The Journal of the Korean Society of Oceanography
Vol. 32, No. 3, pp. 120-127, September 1997

# Depositional Environment and Distribution of Heavy Metal off the Shihwa Dam

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Depositional environment off the Shihwa Dam has been studied to investigate the change of sedimentation process and the pollution. In order to understand how the sediments are distributed, polluted and modified, depositional factors have been analyzed and compared with the previous data. Study area, located off the Shihwa Dam, was surveyed to collect 25 bottom samples and 2 cores in 1996 and echo-sounding in 1997. These sediments were analyzed for the study of the global characteristics of sediment such as grain size and organic matter. Among these samples, the selected twenty surface sediments were analyzed for the comparison with their contents of metallic elements (Al, Mn, Fe, V, Cr, Co, Ni, Cu, Zn, Cd, Pb, As). According to field and lab analysis of sediments, three sedimentological zones have been generally identified around study area; near the dam (sandy Silt), near the dike (Sand) and offshore (silty Sand) zones. Textural parameters show that the content of silt and clay is dominant near the dam excepting the dike zone of LNG Storage Base and offshore (Palmido). The total concentration of Mn, Ni, Fe, Zn and Cd in bulk sediments was increased after the construction of the dam, while the content of Mn and Cr were higher near tidal channel than in the offshore area. Meanwhile, the annual increasing pattern of some heavy metal has appeared in this area. Based on this primary study, modification of the depositional environment may be caused by the construction of the dam and LNG Storage Base. Additionally, environmental evaluation on organic/inorganic factors has been suggested for interpreting environmental changes caused by coastal development in the nearshore such as the Shihwa coastal area.

## INTRODUCTION

Coastal development along the tidal flat, has caused environmental changes in nearshore zones during the last 20~30 years. This environmental changes are organic/inorganic ones which represent respectively biochemical effect and geologic event such as coastal erosion and deposition. Among these ones, the environmental issues on the Shihwa lake is very representative to discuss coastal development and reservation.

The previous studies on nearshore environment off the Shihwa Dam have represented the aspects of the biochemical pollution, although those are more or less descriptive. The sedimentary environment of tide-dominated coastal bay have been studied by many authors (Chang and Oh, 1991; Park *et al.*, 1991; Choi, 1992; Park and Bloom, 1984). Sedimentologic researches in Kyunggi bay including this study area have been done to investigate the change of depositional environment after the establishment of the Submerged Singok Dam in the Han river estuary, due to the increasing demand for the environmental protection. Since 1980s, some investigations around Kyunggi bay have been performed for sedimentation process (Chang and Oh, 1991) and geochemical properties (KORDI, 1993). Nevertheless, scientific studies on the Shihwa area have been restricted to the biochemical reaction and ecologic changes for the purpose of the environmental effect assessment. Park *et al.* (1991) examined the sedimentary characteristics and development of the tidal channel, and thus suggested that morphology of tidal channel may be affected by sediment supply of the Han river and reclamation activities such as Incheon international airport. Several authors discussed certain environment problem of biochemical effects but not inorganic problems. There are little results about depositional environment in this area. This study have to focus on the depositional environment and the change of heavy metal distribution in sediment due to construction of the dam and dike. KORDI (1994) summarized the general aspect of geomorphological and sedimentological changes due to the construction of coastal dam around the bay mouth and estuarine inlet. They reported that the establishment of the dam involved some destruction of environmental equilibrium between inner lake and offshore, resulting in the pollution of the nearshore and fresh water lake. Since 1996, they examine the environmental change, effect after the establishment of the dam and its effective utilization. This paper emphasizes on the zonation of the depositional environment off the dam, based on the data collected during 1995~1997. In addition to sedimentary research, the comparison with geochemical data (Lee *et al.*, 1985, 1991, 1992; Koh, 1996) reported since 1990s has been done to supplement an effective result.

***Study area and hydrodynamic conditions***

This study area (Fig. 1), surrounded by the circum-islands (Youngjongdo-Yongyudo-Taemuuido-Youngheungdo-Taebudo), is located in the southern part of Incheon harbor. The dam, constructed in 1994, make connection between Taebudo and Shihwa. Tide is typically semi-diurnal period and its range represent 8 m in maximum and 5 m in minimum, depending on the lunar cycle. Because of

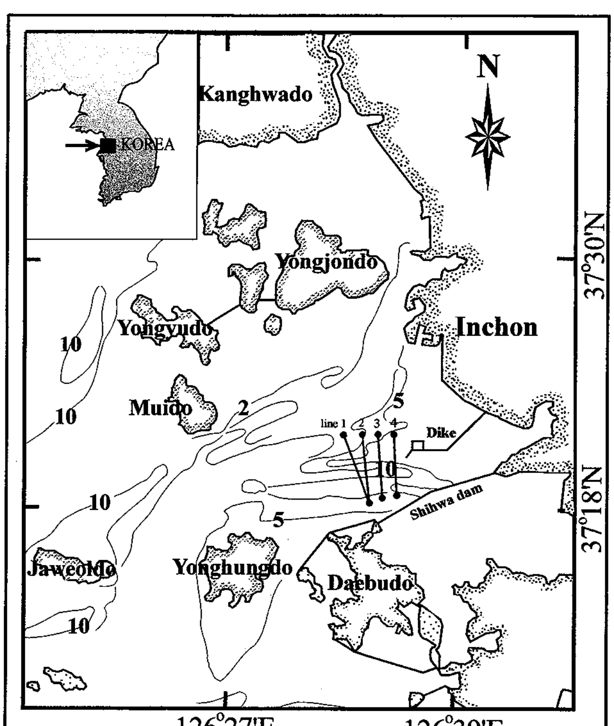


**Fig. 1.** Study area, echo sounding track line and bathymetry showing depth (m).

large tidal range, tidal current playes an important role in the sediment transport and cyclic variation of the suspended sediment.

This area is the macrotidal coast with a strong diurnal asymmetry, a marked spring-neap tide cycle, and the tidal amplitude. This nearshore may be classified as macrotidal coast, according to the classification proposed by Davies (1964).

The two regions, based on its morphology and hydrodynamic, are characterized by tidal channel and subtidal flats: tidal channel is characterized by ravinement, 5~10 m deep connected with Shihwa lake and subtidal flat is characterized by broad flat with depth of 10 m, surrounded by small islands. The development of tidal channel has been regarded as a response of the bottom condition to tidal current. Intertidal-mud flat are widespread along the coastline of the study area. Temporal and spatial variations of the intertidal flats have not been studied because of discontinuous data collection and inaccurate sampling position. Seasonal and vertical variations of salinity (30~32‰) in the study area (KORDI, 1997) are not so much as around the inlet of the Han river, in which they show great variations of 3.5 to 28‰, representing a partially-well mixed estuary (Chang and Oh, 1991). Salinity decrease toward the inlet of the Han river estuary showing a little vertical changes. Previous to the construction of the dam, this study area was characterized by tidal bay and small river estuary. The dam was constructed for the utilization of freshwater and coastal areas. Meanwhile, certain environmental problems, including ecologic change and sea water pollution, have been revealed to discuss some necessity and reutilization of this dam such as tidal power plant and harbor. In addition to the dam construction, some dike was constructed for LNG Storage Base (Fig. 2). These works may contribute to the change of sedimentary process and hydrodynamic conditions. Therefore, the purpose of this study is to elucidate a change of depositional environment prior to the establishment of the dam and dike and to compare geological properties with the previous data.

## METHODS AND MATERIALS

Twenty-five bottom sediments and two core samples were collected for grain-size and heavy metal analysis off the Shihwa Dam in Jan. 1996 and 13 only for heavy metal analysis in Sep. 1996 (Fig.

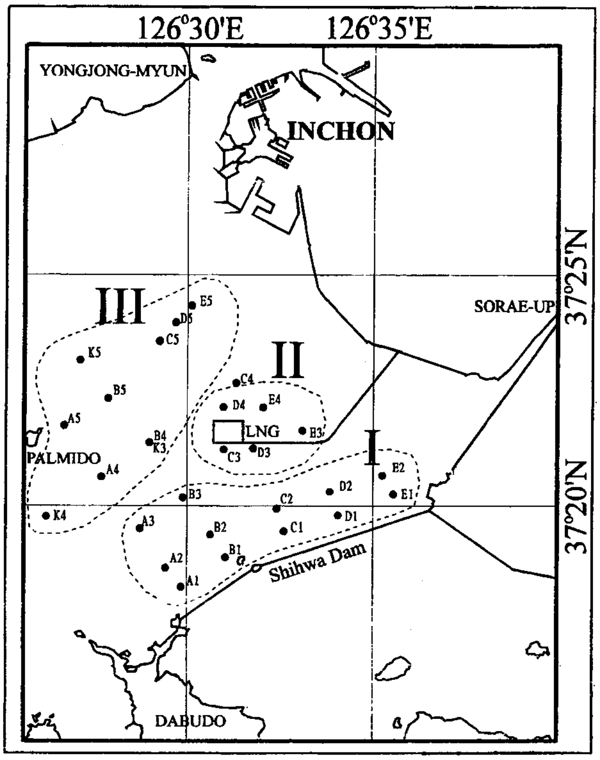


**Fig. 2.** Sampling sites, showing surface sedimentary facies: group I (sandy Silt), group II (Sand), and group III (silty Sand).

2, Table 1, 2). A Dietz-Lafond grab sampler and a piston corer were used for surface and core samples respectively. Echo-sounding was performed on board for mapping a bathymetric chart and confirming a change of sedimentary structure such as sand dune and tidal channel. Raytheon Echosounder was utilized for profiling 4 lines from the dam (Fig. 1).

Total content of metals in bulk sediments were analyzed after drying at 90°C for 24 hours and grinding in a mortar to pass mesh nylon sieve.

In laboratory work, all samples were analyzed using SediGraph 5100 and pipetting method for silt and clay particles (62.5 μm) after wet sieving to remove the sand particles which are dominant along the dike of LNG station and Palmido. Statistical analysis were done for calculation of the textural parameters based on Folk and Ward method (1957). The collected samples were treated for removal of organic matter with $H_2O_2$ and desegregated before analysis by using sodium meta-phosphate. Carbonate content was measured by the acid digestion method using 0.1 N HCl, while organic matter was determined by measuring the weight loss of samples heated 550°C for 2 hours in a furnace. For analysis

**Table 1.** Teaxural parameters, sediment type, total organic matter, concentration of suspended matter, and sediment type in each groups (I, II, III)

| Group | St. No. | Texural Parameter | | | | Sediment Type | Concentration of | | Total Organic |
|---|---|---|---|---|---|---|---|---|---|
| | | MZ | SO | SK | KG | | Surface | Bottom | |
| I | A1 | 6.72 | 2.49 | 0.47 | 0.79 | Z | 23.6 | 10.7 | 7.22 |
| | A2 | 6.57 | 2.68 | 0.38 | 0.78 | sZ | 19.5 | 20.1 | 5.91 |
| | A3 | 5.61 | 2.34 | 0.51 | 1.09 | sZ | 13.7 | 25.1 | 4.36 |
| | A4 | 5.13 | 2.25 | 0.61 | 1.26 | sZ | 34.3 | 50.1 | 4.27 |
| | B1 | 5.68 | 2.82 | 0.36 | 1.13 | sZ | 18.5 | 14.4 | 4.06 |
| | B2 | 6.96 | 2.52 | 0.32 | 0.65 | M | 17.6 | 21.7 | 7.31 |
| | B3 | 6.70 | 2.75 | 0.26 | 0.63 | sM | 11.8 | 29.6 | 6.06 |
| | C1 | 6.55 | 2.56 | 0.48 | 0.85 | sZ | 22.6 | 19.5 | 5.00 |
| | C2 | 6.04 | 2.42 | 0.58 | 1.07 | sZ | 17.4 | 19.6 | 4.47 |
| | D1 | 5.18 | 2.30 | 0.51 | 1.34 | sZ | 19.9 | 19.9 | 4.30 |
| | D2 | 5.07 | 2.54 | 0.41 | 1.55 | sZ | 13.4 | 16.5 | 4.39 |
| | E2 | 4.23 | 3.28 | 0.28 | 1.40 | mS | 27.4 | 24.4 | 8.28 |
| Avg. | | 5.9 | 2.6 | 0.4 | 1.0 | sZ | 20.0 | 22.6 | 5.47 |
| II | C3 | 0.56 | 0.71 | 0.04 | 1.34 | S | 20.4 | 19.5 | 1.00 |
| | C4 | 4.32 | 1.80 | 0.53 | 2.03 | zS | 16.4 | 22.7 | 3.79 |
| | D3 | 1.50 | 0.78 | 0.14 | 2.03 | S | 22.5 | 18.8 | 1.60 |
| | D4 | 2.15 | 0.80 | -0.07 | 0.99 | S | 33.4 | 37.8 | 1.60 |
| | E1 | 2.89 | 1.02 | 0.52 | 1.77 | zS | 23.4 | 16.8 | 2.00 |
| | E3 | 3.28 | 1.58 | 0.29 | 1.36 | zS | 25.0 | 41.0 | 3.00 |
| | E4 | 1.91 | 0.89 | 0.27 | 1.08 | S | 38.6 | 43.6 | 3.70 |
| Avg. | | 2.4 | 1.1 | 0.2 | 1.5 | S | 25.7 | 28.6 | 2.38 |
| III | A5 | 2.35 | 2.63 | 0.21 | 1.24 | zS | 44.7 | 105.6 | 3.40 |
| | B4 | 2.32 | 2.02 | 0.01 | 1.42 | zS | 16.9 | 15.7 | 2.50 |
| | B5 | 2.92 | 2.40 | 0.51 | 1.53 | zS | 29.8 | 84.2 | 2.59 |
| | C5 | 2.25 | 2.45 | 0.13 | 1.59 | zS | 21.3 | 42.5 | 3.48 |
| | D5 | 2.26 | 2.44 | 0.34 | 1.72 | zS | 19.5 | 59.2 | 2.19 |
| | E5 | 2.91 | 2.17 | 0.13 | 1.73 | zS | 24.0 | 31.4 | 2.30 |
| Avg. | | 2.7 | 2.4 | 0.2 | 1.5 | zS | 26.1 | 56.5 | 2.74 |
| | | | | | Total Average | | 23.0 | 32.4 | 3.53 |

**Table 2.** Heavy metal content of 12 elements in the selected stations in Jan. and Sep. '96

| Heavy metal \ Station | | A2 | A3 | B2 | B3 | B5 | C2 | C4 | D2 | E2 | E5 | K4 | K5 | K6 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Al (%) | Jan. | 7.12 | 6.94 | 7.66 | | 5.20 | 7.34 | 8.41 | 5.38 | 5.31 | | | | | |
| | Sep. | 7.49 | 6.97 | 7.37 | 5.58 | 6.74 | 6.78 | 4.83 | 6.42 | 6.42 | 7.34 | 7.15 | 5.25 | 6.87 | 6.55 |
| Mn (ppm) | Jan. | 1022 | 1003 | 961 | | 1862 | 536 | 1864 | 1014 | 1045 | | | | | 1163 |
| | Sep. | 1107 | 825 | 934 | 828 | 749 | 854 | 1710 | 698 | 644 | 998 | 760 | 815 | 798 | 901 |
| Fe (%) | Jan. | 2.93 | 2.69 | 3.41 | | 1.62 | 2.90 | 4.01 | 1.89 | 1.98 | | | | | 2.68 |
| | Sep. | 3.33 | 2.84 | 3.21 | 1.59 | 2.50 | 2.58 | 1.98 | 2.45 | 2.31 | 2.99 | 2.81 | 1.65 | 2.70 | 2.53 |
| V (ppm) | Jan. | 99 | 92 | 113 | | 53 | 105 | 130 | 62 | 68 | | | | | 90.2 |
| | Sep. | 108 | 95 | 109 | 58 | 89 | 88 | 36 | 85 | 85 | 108 | 101 | 62 | 98 | 86.3 |
| Cr (ppm) | Jan. | 58.5 | 58.3 | 75.9 | | 29.2 | 61.2 | 92.2 | 32.3 | 43.8 | | | | | 56.4 |
| | Sep. | 68.0 | 57.0 | 71.5 | 32.1 | 53.6 | 60.9 | 13.8 | 41.1 | 50.5 | 67.0 | 63.9 | 29.4 | 61.8 | 51.6 |
| Co (ppm) | Jan. | 10.5 | 9.5 | 12.0 | | 5.9 | 11.2 | 14.0 | 6.6 | 7.0 | | | | | 9.6 |
| | Sep. | 11.3 | 10.2 | 11.7 | 6.6 | 9.3 | 9.8 | 4.5 | 9.0 | 9.1 | 11.4 | 10.6 | 6.4 | 10.4 | 9.2 |
| Ni (ppm) | Jan. | 20.0 | 16.9 | 26.1 | | 8.2 | 22.9 | 34.2 | 9.0 | 11.4 | | | | | 18.6 |
| | Sep. | 25.0 | 19.0 | 24.7 | 8.4 | 14.3 | 17.8 | 2.5 | 14.4 | 12.6 | 22.9 | 20.2 | 7.1 | 17.8 | 15.9 |
| Cu (ppm) | Jan. | 13.6 | 10.2 | 18.0 | | 6.6 | 16.3 | 26.3 | 5.0 | 14.9 | | | | | 13.9 |
| | Sep. | 17.5 | 12.1 | 26.1 | 6.0 | 7.5 | 10.1 | 2.8 | 13.1 | 6.5 | 21.5 | 12.8 | 4.3 | 10.5 | 11.6 |
| Zn (ppm) | Jan. | 63 | 54 | 77 | | 34 | 63 | 95 | 33 | 44 | | | | | 57.9 |
| | Sep. | 74 | 58 | 72 | 28 | 48 | 52 | 18 | 53 | 39 | 69 | 56 | 30 | 55 | 50.1 |
| Cd (ppm) | Jan. | 0.14 | 0.13 | 0.18 | | 0.13 | 0.15 | 0.28 | 0.13 | 0.17 | | | | | 0.16 |
| | Sep. | 0.22 | 0.12 | 0.25 | 0.18 | 0.15 | 0.18 | 0.09 | 0.12 | 0.13 | 0.21 | 0.16 | 0.11 | 0.16 | 0.16 |
| Pb (ppm) | Jan. | 21.8 | 19.9 | 24.0 | | 22.7 | 20.0 | 27.5 | 19.6 | 18.8 | | | | | 21.8 |
| | Sep. | 24.1 | 20.4 | 22.3 | 19.5 | 19.1 | 19.9 | 23.4 | 20.4 | 18.3 | 21.7 | 18.8 | 19.5 | 19.5 | 20.5 |
| As (ppm) | Jan. | 2.9 | 5.8 | 3.4 | | 4.7 | 3.0 | 7.0 | 4.3 | 1.8 | | | | | 4.1 |
| | Sep. | 7.0 | 3.2 | 5.7 | 2.6 | 3.2 | 4.3 | 3.0 | 1.8 | 2.5 | 4.3 | 4.1 | 3.3 | 3.6 | 3.7 |

of heavy mineral content, 0.2 g of grinded sample was reacted with 5 ml of $HF$-$HNO_3$-$HClO_4$ in teflon beaker and then dried. After addition of $HNO_3$, the treated sample was heated below 100°C until becoming the solution. The solution, diluted with 1% $HNO_3$, was used for analysis of trace metal by ICP/MS at Isotope Research Lab at the Korea Basic Science Institute.

## RESULTS AND DISCUSSION

### *Morphologic characteristics*

In general, there are two most relative depths: a shallow one near islands (Muido, Yonjondo and etc.,) near normal tidal channel and dam (Fig. 1, 3). 4 sounding track lines, performed from north to south, show a significant trace of the dredged channel. Echo sounding profiles show obviously an erosive ravinement whose bottom morphology have been formed by the artificial dredging (Fig. 3). It is probable, therefore, that dredging for the construction of the dam and the dike plays a important role in formulating bathymetric change.

### *Sediment type and texture*

Three different types of sediment are encountered in the bottom sediments: sandy Silt, Sand and silty Sand (Fig. 2, 4). Group I (sandy Silt, mean diameter =5.7 Φ), distributed along the dam, is mainly composed of silt and clay which is more than 90%. Group II (Sand, mean diameter=2.3 Φ), affected by the construction of the dike, is distributed around the dike of LNG Storage Base. Group III (silty Sand, mean diameter=2.7 Φ) are distributed in the eastern channel of Palmido. Average grain size variability in terms of mean diameter of each group range from 2.3 and 5.7 in phi scale (Table 1).

Phi mean (Φ) is small for well-sorted sediments and large for poorly- sorted (Fig. 5). In the other words, The fine sediment is relatively poorly sorted and contains admixture of clay, silt and fine sand. Medium and coarser grained sediments show medium/coarse sandy type composed of gravel, sand and a little silt. The sediments of groups I and III are very poorly-sorted, while those of group II (sand) are relatively moderately well-sorted because of the dike construction. The skewness show positively skewed distribution in all samples (Table 1). The kurtosis values represent platykurtic/mesocurtic, leptocurtic distribution in group I, while those of group II, III are very leptokurtic/very leptokurtic.

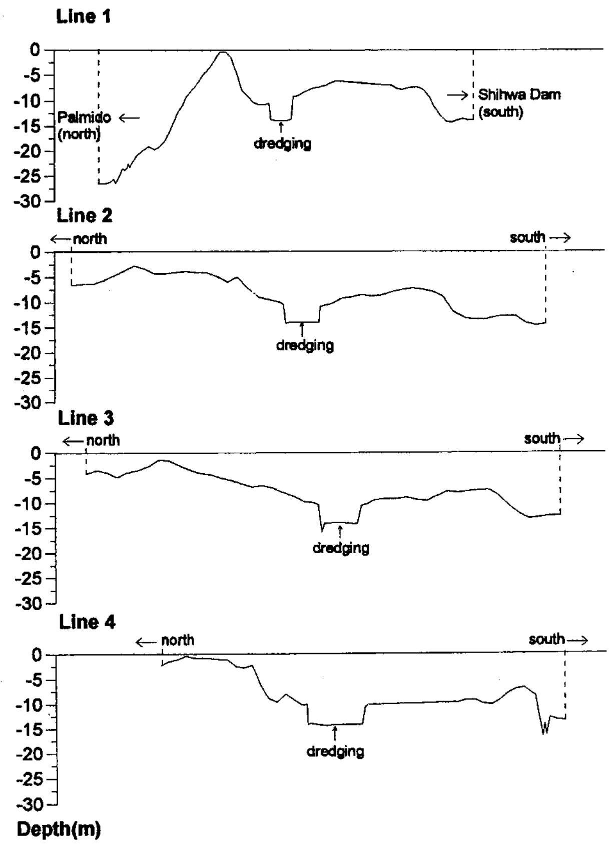


**Fig. 3.** Echo sounding profiles off the LNG Storage Base. Refer to track lines of Fig. 1.

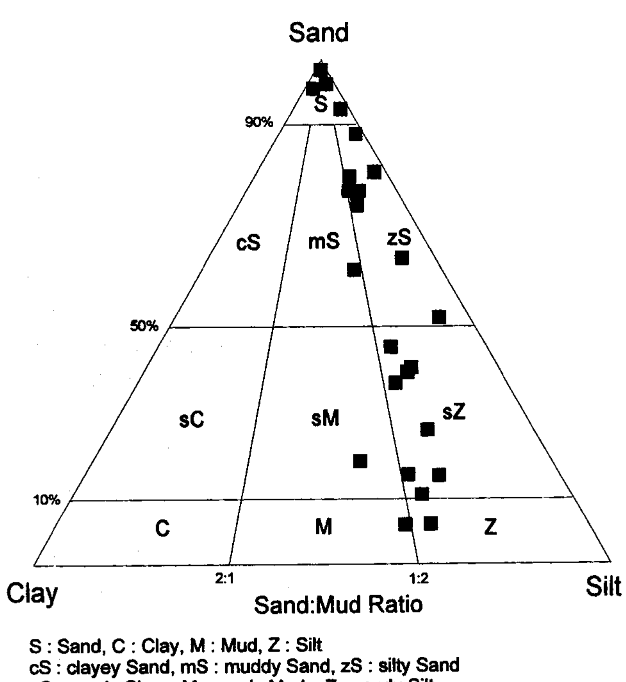


**Fig. 4.** Triangular diagram, showing the varied sediment type composed of sand, silt with low content of clay, and gravel (<5%).

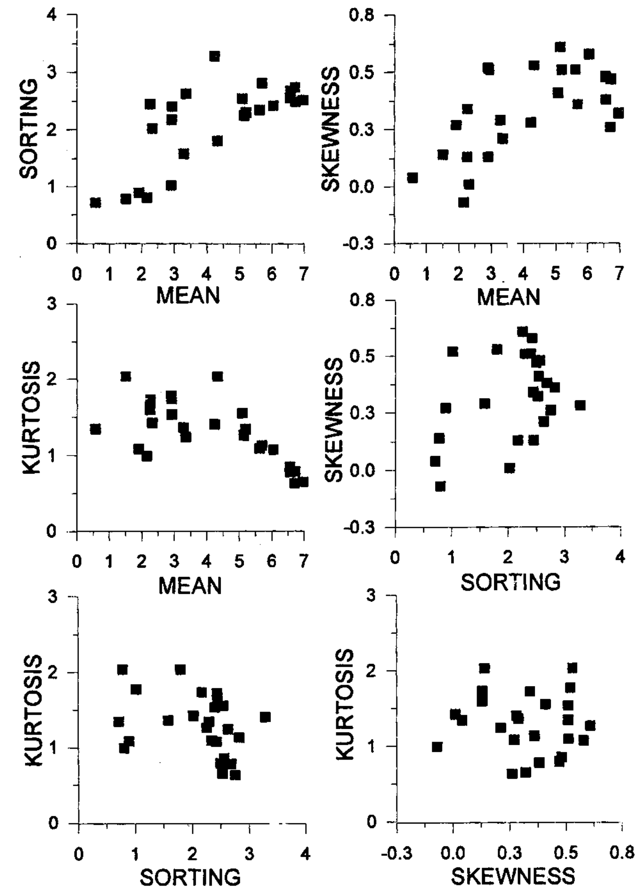


**Fig. 5.** Relation between textural parameters (mean, sorting, skewness, and kurtosis).

However, these 3 groups have been generally formed after the establishment of the Dam. Group II was deposited not only by wave effect, but also by dumping and dredging during construction of the dike.

Textural parameters represent that the variability of grain size distribution is mainly caused by the construction of the dike and affected by tidal current and wave action. The core shows a similar granulometric characters with surface sediment, and does not show any vertical change in depositional environment. However, more core sediments have to be analyzed for measuring sedimentation rate and processes. Bioturbations generally occur as homogeneous layer or as mottled structures in which some disturbance of sediments as a result of the ability of benthic animals are irregularly distributed.

### *Organic matter, carbonate content, and suspended sediment*

Content of organic matter in the surface sediments ranges from 1.0% to 7.3%. The amount of organic matter in this nearshore area show a diverse distribution pattern according to the sediment type. In general, higher values appeared along the dam and the content of organic matter range from 4.0 to 8.3%. This distribution pattern may be considered by concentration and deposition of fine particles under the control of lower flow regime after dam construction. The carbonate content in the surface sediment is characterized by 2 groups, showing a relatively higher value (>3.0%) and lower one (< 1.0%) (Table 1). Higher value appeared in the eastern part located near shoreline, fish-port and lower ones along the dam. Nevertheless, the carbonate fraction in the sediment is mainly composed of the fragmented one affected by human activity.

Suspended sediment matters varies between av. 23.0 mg/l in surface and av. 32.4 mg/l in bottom. Comparison with each other is meaningless because this data was collected with no consideration of tidal fluctuation (Table 1).

### *Metal content and distribution*

Among the heavy metals, 12 metals (Al, Mn, Fe, V, Cr, Co, Ni, Cu, Zn, Cd, Pb, As) are analyzed for comparing 8 samples (Jan. 1996) and 13 samples (Sep. 1996) (Table 2). These metals are generally considered as a major environmental pollutants because of high toxicity and great industrial uses. Especially 5 metals (Mn, Fe, Ni, Cu, Pb) have been compared with each others (Fig. 6). As shown in Table 3. the content of heavy metal in sediments shows relatively higher value in comparison with the previous data (Lee *et al.*, 1985). In comparison to the previous data (Jung and Choi, 1996; Table 3), the average content of 4 metals (Co, Ni, Cu, Pb) is less polluted than the intertidal flat of Shihwa lake because of the hydrodynamic condition such as tide and short duration after the establishment of the

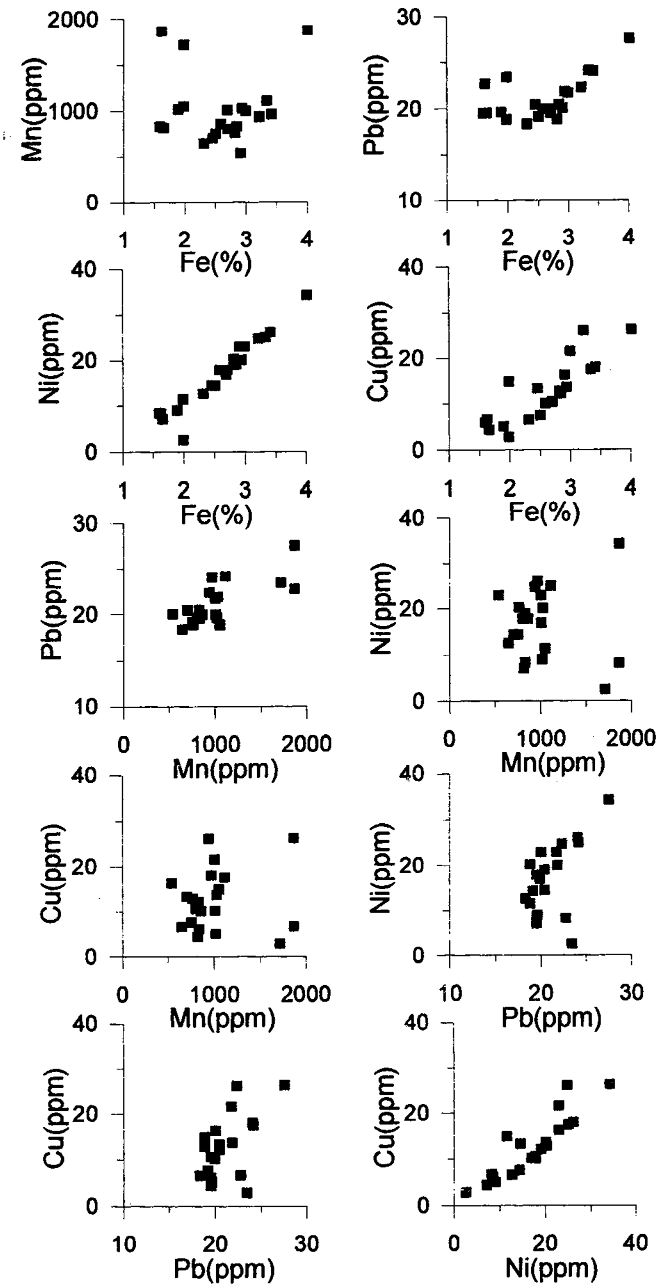


**Fig. 6.** Relation of 5 major elements (Mn, Fe, Ni, Cu, Pb), showing that 3 elements (Fe, Cu, Ni) have a linear relationship.

**Table 3.** Average values and annual variation of 7 heavy metals in each area: Incheon coastal area (A), Shihwa lake (B), and study area (C) (unit: ppm)

| Station | Date | Heavy metals | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Mn | Cr | Ni | Cu | Zn | Cd | Pb |
| A* | May. '94 | 334.6 | 22.2 | 25.1 | 10.2 | 44.8 | 0.18 | 20.5 |
| | Feb. '95 | 518.2 | 28.1 | 31.6 | 10.7 | 54.1 | 0.18 | 26.5 |
| B* | Jun. '94 | 357.4 | 59.9 | 30.6 | 48.0 | 98.9 | 0.26 | 34.6 |
| | Dec. '94 | 418.1 | 81.8 | 70.1 | 81.1 | 153.5 | 0.51 | 46.8 |
| | Mar. '95 | 387.9 | 69.3 | 62.9 | 57.4 | 119.3 | 0.43 | 39.7 |
| C | Jan. '96 | 1163.4 | 56.4 | 18.6 | 13.9 | 57.9 | 0.16 | 21.8 |
| | Sep. '96 | 940.1 | 52.0 | 16.3 | 12.0 | 51.7 | 0.16 | 21.0 |

*Data from KORDI (1995)

dam and the dike.

***Iron, nickel and copper***: The content of iron, varying between 4.01 and 1.59% (av. 2.59%), shows a higher value near the dam and lower one offshore. The nickel content varies between 26.1 and 2.5 ppm (av. 16.9 ppm), showing an co-increasing trend with iron, whereas there are some indistinguishable relationship with the content of Mn. The content of Cu ranges from 2.8 to 26.3 ppm, representing a similar distribution pattern compared to those of the other nearshore environment (4~26 ppm) and a marked relationship with change of iron content (Fig. 7). This particular quantitative relationship between iron content of copper and nickel suggests that a major portion of two metals are associated with the oxides and hydroxides of iron (Lee *et al.*, 1985).

***Manganese and Pb***: In nearshore environment of the study area, the content of Mn shows a wide range which is from 500 ppm to 1900 ppm (Table 3). However, the average content of Mn is higher than one in the other nearshore environments (KORDI, 1993), whereas the average one of Pb are constant except the Shihwa lake (Table 3).

There are an increasing trend of Mn content and contamination pattern occurred along channel, a high degree of variability of some heavy metal content and increasing trend of Mn since the establishment of the dam (Fig. 7). This result seems to be due to inflow of industrial pollutant from lake.

***The others***: As shown in Table 2, the range of V and Cr is 36~136 ppm (av. 87.8 ppm) and 13.8~92.2 ppm (av. 53.4 ppm), respectively. These contents show no distinct regional distribution. The contents of Cd and As, when compared with the unpublished data on the mud-belt in the East Sea, are lower one. This suggests that relatively high value may be related with grain size and mineral because this content is analyzed from the bulk sediment.

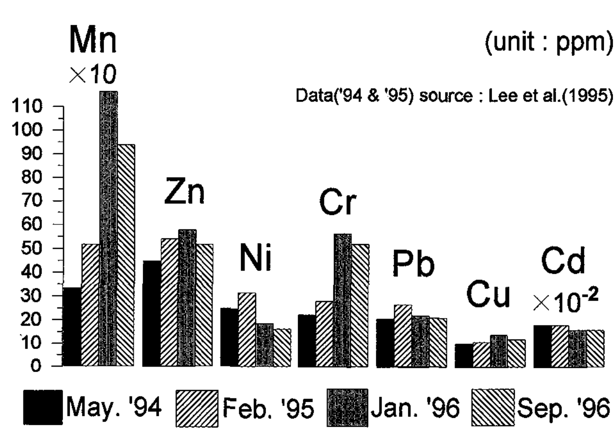


**Fig. 7.** Annual variations of 7 major elements (Mn, Zn, Ni, Cr, Pb, Cu, Cd) between in the Incheon coastal area and in Shihwa area. Content is average one calculated from the previous data (May. '94 and Feb. '95) and this study (Jan. and Sep. '96).

**Table 4.** Average content of 4 elements (Co, Ni, Cu and Pb) in 3 areas, showing a similar distribution pattern in Kyunggi Bay and Shihwa area (unit: ppm)

| | Co | Ni | Cu | Pb |
|---|---|---|---|---|
| Intertidal surface sediments* | 74.3 | 67.3 | 32.6 | 30.7 |
| Offshore bottom sediments (Kyeonggi Bay)* | 7.0 | 26.0 | 12.0 | 32.0 |
| Shihwa area** | 9.6 | 18.6 | 13.9 | 21.8 |

* Source: Lee *et al.*, (1985)
** Average content of this study area (Jan. '96)

### *Change of depositional environment (comparison with the previous study)*

Referred to the data reported by KORDI (1995), statistical analysis and annual comparison with this study have been done for interpreting annual variation of heavy metal content because the study area is nearly similar (Fig. 7). The content of Mn shows relatively rapid increase, although there is higher value along the coast of Korean peninsular (Lee *et al.*, 1991). In considering the different depositional system, relative content in each area (Table 4) suggests that this study area is similar with Kyunggi Bay (Table 4). As shown in Table 3, content in Shihwa lake is higher than one off the dam, this means that heavy metal have been accumulated inside lake.

## CONCLUSIONS

The study area may be divided into 3 depositional characteristic zones based on grain size distribution and textural parameters (Fig. 2).

This result shows that group II (Sand) and III (sandy Silt) may be formed after the establishment of the dam and dike. Textural parameters suggest that the variability of grain size distribution is mainly affected by the construction of the dike as well as by tidal current and wave action. When compared with the previous data (KORDI, 1995), the contents of sedimentary heavy metal show an increasing trend, suggesting environmental effect of potential input of industrial pollutants. Additionally, absolute contents of 4 major metal show that this study area may be classified into tide-dominated nearshore/subtidal coast such as Kyunggi bay. Quantitative comparison of some trace metals (including Cd and As) with the mud-belt sediments (in the East Sea) suggests that grain size may be related to content distribution. In result, changes in depositional environment, attested by irregular sediment distribution and geochemical properties, may be invoked by the establishment of the dam and dike, as well as the discharges of industrial pollutants from the Shihwa lake and Incheon industrial base.

## ACKNOWLEDGEMENTS

This work was supported by '95 Korea Research Foundation (101-H-0055). The author acknowledge the efforts of graduate students Yoo, Kyu-Cheul and Kim, Sung-eun during the fieldwork at sea and data analysis in lab. Review of this paper and discussion with Prof. M.W. Han were greatly helpful to interpret the data. Lee, Yong-guk (KORDI) collaborated with the acquisition and elaboration of echo-sounding data. I express our appreciation to Korea Ocean Research and Development Institute members for providing the previous data.

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