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New microbial ecosystem created by artificial floating island

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ABSTRACT: To scrutinize the microbial ecosystem and processing of water quality improvement under the artificial floating island, water quality parameters, bacterial numbers and extracellular enzyme activities were measured biweekly from 3, November 2001 to 20, April 2002 in Lake Paldang, Korea. Most of the mean environmental parameters were not different from artificially floating island (AFI) site and control site. But, zooplankton numbers were about 100 times higher at AFI site than those of control site, even though the chlorophyll *a* concentrations were not so different. During winter, the ratios of respiratory active bacteria to total bacterial number were two fold higher and enzyme activities of β-glucosidase and phosphatase were extremely higher at AFI site than those of control site. With these high densities of zooplankton, active bacteria and high rates of degradation under the AFI, the organic materials are eliminated at inside of lake with newly created ecosystem.

Key Words: artificial floating island, enzyme activity, Lake Paldang, new ecosystem, respiratory active bacteria

Introduction

Recently, ecotechnology is becoming a new strategy for wastewater treatment, water quality improvement and elimination of pollutants. Since 1960s, studies for using macrophytes to ecotechnology were carried out at diverse areas (Kim and Cho, 1996). One of the ecotechnology implying to pond, lake or reservoir is artificial floating island consisting with macrophytes and their sustainable media (Simatani, 1996). Improvement of water quality was done through by symbiotic and synergistic activities between aquatic plants and microbes (Azam, et al , 1983) . But, artificial floating island could not responsible to improve the water quality efficiently such as TN, TP, COD and other parameters because of limited installed area (Park et al, 2001). Moreover, water column could be easily mixed with physical turbulence and water current, so the water quality of floating island area is similar to that of outer part.

But, artificial floating island is a newly created artificial ecosystem, which never has been there. So we analyzed the microbial densities, activities and determined the ecological roles under the artificial floating island.

Materials and Methods

The investigations were carried out biweekly from 3, November 2001 to 20, April 2002 at the center of artificial floating island (AFI) and outer part (20m from AFI) as control site in Lake Paldang. Korea. The AFI was installed with the size of 2,690m^2 (41.5m*64.8m) at August 1999.

Environmental parameters

BOD, COD, SS, TN, TP and Chlorophyll *a* were analyzed according to standard method (APHA, 2000). Zooplankton density was counted by stereo microscopy (SV-11, Zeiss) in laboratory.

Total bacterial number and respiratory active bacterial number

Bacteria were counted with Acridine Orange staining method (Hobbie *et al.*, 1977). Respiratory active bacteria was measured triplicate with 5-cyano-2, 3-ditolyl tetrazolium chloride (CTC) method (Rodriguez et al., 1992).

Activity of β-glucosidase and phosphatase

Enzyme activity was determined by modified method of Chróst(1989). Methylumbelliferyl (MUF)-β -glucoside was used as substrate for β-glucosidase and MUF-phosphate for phosphatase.

Results

Water quality parameters

Environmental parameters are shown in Table 1. Most of the mean environmental parameters are not different from two site. But, zooplankton abundance is about 100 times higher at AFI site than that of control site.

Table. 1. The data range and mean values of environmental parameters in artificial floating island and control site.

	Range		Mean value	
	AFI	Control	AFI	control
BOD(mg/l)	2.1-14.7	1.5-11.2	7.0	5.4
COD(mg/l)	5.4-17.3	2.6-6.5	9.6	4.8
SS(mg/l)	7.8-34.1	3.6-22.4	21.1	12.7
TN(mg/l)	3.7-12.6	3.3-7.8	9.2	5.7
TP(mg/l)	0.6-2.5	0.3-2.0	1.5	0.9
Chlorophyll a (μg/l)	3.7-99.5	5.1-261.4	36.0	50.6
Zooplankton number (ind./l)	343-3906	2-405	1644	67

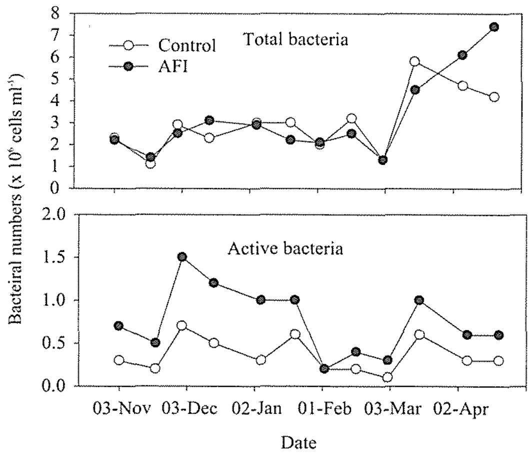

Fig. 1. The variations of total bacteria and respiratory active bacteria in artificial floating island and control site.

Total bacterial and respiratory active bacterial numbers

The variations of total bacterial numbers of two sites are shown in Fig. 1a. In 3, March 2002, the number of bacteria dropped to 1.3×10^6 cells ml^{-1}. After this drop, the bacterial numbers were rapidly increased about three or eight times in both sites. But the total bacterial number was not largely different from both two sites.

The respiratory active bacterial numbers are shown in Fig. 1b. In AFI site, the active bacterial numbers were two times higher than control site. Especially, in winter, the ratios of active bacteria to total bacterial number were two times higher than control site (Fig. 2).

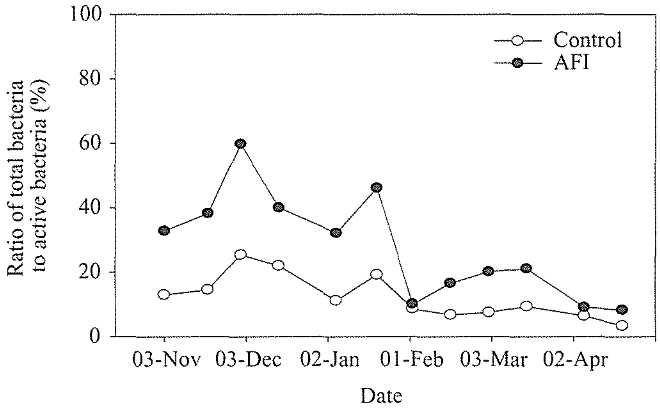

Fig. 2. The ratios of respiratory active bacteria (%) to total bacteria.

β-Glucosdiase and phosphatase activity

In AFI and control site, the Vmax of β-glucosidase were ranged 78 ~ 2358.7 nM $l^{-1}hr^{-1}$ and 8.3~94.8 nM $l^{-1}hr^{-1}$, respectively (Fig. 3). In control site, β-glucosidase activity was lower than artificial floating island and stayed constant till the end of the investigation period. While that of AFI site showed irregular fluctuation.

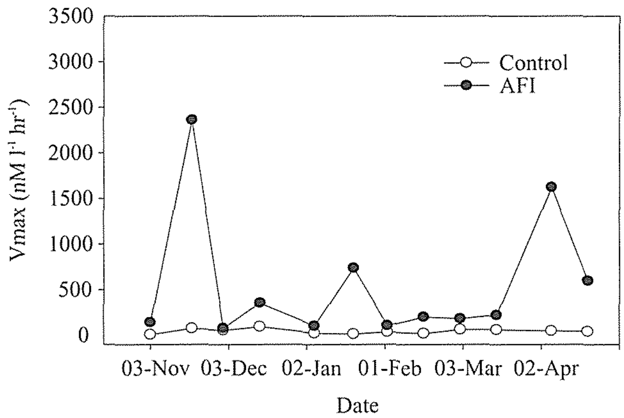

Fig. 3. The variations of s-glucosidase activities in artificial floating island and control site.

The Vmax of phosphatase were ranged 70.8 ~ 480.7 nM $l^{-1}hr^{-1}$ in control site and 271.9 ~ 5761.4 nM $l^{-1}hr^{-1}$ in AFI site. At the first 2 months, no difference of Vm value was found. Similar to the β-glucosidase activity changes, the phosphatase activity had irregular fluctuation. The highest value was shown in 16, January 2002, as 5761.4 nM $l^{-1}hr^{-1}$, twelve times higher than that of control site (Fig. 4).

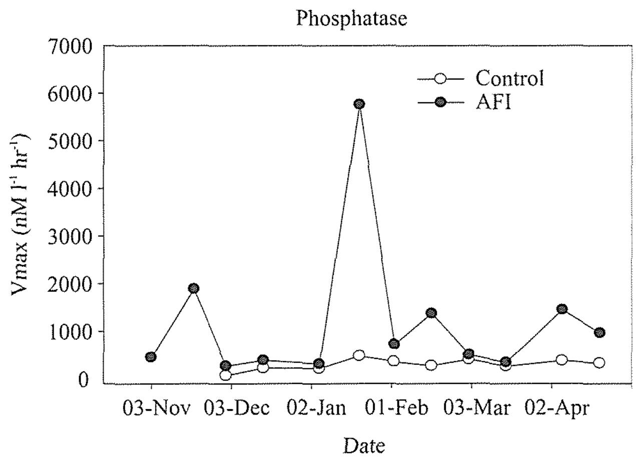

Fig. 4. The variations of phosphatase activities in artificial floating island and control site.

Discussion

This artificial floating island is largest which installed in Korea. Unlike formerly installed AFIs, this AFI is large enough to distinguish water quality and biological parameters between inner part and outer part. At inner part of AFI, the conventional water quality indicators, such as BOD, COD, SS, TN and TP were higher than those at outer part. This is because of attachment of bacteria into the roots and artificial media. It is well known that the bacteria can accumulate the low dissolved organic materials and nutrients into high cellular concentration (ref.).

The abundance of zooplankton at inner part is extremely higher than that at outer part. To sustain the zooplankton population within floating island, large amounts of organic matters have to present in waterbody. Inner part of artificial floating island, biomass of phytoplankton was not sufficient because direct sunlight was blocked by macrophytes, and chlorophyll *a* concentration was not so higher in AFI site. When zooplankton population meet the shortage of phytoplankton as food or increment of cyanobacteria in ambient water column, they changed the food from phytoplankton to bacteria as substitute (Sim and Ahn, 1992). So we may assumed that the bacteria could support the zooplanktonic biomass under the AFI. By these grazing pressure to bacteria, the proportions of active bacteria is higher at inner part than outer part. When grazing pressure of zooplankton to bacteria increased, bacterial activities were rapidly increased also (Guede, 1989).

β-Glucosidase is a broad-specificity enzyme that catalyzes the hydrolysis of β-linked disaccharide of glucose, celluhexose, and carboxymethylcellulose (Barman, 1969) and it is very important and significant for glucose metabolism of microheterotrophs in aquatic ecosystem (Chróst, 1989). This enzyme can be used as an indicator of status molecular weight in water column, and catabolic repression -like reaction is appearing in natural system (Chróst, 1991). Also, at the high molecular fraction, the activity was 1,000 times higher than that at low molecualr fraction (Kim et al, 1999).

Another extracelluar enzyme, phosphatase is the enzyme that hydrolyze the dissolved organic phosphorus and generate the inorganic phosphate, an unique form of bacteria and phytoplankton can utilize as cellular materials. So phosphatase activity is induced when phosphate in the water is exhausted and/or content of cellular phosphate decreased (문헌 ansgjsChróst and Overbeck, 1987). So, phosphatase activity indicates the concentration of available phosphate in water column and the phosphate deficit of the phytoplankton cell (Choi et al., 1992). Therefore, high phsosphatase activity in AFI could be explained that the bacteria and phytoplankton secret phosphatase to get bioavailable phosphate (Jansson et al, 1988). The kinetics of bacterial and phytoplanktonic phosphatase are different each other. Still we do not analyzed the origin of phosphate, but we can find out the phosphate regeneration rate in AFI are faster than that in control site.

In conclusion, organic matters were removed by respiration of dense zooplankton, high activities of bacteria cause by grazing pressure of zooplankton to bacteria under artificial floating island.

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