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BACTERIOLOGICAL WATER QUALITY OF LAKE EUI-AM

*Sang Choe and Geon Chee Kim**

Fishery Resources Lab., Korea Institute of Science and Technology, Seoul, Korea

ABSTRACT

A year-long survey of bacteriological water quality for Lake Eui-am in Kang-won Province, Korea, was conducted from June 1970 to May 1971. The purpose of this investigation was:

1) to determinate the seasonal prevalence of fecal pollution bacteria, such as coliforms, fecal coliforms and enterococci, in Lake Eui-am; 2) to correlate these findings with associated microbiological parameters; and 3) to interpret these results with respect to water quality and environmental health. The membrane filter techniques were used, for the determination of these bacteria.

Densities of total coliforms, fecal coliforms and enterococci exhibited seasonal variations, the numbers of these fecal pollution bacteria being high in summer and fall months in close possitive relation to the amount of rainfall, and being low winter and spring months. On the whole, the level of fecal pollution bacteria in Lake Eui-am is yet quite low. There were not any evident correlation among the density of these pollution bacteria. The ratio of fecal coliforms to enterococci of the lake water varied from 0.01 to 4.25 with average of 1.47.

INTRODUCTION

In previous paper, Choe and Kwak(1971) reported upon the chemical water quality of Lake Eui-am. Concurrently with this investigation, during the period of June 1970 to May 1971, monthly fecal pollution bacteria densities were determined at the same station of the dates in Lake Eui-am.

Coliform organisms and enterococci are present in considerable quantities in the feces of man and other animals. They are always found in sewage and in waters contaminated by sewage. According to Hanes and Fragala (1967), and Choe and Kim (1970), these fecal pollution bacteria are capable of survival in open waters for a sufficient time. The coliform group includes *Escherichia coli* which is the principal indicator of fecal pollution. The other principal coliform organism is the *Aerobacter aerogenes* which is found most frequently on grains and plants but may occur in the feces of man and other animals. On the other hand, the presence of bacteria from the enterococcus group indicates the pollution from warm-blooded animals. In recent years, occurrence of fecal streptococci is used increasingly as one bacteriological measurement of stream pollution (Litsky et al., 1955; Rosebery, 1964; Geldreich and Kenner, 1969). These are not pathogenic, however, the occurrences in large quantities of these organisms are interpreted as a positive proof of fecal pollution of man and warm-blooded animals.

In Korea, informations regarding the nature and sources of variations in bacterial densities in surface waters has been largely unavailable. The horizontal and vertical distributions of fecal pollution bacteria on summer month (August) in Lake Eui-am were already reported (Choe and Kim, 1970). This study was undertaken, concurrently with chemical water quality survey and primary

* Present adress: Dong-A Pharmaceutical Company, Seoul, Korea.

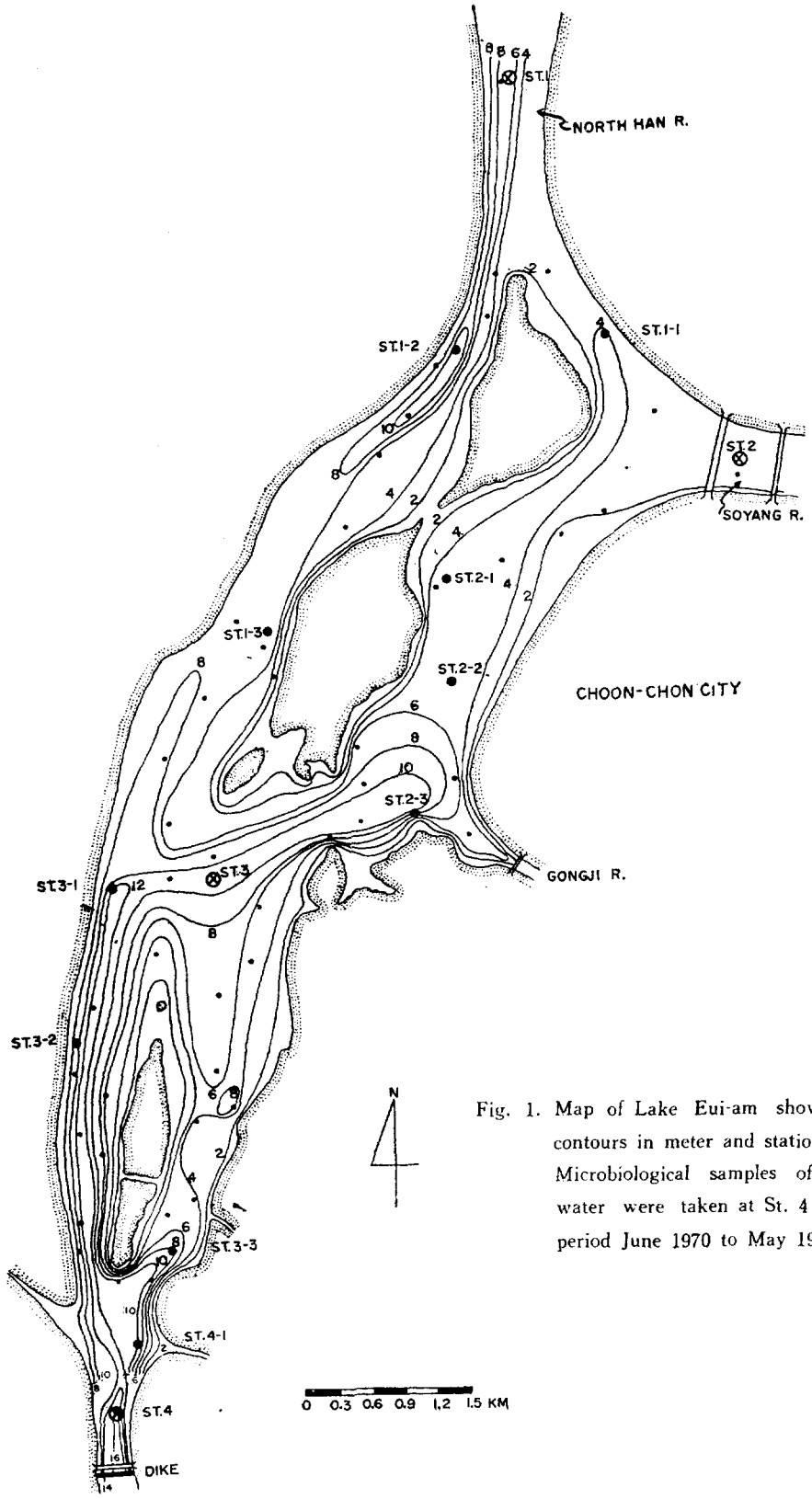

Fig. 1. Map of Lake Eui-am showing depth contours in meter and station locations. Microbiological samples of the lake water were taken at St. 4 during the period June 1970 to May 1971.

production studies of Lake Eui-am, to gain the nature of occurrences of various groups of pollution bacteria over a period of one year. In this paper, the monthly occurrences of total coliform, fecal coliform and enterococcus in the lake water are presented.

MATERIALS AND METHODS

A description of the lake and study area were presented in the previous paper (Choe and Kwak, 1971). Monthly series of bacteriological samples of the lake water were taken at one permanent station during the period of June 1970 to May 1971. The station is located in the deepest basin of 18m depth apart 600 m from the dam (Fig. 1).

Bacteriological water sampling was performed with the sterile Kitahara water sampler at the depths of 30 cm (surface) and bottom. Collected water samples were placed in sterile 1 L polyethylene bottles and were brought back to the laboratory within two hours after sampling, and processed immediately upon arrival at the laboratory.

Total coliform, fecal coliform and enterococcus densities of water samples were determined by the membrane filter technique.

Total Coliform Determination. The method for determining total coliform was conducted to Standard Methods (A.P.H.A., 1965), using M-Endo Broth (Difco) with incubation at 37°C for 18 hours.

Fecal Coliform Determination. The method employed for the determination for fecal coliforms was that of Geldreich et al.(1965), using M-FC Broth with incubation at 44.5°C for 18~24 hours.

Enterococcus Determination. The method for determining enterococci was conducted to Standard Methods(A.P.H.A., 1965), using M-Enterococcus Agar (Difco) with incubation at 37°C for 48 hours.

RESULTS

The monthly data for occurrences of fecal po-

Table 1. Total coliforms, fecal coliforms and enterococci densities at the lower Lake Eui-am, June 1970 ~ May 1971.

(counts per 100 ml of sample)

Date	Total Coliforms		Fecal Coliforms		Enterococci		F. Coli/Ent.	
	Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Bottom
Jun. 12, 1970	51	61	33	8	13	33	2.54	0.24
Jun. 24	7	23	3	18.4	22	9.5	0.14	1.94
Jul. 27	10.6	41.3	4.3	30	0	9.3	—	3.23
Aug.14	75	150	0	62.5	0.5	18	—	3.47
Sep. 23	400	500	45	91	25	114	1.80	0.80
Oct. 22	300	44	2	1	3.5	5.5	0.57	0.18
Nov. 28	43	1,115	1.3	122	30	523	0.04	0.23
Dec. 18	34	47	2	4	21	25	0.10	0.16
Jan. 26, 1971	15	44	0	0	2	6	—	—
Feb. 24	4	212	0	0.3	0.3	75	—	0.01
Mar. 22	73	96.5	0	0	0.5	1	—	—
Apr. 30	60	38	2.5	8.5	0	2	—	4.25
May 18	64	21	5	8.5	0	1.5	—	1.67
Range	4-400	21-1,115	0-45	0-122	0-30	1-523	0.04-2.54	0.01-4.25
Mean	87.4	186.8	7.6	27.3	9.1	63.3	0.87	1.47

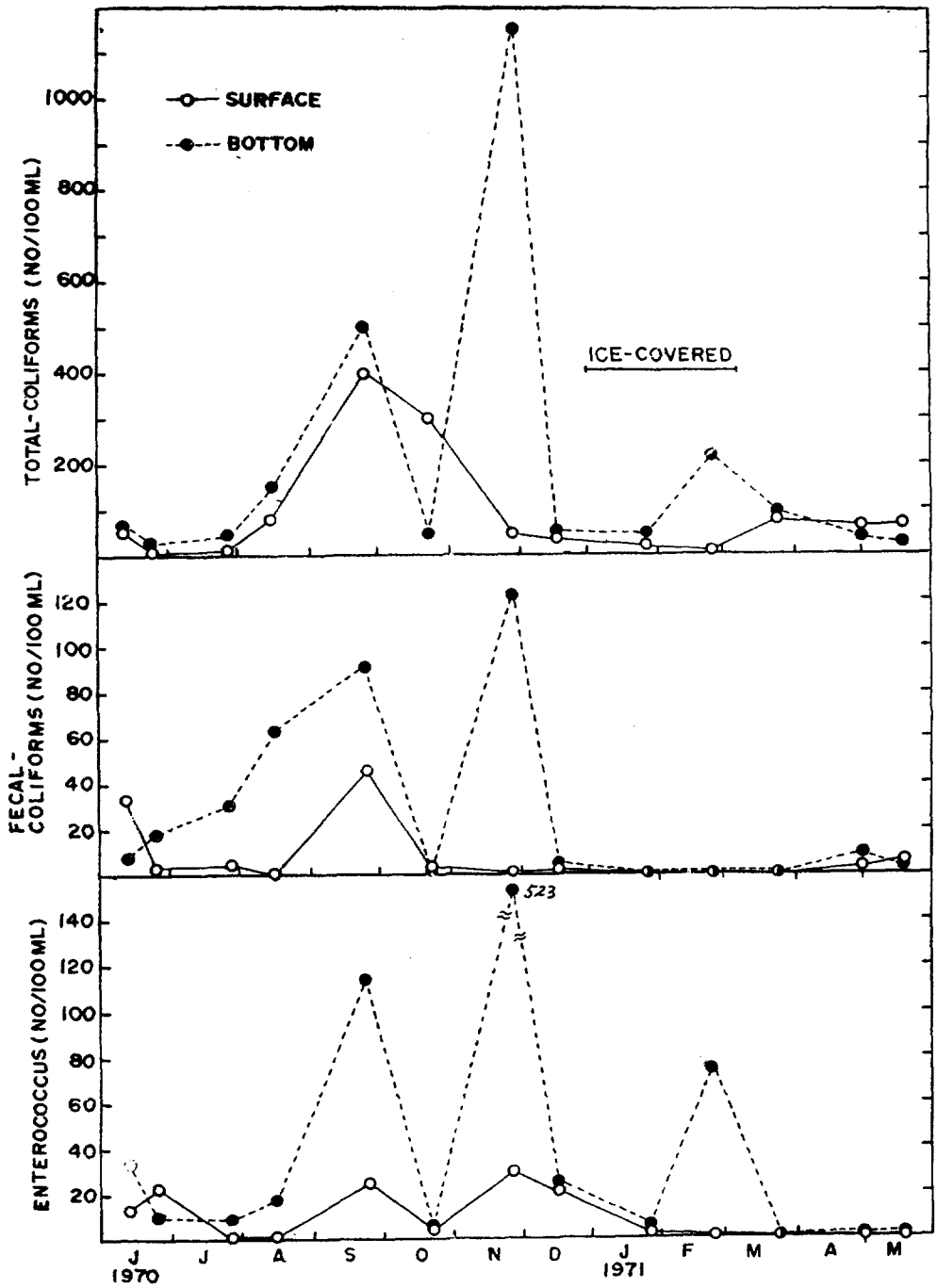

Fig. 2. Seasonal variations of fecal pollution bacteria in the deep site of Lake Eui-am during the period June 1970 to May 1971.

llution bacteria gathered between June 1970 and May 1971 from the lower Lake Eui-am is shown in Table 1. Monthly occurrences of total coliform, fecal coliform and enterococcus organisms from the lake water are presented in Fig. 2.

Total coliform densities varied from 4 to 400

organisms per 100 m*l* of sample water (averaging 87.4 organisms per 100 m*l* of sample water) in the surface, from 21 to 1,150 organisms per 100 m*l* (averaging 186.8 organisms) in the bottom.

Fecal coliform densities varied from zero to 45 organisms per 100 m*l* (averaging 7.5 organisms) in the surface, from zero to 122 organisms per 100 m*l* (averaging 26.8 organisms) in the bottom.

On the other hand, enterococcus densities varied from zero to 30 organisms per 100 m*l* (averaging 9.1 organisms) in the surface, from 1 to 523 organisms per 100 m*l* (averaging 63.3 organisms) in the bottom. These fecal pollution bacterial densities were all but consistently higher at the bottom than at the surface.

There are considerably apparent seasonal variations in total coliform, fecal coliorm and enterococcus organisms, with high values in summer

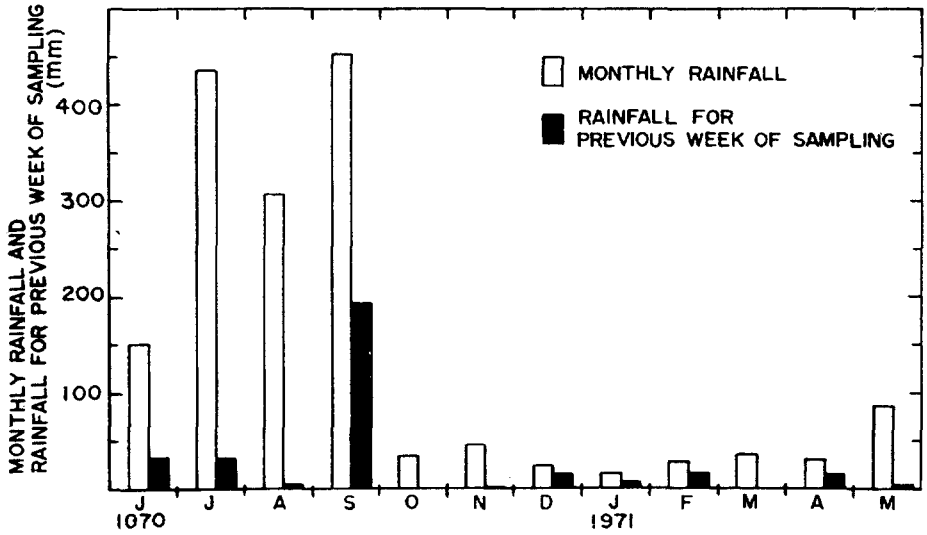

Fig. 3. Monthly rainfall amount and rainfall for previous week of sampling at Choon-chon area.

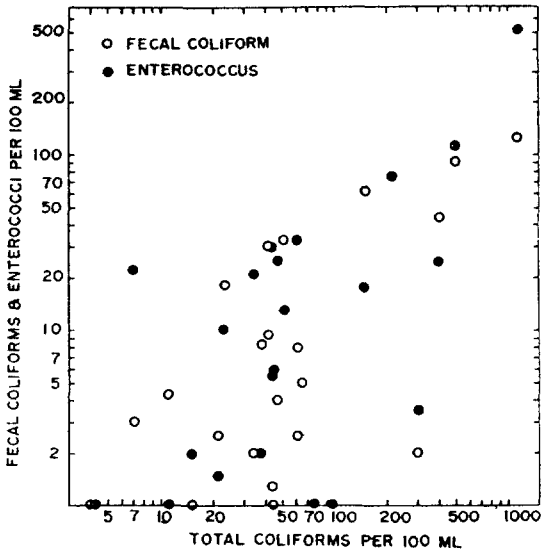

Fig. 4. Relationships of observed total coliforms to observed fecal coliforms and enterococci for the monthly survey.

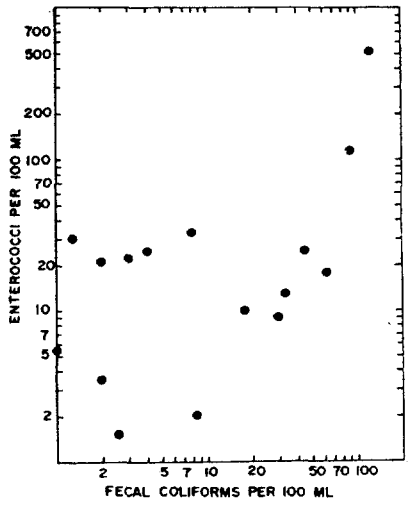

Fig. 5. Relationship of observed fecal coliforms to observed enterococci for the monthly survey.

and fall months. The amounts of monthly total rainfall and of rainfall for the week previous to the sampling in Choon-chon area are shown in Fig. 3. The bacterial densities within the lake are affected by the amounts of runoff waters, especially during the summer and fall. An explanation for the November and February peaks of pollution bacteria at the bottom water is not obvious, but it may reflect an unusual input some fecal pollutants to the lake.

The ratios of fecal coliforms to enterococci ranged between 0.04 and 2.54 in the surface, 0.01 and 4.25 in the bottom. These ratios were varied with season. In general the ratio is higher in spring and summer months, lower in fall and winter months. There are no apparent relationships in occurrence among total, fecal coliforms and enterococcus organisms (Fig. 4 and 5).

DISCUSSION

It is now universally accepted that the presence of fecal coliform and enterococcus organisms in streams usually indicate fecal pollution, and their absence would suggest little or no warm-blooded animal pollution present.

On the whole, the level of fecal pollution bacteria in Lake Eui-am is yet quite low. The surface and bottom mean annual densities of total coliform, fecal coliform and enterococcus were: 87 and 189 organisms per 100 m*l* of water sample; 8 and 27 organisms per 100 m*l*; and 9 and 63 organisms per 100 m*l* respectively.

There are apparent seasonal variations with higher densities in summer and fall months in close possitive relation to the amount of rainfall. Taylor (1940) concluded that periodic fluctuation in numbers of becteria which took place at all depths were found to be directy correlated with the amount of rainfall which had fallen in the drainage area during the week before samples were taken. Also Wilson (1957) stated that as a rule, rivers and upland surface water contained their greatest numbers of bacteria after heavy rainfall. Results of this investigation, fecal pollution becterial densities in the lake are well correlated with the amounts of monthly total rainfall and the rainfall for previous week of sampling.

The bacterial densities are generally higher at the bottom than at the surface. In study of bacterial density in Forrest Lake, Rosebery (1964) stated that during the summer months the bacterial counts were generally higher with a progression in depth; whereas during the fall, winter and spring, the counts were quite similar at all levels. In previous paper (Choe and Kim, 1970), we also reported fecal pollution bacteria in Lake Eui-am on August were increased number with increase in depth. On this reason, we concluded that the suspended matter with conglomerated bacteria plays an important role in regulating of bacterial densities in summer season at lakes.

The minimum ratio of fecal coliforms to enterococci of the lake water was 0.01, whereas the maximum was 4.25. This ratio is varied with month. In general the ratio is higher in spring and summer months, and lower in fall and winter months. Geldreich and Kenner (1969) concluded that in human feces the fecal coliform to fecal streptococcus ratio was 4.4, whereas ratios for all other warm-blooded animal fecal discharges were less than 0.7. According to Geldreich and Kenner (1969) definition, Lake Eui-am water is dominantly contaminated with human fecal discharges in spring and summer months compare with other months.

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