalents should be evaluated against the reference value since these toxins can occur as mixtures. Although the reference value is based on anatoxin-a, limited evidence suggests that all ATXs are similarly toxic.
	Because ATX is acutely toxic, avoiding any exposure above the reference value is recommended.
	It is recommended, as a precautionary measure, that bottle-fed infants and small children be provided with an alternative safe drinking-water source (e.g. bottled water that is certified by the responsible authorities) if concentrations are greater than 6 μg/L, even for short periods.
Assessment date	2020
Principal references	WHO (2020) *Cyanobacterial toxins: anatoxin-a and analogues* Chorus & Welker (2021) *Toxic cyanobacteria in water*

* Although a formal guideline value cannot be established, the provisional reference value was derived based on limited available studies, recognizing that a "bounding value" may be useful, to provide guidance to Member States in the event of need. Reference values are too uncertain to be used for developing regulations or standards.

ATXs have been much investigated because of the rapid animal deaths that have been observed upon ingestion of cyanobacterial cells in beached scum material or dislodged benthic mats—in particular, dogs that ingest significant amounts. In contrast, high concentrations of dissolved ATXs near drinking-water abstraction sites have not been reported, presumably because ATX released from the cells in benthic mats or scums is usually rapidly diluted.

The (+) enantiomer of anatoxin-a binds with high affinity to nicotinic acetylcholine receptors of nerve cells, causing chronic overstimulation. This can lead to increases in heart rate and blood pressure, as well as fatigue and eventual paralysis of muscles, which can cause death when it occurs in respiratory muscles. Although anatoxin-a is the best studied analogue, limited evidence suggests that homoanatoxin-a and the dihydro derivatives of these compounds bind to the same receptor and may have similar potency to anatoxin-a when administered orally.

The toxicological database on ATXs is not adequate to support derivation of a formal guideline value since a nonlethal dose that caused significant adverse effects was not identified in the available repeated-dose studies. Nevertheless, a "bounding value" may be useful to risk assessors. Based on the limited available studies of acute and subchronic anatoxin-a toxicity, a health-based reference value is provided that is unlikely to cause adverse effects in exposed adults. The reference value is based on a 28-day mouse study that found no effects that were clearly ATX related in any of the doses tested. However, as a mouse died from unexplained causes at each of two lower doses, the dose below these two has been selected as the NOAEL. Two other studies indicate that this selection is very conservative.

Practical considerations

Where nutrient (phosphorus and nitrogen) concentrations are elevated in lakes, reservoirs or slowly flowing rivers, cyanobacteria occur widely. Where their excessive growth leads to high biomass, sometimes termed "bloom" events, ATXs can reach concentrations in raw water that are potentially hazardous to human health. Such blooms tend to recur in the same water bodies. Cells of some cyanobacterial species (e.g. *Anabaena*, *Cuspidothrix*, *Dolichspermum*) may accumulate at the surface as scums. Such accumulations may develop rapidly and may be of very variable duration (hours to weeks). In many circumstances, blooms and accumulations are seasonal, whereas others occur perennially.

Cyanobacteria are most effectively controlled in the context of developing a WSP (see chapter 4). Control measures to manage potential risks from cyanobacteria, and in particular from their toxins, in drinking-water should include not only adequate treatment, but also measures to control cyanobacterial bloom development. See section 11.5 for more information on cyanobacteria, including further details on monitoring cyanobacterial blooms, the alert level framework, and prevention and management of cyanobacteria in source waters. Effectively minimizing the formation of blooms and locating the raw water intake away from blooms reduce the treatment steps required to remove cyanotoxins.

Drinking-water treatment that removes particles—that is, soil, slow sand or riverbank filtration, conventional water treatment (coagulation, flocculation and filtration) or dissolved air flotation—can remove cell-bound ATXs effectively. Soil, slow sand and riverbank filtration can also remove dissolved cyanotoxins. For all these processes, it is important that they are optimized to target the removal of cells and dissolved toxins. Chlorination is not reliably effective, whereas ozonation at sufficiently high doses and contact times is effective for degrading dissolved ATXs; however, elevated organic carbon in bloom situations will substantially increase the disinfectant demand. Chlorine dioxide and chloramine are ineffective for degrading ATXs. Both for pre-oxidation and conventional treatment, cell rupture and toxin release should be avoided. GAC and PAC can be effective for removing dissolved ATXs, with efficacy dependent on several factors, including the type of activated carbon, contact times (PAC), flow rates (GAC) and water quality. As the challenges that blooms present for treatment are complex, periodic validation of efficacy during bloom situations and under the specific local conditions is particularly important. Avoiding bloom occurrence and intake is therefore the preferred option.

Antimony

Elemental antimony forms very hard alloys with copper, lead and tin. Antimony compounds have various therapeutic uses. Antimony is used in solders as a replacement for lead, but there is little evidence of any significant contribution to drinking-water concentrations from this source. Total exposure from environmental sources, food and drinking-water is very low compared with occupational exposure.

Guideline value	0.02 mg/l (20 μg/l)
Occurrence	Concentrations in groundwater less than 0.001 μg/l; concentrations in surface water less than 0.2 μg/l; concentrations in drinking-water appear to be less than 5 μg/l
Tolerable daily intake (TDI)	6 μg/kg body weight, based on a NOAEL of 6.0 mg/kg body weight per day for decreased body weight gain and reduced food and water intake in a 90-day study in which rats were administered potassium antimony tartrate in drinking-water, using an uncertainty factor of 1000 (100 for interspecies and intraspecies variation, 10 for the short duration of the study)
Limit of detection	0.01 μg/l by electrothermal atomic absorption spectrometry (AAS); 0.1–1 μg/l by inductively coupled plasma mass spectrometry (ICP-MS); 0.8 μg/l by graphite furnace AAS; 5 μg/l by hydride generation AAS
Treatment performance	Conventional treatment processes do not remove antimony. However, antimony is not normally a raw water contaminant. As the most common source of antimony in drinking-water appears to be dissolution from metal plumbing and fittings, control of antimony from such sources would be by product control.
Guideline value derivation	
• allocation to water	10% of TDI
• weight	60 kg adult
• consumption	2 litres/day
Assessment date	2003
Principal reference	WHO (2003) *Antimony in drinking-water*