WHITE PAPER

Introduction

The intended purpose of this document is to inform BiOWiSH[®] end users which types of algae can affect biological surface water treatment, and how to manage them.

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Floating Macroscopic Plants

Duckweeds

Duckweeds are free-floating plants which, if left unattended, can become a nuisance to surface water ecosystems. Common genera are *Lemna*¹ and *Spirodella*. Their leaves are small (2-5 cm) and disk-like with small roots on their underside. Duckweeds can reproduce quickly via a method called "budding" and can cover a pond surface in weeks.

Watermeal

Watermeal is commonly found in conjunction with duckweeds, but can be distinguished by its red underside. A common genus, *Wolffia*², also reproduces rapidly. Both duckweeds and watermeal prefer nutrient-rich, stagnant water and can be controlled via aeration - which induces native microbial growth to compete with the algae.

Water Ferns

Water Ferns are another type of free-floating plant with scale-like leaves which can reproduce quickly. Water ferns are commonly dried and used as biofertilizer for rice paddies in Asia. A common genus is *Azolla*³.



Fig 1. Lemna





Fig 2. Wolffia

Fig 3. Azolla



Cyanobacteria

Microcystis

The genus *Microcystis*⁴ is a floating cyanobacteria that looks like spilled green paint and can control its buoyancy in the water column using a gas-filled vesicle. This allows it to appear and disappear suddenly. It produces toxins which pose a threat to wildlife and livestock.

Aphanizomenon

The genus *Aphanizomenon*⁵ is a floating cyanobacteria that looks like grass clippings. It also contains buoyancy-regulating gas vesicles and produces neurotoxins. *Aphanizomenon* fixes nitrogen, which works against the purpose of BiOWiSH[®] bacillus. During nitrogen fixation, *Aphanizomenon* takes diatomic nitrogen (N₂) and converts it to more complex nitrogen species (NH₃⁻, NO₂⁻, and NO₃⁻) – exactly what BiOWiSH[®] bacillus are designed to control.

Anabaena

The genus *Anabaena*⁶ is a filamentous, floating cyanobacteria that looks like a clumpy pea soup. *Anabaena* does not have a buoyancy-regulating gas vesicle, but it can still produce toxins and neurotoxins. *Anabaena* fixes nitrogen as described above.

Nostoc

The genus *Nostoc⁷* forms large green, yellow, blue, or brown jelly-like balls or "grapes". *Nostoc* fixes nitrogen and can produce toxins. However, it is generally considered non-toxic.



Fig 4. Microcystis



Fig 5. Aphanizomenon



Fig 6. Anabaena



Fig 7. Nostoc

Oscillatoria, Lyngbya, Phormidium, and Plankthotrix

The genera Oscillatoria⁸, Lyngbya⁹, Phormidium¹⁰, and Plankthotrix¹¹ are dark blue, green, red, brown, or purple and can be floating mats or attached to rocks. Lyngbya and Oscillatoria form "hairy" films, Phormidium forms thin sheets, and Plankthotrix is planktonic (free floating). These genera do not fix nitrogen, but they can produce toxins and neurotoxins.



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Fig 8. Oscillatoria

Fig 9. Lyngbya



Fig 10. Phormidium

Fig 11. Plankthotrix

Filamentous and Flagellated Algae

Filamentous

Filamentous genera such as *Spirogyra*¹², *Mougeotia*, and *Zygnema* form slimy, slippery scums that often trap air bubbles and rise to the surface. The genera *Cladophora* and *Hydrodictyon* form net-like scums that can entangle fish and other wildlife.

Flagellated

Flagellated genera such as *Euglena*¹³ and *Phacus* are commonly seen together as bright green or red foam with a single flagellum for motility. *Euglena* is an indicator of organic pollution and can produce an extremely strong neurotoxin, killing wildlife. The genera *Dinobryon*, and *Prymnesium*¹⁴ do not form distinct scums but can change the color of the water to red, yellow, or brown. These genera are smelly and are the cause of "red tides". They also produce toxins. *Prymnesium* is commonly found in saltwater.







Fig 12. Spirogyra

Fig 13. Euglena

Fig 14. Prymnesium



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Other Scums

Protozoan

Protozoan scums¹⁵ are of interest because protozoa feed on bacteria. They appear whitish-grey and form in stagnant waters. These scums contain a diverse population of protozoa such as Ciliates and Flagellates.

Zooplankton

Zooplankton scums contain free-floating zooplankton that swarm together to reproduce. They can be extremely invasive and compete with bacteria for carbon sources.

Bacterial

Bacterial scums¹⁶ often form in running streams rich in iron. The scums are not toxic, but they can contain ethylene glycol which is harmful to life. They appear orange because of the iron oxide in the sheath of the bacteria.

Diatom

Diatom scums¹⁷ form a brown scum on the surface or bottom of the water. It can be attached to rocks or free floating and contains a diverse population of diatoms.







Fig 15. Protozoan scums

Fig 16. Bacterial scums

Fig 17. Diatom scums

Control Techniques

Mechanical Methods

Mechanical methods of control include pumping or raking surface scum, building barriers to block algae from blooming in certain areas, and using aeration to increase natural microbial activity and competition.

Physical/Chemical Methods

Physical and chemical methods of control include dosing Copper Sulfate, where the electronegative Cu²⁺ cation pulls electrons across the cell membrane, causing algae cells to lyse. Another chemical method is using barley straw. As the barley straw decomposes, it releases hydrogen peroxide which inhibits growth of algae. Another method is using shading to inhibit photosynthetic organism from receiving sunlight. Finally, phosphorus inactivating products such as Aluminum Sulfate $[Al_2(SO_4)_3]$ reduce biological availability of Phosphorus ions by producing precipitates that settle out of the water column.

Biological Methods

Biological methods of control include using non-native microbial products (cyanophages) to virally attack and lyse cyanobacteria. Also, algae-feeding fish can be used to eliminate algae.

References

Kannan, Miriam and Lenca, Nicole. Northern Kentucky University, Field Guide to Algae and Other "Scums" in Ponds, Lakes, Streams, and Rivers. 2013.



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Appendix

Type of Organism	Genera/Name	Description	Nutrient Source	Motility	Danger	Notes
Floating Macroscopic Plants	Lemna	2-5cm green discs				Most common floating plant
	Spirodella		Fixed nitrogen			Red underside
	Wolffia					Smallest flower in the world
	Azolla	Reddish leaves	Fixed nitrogen			Used as fertilizer
Floating Cyanobacteria	Microcystis	Spilled green paint	Fixed nitrogen	Buoyancy-regulating vesicle	Produces toxins	Can appear/disappear suddenly
	Aphanizomenon	Grass clippings	Nitrogen fixation	Buoyancy-regulating vesicle	Produces nuerotoxins	Sold as food suppliment
	Anabaena	Spilled green paint	Nitrogen fixation		Produces toxins	Occur in phosphorus-rich water
	Oscillatoria	hairy mats ranging in color	Fixed nitrogen	"Oscillating" movement	Produces toxins	
	Lyngbya	hairy mats ranging in color	Nitrogen fixation			Found entangled in shore vegetation
	Phormidium	Thin, tough sheets				
	Plankthotrix	hairy mats ranging in color				Planktonic (free floating)
Attached Cyanobacteria	Nostoc	Large colorful jelly-like balls	Nitrogen fixation	Attached to rocks or vegetation		Sold as food suppliment
Flagellated Algae	Euglena	Bright green or red foam		Single flagella	Produces nuerotoxins	Indicator of organic pollution
	Phacus	Bright green or red foam		Single flagella	Produces nuerotoxins	Indicator of organic pollution
	Dinobryon					Smells like cat urine or fish
	Prymnesium			Single flagella	Produces toxins	Saltwater organism
	Dinoflagellates	Turns water yellow, brown, red		Multiple flagella	Produces toxins	Causes "Red Tide"
Diatom Blooms	Diatoms	Brown scum or film		Secret mucilage through raphe		Come in many shapes and sizes
Filamentous Green Algae	Spirogyra	Green, silky, slimy, stringy				Spiral chloroplasts
	Mougeotia	Green, silky, slimy, stringy				Ribbon-shaped chloroplasts
	Zygnema	Green, silky, slimy, stringy				Star-shaped chloroplasts
	Cladophora	Green cotton				Found in running water
	Hydrodictyon	Green "water net"				Found in running water
Bacterial Scums	Sphaerotilus	Frothy, orange scum			Not toxic, but stay away	Found in areas rich in Fe and low in O
Protozoan Scums	Protozoa	Whitish-gray scums/foam		Flagellates, celliates, shells	Pray on bacteria	Come in many shapes and sizes
Zooplankton Scums	Daphnia Lumholtzi	Brown "swarms" or scums		Flagellates		Swarm for sexual reproduction

Figure 18. A comprehensive algae index. Green cells indicate Eukaryotic organisms and red cells indicate Prokaryotic organisms.



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