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ศูนย์วิทยทรัพยากร
จุฬาลงกรณ์มหาวิทยาลัย



APPENDICES

ศูนย์วิทยทรัพยากร
จุฬาลงกรณ์มหาวิทยาลัย

APPENDIX A

Particle size distribution analysis

Particle size distribution (PSD) of sediment samples in this study was carried out by hydrometer technique. This classical method is based on the density of settling particles suspension. The greater the density of suspension, the greater the buoyant force on the hydrometer and the higher the reading. As particles settle out of the suspension, the density decreases and a lower reading is served. Since temperature influences the settling rate, the temperature must be checked and kept constant throughout the determination. Hydrometer reading should also be corrected for the use of dispersing agent.

Apparatus

- hydrometer
- sedimentation cylinder
- Plunger
- Electric blender
- 500 ml beaker

Reagents

- 5% Calgon solution: dissolve 35.7 g of sodium hexametaphosphate and 7.94 g of anhydrous sodium carbonate in distilled water, then dilute to 1 L.
- Amyl alcohol

Procedure

1. Weigh 50 g freeze-dried sediment in a 600 ml beaker.
2. Add 50 ml of 5% Calgon and then add 150 ml of distilled water, mix well and stand overnight.
3. Transfer the suspension into an electric blender and mix the suspension for 1-2 min.

4. Carefully pour the suspension into a sedimentation cylinder. Be sure to wash all of the sample into cylinder.
5. Add distilled water to the cylinder until the level reaches 1000 ml.
6. Using a plunger, stir the suspension in the cylinder up and down 20 times.
7. Add 2-3 drops to 1 ml of Amyl alcohol to eliminate bubble after vertical mixing.
8. Remove the plunger and note the exact time.
9. Carefully lower the hydrometer into the cylinder and read when 40 seconds have elapsed.
10. Remove the hydrometer after reading. Rinse and wipe dry. This reading gives the amount of silt and clay in the sample.
11. Measure and record temperature of suspension.
12. After the first reading, allow the cylinder to stand undisturbed for 2 hours.
13. Place the hydrometer in the cylinder and make the 2-hour reading. This reading indicates the amount of clay in the sample. Also measure the suspension's temperature. (Ideally the temperature should be kept constant throughout the determination).
14. Blank is also determined by the same method described above.
15. Calculate the percentage of sand, silt and clay and then determine the sediment texture by using the texture triangle (see figure A1).

Calculation

$$\%(\text{silt+clay}) = \frac{[(R_s - R_b) + 0.36(T_s - T_b)] \times 100}{\text{wt of sample}} \dots\dots\dots \text{first 40 seconds}$$

R_s = density of sample at first 40 seconds

R_b = density of blank at first 40 seconds

T_s = temperature of sample at first 40 seconds

T_b = temperature of blank at first 40 seconds

$$\% \text{ Clay} = \frac{(R_s - R_b) + 0.36(T_s - T_b) \times 100}{\text{wt of sample}} \quad \dots\dots\dots \text{Next 2 hours.}$$

- R_s = density of sample at 2 hours
- R_b = density of blank at 2 hours
- T_s = temperature of sample at 2 hours
- T_b = temperature of blank at 2 hours

$$\% \text{ Silt} = \%(\text{Silt} + \text{Clay}) - \% \text{ clay}$$

$$\% \text{ Sand} = 100 - \%(\text{Silt} + \text{Clay})$$

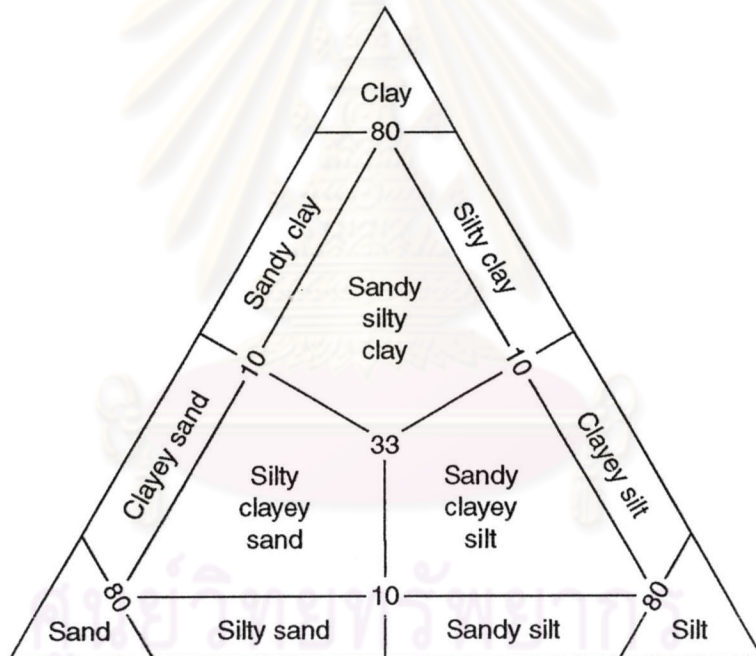


Figure A.1 Triangular classification diagram for particle size distribution (PSD) according to Gorline (1960)

APPENDIX B

Elemental composition analysis

Elemental composition of sediment samples in this study was qualitatively and quantitatively analyzed by X-ray Fluorescence technique. This non-destructive method is based on the fact that emission of fluorescent X-ray after atom is irradiated by primary X-ray. Since fluorescent X-ray of each element has specific wavelength, this can be utilized to specify elements in sample according to Bragg's law (qualitative analysis). Furthermore, the intensity of fluorescent X-ray is also measured for quantitative analysis.

A Siemens SRS3000 sequential X-ray fluorescence spectrometer (XRF) compatible with SPECTRA3000 software is utilized in this study. This spectrometer is installed at the laboratory of the WBB Clay and Minerals company. Diagram of this X-ray unit is shown in Figure B.1. Sediment samples were prepared by fused cast bead method (according to ISO/DIS12677) before analyzing elemental composition by XRFs. Thirty-two certified reference materials were prepared by the same way as samples and used in determining calibration graphs or equations and for correction of matrix effect. Three Japanese standards of sedimentary rocks (JLK-1, JSd-1 and JSd-3) from Geological survey of Japan (1999) were analyzed as samples to check the accuracy and precision of the instrument and methodology. Loss on ignition (LOI) testing was also conducted to measure the accuracy of the analysis.

Principle of X-ray fluorescence spectrometer

According to figure B.1, samples are irradiated with primary X-ray to emit Fluorescent X-ray. The Fluorescent X-ray is then controlled to become parallel beam (by a slit of goniometer) straightforward onto the surface of a plane crystal. Then the fluorescent X-ray diffract from the plane crystal according to Bragg's law ($2d\sin\theta = n\lambda$). A detector that rotates at the same velocity of a goniometer measures the energy of the X-ray quanta (intensity of X-ray) whereas goniometer measure the reflection angle (θ and 2θ) of X-ray. The energy is then converted into electrical impulses or counts and used

in calculation of concentration of element from the equations of X-ray intensities and concentration of elements by computer software (SPECTRA3000).

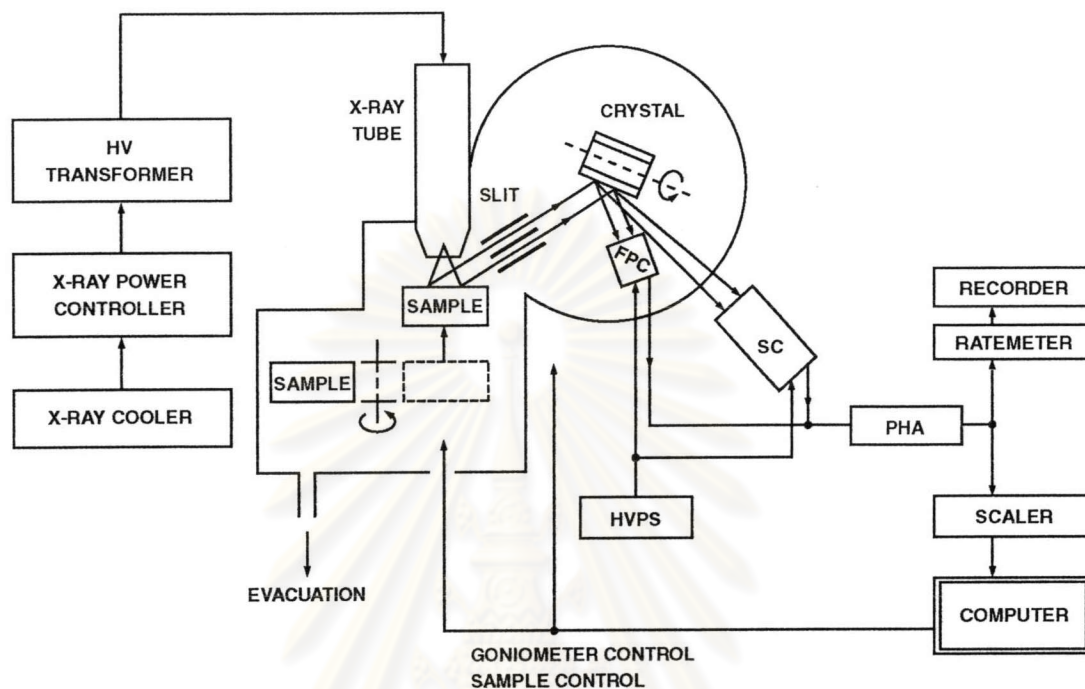


Figure B.1 Diagram of X-ray fluorescence spectrometer

Preparation of sample

Sediment sample of this study were prepared by fused cast bead method according to ISO/DIS12677 (1998). The sediment powder is fused with a suitable flux to destroy its mineralogy and particulate composition.

Apparatus

- Platinum-gold crucible and lid
- Claisse Flux machine, three burner fusion system
- Vacuum dessicator
- Balance
- Oven
- Hood

Chemicals

- Lithium metaborate, $\text{Li}_2\text{B}_4\text{O}_7$
- Lithium Iodide, LiI

Procedure

Dry $125\mu\text{m}$ fraction sediment sample overnight in an oven at $110^\circ\text{C}</math>, cool in a vacuum desiccator. 1 g of the sediment sample is weighed into a platinum-gold crucible with 5 g of pure lithium metaborate and then mix well. One drop of lithium iodide solution is added into the platinum crucible to prevent crack of glass bead after cooling down. Fuse at $1,000^\circ\text{C}</math> with the fluxer machine. After fused flux is poured on a platinum lid, let it cool for 5 min. Label the bead with a piece of label paper and store in a polyethylene seal-bag and then the bag should be stored in the vacuum desiccator until XRF analysis.$$

LOI testing

Loss on ignition (LOI) is used in estimating sediment moisture, organic matter, organic carbon, and carbonate content. LOI is considered to be an essential parameter for the XRF analysis. By ignoring LOI the total cannot be used as a measure of the accuracy of the analysis. LOI has been traditionally done by gravimetric method.

Apparatus

- Platinum crucibles
- Muffle furnace
- Balance
- Vacuum desiccator

Procedure

Weigh 2 g of dried sample into a platinum crucible. Then place the platinum crucible into a furnace. Heat at $1000^\circ\text{C}</math> for 4-10 h and cool it in a vacuum desiccator. Finally, weigh and calculate % of loss on ignition.$

APPENDIX C

Determination of carbonate content in sediment

The acid-base titration technique (Gross, 1971) is chosen because of its simplicity and suitability. The sediment sample is treated with excess amount of standardized hydrochloric acid. Complete the reaction between acid and carbonate by heating, then back titrate the excess acid with sodium hydroxide solution using phenolphthaline as an indicator.

Apparatus

- 250 ml Erlenmayer flasks
- 25 ml Burette with scale division 0.1 ml or more
- pH meter
- waterbath
- magnetic stirrer and magnetic bars
- 50 ml , 100ml , 250 ml , 1000 ml volumetric flasks

Reagents

- 0.5 M HCl
- 0.25 M NaOH
- Phenolphthaline solution: dissolve 100 mg of solid 100 ml of 80 % ethanol
- Na_2CO_3
- Potassium hydrogen pthalate ($\text{KH}_8\text{H}_4\text{O}_4$)
- Bromocresol green solution: dissolve 0.1 g of Brocresol green in 20 % ethanol and dilute to 100 ml

Procedure

1. Accurately weigh 1 g of sediment sample (in this study, particle size is less than $125 \mu\text{m}$) and transfer to 250 ml Erlenmayber flask.
2. Add 10 ml of 0.5 M HCl and then heat at about 90°C for 20 minute.

3. Test pH of solution with pH meter, if pH is more than 2 , add another 10 ml of HCl and repeat heating for 20 minute.
4. When pH is less than 2, dilute the solution with 100 ml of distilled water.
5. Back titrate with 0.25 M NaOH using phenolphthaline as an indicator. The color will change sharply from colourless to pink at the end point. The pH meter is applied to check the end point of reaction (pH = 7) because sediment suspension will hide pink color of end point.

Standardization of 0.25 M NaOH

1. Dry potassium hydrogen pthalate in an oven at 110 °C for 2 hour and cool in a dessicator.
2. Weigh 1.0 g of potassium hydrogen pthalate in 250 ml Erlenmayer flask
3. Dissolve in 100 ml of distilled water.
4. Add 3-4 drops of phenolphthaline.
5. Titrate with 0.25 M NaOH until the pink color develops and persists for 30 seconds.
6. Three replicates should be done.

Standardization of 0.5 M HCl

1. Dry Na₂CO₃ in an oven at 110 °C for 2 hour and cool in a dessicator.
2. Weigh 0.6-0.7 g portion of Na₂CO₃ in a 250 ml Erlenmayer flask.
3. Dissolve the solid with 50 ml distilled water
4. Add 3-4 drops of bromocresol green
5. Titrate with 0.5 M HCl solution until the solution just begins to change from blue to green.
6. Boil the solution for 2-3 minutes, cool at room temperature and complete the tritration if the color is changed from green to blue.
7. Three replicates should be done.

Calculation

$$\text{Percent CaCO}_3 = [100 \times 0.05 \times (\text{ml HCl})(M_{\text{HCl}})] - [(\text{ml}_{\text{NaOH}})(M_{\text{NaOH}})]$$

APPENDIX D

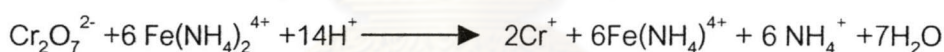
Determination of readily oxidizable organic matter in sediment

The method for determination of readily oxidizable organic matter in three estuarine sediments of this study is the Walkey-Black method (1947) which adopted by Loring and Rantala (1977). The readily oxidizable organic matter in sediment is allowed to oxidize with chromic acid and the excess chromic acid is reduced by using ferrous solution. This method will not interfere other non-sensitive organic carbon like charcoal and graphite, etc. Proteins may also remain unoxidized. Since carbon only constitutes about 58 % of the soft organic remains in sediments, the carbon content can be converted to the organic matter content by multiplying the formular.

The oxidation of carbon by chromic acid may be represented as following:



and the reduction of $\text{Cr}_2\text{O}_7^{2-}$ by ferrous solution may be given as



Reagents:

1. 85 % phosphoric acid (H_3PO_4)
2. Solid sodium fluoride (NaF)
3. Concentrated sulfuric acid (H_2SO_4)
4. Silver sulfate (Ag_2SO_4)
5. Potassium dichromate ($\text{K}_2\text{Cr}_2\text{O}_7$)
6. Ferrous ammonium sulfate ($\text{Fe}(\text{NH}_4)_2(\text{SO}_4)_2 \cdot 6\text{H}_2\text{O}$)
7. Diphenylamine
8. Glucose ($\text{C}_6\text{H}_{12}\text{O}_6$)

Preparation of solutions:

1. Concentrated sulfuric acid (H_2SO_4) with silver sulfate (Ag_2SO_4)

Dissolve 2.5 grams of silver sulfate in one litre of concentrated sulfuric acid. Store the solution in a glass-stoppered bottle.

2. Standard potassium dichromate ($\text{K}_2\text{Cr}_2\text{O}_7$) solution

Dissolve 49.04 grams of potassium dichromate in distilled water. Dilute the solution with distilled water to make one litre. Keep the solution in a glass-stoppered bottle.

3. 0.5 N ferrous ammonium sulfate solution

Dissolve 196.1 grams of ferrous ammonium sulfate in 800 ml of distilled water that is already filled with 20 ml of concentrated sulfuric acid. Store the solution in a glass-stoppered bottle.

4. Diphenylamine indicator

Dissolve 0.5 grams of A.R. grade diphenylamine in a mixture of 20 ml of distilled water and 100 ml of concentrated sulfuric acid. Keep the solution in a glass-stoppered bottle.

Procedure:

Approximately 0.5 grams of freeze-dried sediment is weighed out and placed into a 250 ml flask. Then 10 ml of 1N $\text{K}_2\text{Cr}_2\text{O}_7$ and 20 ml of concentrated H_2SO_4 with Ag_2SO_4 are added to the sediment. The solution is then swirled and left for 30 minutes. After 30 minutes, the solution was diluted to 200 ml with distilled water. Then, 10 ml of 85 % H_3PO_4 , 0.2 grams of NaF, and 15-20 drops of diphenylamine indicator are added. The diluted solution is then back titrated with 0.5 N ferrous ammonium sulfate solution. During the process of titration, the color of the solution gradually changes from a dull green to blue and then to a brilliant green. This final color change indicates the end point.

The procedure is repeated by using 0.01 grams of glucose as the standard in order to determine the definite concentration of the 1 N $\text{K}_2\text{Cr}_2\text{O}_7$ solution. The procedure was also repeated in determining a reagent blank.

Calculations:

After completing the back titration, the following calculation is made in order to determine the percentage (%) of organic matter and organic carbon in each of the sediment samples.

For sample

$$\% \text{ organic matter} = 10(1-T/S)XF$$

when S = the volume of 0.5 N ferrous ammonium sulfate solution used in titrating the "reagent blank"

T = the volume of 0.5 N ferrous ammonium sulfate solution used in titrating the "sediment sample"

$$F = (\text{K}_2\text{Cr}_2\text{O}_7 \text{ concentration}) \times (12/4000) \times 1.72 \times (10/\text{weight of the sample})$$

Which $12/4000$ = milliequivalent (meq.) weight of carbon

1.72 = factor for organic matter from carbon

For standard (glucose, $\text{C}_6\text{H}_{12}\text{O}_6$)

$$\text{meq. per 100 grams} = 10(1-T/S) \times (100/\text{weight of glucose})$$

$$\text{Therefore, meq. per 1 gram} = [10(1-T/S) \times (100/\text{weight of glucose})] / 100 \\ = n$$

then, $n \times \text{meq. per gram} (12/4000) = C$

and, $C \times 100 \% = \% \text{ of concentration} = y\%$

In theory, when titrated with 1 N $\text{K}_2\text{Cr}_2\text{O}_7$, the percentage of concentration should equal to 39.99 %. Therefore,

39.99 % $\text{K}_2\text{Cr}_2\text{O}_7$ will have a concentration of 1 N

and $y\%$ $\text{K}_2\text{Cr}_2\text{O}_7$ will have a concentration of $(y\%/39.99\%)$ N

APPENDIX E

Matrix effect of extractants on standard calibration curve for phosphorus

Table E.1 Matrix effect of extractants on standard calibration curve for phosphorus
- Strickland and Parsons (1972)'s procedure.

Matrix	dilution	slope	deviation	R ²	A _{reagent blank}
deionized water	1	0.0200	0.0000	1.0000	0.000
	1	0.0209	-0.0002	0.9999	0.000
1 M MgCl ₂	5	0.0205	-0.0008	0.9986	0.000
	5	0.0217	0.0000	1.0000	0.000
	5	0.0200	0.0000	1.0000	0.000
	10	0.0200	0.0000	1.0000	0.000
0.5 M NaCl	10	0.0200	0.0000	1.0000	0.000
1 M NaOAc	20	0.0204	-0.0002	0.9999	0.000
	20	0.0206	0.0006	0.9988	0.000
	20	0.2210	-0.0002	0.9999	0.000
1 M NaOAc+1 M MgCl ₂	1	0.0183	0.0000	1.0000	0.000
	1	0.0184	-0.0006	0.9991	0.000
	1	0.0192	-0.0002	0.9999	0.000
0.5 M HCl	20	0.0200	0.0000	1.0000	0.000
1 M HCl	10	0.0200	0.0000	1.0000	0.000
	100	0.0209	-0.0002	0.9999	0.000
	100	0.0200	0.0000	1.0000	0.000
	100	0.0206	-0.0006	0.9996	0.000
6 M HCl	30	0.0204	-0.0002	0.9999	0.000
	30	0.0205	-0.0002	0.9996	0.000
10% SDS+ 6M HCl	30	0.0205	-0.0002	0.9996	0.000
0.1 M NaOH	2	0.0209	-0.0002	0.9999	0.000
	5	0.0208	0.0002	0.9999	0.000
	10	0.0209	-0.0002	0.9999	0.000
1 M NaOH	5	0.0209	0.0008	0.9999	0.001

Table E.2 Matrix effect of extractants on standard calibration curve for phosphorus
-Koroleff (1976) 's procedure.

Matrix	dilution	slope	deviation	R ²	A _{reagent blank}
deionized water	1	0.0230	0.0000	1.0000	0.000
	1	0.0230	0.0000	1.0000	0.000
	1	0.0230	0.0000	1.0000	0.001
1 M MgCl ₂	5	0.0239	0.0002	1.0000	0.000
	5	0.0250	0.0000	1.0000	0.000
	5	0.0230	0.0000	1.0000	0.000
	5	0.0240	-0.0008	0.9995	0.000
	5	0.0250	0.0000	1.0000	0.000
	5	0.0230	0.0000	1.0000	0.000
NaOAc	20	0.0251	-0.0002	0.9999	0.000
	20	0.0250	0.0000	0.9997	0.000
	20	0.0253	0.0005	0.9998	0.000
1 M NaOAc+1 M MgCl ₂	1	0.0208	0.0008	0.9888	0.000
	1	0.0212	-0.0006	0.9989	0.000
	1	0.0280	0.0000	1.0000	0.000
1 M HCl	10	0.0228	0.0004	0.9997	0.000
	10	0.0227	0.0002	1.0000	0.000
	10	0.0215	-0.0002	1.0000	0.000
	20	0.0225	-0.0002	1.0000	0.000
	20	0.0218	-0.0004	0.9999	0.000
	20	0.0226	0.0006	0.9999	0.000
	20	0.0229	0.0006	0.9999	0.000
	20	0.0229	0.0004	0.9999	0.000
	25	0.0228	0.0006	0.9999	0.000
	25	0.0229	0.0007	0.9998	0.000
	25	0.0228	0.0003	1.0000	0.000
	25	0.0227	0.0007	0.9999	0.000

APPENDIX F

Total phosphorus in sediments from various total analytical methods

Table F.1 Total phosphorus ($\mu\text{g/g}$ sediment) from Aspila method (Aspila et al., 1976)

Sample	Replicate	Total P ($\mu\text{g/g}$ sediment)	Mean \pm SD ($\mu\text{g/g}$ sediment)	RSD (%)
Mae Klong (M)	M1	287.33	287.00 \pm 6.68	2.33
	M2	284.60		
	M3	276.41		
	M4	288.07		
	M5	288.07		
	M6	282.66		
	M7	299.44		
	M8	291.32		
Chao Phraya (C)	C1	402.46	398.18 \pm 6.49	1.63
	C2	392.26		
	C3	409.25		
	C4	390.21		
	C5	393.59		
	C6	396.98		
	C7	403.74		
	C8	396.98		
Bang Pakong (B)	B1	525.84	531.90 \pm 9.83	1.84
	B2	522.24		
	B3	522.45		
	B4	545.80		
	B5	535.61		
	B6	539.44		

Note: each replicate was analysed three times

Table F.2 Total phosphorus ($\mu\text{g/g}$ sediment) from Modified Aspila method
(Vink et al., 1997)

Sample	Replicate	Total P ($\mu\text{g/g}$ sediment)	Mean \pm SD ($\mu\text{g/g}$ sediment)	RSD (%)
Mae Klong (M)	M1	359.54	359.49 \pm 0.08	0.02
	M2	359.54		
	M3	359.40		
Chao Phraya (C)	C1	497.27	491.27 \pm 15.53	3.16
	C2	516.87		
	C3	497.47		
	C4	478.68		
	C5	478.68		
	C6	478.68		
Bang Pakong (B)	B1	706.62	687.63 \pm 36.04	5.24
	B2	725.61		
	B3	7.25.61		
	B4	668.63		
	B5	649.63		
	B6	649.63		

Note: each replicate was analysed three times

Table F.3 Total phosphorus ($\mu\text{g/g}$ sediment) from Agemian (1997) 's method

Sample	Replicate	Total P ($\mu\text{g/g}$ sediment)	Mean \pm SD ($\mu\text{g/g}$ sediment)	RSD (%)
Mae Klong (M)	M1	314.41	309.46 \pm 7.40	2.39
	M2	299.60		
	M3	314.39		
Chao Phraya (C)	C1	418.42	418.47 \pm 0.04	0.009
	C2	418.50		
	C3	418.50		
Bang Pakong (B)	B1	555.80	552.41 \pm 9.03	1.63
	B2	555.68		
	B3	545.76		

Note: each replicate was analysed three times

Table F.4 Total phosphorus ($\mu\text{g/g}$ sediment) from total digestion ($\text{HF-HClO}_4\text{-HNO}_3$) - soluble phosphate analysis by the procedure of Strickland and Parsons (1972)

Sample	Replicate	Total P ($\mu\text{g/g}$ sediment)	Mean \pm SD ($\mu\text{g/g}$ sediment)	RSD (%)
Mae Klong (M)	M1	402.18	394.25 \pm 8.58	2.18
	M2	397.42		
	M3	383.14		
Chao Phraya (C)	C1	480.33	480.40 \pm 6.29	1.31
	C2	474.84		
	C3	486.02		
Bang Pakong (B)	B1	657.79	634.54 \pm 27.24	4.29
	B2	646.06		
	B3	599.53		

Note: each replicate was analysed three times

Table F.5 Total phosphorus ($\mu\text{g/g}$ sediment) from total digestion ($\text{HF-HClO}_4\text{-HNO}_3$) - soluble phosphate analysis by the procedure of Koroleff (1976)

Sample	Replicate	Total P ($\mu\text{g/g}$ sediment)	Mean \pm SD ($\mu\text{g/g}$ sediment)	RSD (%)
Mae Klong (M)	M1	347.52	354.83 \pm 8.81	2.48
	M2	364.84		
	M3	351.85		
Chao Phraya (C)	C1	506.72	505.85 \pm 3.64	0.72
	C2	504.14		
	C3	506.72		
Bang Pakong (B)	B1	648.58	674.41 \pm 21.27	3.15
	B2	678.86		
	B3	695.79		

Note: each replicate was analysed three times

APPENDIX G

Sedimentary phosphorus partitioning results by selected sequential extraction methods

- Note: 1. The phosphorus partitioning results expressed in mean values \pm SD in the unit of $\mu\text{g/g}$ sediment.
2. The number 1, 2, 3, and 4 represent number of extraction in each fraction.
3. Three replicates of sediments were analyzed for phosphorus speciation.
4. Three replicates of sediment extract were determined for soluble phosphate.

SEDEX scheme (Ruttenberg, 1992)

Table G.1 Phosphorus partitioning in the Mae Klong estuarine sediment
by SEDEX scheme (Ruttenberg, 1992)

P speciation	1	2	3	4	Total	RSD (%)
Loosely bound P	20.14 \pm 2.37	11.79 \pm 0.6	4.14 \pm 0.24	3.73 \pm 0.33	39.8 \pm 3.54	8.89
Fe-P	648.94 \pm 212.74	0.89 \pm 0.12	ND	-	649.83 \pm 212.86	32.76
Authigenic apatite	47.84 \pm 2.32	2.06 \pm 0.35	0.68 \pm 0.13	0.56 \pm 0.11	51.14 \pm 2.91	5.69
Detrital apatite+ other inorganic P	40.93 \pm 2.63	-	-	-	40.93 \pm 2.63	6.43
Organic P	105.26 \pm 2.05	-	-	-	105.26 \pm 2.05	1.95
Sum of P speciation					851.14 \pm 223.99	54

Table G.2 Phosphorus partitioning in the Chao Phraya estuarine sediment
by SEDEX scheme (Ruttenberg, 1992)

P speciation	1	2	3	4	Total	RSD (%)
Loosely bound P	35.41 \pm 0.38	17.09 \pm 0.32	4.33 \pm 0.06	10.69 \pm 0.45	67.52 \pm 1.21	1.79
Fe-P	671.40 \pm 91.12	1.12 \pm 0.06	ND	-	672.52 \pm 91.18	13.56
Authigenic apatite	32.88 \pm 1.48	0.23 \pm 0.00	ND	ND	33.11 \pm 1.48	4.47
Detrital apatite+ other inorganic P	46.32 \pm 2.42	-	-	-	46.32 \pm 2.42	5.22
Organic P	104.66 \pm 5.82	-	-	-	104.66 \pm 5.82	0.06
Sum of P speciation					851.14 \pm 223.99	25

Table G.3 Phosphorus partitioning in the Bang Pakong estuarine sediment
by SEDEX scheme (Ruttenberg, 1992)

P speciation	1	2	3	4	Total	RSD (%)
Loosely bound P	22.98±0.53	21.04±0.45	4.36±0.07	12.04±0.29	60.42±1.34	2.22
Fe-P	852.38±135.77	0.88±0.07	ND	-	853.26±135.84	15.92
Authigenic apatite	27.63±1.63	3.85±0.05	0.75±0.05	0.27±0	32.5±1.73	5.32
Detrital apatite+ other inorganic P	34.73±0.87	-	-	-	34.73±0.87	2.51
Organic P	133.84±1.44	-	-	-	133.84±1.44	1.08
Sum of P speciation					1114.75±141.22	26

Modified SEDEX scheme (Vink et al., 1997)

Table G.4 Phosphorus partitioning in the Mae Klong estuarine sediment
by Modified SEDEX scheme (Vink et al., 1997)

P speciation	1	2	3	4	Total	RSD (%)
Loosely bound P	25.67±0.39	12.25±0.39	2.63±0.07	4.84±0.19	45.39±1.04	2.29
Organic P	74.06±8.16	-	-	-	74.06±8.16	11.02
Fe-P	111.74±46.78	17.16±2.29	ND	-	128.9±49.07	35.74
Authigenic apatite	41.78±2.25	7.75±0.5	1.81±0.32	0.91±0.14	52.25±3.21	6.14
Detrital apatite+ other inorganic P	37.72±4.71	-	-	-	37.72±4.71	12.49
Residual P	20.32±2.00	-	-	-	20.32±2.00	9.84
Sum of P speciation					358.64±68.19	78

Table G.5 Phosphorus partitioning in the Chao Phraya estuarine sediment
by Modified SEDEX scheme (Vink et al., 1997)

P speciation	1	2	3	4	Total	RSD (%)
Loosely bound P	33.37±1.29	18.43±0.32	4.99±0.13	11.52±0.15	68.31±1.89	2.77
Organic P	77.39±5.23	-	-	-	77.39±5.23	6.76
Fe-P	81.50±0.00	23.60±1.34	ND	-	105.1±1.34	1.27
Authigenic apatite	15.66±0.89	3.76±0.21	1.18±0.15	0.29±0.12	20.89±1.37	6.56
Detrital apatite+ other inorganic P	31.68±1.92	-	-	-	31.68±1.92	6.05
Residual P	16.86±4.18	-	-	-	16.86±4.18	24.79
Sum of P speciation					320.23±15.93	48

Table G.6 Phosphorus partitioning in the Bang Pakong estuarine sediment
by Modified SEDEX scheme (Vink et al., 1997)

P speciation	1	2	3	4	Total	RSD (%)
Loosely bound P	26.78±0.40	21.87±0.34	4.86±0.13	11.88±0.16	65.39±1.03	1.58
Organic P	74.72±0.04	-	-	-	74.72±0.04	0.03
Fe-P	202.36±123.86	23.61±2.70	ND	-	225.97±126.56	56.01
Authigenic apatite	14.59±1.40	2.60±0.15	1.16±0.00	0.33±0.00	18.68±1.55	8.30
Detrital apatite+ other inorganic P	26.35±0.78	-	-	-	26.35±0.78	2.96
Residual P	20.32±2.00	-	-	-	20.32±2.00	9.84
Sum of P speciation					431.13±131.94	79

Table G.7 Phosphorus partitioning in sediments by Agemian's extraction scheme (Agemian, 1997)

P speciation	Sediment of this study		
	Mae Klong	Chao Phraya	Bang Pakong
Loosely sorbed P	21.70±0.00	34.79±1.37	15.50±0.00
Fe-P	212.23±4.43	330.81±6.67	531.19±16.03
Polyphosphate	17.27±0.82	52.05±0.89	133.80±0.00
Calcium bound P	123.99±0.01	115.04±7.00	50.98±6.78
Residual P	27.10±1.59	33.89±1.35	52.98±1.63
Sum of P speciation	402.79±6.85	566.58±17.28	748.45±24.44

Table G.8 RSD (%) of phosphorus partitioning in sediments by Agemian's extraction scheme (Agemian, 1997)

P speciation	Sediment of this study		
	Mae Klong	Chao Phraya	Bang Pakong
Loosely sorbed P	0.00	3.94	0.00
Fe-P	2.09	2.02	3.02
Polyphosphate	4.78	1.71	0.00
Calcium bound P	0.01	6.08	13.30
Residual P	5.87	0.04	3.08
Sum of P speciation	13	14	19

BIOGRAPHY

Patcharee Wiratchapun was born on November 20, 1975 in Bangkok. She graduated with a Bachelor degree of Science in 1996 from Department of Marine Science, Faculty of Science, Chulalongkorn University. After graduation, she worked as an environmental scientist for an environmental consultant company. She has continued her advance study for Master Degree at Inter-Department of Environmental Science, Chulalongkorn University.



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