CHAPTER IV

DISCUSSIONS

In this study the material fluxes through the lower basin of the Chao Phraya River were estimated to describe for both daily and seasonal variations by considering the effects of tide, material concentration and discharge in the river. The study revealed that the tidal currents affected both at Pak Kret and Bang Sai Stations. From the results of daily net fluxes, it can be said that Period 1 (December 6,1987 - January 19,1988) was high discharge conditions (wet season) and Period 2 (March 13,1988 - May 6,1988) was low discharge conditions (dry season). Observing the tidal cycle of Pak Kret Station between two periods, it was obvious that during low discharge conditions (Period 2) the flow patterns were influenced dominantly by flood current (Fig. 10). This caused the material loads to be back transported (imported) on some tidal cycles. In contrast, during high discharge conditions (Period 1) the material fluxes were mostly transported (exported) towards the lower river except the silicate flux showed a back transport of 15.97 tons/day on January 19,1988 (Fig. 15). However, the daily material fluxes depend on the instantaneous discharge corresponding to the instantaneous concentrations of the time series measurements over a tidal cycle. That is, they are largely controlled by a large positive (export) or negative (import) cross-correlation of discharge and concentration over a tidal cycle (Kjerfve and McKellar, 1980).

In addition, it was obvious that the content of suspended sediment, total phosphorus, particulate phosphorus and phosphate phosphorus were different between two periods. During low discharge conditions the concentration of the above parameters were greater than during high discharge conditions (Table 3). This can be concluded that seasonal variations had a strong influence on behaviors of these materials in river water depending on the detailed interaction of solute and flow regimes (Walling and Webb,1982). As for the dissolved reactive silicate concentration, it was found that they were of the same order between the two periods. This is probably because major source of silicate is from weathering reactions and not being influenced by adsorption/desorption processes with river-borne suspended sediment unlike the behavior of phosphorus.

Considering the daily net fluxes through the Pak Kret Transect, it also showed daily and seasonal variation between two periods. It was revealed that they were different both in magnitude and direction. For example, the suspended sediment flux during high discharge conditions mostly yields an export in the range of 245.97-1233.20 tons/day. In contrast, during low discharge conditions yield both export and import, such as on April 22, 1988 yielded a maximum export of 2019.91 tons/day while on April 8, 1988 yielded a maximum import of 1738.46 tons/day (Fig. 15).

On consideration of the daily patterns of total phosphorus and particulate phosphorus, it appeared that they varied in a similar pattern to the suspended sediment as had been mentioned above. The maximum export of total phosphorus and particulate phosphorus to the lower river during low discharge conditions were 2.89 tons/day and

1.82 tons/day respectively.

Furthermore, the maximum dissolved load of phosphate phosphorus and reactive silicate transported to the lower river were observed during high discharge conditions in an order of 1.22 tons/day and 308.78 tons/day respectively. However, during high discharge conditions most of the daily silicate fluxes were greater than during low discharge conditions (Fig. 15). These indicated that the important factor in controlling the silicate fluxes is discharge which may be affected by rainfall/run off processes in river system. Moreover, the study of Umnuay (1984) revealed that the dissolved silicate in the Chao Phraya River behaves conservatively. Thus, it is possible to conclude that silicate introduced by the Chao Phraya river in solution are transported through the estuary conservatively (i.e. no loss or gain).

On comparing the daily net fluxes between the Pak Kret and Bang Sai Transects during March 22, 1988 to April 22, 1988, it appeared that they were different both in magnitude and direction. For example the suspended sediment fluxes observed on April 8, 1988 at Pak Kret Transect yielded an import of 1738.48 tons/day while at Bang Sai Transect it yielded an export of 525.32 tons/day (Fig. 21). Therefore, it is obvious that the material fluxes at Pak Kret and Bang Sai Transects showed spatial variations.

Considering the annual regimes of the monthly mean content of materials, it was found that they also showed seasonal variations by comparing with the regimes of discharge and rainfall. Trends of material contents were considerably different between two forms of the particulate matter and dissolved species. Variability in the annual regime of material contents of suspended sediment, total phosphorus, and particulate phosphorus corresponded to the flow patterns. On the contrary, the regimes of the content of phosphate phosphorus and silicate were not consistent (Fig. 14). It was clearly seen that the content of phosphate phosphorus during dry season in April 1988 (2.18 µM) and wet season in July 1988 (2.15 µM) were relatively high when compared with other months (Table 5). This was probably because during dry season the dilution effects in the watershed was negligible. During wet season it also attained peaks due to the addition of dissolved phosphorus from fertilizers used in agriculture introduced into the river by the influence of rainfall/runoff processes. These patterns were similar to the annual flux regimes of suspended sediment, total phosphorus and particulate phosphorus which were seen that they corresponded to the flow pattern attaining peaks during high discharge condition in October 1988 (Fig. 22). In contrast, the annual dissolved load patterns of phosphate phosphorus and silicate may be varied and modified by (1) seasonal variations of discharge and concentration in the river conditions (Foster, 1978 a) and (2) geochemical processes that might influence the behavior of dissolved species behavior (Stallard and Edmond, 1983).

The mixing experiment in this study revealed that under experimental condition phosphorus behaves conservatively at salinities above 18 ‰. This means that during estuarine mixing at salinity higer than 18 ‰ the phosphorus introduced in solution by the Chao Phraya river is transported to the sea conservatively. However, in the region of 0 to 18 ‰ small removal occurred which was probably caused by a strong adsorption capacities of phosphorus on suspended sediments as shown in this study (Fig. 26). Therefore, it can be concluded that dissolved phosphorus load carried to the sea by the Chao Phraya River is less than the actual loads introduced to the river systems.

In addition, a strong relationship between total phosphorus and suspended sediment in this study (Fig. 26) implies that fluxes of total phosphorus and particulate phosphorus through the river depend on adsorption/desorption processes of reactive phosphorus onto the river-borne suspended sediment. Thus it appeared that the load of total phosphorus and suspended sediment should be transported by the river in almost constant proportions as had occurred in some Lake Erie watersheds (Cahill,1977).

The results discussed above provide a better understanding about the influences of hydrology and geochemical processes governing the material fluxes through the Chao Phraya River. The study pointed out that the seasonal difference is an important factor in controlling material loads in the river. One possible explanation in supporting this case study is the hysteresis formation derived from relationships between discharge and water chemistry by regression techniques of both stations. This phenomenon had been shown by Sundborg (1986) to be typical of particulate flux for rivers in very wide range of environments. In the case of the Fraser River at Hope, in British Columbia, Canada, it was suggested that this phenomenon may be caused by seasonal difference in stream conditions, biological uptake, source contributions and storage-discharge relationship (Whitfield, 1981). In the case of Pak Kret and Bang Sai Stations, it can be assumed that the hysteresis effects are due to the seasonal variations (Fig. 23-25). This means that a chemical concentration will be varied by a given flow level occuring in different parts of a storm hydrograph (e.g. rising or falling limbs) or in different seasons of the year (Hendrickson and Krieger, 1986; Toler, 1965; Collins, 1979).

Moreover, man's influences also increase fluxes of dissolved and suspended matter discharged by rivers, particularly of nitrogen and phosphorus (Vollenweider, 1968 ; Stumm, 1973 ; Van Bennekom and Salomon, 1981 ; Meybeck, 1982). Phosphorus is an essential element used to indicate the influence of anthropogenic inputs in many polluted rivers. In polluted rivers, dissolved and particulate phosphorus are about equal, and half of phosphorus flux is therefore taken to be in the dissolved state (Van Bennekom and Salomons, 1981). The concentrations of phosphate phosphorus in some major unpolluted tropical rivers is in the range of 1.5-24 μg P/l or 0.048-0.77 μM (Meybeck, 1982). In this study, it was in the range of 0.40-2.18 μM (Table 5). On comparing the contents of phosphorus between Pak Kret and Bang Sai Stations, it is seen that Bang Sai Station receives less human influence than Pak Kret Station. The results shown in Table 3 suggested that the content of phosphate phosphorus at Bang Sai Station are a little lower than at Pak Kret Station except on March 25, 1988. This was probably because on March 25, 1988 the suspended sediment concentration of Bang Sai Station is about twice that of Pak Kret Station, thus, the phosphorus adsorbed on river-borne suspended sediment was released to the overlying water and showed a higher level of phosphorus in solution.

In the case of silicate concentration, it was found that they were of the same order for both Stations. At Pak Kret Station it was in the range of 99-208 uM while at Bang Sai Station ranged from 78-205 uM (during March 25, 1988 to May 6, 1988 ; see Table 3). This is mainly due to the fact that the content of silicate in the Chao Phraya River dominantly originated from erosion and weathering of watershed.

Golterman (1977) found that the load ratio of PO_4-P : SiO_2 in the erosion watershed is 1 : 110. This ratio is consistent with this study which also found that PO_4-P flux : Silicate flux = 0.63×10^3 : 69.49×10^3 = 1 : 110. So, it may be suggested that the silicate transport in the Chao Phraya River was dominantly affected by natural erosion processes of watershed. However, the silicon load carried by the river in solution is also varied and modified by the influence of discharge as had been mentioned.

In order to better understand the material transport in the watershed of the Chao Phraya River, therefore, the annual mean fluxes in metric tons yr^{-1} and as specific transport rate for the discharge of 155×10^8 m^3yr^{-1} during December 1987 to December 1988 were also estimated. The material loads carried by river showed spatial and temporal variations which also depend on the basin size together with catchment topography (Wolman and Miller, 1960 ; Webb and Walling, 1984).

In the previous data of the Environmental Science Section, Environmental Health Division, Department of Health (1984), it was pointed out that material transport in the rivers has spatial variation which also depend on the basin size. The drainage area will reflect the mean runoff of the river systems, see Table 10.

Table 10 Comparison of the material load carried into the Gulf of Thailand (During 1981-1983) by the rivers covering different drainage areas in Thailand.

River	Drainage Area (km^2)	Discharge ($x\ 10^8 m^3/sec$)	Suspended Sediment ($x\ 10^3 tons\ yr^{-1}$)	Total-P ($x\ 10^3 tons\ yr^{-1}$)
Chao Phraya	162,000	174	1,792	5.2
Bang Pakong	18,000	99	1,802	3.0
Tha Chin	6,300	16.1	48.3	0.3
This Study focussed on (Chao Phraya)	142,000	155	1,566	4.43

In this study the suspended sediment flux also estimated as specific transport rate in ton $km^{-2}\ yr^{-1}$ for the whole upper and central drainage areas of about 142,000 km^2 is 11.02 tons $km^{-2}\ yr^{-1}$. The results compared with other rivers are shown in Table 11.

Table 11 Comparison of suspended sediment fluxes between this study with some selected major rivers differentiated according to climate (after Meybeck,1976).

River	Drainage Area ($\times 10^3$ km^2)	Suspended Sediment (ton km^{-2} yr^{-1})	Climate
Chao Phraya (This Study)	142 (whole upper basin)	11.02	Tropical
Mekong	795	435	Tropical
Amazon	6,300	79	Tropical
Volga	1,350	19	Temperate
Columbia	670	43	Temperate
Oranges	1,000	150	Desert

Meybeck (1982) suggested that the specific transport rate in river water for phosphate phosphorus is generally between 0.5 and 10 kg P km^{-2} yr^{-1}. Maximum specific transport occurs in wet tropical rivers (Zaire, Indonesia, Amazonia) and minimum in the subarctic rivers. In comparison to this study of about 4.43 kg P km^{-2} yr^{-1}, it can be concluded that the water in the lower basin of the Chao Phraya River, particularly in the study area of Pak Kret, is contaminated due to the anthropogenic inputs, such as polyphosphate detergents and fertilizers from urban and agricultural sewage. This is clearly seen by comparing the dissolved phosphorus contents (µM) between this study and some major contaminated rivers (Table 12).

Table 12 Comparison of dissolved phosphorus contents (µM) between this study and some major contaminated rivers (Meybeck, 1982).

River	Phosphate-P	Total-P	Continent
Chao Phraya (This Study)	0.40 - 2.18	1.07 - 11.98	Asia
Ganges (India)	1.61	3.23	Asia
Hudson (USA)	-	2.26	North America
Mississippi (USA)	-	9.74	North America
Rhine (Switzerland)	1.96	3.61	Europe

In addition, the specific transport rates of silicate flux for various rivers of mean value 4.85 mg Si/l (173 µM) yields a mean continent export of 1,800 kg Si $km^{-2}yr^{-1}$ (Meybeck, 1979). In comparison to this study of annual mean value 5.02 mg Si/l yields an export of 489.30 kg Si $km^{-2}yr^{-1}$.