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CHEMICAL WATER QUALITY OF LAKE EUI-AM

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ABSTRACT

An year-long survey of chemical water quality for Lake Eui-am in Kang-won Province, Korea, was conducted from June 1970 to May 1971 to study the water quality and seasonal variations of productivities in relation to selected physical and chemical environmental factors. A monthly series of water samples were taken at the deepest basin of 18 m depth of the lake. Water quality parameters determined were water temperature, Secchi disc reading (transparency), *p*H, O_2, CO_2, alkalinity, acidity, Cl, hardness, Ca, Mg, total residue, total ignitious residue, COD, BOD_5, nutrients, total-Fe, soluble-Fe, Mn and Cu.

On the whole, the results indicate that the chemical water quality of Lake Eui-am is high, and vary with season. The lake water is characterized that higher levels of dissolved oxygen (8.6 m*l*/L in mean of whole water) or percent saturation of dissolved oxygen (114%), and of nitrate nitrogen (523 μg/L). On the other hand, CO_2 (9.6 ppm), chlorides (3.5 ppm), Ca (7.7 ppm), Mg (2.2 ppm), hardness (28.5 ppm), silica (2.4 ppm) and BOD_5 (1.08 ppm) are quite low. In terms of nutrient levels, the lake water exhibit slight signs of eutrophication. The high values for nitrate nitrogen, soluble iron and Cu of the lake water suggest that there are some imputs such as domestic and industrial discharges to the lake.

INTRODUCTION

The raising of fish in ponds and lakes represents realistic means of rapid providing large quantities of animal protein. In Korea, we have many freshwater reservoirs and man-made lakes for the agricultural irrigation and generating electricity. These reservoirs and man-made lakes, however, are little or no use for fish cultures.

Since Lake Eui-am is one of the most suitable reservoir for fishing, many water supplies for drinking, agricultural and industrial uses and water-dependent outdoor recreations, it is desirable to know qualities of the lake water. For these reasons, we conducted a monthly limnological survey of Lake Eui-am to investigate its physical, chemical, bacteriological water characteristics and primary production, and their relationships in the lake water between June 1970 and May 1971.

From 1968, several investigations for the Lake Eui-am were carried out by several workers. These are some chemical and physical studies of the lake water (Hong *et al.*, 1969), vernal changes of phytoplankton in the lake (Chung, 1969), faunal study of the zooplankton in the lake (Kang, 1969), fish population study of the lake (Choi, 1969), concentration and distribution of iron in the lake water (Choe and Kwak, 1970), and occurrence of fecal pollution bacteria of the lake water in summer (Choe and Kim, 1970). But no studies for year-round physical, chemical, and bacteriological water qualities nor any primary productivity determinations for the lake water were made.

The results of physical, chemical, bacteriological and photosynthetic characteristics of the lake water are very valuable for fish production in the lake and various other uses for the lake water resource, and also to provide base-line data for future monitoring of pollution or eutrophication of the lake water. In this paper, the physical and chemical water qualities for Lake Eui-am are presented, and bacteriological water quality and primary productivities of the lake water are discussed in another papers (Choe and Kim, 1971).

DESCRIPTION OF THE LAKE

Lake Eui-am is located in Choon-chon City, Kang-won Province, about 90 km northeast of Seoul. This lake is one of the large man-made impoundment for generating electricity which had been constructed in the year of 1967 intercepting the main stream of north Han River. So that the lake is very young, and the shape of lake is relatively narrow (max. 2.2 km) and long (about 9.5 km). Lake Eui-am watershed totals 15.8 km^2 and has a pondage of approximately 84×10^6 m^3, and 340 m^3 per second of the lake water are discharged continuously for generating electricity. This means the total lake water is refreshed in the every three days by calculation.

Choon-chon City has a population of approximately 130,000. The municipal sewage system of the city provide little or no treatment of wastes. In addition to the municipal waste load, the waste from industrial complexes adjacent to the lake were directly discharged in to the lake water. These significant industrial wastes come from one brewing industry, one confectionary, two textile industries and one corn milling. Many of these industries provide little or no waste treatment prior to discharge.

MATERIALS AND METHODS

Monthly series of physical and chemical 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 18 m depth apart 600 m from the dam (Fig. 1). Surface water samples were taken from 30 cm under the surface by using a polyethylene water sampling bottle, and bottom water samples were collected by the syphon method using a polyethylene tube. Water samples were stored in 4 L colored polyethylene containers and were brought back to the laboratory within two hours after sampling. Dissolved oxygen, carbon dioxide, acidity and alkalinity were analysed in the field. Water samples for analyses of major ions and trace elements were quick-freezed at -20°C, and usually all analyses were completed within two day. All colorimetric analytical determinations were performed on a Beckman Model DU-2 spectrophotometer.

Water Temperature. Water temperature was determined at the time of sampling using a mercury thermometer to the nearest 0.1°C.

Transparency. The depth of Secchi disc reading was presented as transparency. The Secchi disc reading was made with a disc of 25 cm diameter painted black and white in alternate quadrants.

Hydrogen Ion Concentration. *p*H measurement was taken with a Beckman Expandomatic *p*H meter.

Dissolved Oxygen. O_2 concentration was determined by the Winkler method.

Carbon Dioxide. Free CO_2 concentration was determined by titrimetric method in Standard Methods (A. P. H. A., 1965).

Acidity. Phenolphthalein acidity was determined by titration with phenolphthalein indicator.

Alkalinity. Methyl red alkalinity was determined by titration with methyl red indicator.

Hardness, Calcium and Magnesium. Hardness, Ca and Mg were determined by titration

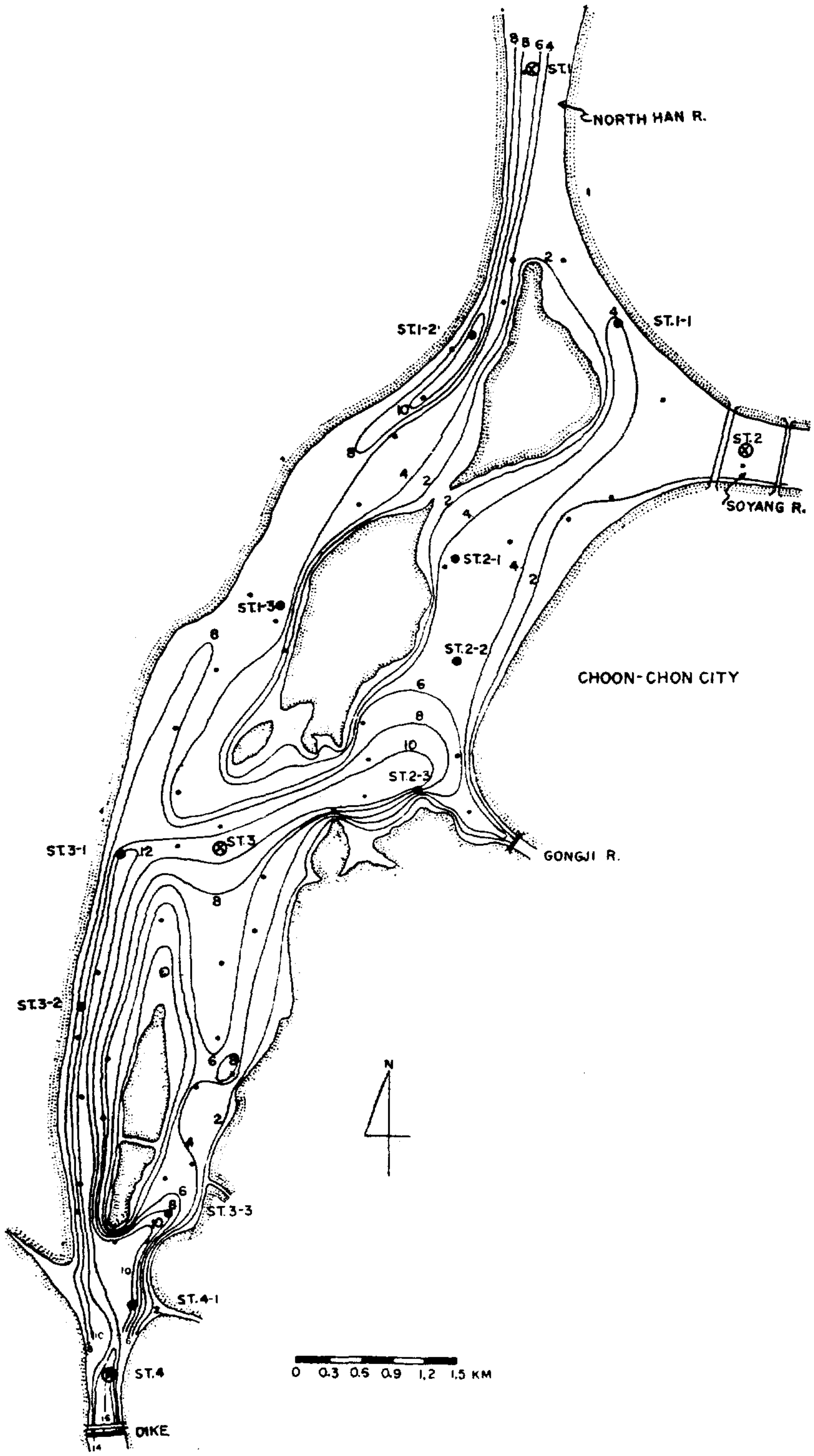

Fig. 1. Map of Lake Eui-am showing depth contours in meter and station locations. Water samples for the chemical water quality were taken at St. 4 during the period June 1970 to May 1971.

with EDTA using Eriochrome Black T and NANA as the respective indicators.

Chloride. Cl was determined by titration with mercuric thiocyanate and ferric alum (Utsumi, 1952).

Chemical Oxygen Demand. COD was measured by titration with potassium permanganate.

Biochemical Oxygen Demand. Five day BOD's was performed using the techniques outlined in Standard Methods (A. P. H. A., 1965).

Total Residue and Total Ignitious Residue. Total residue was determined by evaporation at 103°C, and total ignitious residue by heating the total residue at 600°C for 1 hour.

Ammonia. NH_4—N was determined with Richards and Kletsch method as described by Strickland and Parsons (1968).

Nitrite. NO_2—N was determined with Shinn method as described by Strickland and Parsons (1968).

Nitrate. NO_3—N was determined with modified Mullin and Riley method according to the procedures described by Strickland and Parsons (1960).

Phosphate. PO_4—P was determined with Murphy and Riley method as described by Strickland and Parsons (1968).

Silica. SiO_2—Si was determined with modified Mullin and Riley method according to the procedures described by Strickland and Parsons (1968).

Soluble Iron and Total Iron. Soluble Fe and total Fe were determined by the *o*-Phenanthroline procedures in Standard Methods (A. P. H. A., 1965).

Manganese. Mn was determined by formaldoxim method (Goto *et al.*, 1962).

Copper. Cu was determined by diethyl-dithiocarbamic acid with solvent extraction (CCl_4).

RESULTS

The results of this investigaiton are presented in Table 1. Seasonal variations of water temperature, transparency, *p*H, dissolved oxygen, percent saturation of dissolved oxygen and carbon dioxide are shown in Fig. 2.

Water Temperature. The water temperature was measured under the ice during the ice-covered period from the end of December to early in March. Water temperature curves display the expected seasonal variation. The water temperature ranged between 1° and 29°C (averaging 15.0°C) in the surface, 3° and 21.5°C (averaging 12.3°C) in the bottom. In August the maximum temperature and in February the minimum temperature were recorded.

Transparency. The transparency (the Secchi disc reading) curve shows conspicuous seasonal change, low values in summer months, high values in winter months with the range of 0.8 and 5 meters. The variation in transparency reflects the inverse relationship with water temperature.

Hydrogen Ion Concentration. *p*H values ranged between 5.8 and 7.8 (averaging 6.9) in the surface, 5.6 and 7.5 (averaging 6.8) in the bottom. *p*H values are higher in spring months, and lower in winter months.

Dissolved Oxygen and Oxygen Percent Saturation. Dissolved oxygen curves display the expected seasonal variation. The oxygen content of lake water is quite healthy, never decreased below the level of 6.0 m*l*/L. The concentration of dissolved oxygen as well as the percent saturation was almost consistently higher at the surface than at the bottom. The percent saturation of dissolved oxygen is always greater than 100% without at the bottom in summer months. The observed upper limit for oxygen percent saturation of the lake water was 158, the lower limit for dissolved oxygen was 80% saturation. The super-saturation in spring months is thought to result from a spring algal bloom. The variation

Table 1. Chemical water quality of Eui-am lake water. Mean concentrations of the each water parameter are based on the averages of 12 monthly surveys (June 1970—May 1971).

Parameter	Unit	Surface Water		Bottom Water		Whole Water	
		Range	Mean	Range	Mean	Range	Mean
W.T.	°C	1.0—29.0	15.0	3.0—21.5	12.3	1.0—29.0	13.7
*p*H		5.8— 7.8	6.9	5.6— 7.5	6.8	5.6— 7.8	6.8
Transparency	m	—	—	—	—	0.8— 5.0	2.7
O_2	m*l*/L	6.27—12.54	8.77	5.97—10.85	8.44	5.97—12.54	8.61
O_2 Sat.	%	104.2—142.3	118.4	79.7—157.5	109.2	79.7—157.5	113.8
Free CO_2	ppm	5.2—17.6	8.1	6.0—19.8	11.1	5.2—19.8	9.6
P-Acidity	$CaCO_3$ ppm	5.75—20.13	9.21	6.77—22.60	12.56	6.77—22.60	10.89
M-Alkalinity	$CaCO_3$ ppm	16.01—34.51	23.97	18.49—35.09	27.11	16.01—35.09	25.54
HCO_3	ppm	19.53—42.07	29.24	22.54—42.07	33.00	19.53—42.07	31.12
Hardness	$CaCO_3$ ppm	18.5—35.1	26.9	17.5—36.0	30.0	17.5—36.0	28.5
Ca	ppm	4.94—9.60	7.18	4.86—10.98	8.23	4.86—10.98	7.71
Mg	ppm	1.10—2.72	2.20	1.30—3.06	2.27	1.10—3.06	2.24
Mg/Ca		0.20—0.42	0.31	0.20—0.38	0.28	0.20—0.42	0.30
Cl	ppm	1.9—6.7	3.6	1.6—5.6	3.4	1.6—6.7	3.5
Total-Res.	ppm	47—124	72	49—154	88	47—154	75
Total-Ig.-Res.	ppm	13—91	34	7—136	47	7—136	40.5
COD	ppm	0.83—5.23	3.51	0.91—5.67	3.43	0.83—5.67	3.47
BOD_5	O_2 ppm	0.09—3.96	1.15	0.26—1.95	1.00	0.09—3.96	1.08
NH_4-N	μg/L	1.4—34.0	20.6	1.8—65.5	27.8	1.4—65.5	24.2
NO_2-N	μg/L	1.1—6.9	3.9	1.0—5.3	2.7	1.0—6.9	3.3
NO_3-N	μg/L	250—910	526	290—770	521	250—910	523
Total Inorg.-N	μg/L	280—930	552	330—780	551	280—930	551
PO_4-P	μg/L	3—16	6.3	6—22	8.6	3—22	7.5
SiO_2-Si	ppm	0.82—3.52	2.41	0.86—3.43	2.33	0.82—3.52	2.37
Total-Fe	μg/L	73.7—605.2	259.9	62.4—1938.5	426.2	62.4—1938.5	343.1
Sol.-Fe	μg/L	31.4—161.4	83.1	36.6—175.9	81.4	31.4—175.9	82.3
Part.-Fe	μg/L	5.2—443.8	176.8	5.2—1850.7	344.9	5.2—1850.7	260.9
Fe^{+2}	μg/L	3.5—63.4	30.6	15.9—68.6	38.1	3.5—68.6	34.3
Fe^{+3}	μg/L	9.3—117.7	50.2	20.4—145.5	43.3	9.3—145.5	46.8
Mn	μg/L	3.6—85.0	34.3	1.2—83.3	35.1	1.2—85.0	34.7
Cu	μg/L	0.6—10.7	3.3	0.02—3.2	1.6	0.02—10.7	2.5

in dissolved oxygen reflects the inverse relationship with water temperature.

Carbon Dioxide. Free CO_2 concentrations varied from 5.2 to 17.6 ppm (averaging 8.1 ppm) in the surface, from 6.0 to 19.8 ppm (averaging 11.1 ppm) in the bottom, consistently greater in bottom water than in surface water. There is no apparent seasonal variation in CO_2 concentration.

Seasonal variations of total residue, total ignitious residue, acidity and alkalinity are shown in Fig. 3.

Total Residue and Total Ignitious Residue. Values of total residue varied from 47 to 124 ppm (averaging 72 ppm) in the surface, from 49 to 154 ppm (averaging 88 ppm) in the bottom. Values of total ignitious residue varied from 13 to 91 ppm (averaging 34 ppm) in the surface, from 7 to 136 ppm (averaging 47 ppm) in the bottom.

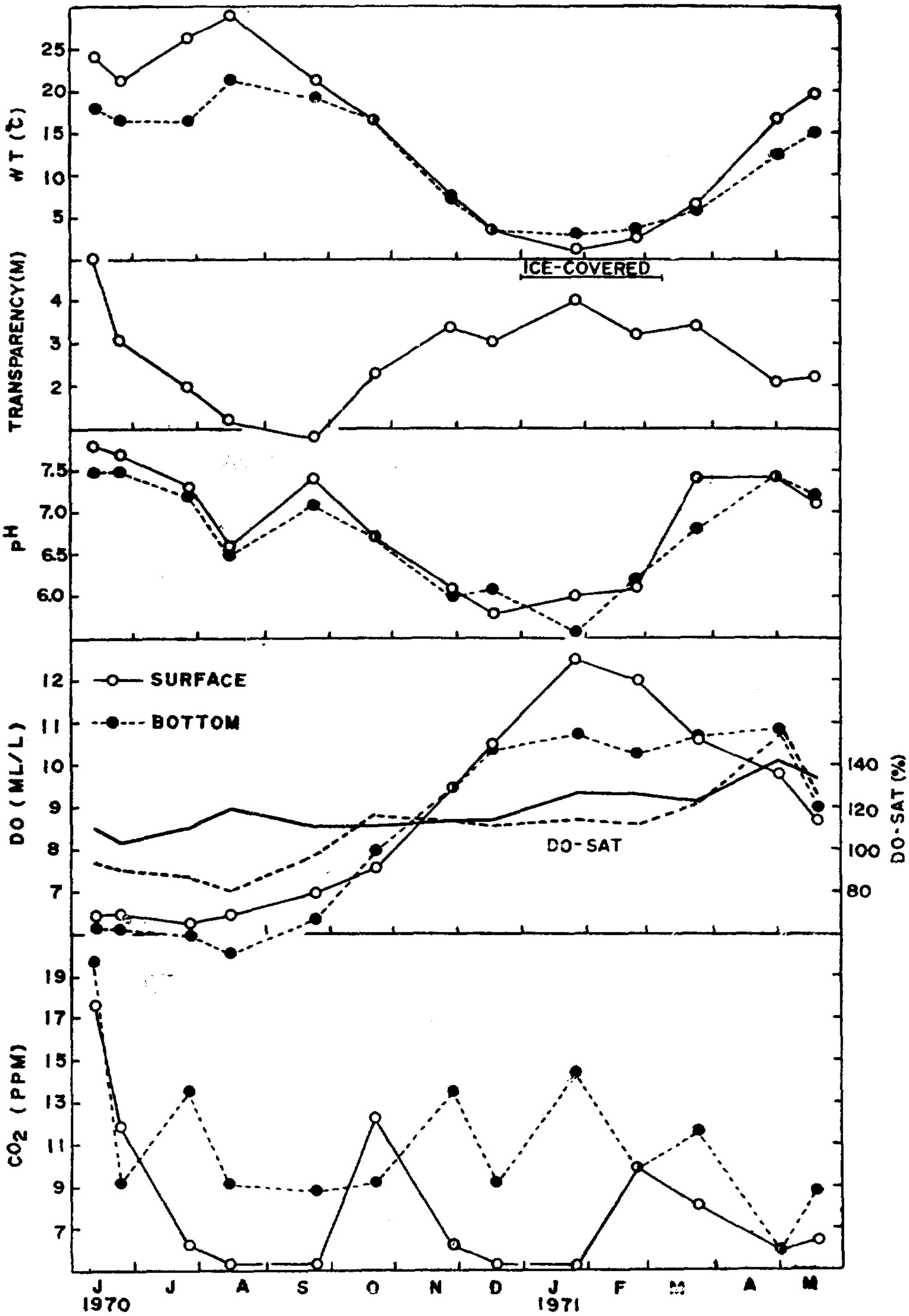

Fig. 2. Seasonal variations of water temperature, transparency, *p*H, dissolved oxygen, carbon dioxide in the deep site of Lake Eui-am during the period June 1970 to May 1971.

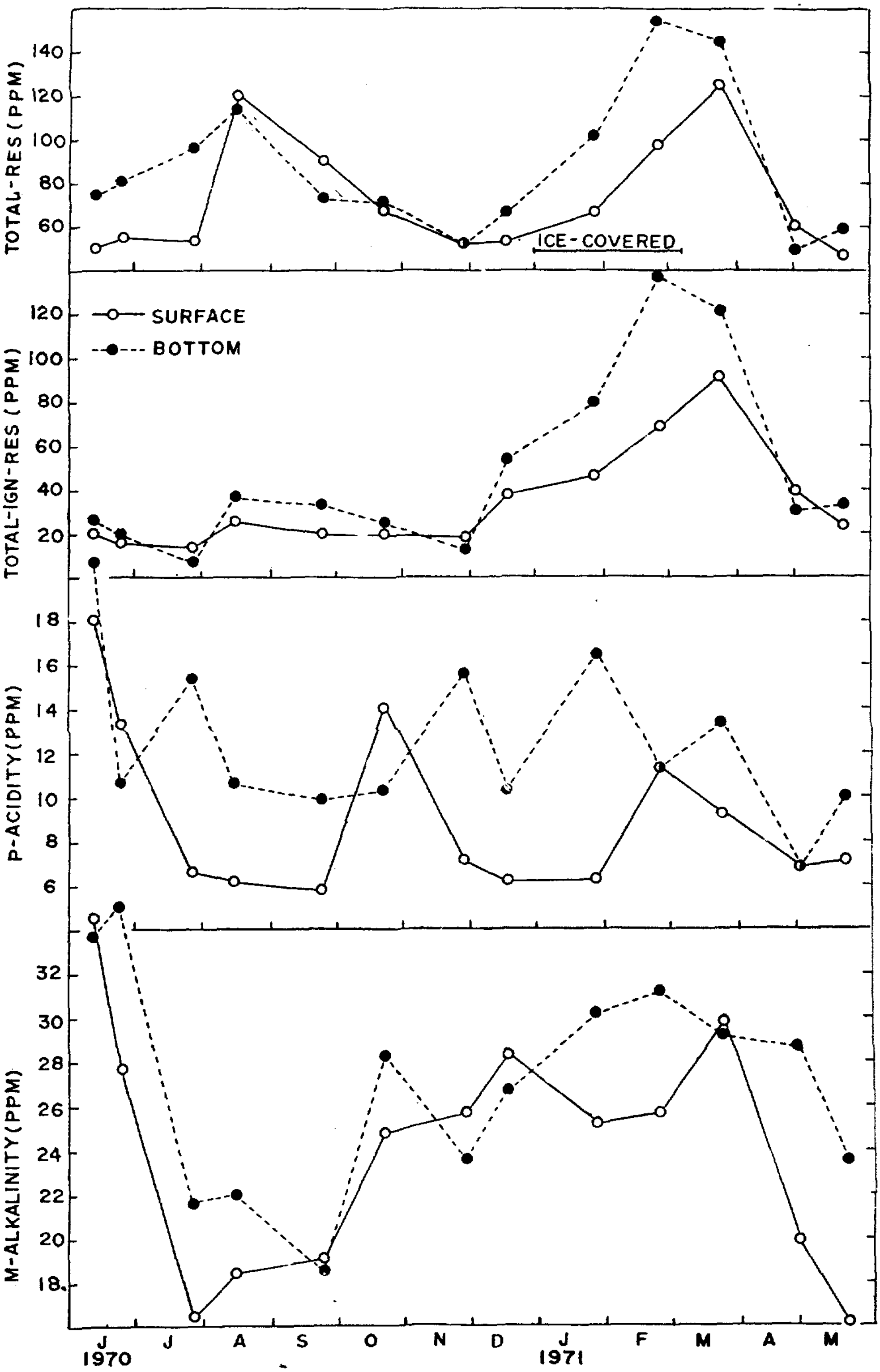

Fig. 3. Seasonal variations of total residue, total ignitious residue, P-acidity and M-alkalinity in the deep site of Lake Eui-am during the period June 1970 to May 1971.

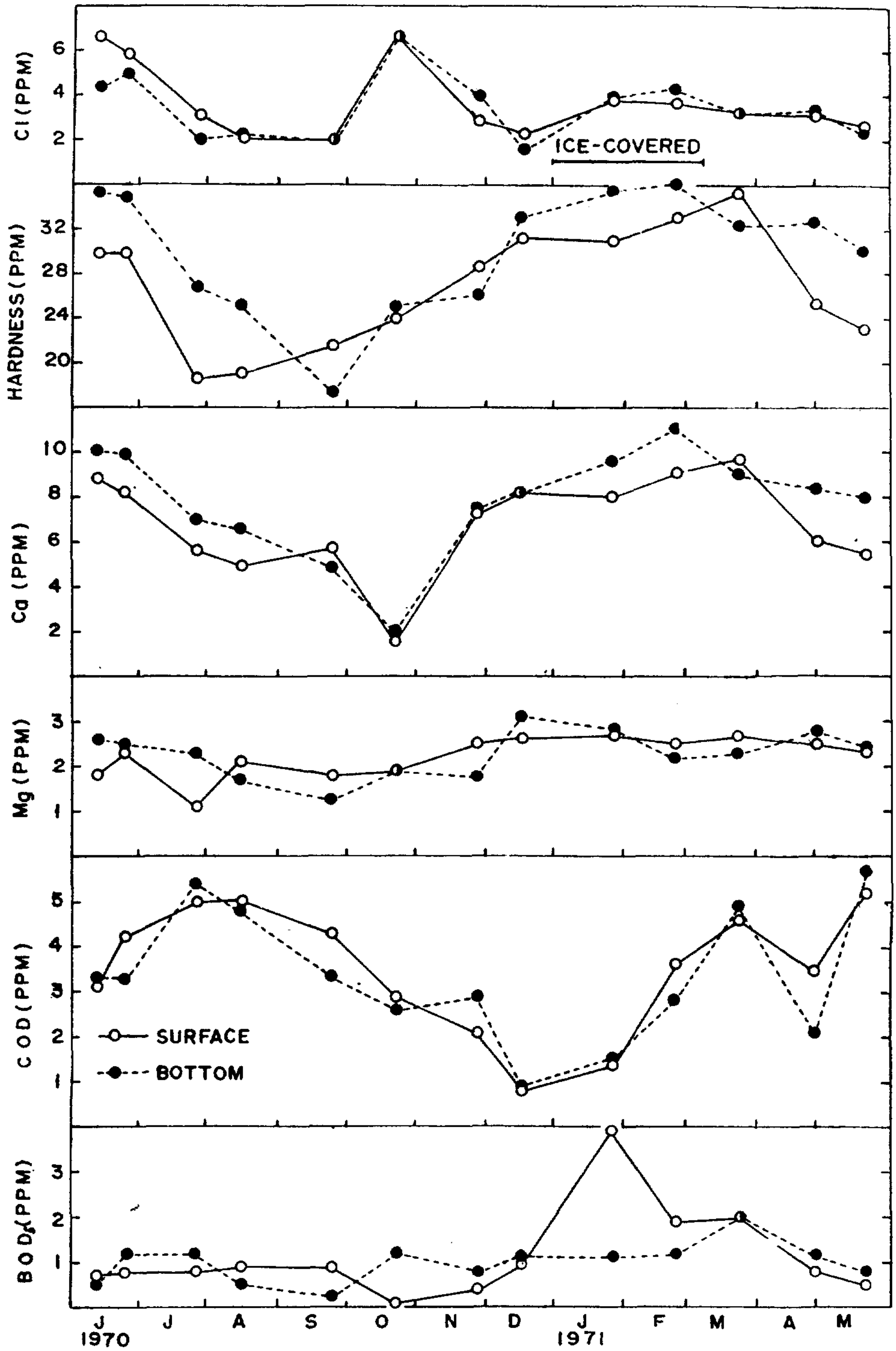

Fig. 4. Seasonal variations of Cl, hardness, Ca, Mg, COD and BOD_5 in the deep site of Lake Eui-am during the period June 1970 to May 1971.

The seasonal variations in concentrations of total residue and total ignitious residue were very similar; with high concentrations in rainy and thawing seasons, and low in spring and fall months. Both concentrations were consistently greater at the bottom than at the surface. Total residue and total ignitious residue in the lake were in general rather low with values seldom exceeding 120 ppm.

Acidity. Phenolphthalein acidity varied from 5.75 to 20.13 ppm (averaging 9.21 ppm) in the surface, from 6.77 to 22.60 ppm (averaging 12.56 ppm) in the bottom. There is close possitive relation with the CO_2 content and no seasonal variation is found.

Alkalinity. Values of methyl-red alkalinity varied from 16.01 to 34.51 ppm (averaging 23.97 ppm) in the surface, from 18.49 to 35.09 ppm (averaging 27.11 ppm) in the bottom. The seasonal variation of alkalinity show close possitive relation with *p*H and hardness. In general, a decrease in *p*H permit a greater solubility of carbonates, and an increase in alkalinity and hardness. However, rainfalls following a decrease in *p*H, and this again reflects a dilution effect resulting in lower carbonates. Alkalinity is higher during fall and winter months whereas *p*H is lower during the same period.

Seasonal variations of chlorides, hardness, calcium, magnesium, COD and BOD_5 are shown in Fig. 4.

Chlorides. Concentrations of chloride varied from 1.9 to 6.7 ppm (averaging 3.6 ppm) in the surface, from 1.6 to 5.6 ppm (averaging 3.4 ppm) in the bottom, and seasonal variation is not obvious. The chloride in the lake was in general very low with values seldom exceeding 6 ppm.

Hardness, Calcium and Magnesium. Values of hardness varied from 18.5 to 35.2 ppm (averaging 26.9 ppm) in the surface, from 17.5 to 36.0 ppm (averaging 30.0 ppm) in the bottom, with low values in the rainy season, and high values in the thawing season. Calcium concentrations which closely paralleled the changes in hardness varied from 4.94 to 9.60 ppm (averaging 7.18 ppm) in the surface, from 4.86 to 10.98 ppm (averaging 8.23 ppm) in the bottom. Magnesium concentrations varied from 1.10 to 2.72 ppm (averaging 2.20 ppm) in the surface, from 1.30 to 3.06 ppm (averaging 2.27 ppm) in the bottom. Both calcium and magnesium concentrations of the lake water were slightly lower in summer and fall months, and higher in winter and spring months. It is notable that concentrations of 36 ppm hardness, 11 ppm calcium and 3 ppm magnesium for the lake water are close to the maximum annual limits. In general, these are extremely low values. On the other hand, the concentration of magnesium showed one of the least variation of examined water quality parameters in this study.

Chemical Oxygen Demand. COD's values varied from 0.83 to 5.23 ppm (averaging 3.51 ppm) in the surface, from 0.91 to 5.67 ppm (averaging 3.43 ppm) in the bottom, with higher values in spring and summer months, and lower values in fall and winter months. This is due to the variation of organic matters in the lake water.

Biochemical Oxygen Demand. 5 day BOD's values varied from 0.09 to 3.96 ppm (averaging 1.15 ppm) in the surface, from 0.26 to 1.95 ppm (averaging 1.00 ppm) in the bottom. During the period of spring, summer and fall months, BOD_5 values of the lake water were less than 1.2 ppm. In winter months, surface BOD_5 values were slightly higher. On the whole, BOD_5 levels of Lake Eui-am are quite low (less than 2 ppm). Also the BOD_5 value showed one of the least variation of the examined water quality parameters in this study.

Seasonal variations of ammonia nitrogen, nitrite nitrogen, nitrate nitrogen, total inorganic nitrogen,

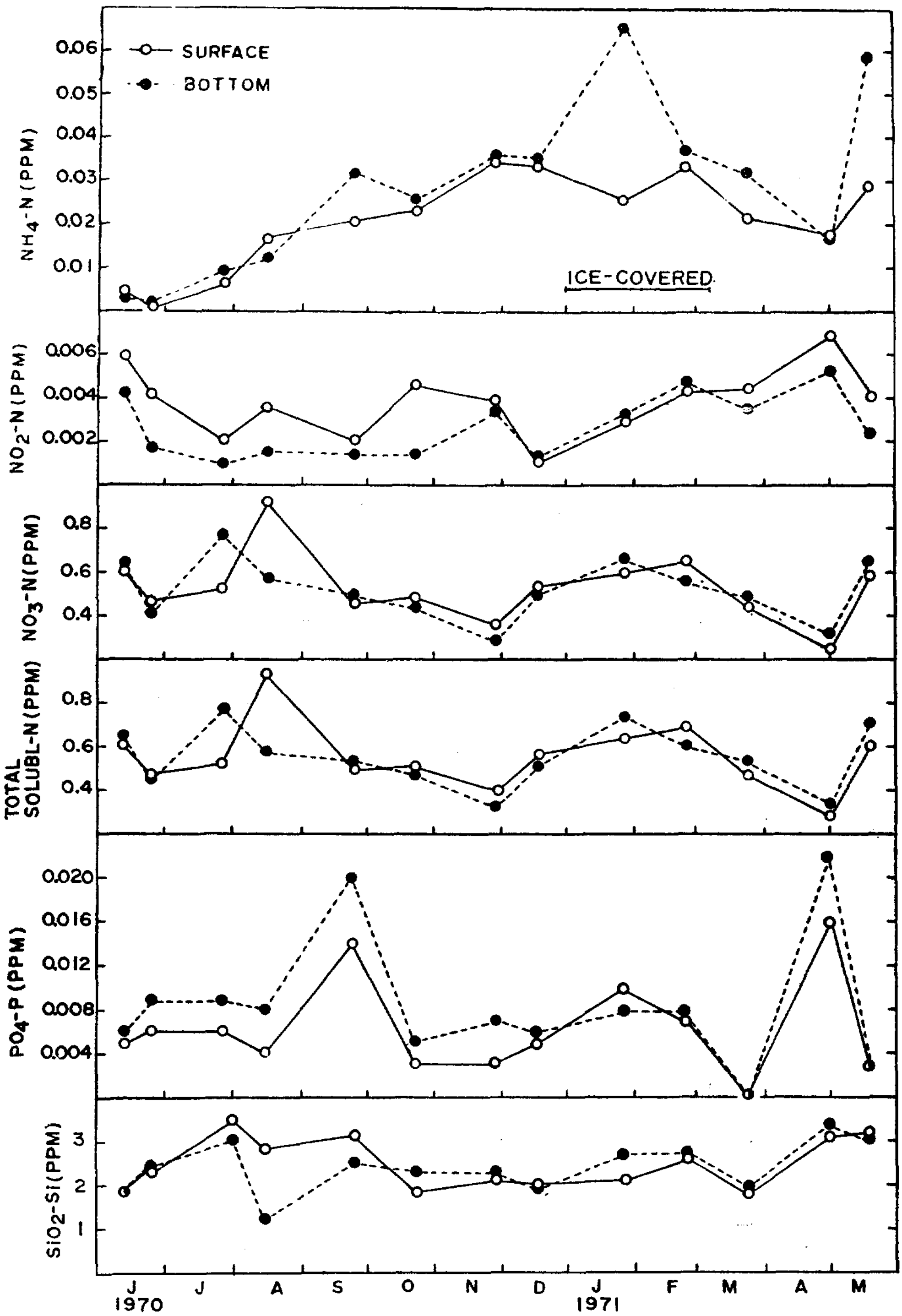

Fig. 5. Seasonal variations of nutrients in the deep site of Lake Eui-am during the period June 1970 to May 1971.

phosphate phosphorus and silica concentrations are shown in Fig. 5.

Nutrients. The surface and bottom concentrations of NH_4-N, NO_2-N, NO_3-N and total inorganic N were: 1.4-34.0 μg/L (averaging 2.06 μg/L) & 1.8-65.5 μg/L (averaging 27.8 μg/L); 1.1-6.9 μg/L (averaging 3.9 μg/L) & 1.0-5.3 μg/L (averaging 2.7 μg/L); 250-910 μg/L (averaging 526 μg/L) & 290-770 μg/L (averaging 521 μg/L) and 280-930 μg/L (averaging 552 μg/L) & 330-780 μg/L (averaging 551 μg/L) respectively. These soluble nitrogen nutrients are rather uniformly distributed from surface to bottom, and maximum annual levels are 66 μg/L NH_4-N, 7 μg/L NO_2-N, 910 μg/L NO_3-N and 930 μg/L total inorganic N. There were no seasonal variations in nutrients of the inorganic nitrogen. Inorganic nitrogen nutrient levels of the lake water were in general rather high with the mean total inorganic nitrogen concentrations seldom dropping 400 μg/L.

Concentrations of phosphate phosphorus varied from 3 to 16 μg/L (averaging 6.3 μg/L) in the surface, from 6 to 22 μg/L (averaging 8.6 μg/L) in the bottom. These were comparatively lower values. Seasonal variation was not obvious although the high values obtained on April and September may have resulted from the vernal and autumnal circulations of the lake.

The concentration of silica varied from 0.82 to 3.52 ppm (averaging 2.41 ppm) in the surface, from 0.86 to 3.43 ppm (averaging 2.33 ppm) in the bottom. These were very low with values seldom exceeding 3.5 ppm, and showed one of the least variation of the examined water quality parameters in this study.

Seasonal variations of soluble iron, particulate iron, total iron, manganese and copper concentrations are shown in Fig. 6.

Iron. The surface and bottom concentrations of soluble iron, particulate iron and total iron were: 31.4-161.4 μg/L (averaging 83.1 μg/L) & 36.6-175.9μg/L (averaging 81.4μg/L); 5.2-443.8 μg/L (averaging 176.8 μg/L) & 5.2-1,850.7 μg/L (averaging 344.9 μg/L) and 73.7-605.2 μg/L (averaging 259.9 μg/L) & 62.4-1,938.5 μg/L (averaging 426.2 μg/L) respectively. The seasonal fluctuations in concentrations of soluble iron, particulate iron and total iron were very similar, with high concentrations in rainy and thawing seasons, low values in late spring, fall and winter months. On the whole, mean concentrations of whole lake water of 82 μg/L soluble iron, 261 μg/L particulate iron and 343 μg/L total iron are considerably high.

Manganese. The concentrations of manganese varied from 3.6 to 85.0 μg/L (averaging 34.3μg/L) in the surface, from 1.2 to 83.8 μg/L (averaging 35.1 μg/L) in the bottom. The seasonal variation of manganese is similar to that of iron. On the whole manganese level of Eui-am lake water is relatively high.

Copper. The concentrations of copper varied from 0.6 to 10.7 μg/L (averaging 3.3 μg/L) in the surface, from 0.02 to 3.2 μg/L (averaging 1.6 μg/L) in the bottom. There was no seasonal variation in copper content, and the concentration was consistently higher at the surface than at the bottom. The high value at the surface suggests that an industry discharges some copper pollutants.

DISCUSSION

The Lake Eui-am is one of the large man-made impoundment, which was constructed in 1967. The major tributaries, of which the main stream of north Han River and Soyang River are the most important, enter along the north and east shores of the northern side of the lake. Considerably a large urban settlement, namely Choonchon with populations of 130,000, is located on the right shore.

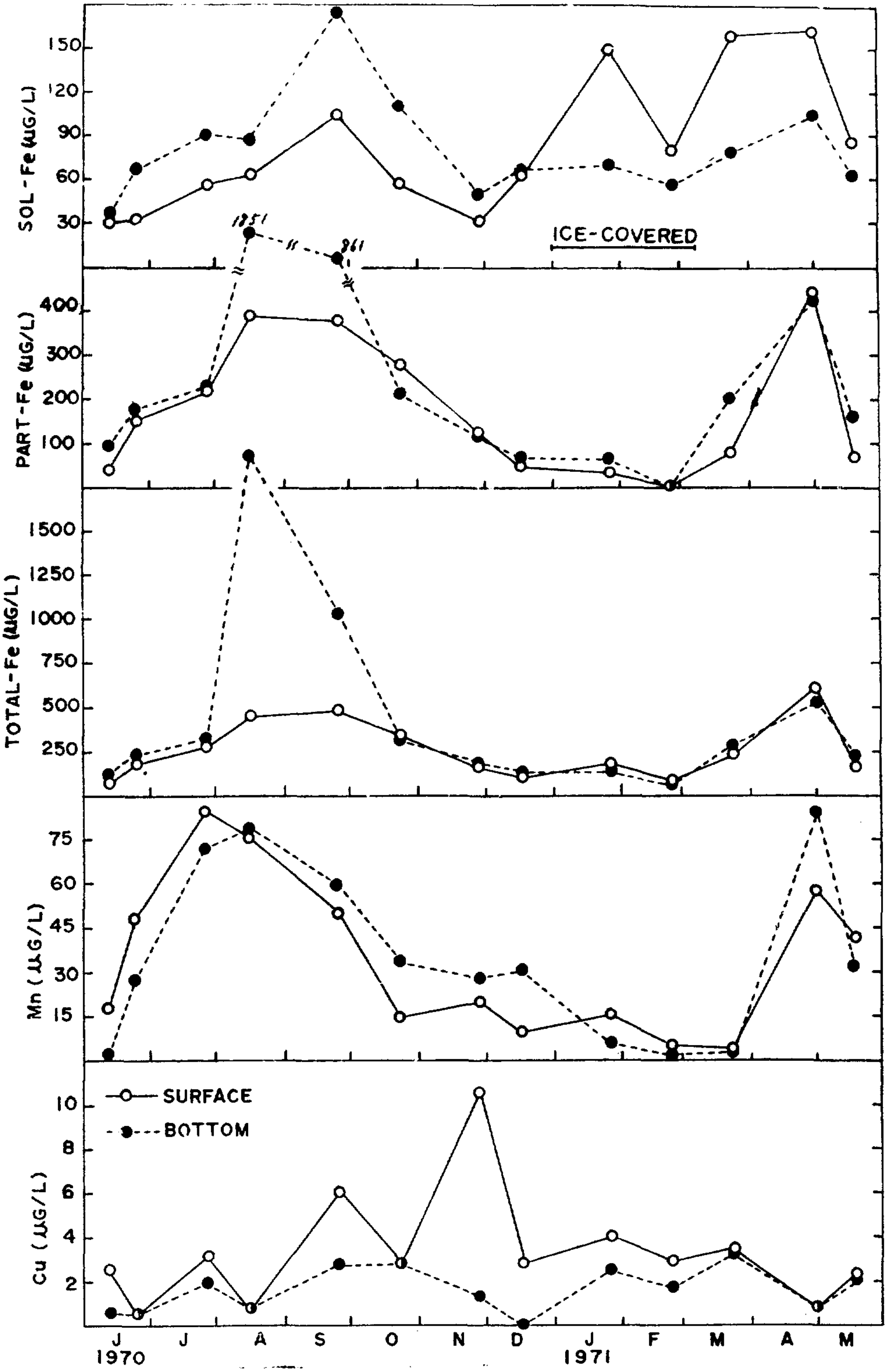

Fig. 6. Seasonal variations of iron, manganese and copper in the deep site of Lake Eui-am during the period June 1970 to May 1971.

According to thermal property, the Lake Eui-am is, by Hutchinson (1957) definition, a dimictic lake of the second order. Thermal stratification is developed in smmer months.

On the whole, the chemical data obtained in this study indicate that the water quality of Lake Eui-am is quite high. The results of our study show that many of the parameters are approximately similar to those obtained at the downstream station (Kwangnaru) of Han River during the period of May 1966 and April 1967 (Choe *et al.*, 1968; Choe, 1968). However, there are some differences in water quality between the Lake Eui-am and Kwangnaru though both belong to same stream, indicating that some pollution has been affected in the lake area.

The lake water is characterized that higher values of dissolved oxygen or percent saturation of dissolved oxygen, and of nitrate nitrogen. Even in the summer stagnated period, the dissolved oxygen content of bottom water has never dropped less than 6 m*l*/L or 80% oxygen saturation. The level of nitrate nitrogen keeps greater than 250 ppm at the surface even in the season of algal bloom.

On the other hand, values for CO_2, chlorides, Ca, Mg, hardness, silica and BOD_5 are quite low. The maximum values of annual fluctuations are 6.7 ppm in chlorides, 11.0 ppm in Ca, 3.1 ppm in Mg, 36.0 ppm in hardness, 3.5 ppm in silica and 4.0 ppm in BOD_5 respectively.

A comparison of mean annual concentrations of

Table 2. Comparison of mean concentrations[1*] of water quality parameters of Lake Eui-am with other earlier study at the downstream of Han River.

Parameter	Unit	Lake Eui-am*2 (June 1970–May 1917)		Kwangnaru*3 (April 1966–May 1967)	
		Surface Water	Bottom Water	Surface Water	Bottom Water
W.T.	°C	15.0	12.3	13.3	13.2
*p*H		6.9	6.8	6.9	7.0
O_2	m*l*/L	8.77	8.44	7.49	7.46
O_2 Sat.	%	118.4	109.2	98.3	97.6
CO_2	ppm	8.1	11.1	17.0	15.8
Hardness	$CaCO_3$ ppm	26.9	30.0	34.9	36.6
Cl	ppm	3.6	3.4	9.1	8.9
Ca	ppm	7.18	8.23	6.64	6.54
Mg	ppm	2.20	2.27	4.61	5.15
COD	ppm	3.51	3.43	2.45	2.62
BOD_5	ppm	1.15	1.00	1.14	0.93
NH_4-N	μg/L	20.6	27.8	60.6	53.2
NO_2-N	μg/L	3.9	2.7	5.3	6.0
NO_3-N	μg/L	526	521	243	251
Total Inorg.-N	μg/L	552	551	309	322
PO_4-P	μg/L	6	9	7	8
SiO_2-Si	ppm	2.41	2.33	8.49	8.06
Sol.-Fe	μg/L	83.1	81.4	49.9	49.8
Mn	μg/L	34.3	35.1	32.0	31.0
Cu	μg/L	3.3	1.6	1.5	1.4

*1 Mean concentrations of the each water parameter are based on the averages of 12 monthly surveys.

*2 Present investigation.

*3 Quoted from Choe *et al.*, 1968; and Choe, 1968.

various water quality parameters, found in the present study, with those of earlier studies at the downstream of Han River is presented in Table 2. The levels of *p*H, PO_4-P and BOD_5 of the lake water are in close agreement to those of the levels at Kwangnaru of Han River. Concentrations of dissolved oxygen, percent saturation of dissolved oxygen, Ca, COD, Mn and Cu are a little high, while CO_2 and hardness are rather low compared to those for Kwangnaru of Han River. Concentrations of NH_4—N, NO_2—N SiO_2—Si, Cl and Mg of the lake water are half and one-fourth, while NO_3—N and soluble iron are twice compared to those for Kwangnaru of Han River. These reasons are not apparent. The high values for NO_3—N, soluble iron and Cu of the lake water compared to those for Kwangnaru suggest that there are some imputs such as domestic and industrial discharges to the lake.

The combination of high nutrient levels and slow rate of discharge in the lake may greatly increase the potential for plankton production. According to Reinhard (1931), the productivity of a stream is proportional to the age of its water and inversely proportional to its velocity. Hasler (1947) has defined eutrophication as the intentional or unintentional enrichment of water. Other sources indicate that eutrophica tion is simply a biological lake aging process. Eutrophication becomes evident as the concentration of nutrients increases, thereby stimulating the growth of planktonic algae. An over-abundance of this algae results in a green, gloomy water surface often producing unpleasant odors and unsightly scums. In terms of nutrient levels, the Eui-am lake water exhibit slight signs of eutrophication.

In studies of Wisconsin lakes, Sawyer (1952) concluded that concentrations in excess of 10 μg/L of inorganic phosphorus and 300 μg/L of inorganic nitrogen at the time of spring overturn could be expected to produce algal blooms of such density as to cause niusance. Nitrogen and phosphate concentrations in April at Lake Eui-am are well above the critical requirements for abundant algal growths. The relation between nutriens and productivities of Lake Eui-am will discuss at the another paper.

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