5. New International Problems Related to Lakes and Marshes

This chapter deals with problems that are newly emerging as common international tasks relating to the water environment at lakes and marshes.

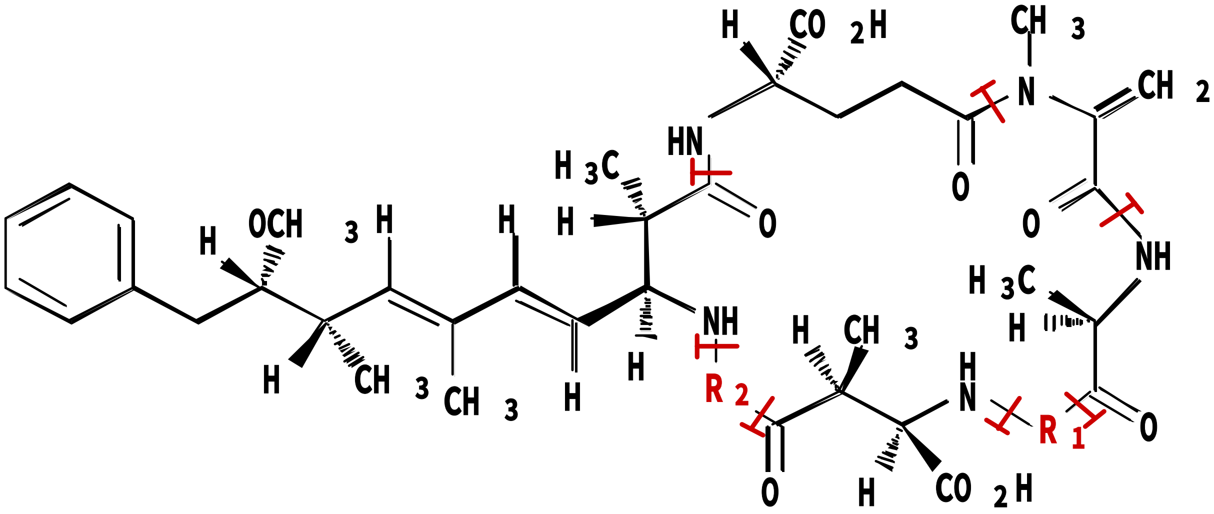
5-1 Animal death due to toxic microcystins produced by water-blooms

Among bloom-forming blue-green algae, some toxic species have been confirmed to exist in eutrophic lakes. Representative toxin-producing blue-green algal species are the *Anabaena* genus, the *Aphanizomenon* genus, the *Cylindrospermopsis* genus, the *Microcystis* genus, the *Nodularia* genus, the *Nostoc* genus and the *Oscillatoria* genus. In particular, microcystins are frequently detected in eutrophic lakes all over the world. Representative types of toxic blue-green algae and toxic substances are shown in Table 5-1-1. In lakes and marshes across the world toxic water-blooms have been unusually proliferate, and cases of the death of livestock and humans arising out of such toxic algae are being revealed. Harm to livestock deriving from toxins produced by blue-green algae has been reported in Australia, the United States, Finland and so forth; animals afflicted are cows, horses, pigs, sheep, poultry, etc. In a Caruaru hospital in the state of Pernambuco, Brazil, microcystins got mixed in the hospital's private tap water system and killed more than 50 people. Against such a background, the WHO (World Health Organization) in its guidelines on drinking water quality provisionally provides that microcystin-LR shall be under 1μg/ *l*. The microcystin is a cyclic peptide consisting of seven amino acids (Fig. 5-1-1). Due to differences of the amino acids positioned at X and Z, microcystins can be divided into microcystin-RR, microcystin-YR, microcystin-LR and others. The microcystin is believed to have nearly 60 homologues. Of all the microcystins, the most toxic is microcystin-LR. Its LD_{50} (lethal concentration 50%) in mice is reported as 50 μg/kg. Some members of the *Microcystis* genus contain microcystins and therefore are toxic, while some others do not contain microcystins and are not toxic.

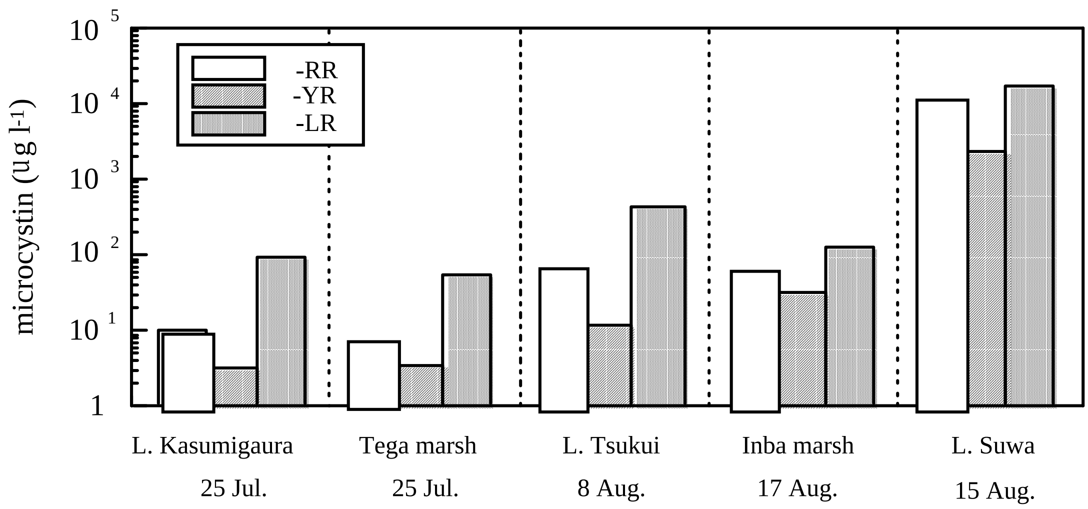
Table 5-1-1 Toxic blue-green algae and their toxins

Anabaena flos-aquae	anatoxin	(neurotoxin)
	microcystin	(hepatotoxin)
Aphanizomenon flos-aquae	aphantoxin	(neurotoxin)
Cylindrospermopsis raciborskii	cylindrospermopsin	(hepatotoxin)
Microcystis aeruginosa	microcystin	(hepatotoxin)
Nodularia spumigena	nodularin	(hepatotoxin)
Oscillatoria agardhii	microcystin	(hepatotoxin)

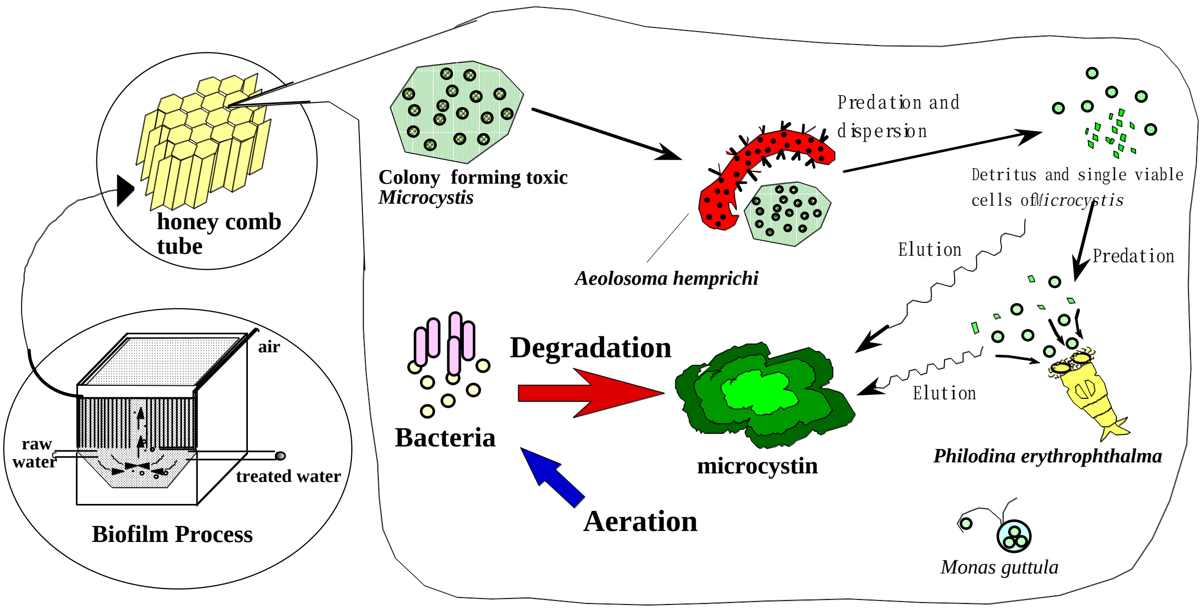
Consequently, the microcystin content varies greatly depending upon which type is dominant, a toxic type or a non-toxic type. The blue-green algae beginning with the *Microcystis* have a strong tendency to float, and are likely to be driven by wind to become accumulated; therefore, the microcystin concentration differs greatly even in the same water area depending upon the place. The *Microcystis* genus prefers high temperatures and therefore, in the temperate regions, microcystins appear mainly in summer and their concentration varies depending upon the time of the outbreak. Various cases of microcystin content have been reported. Such cases report 0.2 to 0.4 mg MCYST/g dry weight on lakes in Japan, 0.7 to 0.8 mg MCYST/g dry weight on impounding reservoirs in Thailand and 0.05 to 0.415 mg MCYST/g dry weight on impounding reservoirs in South Africa. The existing quantities of microcystins at Japanese lakes are as shown in Fig. 5-1-2. In Japan, microcystins appear principally in summertime revealing the dominance of the microcystin-RR and microcystin-LR in many cases.



	R_1	R_2
RR	arginine	arginine
YR	tyrosine	arginine
LR	leusine	arginine



Effective methods to remove microcystins from drinking water are the ozone treatment, the activated carbon treatment and the biological treatment. In the biological treatment, it is reported that protozoans and metazoans eat blue-green algae, and the eluted microcystins are ingested and decomposed by bacteria (Fig. 5-1-3). Microcystins are usually present within cells, and elute into the water when dead. Those who control water purification facilities need to be careful about the microcystin concentration in each process at the time when microcystins die. The blue-green algal proliferation is triggered by increased concentrations of nitrogen and phosphorous that flow into the water area contained in residential wastewater, business wastewater and livestock-related wastewater; therefore, strengthening measures against nitrogen and phosphorous is very effective in preventing blue-green algal outbreaks.



5-2 Fish Death by Aggressive *Dinoflagellida Pfiesteria*

Among *Dinoflagellidas*, there are species that produce toxic substances. These species are known to be harmful to fish and shellfish; they accumulate toxins within fish and shellfish, and humans who eat them suffer poisoning. The toxins produced by *Dinoflagellidas* are ciguatera toxins, saxitoxins, okada acids and so forth. Of all the members of *Dinoflagellidas*, the most problematic of recent years is the *Pfiesteria piscicida*, which is one of the species of *Dinoflagellidas* known as red-tide algae that have as many as 2,000 different types throughout the world. *P. piscicida* is said to be responsible for the massive fish deaths occurring in the estuaries in North Carolina and Maryland. The Unites States provide that any research on this microorganism requires a Level-3 laboratory. The toxin produced by *P. piscicida* destroys the skin of the fish and damages its nervous system and vital organs. Furthermore, this species has the great ability to produce volatile toxins harmful particularly to human health, react severely in fish and in a short time, change from being nonpoisonous to being poisonous. Also reported is the fact that the existence of *P. piscicida* prevents fish eggs from hatching and deprives young shellfish of their ability to close their shells. Photos showing the stage of *P. piscicida* proliferation confirm that microorganisms similar in form exist in nature; however, it appears that in many places, no problem has ever been induced by such microorganisms. That is to say, judgment from mere appearance may lead to incorrect identification, and therefore their culture is necessary. Ocean vessels may bring in ballast water allowing *P. piscicida* to move to other countries; therefore, the utmost care is required at seaports where the loading and unloading of cargo or the transfer of large amounts of ballast water is conducted. Furthermore, imports of raw materials such as sea urchins may allow *P. piscicida* to move to other countries; thus, a check should be made to determine whether *P. piscicida* has ever been present in places where such sea animals existed. The factor that allows *P. piscicida* to massively proliferate is eutrophication due to the inflow of nitrogen and phosphorous. *P. piscidida* is supposed to proliferate on a massive algal outbreak; therefore, to prevent such toxic *Dinoflagellidas* from unusual proliferation, measures against nitrogen and phosphorous occupy a very important position.

5-3 Bird death due to Toxin-Producing Botulinus

Botulinus bacilli (*Clostridium botulinum)* are gram-positive bacteria and obligate anaerobes. Their spores are present in diverse environments such as soil, water environments and animal intestines. Resistive to high temperature, they proliferate in food and cause food poisoning. The botulinus bacilli are the causative fungi of poisoning derived from the putrefaction of food placed in an anaerobic condition such as sausages and canned food. The botulinus bacilli produce a neurotoxin consisting of a protein called botulinus toxin and cause botulism in anyone who ingests it. There are seven types of botulinus toxins, A - G, on which botulinus bacilli are classified. Botulism occurs all over the world. Besides humans, domestic animals such as chickens and cows, and wild animals such as mink and seabirds are also infected. The sources of infection are food for humans, feed for livestock and dead and decomposed fish and animals for wild animals. Birds also become infected when they eat dead animals in which botulinus bacilli have proliferated and produced toxins. Birds' botulism is caused by botulinus bacillus type C and type D. The lethal dose of 50% (LD50) is so small that in an experiment with a mouse, less than 1ng per kg of body weight injected in its body is lethal.

5-4 Obstacles by Unusual Proliferation of Free Floating Plants

5-4-1 Current status of unusual proliferation of free-floating plants

In water areas where nitrogen and phosphorous concentrations are high and water is stagnant, plants such as water hyacinths and water lettuce freely float and absorb nutritive salts such as nitrogen and phosphorous directly from water to proliferate; then, such plants become dominant at the waterside. Free-floating plants have their leaves above water; they are not affected by decreased transparency and little affected by waves as they move with the motion of the waves. Within communities, they interrupt light and contain phytoplankton proliferation. In Kyushu, Shikoku and Chugoku districts in Japan, there has been a huge outbreak of water hyacinths; they have occupied closed water areas including Lake Kojima and adjacent creeks, and are a menace to the existing plants and animals; furthermore, they clog the water intakes. In autumn, they decay and deteriorate the water quality to a great extent. In China, *Alternanthera philoxeroides* (Chinese name "xi han lian zi cau") grow out of the creek waterside, store air between joints through an extraction period, float stalks on the water surface and form intervolved communities; once their old joints have connected to the water bottom or the waterside has become rotten, they shift to a free-floating life and proliferate, filling up the whole waterside. They are not liked by domestic animals, and therefore have little added value; however, when compared with water hyacinths, they cause a large number of biofilms to be attached to their rootstalks and provide habitats for aquatic insects such as larva of midge; therefore, they are supposed to contribute to the proliferation of aquatic animals. In China, there are also a large number of water hyacinths. In Dian Chi that extends south of Kunming, this plant has flourished covering over half of the water surface at Lake Cau Hai (an inner lake) that leads to the city zone. In the Kingdom of Thailand, other floating plants are more dominant; therefore, "Xi han lian zi cau" which is known as "alligator weed," is seen only at the waterside or on land. In the Kingdom of Thailand, principal free-floating plants are water hyacinths, swamp cabbage and *Neptunia oleracea*. Of swamp cabbage and *Neptunia oleracea*, edible kinds are selected and cultivated on water as vegetables. In heavily polluted water areas, water hyacinths are dominant, and in agricultural districts where no aquaculture is in practice, swamp cabbage spreads on the water surfaces in many places.

5-4-2 Measures against Free-Floating Plants

Representative problems that are caused by free-floating plants are the hindrance to boat navigation, the clogging of water intakes, the formation of anaerobic water masses and deterioration in water quality by dead stumps. Water hyacinths are not strongly connected to each other; however, they are highly proliferating. They form large communities and obstruct boat navigation. They drift separately and gather at water intakes, blocking them. Furthermore, they interrupt light obstructing photosynthesis under water below the communities. As they have low added value, they are left to die uncared for and deteriorate water quality, creating yet another hindrance. In China, pig farmers collect water hyacinths to feed pigs; then, the diffusion of a collecting and reusing system of such floating plants appears to be useful. Swamp cabbage serves as food and has a high added value, and actually, they are distributed for sale in the Kingdom of Thailand and other countries. Swamp cabbage forms communities interconnected with stalks; therefore, if fixed by bamboo stakes at two points or bound to bamboo floated between two stakes, the cabbage will not flow out on the current. The swamp cabbage has a larger capacity to supply oxygen under water than water hyacinths and its stalks and leaves are cropped and brought to the market for mass consumption. However, as they are not as resistive to waves as water hyacinths or *Alternanthera philoxeroides,* they can be cultivated only in calm inlets at lakes; therefore, they are cultivated principally at creeks attached to inflowing rivers or lakes. In the Kingdom of Thailand, at some places swamp cabbage and *Neptunia oleracea* are cultivated in a continuous creek under careful control along with some fisheries, while at other places, water hyacinths block the water areas rendering them quite unusable. Right granting for the use of creeks properly partitioned and the introduction of a system to set up responsibility for its control will enable productivity improvement and water purification to coexist, and thus, recycle-based water purification will be established.

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