CHAPTER IV

RESULTS AND DISCUSSIONS

4.1 EFFECTS OF THE NUMBER OF PADDLES AND UP-FLOW VELOCITY ON PERFORMANCE OF THE PROCESSE

The efficiency of the up-flow pelletization depends primarily on operating conditions. Mixing has a significant influence on efficiency of pelletizer. In pelletizing step, the process needs appropriate intensity to disperse the chemical uniformly throughout the water and to build up a readily settling floc.

In this study, experimental running was conducted by varying the numbers of paddles (2, 4, and 6 paddles) with constant up-flow velocity. The number of paddles of 2, 4, and 6 paddles was selected because of the previous study by Palapatra (1997). Mean that velocity gradient was in the range of 7-12 s^{-1}, which is the optimum for pelletizing.

4.1.1 Effects of the number of paddles and up-flow velocity on TOC, UV260, and turbidity removal.

4.1.1.1 At 6 m/h of up-flow velocity

The experiments were conducted using various numbers of paddles (2, 4, and 6 paddles) with constant up-flow velocity of 6 m/h .

a) Effects on TOC removal

The effects of number of paddles with 6 m/h of up-flow velocity are listed in Table 4.1. The results show that the percentage of TOC removal increase with increasing number of paddles. The highest TOC removal was observed at 6 paddles and the lowest was at 2 paddles.

Table 4.1 Effects of the number of paddles with 6 m/h of up-flow velocity on TOC removal.*

number of paddle (paddles)	TOC (mg/L)		Percentage of TOC removal
	Raw water	Treated water	
2	4.6	4.07	11.6
4	7.03	5.71	18.8
6	7.09	5.32	25.0

* Note: average results at steady-state period

b) Effects on UV260

Table 4.2 shows the effects of number of paddles with 6 m/h up-flow velocity. From the results, the influent UV260 was in the range of 0.143–0.293 cm^{-1}, while the effluent UV260 was in the range of 0.114-0.135 cm^{-1}. The percentage of UV 260 removal at 2, 4, and 6 paddles were 16.6, 37.9, and 49.7, respectively.

Table 4.2 Effects of the number of paddles with 6 m/h of up-flow velocity on UV260 removal*

Number of paddle (paddles)	UV260 (cm^{-1})		Percentage of UV260 removal
	Raw water	Treated water	
2	0.16	0.13	16.6
4	0.21	0.13	37.9
6	0.26	0.13	49.7

* Note: average results at steady-state period

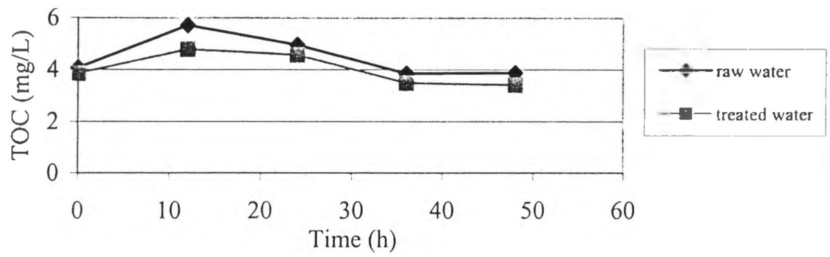

Figure 4.1 TOC of raw and treated waters at 2 paddles with 6 m/h up-flow velocity

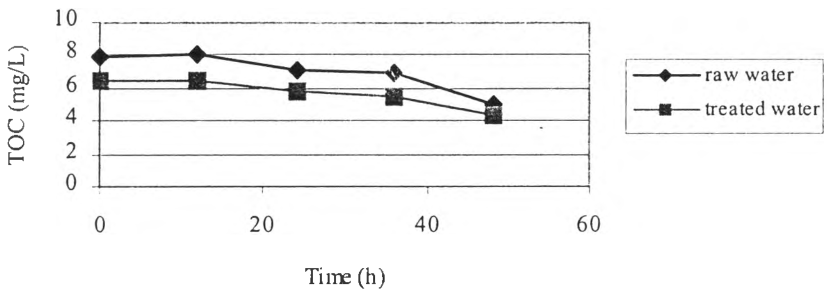

Figure 4.2 TOC ofraw and treated waters at 4 paddles with 6 m/h up-flow velocity

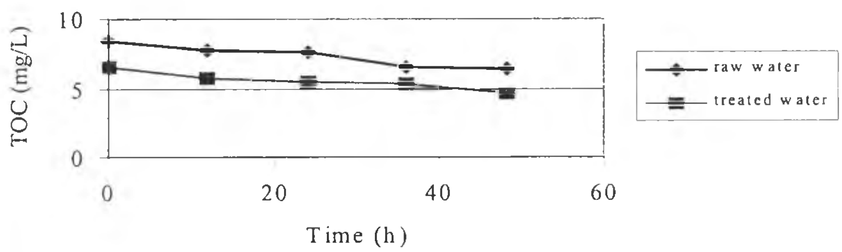

Figure 4.3 TOC of raw and treated waters at 6 paddles with 6 m/h up-flow velocity

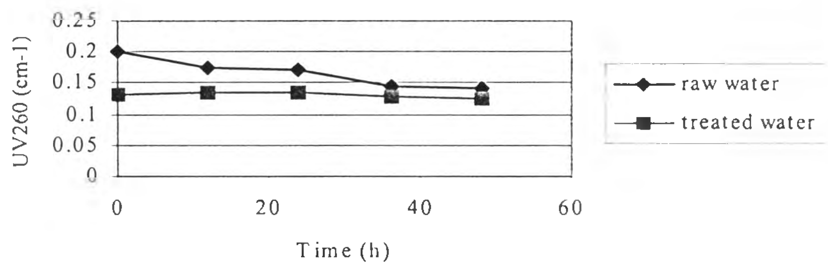

Figure 4.4 UV260 of raw and treated waters at 2 paddles with 6 m/h up-flow velocity

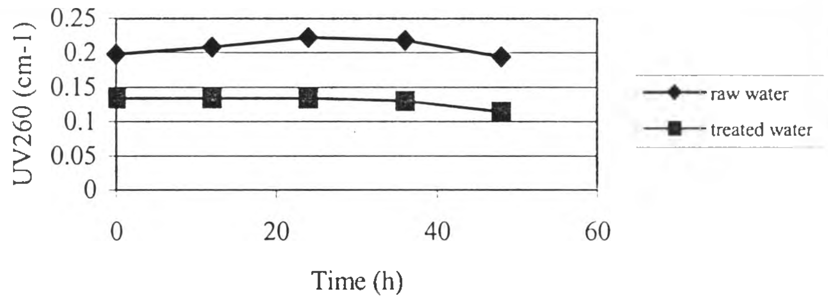

Figure 4.5 UV260 of raw and treated waters at 4 paddles with 6 m/h up-flow velocity

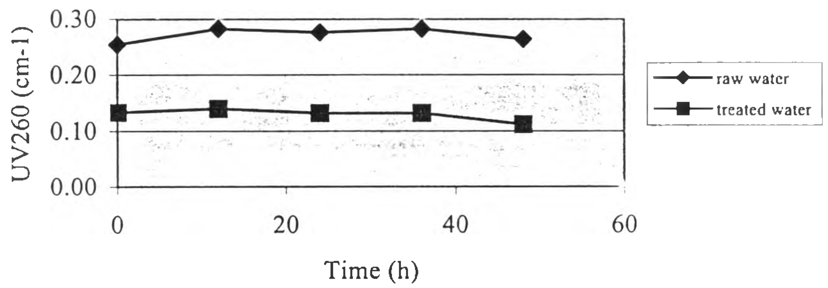

Figure 4.6 UV260 of raw and treated waters at 6 paddles with 6 m/h up-flow velocity

c) Effects on turbidity removal

Table 4.3 shows the results of turbidity removal using various numbers of paddles with 6 m/h up-flow velocity. The influent turbidity was in the range of 56.13-115.86 NTU, whereas the unfiltered effluent turbidity was in the range of 8.49-9.61 NTU. The percentage of turbidity removal at 2, 4, and 6 paddles were 84.7, 89.7 and 91.7, respectively.

Table 4.3 Effects of the number of paddles with 6 m/h of up-flow velocity on turbidity removal.*

number of paddle (paddles)	Turbidity (NTU)		Percentage of turbidity removal
	Raw water	Treated water	
2	56.13	8.54	84.7
4	82.26	8.49	89.7
6	115.86	9.61	91.7

* Note: average results at steady-state period

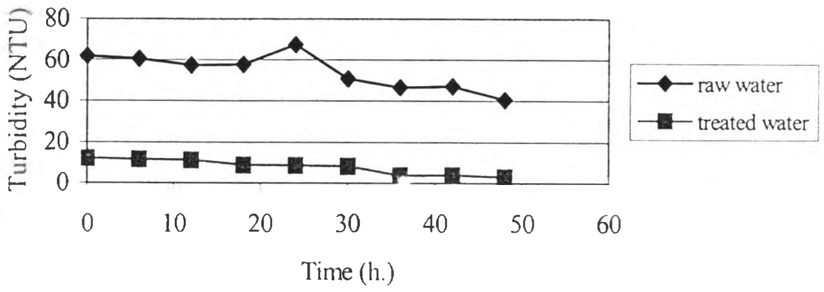

Figure 4.7 Turbidity of raw and treated waters at 2 paddles with 6 m/h up-flow velocity

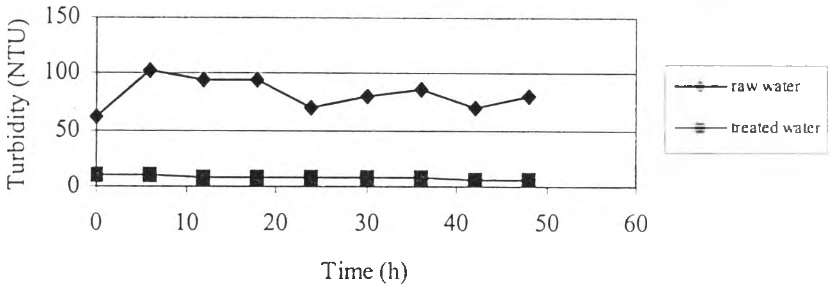

Figure 4.8 Turbidity of raw and treated waters at 4 paddles with 6 m/h up-flow velocity

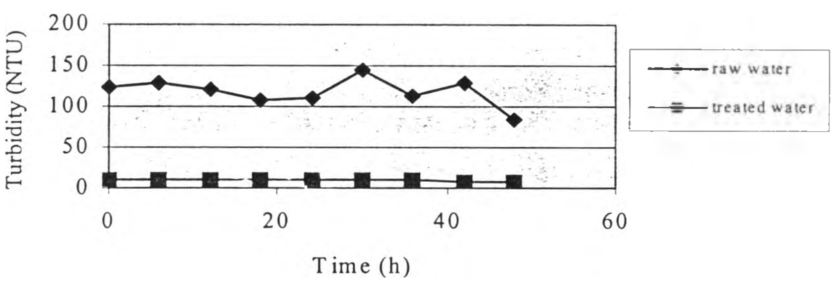

Figure 4.9 Turbidity of raw and treated water at 6 paddles with 6 m/h up-flow velocity

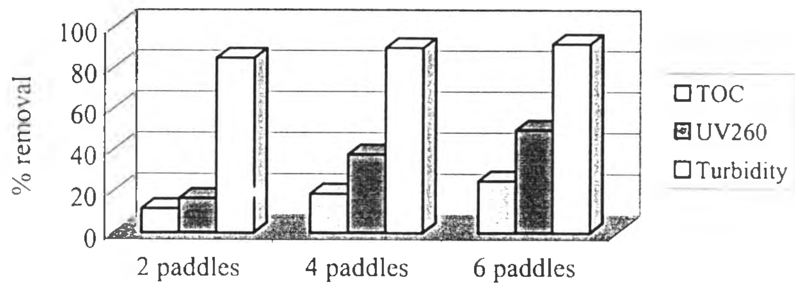

Figure 4.10 Percentage of TOC, UV260, and turbidity removal with 6 m/h up-flow velocity

The effects of number of paddles on the performance of pelletizer in terms of TOC, UV260, and turbidity removal are shown in Tables 4.1, 4.2, and 4.3. With 6 m/h of up-flow velocity, the performance of the process with regard to TOC, UV260, and turbidity removal increases with increasing number of paddles. Turbidity removal percentage is higher than TOC and UV260 removal because turbid particles entrapped into pellet particle more effectively than organic materials (humic substance).

In general, the degree of completion of the pelletization process depends on the power imparted to the water, which is measured by the velocity gradient (Camp, 1986). The rate of particulate collisions is proportional to the velocity gradient, *G*; therefore the gradient must be sufficient to furnish the desired rate of particulate collisions.

The maximum removal of all parameters was found at 6 paddle as shown in Figure 4.10. The results indicate that 6 paddles could give sufficient velocity gradient (11.33 s^{-1}) to reduced non-uniformity in composition of material, promote particulate collision and also increase movement of material including organic materials and turbid particles into mass of pellet. Thus, good quality water could be obtained.

4.1.1.2 At 8 m/h of up-flow velocity

Tables 4.4, 4.5, and 4.6 illustrate the effects of number of paddles with 8 m/h up-flow velocity on water quality. The experiments were conducted with 2, 4, and 6 paddles with constant up-flow velocity at 8 m/h of up-flow velocity.

a) Effects on TOC removal.

Table 4.2 summarized the effects of number of paddles with 8 m/h up-flow velocity on TOC removal. The results show that the influent TOC was in the range of 4.30-6.42, while the effluent TOC was in the range of 3.78-4.80 mg/L. The data also show that the percentage of TOC removal at 2, 4, and 6 paddles were 12.1, 21.4, and 27.7 respectively.

Table 4.4 Effects of the number of paddles with 8 m/h of up-flow velocity on TOC removal.*

Number of paddles (paddle)	TOC (mg/L)		Percentage of TOC removal
	Raw water	Treated water	
2	4.30	3.78	12.1
4	6.11	4.80	21.4
6	6.42	4.64	27.7

* Note: average results at steady-state period

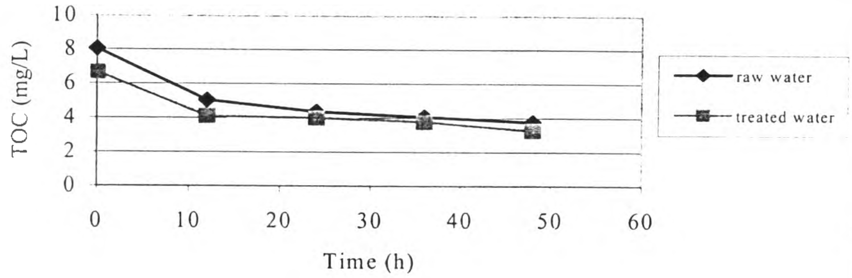

Figure 4.11 TOC of raw and treated water at 2 paddles with 8 m/h up-flow velocity

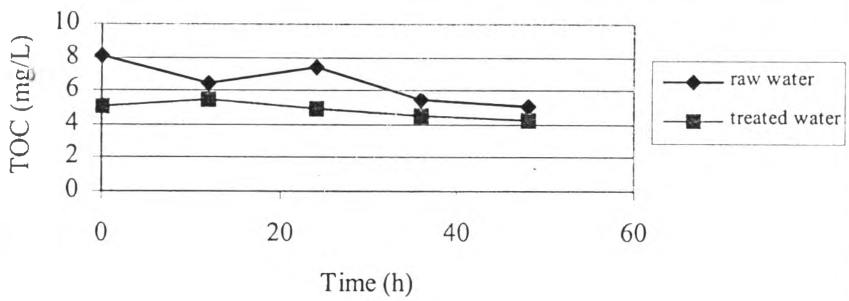

Figure 4.12 TOC of raw and treated water at 4 paddles with 8 m/h up-flow velocity

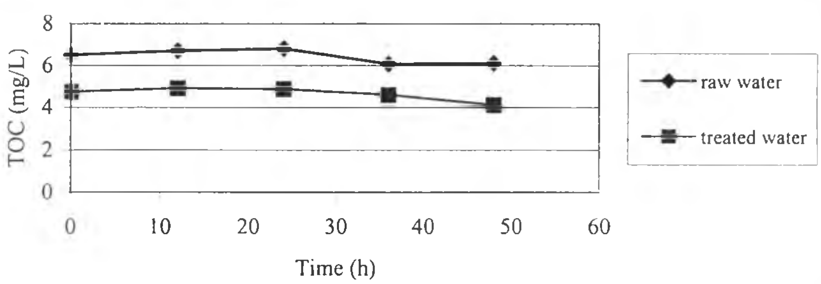

Figure 4.13 TOC of raw and treated waters at 6 paddles with 8 m/h up-flow velocity

b) Effects on UV 260

The effects of number of paddles with 8 m/h up-flow velocity are shown in Table 4.5. The results show that the UV260 of influent was in the range of 0.18-0.26 cm^{-1}, while the effluent was in the range of 0.14-0.13 cm^{-1}. The percentage of UV260 removal at 2, 4, and 6 paddles were 26.5, 40.2, and 49.7, respectively.

Table 4.5 Effects of the number of paddles with 8 m/h of up-flow velocity on UV260 removal.*

Number of paddle (paddles)	UV260 (cm^{-1})		Percentage of UV260 removal
	Raw water	Treated water	
2	0.18	0.13	26.5
4	0.23	0.14	40.2
6	0.26	0.13	49.7

* Note: average results at steady-state period.

c) Effects on turbidity removal

The effects of number of paddles with 8 m/h up-flow velocity are shown in Table 4.6. The results show that the turbidity of influent was in the range of 34.93-116.2 NTU, while the effluent was in the range of 3.79-8.85 NTU. The percentage of turbidity removal at 2, 4, and 6 paddles were 89.1, 90.8, and 92.7, respectively.

Table 4.6 Effects of the number of paddles with 8 m/h of up-flow velocity on turbidity removal.*

Number of paddle (paddles)	Turbidity (NTU)		Percentage of turbidity removal
	Raw water	Treated water	
2	34.93	3.79	89.1
4	62.5	5.74	90.8
6	116.2	8.85	92.7

* Note: average results at steady-state period.

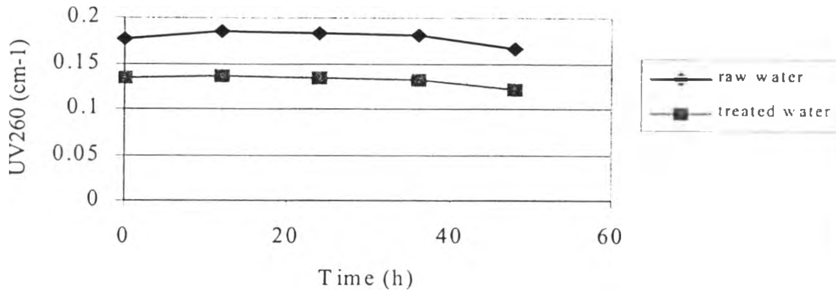

Figure 4.14 UV260 of raw and treated water at 2 paddles with 8 m/h up-flow velocity

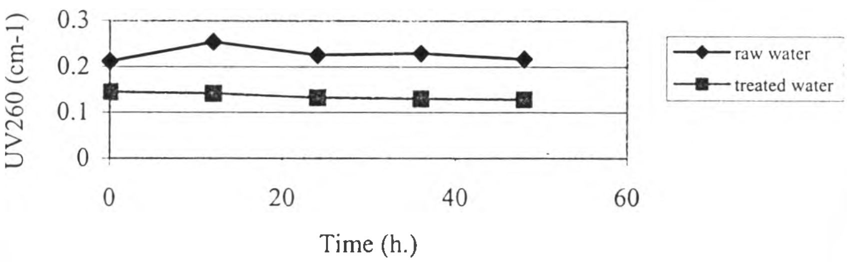

Figure 4.15 UV260 of raw and treated waters at 4 paddles with 8 m/h up-flow velocity

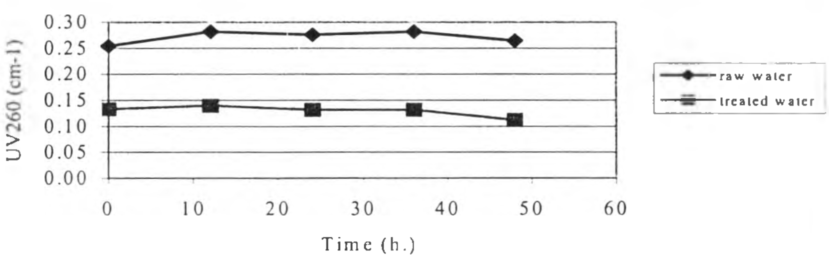

Figure 4.16 UV260 of raw and treated water at 6 paddles with 8 m/h up-flow velocity

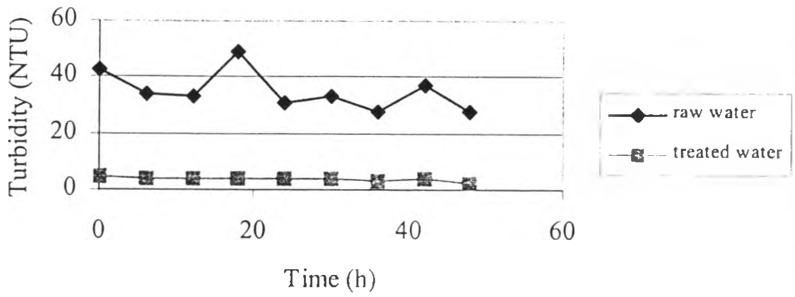

Figure 4.17 Turbidity of raw and treated water at 2 paddles with 8 m/h up-flow velocity

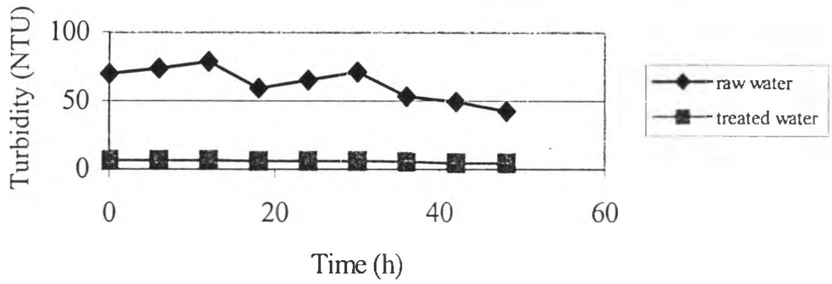

Figure 4.18 Turbidity of raw and treated waters at 4 paddles with 8 m/h up-flow velocity

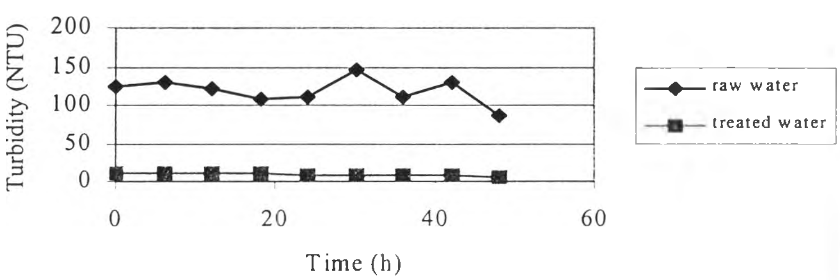

Figure 4.19 Turbidity of raw and treated waters at 6 paddle with 8 m/h up-flow velocity

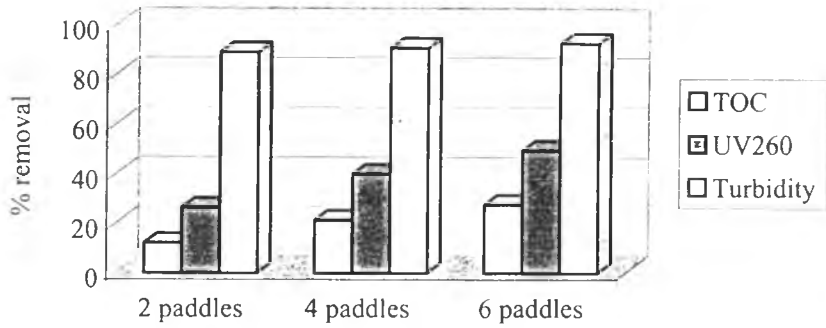

Figure 4.20 Percentage of TOC, UV260, and turbidity removal with 8 m/h up-flow velocity

The results at up-flow velocity of 8 m/h indicate that increasing number of paddles caused slightly increase in percentage of TOC, UV260, and turbidity removal. (Figure 4.20)

The maximum removal of TOC, UV260, and turbidity was obtained with 6 paddles. The maximum removal was 27.7% TOC, 49.7% UV260, and 92.7% turbidity. The higher number of paddles, the better the performance of pelletizer. When the number of paddles increase from 2 paddles to 6 paddles, velocity gradient increase from 7.34 to 11.33 s^{-1}. The higher velocity gradient produced intensity sufficient to reduced non-uniformity in composition of materials, promote particulate collision and also increase movement of materials including organic materials and turbid particles into mass of pellet. Thus, good quality water could be obtained.

4.1.1.3 At 10 m/h up-flow velocity

a) Effects of TOC removal

Table 4.7 summarized the effects of number of paddles with 10 m/h up-flow velocity. The results show that the TOC removal of influent was in the range of 3.48-6.96, while the effluent was in the range of 2.99-4.81mg/L. The percentage of TOC removal at 2, 4, and 6 paddles were 14.1, 24.1, and 31.0 respectively.

Table 4.7 Effects of the number of paddles with 10 m/h of up-flow velocity on TOC removal. *

Number of paddle (paddles)	TOC (mg/L)		Percentage of TOC removal
	Raw water	Treated water	
2	3.48	2.99	14.1
4	6.17	4.68	24.1
6	6.96	4.81	31.0

* Note: average results at steady-state period.

b) Effects on UV260 removal

The effects of number of paddles with 10 m/h up-flow velocity are shown in Table 4.8. The results show that the UV260 influent was in the range of 0.18-0.27 cm^{-1} , while the effluent was in the range of 0.12-0.13 cm^{-1}. The percentage removal of UV260 at 2, 4, and 6 paddles were 27.0, 47.0, and 56.4, respectively.

Table 4.8 Effects of the number of paddles with 10 m/h of up-flow velocity on UV260 removal.*

Number of paddle (paddles)	UV260 (cm^{-1})		Percentage of UV260 removal
	Raw water	Treated water	
2	0.18	0.13	28.0
4	0.25	0.13	47.0
6	0.27	0.12	56.4

* Note: average results at steady-state period.

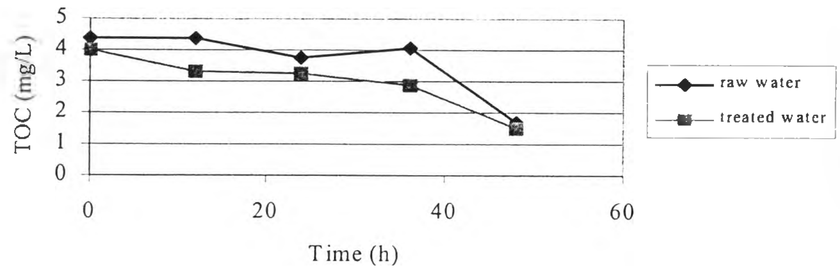

Figure 4.21 TOC of raw and treated water at 2 paddles with 10 m/h up-flow velocity

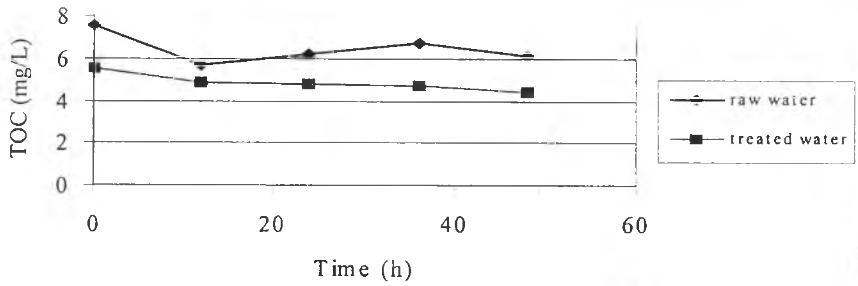

Figure 4.22 TOC of raw and treated waters at 4 paddles with 10 m/h up-flow velocity

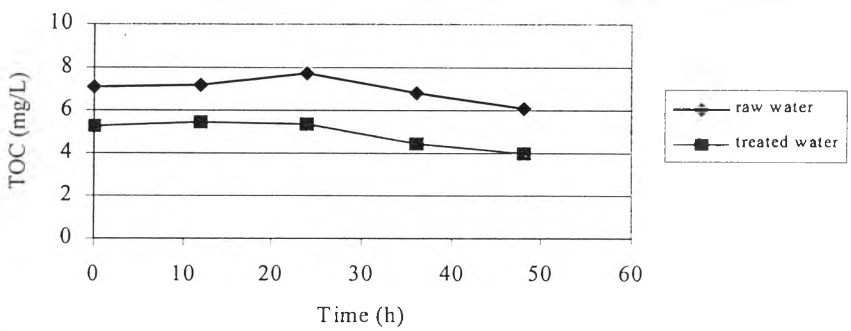

Figure 4.23 TOC of raw and treated waters at 6 paddles with 10 m/h up-flow velocity

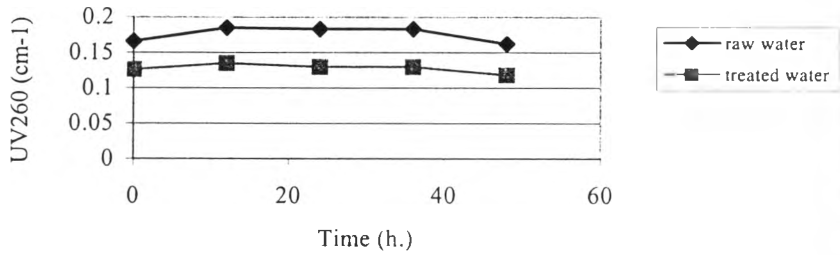

Figure 4.24 UV260 of raw and treated at 2 paddles with 10 m/h up-flow velocity

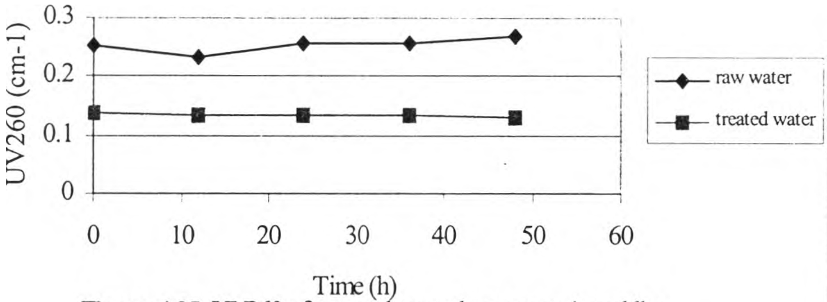

Figure 4.25 UV260 of raw and treated waters at 4 paddles with 10 m/h up-flow velocity

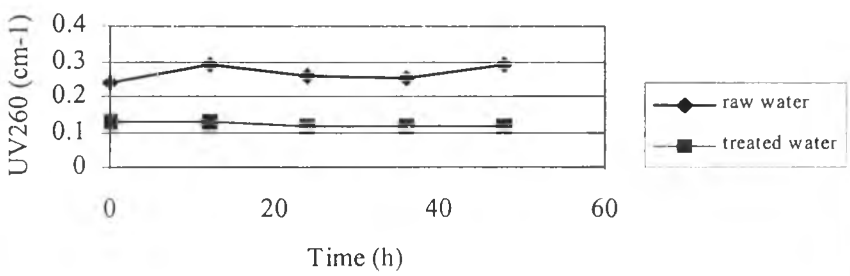

Figure4.26 UV260 of raw and treated water at 6 paddles with 10 m/h up-flow velocity

c) Effects on turbidity removal

Table 4.9 shows the results of turbidity removal using various numbers of paddles with 10 m/h up-flow velocity. The influent turbidity was in the range of 36.65-129.43 NTU, while the effluent turbidity was in the range of 3.93-8.98 NTU. The percentage of turbidity removal at 2, 4, and 6 paddles were 91.0, 91.1, and 93.1, respectively.

Table 4.9 Effects of the number of paddles with 10 m/h of up-flow velocity on turbidity removal.*

Number of paddle (paddles)	Turbidity (NTU)		Percentage of turbidity removal
	Raw water	Treated water	
2	36.65	3.93	91.0
4	96.07	8.55	91.1
6	129.43	8.98	93.1

* Note: average results at steady-state period.

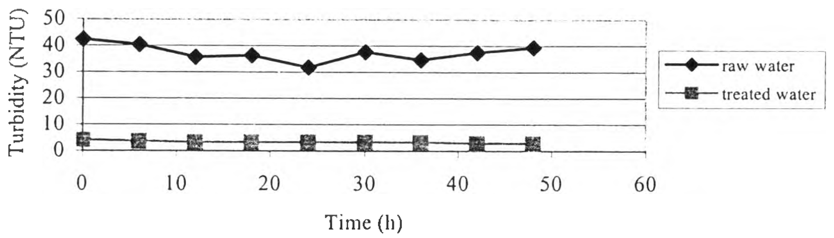

Figure 4.27 Turbidity of raw and treated waters at 2paddles with 10 m/h up-flow velocity

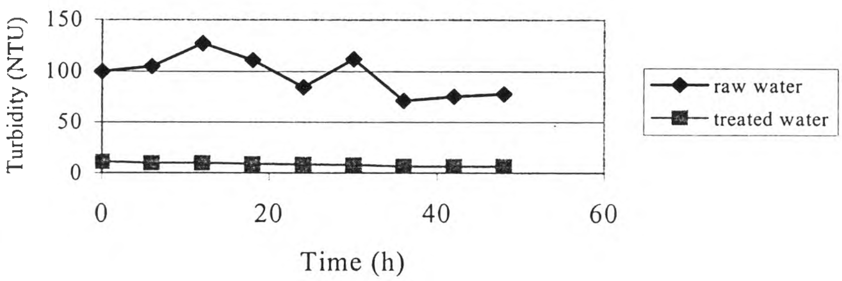

Figure 4.28 Turbidity of raw and treated waters at 4 paddles with 10 m/h up-flow velocity

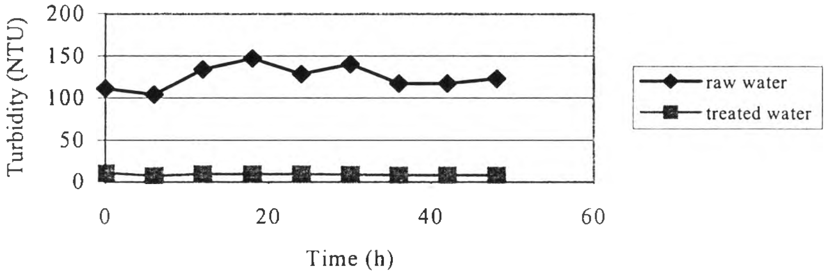

Figure 4.29 Turbidity of raw and treated waters at 6 paddles with 10 m/h up-flow velocity

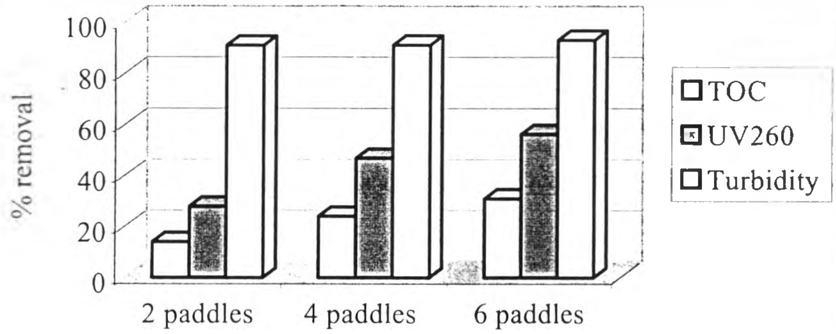

Figure 4.30 Percentage of TOC, UV260, and turbidity removal with 10 m/h up-flow velocity

Figure 4.30 shows the experimental average results of the process with 10 m/h up-flow velocity. The results show that percentage of TOC, UV 260, and turbidity removal tend to increased with increasing number of paddles (slightly significant). Similar results were obtained at 6 and 8 m/h up-flow velocity. Maximum removal of these parameters was found at 6 paddles. Maximum removal of TOC, UV260, and turbidity were 31, 56.4, and 93.1 %, respectively. These high percentage removals may be due to the fact that at 6 paddles produced appropriate mixing to increase diffusion of material including organic materials and turbid particles into mass of pellet. Thus, good quality water could be obtained.

4.1.2 Effects of the number of paddles and up-flow velocity on characteristics of pellets

4.1.2.1 Effects on mass of pellets

Tables 4.10, 4.11, and 4.12 show the effects of number of paddles and up-flow velocity on mass of pellets. The results can be described as follow:

4.1.2.1.1 At 6 m/h up-flow velocity

The effects of number of paddles at 6 m/h up-flow velocity on mass of pellets are shown in Table 4.10.

The results show that mass of pellets in the reactor tend to decrease with increasing number of paddles. The mass of pellets at 2, 4, and 6 paddles were 1,000.0, 913.4, and 745.8 kg/L, respectively.

Table 4.10 Effects of the number of paddles with 6 m/h up-flow velocity on mass of pellets. *

Number of paddles (paddles)	Mass (kg/L)
2	1,000.0
4	913.4
6	745.8

* Note: average results at steady-state period (at 12-48 h)

4.1.2.1.2 At 8 m/h up-flow velocity

The effects of number of paddles with 8 m/h up-flow velocity on mass of pellets are shown in Table 4.11.

The results show that mass of pellets in the reactor decreased with increasing number of paddle. The mass of pellets at 2, 4, and 6 paddles were 1000.0, 825.0, and 211.8 kg/L, respectively.

Table 4.11 Effects of the number of paddles with 8 m/h up-flow velocity on mass of pellets. *

number of paddle (paddles)	Mass (kg/L)
2	1,000.0
4	825.0
6	211.8

* Note: average at steady-state period (at 12-48 h)

4.1.2.1.3 At 10 m/h up-flow velocity

The effects of number of paddles with 10 m/h up-flow velocity on mass of pellets are shown in Table 4.12.

The results show that mass of pellets in the reactor decrease tend to with increasing number of paddle. The average mass of pellets at 2, 4, and 6 were 938.4, 655.0, and 182.4 kg/L, respectively.

Table 4.12 Effects of the number of paddles with 10 m/h up-flow velocity on mass of pellets. *

number of paddles (paddle)	Mass (kg/L)
2	938.4
4	655.0
6	182.4

* Note: average results at steady-state period (at 12-48 h)

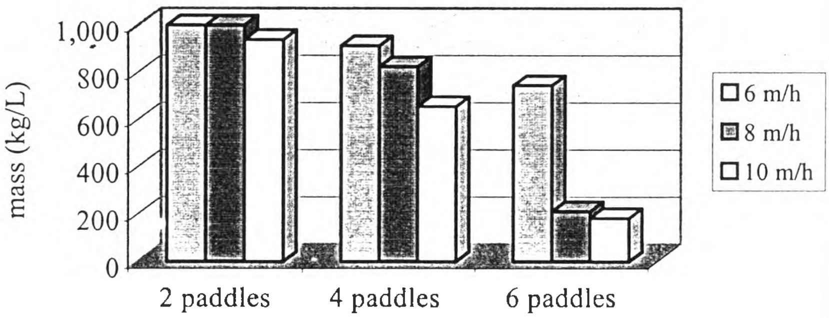

Figure 4.31 Effect of the number of paddles and up-flow velocity on mass of pellets

Tables 4.10, 4.11, and 4.12 illustrate the effects of number of paddles on pellet mass in pelletizer. The results show that at all rates of up-flow velocity, the mass of pellets decreased as the number of paddles increased. Similar results have been reported previously (Tambo, 1989). With 6 paddles, very small and light pellets are pushed upward to the upper part of the reactor and out with the treated water by intensity of paddles.

A comparison of the mass of pellets in pelletizer at the various rate of up-flow velocity of 6, 8, and 10 m/h show that at same number of paddle mass of pellets decreased with increasing up-flow velocity (Figure 4.31). For example, with 6 paddles and 6 m/h up-flow velocity, mass of pellet was 745.8 kg/L and dropped to 182.4 kg/L at 10 m/h up-flow velocity. Hence, this experiment indicated that the increasing up-flow velocity could push pellets out over by incoming flow.

4.1.2.2 Effects on size of pellets

Tables 4.13, 4.14, and 4.16 show the effects of number of paddles and up-flow velocity on size of pellets. The results can be described as follow:

4.1.2.2.1 At 6 m/h up-flow velocity

Table 4.13 shows the effects of number of paddles with 6 m/h up-flow velocity on size of pellets. The size of pellets tend to increased with increasing number of paddle. The pellet sizes at 2, 4, and 6 paddles were 0.29, 0.43, and 0.44 mm, respectively.

Table 4.13 Effects of the number of paddles with 6 m/h up-flow velocity on size of pellets.*

number of paddle (paddles)	Size (mm)
2	0.29
4	0.43
6	0.44

* Note: average results at steady-state period (at 12-48 h)

4.1.2.2.2 At 8 m/h up-flow velocity

The effects of number of paddles with 8 m/h up-flow velocity on size of pellets are shown in Table 4.14

The results show that size of pellets tend to increased with increasing number of paddles. The pellet sizes at 2, 4, and 6 paddles were 0.32, 0.44, and 0.47 mm, respectively.

Table 4.14 Effects of the number of paddles with 8 m/h up-flow velocity on size of pellets.*

Number of paddle (paddles)	Size (mm)
2	0.32
4	0.44
6	0.47

* Note: average results at steady-state period (at 12-48 h)

4.1.2.2.3 At 10 m/h up-flow velocity

The effects of number of paddles with 10 m/h up-flow velocity on size of pellets are shown in Table 4.15

The results show that size of pellets tend to increased with increasing number of paddles. The average pellet size at 2, 4, and 6 paddles were 0.35, 0.51, and 0.54 mm, respectively.

Table 4.15 Effects of the number of paddles with 10 m/h up-flow velocity on size of pellets.*

Number of paddle (paddles)	Size (mm)
2	0.29
4	0.43
6	0.44

* Note: average result at steady-state period (at 12-48 h)

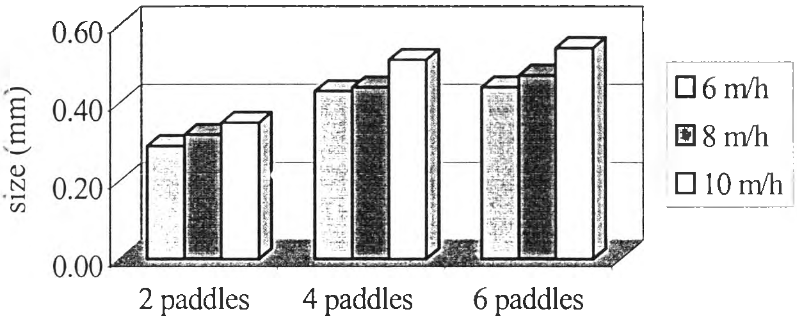

Figure 4.32 Effects of the number of paddles and up-flow velocity on size of pellets

Tables 4.13, 4.14, and 4.15 illustrate the effects paddle number on pellet mass in pelletizer at the different of up-flow velocity. The results show that at all rate of up-flow velocity, size of pellets increased with increasing the number of paddle (slightly significant). The higher number of paddles could give sufficient intensity to produced large number of collision during aggregation and breakdown irregular growth parts of pellet that cause rearrangement of floc in aggregates. Under such condition, the structure of pellet become larger and denser.

Figure 4.32 compares the size of pellets at the various up-flow velocity. The results indicate that all up-flow velocity produce the same range of pellet size (0.29-0.47 mm). These results indicate that up-flow velocity has no significant effect on pellet size.

4.1.2.3 Effects on settling velocity of pellets

Tables 4.16, 4.17, and 4.18 show the effects of number of paddles and up-flow velocity on settling velocity of pellets. The results can be described as follow.

4.1.2.3.1 At 6 m/h up-flow velocity

The effects of number of paddles with 6 m/h up-flow velocity on settling velocity of pellets are shown in Table 4.16

The results show that settling velocity of pellets tend to increased with increasing number of paddles. The settling velocity at 2, 4, and 6 paddles were 45.12, 62.16, and 63.14 m/h, respectively.

Table 4.16 Effects of the number of paddles with 6 m/h up-flow velocity on settling velocity of pellets.*

number of paddle (paddles)	Settling velocity (m/h)
2	45.12
4	62.16
6	63.14

* Note: average results at steady-state period (at 12-48 h)

4.1.2.3.2 At 8 m/h up-flow velocity

The effects of number of paddles with 8 m/h up-flow velocity on settling velocity of pellets are shown in Table 4.17.

The results show that settling velocity of pellets tend to increase with increasing number of paddles. The settling velocity at 2, 4, and 6 paddles were 45.32, 63.42, and 66.30 m/h, respectively.

Table 4.17 Effects of the number of paddles with 8 m/h up-flow velocity on settling velocity of pellets.*

number of paddle (paddles)	Settling velocity (m/h)
2	45.32
4	63.42
6	66.30

* Note: average results at steady-state period (at 12-48 h)

4.1.2.3.3 At 10 m/h up-flow velocity

The effects of number of paddles with 10 m/h up-flow velocity on settling velocity of pellets are shown in Table 4.18.

The results show that settling velocity of pellets increased with increasing number of paddles. The settling velocity at 2, 4, and 6 paddles were 55.75, 64.07, and 68.97 m/h, respectively.

Table 4.18 Effects of the number of paddles with 10 m/h up-flow velocity on settling velocity of pellets.*

number of paddle (paddles)	Settling velocity (m/h)
2	55.75
4	64.07
6	68.97

* Note: average results at steady-state period (at 12-48 h)

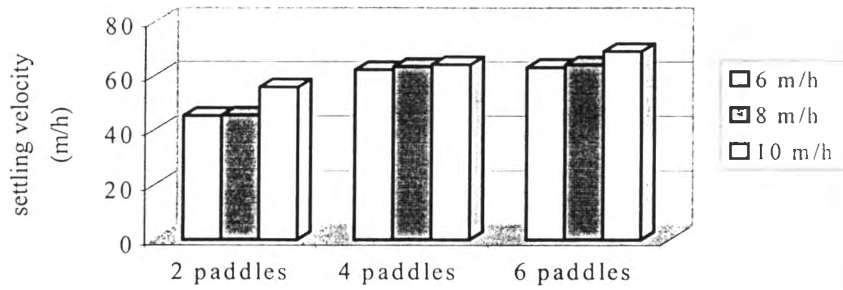

Figure 4.33 Effects of the number of paddles and up-flow velocity on settling velocity of pellets

The effects of number of paddles on settling velocity of pellets are shown in Tables 4.16, 4.17, and 4.18. The results indicate that the higher the number of paddles, the higher settling velocity of pellets. The higher number of paddle can produce high shear force to exude the liquid out of floc and also to promote particulate collision. Therefore, compact and high settling pellets could be obtained.

Figure 4.33 shows a comparison of the different up-flow velocity on settling velocity of pellets. The results indicate that pellet settling velocity at 6 m/h up-flow velocity tend to slightly slower than at 8 and 10 m/h up-flow velocity. The reason is that the greater degree of up-flow velocity increases surface area of particulate collision. So, more settleable pellets could be obtained.

4.2 EFFECTS OF COAGULANT AND COAGULANT AID DOSAGES ON PERFORMANCE OF THE PROCESS

In this study, PACl and nonionic polymer were used as coagulant and coagulant aid. The experimental was conducted by varying coagulant dosages from 3-5 mg/L and those of coagulant aid from 0.1-0.3 mg/L.

4.2.1 Effects of coagulant and coagulant aid dosages on TOC, UV260, and turbidity removal.

4.1.1.1 At 0.1 mg/L of nonionic polymer dosage

The experiments were conducted at various PACl dosages (3, 4, and 5 mg/L) with constant nonionic polymer dosage of 0.1 mg/L.

a) Effects on TOC removal

Table 4.19 summarized the effects of PACl dosage with 0.1 mg/L of nonionic polymer. The results show that the influent TOC was in the range of 2.84-1.99, while the effluent TOC was in the range of 1.34-1.68 mg/L. The percentage of TOC removal at 3, 4, and 5 mg/L of PACl were 21.8, 30.7, and 41.0, respectively.

Table 4.19 Effects of PACl dosage with 0.1 mg/L of nonionic polymer on TOC removal.*

PACl dosage (mg/L)	TOC (mg/L)		Percentage of TOC removal
	Raw water	Treated water	
3	2.03	1.59	21.8
4	1.99	1.38	30.7
5	2.84	1.68	41.0

* Note: average results at steady-state period

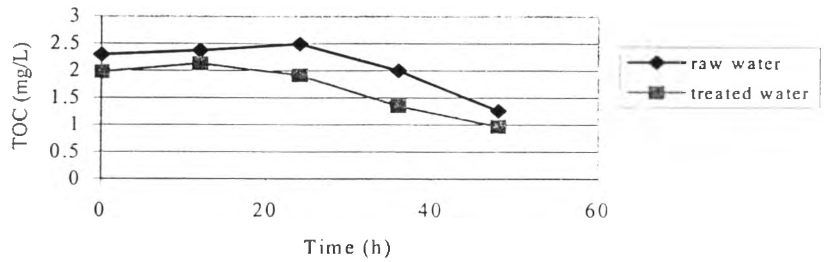

Figure 4.34 TOC of raw and treated waters at 3 mg/L of PACl with 0.1 mg/L of nonionic polymer

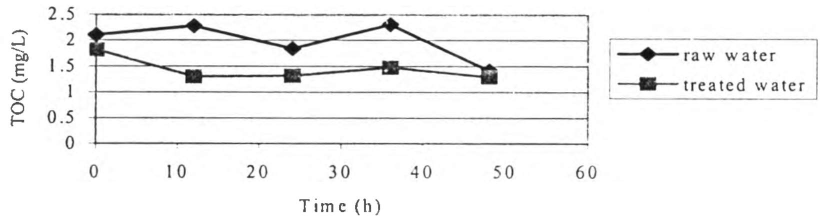

Figure 4.35 TOC of raw and treated waters at 4 mg/L of PACl with 0.1 mg/L of nonionic polymer

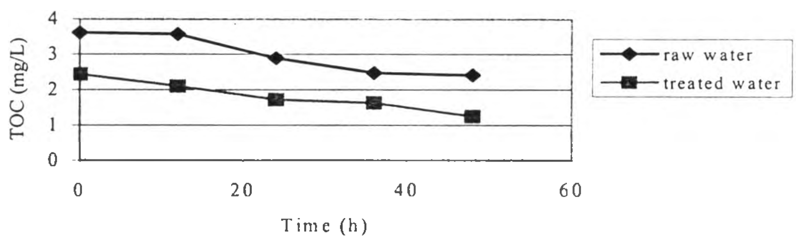

Figure 4.36 TOC of raw and treated waters at 5 mg/L of PACl with 0.1 mg/L of nonionic polymer

b) Effects on UV260

Table 4.20 shows the effects of PACl dosage with 0.1 mg/L of nonionic polymer. From the results, the influent UV260 was in the range of 0.18-0.22 cm^{-1}, while the effluent UV260 was in the range 0.05-0.06 cm^{-1}. The percentage of UV 260 removal at 3, 4, and 5 mg/L of PACl dosage were 69.2, 70.0, and 72.1, respectively.

Table 4.20 Effects of PACl dosage with 0.1 mg/L of nonionic polymer on UV260 removal.*

PACl dosage (mg/L)	UV260 (cm^{-1})		Percentage of UV260 removal
	Raw water	Treated water	
3	0.18	0.05	69.5
4	0.19	0.05	72.0
5	0.22	0.06	72.1

* Note: average results at steady-state period

c) Effects on turbidity removal

Table 4.21 shows the results of turbidity removal at various dosages of PACl with 0.1 mg/L of nonionic polymer. The influent turbidity was in the range of 103.93-148.43 NTU, while the effluent turbidity was in the range of 5.22-7.97 NTU. The percentage of turbidity removal at 3, 4, and 5 mg/L of PACl were 94.5, 94.6, and 95.0, respectively.

Table 4.21 Effects of PACl dosage with 0.1 mg/L of nonionic polymer on turbidity removal.*

PACl dosage (mg/L)	Turbidity (NTU)		Percentage of turbidity removal
	Raw water	Treated water	
3	119.14	6.52	94.5
4	148.43	7.97	94.6
5	103.93	5.22	95.0

* Note: average results at steady-state period

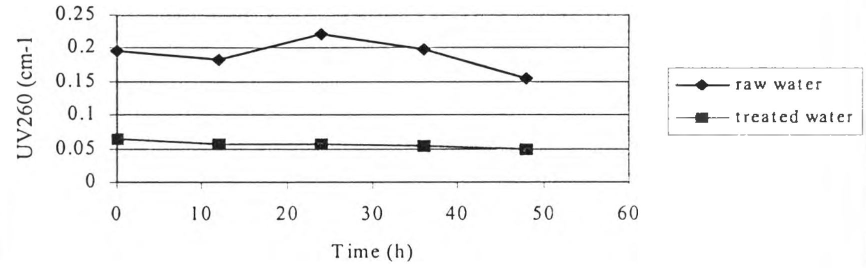

Figure 4.37 UV 260 of raw and treated waters at 3 mg/L of PACl with 0.1 mg/L of nonionic polymer

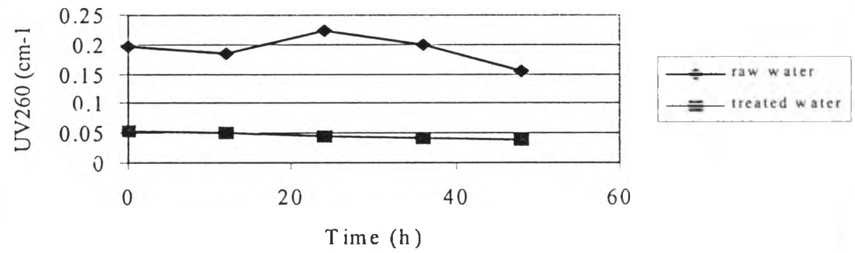

Figure 4.38 UV 260 of raw and treated waters at 4 mg/L with 0.1 mg/L of nonionic polymer

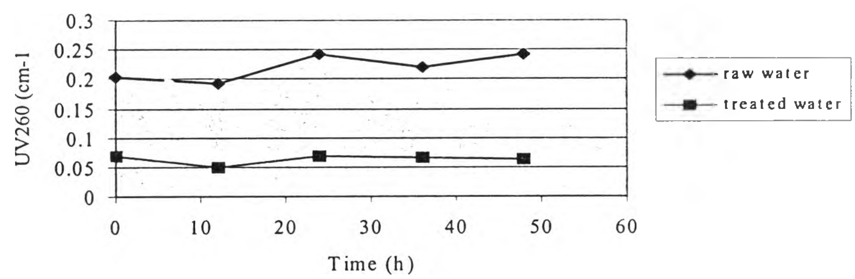

Figure 4.39 UV260 of raw and treated waters at 5 mg/L of PACl with 0.1 mg/L of nonionic polymer

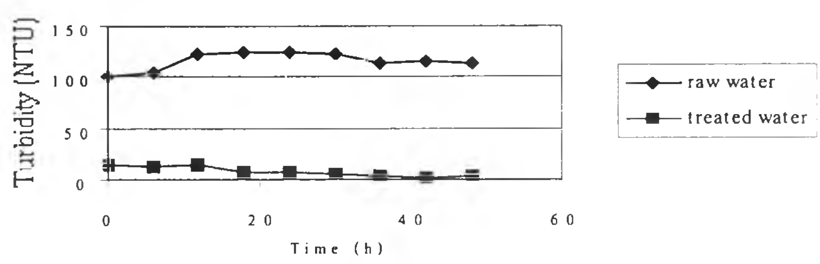

Figure 4.40 Turbidity of raw and treated waters at 3 mg/L of PACl with 0.1 mg/L of nonionic polymer

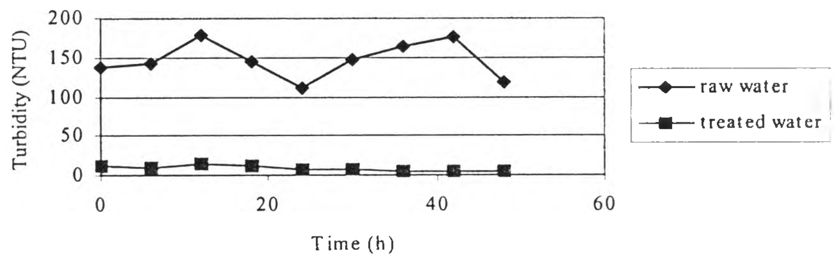

Figure 4.41 Turbidity of raw and treated water 4 mg/L of PACl with 0.1 mg/L of nonionic polymer

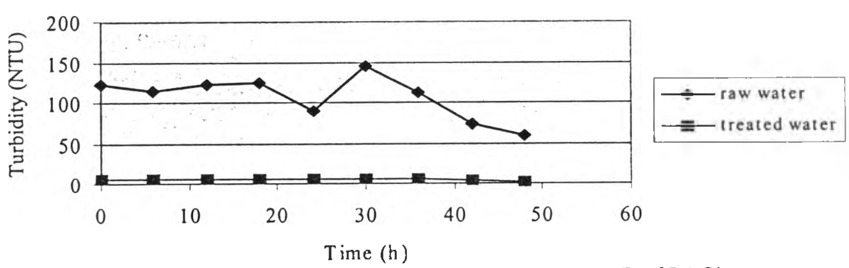

Figure 4.42 Turbidity of raw and treated waters at 5 mg/L of PACl with 0.1 mg/L of nonionic polymer

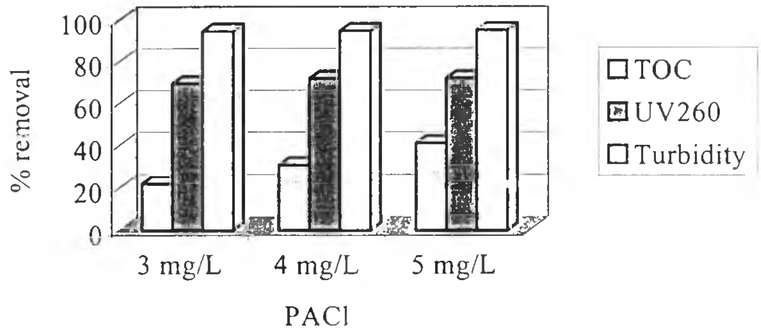

Figure 4.43 Percentage of TOC, UV260, and turbidity removal with 0.1 mg/L of nonionic polymer

The results of effects of PACl with 0.1 mg/L of nonionic polymer on TOC, UV260 and turbidity removal are summarized in Tables 4.19, 4.20, and 4.21. The results show that the removal of TOC, UV260, and turbidity slightly increased with increasing in PACl dosage. The maximum percentage removal of TOC, UV260 and turbidity was obtained at 5 mg/L of PACl. It is evident that the higher PACl dosage can promote a slightly better charge neutralization of the colloidal particles and also can permit better attachment of the particles into pellets. Therefore, higher PACl dosage could produce better quality water than lower PACl dosage.

4.1.1.2 At 0.2 mg/L of nonionic polymer dosage

The experiments were conducted using various PACl dosages (3, 4, and 5 mg/L) with constant nonionic polymer dosage of 0.2 mg/L.

a) Effects on TOC removal

Table 4.22 summarized the effects of PACl dosage with 0.2 mg/L of nonionic polymer. The results show that the influent TOC was in the range of 1.43-2.92, whereas the effluent TOC was in the range of 0.76-2.00 mg/L. The percentage removal of TOC at 3, 4, and 5 mg/L of PACl were 31.4, 34.9, and 46.6, respectively.

Table 4.22 Effects of PACl dosage with 0.2 mg/L of nonionic polymer on TOC removal.*

PACl dosage (mg/L)	TOC (mg/L)		Percentage of TOC removal
	Raw water	Treated water	
3	2.92	2.00	31.4
4	1.97	1.25	34.9
5	1.43	0.76	46.6

* Note: average results at steady-state period

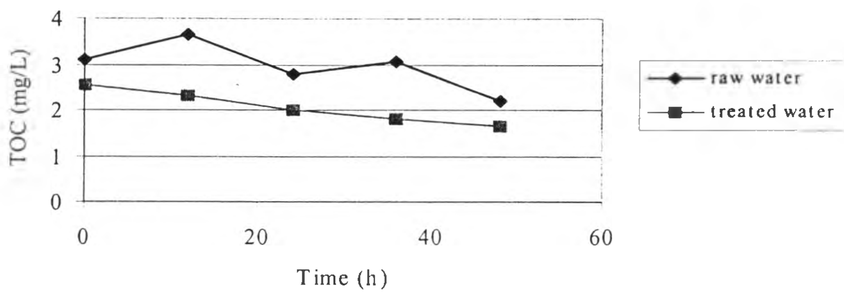

Figure 4.44 TOC of raw and treated waters at 3 mg/L of PACl with 0.2 mg/L of nonionic polymer

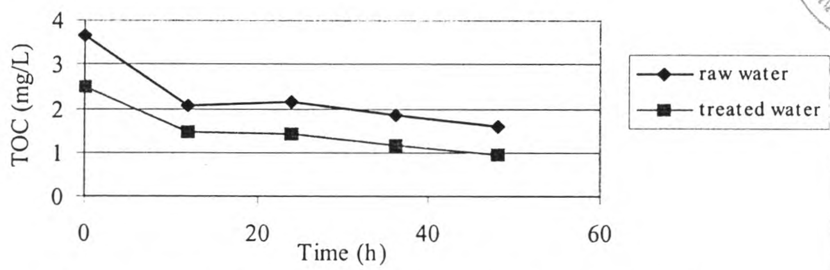

Figure 4.45 TOC of raw and treated waters at 4 mg/L of PACl with 0.2 mg/L of nonionic polymer

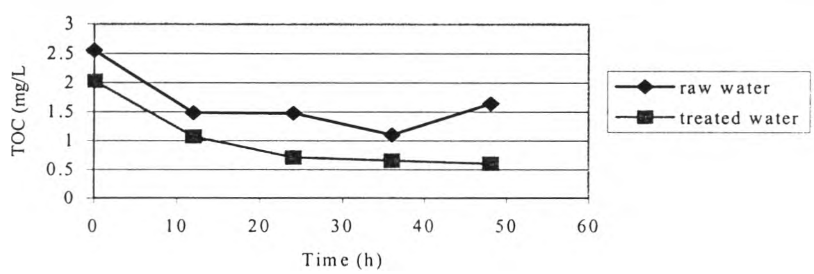

Figure 4.46 TOC of raw and treated water at 5 mg/L of PACl with 0.2 mg/L of nonionic polymer

b) Effects on UV260

Table 4.23 shows the effects of PACl dosage with 0.2 mg/L of nonionic polymer. From the results, the influent UV260 was in the range of .15-0.16 cm^{-1}, while the effluent UV260 was in the range of 0.04-0.05 cm^{-1}. The percentage removal of UV 260 at 3, 4, and 5 mg/L of PACl dosage were 70.7, 70.9, and 73.4, respectively.

Table 4.23 Effects of PACl dosage with 0.2 mg/L of nonionic polymer on UV260 removal.*

PACl dosage (mg/L)	UV260 (cm^{-1})		Percentage of UV260 removal
	Raw water	Treated water	
3	0.16	0.05	70.7
4	0.15	0.04	70.9
5	0.16	0.04	73.4

* Note: average results at steady-state period

c) Effects on turbidity removal

Table 4.24 shows the effects of PACl dosage with 0.2 mg/L of nonionic polymer on turbidity removal. The influent turbidity was in the range of 103.93-148.43 NTU, whereas unfiltered effluent was in the range of 5.22-6.52 NTU. The percentage of turbidity removal at 3, 4, and 5 mg/L of PACl were 94.7, 97.5, and 98.0, respectively.

Table 4.24 Effects of PACl dosage with 0.2 mg/L of nonionic polymer on turbidity removal.*

PACl dosage (mg/L)	Turbidity (NTU)		Percentage of turbidity removal
	Raw water	Treated water	
3	109.51	3.64	94.7
4	101.50	2.77	97.5
5	116.44	2.41	98.0

* Note: average results at steady-state period

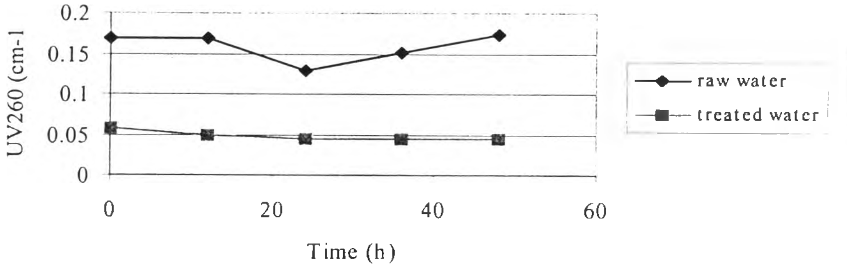

Figure 4.47 UV 260 of raw and treated waters at 3 mg/L of PACl with 0.2 mg/Lof nonionic polymer

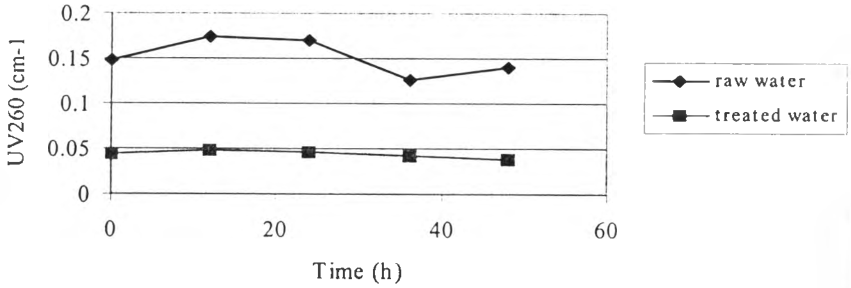

Figure 4.48 UV260 of raw and treated waters at 4 mg/L of PACl with 0.2 mg/L of nonionic polymer

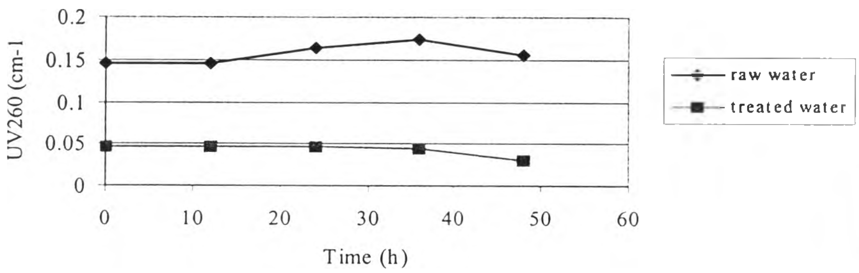

Figure 4.49 UV260 of raw and treated waters at 5 mg/L of PACl with 0.2 mg/L of nonionic polymer

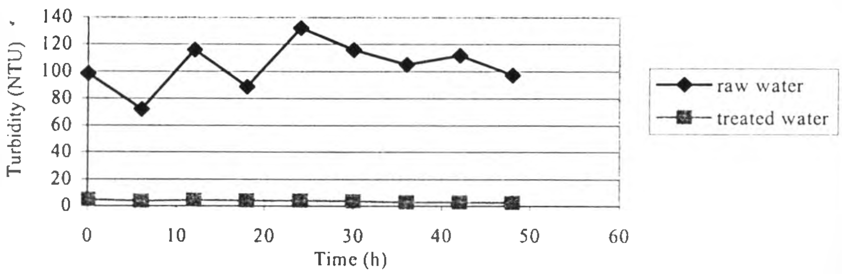

Figure 4.50 Turbidity of raw and treated waters at 3 mg/L of PACl with 0.2 mg/L of nonionic polymer

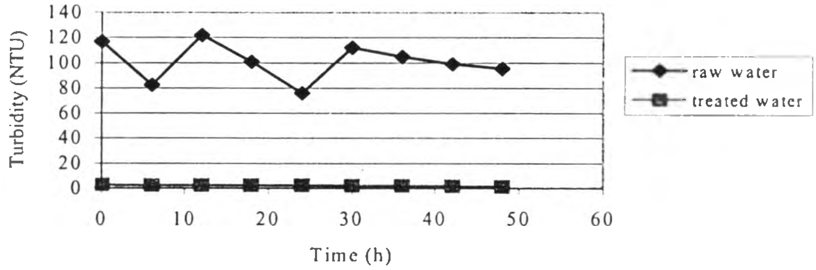

Figure 4.51 Turbidity of raw and treated waters at 4 mg/L of PACl with 0.2 mg/L of nonionic polymer

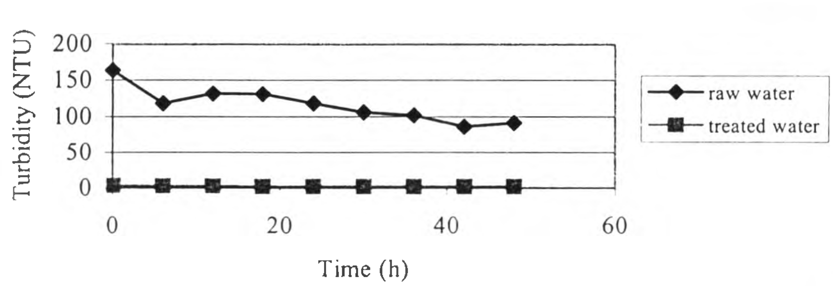

Figure 4.52 Turbidity of raw and treated water at 5 mg/L of PACl with 0.2 mg/L of nonionic polymer

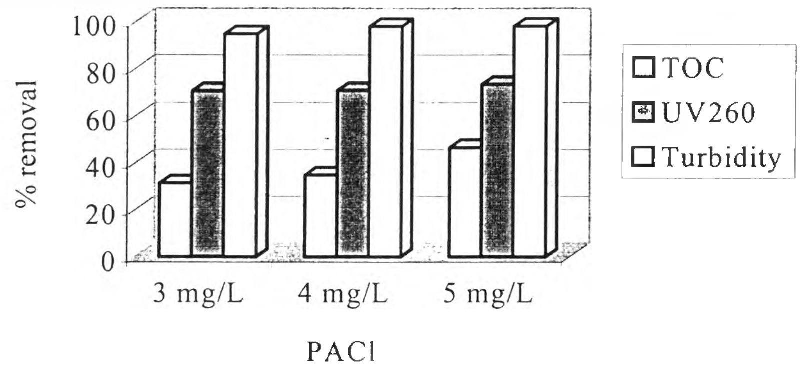

Figure 4.53 Percentage of TOC, UV260, and turbidity removal with 0.2 mg/L of nonionic polymer

Figure 4.53 shows the effects of PACl with 0.2 mg/L of nonionic polymer on TOC, UV260 and turbidity removal. The results show that the removal of TOC, UV260, and turbidity decreased with increasing in PACl dosage. The maximum percentage removal of TOC, UV260, and turbidity was found to be 5 mg/L of PACl. It is evident that the higher PACl dosage can promote charge neutralization of the colloidal particles, increase the inter-particle collision rate and also can permit better attachment of the particles into pellets. Therefore, higher PACl dosage could produce better quality water than lower PACl dosage.

4.1.1.3 At 0.3 mg/L of nonionic polymer dosage

The experiments were conducted at various PACl dosages (3, 4, and 5 mg/L) with constant nonionic polymer dosage of 0.3 mg/L.

a) Effects on TOC removal

Table 4.25 summarized the effects of PACl dosage with 0.3 mg/L of nonionic polymer. The results show that the influent TOC was in the range of 2.52-2.64 mg/L, whereas the effluent TOC was in the range of 1.36-1.60 mg/L. The percentage removal of TOC at 3, 4, and 5 mg/L of PACl were 36.6, 43.2, and 48.6, respectively.

Table 4.25 Effects of PACl dosage with 0.3 mg/L of nonionic polymer on TOC removal.*

PACl dosage (mg/L)	TOC (mg/L)		Percentage of TOC removal
	Raw water	Treated water	
3	2.52	1.60	36.6
4	2.54	1.44	43.2
5	2.64	1.36	48.6

* Note: average results at steady-state period

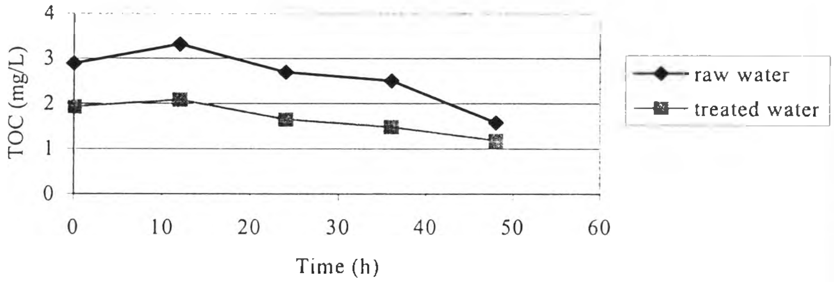

Figure 4.54 TOC of raw and treated waters at 3 mg/L of PACl with 0.3 mg/L of nonionic polymer

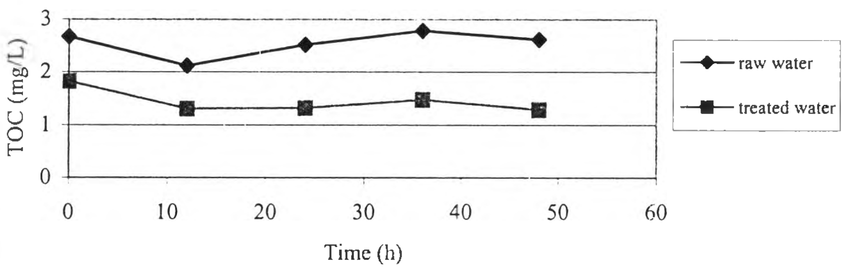

Figure 4.55 TOC of raw and treated waters at 4 mg/L of PACl with 0.3 mg/L of nonionic polymer

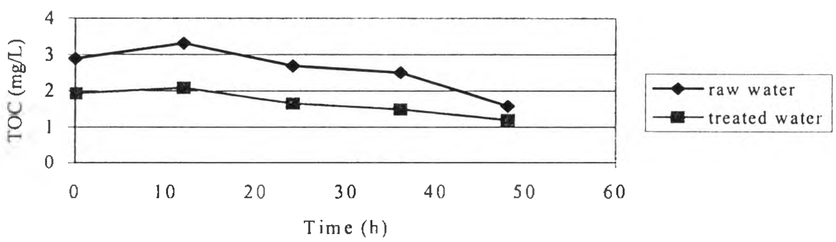

Figure 4.56 TOC of raw and treated waters at 5 mg/L of PACl with 0.3 mg/L of nonionic polymer

b) Effect on UV260

Table 4.26 shows the effect of PACl dosage with 0.3 mg/L of nonionic polymer on UV 260 removal. The results show that percentage of UV 260 removal at 3, 4, and 5 mg/L of PACl dosage were 70.7, 70.9, and 73.4, respectively.

Table 4.26 Effect of PACl dosage with 0.3 mg/L of nonionic polymer on UV260 removal.*

PACl dosage (mg/L)	UV260 (cm^{-1})		Percentage of UV260 removal
	Raw water	Treated water	
3	0.20	0.05	73.2
4	0.18	0.05	74.6
5	0.22	0.05	78.9

*Note: average results at steady-state period

c) Effect on turbidity removal

Table 4.27 shows the results of turbidity removal at various dosages of PACl with 0.3 nonionic polymer. The influent turbidity was in the range of 122.43-156.14 NTU, whereas the unfiltered effluent turbidity was in the range of 4.5-5.8 NTU. The percentage of turbidity removal at 3, 4, and 5 mg/L of PACl dosage were 96.3, 96.3, and 95.7, respectively

Table 4.27 Effect of PACl dosage with 0.3 mg/L of nonionic polymer on turbidity removal.*

PACl dosage (mg/L)	Turbidity (NTU)		Percentage of turbidity removal
	Raw water	Treated water	
3	122.43	4.5	96.3
4	156.14	5.8	96.3
5	127.21	5.0	95.7

*Note: average results at steady-state period

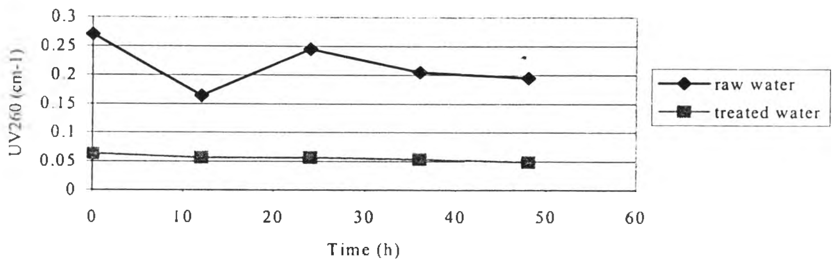

Figure 4.57 UV 260 of raw and treated waters 3 mg/L of PACl with 0.3 mg/L of nonionic polymer

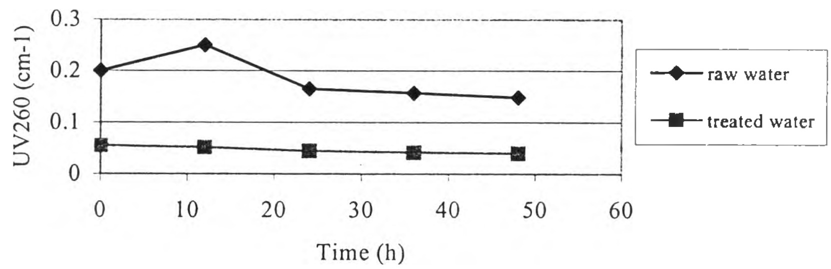

Figure 4.58 UV260 of raw and treated waters at 4 mg/L of PACl with 0.3 mg/L of nonionic polymer

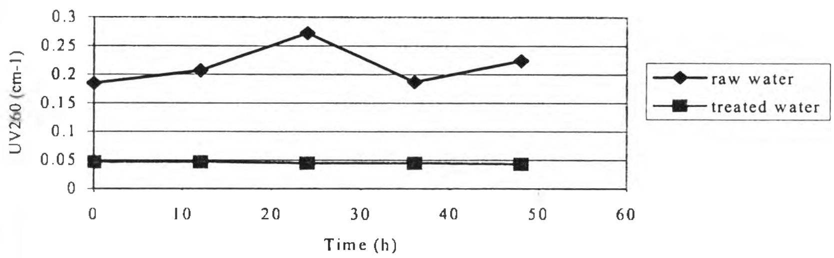

Figure 4.59 UV260 of raw and treated waters at 5 mg/L of PACl with 0.3 mg/L of nonionic polymer

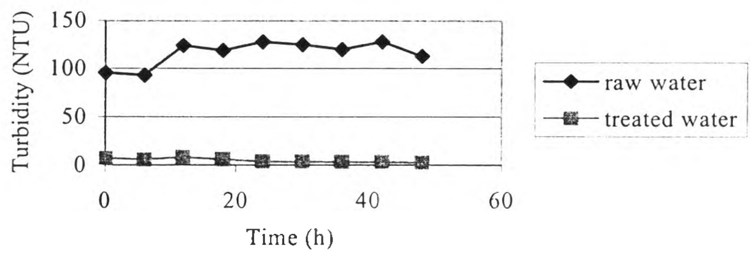

Figure 4.60 Turbidity of raw and treated waters at 3 mg/L of PACl with 0.3 mg/L of nonionic polymer

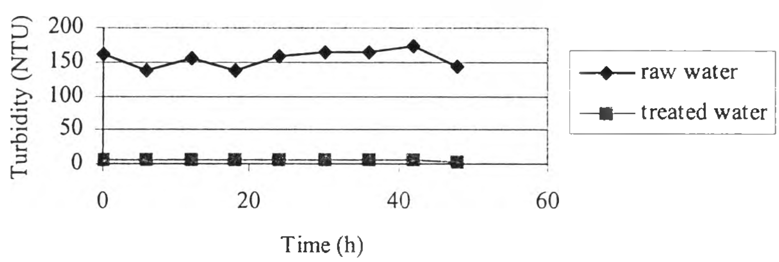

Figure 4.61 Turbidity of raw and treated waters at 4 mg/L of PACl with 0.3 mg/L of nonionic polymer

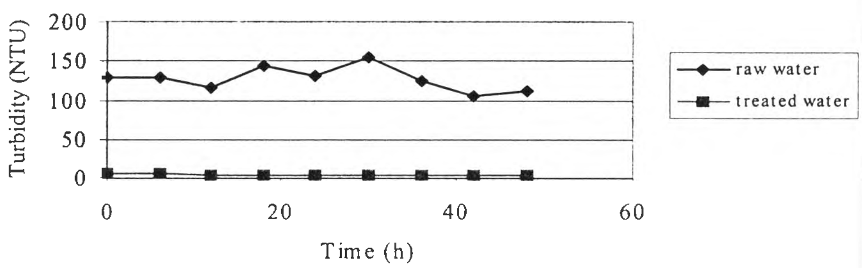

Figure 4.62 Turbidity of raw and treated waters at 5 mg/L of PACl with 0.3 mg/L of nonionic polymer

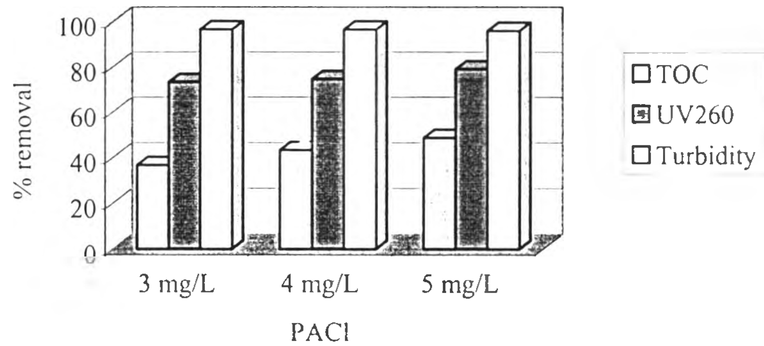

Figure 4.63 Percetage of TOC, UV260, and turbidity removal with 0.3 mg/L of nonionic polymer

Figure 4.63 shows the effects of PACl dosage on TOC, UV260, and turbidity removal. With 0.3 mg/L of nonionic polymer as the coagulant aid, the performance with regards to TOC and UV260 removal increased with an increasing in PACl dosage. The results indicate that the higher PACl dosage tend to promote better charge neutralization of organic material and to reduce the repulsive force between particles more than the lower PACl dosage. The results also show that percentage of UV260 removal is higher than TOC removal in all conditions. This observation is consistent with previous studied suggesting that the humic substances be removed more efficiently by chemical coagulation than other NOM fractions (Hubel, 1987; Hall, 1965 and Randtke, 1988)

Randtke et.al. (1985) reported the major mechanism by which naturally occurring organics can be removed by coagulation involving charge neutralization of colloidal organic matters, precipitatation as humate or fulvates, coprecipitation by adsorption on the coagulant. Under high pH condition in this study (7.08-8.05), a significantly large fraction of humic substances was removed by hydroxide precipitation. However, this mechanism has believed less effective than former charge neutralization mechanism in removing organic matters, that occurring at low pH condition (Hall et.al. 1965.)

With regard to turbidity removal, efficiency of process on turbidity removal did not change is increased from 3 to 4 mg/L of PACl. But, when increased PACl dosage was increased up to 5 mg/L, percentage of turbidity removal slightly dropped to 95.7 %. Possibilities that could explain poorer turbidity removal include restabilization because of charge reversal or changing in pellets size and density that adversely affected pellet settleability.

A comparison percentage of TOC, UV260, and turbidity removal at the various of nonionic polymer dosages (0.1, 0.2, and 0.3 mg/L) as shown in Table 4.28. The maximum of TOC and UV 260 removal were observed at 5 m/g of PACl with 0.3 mg/L of nonionic polymer. The results also indicate that at same PACl dosage, the percentage of TOC and UV260, and turbidity removal increased with increase in nonionic dosage. The reason is that higher polymer dosage increased interactions strongly with oppositely charged surfaces and improved shear resistance as a result of the bridging action of the nonionic dosage. This led to the formation of more settleable pellet. Thus, good quality could be obtained. Although, the 0.3 mg/L of nonionic polymer could give the highest percentage of TOC and UV260 removal. However, it could be suggested that the nonionic polymer dosage should be used only 0.2 mg/L because the results between using 0.2 and 0.3 mg/L of nonionic polymer showed no significant difference. This could help to minimize the operation cost as well as the use of chemical since high dosage of polymer has been shown to be toxic (Kuperman, 1985) .

From the present study, the highest efficiency of turbidity was achieved at 5 mg/L of PACl with 0.2 mg/L of nonionic polymer. The addition nonionic polymer dosage combination with PACl dosage for turbidity removal is lower nonionic polymer dosage than TOC and UV260 removal because charge of particle was easily neutralized and entrapped in to pellet particle than organic particle.

Table 4.28 Effects of coagulant and coagulant aid dosages on TOC, UV260, and turbidity removal.

Nonionic polymer (mg/L)	PACl (mg/L)	Percentage of removal		
		TOC	UV260	Turbidity
0.1	3	21.8	69.5	94.5
	4	30.7	72.0	94.6
	5	41.0	72.1	95.0
0.2	3	31.4	70.7	94.7
	4	34.9	70.9	97.5
	5	46.6	73.4	98.0
0.3	3	36.6	73.2	96.3
	4	43.2	74.6	96.3
	5	48.6	78.9	95.7

4.2.2 Effect of coagulant and coagulant aid dosages on pH

In this experiment is to determine the effects of coagulant and coagulant aid dosages on pH by observation the change of pH between feed water and treated water.

4.2.2.1 At 0.1mg/L of nonionic polymer

The effect of PACl dosage with 0.1 mg/L of nonionic polymer on pH are shown in Table 4.29.

Table 4.29 Effect of PACl dosage with 0.1 mg/L of nonionic polymer on pH.*

PACl dosage (mg/L)	pH	
	Raw water	Treated water
3	7.86	7.82
4	8.05	7.98
5	7.79	7.72

* Note: average results at steady-state period.

4.2.2.2 At 0.2 mg/L of nonionic polymer

The effect of PACl dosage with 0.2 mg/L of nonionic polymer on pH are shown in Table 4.30.

Table 4.30 Effect of PACl dosage with 0.2 mg/L of nonionic polymer on pH.*

PACl dosage (mg/L)	pH	
	Raw water	Treated water
3	7.92	7.89
4	7.74	7.68
5	7.88	7.84

* Note: average result at steady-state period.

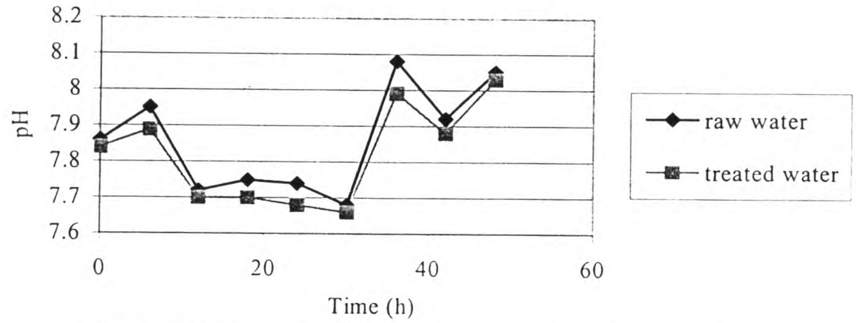

Figure 4.64 The pH of raw and treated waters at 3 mg/L of PACl
with 0.1 mg/L of nonionic polymer

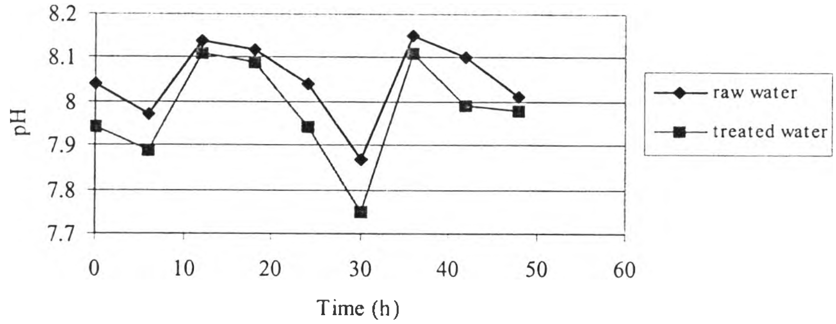

Figure 4.64 The pH of raw and treated waters at 4 mg/Lof PACl
with 0.1 mg/L of nonionic polymer

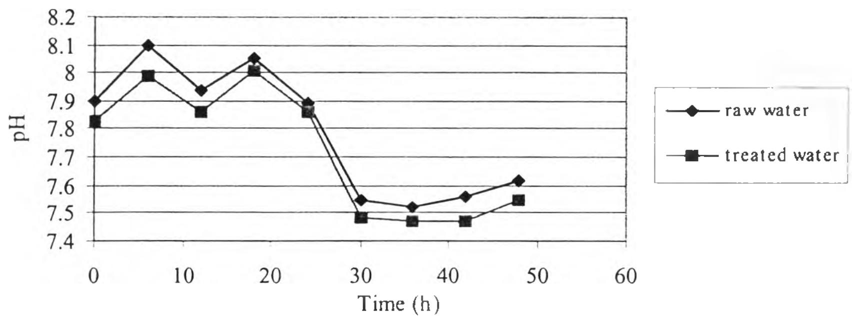

Figure 4.66 The pH of raw and treated waters at 5 mg/L of PACl
with 0.1 mg/L of nonionic polymer

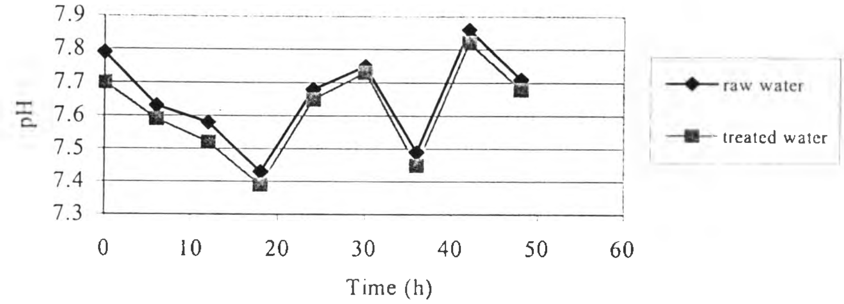

Figure 4.67 The pH of raw and treated waters at 3 mg/L of PACl with 0.2 mg/L of nonionic polymer

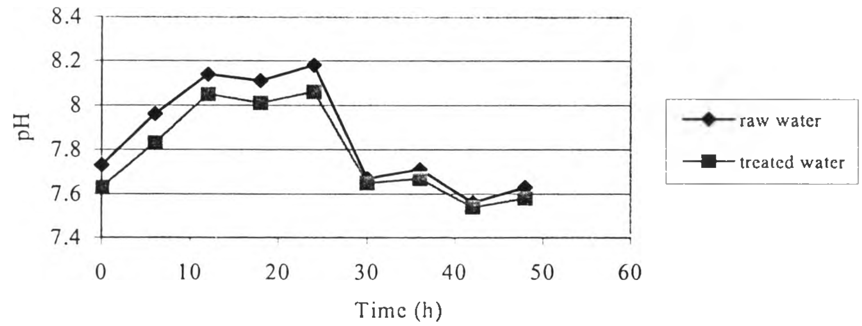

Figure 4.68 The pH of raw and treated waters at 4 mg/L of PACl with 0.2 mg/L of nonionic polymer

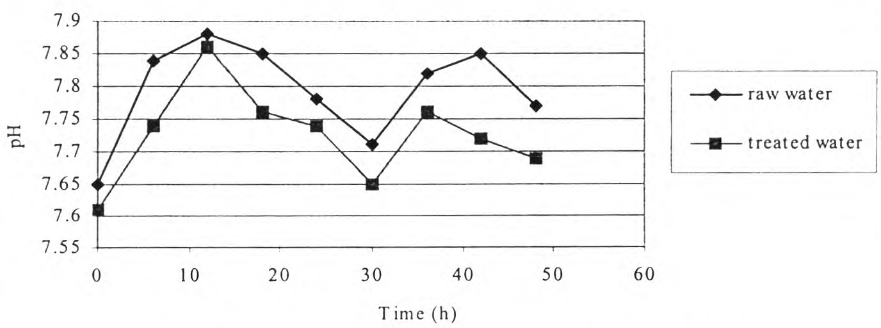

Figure 4.68 The pH of raw and treated waters at 5 mg/L of PACl with 0.2 mg/L of nonionic polymer

4.2.2.2 At 0.3 mg/L of nonionic polymer

The effects of PACl dosage with 0.3 mg/L of nonionic polymer on pH are shown in Table 4.31.

Table 4.31 Effects of PACl dosage with 0.3 mg/L of nonionic polymer on pH.*

PACl dosage (mg/L)	pH	
	Raw water	Treated water
3	7.66	7.63
4	7.85	7.78
5	7.79	7.73

* Note: average results at steady-state period.

The results of the present study, the effects of coagulant and coagulant aid on pH, are shown in Tables 4.29, 4.30, and 4.31. The results indicate that at all of PACl and nonionic polymer dosages condition, the addition of PACl and nonionic polymer, the pH of treated water was slightly dropped due to hydrolysis by-product of PACl. The hydrolysis of PACl could be described by the following equation:

$$Al^{+3} + H_2O \longrightarrow Al(OH)^{+2} + H^{+} \qquad (a)$$

$$8Al^{+3} + 20H_2O \longrightarrow Al(OH)^{+4}{}_{20} + 20H^{+} \qquad (b)$$

$$Al(OH)_3 + H_2O \longrightarrow Al(OH)^{-}{}_{4} + H^{+} \qquad (c)$$

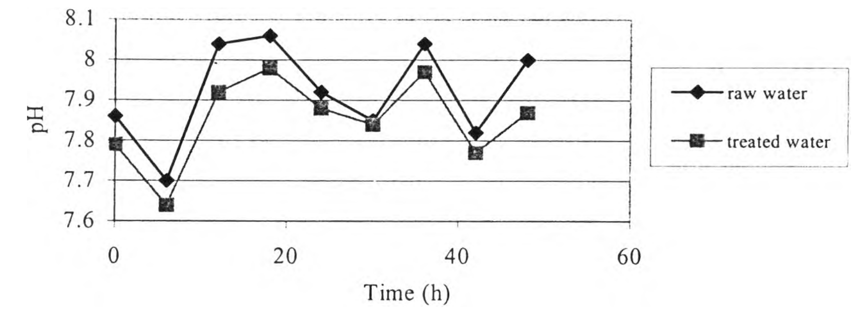

Figure 4.70 The pH of raw and treated waters at 3 mg/L of PACl with 0.3 mg/L of nonionic polymer

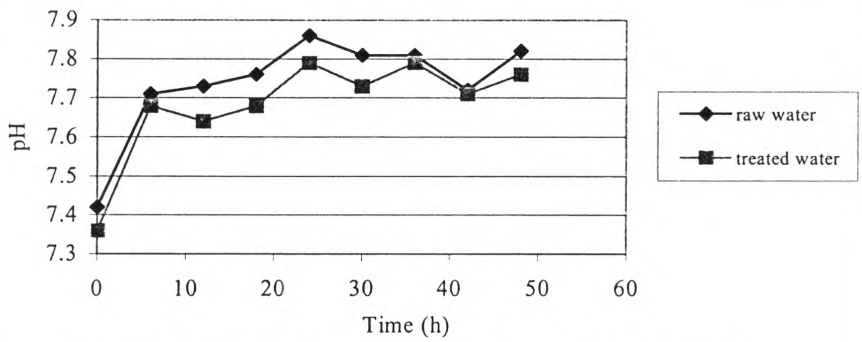

Figure 4.71 The pH of raw and treated waters at 4 mg/L of PACl with 0.3 mg/L of nonionic polymer

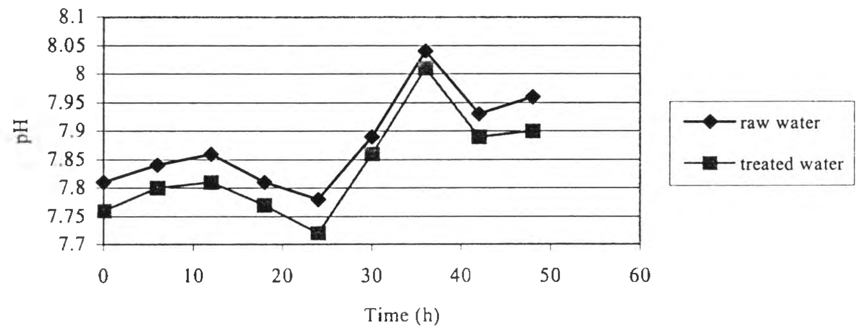

Figure 4.72 The pH of raw and treated waters at 5 mg/L of PACl with 0.3 mg/L of nonionic polymer

4.2.3 Effects of coagulant and coagulant aid dosages on characteristics of pellets

4.2.3.1 Effects on mass of pellets

Tables 4.32, 4.33, and 4.34 show the effects of number of paddles and up-flow velocity on mass on pellets. The results can be described as follow:

4.2.3.2.1 At 0.1 mg/L of nonionic polymer

The effects of PACl dosage with 0.1 mg/L of nonionic polymer on mass of pellets are shown in Table 4.32.

The results show that mass of pellets in the reactor increased with increasing in PACl dosage. The mass of pellets at 3, 4, and 5 mg/L of PACl were 97, 100, and 200 mg/L, respectively.

Table 4.32 Effects of PACl dosage with 0.1 mg/L of nonionic polymer on mass of pellets.*

PACl dosage (mg/L)	Mass (kg/L)
3	97
4	100
5	200

* Note: average results at steady-state period (at 12-48 h)

4.2.3.2.2 At 0.2 mg/L of nonionic polymer

The effects of PACl dosage with 0.2 mg/L of nonionic polymer on mass of pellets are shown in Table 4.33.

The results show that mass of pellets in the reactor at 3, 4, and 5 mg/L of PACl were 100, 200, and 300 kg/L, respectively.

Table 4.33 Effects of PACl dosage with 0.2 mg/L of nonionic polymer on mass of pellets.*

PACl dosage (mg/L)	Mass (kg/L)
3	100
4	200
5	300

* Note: average result at steady-state period (at 12-48 h)

4.2.3.2.3 At 0.3 mg/L of nonionic polymer

The effects of PACl dosage with 0.3 mg/L of nonionic polymer on mass of pellets are shown in Table 4.34.

The results show that mass of pellets in the reactor at 3, 4, and 5 mg/L of PACl were 200, 300, and 300 kg/L, respectively.

Table 4.34 Effects of PACl dosage with 0.3 mg/L of nonionic polymer on mass of pellets.*

PACl dosage (mg/L)	Mass (kg/L)
3	200
4	300
5	300

* Note: average results at steady-state period (at 12-48 h)

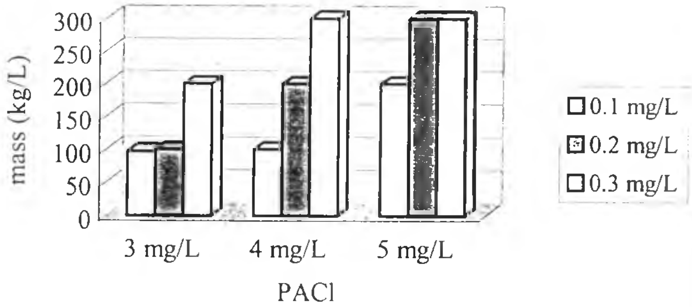

Figure 4.73 Effects of PACl and nonionic polymer dosages on mass of pellets

The increasing of PACl and nonionic dosages used for enhanced coagulation may be of concern because they may cause increase in the mass of sludge produced at the plants and in the in the load of heavy metals discharged per day. The effects of coagulant and coagulant aid on mass of sludge are shown in Figure 4.73. The results indicate that mass of pellets tend to increased with increasing in PACl dosage, and gradually increased when increased nonionic polymer dosage. Because these high dosages produced the greater degree of collision particulate. Therefore, leading to produce large amount of pellets particle. Thus, mass of pellets is increased as a result of increasing in PACl and nonionic polymer.

4.2.3.3 Effects on size of pellets

Tables 4.35, 4.36, and 4.37 shows the effects of the number of paddles and up-flow velocity on size of pellets The results can be described as follow:

4.2.3.3.1 At 0.1 mg/L of nonionic polymer

Table 4.35 shows the effects of PACl dosage with 0.1 mg/L of nonionic polymer on size of pellets. The results show that size of pellets decreased with increasing in PACl dosage. The pellet size at 3, 4, and 5 mg/L of nonionic polymer were 0.27, 0.21, and 0.19 mm, respectively.

Table 4.35 Effects of PACl dosage with 0.1 mg/L of nonionic polymer on size of pellets.*

PACl dosage (mg/L)	Size (mm)
3	0.27
4	0.21
5	0.19

* Note: average resu.. at steady-state period (at 12-48 h)

4.2.3.3.2 At 0.2 mg/L of nonionic polymer

Table 4.36 shows the effects of PACl dosage with 0.1 mg/L of nonionic polymer on size of pellets. The results show that size of pellets decreased with increasing in PACl dosage. The pellet size at 3, 4, and 5 mg/L of nonionic polymer were 0.34, 0.28, and 0.25 mm, respectively.

Table 4.36 Effects of PACl dosage with 0.2 mg/L of nonionic polymer on size of pellets.*

PACl dosage (mg/L)	Size (mm)
3	0.34
4	0.28
5	0.25

* Note: average at steady-state period (at 12-48 h)

4.2.3.3.3 At 0.3 mg/L of nonionic polymer

Table 4.37 shows the effects of PACl dosage with 0.3 mg/L of nonionic polymer on size of pellets. The results show that size of pellets decreased with increasing PACl dosage. The pellet size at 3, 4, and 5 mg/L of nonionic polymer were 0.39, 0.35, and 0.33 mm, respectively.

Table 4.37 Effects of PACl dosage with 0.3 mg/L of nonionic polymer on size of pellets.*

PACl dosage (mg/L)	Size (mm)
3	0.39
4	0.35
5	0.33

* Note: average results at steady-state period (at 12-48 h)

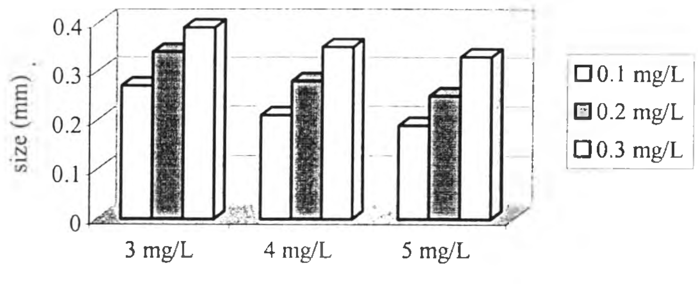

Figure 4.74 Effects of PACl and nonionic polymer dosages on size of pellets

Figure 4.74 shows the effects of PACl and nonionic dosages on size of pellets. The results indicate that increasing in PACl caused a slightly decrease in size of pellet. At high PACl dosage could produce smaller pellet size than using low PACl dosage.. This was because high PACl dosage produced more water molecules from hydrolysis reaction. The water molecules were displacing in the floc. Thus, pellet-flocs generated much more void water and bulky. After that bulky floc was broken down to become smaller size.

When using PACl combination with high nonionic polymer dosage, pellets became larger size resulted from improving of charge neutralization and improving of shear resistance as a result of the bridging action of nonionic polymer.

4.2.3.3 Effects on settling velocity of pellets

Tables 4.38, 4.39, and 4.40 shows the effects of coagulant and coagulant aid dosages on settling velocity of pellets. The results can be described as follow.

4.2.3.3.1 At 0.1 mg/L of nonionic polymer

The effects of of PACl dosage with 0.1 mg/L of nonionic polymer on settling velocity of pellets are shown in Table 4.38

The results show that settling velocity of pellets tend to decrease with increasing in PACl dosage. The settling velocity at 3, 4, and 5 mg/L of PACl were 34.48, 23.56, and 19.66 m/h, respectively.

Table 4.38 Effects of PACl dosage with 0.1 mg/L of nonionic polymer velocity on settling velocity of pellets.*

PACl dosage (mg/L)	Settling velocity (m/h)
3	34.48
4	23.56
5	19.66

* Note: average results at steady-state period (at 12-48 h)

4.2.3.3.2 At 0.2 mg/L of nonionic polymer

The effects of of PACl dosage with 0.2 mg/L of nonionic polymer on settling velocity of pellets are shown in Table 4.39

The results show that settling velocity of pellets tend to decrease with increasing in PACl dosage. The settling velocity at 3, 4, and 5 mg/L of PACl were 38.78, 34.40, and 32.81 m/h, respectively.

Table 4.39 Effects of PACl dosage with 0.2 mg/L of nonionic polymer on settling velocity of pellets.*

PACl dosage (mg/L)	Settling velocity (m/h)
3	38.78
4	34.40
5	32.81

* Note: average results at steady-state period (at 12-48 h)

4.2.3.3.3 At 0.3 mg/L of nonionic polymer

The effects of of PACl dosage with 0.3 mg/L of nonionic polymer on settling velocity of pellets are shown in Table 4.40

The results show that settling velocity of pellets tend to decrease with increasing in PACl dosage.The settling velocity at 3, 4, and 5 mg/L of PACl were 53.96, 46.32, and 37.68 m/h, respectively.

Table 4.40 Effects of PACl dosage with 0.3 mg/L of nonionic polymer on settling velocity of pellets.*

PACl dosage (mg/L)	Settling velocity (m/h)
3	53.96
4	46.32
5	37.68

* Note: average results at steady-state period (at 12-48 h)

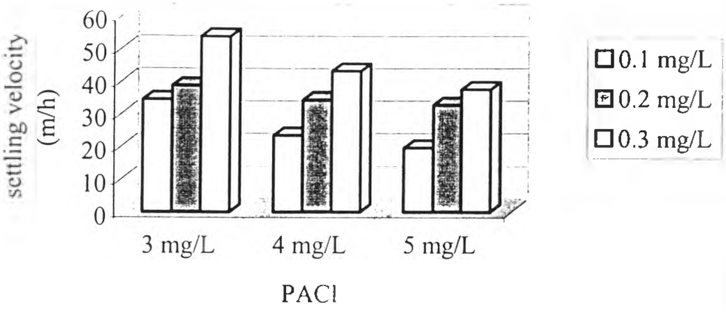

Figure 4.75 Effects of PACl and nonionic polymer dosages on settling velocity of pellets

With respect to pellet settleability, pellet size, density and permeability all affect settling velocity (Gregory 1977). Tambo and Watanabe (1979) and Bache et al. (1995) showed that the density of pellet with a given diameter decreasing with increasing aluminum ion to particle. Thus, an increase in coagulant dosage may produce a decrease in the settling velocity of pellet, depending on the resulting pellet size.

Similar results were obtained from this study. The results in Figure 4.75 indicate that settling of pellet slightly decreased with increasing PACl dosage. It is therefore that higher PACl dosage, accompanied by decrease in coagulation pH, altered floc size and density such that pellet settleability decrease. As a result of the nonionic polymer addition, both improving charge neutralization and interparticle bridging led to the formation more settleable pellet. Thus, higher nonionic polymer dosage could produce pellets with higher settlingability than using lower nonionic polymer dosage.

4.3 THM FORMATION POTENTIAL OF RAW AND TREATED WATERS

Sample in this part obtained from part II, with condition 5 mg/L of PACl and 0.3 mg/L of nonionic polymer. The TOC concentration of raw water and treated water were 2.64 mg/L and 1.36 mg/L. Table 4.41 shows the formation potential of THM from the chlorinating of raw and treated water, with chlorine dosage of 4 mg/L.

Table 4.41 THM formation potential of raw and treated water by chlorine disinfection.*

Chlorine dosage (mg/L)	Contact time (h)	THM (μg/L)	
		Raw water	Treated water
4	3	58.45	29.24
	6	64.37	33.87
	9	71.53	41.05
	12	78.23	47.23
	24	87.23	49.51

* THM species that occurred was chloroform, the other species was not detected.

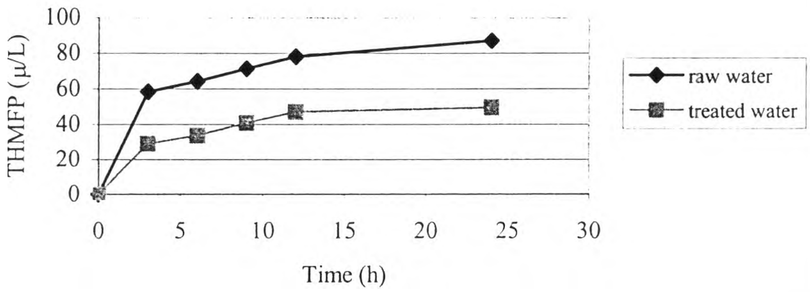

Figure 4.76 THM formation potential of raw and treated waters

Figure 4.76 illustrates the reaction rate curve for the formation potential of THM at 25 °C. At the end of the test run, the THM formation potential of raw and treated water was found approximately 87.23 and 49.51 µg/L and the reaction rate curve still indicates a great increase in the THM formation potential concentration. This shows that at 24 h contact time, the reaction was still incomplete and there was a possibility of higher concentrations of THM formation potential beyond the 24 h contact time.

A comparison of THM formation potential concentrations of raw and treated water at the end test run (at contact time of 24 h), it is evident that the THM formation potential concentrations of treated water was decreased approximately 37.72 µg/L or 43.2 %. These results also indicate that the amount of precursor materials in treated water residual has smaller amount when compared with raw water. From the present study, It is possible to say that up-flow pelletization process could be applicable for THM precursors removal.