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HEAVY METALS IN SEDIMENTS FROM JINHAE BAY, KOREA.

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ABSTRACT

Sediments were collected from 23 stations in Jinhae Bay and Cd, Cr, Co, Cu, Fe, Pb, Ni, Mn and Zn were determined by atomic absorption spectrophotometry.

The concentrations of Cd, Cr, Cu, Pb and Zn in the sediments decreased gradually with increasing distance from the head of Masan Bay, indicating pollutant transport from industrial and municipal wastewaters. But the levels of Co, Ni, Mn and Fe showed no difference throughout the bay.

Analysis of correlation coefficients showed that Cd, Cr, Cu, Pb and Zn in the sediments were closely associated to one another, whereas Co, Ni, and Fe were so associated.

INTRODUCTION

Coastal marine sediments are well known to be good indicators of geochemical and environmental changes. Those changes include transport into coastal waters of pollutants, especially heavy metals, through river inputs (Soutar *et al.*, 1977; Goldberg, 1978). In the last two decades, many industrial complexes for heavy and chemical industries have been established near the coastline of Korea, thereby increasing the pollution burden on coastal waters and sediments.

Jinhae Bay is one of the most polluted coastal areas in Korea, the main sources of pollutants being domestic and industrial wastewaters from Masan, Changweon and Jinhae (Lee *et al.*, 1980). The deterioration in water quality has recently caused serious damage to aquaculture in the bay.

In the present study, heavy metal concentrations were measured in sediments from various parts of Jinhae Bay and related to their probable sources.

SAMPLING AND ANALYTICAL METHODS

Sampling stations of sediments in Jinhae Bay are shown in Fig. 1. Samples were collected in September, 1982, at 23 stations with a sediment snapper, put into 100ml polyethylene bottles, and transported in an ice box to the laboratory for analysis.

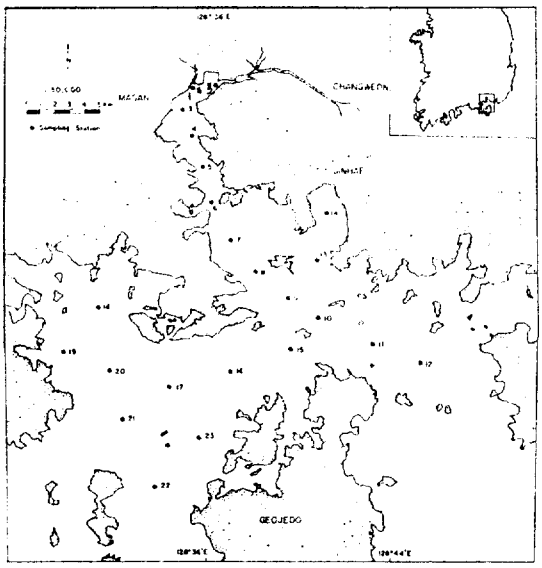

Fig. 1. Sampling stations of Jinhae Bay.

The samples were dried in a freeze dryer, ground with a mortar, and passed through an 80-mesh nylon sieve. One gram of each sample was pyrolyzed in porcelain crucible for three hours at 550°C in a muffle furnace. The sample then was transferred to a 30 ml-pyrex test tube. Three ml of conc. HNO_3 was added and the mixture heated at 140°C on an oil bath to dryness. After digestion, 20ml of 1N HNO_3 was added and it was shaken by an electric shaker. Dilution of 100 times was needed for the Fe and Mn determination.

The concentrations of heavy metals were determined by flame atomic absorption spectrophotometry (AAS) with a Varian Model 875 with deuterium source automatic background correction.

RESULTS AND DISCUSSION

Heavy metals in sediments determined were cadmium (Cd), chromium (Cr), cobalt (Co), copper (Cu), iron (Fe), lead (Pb), nickel (Ni), manganese (Mn) and zinc (Zn).

Cadmium

The range and mean concentrations of Cd in the sediments of the bay were 0.1~2.4ppm and 0.7ppm, respectively. Table 1 shows that the Cd concentrations were particularly high in Masan Bay, whereas other areas exhibited low Cd levels. The mean concentration of Cd in Masan Bay (1.5ppm) was three times higher than that in the Masan Waterway (0.5ppm), Haengam Bay (0.5ppm) or the Gajodo Area (0.4ppm). In

Table 1. Heavy metal concentrations in sediments in Jinhae Bay (ppm dry weight).

Area \ Element / St.		Cd	Cr	Cu	Co	Ni	Pb	Zn	Mn	Fe (%)
Masan Bay	1	2.4	114	105	12	28	85	447	340	3.1
	2	1.2	50	31	9	17	51	149	225	2.7
	3	1.9	85	66	11	20	73	267	200	3.3
	4	1.0	59	23	13	20	43	130	300	3.6
	5	1.1	64	37	12	28	46	152	365	3.3
Masan Waterway	6	0.7	59	31	13	30	38	125	400	3.6
	7	0.8	50	17	11	22	32	102	150	3.3
	8	0.6	47	24	12	30	32	111	420	3.9
	9	0.5	45	21	13	30	30	101	410	3.9
	10	0.2	64	20	13	30	28	94	410	3.9
	11	0.1	45	19	14	27	33	107	450	3.6
	12	0.3	55	20	13	25	29	90	420	3.7
Haengam Bay	13	0.2	55	19	10	21	26	93	725	2.7
	14	0.8	56	24	12	31	34	109	235	3.7
Gajodo Area	15	0.3	45	22	13	28	29	97	475	3.7
	16	0.3	75	24	13	33	30	98	450	3.3
	17	0.2	57	29	13	30	33	104	800	5.1
	18	0.6	66	34	14	30	29	100	320	4.2
	19	0.8	57	27	12	31	32	99	275	4.2
	20	0.3	68	30	14	30	24	96	400	4.2
	21	0.2	50	22	13	30	31	98	375	3.6
	22	0.5	45	23	13	30	32	98	300	3.6
	23	0.4	57	21	13	23	26	88	435	3.6
	Mean	0.7	59	30	12	27	37	128	386	3.6

Table 2. Correlation coefficients significant at the 99% level in Jinhae Bay (N=23).

	Cd	Cr	Cu	Pb	Zn	Co	Ni	Fe
Cd	1.000							
Cr	0.714	1.000						
Cu	0.867	0.888	1.000					
Pb	0.943	0.741	0.907	1.000				
Zn	0.894	0.839	0.975	0.948	1.000			
Co	—	—	—	—	—	1.000		
Ni	—	—	—	—	—	0.637	1.000	
Fe	—	—	—	—	—	0.648	0.575	1.000

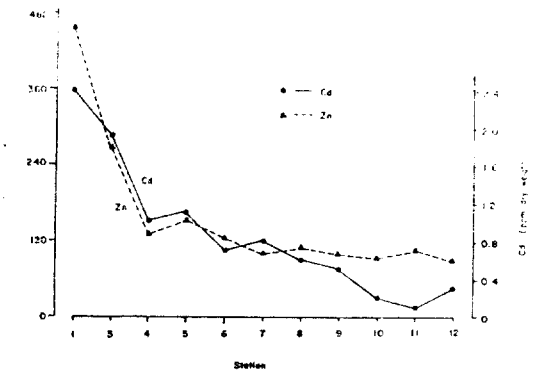

Fig. 2. Concentrations of Cd and Zn at Sts. 1~12.

Masan Bay, the samples from the inner bay were particularly high in Cd levels compared to those from other stations. This apparently is due to domestic and industrial wastewaters from Masan and Changweon. The Cd level from St. 2 was only half that from St. 1 near which the main stream with pollutants enters the bay.

As shown in Fig. 2, the Cd concentrations in Masan Bay decreased gradually with increasing distance from the head of the day. Table 2 shows that Cd exhibited significant positive correlation with Cr, Cu, Pb or Zn, but not with Co, Ni, Mn or Fe.

There is no good agreement as to the mean concentrations of Cd from various marine sediments. The mean Cd concentrations reported for sediments range from 0.17ppm (Bowen, 1979) to 0.5ppm (Brooks, 1977). Compared to the Brooks' mean Cd concentration, the mean levels of Cd of the Masan Waterway, Haengam Bay, and the Gajodo Area were very similar, whereas Masan Bay showed three times higher levels of Cd than the Brooks' mean Cd level. The mean Cd concentration of this study (0.7 ppm) was similar to that of Israeli coast (Roth and Hornung, 1977) or that of Chesapeake Bay (Goldberg *et al.*, 1978).

Chromium and Copper

The range and mean concentrations of Cr of the whole bay were 45~114ppm, 59ppm and of Cu 17~115ppm, 30ppm, respectively. The distribution of Cr and Cu tended to be similar to that of Cd. Masan Bay showed considerably high levels of Cr and Cu, compared to other areas. The mean Cu concentration in Masan Bay (52 ppm) was two times higher than that in the Masan Waterway (22 ppm), Haengam Bay (22 ppm), or the Gajodo Area (26 ppm). This trend was also observed with the Cr distribution. The mean Cr levels were shown highest in Masan Bay (74 ppm) and, then the Gajodo Area (58 ppm), Haengam Bay (56 ppm) and the Masan Waterway (52 ppm) in the decreasing order. It should be noted that sediments from St. 1 in the innermost part of Masan Bay contained especially high levels of Cr and Cu because of the river water inputs. Fig. 3 shows that in Masan Bay the Cr and Cu concentrations tended to decrease with increasing distance from the head of the bay. As presented in Table 2, Cr and Cu showed the significant positive correlation with Cd, Pb or Zn, but not with Co, Ni, Mn or Fe.

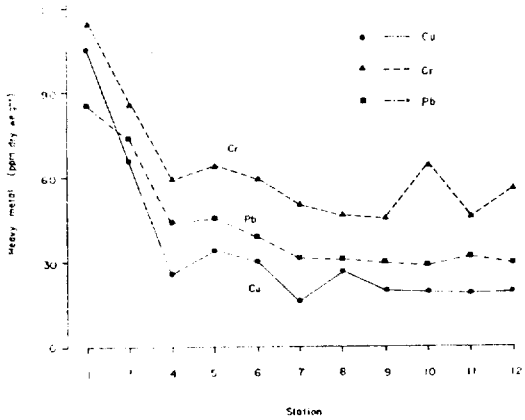

Fig. 3. Concentrations of Cr, Cu and Pb at Sts. 1~12.

Compared to the results of Do *et al.* (1981) in which 56.9 ppm of Cr were found, in Masan Bay, the mean Cr concentration in this area in the present study was much higher (74 ppm), whereas the Cu levels were nearly the same in the two studies. The mean levels of Cr and Cu in the present study were lower than the mean values for marine sediments (Cr 72 ppm, Cu 33 ppm) reported by Bowen (1979).

Cobalt and Nickel

The range and mean concentrations of Co for the whole bay were 9~14 ppm, 12 ppm and of Ni 17~33 ppm, 27ppm, respectively. It is interesting to note that samples from Masan Bay showed slightly lower mean levels of Co and Ni than other areas. But the Co and Ni concentrations showed no appreciable difference between areas. In addition, the mean levels of Co and Ni of this study were lower than those of marine sediments (Co 14 ppm, Ni 52 ppm; Bowen, 1979). It appears that the amounts of Co and Ni in Jinhae Bay had no direct relationship with pollutant inputs from various wastewaters. This fact was also indicated in the previous reports (Lee *et al.*, 1978 and 1982). In the present study Co and Ni showed the significant correlation only with Fe, but not with other metals.

Lead and Zinc

The range and mean concentrations of Pb of the whole bay were 24~85 ppm, 37 ppm and of Zn 88~447 ppm, 128 ppm, respectively. The distributional trends of Pb and Zn were very similar to those of Cd, Cr and Cu. Masan Bay showed the highest Pb and Zn levels among the areas. The mean concentrations of Pb and Zn in Masan Bay (Pb 60 ppm, Zn 229 ppm) were two times higher than those of the Masan Waterway (Pb 32 ppm, Zn 104 ppm), Haengam Bay (Pb 30 ppm, Zn 101 ppm), or the Gajodo Area (Pb 30 ppm, Zn 98 ppm). Sediments from St. 1 showed the highest Pb and Zn levels. Figs. 2 and 3 show that the concentrations of Zn and Pb in Masan Bay decreased gradually with increasing distance from the head of the bay, as previously shown with Cd, Cr and Cu. In the present study, Pb and Zn showed significant positive correlation with Cd, Cr and Cu. In contrast, they exhibited no correlation with the rest of metals.

The mean values of Pb and Zn of this study were much higher than the mean levels for marine sediments (Pb 19 ppm, Zn 95 ppm) reported by Bowen (1979) or those of the southeastern coastal area of Korea (Pb 28ppm, Zn 111 ppm) reported by Lee *et al.* (1978).

Manganese and Iron

The range and mean concentrations of Mn were 150~800 ppm, 386 ppm and of Fe 2.7~5.1%, 3.6%, respectively. It is interesting to note that the mean concentrations of Mn and Fe in Masan Bay (Mn 286 ppm, Fe 3.2%) were lower than those of the Masan Waterway (Mn 380 ppm, Fe 3.7%), Haengam Bay (Mn 480 ppm, Fe 3.2%), or the Gajodo Area (Mn 426 ppm, Fe 3.9%). A similar trend was also shown with Co and Ni. As was the case of Co and Ni, Mn and Fe exhibited no appreciable difference in the mean levels among the areas. This is probably due to the high indigenous contents of

Mn and Fe in sediments. The mean concentrations of Mn and Fe from this study were much lower than the mean levels for marine sediments (Mn 770 ppm, Fe 4.1%) reported by Bowen (1979).

CONCLUSIONS

In view of the high levels of Cd, Cr, Cu, Pb and Zn in Masan Bay and the significant correlations among them at the 99% confidence level, those five metals appeared to be associated with inputs of pollutants into Masan Bay. In contrast, Co, Ni, Mn and Fe were present in relatively low concentrations in Masan Bay with no differences among the areas studied.

In Masan Bay, the concentrations of Cd, Cr, Cu, Pb, and Zn decreased gradually with increasing distance from the head of the bay, indicating that those metals were highly affected by wastewaters entering into the bay.

REFERENCES

Bowen, H.J.M. 1979. Environmental chemistry of the elements, Academic Press, London, U.K.

Brooks, R.R. 1977. Pollution through trace elements. (In) J. O'M. Bockris(ed.), Environmental Chemistry, Plenum Press, New York, U.S.A.

Do, K.M., Z.U. Bae, and S. Hong. 1981. A synthetical survey for the contamination of Masan Bay. Research Report of the Institute of Environment, Kyungnam University, 3:12-12.

Goldberg, E.D. 1978. Pollution history of some U.S. estuaries. Proceedings of the colloquium on aquatic environment in Pacific Region. Scope, Academical Sinica, Taipei, Republic of China, 8-18.

Goldberg, E.D., V. Hodge, M. Koide, J. Griffin, E. Gamble, O.P. Bricker, G. Matisoff, G.R. Holdren, Jr. and R. Braun. 1978. A pollution history of Chesapeake Bay. Geochim. Cosmochim. Acta, **42**: 1413-1425.

Lee, D.S. and S.J. Han. 1978. The contents of heavy metals in sediments from the Southeastern coastal area of Korea. J. Oceanol. Soc. Korea, **13**:11-16.

Lee, K.W., H.S. Kwak, S.H. Lee, D.B. Yang, and G.H. Hong. 1980. III. Chemical study on Jinhae Bay. (In) A preliminary investigation on the monitoring system for the red tides in Jinhae Bay. Report of KORDI. BSPE 00022-43-7.

Lee, K.W., H.S. Kwak, S.H. Lee, D.B. Yang, E.S. Kim and J.Y. Oh. 1981. II. Chemical study on Jinhae Bay. (In) A study on the monitoring system for the red tides in Jinhae Bay. Report of KORDI. BSPE 00031-56-7.

Lee, K.W., S.H. Lee, D.B. Yang, J.Y. Oh, and E.S. Kim. 1982. A preliminary study on the Korean mussel watch. Report of KORDI. BSPE 00032-60-4.

Roth, I., and H. Hornung. 1977. Heavy metal concentrations in water, sediments and fish from Mediterranean coastal area, Israel, Environ. Sci. and Tech., **11**:265-269.

Soutar, A., S.K. Kling, P.A. Crill, E. Duffrin, and K.W. Bruland. 1977. Monitoring the marine environment through sedimentation. Nature, **266**:136-139.

진해만 퇴적물중의 중금속 함량

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要 約

진해만의 중금속 오염 현황 파악을 위하여 퇴적물중의 중금속함량을 조사하였다. 조사된 중금속은 Cd, Cr, Co, Cu, Fe, Ni, Mn, Pb, Zn등 9가지 원소이며 모두 23개 조사점에서 시료를 채취하여 원자흡수 분광법에 의해 중금속 함량을 분석하였다. 본 조사 결과로는 Cd, Cr, Cu, Pb, Zn 등의 함량은 마산만이 다른 해역보다 월등히 높았으며 또 내만에서 외양으로 나갈수록 함량이 뚜렷하게 감소하였으나 Co, Fe, Ni, Mn 등은 해역간에 별다른 농도 차이를 나타내지 않았다. 중금속의 통계학적 상관 관계를 보면 Cd, Cr, Cu, Pb, Zn group과 Co, Fe, Ni group으로 나뉘어져 각 group 내에서는 중금속 상호간에 유의성 있는 상관 관계를 나타내었으나 group 간에는 상관 관계를 보이지 않았다.