

Middle Layer

Bottom Layer



Upper Layer

Middle Layer

Bottom Layer

Figure 2.3.4



Middle Layer

Bottom Layer



Upper Layer

Middle Layer

Bottom Layer

Figure 2.3.5



Middle Layer

Bottom Layer



Upper Layer

Middle Layer

Bottom Layer

Figure 2.3.6



Middle Layer

Bottom Layer



Upper Layer

Middle Layer

Bottom Layer

Figure 2.3.7

2.4. Similarity between Survey Points in Water Quality Characteristics

The similarity between survey points was analyzed by water quality characteristics. Survey points with high similarity during spring tide and neap tide in the rainy and dry seasons were gathered by cluster analysis, based on components of No. 1 to 3 obtained by principal component analysis. Ten groups of high similarity were gathered from 25 points in the dry season and the other ten from 26 points in the rainy season, setting the cluster number as 10. An example of the result of cluster analysis is shown in Figure 2.4.1. High similarity points that belong to the same cluster are summarized in Table 2.4.1. The characteristics of the similarity were as below.

- 1) In the rainy season, the upper bay area from P01 to P07 and bay mouth area from P19 to P23 showed high similarity of water quality in both the upper and bottom layers. The central bay area from P19 to P23 showed high similarity in the upper layer but not very much similarity in the bottom layer.
- 2) In the rainy season, points in the upper layer, forming a central line from P8 of the upper bay towards bay mouth such as P8, P11, P14, and P17, showed high similarity suggesting that inflowing river water goes out through this line. In the lower layer, points of P24, P21, P19, and P8 showed high similarity suggesting that seawater of outer sea enters through this path.
- 3) In the dry season, points of the upper bay from P0 to P5 showed high similarity in the upper layer. Points of the bay mouth from P19 to P25 showed high similarity in both the upper and bottom layer.
- 4) P10 in Shenzhen Bay showed no similarity with other points.
- 5) As a result of a similarity analysis for 2 seasons × 2 tidal timings × 2 layers, the following points showed more than 50 % similarity.

Upper Bay Area	P01-P05, P02-P05, P03-P04, P03-P07, P05-P06
Central Bay Area	P11-P17, P11-P19
Bay Mouth Area	P20-P22, P20-P23, P20-P25, P22-P25

	POIL	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	P13	P14	P15	P 16	P17	P18	P19	P20	P21	P 22	P23	P24	P25	P26	P27
DO1		1 02	1 00	101	1375	5		100									/								<u> </u>		
F UI	75.587		2276		22602	not he			100.00	_	_					(3 55)				Rai	ny S	eas	on, l	Jppe	er la	yer	
FUZe Dog	<u> Antar</u>		S	-	_	_	TERM	_							_	-192 			- 1	1							_
P03								1923				1.042.0	5 2331	<u>1985</u> 9		Philip	17		-						- 1		-
FU4					~		in the second	<u>resea</u>			H:LAC	342776.7	2222	.≂:284			0.5 44								-1		_
PUDE		12710			12202																						-1
P06	-	19	and and	Photo: 84	-			667777E			-20-12	प्रहोह क	and the second second	(alternated			2000										_
P07			系的	(Hide)				14:2			(2014) (2014)	228.5 2728.5	279333	2020 9			22.04										
P08												2002	2.75271			3767015								_			_
P09								.—		<u> </u>		358				10000											
P10	_							649763				स्टब्स	*****														_
P11 211								1973 1973						1.000		15375	1.000				.						
P12	_						Context 1							1000	797153273	24.5	2.5		325701	\$735E			132151				_
P13					aicean								$ \rightarrow$	2233) 			100										
P14		.			鐵		N						E.S.					- 	क्राइट के	748.72			-				
P15									1.1074.2		1.3962		1 erer						新运	PDA:E							_
P16									1210				┝╍┥		(general)												Ĩ
P17					<u> </u>			推測	distant.			100-100			5. BA	1000				_	27.467						
P18									199		Digital and	陸林袋					S.C.I.D.				1.20		Carlos				_
P19				L	<u> </u>				-			\vdash	<u> </u>			100000	8	23. yrs. 21	ert		\$2.000 192000	SEC.	1940 1940				<u> </u>
P20			<u> </u>													67 <u>83</u>	2	40-0-2				2.073 D.01#	UN XE.				
P21								-								1-1-1 -1 -10	Шњ.	1	201323		-				COMPG		
P22								2223								328		100				311163					_
P23											MENTS.	<u> </u>	<u> </u>			_	-	2001		200 2		0.00				_	
P24																		0-17-2		270005		57.00					
P25								i				<u> </u>				-				<u>EHB</u>		27.274	12445			<u> </u>	_
P26		Rai	nv S	eas	on. F	Sotte	om l	avei								教室							2 .53		5.442 		$ \rightarrow $
P27					, -							- 1		-		-	-	- 1	-	-	-	-		•	Ŧ	•	
			_		_			_						· · · · ·			•	•									
	Deel	200		IDe (-	1700	Dog		Theorem	D10		1010			1015	1010	D17	1010	D10	Dou	D91	1000	D92	D94	D 95	Doc	D 97
	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	P13	P14	P15	P16	P17	P18	P19	P20	P21	P22	P23	P24	P 25	P26	P27
P01	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	P13	P14	P15	P16	P17	P18	P19	P20 Dr	<u>Р21</u> у Se	P22 easo	P23 n, U	P24 ppe	P25 r lay	P26 ver	P27
P01 P02	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	P13 - -	P14	P15	P16	P17	P18	P19	P20 Dr	<u>Р21</u> у Se	P22 easo	P23 n, U	P24 ppe	P25 r lay	P26 ver	P27
P01 P02 P03	P01	P02	P03	P04	P05	P06	P07	P08 務選	P09	P10	P11	P12	P13 - - -	P14	P15	P16	P17	P18	P19	P20 Dr	P21 y Se	P22 easo	P23 n, U	P24 ppe	P25 r lay	P26 yer	P27
P01 P02 P03 P04	P01	P02	P03	P04	P05	P06	P07	P08 飛躍	P09	P10	P11	P12	P13 - - -	P14	P15	P16	P17	P18	P19	P20 Dr	P21 y Se	P22 2830	P23 n, U	P24 ppe	P25 r lay	P26 /er -	P27
P01 P02 P03 P04 P05	P01	P02	P03	P04	P05	P06	P07	P08 系握	P09	P10	P11	P12	P13 - - - -	P14	P15	P16	P17	P18	P19	P20 Dr	P21 y Se	P22 easo	P23 n, U	P24 ppe	P25 r lay	P26 /er - -	P27
P01 P02 P03 P04 P05 P06	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	P13 - - - - -	P14	P15	P16	P17	P18	P19	P20 Dr	P21 y Se	P22 easo	P23 n, U	P24	P25 r lay	P26 /er - -	P27
P01 P02 P03 P04 P05 P06 P07		P02	P03	P04	P05	P06	P07	P08 照 調 調 調 調 調	P09	P10	P11	P12	P13	P14	P15	P16	P17	P18	P19	P20 Dr	P21 y Se	P22 easo	P23 n, U	P24 ppe	P25 r lay	P26 /er - - -	P27
P01 P02 P03 P04 P05 P06 P07 P08		P02	P03	P04	P05	P06	P07 靈麗	P08 課題 調題	P09	P10	P11	P12	P13 - - - - - - -	P14	P15	P16	P17	P18	P19	P20	P21 y Se	P22	P23 n, U	P24 ppe	P25 r lay	P26 /er - - -	P27
P01 P02 P03 P04 P05 P06 P07 P08 P09		P02	P03	P04	P05	P06	P07	P08 题 關聯/	P09	P10	P11	P12	P13	P14	P15	P16	P17	P18	P19	P20	P21	P22 2aso	P23	P24 ppe	P25	P26 /er - - - -	P27
P01 P02 P03 P04 P05 P06 P07 P08 P09 P10		P02	P03	P04	P05	P06	P07 靈麗	P08 题	P09	P10	P11	P12	P13	P14	P15	P16	P17	P18	P19	P20	P21	P22	P23	P24	P25	P26	P27
P01 P02 P03 P04 P05 P06 P07 P09 P10 P10 P11		P02	P03	P04	P05	P06	P07		P09	P10	P11	P12	P13	P14	P15	P16	P17	P18	P19	P20	P21	P22	P23	P24 ppe	P25	P26	P27
P01 P02 P03 P04 P05 P06 P07 P08 P09 P10 P11 P12		P02			P05	P06	P07		P09	P10	P111	P12	P13	P14	P15	P16	P17	P18	P19	P20 Dr	P21		P23	P24	P25	P26 ver - - - - - - - - - - - - -	P27
P01 P02 P03 P04 P05 P06 P07 P08 P09 P10 P11 P12 P13 P13		P02	P03		P05	P06	P07	P08 题 图 图	P09	P10	P11	P12	P13	P14	P15	P16	P17	P18	P19	P20 Dr	P21 y Se		P23	P24	P25	P26 /er - - - - - - - - - - - -	P27
P01 P02 P03 P04 P05 P06 P07 P08 P09 P10 P11 P12 P13 P14		P02		P04	P05	P06	P07	P08 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	P09	P10	P11	P12	P13	P14	P15	P16	P17	P18	P19	P20 Dr	P21 y Se	P22	P23	P24	P25	P26 /er - - - - - - - - - - - - - -	
P01 P02 P03 P04 P05 P06 P07 P08 P09 P10 P11 P12 P12 P14 P15		P02		P04	P05		P07	P08	P09 - 職 / 調麗 - 職	P10				P14	P15	P16	P17	P18		P20 Dr	P21 y Se		P23	P24	P25	P26 	P27
P01 P02 P03 P04 P05 P06 P07 P08 P09 P10 P11 P12 P13 P14 P15 P14		P02			P05		P07	P08 200 200 200 200 200 200 200 200 200 2	P09 國國一一國國一一國國一一國國		P11	P12	P13	P14	P15	P16	P17	P18		P20 Dr	P21 y Se		P23	P24	P25	P26	P27
P01 P02 P03 P04 P05 P06 P07 P08 P09 P10 P11 P12 P13 P14 P15 P16 P15 P16 P17		P02			P05				P09					P14	P15	P16	P17		P19	P20 Dr	P21 y Se		P23	P24 ppe	P25	P26	P27
P01 P02 P03 P04 P05 P06 P07 P08 P09 P10 P11 P12 P13 P14 P15 P16 P17 P18		P02			P05		P07		P09			P12	P13	P14		P16		P18	P19	P20 Dr	P21 y Se		P23	P24 ppe	P25	P26	P27
P01 P02 P03 P04 P05 P06 P07 P08 P09 P10 P11 P12 P13 P14 P15 P16 P17 P18 P19 P19		P02			P05		P07		P09			P12		P14		P16			P19		P21 y Se		P23	P24 ppe	P25	P26	P27
P01 P02 P03 P04 P05 P06 P07 P08 P09 P10 P11 P12 P13 P14 P15 P16 P17 P18 P19 P19 P19 P19 P19 P19 P19 P19 P19 P19		P02			P05				P09				P13	P14	P15	P16			P19 麗子 開麗 加 / 照		P21 y Se		P23	P24 ppe	P25	P26	
P01 P02 P03 P04 P05 P06 P07 P08 P09 P10 P11 P12 P13 P14 P15 P16 P17 P18 P19 P19 P19 P121 P18 P19 P19 P19 P19 P19 P19 P19 P19 P19 P19		P02			P05				P09				P13						P19 翻翻 翻		P21 y Se		P23	P24 ppe	P25	P26	
P01 P02 P03 P04 P05 P06 P07 P08 P09 P10 P11 P12 P13 P14 P15 P16 P17 P18 P15 P16 P17 P18 P19 P12 P18 P19 P12 P19 P12 P19 P11 P12 P19 P19 P19 P19 P19 P19 P19 P19 P19 P19		P02			P05				P09					P14					219 篇		P21 y Se		P23	P24	P25	P26	
P01 P02 P03 P04 P05 P06 P09 P10 P11 P12 P13 P14 P15 P16 P17 P18 P15 P16 P17 P18 P19 P12 P12 P12 P12 P12 P12 P12 P12 P12 P12		P02			P05								P13								P21 y Se		P23	P24 ppe	P25	P26	P27
P01 P02 P03 P04 P05 P06 P09 P10 P11 P12 P13 P14 P15 P16 P17 P18 P17 P18 P19 P12 P18 P19 P12 P12 P12 P12 P12 P12 P12 P12 P12 P12					P05																P21 y Se		P23 n, U	P24 ppe	P25 r lay	P26	
P01 P02 P03 P04 P05 P09 P10 P11 P12 P13 P14 P15 P16 P17 P18 P19 P17 P18 P19 P12 P12 P12 P12 P12 P12 P12 P12 P12 P12																					P21 y Se		P23 n, U	P24 ppe	P25 r lay	P26	
P01 P02 P03 P04 P05 P09 P10 P11 P12 P13 P14 P15 P16 P17 P18 P19 P12 P12 P12 P12 P12 P12 P12 P12 P12 P12		P02	P03 题。 题。		P05			P08						P14					P19 潮 潮 潮 潮 潮 潮 潮 潮 潮 潮 潮 බ <		P21 S		P23 n, U	P24 ppe	P25 r lay	P26	

ı.

Table 2.4.1Similarity of Water Quality among Monitoring Points by Cluster Analysis
(Number of Cluster: 10; put together 25 or 26 points to 10 groups)

Same Cluster in both of Spring tide and Neap tide

Same Cluster in one of Spring tide or Neap tide



Figure 2.4.1 Results of Cluster Analysis (Case: Dry Season, Spring tide) (Number of Clusters : 10)

ļ

3. Bottom Sediment Quality

3.1. Overview of Existing Information

Heavy metals in seawater may be transferred into the bottom sediment by many pathways, such as adsorption by suspended matters, complexation, flocculation, codeposition and biological absorption. The enrichment coefficient of heavy metals, dependent on these phenomena, was investigated in Lingdinyang during 1976 to 1977 and March of 1987 (See Table 3.1.1). These results showed that the enrichment coefficients of the 1987 result had increased markedly from those of 1976 to 1977 (Han Wuying et al. 1995).

3.2. Bottom Sediment Quality by the Monitoring Program

Fine grain (silt and clay) is the main size of grain in the Pearl River Estuary. Fine grain composition is over 70% at most survey points, and over 90% in the western part of the bay mouth. As an exception, gravel or sand is dominant composition at a point in the eastern channel of the estuary, where dredging is under way.

Organic matter and oils are not high in the estuary, except in Shenzhen Bay where levels are slightly elevated.

A tendency towards reduction is evident for sulfide and Eh in Shenzhen Bay.

All heavy metals except Hg exceed the standard for coastal bottom sediment quality at many survey points (Hg: <0.2mg/kg, Cu: <30mg/kg, Cd: <0.5mg/kg, Zn: 80mg/kg, Pb: 25mg/kg, As: 15mg/kg) (See Table 3.2.1, 3.2.2, 3.2.3, and 3.2.4).

Horizontal distribution patterns of Zn and As show slightly elevated levels in the western part of the bay mouth and in the upper bay. However, the distribution pattern of other heavy metals do not show any significant distribution characteristics (See Figure 3.2.1).

	year	Hg	Pb	Cr	Cd	Cu	Zi	As
Enrichment	1976-1977	4.6-7.3	0.4-3.8	84.8-144	0.2-1.4	2.6-6.3	1.4-4.8	2.5-9.8
coefficient	1987	-	25.51		6.78	21.86	14.1	•

•

į.

Table 3.1.1The heavy metal ion enrichment coefficients in the sediments of
Lingdingyang, the Pearl River Mouth ($\times 10^3$)

Items/Season		Organic N	Matter(%)	Oils Conte	nts(mg/kg)
Area/Point		Rainy S.	Dry S.	Rainy S.	Dry S.
Bay head	(P01)	2.3	1.4	152	105
River mouth	(P04)	1.5	1.1	47	92
Shenzhen Bay	(P10)	3.2	2.1	85	2585
Western part of bay	(P14)	2.7	2.1	279	129
mouth	(P24)	2.1	1.7	703	791
Eastern part of bay mouth	(P22)	2.1	-	216	-

 Table 3.2.1
 Bottom Sediment Quality (Organic Matter and Oils Contents)

Table 3.2.2Bottom Sediment Quality (Sulfide and Eh)

Items/Season		Sulfide	(mg/kg)	Eh(mV)
Area/Point		Rainy	Dry	Rainy	Dry
Bay head	(P01)	7	35	110	360
River mouth	(P04)	17	56	78	88
Shenzhen Bay	(P10)	78	489	18	-20
Western part of bay	(P14)	54	38	29	281
mouth	(P24)	47	100	43	10
Eastern part of bay mouth	(P22)	135	-	49	-

Table 3.2.3Bottom Sediment Quality (Hg, Cu and As)

Items/Season	Items/Season			Cu(m	g/kg)	As(mg/kg)		
Area/Point		Rainy	Dry	Rainy	Dry	Rainy	Dry	
Bay head	(P01)	0.22	0.09	42	31	24	20	
River mouth	(P04)	0.09	0.10	57	27	18	18	
Shenzhen Bay	(P10)	0.06	0.14	20	54	12	11	
Western part of bay	(P14)	0.20	0.19	57	49	33	30	
mouth	(P24)	0.20	0.18	39	40	27	27	
Eastern part of bay mouth	(P22)	0.10	-	27	-	15	•	

Table 3.2.4 Bottom Sediment Quality (Zn, Pb and Cd)

Items/Season	Items/Season			Pb(m	g/kg)	Cd(mg/kg)		
Area/Point		Rainy	Dry	Rainy	Dry	Rainy	Dry	
Bay head	(P01)	189	121	54	42	0.94	0.98	
River mouth	(P04)	97	90	35	29	0.89	1.09	
Shenzhen Bay	(P10)	81	86	44	51	0.87	0.70	
Western part of bay	(P14)	157	99	47	57	1.29	0.68	
mouth	(P24)	187	196	45	55	1.17	0.83	
Eastern part of bay mouth	(P22)	90	-	50	-	0.87	-	



Figure 3.2.1 Horizontal Distribution of Sediment Quality in Rainy Season