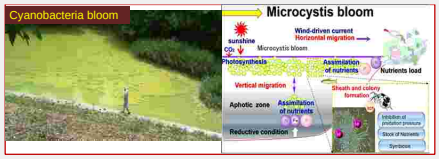
85th ICOLD Annual Meeting
July 3–7, 2017, Prague, Czech Republic
du 3 au 7 juillet 2017, Prague, République tchèque
Annual Meeting of International Commission on Large Dams
Réunion annuelle de la Commission internationale des grands barrages

CONTROL METHOD OF WATER BLOOM USING CHARACTERISTICS OF RESERVOIR ECOSYSTEM

Yasushi Iseri, Masayoshi Mori[1] , Katsuhiro Kudo, Shintaro Yamamoto[2]
[1]West Japan Engineering Consultants, Inc.; [2] Water resources Environment Center

Cyanobacteria bloom

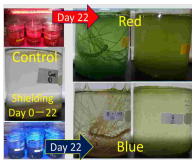


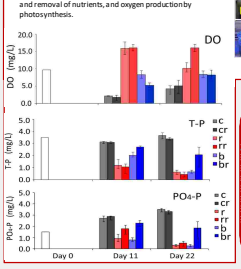
Major eutrophication countermeasures employed in Japan

Method	Aim and Principle
Epilimnetic Aeration	Air is injected from the mid-depth or epilimnetic layer of the water column in the reservoir. The buoyancy of the air bubbles generates upward flow to form a circulating mixed zone in the reservoir. This brings about a lowered water temperature in the epilimnetic layer, drawing phytoplankton to layers below the euphotic zone, as well as algae diffusion and other phenomena, thereby suppressing the growth and accumulation of phytoplankton.
Hypolimnetic Oxygenation	Oxygen is supplied to the hypolimnetic layer while water column stratification is maintained. This inhibits the release of iron, manganese, hydrogen sulfide and nutrients from the sediment to prevent the occurrence of rust-colored water or black (manganese-infused) water and the diffusion of nutrients across the reservoir during the turnover seasons.
Overall Aeration	Aerating and circulating the entire water body in a reservoir to forcibly move water in the hypolimnetic layer to the epilimnetic layer. The forced migration of phytoplankton to the aphotic zone and the lowered water temperature in the epilimnetic layer lead to suppressed phytoplankton growth. However, caution is required, as the process may disturb sediment and cause nutrients to migrate.
Fountain System	Pressure, agitation, and the percussive effect of falling water generated by the fountain pump damage phytoplankton cells, thereby inhibiting the proliferation of algae. In addition, the sun-screening effect of the falling water, evapotranspiration, and the stirring of water inside the reservoir prevent an increase in the epilimnetic water temperature and lower the thermocline, which leads to inactivation of phytoplankton and the suppression of its growth.
Floating Artificial Wetlands and Artificial Ecology Reef	Floating wetlands are man-made floating mats covered with wetland plants. Those designed to prioritize water purification are called artificial ecology reefs. The overgrowth of algae is inhibited by the absorption of nutrients by the plants and algae attached to the plants and mats, and algae control is facilitated by the relationships between diverse organisms (competition for nutrients, zooplankton grazing on phytoplankton, etc.), and by suppressed photosynthesis due to blocked light penetration.
Selective Water Intake System	In a reservoir where thermal stratification has been formed, effluent water quality (primarily, water temperature and turbidity) is controlled by changing the water intake height to allow water to be selectively taken from any layer of the water column. In addition, the entry depth of turbid influent water is controlled as the status of stratification in the reservoir is changed by the operation of the selective intake system. The effects of this system help mitigate cold water and warm water phenomena, as well as prolonged turbid water phenomenon.
Flow Control Fence	A fence is installed at the end of the inflow zone in a reservoir to guide highly turbid and nutrient-rich influent water into the hypolimnetic layer when floods occur. With this, turbidity in the epilimnetic layer is reduced, the supply of nutrients to phytoplankton is inhibited, and the growth of phytoplankton is suppressed. Meanwhile, the combined use of the fence with the selective intake system is effective in preventing nutrients from re-ascending into the euphotic zone.
Bypass (Diversion)	There are several types of bypasses. A clean water bypass is used when water turbidity inside the reservoir has increased, to bypass the reservoir and discharge low-turbidity upstream water directly downstream. A turbid water bypass is used during flood periods to bypass the reservoir and discharge turbid water directly downstream, to prevent water in the reservoir from becoming turbid. A counter-eutrophication bypass is used to prevent effluent and other water from entering the reservoir by diverting it to the downstream area near the reservoir, to prevent eutrophication.

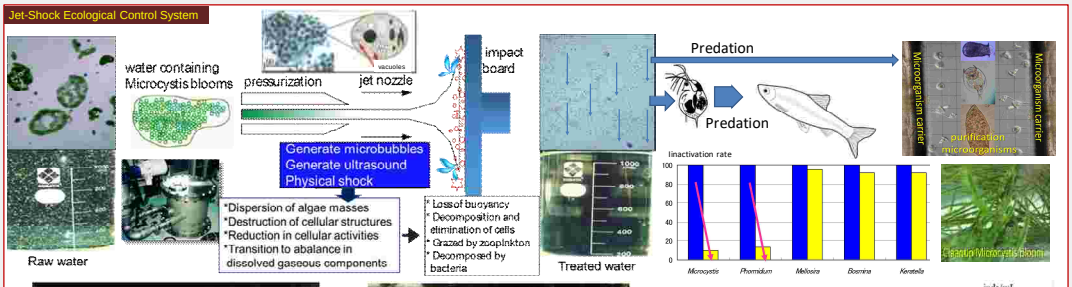
LED Radiation System

The LED radiation system supplies light directly above the sediment to suppress formation of dysoxic water mass through activated photosynthetic bacteria and algae, promoted decomposition of organic substances, absorption and removal of nutrients, and oxygen production by photosynthesis.





Jet-Shock Ecological Control System



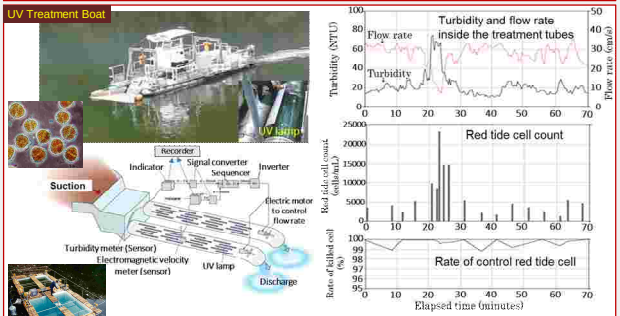
Jet-Shock System, which destroys the cyanobacteria colonies that store nutrients and protect the cyanobacteria from predators, and which inactivates the vertical mobility that helps them photosynthesize and acquire nutrients. In this way the cells are turned into feed for protozoa and zooplankton that graze on Microcystis blooms. This system has achieved the elimination of around 10,000 m2 of Microcystis blooms when conditions are favorable for treatment, such as during the stable formation of a wind-induced current.

inds/mL

Type	Species	Jet-shock area	Control
Bloom	*Microcystis* spp.	1,955	140,300
Phytoplankton	*Gloeocystis* spp.	325	278
	Oocystis sp.	403	336
	Melosira granulata	710	456
	Fragilaria crotonensis	11,399	9,765
Zooplankton	*Tintinnopsis cratera*	2.01	1.07
	Polyarthra spp.	0.93	0.49
	Bosmina longirostris	0.33	0.39
	Nauplius of Copepoda	0.78	0.72

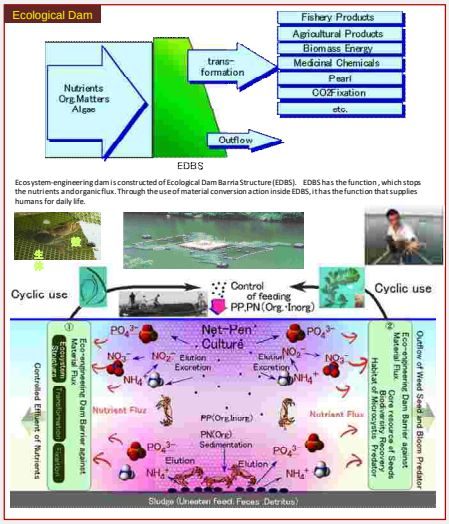
Bloom Control Fence

UV Treatment Boat



This boat is equipped with a sequencer (PLC), in which data has been input regarding the relationship between the minimum amount of UV exposure required to inhibit cell division and the cell density of abnormally increased plankton. One boat can treat up to 1,000 m3 of fresh water red tides per hour or around 700 m3 of cyanobacteria blooms per hour.

Ecological Dam



Ecosystem-engineering dam is constructed of Ecological Dam Barria Structure (EDBS). EDBS has the function , which stops the nutrients and organic flux. Through the use of material conversion action inside EDBS, it has the function that supplies humans for daily life.