The Physico-Chemical and Microbiological Water Quality of the Artificial Lake Keumgang

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ABSTRACT: This study was performed to investigate the changing environment of Keum River after the construction of the floodgate at the mouth of Keum River. Samples were taken from the surface waters at 3 stations near the floodgate of the artificial lake Keumgang to measure the physico-chemical and microbiological water qualities from May, 2001 to April, 2002. The results were as follows; water temperature ranged from 2 to 28°C,and pH values varied from 7.5 to 9.1 respectively .The dissolved oxygen contents and COD of each station varied from 7.13 to 14.10 mg l^{-1} and from 5.2 to 9.4 mg l^{-1} respectively. And total nitrogen and total phosphate values varied from 0.99 to 3.15 mg l^{-1} ,and from 0.01 to 0.12 mg l^{-1} during survey periods, which meant the sampling stations have set in eutrophic level The population density of heterotrophic bacteria ranged from $0.4 \pm 0.1 \times 103$ cfu ml^{-1} to $3.5 \pm 0.6 \times 10^{3}$ cfu ml^{-1} during survey periods. The population densities of physiological groups of aerobic bacteria ranged from $2.0 \pm 1.0 \times 10^{2}$ to $1.7 \pm 0.2 \times 10^{3}$ cfu ml^{-1} for amylolytic bacteria, from $0.3 \pm 0.1 \times 10^{2}$ to $1.3 \pm +0.5 \times 10^{3}$ cfu ml^{-1} for proteolytic bacteria, from $0.2 \pm 0.1 \times 10^{3}$ to $4.9 \pm 1.3 \times 10^{3}$ cfu ml^{-1} for lipolytic bacteria, and from $0.2 \pm 0.1 \times 10^{2}$ to $2.7 \pm 0.7 \times 10^{3}$ cfu ml^{-1} for cellulolytic bacteria during survey periods, respectively. Among the measured numbers of physiological groups of bacteria, lipolytic bacteria showed the highest population density. However, the numbers of amylolytic, proteolytic, and cellulolylic bacteria showed the similar tendency.

Introduction

The Keum river, which is approximately 400 km long, originated from Sobaek Mountains, and goes through the middle west area of the Korean Peninsula, and finally flows into the Yellow Sea. Along the Keum river, large cities, farm lands, and industrial complexes are dotted. The role of Keum river is very important as the sources of irrigational, industrial, and portable water according to the development of industry and increase of population. However, because of the gradient of river basin is very small, its basin area is very unfavorable conditions to use the water resources. Therefore, in 1990, the river basin barrage, which is 1,841 m long and 0.36 billion ton of storage volume of water per year, was constructed and arranged at the estuary mouth area not only to prevent water loss and to supply agricultural and industrial water, but also to promote ship harboring. The construction of barrage turned salt water to fresh water and

is able to prevent sand and soil depositing in Gunsan harbor. It also connects Gunsan City and Janghang City by overland and provides the visiting site of migratory birds. However, in the long-term of view, the ecological changes of Keum river may occur because of the construction of barrage. Therefore, it is necessary to understand the ecosystem change by baseline survey and by comparing with the analysis of pre-existed data (Lee, 1986).

In this paper, we focus on the variation of physico-chemical factors and the distribution of heterotrophic and physiological groups of bacteria in the changing environment after the construction of the floodgate at the mouth of Keum river.

Material and Methods

Sampling station

Samples were taken from the surface waters at 3 stations near the floodgate of the artificial lake Keumgang from May, 2001 to April, 2002 (Station A: located on the barrage toward Gunsan City, Station B: located on the barrage toward Janghang City, Station C: located upstream about 4 km from the barrage)(Fig. 1).

Sampling and counting of bacteria

All samples were collected from surface water by using Niskin water sampler with sterilized polypropylene bottles from May 2001 to June 2002. Samples were processed within a few hours of collection and maintained 5oc during storage.

Physico-chemical parameter

The water temperature and pH were measured in situ with electric thermometer (Delta PC-9400, Japan) and pH meter (TOA HM-16S, TOA Electronics Ltd., Japan), respectively. The concentration of dissolved oxygen, COD, NH_4^+-N, NO_2^--N, NO_3^--N, total N, and total P were measured according to Standard methods (APHA, 1989).

Microbiological parameter

Nutrient agar (Difco) and EMB agar (Difco) were used for plating viable heterotrophic bacteria and fecal coliform bacteria, respectively. For the determination of physiological groups of bacteria, soluble starch (1%) for amylolytic bacteria, skim milk (1%) for proteolytic bacteria, tween 80 (0.5%) for lipolytic bacteria, and carboxyl-methylcellulose (0.5%) for cellulolytic bacteria were added, respectively, as the sole carbon source to the Trypticase soy broth (Wollum, 1982). After incubation at $25 \pm 2°C$ for 2 days, colonies were counted.
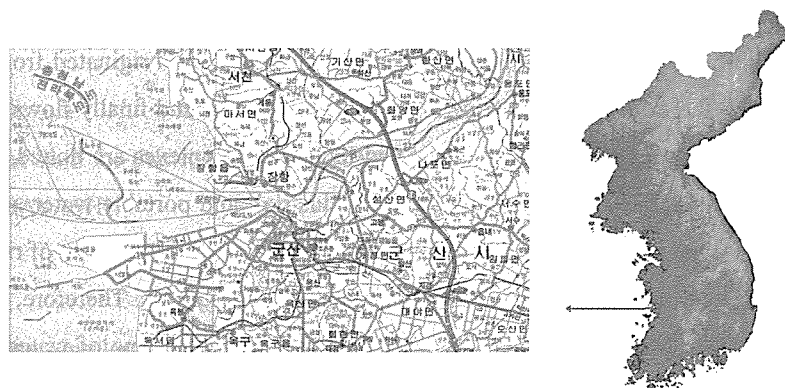

Fig. 1. The sampling stations at the artificial Lake Keumgang.

Parameter Correlation

The correlations of each parameter were calculated by the method of SPSS 10.0K for Windows.

Results and Discussion

Physico-chemical water qualities at each sampling stations are shown in Table 1. The distribution of water temperature, depending largely on the air temperature, ranged from 2 °C (Jan., 2002) to 27.5 °C (Aug., 2001) during the survey periods. Comparing this values with the results of Nakdong river (ISWACO, 1987), values in summer were somewhat higher and values in winter were lower than those of Nakdong river, which was mainly due to the difference of water quantity in the whole river. The variation of pH ranged from 6.94 to 9.63. Comparing this values with those of Nakdong river (ISWACO, 1987), the variation of pH range was higher than that of Nakdong river, especially in spring and autumn, which may be mainly due to the eutrophication at that season. The concentration of dissolved oxygen varied from 7.10 to 12.6 mg l^{-1} during the survey periods. In general,the concentration of dissoived oxygen is closely correlated with water temperature. Such tendency was also shown at the sampling stations of artificial Lake Keumgang. The values of COD varied from 5.2 mg l^{-1} to 9.4 mg l^{-1}, which was a little lower than those of Nakdong river (ISWACO, 1987). It showed seasonal variation, which was mainly affected by the increase of introduced pollutants.

Ammonia is produced by the deamination of organic nitrogen compounds and by the reduction of nitrate under anaerobic conditions. Ammonia can be the pollution indicator of fecal, domestic, and waste pollution. Nitrate-N originated from recent input of domestic sewage and is also a influential indicator of pollution. It should not be detected in drinking water simultaneously when ammonia-N is detected. The values of ammonia-N, nitrite-N, nitrate-N are important indicators of water pollution and they varied from 0.11 to 1.47 mg l^{-1} (Fig. 2), from 0.01 to 0.10 mg l^{-1} (Fig. 3), from 0.67 to 1.76 mg l^{-1} (Fig. 4), respectively. And total nitrogen and total phosphate values varied from 0.99 to 3.15 mg l^{-1}
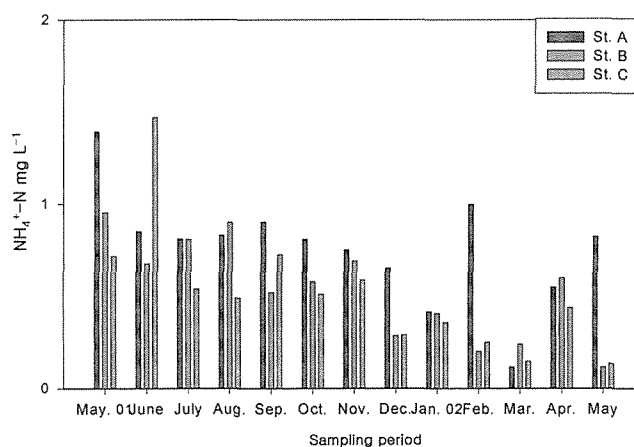

Fig. 2. The monthly variation of the values of ammonia-N at the artificial Lake Keumgang during survey period.
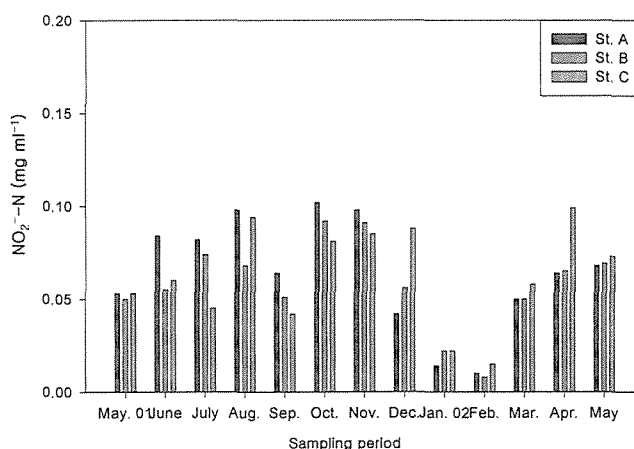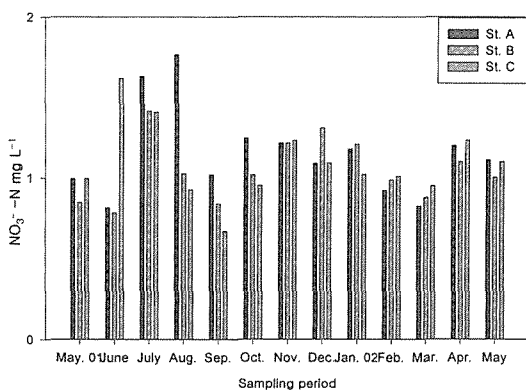

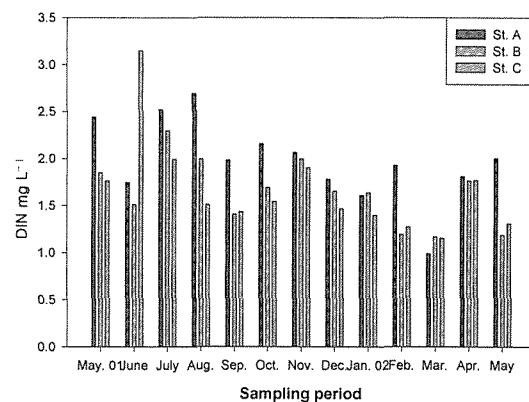**Fig. 3.** The monthly variation of the values of nitrate-N at the artificial Lake Keumgang during survey period.

and from 0.01 to 0.12 mg l^{-1} during survey periods (Fig. 5, 6). Such values were more than hundred times higher than those of Daechung Dam, which is located on the upstream of Keum river (Han et al., 1993; Lee et al., 2000). The water quality of the sampling stations near barrage have already set in eutrophic level.

In aquatic environments, heterotrophic bacteria contributed the ecosystem not only by decomposing and mineralizing the dead organisms, but also acting as secondary producers by transformation of dissolved organic matter to particulated organic matter. The study of the distribution of heterotrophic bacteria could be used for the indicator of water quality. The population density of heterotrophic bacteria ranged from 0.4 ± 0.1 x 10^3 to 1.5 ± 0.1 x 10^4 cfu ml^{-1} during survey periods (Fig, 7). The highest numbers of heterotrophic bacteria were found at station A on May, 2002, while the lowest ones at station C on January, 2002. Comparing with the annual variation of heterotrophic numbers in Mankyong river. These values showed little annual fluctuation than those in Mankyong river (Lee and Lee, 1993). In case of the artificial Lake Keumgang, the distribution of heterotrophic bacterial numbers was strongly correlated with the overlying water temperature.

The population densities of physiological groups of aerobic bacteria ranged from 2.0 ± 1.0 x 10^2 cfu ml^{-1}
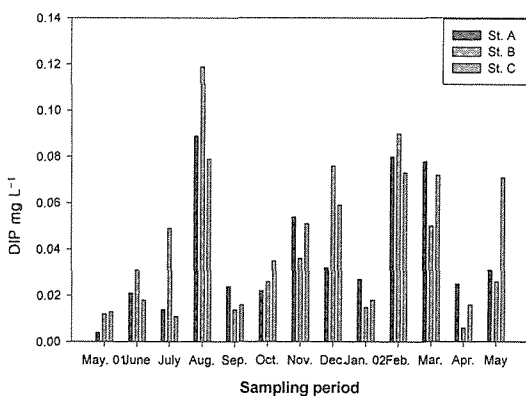

**Fig. 4.** The monthly variation of the values of nitrate-N at the artificial Lake Keumgang during survey period.

Fig. 5. The monthly variation of the values of total nitrogen at the artificial Lake Keumgang during survey period.

to 1.7 ± 0.2 x 10^3 cfu ml^{-1} fur amylolytic bacteria, from 0.3 ± 0.1 x 10^2 cfu ml^{-1} to 1.3 ± 0.5 x 103 cfu ml^{-1} for

Fig. 6. The monthly variation of the values of total phosphate at the artificial Lake Keumgang during survey period.
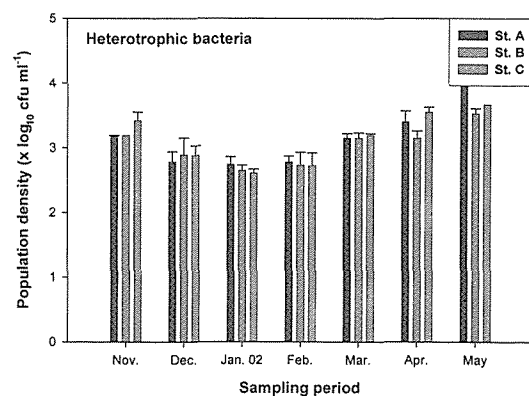
Fig. 7. The distribution of heterotrophic bacterial population density at the Artificial Lake Keumgang during survey period.
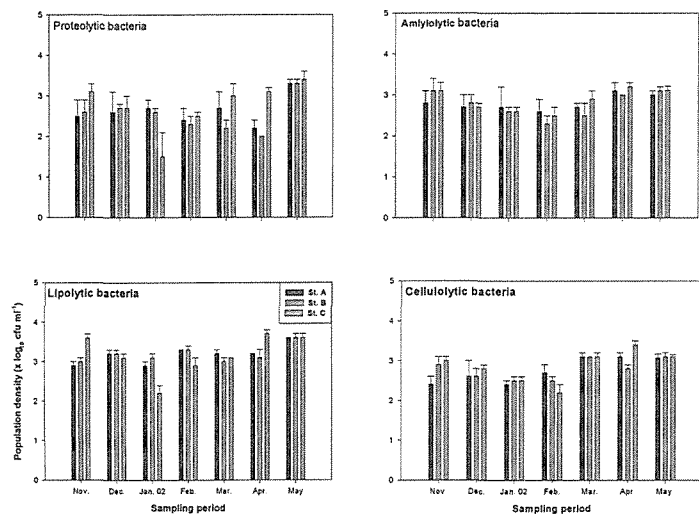
proteolytic bacteria, from $0.2 \pm 0.1 \times 10^3$ to $4.9 \pm 1.3 \times 10^3$ cfu ml^{-1} for lipolytic bacteria, and from $0.2 \pm 0.1 \times 10^2$ to $2.7 \pm 0.7 \times 10^3$ cfu ml^{-1} for cellulolytic bacteria during survey periods, respectively (Fig. 8).

The proportions of amylolytic, proteolytic, lipolytic, and cellulolytic bacteria to total heterotrophic bacteria were between 7 ～ 91%, 6 ～ 91%, 27 ～ 411%, and 8 ～ 96%, respectively. Among the measured numbers of physiological groups, lipolytic bacteria showed the highest population density. However, the numbers of amylolytic, proteolytic, and cellulolytic bacteria showed the similar tendency.

Fig. 8. The distribution of physiological groups of bacteria at the artificial Lake Keumgang during survey period.

It carried out the correlation analysis to find out the factors that determined the distribution of heterotrophic and physiological groups of bacteria. As shown in Table 2, the numbers of heterotrophic bacteria were closely correlated to water temperature and physiological groups of bacteria showed negative correlation with dissolved oxygen.

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