

Table 1: Examples of guidance values or standards and other national regulations or recommendations for managing cyanotoxins in drinking-water

Country /source document	RMF* required	Cyanotoxins and/ or Cyanobacteria explicitly regulated	S, (P)GV, (P)MAV, (P)MAC or HAL**	Comments; specific action in case of derogation
WHO	√	Microcystin-LR	PGV: 1 µg/L	Depends on setting; strong emphasis on assessing cyanotoxin risks in relation to other risks
Argentina		Requirements neither for Risk Management Framework nor for cyanotoxin surveillance, but some water utilities have implemented either or both; these refer to the provisional guideline by WHO for Microcystin-LR of 1 µg/L		
Australia	√	Microcystin (toxicity equivalents of MCYST-LR); equivalent to 6500 cells/mL or a biovolume of 0.6 mm ³ L ⁻¹ of a highly toxic strain of <i>Microcystis aeruginosa</i>	GV: 1.3 µg/L	The Australian Drinking Water Guidelines (2011) are a set of national guidelines which include fact sheets with information on key cyanotoxins; Health Alert can be triggered by the toxin concentrations or the equivalent cell or biovolume concentrations. Trigger levels for each of the 4 key toxin-producing species are also provided for immediate notification to the health authority; Individual states/territories use the national framework as the basis for their specific regulatory requirements.
		Nodularin HAL at 40 000 cells mL ⁻¹ or a biovolume of 9.1mm ³ L ⁻¹ of a highly toxic strain of <i>Nodularia spumigena</i>	No value	
		Cylindrospermopsin equivalent to 15 000 – 20 000 cells mL ⁻¹ or a biovolume of 0.6 – 0.8 mm ³ L ⁻¹ of <i>Cylindrospermopsis raciborskii</i>	HAL: 1 µg/L	
		Saxitoxins (toxicity equivalents to STX); equivalent to 20,000 cells mL ⁻¹ or a biovolume of 5 mm ³ L ⁻¹ of a highly toxic strain of <i>A. circinalis</i>	HAL: 3 µg/L	
Brazil (2005)		Cyanobacteria	GV: 10 000 – 20 000 cells/mL or 1 mm ³ /L biovolume	at >10 000 cells/ml weekly monitoring is required; at > 20 000 cells/ml toxicity testing and/or quantitative cyanotoxin analysis in drinking-water are required
		Microcystins	S: 1 µg/L	
		Cylindrospermopsin	GV: 15 µg/L	
		Saxitoxin	GV: 3 µg/L (STX equiv.)	

Canada		Microcystin-LR	MAC: 1.5 µg/L	MAC for Microcystin-LR is considered protective against exposure to other microcystins; monitoring frequencies driven by bloom occurrence – more frequent where there is a history of bloom formation	
		Anatoxin-a	PMAC: 3.7 µg/L	ATX regulated only in Quebec	
Czech Republic		Cyanobacteria in raw water (as cell counts or biomass or concentration of chlorophyll-a)	≥ 1 colony/mL or ≥ 5 filaments/mL	<u>Vigilance Level</u> : quantification of cyanobacteria in the raw water s at least once per week; visual observations of the abstraction point (water blooms at the surface of water level)	
			≥ 2 000 cells/mL or ≥ 0.2 mm ³ /L biovolume or ≥ 1 µg/L chlorophyll-a	<u>Alert Level 1</u> : attempt reduction by changing abstraction depth. If that is not possible, ascertain that treatment sufficiently reduces cyanobacteria and toxins (data from operational parameters, if necessary also toxin analyses)	
			≥ 100 000 cells/mL or ≥ 10 mm ³ /L biovolume or ≥ 10 µg/L chlorophyll-a	<u>Alert Level 2</u> : as Alert Level 1, but with stronger emphasis on treatment efficacy and microcystin monitoring	
		Microcystin-LR in treated water	S: 1 µg/L	Monitored once per week in treated water	
Cuba No regulatory requirement, but framework currently being tested		Phytoplankton cells	< 20 000 cells/mL	Monthly visual inspection and sampling at least four months a year <u>Alert</u> : increased sampling (weekly and more sites); daily inspection; notification to public health unit and local managers; report to local government; warning of the public <u>Action (in red)</u> : as for “Alert”, but with increased actions for public communication and water use restrictions	
		Cyanobacterial cells	< (or only slightly above) 1500 cells/mL		
		Phytoplankton and proportion of cyanobacteria	20 000 – 100 000 cells/mL - >50% cyanobacteria		
		Cyanobacteria known as potentially toxic	At least one of the species		
		Any report of toxic effect (humans or animals)			
		Scum consistently present; confirmed bloom persistence			
Denmark		no cyanotoxin drinking water regulation; use of the provisional guideline by WHO for Microcystin-LR of 1 µg/L when needed			
France	√	Microcystins (sum of all variants)	S: 1 µg/L	Analysis required in raw water and at the point of distribution only when cyanobacteria proliferate (visual observation and/or analytical results)	

Finland	√	Potentially toxic Cyanobacteria in raw water (as cell counts or biomass; biomass is equal to biovolume assuming a 1:1 ratio of volume to mass)	>5000 cells/mL or >1 mg/L biomass	microcystin monitoring; enhanced treatment
		Potentially toxic Cyanobacteria in raw water	>100 000 cells/mL, >20 mg/L biomass	change of abstraction site and/or restrictions of water use; information to the water users, particularly if microcystins are found in finished drinking water
		Microcystins (sum of all variants) in raw water	>1 µg/L	
			GV: >1 µg/L	Restrictions of water use; unlikely on basis of experience so far
		Microcystins (sum of all variants) in finished drinking-water	GV: >10 µg/L	Ban on water use; highly unlikely
Germany		No specific cyanotoxin regulations as only about 20% of water supply is from surface water, and that mostly from well protected reservoirs. However, for non-regulated chemicals the Drinking-water Ordinance requires that they do not occur in hazardous concentrations. On this basis, where cyanobacteria do occur, the WHO GV can be applied for microcystins . National guidance for substances with incomplete toxicological evidence proposes <0.1 µg/L if carcinogenesis cannot be excluded (until data are generated that allow higher levels), and this can be applied to Cylindrospermopsin .		
Hungary		Drinking-water legislation includes “biological parameters” to be monitored by microscopy, e.g cyanobacteria	frequency of examination based on amount of water supplied and source of drinking water (cyanobacteria if source is surface water); at least once a year for every network for all biological parameters	
Italy		National decree includes “algae” as accessory parameter to monitor if local authorities presume a risk. For this assessment, it uses the provisional WHO GV for Microcystin-LR.		
Netherlands		No specific regulations for cyanotoxins in drinking water, although about 40% of water supply is from surface water, mainly from well protected reservoirs and infiltration basins. However, concentrations of micro-organisms may not exceed levels which may have adverse consequences for public health. For the production of drinking water, barriers in the treatment process to prevent cyanobacterial cells and microcystins from reaching finished drinking water. In case this should happen, the Netherlands would apply WHO guidance, i.e. for cells < 4.700 mL ⁻¹ as described in Chorus and Bartram (2000) and for microcystins the WHO GV of 1µg/l.		
New Zealand	√ PHRMPs	Microcystins (as MC-LR equivalents)	PMAV 1.3 µg/L	Effective implementation of the protocols required by Public Health Risk Management Plans (PHRMPs) has prevented concentrations > PMAV from reaching the consumers
		Cylindrospermopsin	PMAV 1 µg/L	
		Saxitoxin	PMAV 1 µg/L	
		Anatoxin-a	PMAV 6 µg/L	
		Anatoxin-a(s)	PMAV 1 µg/L	
		Homoanatoxin-a	PMAV 2 µg/L	

		Nodularin	PMAV 1 µg/L	
Singapore	√	Microcystin-LR in free and cellbound forms	1 µg/L	Every supplier of piped drinking water is legally required to prepare and implement a water safety plan to ensure that the piped drinking water supplied complies with the piped drinking water standards (stated as 1 µg/L for total microcystin-LR, in free and cellbound forms).
Poland		No regulations		GV for MCYST-LR excluded from Polish legislation since EU DWD does not include cyanotoxins
Spain		Microcystins	S: 1 µg/L	to be analysed when eutrophication is evident in the water sources (one known case of exceedance; Quesada 2012)
Turkey (proposed for 2014 at the time of this publication)		Cyanobacteria	>5000 cells/mL or >1 µg/l Chlorophyll-a	monthly analysis if in raw water; if exceeded, weekly sampling (of water column) and toxin analysis
		Sum of all microcystins	1 µg/L MC-LR-equivalents	If >1 µg/l, toxin analysis in treated water and advanced treatment (ozonation or active carbon) or alternative water supply
Uruguay		Microcystin-LR	S: 1 µg/L	Decree: <i>“Drinking water should not contain amounts of cyanobacteria that could affect water characteristics or human health”</i>
South Africa		Microcystin-LR	GV: 1 µg/L	supported by guidelines for chlorophyll-a and cyanobacterial cell counts

Table 2: Examples of guidance values or standards and other national regulations or recommendations for managing cyanotoxins in recreational-waters

Country /source document	Management framework required or other comments	Parameter regulated	Values	Actions taken / consequences of derogations
World Health Organization		Cells or Chlorophyll-a with dominance of cyanobacteria	20 000 cells/mL or 10 µg/L Chl.-a	Information to site users and to relevant authorities
			100 000 cells/mL or 50 µg/L Chl.-a	Information to site users and to relevant authorities; watch for scums; restrict bathing and further investigate the hazard
		Scum	Observation in bathing area	Action to prevent scum contact; possible prohibition of swimming and other water contact activities; public health follow-up investigation; information of relevant authorities
European Union	Bathing Water Directive (EU BWD)	Requires 'bathing water profiles' indicating – among other parameters – the potential of the site for cyanobacterial proliferation; monitoring based on the bathing water's history and regional climatic conditions; conformity as a matter of appropriate management measures and quality assurance, not merely of measuring and calculation. Applies to any element of surface water where a large number of people to practice bathing and bathing is not prohibited or advised against (termed "bathing water"). Article 8: 1) When the bathing water profile indicates a potential for cyanobacterial proliferation, appropriate monitoring shall be carried out to enable timely identification of health risks. 2) When cyanobacterial proliferation occurs and a health risk has been identified or presumed, adequate management measures shall be taken immediately to prevent exposure, including information to the public.		
Australia	Annual assessment of susceptibility to cyanobacterial growth in categories of Very Poor, Poor, Fair, Good, Very Good	Cells or Biovolume	≥500 to <5000 cells/mL <i>M. aeruginosa</i> or biovolume >0.04 to <0.4 mm ³ /L for the combined total of all cyanobacteria	Green level Surveillance mode: • Regular monitoring
			≥5000 <50 000 cells/mL <i>M. aeruginosa</i> or biovolume ≥0.4 to <4 mm ³ /L for the combined total of all cyanobacteria with a known toxin producer dominant or ≥0.4 to <10 mm ³ /L for the combined total of all cyanobacteria where known toxin producers are not present	Amber level Alert mode • Notify agencies as appropriate • Increase sampling frequency • regular visual inspections of water surface for scums • Decide on requirement for toxicity assessment or toxin monitoring
			≥10 µg/L total microcystins	Red level Action mode

			<p>or $\geq 50\,000$ cells/mL toxic <i>M. aeruginosa</i></p> <p>or biovolume ≥ 4 mm³/L for the combined total of all cyanobacteria with a known toxin producer dominant</p> <p>or ≥ 10 mm³/L for total biovolume of all cyanobacterial material where known toxins are not present.</p> <p>or cyanobacterial scums consistently present</p>	<ul style="list-style-type: none"> Continue monitoring as for alert mode Immediately notify health authorities for advice on health risk toxicity assessment or toxin analysis (if this has not already been done) Health authorities warn of risk to public health (i.e. the authorities make a health risk assessment considering toxin monitoring data, sample type and variability) 	
Canada	Bloom risk management programs in some provinces	Microcystin-LR; or Cell Counts	≤ 20 µg/L $\leq 100,000$ cells/mL	If either of guideline values is exceeded, a swimming advisory may be issued by the responsible authority. Contact with waters where an advisory has been issued should be avoided until the advisory has been rescinded	
Cuba	No regulatory requirement, but framework currently being tested	Phytoplankton	<1500 cells/mL	Monthly visual inspection and sampling at least four months a year	
		Cyanobacteria	<500 (or only slightly above) cells/mL		
		Phytoplankton cells; proportion cyanobacteria	20 000 – 100 000 cells/mL ⁻¹ ; >50% cyanobacteria	Alert: increased sampling (weekly and more sites); daily inspection; notification to public health unit and local managers; report to local government; warning of the public	
		Cyanobacteria known as potentially toxic	At least one of the species		
		Any report of toxic effect (humans or animals)		Action (in red): as for “Alert”, but with increased actions for public communication	
		Scum consistently present; confirmed bloom persistence			
Czech Republic	70% of sites used for recreation tend to develop blooms	Cells and/or Chlorophyll-a	>20 000 cells/mL	1 st warning level	
			>100 000 cells/mL	2 nd warning level: closure for public recreation	
Denmark	EU BWD is implemented by risk assessment in response to larger blooms with the consequence of e.g. publishing warnings, informing authorities and local user groups such as kindergardens, scouts, water sports clubs. Policy strongly focuses on nutrient load reduction.				
Finland	National implementation of EU BWD	Visual inspection, including by trained	No algae on the water surface or on the shore line. Water transparency (Secchi depth) is not	<u>Level 0</u> : not detected	

	For the Baltic: monitoring with automated sensors on commercial ships; visual observations submitted by the Finnish Border Guard from the air; with satellite images	volunteers Note that “algae” includes cyanobacteria	affected by algae. Greenish flakes detected in the water or when taken into a transparent container, or narrow stripes on the shore. The Secchi depth is reduced by algae. The water is coloured by algae, small surface scums or cyanobacterial mass on the beach are detected. Wide and heavy surface scums or thick aggregates of cyanobacteria are detected on the shore.	<u>Level 1</u> : detected Possibly microscopical examination and even toxin analysis if there is a specific cause such as very popular beach or reports of adverse health effects or animal deaths <u>Level 2</u> : high amount Preferably microscopical examination; toxin analysis; warning of the public is compulsory <u>Level 3</u> : very high amount Preferably microscopical examination; toxin analysis; warning of the public is compulsory
France	National implementation of EU BWD	Visual inspection	visible bloom, scums, change in water colour	Microscopy examination. If cyanobacteria are absent: no further action. If present: counting and genus identification
		Cyanobacteria	<20 000 cells/mL ± 20 %	Active daily monitoring. Counting at least on a weekly basis. Normal recreational activity at the site
			20 000 – 100 000 cells/mL ± 20 %	Active daily monitoring. Counting on a weekly basis. Recreational activities are still allowed; the public is informed by posters on site.
Cyanobacteria; Microcystins	> 100 000 cells/mL ± 10 %. 25 µg/L MC-LR equivalent ± 5 %	if MC < 25 µg/L bathing and recreational activities are restricted. if MC > 25 µg/L bathing is banned and recreational activities are restricted. In either case, public is informed.		
Germany	National implementation of EU BWD The water body's capacity for bloom development is assessed on the basis of total phosphorus concentration (i.e. >20-40 µg/L) and transparency (Secchi Disk). Microcystin monitoring is optional, intended as basis for de-warning if use of site is to be continued in spite of	Transparency in combination with an “indicator” for cyanotoxin potential: Chlorophyll-a with dominance of cyanobacteria or Biovolume (BV) or Microcystins (MCYST)	Secchi Disk reading >1 m and <40 µg/L Chl.a or <1 mm³/L BV or <10 µg/L MCYST	Monitor further cyanobacterial development
			Secchi Disk reading < 1 m and >40 µg/L Chl-a or > 1mm³/L BV or > 10 µg/L MCYST	Publish warnings, discourage bathing, consider temporary closure
		Scums and / or Microcystins	observation of heavy scum and/or >100 µg/L MCYST	Publish warnings, discourage bathing, temporary closure is recommended

	high cyanobacterial density			
Hungary	National implementation of EU BWD	Chlorophyll-a with dominance of cyanobacteria or Cell counts or Microcystin-LR equivalents	<10 µg/L or <20 000 cells/mL or < 4 µg/L	excellent
			<25 µg/L or <50 000 cells/mL or <10 µg/L	good
			<50 µg/L or <100 000 cells/mL or <20 µg/L	acceptable
			>50 µg/L or >100 000 cells/mL or >20 µg/L	unacceptable
Italy	National implementation of EU BWD	Microcystins or Scum	>25 µg/L or occurrence / observation of scum	Bathing prohibited; prohibition can be relaxed in spite of scum or high cell count if toxin concentrations are low Information to the public
Netherlands	National Water Authority and National implementation of EU BWD Samples are taken at fortnightly intervals at bathing locations and cyanobacteria quantified. Presence and intensity of surface scums is noted	Surface scum intensity and/or Biovolume or Chlorophyll attributable to cyanobacteria	scums category I; cyano-chl-a <12.5 µg/L or cyano-biovolume < 2.5 mm ³ /L	<u>Surveillance level</u> : continue fortnightly monitoring
			or scum category II or cyano-chl-a 12.5 – 75 µg/L or cyano-biovolume 2.5 – 15 mm ³ /L	<u>Alert Level 1</u> : weekly monitoring and issue warning (by site operator) for duration of that week: “Toxic blue-green algae. Risk of skin irritation or intestinal problems”. In case of daily site inspection, re-evaluate the warning on a daily basis
			scums category III or cyano-chl-a > 75 µg/L or cyano-biovolume > 15 mm ³ /L If 80% dominance of MC–producers and MC < 20 µg/L, revert to Alert Level 1.	<u>Alert Level 2</u> : weekly monitoring and advice against bathing (by public authority): “You are advised not to bathe in this water”; prohibition by local authority is possible.
New Zealand	Guidelines include identifying high-risk water bodies, sampling and site surveys (including benthic cyanobacteria), a list of laboratories, examples for media releases, warning signs and sampling forms, photos of blooms and . Photographs of cyanobacteria blooms and benthic mats are provided to assist samplers with minimal cyanobacterial	Cells	<500 cells/mL	<u>Surveillance</u> : Where cyanobacteria are known to proliferate, weekly or fortnightly visual inspection and sampling between spring and autumn
		Biovolume	0.5 to < 1.8 mm ³ /L of potentially toxic cyanobacteria or 0.5 to < 10 mm ³ /L total biovolume of all cyanobacterial material	<u>Alert</u> : increase inspection and sampling to weekly, including multiple sites; notify the public health unit
		Microcystins or Biovolume or Scums	≥ 12 µg/L total microcystins or biovolume ≥ 1.8 mm ³ /L of potentially toxic cyanobacteria or ≥ 10 mm ³ /L total biovolume of all cyanobacterial material	<u>Action</u> : Continue monitoring as for alert; if potentially toxic taxa are present, consider testing samples for cyanotoxins Notify the public of a potential risk to health.

	expertise to collect the correct samples. This has proved particularly useful for benthic cyanobacteria.		or consistent presence of scums	
		Benthic mats	Similarly, three Alert levels for benthic cyanobacteria defined by coverage of surfaces (<20%, 20-50% and > 50%) and by river flow (as this can detach benthic cyanobacteria); responses similar to those for planktonic cyanobacteria	
Poland	National implementation of EU BWD	Sampling of bathing sites not less than 4 times per season (the interval between sampling does not exceed one month), including responses to cyanobacteria if blooms are observed		
Scotland		Cells or Chlorophyll-a	<p>< 20 000 cells/mL or < 10 µg/L chlorophyll-a</p> <p>.....</p> <p>< 100 000 cells/mL or < 50 µg/L chlorophyll-a</p> <p>.....</p> <p>Cyanobacterial scum formation in bathing areas</p>	<p>Post on site advisory signs and inform relevant authorities</p> <p>In addition to the above: watch for scums or conditions conducive to scums. Discourage bathing and further investigate hazard.</p> <p>Immediate action to control contact with scums: possible prohibition of swimming and other water contact activities. Public health follow up investigation.</p>
Signapore	Guidelines adopted from WHO Guidelines; applied to water bodies used for primary contact activities (e.g. swimming, skiing, wakeboarding) with frequent immersion of body, face or trunk, water ingestion likely	Chlorophyll-a	≤ 50 µg/L for 95% of a 3-year rolling period	Status of the sites reviewed annually. If the assessment is that the water body is unsuitable for primary water contact activities; the public is notified.
Spain	National implementation of EU BWD Classification of sites by probability of cyanobacterial proliferation (basis: 2 years of intensive monitoring)	Probability for cyanobacterial proliferation	<p>Low probability</p> <p>.....</p> <p>Medium probability</p> <p>.....</p> <p>High probability</p>	Criteria for assessment of health risk and response are set locally; some health authorities use WHO scheme, others include further risk parameters (such as number of users, type of use); temporary closure has occasionally occurred based on the abundance of cyanobacteria
Turkey	Under discussion for	Cells or	< 20 000 cells/mL	<u>Level 1</u> : recreational activities are allowed to continue and users are informed by posters on site. Monitoring (sampling, counting

	implementation in 2014 at the point of publication of this document	Microcystin-LR or Chlorophyll-a (if largely from cyanobacteria)	or <10 µg/L Microcystin-LR equivalents or <10 µg/L chlorophyll-a	and species identification) should be done fortnightly.
		Cells or Microcystin-LR	20 000 – 100 000 cells/mL or >25 µg/L Microcystin-LR equivalents	<u>Level 2</u> : At >20 000 cells/mL, microcystins are analysed. If MC-LR equivalents >25 µg/L, immediate action to inform relevant authorities and public. Discourage users from swimming and other water-contact activities by advisory signs on site.
		Scums in bathing area	Visual inspection	<u>Level 3</u> : all activities in the water may be

Table 3: Examples of guidance values or standards and other national regulations or recommendations for managing cyanotoxins in Freshwater sea-food

Country	Management framework	Toxin	Values	Comments
Australia (Victoria)		Cylindrospermopsin	18–39 µg/kg whole organism	Alert levels for toxins in Seafood
		Microcystin-LR eq.	24-51 µg/kg whole organism	
		Saxitoxins	800 µg/kg whole organism	
Denmark	EU regulations on food hygiene and control of products from animal origin	No specific regulations for cyanotoxins. Harvesting and distribution of mussels only allowed when no algal toxins (of all types) are detected in water		
France		Microcystins	5.6 µg/kg fish tissue (adults) 1.4 µg/kg fish tissue (children)	
USA (California)		Microcystins	10 ng/g wet weight	
		Cylindrospermopsin	66 ng/g wet weight	
		Anatoxin	1100 ng/g wet weight	