KOR. JOUR. MICROBIOL. Vol. 10, 97~104 (1972)

夏季 京畿灣의 水質汚染과 生產力에 관한 硏究 (第1報)

——夏季 京畿灣의 水質汚染에 關하여——

李敏載・洪淳佑*・河永七
(서울大學校 文理科大學 植物學科 *微生物學科)

Studies on Water Pollution and Productivity in Kyonggi Bay in Summer Seasons(I)

——On the Water Pollution along the Seo Channel in the Kyonggi Bay during Summer Seasons——

LEE, Min Jai, Soon Woo HONG* and Yung Chil HAH
(Dept. of Botany, *Dept. of Microbiology, Seoul National University.)

ABSTRACT

The extent of water pollution was investigated at 4 stations in Kyonggi Bay during the summer seasons in 1970 and 1971. The concentrations of dissolved oxygen, total hardness, ammonia, nitrate, nitrite, phosphate, chemical oxygen demand, salinity, biochemical oxygen demand, coliform bacteria and fecal coli were examined together with the measurement of *p*H and transparency. The relationship between the extent of pollution and the distance from the Inchon Bay also was examined.

The concentrations of biochemical oxygen demand, chemical oxygen demand, ammonia, nitrate, nitrite, phosphate, coliform bacteria and fecal coli were all highest at station 1, and lowest at station 4. Values were somewhat higher at low tide level in general. On the contrary, dissolved oxygen concentration was highest at station 4 and lowest at station 1.

The highest and lowest values of biochemical oxygen demand were 10.88 ppm at station 1 and 0.27 ppm at station 4. The chemical oxygen demand concentrations at station 1 and 4 were 1.90 ppm and 0.63 ppm. Ammonia concentration at station 1 was 0.43 ppm and was nearly 5 times as much as that at station 4. Nitrate concentration at station 1 was 4 times as much as that at station 4. The values were 2.45×10^{-3} ppm at station 1, and 6×10^{-4} ppm at station 4. Nitrite concentration at station 1 was 3×10^{-4} ppm and was the highest, while the lowest was 9.5×10^{-5} ppm at station 4. Phosphate value at station 1 too was the highest and was about 4 times as much as that at station 4. Coliform bacteria were most abundant at station 1, and were counted to be 1.7×10^{5}cells/ml. At station 4, the number greatly reduced to 8×10^{2} cells/ml. The number of fecal coli at station 1 was 2×10^{4} cells/ml. But at station 4, no fecal coli was detected at high tide level. At low tide level, 3 cells/ml were counted at station 4.

In all of these, the highest data were obtained at low tide level, while most of the lowest value, at high tide level. Generally, values at station 1 were 3-5 times as much as those at station 4.

* Partial expenses of this survey were supported by the IBP, PM section in Korea in 1970 and 1971.

Concentration of dissolved oxygen at station 1 was 0.366 mg-atoms/l and was the lowest. The highest value was 0.420 mg-atoms/l and was recorded at station 4. The values of salinity and total hardness concentrations too were lowest at station 1 and highest at station 4, which certainly were believed to be the result of the dilution by the fresh water of the Han river flowing into the Inchon Bay.

As we can see from the data above, the extent of pollution was highest at station 1, the nearest from Inchon harbor, and lowest at station 4, where is the farthest. Station 1 and 2 were proved to be much polluted, but station 3 and 4, not.

INTRODUCTION

Owing to the rapid development of industry and the concentration of population in large cities, the extent of water and air pollution in Korea is ever increasing recently. The fresh- and marine-water in some industrial regions such as Inchon and Ulsan are considered to be especially polluted by the waste water of the crowded factories. But there has not yet been any systematic study on the pollution problems in these heavily polluted regions. Some extensive study on the extent of the pollution and on its solution is very urgent, we believe.

The Inchon Bay has long been suspected to be severely polluted by the waste water of the nearby factories and the sewage from Inchon city. In this research, we investigated the water pollution at four stations in Kyonggi Bay along the Seo channel, one of the channels through which the marine water flows into the Han river at high tide level, and examined the change of extent in connection with the distance from Inchon harbor, where the pollutants from all the nearby factories and Inchon city are discharged into the sea.

MATERIALS AND METHODS

Four stations were selected in Kyonggi Bay along the Seo channel for this survey. Station 1 is between Wolmi Island and Yongjong Island, and is 5 km away from Inchon harbor. Station 2 is near Palmi Island, 16 km away from the harbor. Station 3 locates between Chawol and Choji Island, station 4 locates between Mungap Island and Songap Island, and are 37 km and 56 km away, respectively. The Seo channel originates from the estuary of the Han river and is one of the channels through which the marine water flows into the Han river at high tide level and the fresh water of the Han river flows into the Inchon Bay at low tide level. The experimental stations were selected along this channel so that the effect of the fresh water on the dilution of the pollutants could be traced.

The experimental stations and their distances from the Inchon harbor are illustrated in Table 1 and Fig. 1.

Table 1. The location of each station.

Station	St. 1	St. 2	St. 3	St. 4
Location	Wolmi Isl.	Palmi Isl.	Chawol Isl.	Mungap Isl.
Distance from Han river estuary	5 km	16 km	37km	56 km

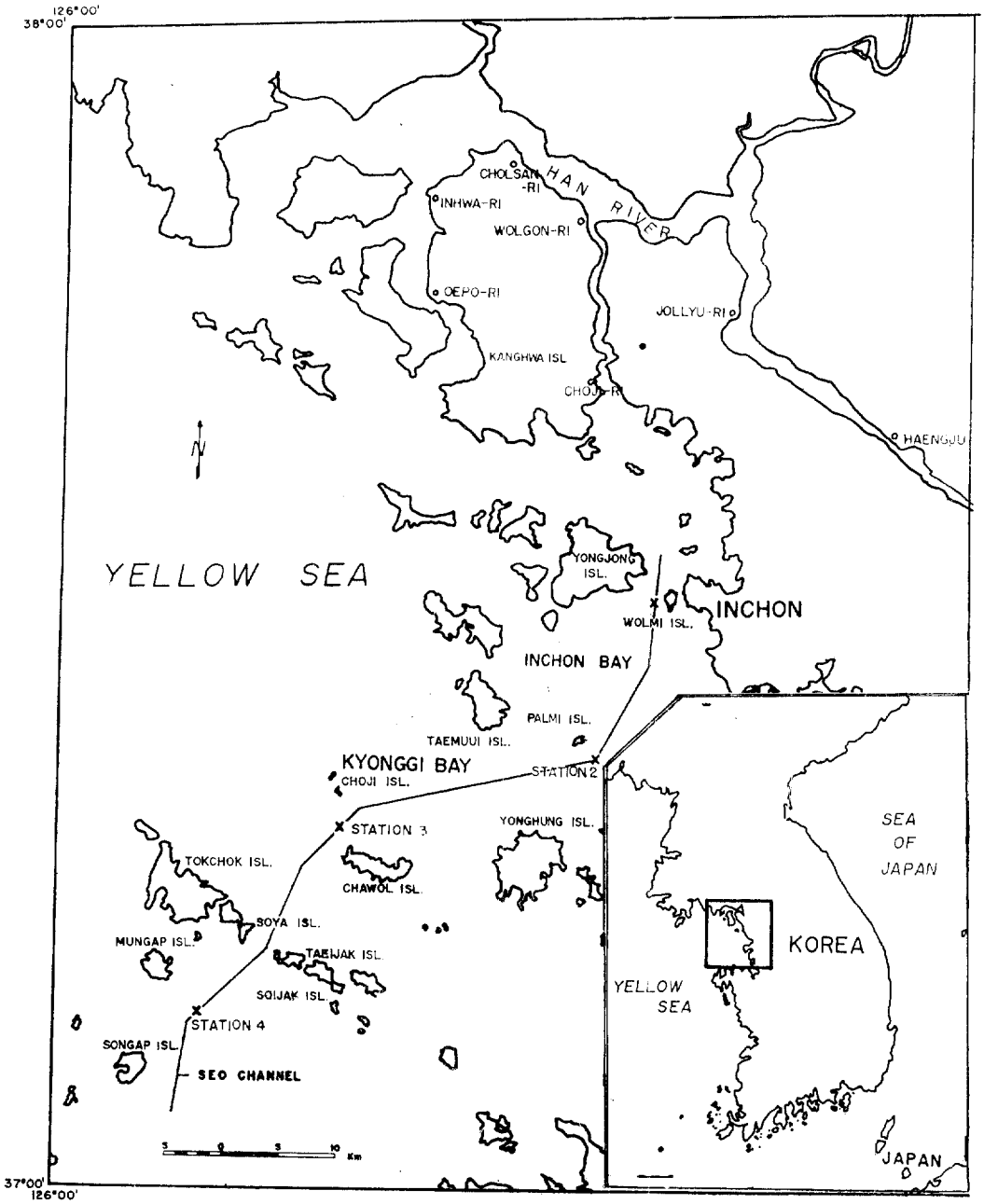

Fig. 1. Map of the stations experimented.

Sampling was done twice a day at a station at low tide level and high tide level. Samples were collected with Eckman water sampler and were stored in 4 litter plastic bottles in ice box and maintained at 5°C until they were analyzed. 3 bottles were taken at each station and each of which was used for the determination of biochemical oxygen demand, bacteria and chemical analyses.

*p*H was tested with MRK portable *p*H meter (Model 10-250c II) at each station.

Transparency was measured with Secchi disc.

Dissolved oxygen (DO) was determined by modified Winkler's method with duplicate samples.

Colorimetric methods were adopted for the determination of ammonia, nitrate, nitrite and phosphate. Nessler's reagent was used for the ammonia determination. Nitrate and nitrate were analyzed by the G.R. method and phosphate, with the ammonium molybdate method.

Total hardness, chemical oxygen demand (COD) and salinity were determined titrimetrically by the EDTA, oxalic acid-potassium permanganese, and silver nitrate method, respectively.

Samples were incubated for 5 days at 20°C and were examined by modified Winkler's method to determine biochemical oxygen demand (BOD). The water sampled at station 4 in 10 m depth was used for the dilution of these samples.

Coliform bacteria and fecal coli were tested using Millipore filter method. Samples were incubated at 37°C and 44°C for 16 hours after the preculture for 2 hours on glucose nutrient broth at 37°C. The filter papers after incubation were examined under stereoscopic microscope.

RESULTS AND DISCUSSION

DO content was lowest at station 1 and highest at station 4 showing the tendency to increase as the distance from Inchon harbor grows farther. The lowest value was 0.366 mg-atoms/l and the highest was 0.416 mg-atoms/l. The values were slightly high at low tide level in general. Comparing this with the results obtained from the research in the Tokyo Bay in 1970, which show the maximum and minimum concentrations of 0.902 mg-atoms/l and 0.223 mg-atoms/l, we can see that the Inchon Bay is much more deficient in its DO content. Besides, the DO content at several points near Kanghwa Island (Fig. 1) were between 0.556 and 0.475 mg-atoms/l in 1967 (Hong, *et al*, 1968) showing much higher values than those obtained in this research.

Concentrations of BOD and COD too were highest at station 1. The BOD concentration at station 1 was 10.88 ppm at low tide level. Similar concentration was obtained at station 2. But the values quickly dropped at station 3 and 4 and were below 0.1 ppm at both stations. The COD concentration at station 1 was 1.9 ppm and, after gradual decrease, the lowest value of 0.63 ppm was recorded at station 4. In the Tokyo Bay, COD concentrations varied between 1.4 ppm and 4.7 ppm in 1970.

With these results, which are also shown in Figs. 2, 3 and 4, it can be presumed that the low DO concentrations at station 1 and 2 are directly related with the high concentrations of BOD and COD (In Fig. 2 and other Figures following, the stations are placed on the horizontal axis. They are arranged so that they indicate the relative distances of the 4 stations.).

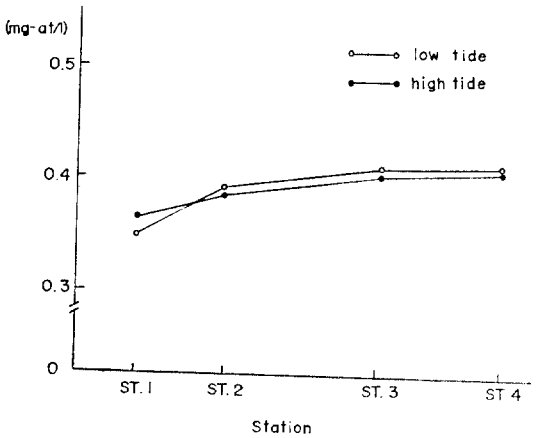

Fig. 2. Concentrations of dissolved oxygen at 4 stations measured at low tide level and high tide level.

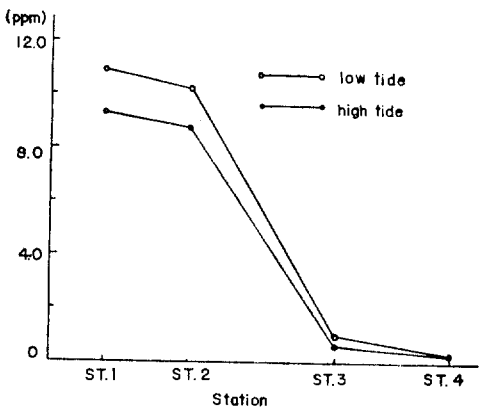

Fig. 3. Results of the analyses of BOD at 4 stations.

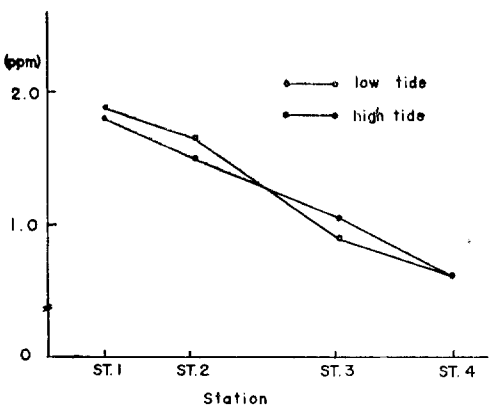

Fig. 4. Concentrations of COD.

The concentrations of ammonia, nitrate, nitrite, phosphate and bacteria also were highest at station 1 and were lowest at station 4 and, in general, the values were slightly high at low tide level.

Ammonia concentration was 0.43 ppm at station 1. At station 2, the value rapidly decreased to 0.22 ppm and the curve slowed down thereafter. The lowest value was 0.09 ppm, which was recorded at station 4. The results are shown in Fig. 5.

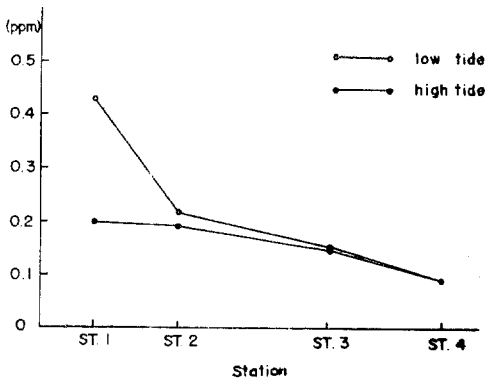

Fig. 5. Concentrations of ammonia.

The highest concentration of nitrate was 2.42×10^{-3} ppm at low tide level at station 1 and the lowest one was 5.8×10^{-4} ppm at high tide level at station 4. Station 3 and 4 showed similar concentrations (Fig. 6).

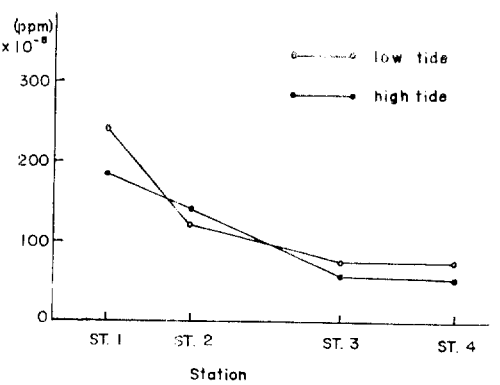

Fig. 6. Results of nitrate determination.

Variation of nitrite concentration was between 3.0×10^{-4}ppm and 1.0×10^{-4}ppm (Fig. 7).

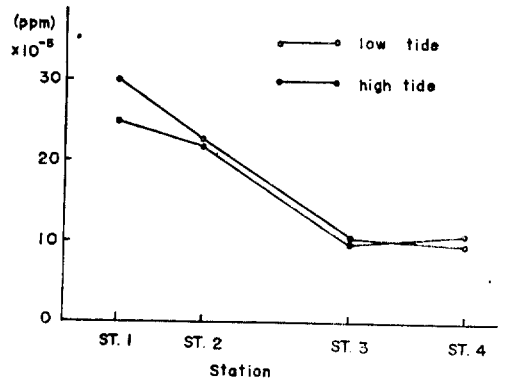

Fig. 7. Results of nitrite determination.

The highest and lowest concentrations of phosphate were also recorded at station 1 and station 4 with the value of 1.70 ppm and 0.46 ppm, respectively (Fig. 8).

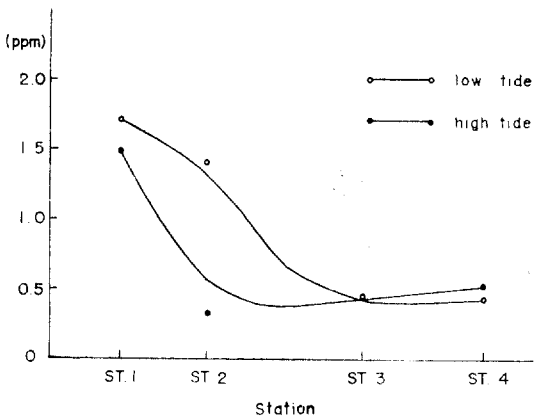

Fig. 8. Concentrations of phosphate at 4 stations.

Coliform bacteria and fecal coli at station 1 were most abundant among the four and were counted to be 1.7×10^5 cells/ml and 2.0×10^4 cells/ml respectively at low tide level. No conspicuous variation between station 1 and station 2 was observed. The concentration of coliform bacteria at station 4 was 3.9×10^3 cells/ml at high tide level and was the lowest. Fecal coli was not detected at station 4 at high tide level (Fig. 9). In the Han River Estuary, near Kanghwa Island, the coliform bacteria were counted to be between 2.7×10^4 cells/ml and 1.7×10^5 cells/ml in 1967 (Hong, *et al.*, 1968). But in that report, the bacteria at Oepo-ri and Choji-ri (Fig. 1) were only 2.7×10^4 and 3.2×10^4 cells/ml, which were similar values to those obtained at station 3 and 4 in this report. Comparing these, it can be assumed that station 1 and 2 are much polluted, though there are some difficulties in the comparison because that data were obtained 4 years ago.

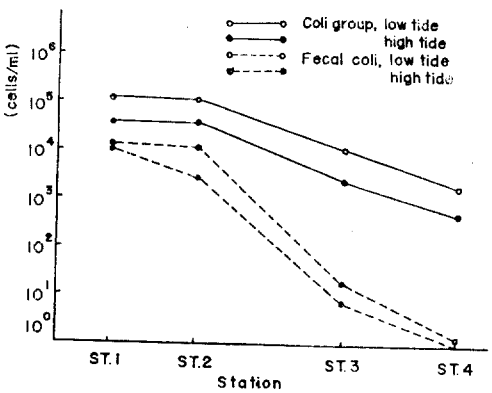

Fig. 9. Populations of coliform bacteria and fecal coli.

Salinity and total hardness were lowest at station 1. This is believed to be the result of dilution by the fresh water of the Han river flowing into the Inchon Bay.

Total hardness increased gradually from station 1 to station 4 making sigmoid curves (Fig.10). The concentrations varied between 13,100 ppm and 14,540 ppm.

Salinity of station 1 reached only to 25.28 ‰ at low tide level. But at high tide level, it was recorded to be 28.29 ‰ at the same place. The highest concentration observed was 30.93 ‰ at station 4 (Fig.11).

Results of pH and transparency measurements are recorded in Table 2. *p*H at 4 stations were observed to be very similar

and showed little variation. The range was between 8.30 and 8.45 and can be said to be somewhat normal.

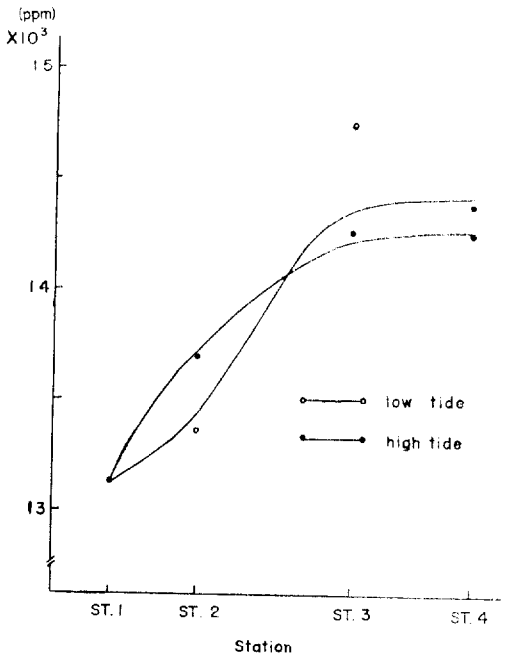

Fig. 10. Total hardness at 4 stations.

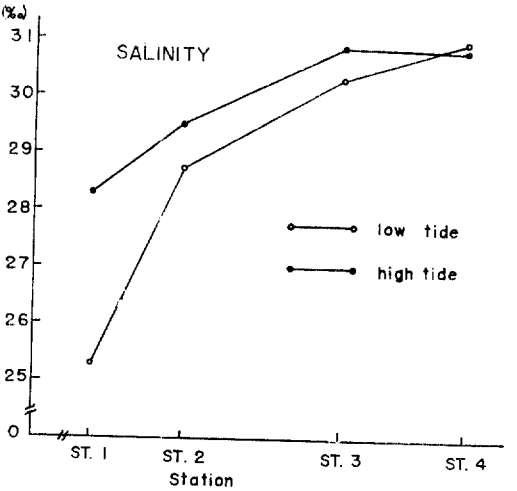

Fig. 11. Salinity measured at 4 stations.

The transparency was relatively low and the variation range was between 1.8 m and 3.3 m. Unexpectedly, station 3 showed very low value, but the reason was not detected.

Table 2. The *p*H and transparency of each station.

Item	Tide level	St. 1	St. 2	St. 3	St. 4
*p*H	Low Tide	8.40	8.40	8.40	8.30
	High Tide	8.45	8.45	8.40	8.30
Transparency	Low Tide	1.8m	1.9m	1.9m	3.0m
	High Tide	2.5m	2.3m	1.9m	3.3m

In almost all the data analyzed, station 1 proved to be most polluted. Though station 2 showed slightly lower values than station 1, there was no significant difference between the two, indicating that the pollutants can not be effectively diluted even at station 2, and that station 2 is not much less polluted than station 1. Results from station 3 and station 4 were relatively low and similar at both stations, and it was thought that these stations are not polluted as yet. But it should not be overlooked that fecal coli were detected at both places.

Regarding all these, it is apparent that station 1 and station 2 are polluted considerably. Though there are little evidences that station 3 and station 4 are polluted, we can estimate that these stations too will be polluted sooner or later with regard to the fact that more and more large plants such as petroleum refinery are being built in Inchon Industrial Region.

In this survey, only 4 stations could be

examined. But to understand the nature of water pollution in this area more exactly, the waste water from every plant in this region and the sewage from Inchon city too should be analyzed, and continuous study for much longer period is required.

摘 要

1970年과 1971년의 夏季의 京畿灣의 水質汚染을 仁川港으로 부터의 거리에 따라 選擇한 4個 地點에서 調査하였다. 이 調査地點은 또한 漢江河口에서 부터 由來하는 西水道上에 位置하고 있으며, 이 西水道는 海水가 外海로 부터 京畿灣을 거쳐 漢江으로 流入하는 進路이며 同時에 漢江水가 外海로 流出되는 通路인 數個 水道中의 하나이다.

따라서 本 調査에서는 各種 汚染物質이 이 西水道를 따라 外海로 擴散되면서 距離에 따라 그 濃度가 變化하는 程度에 主眼點을 두고 諸般 汚染指標物質의 含量을 調査하였다. 調査한 項目은 溶存 酸素, ammonia, nitrate, nitrite, total hardness, phosphate, chemical oxygen demand, salinity, biochemical oxygen demand, coliform bacteria, fecal coli 및 *p*H와 transparency였다.

BOD, COD, ammonia nitrate, nitrite, phosphate, coliform bacteria 및 fecal coli는 모두 station 1에서 가장 농도가 짙었으며 station 2에서도 비슷한 양이 檢出되었다. 한편 溶存 酸素는 反對로 station 1에서 가장 낮았으며 station 4에서 가장 높은 含量을 보였다. 全般的으로 干潮時의 含量이 滿潮時의 含量보다 약간 높은 것으로 나타났다.

BOD의 含量은 最高 10.88 ppm이며 最低濃度는 0.27 ppm으로서 距離에 따른 差異가 매우 많음을 알 수 있다. COD 含量은 最高 1.90 ppm, 最低 0.63 ppm이었다. station 1의 ammonia 含量은 0.43 ppm으로서 全 調査地域中 가장 높으며 이는 最低値를 記錄한 station 4의 값의 약 五倍에 該當한다. nitrate의 量도 station 1의 값이 2.45×10^{-3}ppm으로서 最低値인 station 4의 6.0×10^{-4}ppm의 4倍에 達한다. station 1의 nitrite 濃度는 3.0×10^{-4} ppm으로서 最低値의 約 三倍에 該當하는 값이다. 또한 phosphate도 station 1의 값이 station 4의 값의 4倍에 이르고 있다. station 1의 coliform bactera와 fecal coli의 數는 各其 1.7×10^{5} cells/ml, 2.0×10^{4} cells/ml로서 역시 가장 높으며 最小地域인 station 4에서는 coliform bacteria가 8×10^{2} cells/ml이고 fecal coli는 滿潮時에 0, 干潮時에 3 cells/ml로 나타나 急激히 減少하고 있음을 알 수 있다.

上記 結果中 最高 濃度는 모두 干潮時의 記錄이며 最低 濃度는 대부분 滿潮時에 얻어진 것이다. 以上에서 알 수 있는 바와 같이 station 1은 대체로 station 4 보다 3~5倍의 濃度를 보여 주고 있다.

DO 含量은 station 1이 0.366 mg-atoms/*l*로서 最小이며 station 4에서 0.420mg-atoms/*l*로 最大値를 보인다. Salinity와 total hardness 역시 station 1이 가장 낮고 西水道를 따라 station 4에 가까워 질수록 漸次 上昇하고 있는데 이는 漢江水에 依한 海水의 稀析의 結果에 起因한 것으로 믿어진다.

上記 諸般 資料의 綜合 分析 結果, 仁川港에서 가장 가까이에 位置한 station 1은 4 地點中 가장 汚染度가 甚하였으며 station 2도 이와 類似한 것으로 判明되었다. 그러나 station 3과 4는 現段階로서는 汚染되어 있지 않은 것으로 나타났다.

引 用 文 獻

1. 崔奎漢, 金建鎬, 權鼎杓, 魯一協, 1968. 衛生化學, 東明社, 서울. pp. 350-362.
2. Difco Laboratories, 1953, Difco Manual of dehydrated culture media and reagents for microbiological and chemical laboratory procedures, 9th ed. pp. 32-33.
3. Golterman, H. L., 1969. Methods for chemical analysis of fresh water. Blackwell Scientific Publications, Oxford and Edinburgh. pp. 69-70, 105-107, 124-128.
4. Hong, S.W., Y.C. Hah, and K.W. Lee, 1968. Microbial populations in Han River Estuary. *Kor. Jour. Microbiol.*, 6, No.4, pp.107-112.
5. 梶沼孟彦, 1972. 東京都 內灣の 汚濁の 實態. *Jour. Water and Waste.* 14, No.5, pp. 108-112.
6. 氣象廳, 1970. 海洋 觀測 指針, 日本海洋學會. 東京. pp.155-168.
7. Mackie, T.J., and J.E. McCartney, 1959. Handbook of practical Bacteriology, 9th ed. E. & S. Livingstone Ltd., Edinburgh and London. pp.673-676.
8. 松江吉行, 1969. 公共用水域保全のための水質汚濁調査指針, 3rd ed. 恒星社厚生閣, 東京. pp.120-122, 131-137.