CHAPTER IV
RESULTS

4.1 General characteristics of sediments

Based on the general features observed from the sediment samples and their particle size distributions (as shown in Table 4.1), the general characteristics of sediments can be described as follows:

Mae Klong sediment is blackish green, very fine-grained sediment with some shell fragments. Based on the particle size distribution, its texture is classified as silty clayey sand.

Chao Phraya sediment is blackish brown, very fine-grained sediment containing some shell fragments and wood residues. Based on the particle size distribution, its texture is classified as sandy clayey silt.

Bang Pakong sediment is greenish brown, very fine-grained sediment. Based on the particle size distribution, its texture is classified as silty clay.

Table 4.1 General characteristics of sediments in this study

Sediment	General features				Particle size distribution			Texture
	Color	Shell	Wood	Odor	Sand (%)	Silt (%)	Clay (%)	
Mae Klong (M)	Blackish green	X	-	-	44.2	36.0	19.8	Silty clayey sand
Chao Phraya (C)	Blackish brown	X	X	X	24.1	45.4	30.5	Sandy clayey silt
Bang Pakong (B)	Greenish brown	-	-	-	0.2	44.6	55.2	Silty clay

4.2 Elemental composition of sediments

Major elements and total P of <125 μm fraction of sediment samples analyzed by XRF technique are shown in Table 4.2 together with the average sedimentary rocks from AGI datasheets complied by Dutro et al. (1989). It was found that all sediments in this study have nearly the same phosphorus contents as the average sedimentary rocks.

Table 4.2 Elemental composition (%) in <125 μm fraction of sediments together with the average sedimentary rocks from AGI datasheets (Dutro et al., 1989)

Elements	Average sedimentary rocks			Sediments of this study		
	Sandstone	Graywacke	Platform Shale	Mae Klong	Chao Phraya	Bang Pakong
SiO_2	70.00	66.70	50.70	72.10	70.50	57.90
Al_2O_3	8.20	13.5	15.1	10.30	11.90	17.60
Fe_2O_3(total)	4.15	5.45	6.71	3.49	5.30	6.24
MnO	0.06	0.10	0.08	0.12	0.17	0.28
MgO	1.90	2.10	3.30	1.38	1.64	1.90
CaO	4.30	2.50	7.20	2.01	0.72	0.33
Na_2O	0.58	2.90	0.80	1.10	1.50	2.19
K_2O	2.10	2.00	3.50	2.39	1.92	1.77
P_2O_5	**0.10**	**0.10**	**0.10**	**0.10**	**0.11**	**0.14**
TiO_2	0.58	0.60	0.78	0.56	0.63	0.78
LOI	7.60	3.90	11.80	6.73	6.80	10.68

4.3 Oxidizable organic matter in sediments

The average values of oxidizable organic matter in <125 μm fractions of sediment samples from the Mae Klong, Chao Phraya and Bang Pakong Estuaries (as presented in Table 4.3) analyzed by chromic method (Loring and Rantala, 1977) are 1.84%, 1.68% and 2.77 %, respectively.

Table 4.3 Average oxidizable organic matter (%) in <125 μm fraction of sediments

Mae Klong sediment	Chao Phraya sediment	Bang Pakong sediment
1.84	1.68	2.77

Note: the average results calculated from 9 replicates

4.4 Carbonate content of sediments

The average values of carbonate contents in <125 μm fraction of sediment samples from the Mae Klong, Chao Phraya and Bang Pakong Estuaries (as presented in Table 4.4) analyzed by acid-base titration (Gross, 1971) are 4.61%, 2.67% and 0.96 %, respectively. It was found that the Mae Klong sediment contains relatively higher amount of carbonate than the Chao Phraya and Bang Pakong sediments, respectively.

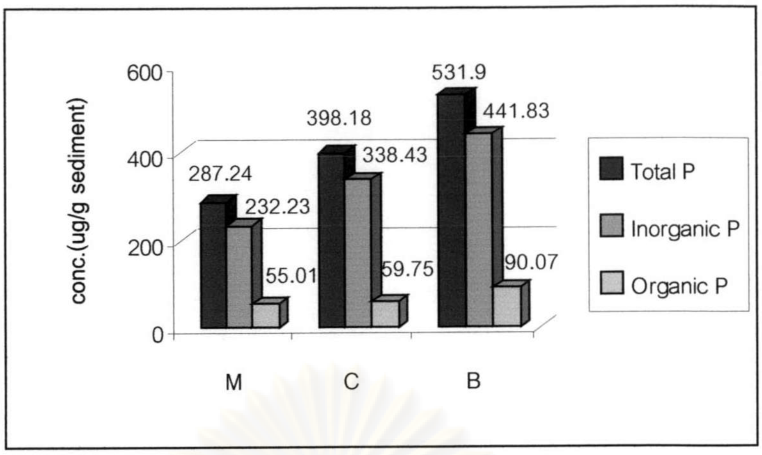
Table 4.4 Average carbonate contents (%) in <125 μm fraction of sediments

Mae Klong sediment	Chao Phraya sediment	Bang Pakong sediment
4.61	2.67	0.96

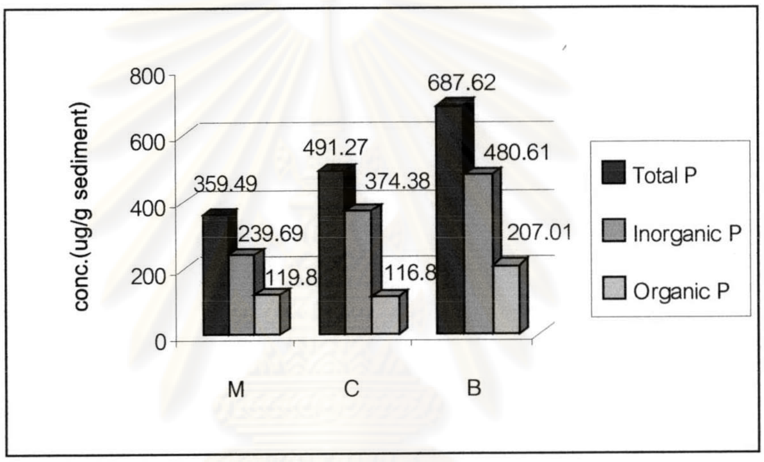
Note: the average results calculated from 9 replicates

4.5 Total, inorganic and organic phosphorus in sediments

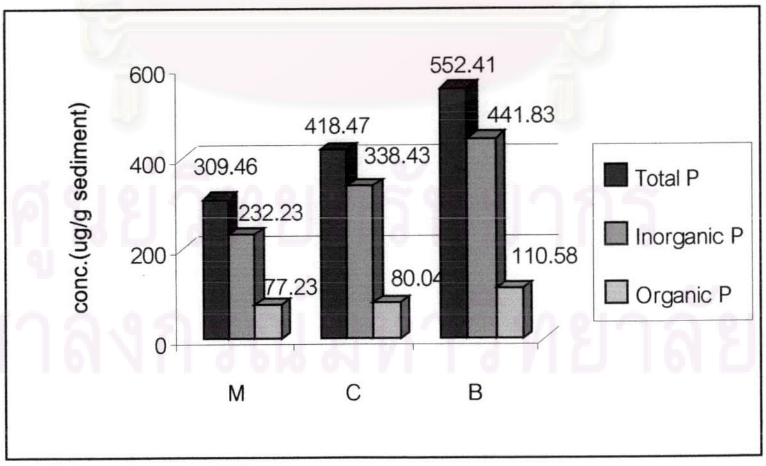
The average values of total, inorganic and organic phosphorus in <125 μm fraction of sediment samples analyzed by three ignition methods (Aspila et al., 1976; Vink et al., 1997 and Agemian, 1997) are presented in Figure 4.5. The results of total, inorganic and organic P in sediments depend on the method employed. However, all ignition methods provide the same patterns of total, inorganic and organic P contents in all sediments. More than 80 % of total P in all sediments are inorganic P.



(a)



(b)



(c)

Figure 4.5 Total, inorganic and organic P (μg/g sediment) in the Mae Klong (M), Chao Phraya (C) and Bang Pakong (B) sediments analyzed by ignition methods of (a) Aspila et al. (1976), (b) Vink et al. (1997), and (c) Agemian (1997)

4.6 Total phosphorus in sediments

Total P results can be utilized to confirm the phosphorus partitioning results in sediments obtained through various extraction schemes. However, total P can be analyzed by various methods; therefore, comparison of total P results from six total P analytical methods [XRF, ignition methods (Aspila et al., 1976; Vink et al., 1997; and Agemian, 1997) and total digestions ($HF\text{-}HClO_4\text{–}HNO_3$) with phosphomolybdate blue methods of Strickland and Parsons (1972) and Koroleff (1976)] were also carried out in this study in order to specify the best total P analytical method. The average results of total P obtained through various methods in sediment samples are shown in Tables 4.6.1, 4.6.2 and 4.6.3. More details of total P results from various methods are presented in Appendix F.

Table 4.6.1 Total phosphorus in the Mae Klong sediments (mean±SD μg/g sediment) from various total phosphorus analytical methods

Methodology		Total P (μg/g sediment)
Digestion method	Phosphate analysis	
Ignition-1 M HCl 16 h (Aspila et al. 1976)	Koroleff (1976)	287.24±6.68
Ignition-6 M HCl 16 h (Vink et al., 1997)	Strickland&Parsons (1972)	359.14±0.08
Ignition-1 M HCl 16 h (Agemian, 1997)	Strickland&Parsons (1972)	309.46±7.40
$HF\text{-}HClO_4\text{-}HNO_3$	Strickland&Parsons (1972)	354.83±8.81
$HF\text{-}HClO_4\text{-}HNO_3$	Koroleff (1976)	394.25±8.58
XRF		437.00±6.56

Table 4.6.2 Total phosphorus in the Chao Phraya sediments (mean±SD μg/g sediment) from various total phosphorus analytical methods

Methodology		Total P (μg/g sediment)
Digestion method	Phosphate analysis	
Ignition-1 M HCl 16 h (Aspila et al. 1976)	Koroleff (1976)	398.20±7.46
Ignition-6 M HCl 16 h (Vink et al., 1997)	Strickland&Parsons (1972)	491.27±15.53
Ignition-1 M HCl 16 h (Agemian, 1997)	Strickland&Parsons (1972)	418.47±0.04
$HF-HClO_4-HNO_3$	Strickland&Parsons (1972)	480.40±6.29
$HF-HClO_4-HNO_3$	Koroleff (1976)	505.85±3.64
XRF		480.00±7.20

Table 4.6.3 Total phosphorus in the Bang Pakong sediments (mean±SD μg/g sediment) from various total phosphorus analytical methods

Methodology		Total P (μg/g sediment)
Digestion method	Phosphate analysis	
Ignition-1 M HCl 16 h (Aspila et al. 1976)	Koroleff (1976)	531.90±9.83
Ignition-6 M HCl 16 h (Vink et al., 1997)	Strickland&Parsons (1972)	687.62±36.04
Ignition-1 M HCl 16 h (Agemian, 1997)	Strickland&Parsons (1972)	552.41±9.03
$HF-HClO_4-HNO_3$	Strickland&Parsons (1972)	634.54±27.24
$HF-HClO_4-HNO_3$	Koroleff (1976)	674.41±21.27
XRF		611.00±7.20

4.7 Phosphorus partitioning in sediments

The average values of each phosphorus species in sediments of this study analyzed by the sequential extraction schemes of Ruttenberg (1992), Vink et al. (1997) and Agemian (1997) are individually presented below. More details about phosphorus partitioning results by all extraction schemes are shown in Appendix G.

4.7.1 Ruttenberg (1992)'s method

Mae Klong sediment

The phosphorus partitioning in the Mae Klong sediment (in Figure 4.7.1) shows that Fe-P is relatively higher than organic P, authigenic apatite, detrital apatite and loosely sorbed P, respectively.

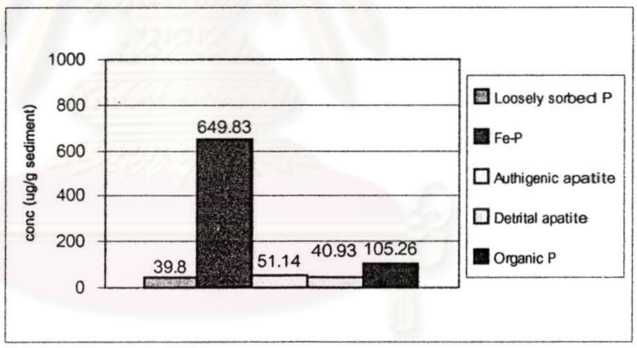


Figure 4.7.1 Phosphorus partitioning in the Mae Klong sediment (μg/g sediment) by Ruttenberg (1992)'s extraction scheme

Chao Phraya sediment

The phosphorus partitioning in the Chao Phraya sediment (in Figure 4.7.2) indicates that Fe-P is relatively higher than organic P, loosely sorbed P, detrital apatite and authigenic apatite, respectively.

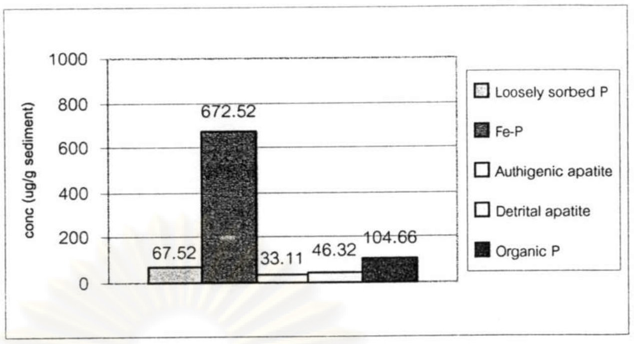


Figure 4.7.2 Phosphorus partitioning in the Chao Phraya sediment (μg/g sediment) by Ruttenberg (1992)'s extraction scheme

Bang Pakong sediment

The phosphorus partitioning in the Bang Pakong sediment (in Figure 4.7.3) illustrates that Fe-P is quite relatively higher than organic P, loosely sorbed P, detrital apatite and authigenic apatite, respectively.

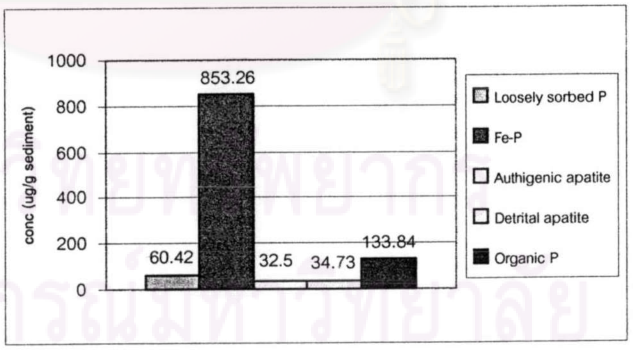


Figure 4.7.3 Phosphorus partitioning in the Bang Pakong sediment (μg/g sediment) by Ruttenberg (1992)'s extraction scheme

4.7.2 Vink et al. (1997)'s method

Mae Klong sediment

The phosphorus partitioning in the Mae Klong sediment (in Figure 4.7.4) shows that Fe-P is relatively higher than organic P, Authigenic apatite, detrital apatite, loosely sorbed P and residual P, respectively.

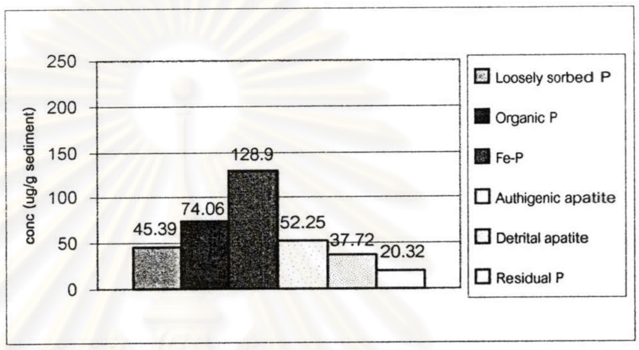


Figure 4.7.4 Phosphorus partitioning in the Mae Klong sediment (μg/g sediment) by Vink et al. (1997)'s extraction method

Chao Phraya sediment

The phosphorus partitioning in the Chao Phraya sediment (in Figure 4.7.5) indicates that Fe-P is relatively higher than organic P, loosely sorbed P, detrital apatite, authigenic apatite and residual P, respectively.

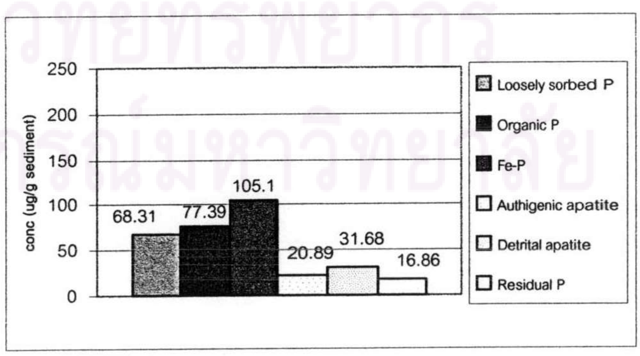


Figure 4.7.5 Phosphorus partitioning in the Chao Phraya sediment (μg/g sediment) by Vink et al. (1997)'s extraction method

Bang Pakong sediment

The phosphorus partitioning results in the Bang Pakong sediment (in Figure 4.7.6) shows that Fe-P is much relatively higher than organic P, loosely sorbed P, detrital apatite, authigenic apatite and residual P, respectively.

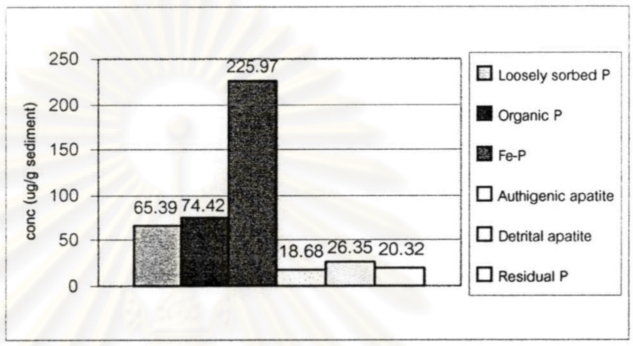


Figure 4.7.6 Phosphorus partitioning in the Bang Pakong sediment (μg/g sediment) by Vink et al. (1997)'s extraction scheme

4.7.3 Agemian (1997)'s method

Mae Klong sediment

The phosphorus partitioning in the Mae Klong sediment (in Figure 4.7.7) indicates that Fe and Al bound P is relatively higher than calcium bound P, refractory P, loosely bound P and polyphosphate, respectively.

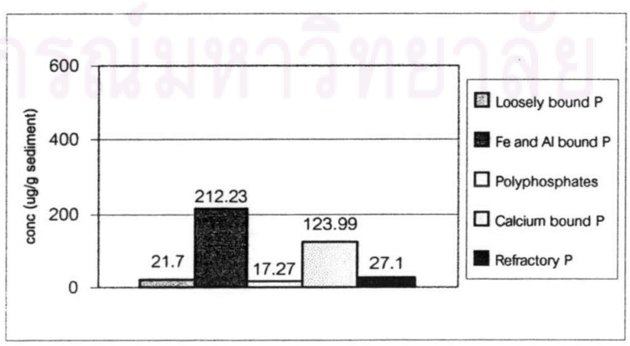


Figure 4.7.7 Phosphorus partitioning in the Mae Klong sediment (μg/g sediment) by Agemian (1997)'s extraction method

Chao Phraya sediment

The phosphorus partitioning in the Chao Phraya sediment (in Figure 4.7.8) illustrates that Fe and Al bound P is relatively higher than calcium bound P, polyphosphate, loosely bound P and refractory P, respectively.

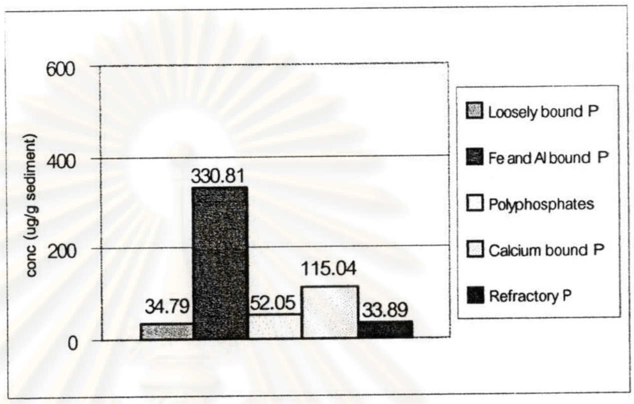


Figure 4.7.8 Phosphorus partitioning in the Chao Phraya sediment (µg/g sediment) by Agemian (1997)'s extraction method

Bang Pakong sediment

The phosphorus partitioning in the Bang Pakong sediment (in Figure 4.7.9) exhibit that Fe and Al bound P is relatively very higher than polyphosphate, refractory P, calcium bound P and loosely bound P, respectively.

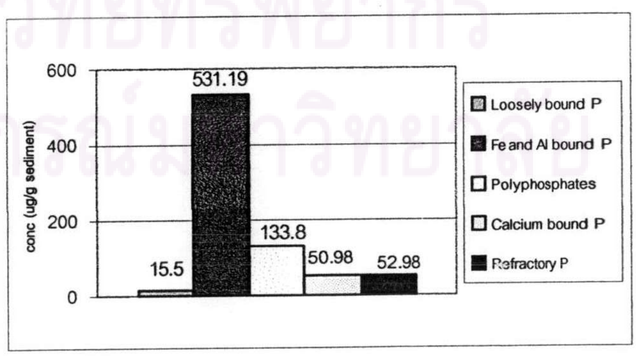


Figure 4.7.9 Phosphorus partitioning in the Bang Pakong sediment (µg/g sediment) by Agemian (1997)'s extraction scheme

4.8 Organic phosphorus in sediments

Organic phosphorus contents in sediments were obtained from sequential extraction schemes and the difference between total phosphorus and inorganic phosphorus by ignition method. According to Table 4.8, the difference in organic phosphorus content obtained by different methods was found in all three sediment samples. This may be due to the method utilized to obtained the results.

Table 4.8 Organic phosphorus contents in sediments (μg/g sediment) from sequential extraction schemes and the difference between total P and inorganic P from ignition methods

Methodology		Sediments of this study		
Method	phosphate analysis	Mae Klong	Chao Phraya	Bang Pakong
Step V-ash,1 M HCl 16 h (Ruttenberg, 1992)	Koroleff (1976)	105.26	104.66	133.84
StepII-SDS,ash-6M HCl16 h (Vink et al., 1997)	Strickland&Parsons (1972)	74.06	77.39	74.42
TP-TIP (Agemian, 1997)	Strickland&Parsons (1972)	77.23	80.04	110.58
TP-TIP (Aspila et al., 1976)	Koroleff (1976)	55.01	59.75	90.07
TP-TIP (Vink et al., 1997)	Strickland&Parsons (1972)	119.8	116.89	207.01