Volume 3 Datasheets – Micro-organisms

Part 1.5: Other

2019

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**Note**

Microsporidia are spore-forming pathogens often referred to as obligate intracellular protozoa belonging to the phylum Microspora, but there is increasing argument to have them reclassified with the fungi. However, the datasheet for microsporidia appears with the protozoa.

# Helminths (pathogenic)

### General description

The word “helminth” comes from the Greek word meaning “worm” and refers to all types of worms, both free-living and parasitic. The major parasitic worms are classified primarily in the phylum Nematoda (roundworms) and the phylum Platyhelminthes (flatworms, including trematodes).

### Human health effects

Helminth parasites infect a large number of people and animals worldwide. For most helminths, drinking-water is not a significant route of transmission. There are two exceptions: *Dracunculus medinensis* (guinea worm) and *Fasciola* spp. (*F. hepatica* and *F. gigantica*) (liver flukes).

Dracunculiasis and fascioliasis both require intermediate hosts to complete their life-cycles but are transmitted through drinking-water by different mechanisms.

Other helminthiases can be transmitted through water contact, eg, schistosomiasis (also known as bilharzia, bilharziosis or snail fever) caused by *Schistosoma* spp, or are associated with the use of untreated wastewater in agriculture (ascariasis, trichuriasis, hookworm infections and strongyloidiasis) but are not usually transmitted through drinking-water. The genus *Schistosoma* is a member of the class Trematoda, commonly known as trematodes or blood flukes. Schistosomes occur in tropical and subtropical freshwater sources. *Schistosoma mansoni* is found in Africa, the Arabian Peninsula, Brazil, Suriname, the Bolivarian Republic of Venezuela and some Caribbean islands; *S. haematobium* is found in Africa and the Middle East; *S. japonicum* is found in China, the Philippines and the Sulawesi Island of Indonesia; *S. intercalatum* is found in some countries of Central Africa; and *S. mekongi* is limited to the Mekong River in Cambodia and the Lao People’s Democratic Republic. Water resource development projects, including dam construction, have been identified as potential sources of elevated rates of schistosomiasis as a result of the production of increased habitats for freshwater snails. Humans are the principal reservoirs of *S. haematobium*, *S. intercalatum* and *S. mansoni*, although the latter has been reported in rodents. Various animals, such as humans, dogs, cats, rodents, pigs, cattle and water buffalo, are potential reservoirs of *S. japonicum*, whereas humans and dogs are potential reservoirs of *S. mekongi*. There is no need to include a datasheet for *Schistosoma* in these Guidelines. Interested readers can refer to WHO (2004/2011) for more details. A further update appears in WHO (2012, particularly in Chapter 2).

IARC (2011) concluded that infection with *Schistosoma haematobium* is carcinogenic to humans (Group 1).

Infection with guinea worm is geographically limited to a central belt of countries in sub-Saharan Africa. Drinking water containing infected *Cyclops* (a copepod) is the only source of infection with *Dracunculus*. Therefore there is no need to include a datasheet for *Dracunculus medinensis* in these Guidelines. Interested readers can refer to WHO (2004/2011/2016) for more details. Dracunculiasis is a crippling parasitic disease on verge of eradication, with only 22 cases reported in 2015. Of 20 countries that were endemic in the mid-1980s, only four countries reported cases in 2015 (Chad (9), Mali (5), South Sudan (5) and Ethiopia (3)).

Fascioliasis is caused by two trematode species of the genus *Fasciola*: *F. hepatica*, present in Europe, Africa, Asia, the Americas and Oceania, and *F. gigantica*, mainly distributed in Africa and Asia. Human fascioliasis was considered a secondary zoonotic disease until the mid-1990s. In most regions, fascioliasis is a foodborne disease. However, the discovery of floating metacercariae in hyperendemic regions (including the Andean Altiplano region in South America) indicates that drinking-water may be a significant transmission route for fascioliasis in certain locations. Major health problems associated with fascioliasis occur in Andean countries (Bolivia, Peru, Chile, Ecuador), the Caribbean (Cuba), northern Africa (Egypt), Near East (Iran and neighbouring countries) and western Europe (Portugal, France and Spain). Therefore there is no need to include a datasheet for *Fasciola* in these Guidelines. Interested readers can refer to WHO (2004/2011) for more details.

Although once common, hydatid disease, caused by the larvae of the tapeworm *Echinococcus granulosus*, which lives in the gut of dogs, is now rare in New Zealand. Its lifecycle also involves an intermediate host, which in the case of New Zealand is mainly sheep and, to a lesser extent, cattle. Pigs and deer are rarely involved. Humans are also a host. Human infection most often occurs in children, and is caused by the hand to mouth transfer of eggs after handling infected dogs. The disease can also be acquired by a person swallowing food, water or soil contaminated with eggs or by mouth contact with contaminated items like eating utensils or toys. Flies can spread eggs from faeces on to other surfaces or objects. Hydatid cysts, which usually appear in the liver or lungs but can occur in other viscera, are a result of this infestation. The effect on people can vary from no symptoms to severe illness and death, depending on the number of cysts formed and their site and size. However, since 2001 in New Zealand no cysts have been found in any animals at slaughter, which each year comprises about 26 million lambs, almost 6 million adult sheep, 3.5 million cattle and about 0.5 million deer. Most cases today represent new diagnoses of past infection and not recently acquired infection.

There are many different types of tapeworms (parasitic flatworms) with different life cycles affecting most mammals but some types in particular affect human beings, including *Taenia saginata* which is sometimes called beef tapeworm. Taeniasis, the infection of a human with a tapeworm, is rare in New Zealand but a few cases of infection have been reported. Cooking or freezing beef kills the larval stage of the tapeworm which can cause human infection. Pastures can be infested with eggs by tapeworm-carrying humans defaecating on pastures, or from untreated sewage. This tapeworm is not endemic in New Zealand as it is in some other meat-exporting countries. However cattle could become infected with this tapeworm when eating pasture or drinking water that is contaminated with *Taenia saginata* eggs from an infested human’s faeces. In New Zealand, human sewage is not permitted to contaminate any pasture for any animal.

### Water treatment

Not a lot is known about the effect of chemical or UV disinfection processes for inactivating nematodes. Because nematodes are generally larger than 0.1 mm (100 µm), any water treatment process that removes particles such that the DWSNZ protozoal compliance criteria are satisfied is also likely to remove nematodes, and any organisms harbouring the nematodes.

The egg stage of most worms is usually about 40 to 80 µm diameter (ie, the individual egg, egg sacs are usually visible to the human eye) so should be removed from water by most filtration processes.

It is not uncommon in the summer in rural areas for mass migrations of flying insects to be attracted to the lights of houses resulting in huge numbers landing on the roof. Many of these animals will have been associated with animal wastes so may be carrying protozoa and helminth eggs, etc. It is advisable to shut the intake and clean the roof and gutters before the next rain event.

### Maximum Acceptable Value

There is no MAV for pathogenic helminths in the current DWSNZ. In the 2000 (and earlier) DWSNZ, there was a MAV of less than 1 per 100 litre sample of drinking-water.

### Bibliography

*Factsheet on Hydatids*. Accessed July 2010. <http://www.lifestyleblock.co.nz/working-dogs/article/344-fact-sheet-on-hydatids.html>.

IARC. 2011. *IARC monographs on the evaluation of carcinogenic risks to humans.* Volume 100B. *A Review of Human Carcinogens: Biological agents*. <http://monographs.iarc.fr/ENG/Monographs/vol100B/index.php>.

NZFSA. 2009. *Taenia saginata* – beef tapeworm in humans. See: <http://www.nzfsa.govt.nz/consumers/animal-disease-affecting-human/taenia-beef-tapeworm/index.htm>.

WHO. 2004. *Guidelines for Drinking-water Quality* (3rd edition). Geneva: World Health Organization. <http://www.who.int/water_sanitation_health/dwq/gdwq3rev/en/> see also the addenda.

WHO. 2011. *Guidelines for Drinking-water Quality* (4th edition). Geneva: World Health Organization. <http://www.who.int/water_sanitation_health/publications/drinking-water-quality-guidelines-4-including-1st-addendum/en/index.html>.

WHO. 2012. *Animal Waste, Water Quality and Human Health*. Geneva: World Health Organization. 489 pp. <http://www.who.int/water_sanitation_health/publications/2012/animal_waste/en/index.html>.

WHO. 2016. *Dracunculiasis (guinea-worm disease)*. WHO Media Centre. <http://www.who.int/mediacentre/factsheets/fs359/en/>.

WHO. 2017. *Guidelines for Drinking-water Quality: Fourth edition incorporating the first Addendum*. Geneva: World Health Organization. 631 pp. [http://www.who.int/water\_sanitation\_health/publications/drinking-water-quality-guidelines-4-including-1st-addendum/en/](file:///C:/Users/sgilbert/AppData/Local/Microsoft/Windows/INetCache/Content.Word/www.who.int/water_sanitation_health/publications/2011/dwq_guidelines/en/).

# Nematodes (free-living)

Mostly copied from the draft WHO factsheet.

### General description

Nematodes are the most numerous metazoan (many-celled) animals on earth. Many are parasites of insects, plants or animals including humans. Free-living species are abundant in the aquatic environment, both fresh and salt water, and soil habitats. Not only is the vast majority of species poorly understood biologically, but there may be thousands more unknown species yet to be discovered. Nematodes are structurally simple with a digestive tract running from the mouth on the anterior end, to the posterior opening near the tail, being characterised as a tube in a tube. Nematodes found in drinking-water systems range from 0.1 mm to over 0.6 mm in size.

Around 20 different orders have been distinguished within the phylum Nematoda. Four of these orders (Rhabditida, Tylenchida, Aphelenchida, and Dorylaimida) are particularly common in soil. Non-pathogenic free-living nematodes that have been found in drinking-water include *Cheilobus*, *Diplogaster*, *Tobrilus*, *Aphelenchus*, and *Rhabditis*.

### Human health effects

The presence of free-living nematodes in drinking-water does not necessarily indicate a direct health threat. It has been regarded largely by water suppliers as an aesthetic problem, either directly or through their association with discoloured water. High concentrations of nematodes in drinking-water have been reported to impart an unpleasant taste. The presence of free-living nematodes in drinking-water reduces its acceptability to the consumer. WHO (2011) states that free-living nematodes other than *Dracunculus medinensis* are more likely to transmit illness via food and soil than drinking-water.

It has been suggested that free-living nematodes could carry pathogenic bacteria in their gut. Such bacteria would be protected from chlorine disinfection and might therefore present a health hazard. Bacteria have been isolated from the microflora in the guts of nematodes taken from treated water supply and from the raw water from which it was derived (Lupi et al 1995).

In some cases, the motile larvae of pathogens such as hookworms (*Necator americanus*, and *Ancylostoma duodenale*) and threadworms (*Strongyloides stercoralis*) are capable of moving through sand filters or may be introduced into drinking-water during distribution as the result of faecal contamination.

### Source and occurrence

Because free-living nematodes are ubiquitous they, as an egg or free-living larval or adult form, can enter the drinking-water supply at the storage, treatment, distribution or household levels. The concentration of free-living nematodes in the raw water source generally corresponds to the turbidity of the water; the higher the turbidity the larger the concentration of free-living nematodes.

In warm or even temperate weather, slow sand filters may discharge nematodes (and Oligochaete, eg, *Aeolosoma* spp., insect larvae, eg, *Chironomus* spp. and mosquitoes (*Culex* spp.)) by drawdown into the filtered water. Aquatic animals that successfully penetrate drinking-water treatment processes are largely benthic species, living on the bottoms or margins of water bodies.

### Route of exposure

Potential health concerns arise from exposure to the nematodes through ingestion of drinking-water, during recreation, and potentially through consumption of fresh vegetables fertilised with sewage. Distinguishing pathogenic larvae of the hookworm and threadworm from free-living non-pathogenic nematodes in water is difficult (and requires special knowledge of nematology).

### Significance in drinking-water

Large numbers of nematodes are not normally found in well-maintained, piped drinking-water systems. Eggs or infective larvae from species parasitic to man (*Ascaris*, *Trichuris, Ancylostoma*, *Necator,* and *Strongyloides*) and the many non-pathogenic nematodes are not usually present in protected groundwater sources or are generally removed during treatment processes.

In some circumstances, when the water contains a high nutrient or organic content and the ambient temperatures are appropriate, it may be possible for free-living nematodes to feed on microbial growth in the biofilms or slimes in treatment processes or in water mains and thus multiply within the system. This is true particularly if drinking-water sources have not been adequately protected, treatment systems are not adequate or not operated and maintained properly, the distribution system is open or leaking, or there are many stagnant or dead zones in the distribution system. It may be feasible to assume that if large numbers of nematodes (live and dead) are detected in drinking-water, then there is a problem that needs to be resolved, without necessarily implying a direct health risk.

### Water treatment

Not a lot is known about the effect of chemical or UV disinfection processes for inactivating nematodes. Because nematodes are generally larger than 0.1 mm (100 µm), any water treatment process that removes particles such that the DWSNZ protozoal compliance criteria are satisfied is also likely to remove nematodes, or the organisms harbouring the nematodes.

It is not uncommon in the summer in rural areas for mass migrations of flying insects to be attracted to the lights of houses resulting in huge numbers landing on the roof. Many of these animals will have been associated with animal wastes so may be carrying protozoa and helminth eggs, nematodes, etc. It is advisable to shut the intake and clean the roof and gutters before the next rain event.

### Maximum Acceptable Value

There is no MAV for free-living nematodes in the DWSNZ.

WHO has not established guideline values for nematodes in drinking-water. If good water source protection, treatment, and distribution practices are followed, as outlined in the WHO *Guidelines for Drinking Water Quality*, then these organisms should be absent or present in very low numbers in the drinking-water.

### Bibliography

Endo T, Morishima Y. 2004. Major helminth zoonoses in water. In Cotruvo JA, Dufour A, Rees G, et al (eds) *Waterborne Zoonoses*, IWA Publishing, pp 291–304.

Evins C, Greaves GF. 1979. *Penetration of Water Treatment Works by Animals*. Technical Report TR 115. Medmenham, UK: Water Research Centre.

Lupi E, Ricci V, Burrini D. 1995. Recovery of bacteria in nematodes from a drinking water supply. *Journal of Water Supply: Research and Technology – Aqua* 44: 212–18.

WHO. 2004. *Guidelines for Drinking-water Quality* (3rd edition). Geneva: World Health Organization. <http://www.who.int/water_sanitation_health/dwq/gdwq3rev/en/> see also the addenda.

WHO. 2006. *Nematodes in Drinking-water: Factsheet (draft) for the Rolling Revision of the WHO Guidelines for Drinking-Water Quality*. 3 pp. See: <http://www.who.int/water_sanitation_health/gdwqrevision/nematodes/en/index.html>.

WHO. 2011. *Guidelines for Drinking-water Quality* (4th edition). Geneva: World Health Organization. <http://www.who.int/water_sanitation_health/publications/drinking-water-quality-guidelines-4-including-1st-addendum/en/index.html>.

WHO. 2017. *Guidelines for Drinking-water Quality: Fourth edition incorporating the first Addendum*. Geneva: World Health Organization. 631 pp. [http://www.who.int/water\_sanitation\_health/publications/drinking-water-quality-guidelines-4-including-1st-addendum/en/](file:///C:/Users/sgilbert/AppData/Local/Microsoft/Windows/INetCache/Content.Word/www.who.int/water_sanitation_health/publications/2011/dwq_guidelines/en/).

# Fungi (moulds)

### General description

Fungi are a diverse group of organisms belonging to the kingdom Eumycota. This kingdom comprises five phyla, namely Ascomycota, Basidiomycota, Zygomycota, Chytridiomycota and Glomeromycota. As a practical approach to classification, fungi have been divided into groups, such as the filamentous fungi, also called moulds, the yeasts (qv), and the mushrooms. Some fungi are primarily adapted to aquatic environments, and will, therefore, naturally be found in water. These fungi are zoosporic, and many belong in phyla Chytridiomycota.

Fungi are categorised as moulds if they have branching, threadlike filaments, and yeasts if they are single-celled organisms that reproduce by budding.

The WHO Guidelines (section 10.1.1) state that actinomycetes and fungi can be abundant in surface water sources, including reservoirs. They also appear frequently in the biofilms growing on unsuitable materials in the water supply distribution systems, such as rubber. They can give rise to geosmin, 2-methyl isoborneol, and other substances resulting in objectionable tastes and odours in the drinking-water. Many of the early studies related to taste and odour issues.

Methods for isolating fungi from water are not standardised and this makes comparisons between different studies difficult, and may explain much of the variation in the results reported.

### Source and occurrence

Fungi, above all, the filamentous fungi, can occur almost everywhere, even in water. They can grow in such a quantity in water that they can affect the health of the population or have negative effects on food production.

Naturally-occurring fungi can enter drinking-water distribution systems through several contamination pathways, including treatment breakthrough, deficiencies in stored water facilities, cross-connections, mains breaks and intrusions, and during mains installation and maintenance. Once introduced, fungal species can become established on the inner surfaces of pipes, including interaction and reaction with sealings and coatings, and biofilms within distribution systems, or can be suspended in the water. The results of sample analysis from customer taps and other points within distribution systems often reveal higher numbers of fungi than the analysis of samples following treatment, prior to entry into the distribution system. Such increases through the distribution system could be due to two reasons:

i. the fungi that remain present after treatment multiply within the system or that fungi that were only partially inactivated later recover

ii. fungi enter the system via pathways of secondary contamination. Accumulation of fungi in stored water at the consumer end, such as in water tanks, has also been observed. For example, higher numbers of colony forming units of *Aspergillus* have been found in hospital water storage tanks than in the municipal water supply (DEFRA 2011).

Fungi grow over a wide range of temperatures. At one extreme are the pyschrophilic fungi such as *Cryptococcus* which can grow down to 0°C, and *Mucor sp* which cannot grow above 20°C, whereas *Aspergillus fumigatus* tolerates 50°C and *Thermomyces lanuginosus* 60°C.

Thirty-eight water samples from drinking water and groundwater in Austria were analysed (Kanzler et al 2008). Fungi were isolated by using membrane filtration and plating methods with subsequent cultivation on agar plates. The different taxa of fungi were identified using routine techniques as well as molecular methods. Fungi were isolated in all water samples examined. The mean value for drinking water was 9.1 CFU per 100 mL and for groundwater 5400 CFU per 100 mL. Altogether 32 different taxa of fungi were found. The taxa which occurred most frequently were *Cladosporium spp*., *Basidiomycetes* and *Penicillium spp.* (74.6 percent, 56.4 percent and 48.7 percent, respectively). Other studies have found more fungi in drinking-water with surface origin than groundwater origin.

The mycoflora of chlorinated drinking water in France has been examined (Hinzelin and Block 1985). Of 38 samples, 50 percent and 81 percent were yeast and filamentous fungi contaminated respectively. The concentrations ranged between 1 and 28 yeasts per litre and between 2 and 65 filamentous fungi per litre. The genus *Candida* was the most representative for the yeast population, while the three genera *Penicillium*, *Aspergillus* and *Rhizopus* represented around the half of isolated fungi strains. From a limited number of samples no correlations were found between total bacteria, yeasts, filamentous fungi and chlorine.

Relatively few studies have investigated the fungi found in treated drinking-water. The numbers of fungi found in the existing studies range from 1 CFU per litre to 5,000 CFU per litre. Of the sixty-five genera that have been isolated in the studies analysed during this review (DEFRA 2011), the majority were filamentous fungi. The most commonly isolated genera were *Penicillium*, *Cladosporium*, *Aspergillus*, *Phialophora* and *Acremonium*.

Some fungi are being developed as biopesticides. For example, *Ulocladium oudemansii* (U3 strain) is a naturally occurring soil fungus existing as a saprophyte of dead and decaying plant matter. Used as a biofungicide, it is intended to protect fruit and vegetable crops, and ornamental plants from plant pathogenic diseases by competing for the same ecological niches (senescent plant material) and nutrients. The USEPA (2009) has determined that *Ulocladium oudemansii* (U3 strain) presents no issues of toxicological, ecological, or environmental concern, so has granted a time-limited registration for *Ulocladium oudemansii* (U3 strain) under Section 3(c)(5) of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). *Ulocladium oudemansii* is also approved for use in NZ, appearing on the NZFSA’s complete database of Agricultural Compounds and Veterinary Medicines (ACVM) as at 2012 (see [https://eatsafe.nzfsa.govt.nz/web/public/acvm-register and select entire register](http://www.nzfsa.govt.nz/acvm/registers-lists/acvm-register/index.htm)). Potential exposure via surface water would be negligible and exposure via drinking water would be impossible to measure. *Ulocladium oudemansii* (U3 Strain) is intended for use on agricultural and horticultural crops, and has limited survival potential once its carrier nutrient source is exhausted. The risk of the micro-organism passing through soil to groundwater is minimal to unlikely. Dietary exposure via drinking-water is not expected to pose harm to populations because the biofungicide is not known to grow or thrive in aquatic environments and is not expected to survive municipal treatment of drinking water. The product was developed by Botry-Zen Ltd of Dunedin, New Zealand, for control of botrytis.

### Human health effects

Filamentous fungi (moulds) are the most commonly found types in water, but yeasts also occur. A wide diversity of mould species has been isolated from drinking-water including potentially pathogenic, allergic and toxigenic species including *Aspergillus fumigatus*. This species is a significant pathogen in severely immuno-compromised patients in hospitals, and hospital water systems have been proposed as a possible source of *A. fumigatus* and other fungal pathogens. Fungi may be aerosolised from taps and showers and therefore introduced to severely immuno-compromised patients (Hageskal et al 2009).

Some members of the genus *Aspergillus* produce mycotoxins, such as aflatoxin, a potent carcinogen produced by toxigenic strains of *A. flavus*. Other members of the genus *Aspergillus* have been domesticated for commercial use, such as *Aspergillus niger* for production of enzymes (eg, alpha-galactosidase). *Aspergillus flavus* AF36 is characterised as an atoxigenic strain by its lack of production of aflatoxin and it is approved for use in the US as a biopesticide/biocontrol (see PMEP).

Likewise, the naturally occurring soil fungus *Myrothecium verrucaria* (strain AARC-0255) is approved for use as a nematicide (after heat treatment) in New York State (see PMEP). Because the product is applied into the soil, the risk from run-off is considered slight, nor should it impact groundwater.

Two case reports from Finland indicated fungal-contaminated water as the source of hypersensitivity pneumonitis. Metzger and colleagues (1976 – see in Hageskal) indicated that elevated levels of the fungus *Aureobasidium pullulans* in water from a home sauna were causing hypersensitivity pneumonitis, and the symptoms were referred to as ‘sauna-takers disease’.

Although fungi have been found in drinking-water distribution systems and biofilms, fungi have not been conclusively implicated in waterborne disease. Those pathogenic fungi that have been detected in the distribution system are opportunistic and infrequently cause illness, whatever the route of infection. However, *A. flavus* and several other *Aspergillus* species detected in distribution systems produce potent toxins (mycotoxin), including aflatoxins (USEPA 2002).

Secondary metabolites produced by fungi, particularly those growing in localised pockets near the consumer end may be responsible for altering the taste and odour of drinking-water. It is thought that the threshold level for numbers of fungi that can cause such issues may be around 102–103 CFU per litre. While problems with taste and odour do not necessarily imply a health risk they are often perceived as such by the consumer (DEFRA 2011).

### Water treatment

Section 8.4.4 of the WHO Guidelines states that UV disinfection can be used to inactivate fungi and yeasts. Because fungi are generally larger than *Cryptosporidium* oocysts, any water treatment process that removes particles such that the DWSNZ protozoal compliance criteria are satisfied is also likely to remove fungi, or any organisms harbouring them. DEFRA (2011) reports that pigmented fungi are better protected against radiation so less susceptible to UV treatment; chlorine, chlorine dioxide and ozone treatment appear to be quite effective. Spores are more resistant than hyphal cells, with some being extremely chlorine-resistant.

### Analysis

A number of different methods of analysing drinking-water samples are used, including culture, measurement of ergosterol, quantitative PCR, gene markers and probes, protein probes, direct observation and mass spectrometry. There is currently no international standard specifically for the measurement of fungi in drinking-water, and there is no widespread adoption of other relevant standards. Therefore, differences in analytical methods limit the extent to which results can be compared between studies. Furthermore, the most commonly used unit of quantification is numbers of Colony Forming Units (CFUs). However, this measure does not necessarily give an accurate representation of the number of fungi present in a sample, because not all species can be detected using culturing methods. It is also likely that one colony is formed of many different fungal structures, such as hyphae, conidia, conidiophores, from different “individuals” clumped together into one CFU (DEFRA 2011).

### Maximum Acceptable Value

There is no MAV for any fungi in the DWSNZ.

DEFRA (2011) reports that Sweden limits fungal numbers in drinking-water under their National Food Administration Regulation regarding drinking-water. The Regulation limits microfungi to 100 CFU per 100 mL. This limitation applies at the point of water use, and therefore takes into account fungi which enter the system through pathways of secondary contamination. In the UK fungi are not required to be monitored or controlled.

### Bibliography

DEFRA. 2011. *A Review of Fungi in Drinking Water and the Implications for Human Health*. Reference: WD 0906. UK: Department for Environment, Food and Rural Affairs. 107 pp. <http://dwi.defra.gov.uk/research/completed-research/reports/DWI70-2-255.pdf>.

Hageskal G, Lima N, Skaar I. 2009. The study of fungi in drinking water. *Mycological Research* 113(2): 165–172. Summarised in *Health Stream* 54: June 2009, WQRA Australia, see: <http://www.waterquality.crc.org.au/hsarch/HS54i.htm>.

Hinzelin F, Block JC. 1985. Yeasts and filamentous fungi in drinking water. [*Environmental Technology*](http://www.informaworld.com/smpp/643502940-53802793/title~db=all~content=t791546829) [6](http://www.informaworld.com/smpp/643502940-53802793/title~db=all~content=t791546829~tab=issueslist~branches=6#v6)([1):](http://www.informaworld.com/smpp/643502940-53802793/title~db=all~content=g906906317) 101–6.

[Kanzler D](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Kanzler%20D%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Buzina](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Buzina%20W%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus) W, [Paulitsch](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Paulitsch%20A%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus) A, et al. 2008. Occurrence and hygienic relevance of fungi in drinking water. [*Mycoses*](javascript:AL_get(this,%20'jour',%20'Mycoses.');) 51(2): 165–9.

PMEP. Accessed 2011. *Pesticide Active Ingredient Information, Biopesticides and Biocontrols*. <http://pmep.cce.cornell.edu/profiles/index.html>.

USEPA. 2009. *Biopesticide Registration Action Document Ulocladium oudemansii (U3 strain)*. PC Code: 102111. 33 pp. <http://www.epa.gov/oppbppd1/biopesticides/ingredients/tech_docs/brad_102111.pdf>.

USEPA. 2002. *Health Risks from Microbial Growth and Biofilms in Drinking Water Distribution Systems*. Office of Ground Water and Drinking Water. Distribution System White Paper. 52 pp. <http://water.epa.gov/lawsregs/rulesregs/sdwa/tcr/regulation_revisions.cfm>.

WHO. 2004. *Guidelines for Drinking-water Quality* (3rd edition). Geneva: World Health Organization. <http://www.who.int/water_sanitation_health/dwq/gdwq3rev/en/> see also the addenda.

WHO. 2011. *Guidelines for Drinking-water Quality* (4th edition). Geneva: World Health Organization. <http://www.who.int/water_sanitation_health/publications/drinking-water-quality-guidelines-4-including-1st-addendum/en/index.html>.

WHO. 2017. *Guidelines for Drinking-water Quality: Fourth edition incorporating the first Addendum*. Geneva: World Health Organization. 631 pp. [http://www.who.int/water\_sanitation\_health/publications/drinking-water-quality-guidelines-4-including-1st-addendum/en/](file:///C:/Users/sgilbert/AppData/Local/Microsoft/Windows/INetCache/Content.Word/www.who.int/water_sanitation_health/publications/2011/dwq_guidelines/en/).

# Yeasts

### General description

Fungi (qv) are categorised as moulds if they have branching, threadlike filaments, and yeasts if they are single-celled organisms that reproduce by budding (USEPA 2002). There is some discussion on yeasts in the fungi datasheet.

Yeasts have been reported in drinking-water supplies, but information on their frequency, density and regrowth is limited.

### Source and occurrence

Yeasts are known to occur in many warm-blooded animals. Densities in human faeces may range up to 100,000 per gram and in raw sewage may range from a few thousand to 25,000 colonies per litre. Yeast colonies have been found up to 125 per litre in river water.

The mycoflora of chlorinated drinking water in France has been examined (Hinzelin and Block 1985). Of 38 samples, 50 percent and 81 percent were yeast and filamentous fungi contaminated respectively. The concentrations ranged between 1 and 28 yeasts per litre and between 2 and 65 filamentous fungi per litre. The genus *Candida* was the most representative for the yeast population.

The most frequently isolated yeasts in a seasonal study of four lakes were *Candida sp*, *Rhodotorula glutinis*, *Rhodotorula rubra* and *Torulopsis sp*.

### Human health effects

The yeast *Candida albicans* is an opportunistic pathogen, dangerous to individuals stressed from diabetes, cancer and immunological defects.

### Water treatment

Chemical coagulation/filtration can remove up to 99 percent of yeasts from the raw water. Disinfection is less effective. Yeasts have been found to resist chlorination up to 1.2 mg/L in the distribution system, primarily due to the rigidity and thickness of the cell wall, whereas ozone is as effective on yeasts as it is on bacteria.

Section 8.4.4 of the WHO Guidelines states that UV disinfection can be used to inactivate fungi and yeasts.

### Maximum Acceptable Value

There is no MAV for yeasts in the DWSNZ.

### Bibliography

Geldreich EE. 1996. *Microbial Quality of Water Supply in Distribution Systems*. Lewis Publishers.

Hinzelin F, Block JC. 1985. Yeasts and filamentous fungi in drinking water. [*Environmental Technology*](http://www.informaworld.com/smpp/643502940-53802793/title~db=all~content=t791546829) [6](http://www.informaworld.com/smpp/643502940-53802793/title~db=all~content=t791546829~tab=issueslist~branches=6#v6)([1):](http://www.informaworld.com/smpp/643502940-53802793/title~db=all~content=g906906317) 101–6.

USEPA. 2002. *Health Risks from Microbial Growth and Biofilms in Drinking Water Distribution Systems*. Office of Ground Water and Drinking Water. Distribution System White Paper. 52 pp. <http://water.epa.gov/lawsregs/rulesregs/sdwa/tcr/regulation_revisions.cfm>.

WHO. 2004. *Guidelines for Drinking-water Quality* (3rd edition). Geneva: World Health Organization. <http://www.who.int/water_sanitation_health/dwq/gdwq3rev/en/> see also the addenda.

WHO. 2011. *Guidelines for Drinking-water Quality* (4th edition). Geneva: World Health Organization. <http://www.who.int/water_sanitation_health/publications/drinking-water-quality-guidelines-4-including-1st-addendum/en/index.html>.

WHO. 2017. *Guidelines for Drinking-water Quality: Fourth edition incorporating the first Addendum*. Geneva: World Health Organization. 631 pp. [http://www.who.int/water\_sanitation\_health/publications/drinking-water-quality-guidelines-4-including-1st-addendum/en/](file:///C:/Users/sgilbert/AppData/Local/Microsoft/Windows/INetCache/Content.Word/www.who.int/water_sanitation_health/publications/2011/dwq_guidelines/en/).

# Plankton

### General description

Strictly speaking, plankton are drifting organisms living in the sea or freshwater and include plants, bacteria and invertebrate animals. Although many are microscopic, some are large, eg, seaweeds and jellyfish. Sometimes plankton have been classified by size, with a common grouping called the nannoplankton, which tend to fall into the  
2–20 µm diameter range. Macrophytes include the complex vascular plants, usually with roots, stems and leaves.

Organisms that can swim are collectively known as nekton. Nekton and plankton together are described as pelagic organisms, as opposed to the benthic organisms which are attached to a substrate. Periphyton are the microscopic plants and animals that are associated with the surfaces of submersed objects.

Zooplankton include small protozoans, metazoans, rotifers, cladocerans and copepods; by far the commonest are the crustaceans, sometimes called the “insects” of water.

Phytoplankton are algae that live in water where there is sufficient light for them to photosynthesise, thereby producing oxygen. Phytoplankton are reported to produce between 50 to 90 percent of the Earth’s oxygen! Note that the blue-green algae or cyanobacteria are covered in their own set of datasheets – 1.3.

The algal phyla which most concern the freshwater biologist today are:

* Bacillariophyta. Better known as [diatoms.](http://www.micrographia.com/specbiol/alg/diato/diat0100.htm) Unicellular and colonial. Have a silica shell (frustule) in two parts and no flagellae. Enormously abundant in the oceans and freshwater. They comprise a sizeable fraction of all life on Earth.
* Charophyta. Stoneworts: occur in ponds attached to the bottom by rhizoids. Includes *Chara*, *Nitella*.
* Chlorophyta. A large and varied group of green pigmented algae which store energy in pyrenoids and as starch. Forms include unicellular, filamentous and colonial varieties. Includes *Chlorella*, [*Spirogyra*,](http://www.micrographia.com/specbiol/alg/filamen/fila0100.htm#spiroglink) [*Scenedesmus*,](http://www.micrographia.com/specbiol/alg/colo/colo0100.htm#synuralink) [*Oedogonium*,](http://www.micrographia.com/specbiol/alg/filamen/fila0200.htm) [*Volvox*.](http://www.micrographia.com/specbiol/alg/colo/colo0100.htm#volvoxlink)
* Chrysophyta. Golden-brown algae. Includes [*Synura*,](http://www.micrographia.com/specbiol/alg/colo/colo0100.htm#synuralink) *Uroglena*.
* Cryptophyta. Unicellular, with two slightly unequal flagellae at the apical end. Includes [*Chilomonas*,](http://www.micrographia.com/specbiol/protis/flagell/flag0100.htm#chilolink) *Cryptomonas*.
* Dinophyta (= Pyrrophyta). Dinoflagellates. Unicellular, biflagellate with flagellae in two different planes. External cell wall often features sculptured plates. Frequently the main organism in toxic algal blooms.
* Euglenophyta. Unicellular with single obvious flagellum. Usually have a red eyespot, green plastids and paramylon granules, called pyrenoids. Includes [*Euglena*,](http://www.micrographia.com/specbiol/alg/motil/moti0100.htm#euglenalink) *Phacus*, [*Trachelomonas*.](http://www.micrographia.com/specbiol/alg/motil/moti0100.htm#trachlink)
* Haptophyta, also called Haptomonada. A smaller group of unicells bearing calcareous plates (scales and coccoliths) and a haptonema, visible only with an electron microscope in most cases. Primarily marine; few freshwater genera.
* Xanthophyta. Yellow-green algae; colour due to chlorophyll and carotenoid pigments. May be unicellular, filamentous, colonial or siphonaceous in form. Includes *Tribonema*, *Botrydium*.
* Phaeophyta. Overwhelmingly marine and macroscopic. Includes kelps.
* Rhodophyta. Mainly marine.

The more important freshwater zooplankton include the protozoans, rotifers, cladocerans and copepods.

For many years, water supply biologists have been using Part 10000 of APHA (2005) for general information, identifications and laboratory techniques. However, the taxonomy of the algae is forever “developing”, see Cassie Cooper (2001).

### Human health effects

Zooplankton have been reported to harbour disease-causing bacteria or viruses, such as *Vibrio cholerae* – see *Vibrio* datasheet. Copepods have been reported to transmit helminth eggs. Nematodes can ingest human enteric pathogens and these bacteria and viruses may survive disinfection while inside the nematode.

The main concern arising from freshwater algae in New Zealand relates to taste and odour. Although the exuded chemicals generally do not give rise to health effects, aesthetically unpleasing drinking-water has been known to lead consumers to a less safe source of water for drinking. Chapter 18 of these Guidelines discusses the problems and treatment solutions to taste and odour problems caused by micro-organisms. Many of the chemicals produced by micro-organisms that have been identified as causing tastes and odours have a datasheet, most being organic chemicals so appear in Datasheets 2.2.

### Water treatment

Chapter 9 of these Guidelines discusses issues related to the growth and control of cyanobacteria (blue-green algae) in source waters. Much of this is relevant to phytoplankton as well.

Chapter 8 of WHO (2003) discusses (in 23 pages) algae and cyanobacteria in fresh waters. Most of the discussion is directed towards cyanobacteria. Chapter 5 discusses free-living micro-organisms, some of which covers amoebae.

WHO (2004) states that UV radiation, emitted by a low-pressure mercury arc lamp, is biocidal between wavelengths of 180 and 320 nm. It can be used to inactivate protozoa, bacteria, bacteriophage, yeast, viruses, fungi and algae.

Normally water suppliers would prefer to remove algae by coagulation/filtration processes – see Chapters 4, 12, 13 and 14.

### Maximum Acceptable Value

There is no MAV for any of the plankton in the DWSNZ.

### Bibliography

APHA. 2005. *Standard Methods for the Examination of Water and Wastewater* (21st edition). Washington: American Public Health Association, American Water Works Association, Water Environment Federation.

Cassie Cooper V. 2001. Recent name changes in eukaryotic freshwater algae of New Zealand. *New Zealand Journal of Botany* 39: 601–16.

WHO. 2003. *Guidelines for Safe Recreational Water Environments*. Volume 1: Coastal and Fresh Waters. <http://www.who.int/water_sanitation_health/bathing/srwe1/en/>.

WHO. 2004. *Guidelines for Drinking-water Quality* (3rd edition). Geneva: World Health Organization. <http://www.who.int/water_sanitation_health/dwq/gdwq3rev/en/> see also the addenda.

WHO. 2011. *Guidelines for Drinking-water Quality* (4th edition). Geneva: World Health Organization. <http://www.who.int/water_sanitation_health/publications/drinking-water-quality-guidelines-4-including-1st-addendum/en/index.html>.

WHO. 2017. *Guidelines for Drinking-water Quality: Fourth edition incorporating the first Addendum*. Geneva: World Health Organization. 631 pp. [http://www.who.int/water\_sanitation\_health/publications/drinking-water-quality-guidelines-4-including-1st-addendum/en/](file:///C:/Users/sgilbert/AppData/Local/Microsoft/Windows/INetCache/Content.Word/www.who.int/water_sanitation_health/publications/2011/dwq_guidelines/en/).