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APPENDIX

Test No 1Determination of Fast Mixing Speed

## Raw water characteristics:

Sample 1	Surface water
Turbidity	89 % Transmission
pH	7.4
Alkalinity	63.mg/l.as $\text{CaCO}_3$

Conditions:	Slow mixing speed	40 rpm, 1 min
	Settling time	10 min
	$\text{Al}_2(\text{SO}_4)_3 \cdot 18\text{H}_2\text{O}$	40 mg/l.

Fast mixing speed, rpm	Fast mixing time, Sec	Turbidity, % Transmission
60	20	89
	40	91
	60	93.5
	80	95
	100	95
80	20	88
	40	92
	60	93
	80	94
	100	95

Fast mixing Speed, rpm	Fast mixing time, sec	Turbidity, % Transimssion
100	20	91
	40	91
	60	95
	80	95
	100	95



Test No 2Determination of Slow Mixing Speed

Raw water characteristics:

Sample 1	Surface water
Turbidity	89 % Transmission
pH	7.4
Alkalinity	63 mg/l. as CaCO <sub>3</sub>
Fast mixing speed	100 rpm, 60 sec
settling time	10 mins
Al <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> ·18H <sub>2</sub> O	40 mg/l.

Slow mixing speed, rpm	Slow mixing time, min	Turbidity, % Transmission
20	1	91
	2	93
	3	93
	4	94
	5	95
40	1	96
	2	96.5
	3	97
	4	97
	5	97

Slow mixing speed, rpm	Slow mixing time, min	Turbidity, % Transmission
60	1	97
	2	96
	3	97
	4	97
	5	97.5
80	1	95
	2	97
	3	97
	4	98
	5	99.5
100	1	96
	2	97
	3	95
	4	96
	5	96

Test No 3Determination of Total Settling Time

Raw water      Characteristics:

Sample 1      Surface water

Turbidity      89% Transmission

pH      7.4

Alkalinity      63 mg/l. as CaCO<sub>3</sub>

Conditions:    Fast mixing speed      100 rpm, 1 min

                  Slow mixing speed      40 rpm, 3 min

                  Al<sub>2</sub>(SO<sub>4</sub>)<sub>3</sub> · 18H<sub>2</sub>O      40 mg/l. as CaCO<sub>3</sub>

Settling time, min	Turbidity % Transmission
1	90
5	92
10	94.5
15	96
20	96
30	96



Test No 4Determination of Settling Time

Raw water                      Characteristics:

Sample 5	Surface water
Turbidity	85% Transmission
pH	7.4
Alkalinity	68 mg/l. as CaCO <sub>3</sub>

Conditions:

Fast mixing speed	100 rpm, 1 min
Slow mixing speed	40 rpm, 3 min
Al <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> · 18H <sub>2</sub> O	40 mg/l.

Settling time, min	Turbidity, % Transmission
1	92.5
5	95.5
10	97
15	97.5
20	97.5
30	97.5

Test No 5Determination of  $\text{Al}_2(\text{SO}_4)_3 \cdot 18\text{H}_2\text{O}$  Utilized

Raw water

Characteristics:

Sample 1	Surface water
Turbidity	89% Transmission
pH	7.4
Alkalinity	63 mg/l. as $\text{CaCO}_3$
Fast mixing speed	100 rpm, 1 min
Slow mixing speed	40 rpm, 3 min
Settling time	15 min

$\text{Al}_2(\text{SO}_4)_3 \cdot 18\text{H}_2\text{O}$ mg/l.	Turbidity, % Transmission	Alkalinity, mg/l. as $\text{CaCO}_3$	pH
0	89.0	63.0	7.4
20	92.5	55.0	7.3
30	94.0	48.0	6.9
40	95.5	44.0	6.7
50	95.0	38.0	6.4
60	94.5	34.0	6.2
70	93.5	31.0	6.0

Test No 6Determination of  $\text{Al}_2(\text{SO}_4)_3 \cdot 18\text{H}_2\text{O}$  Utilized

Raw water Characteristics:

Sample	Surface water
Turbidity	85% Transmission
pH	7.4
Alkalinity	68 mg/l. as $\text{CaCO}_3$

Conditions: Fast mixing speed	100 rpm, 1 min
Slow mixing speed	40 rpm, 3 min
Settling time	15 min

$\text{Al}_2(\text{SO}_4)_3 \cdot 18\text{H}_2\text{O}$ mg/l.	Turbidity, % Transmission	Alkalinity, Mg/l. as $\text{CaCO}_3$	pH
0	85.0	54	7.3
10	88.5	48	7.2
20	92.0	43	6.8
30	93.5	38	6.5
40	94.5	34	6.3
50	94.0	31	6.1
60	94.0	29	6.0

Test No 7Determination of Optimum pH Range for  $Al_2(SO_4)_3 \cdot 18H_2O$  Coagulation

Raw Water Characteristics:

Sample 1	Surface water
Turbidity	89% Transmission
pH	7.4
Alkalinity	63 mg/l. as $CaCO_3$

Sign No	pH	Turbidity, % Transmission
1	4	93.0
2	5	95.5
3	6	97.0
4	7	97.0
5	8	96.0
6	9	95.0

Test No 8Determination of Optimum pH Range for  $\text{Al}_2(\text{SO}_4)_3 \cdot 18\text{H}_2\text{O}$  Coagulation

Raw water

Characteristics:

Sample 5

Surface water

Turbidity

85% Transmission

pH

7.4

Alkalinity

68 mg/l. as  $\text{CaCO}_3$ 

Sign No	pH	Turbidity, % Transmission Sample 5
1	4	91.5
2	5	94.5
3	6	96.5
4	7	96.0
5	8	95.0
6	9	93.5

Test No 9Iron Removal by  $\text{Al}_2(\text{SO}_4)_3 \cdot 18\text{H}_2\text{O}$  Coagulation

Raw water Characteristics:

Sample 1	Surface water
Turbidity	89 % Transmission
pH	7.4
Alkalinity	63 mg/l. as $\text{CaCO}_3$
Sample 5	Surface water
Turbidity	85% Transmission
pH	7.4
Alkalinty	68 mg/l. as $\text{CaCO}_3$

Sign No	Sample	Total Iron, mg/l. Before coagulation	Total Iron, mg/l. After coagulation
1	1	0.39	0.18
2	5	0.62	0.06

Test No 10

Raw water

Charactetistics:

Sample 1

Surface water

Turbidity

89% Transmission

Alkalinity

63 mg/l. as CaCO<sub>3</sub>

pH

7.4

Condition:

Flow rate

0.6 l/min

Power supply

265 W

Losses in equipments

54 W

Net power supply

211 W

Inlet temperature

29 °C

Outlet temperature

43 °C

Settling time, min	Turbidity or color, percent transmission	
	upper*	lower**
0	89	89
1	91	92.5
5	94	95
10	96	95
15	-	-
20	97	97
30	98	97
60	98	97
90	98	97

Remarks: \*Indicated percent transmission measured at depth  
130 cm from the bottom of settling column.

\*\*Indicated percent transmission measured at depth  
70 cm from the bottom of settling column.



Test No 11

Raw water	Characteristic:	
	Sample 1	Surface water
	Turbidity	89% Transmission
	pH	7.4
	Alkalinity	6.3 mg/l. as CaCO <sub>3</sub>
Condition:	Flow rate	0.8 l/min
	Power supply	162 W
	Losses in equipments	54 W
	Net power supply	108 W
	Inlet temperature	29°C
	Outlet temperature	39°C

Settling time, min	Turbidity or color, percent transmission	
	Upper*	Lower**
0	89	89
1	93	93.5
5	96	97
10	96.5	98
20	98.5	98
30	99	99
60	99	99
90	99	99

Remarks: \*Indicated percent transmission measured at depth 190 cm from the bottom of the settling column.

\*\*Indicated percent transmission measured at depth 70 cm from the bottom of the settling column.

Test No 12

Raw water

Characteristics:

Sample 1

Surface water

Turbidity

89% Transmission

pH

7.4

Alkalinity

63 mg/l. as  $\text{CaCO}_3$ 

Condition:

Flow rate

1.87 l/min

Power supply

162 W

Losses in equipments

54 W

Net power supply

108 W

Inlet temperature

27°C

Outlet temperature

31°C

Settling time, min	Turbidity or color, percent transmission
0	84.5
1	85
5	86.5
10	88
20	90
30	91
40	92
50	92
60	92
70	92
80	92
90	92.5
120	92.5

Test No 13

Raw water

Characteristics:

Sample 2

Surface water

Turbidity

72% Transmission

pH

7.8

Alkalinity

67 mg/l. as  $\text{CaCO}_3$ 

Conditions:

Flow rate

3.18 l./min

Power supply

162 W

Losses in equipments

54 W

Inlet temperature

29°C

Outlet temperature

34°C

Settling time, min	Turbidity or color, percent transmission
0	75
1	76
5	80
10	82
15	84
20	85
30	86.5
40	87.5
50	88.5
60	89.5
75	90.5
90	91
120	91.5

Test No. 14

Raw water

Characteristics:

Sample 2

Surface water

Turbidity

89% Transmission

pH

7.4

Alkalinity

63 mg/l. as CaCO<sub>3</sub>

Conditions:

Flow rate

1.25 l/min

Power supply

162 W

Losses in equipments

54 W

Net power supply

108 W

Inlet temperature

28°C

Outlet temperature

33°C

Settling time, min	Turbidity or color, percent transmission
0	85
1	86
5	88
10	90
15	91
20	92
30	94
40	95
50	95.5
60	96
90	96
120	96.5

Test No. 13

Raw water

## Characteristics:

Sample 2

Surface water

Turbidity

89 % Transmission

pH

7.4

Alkalinity

63 mg/l. as  $\text{CaCO}_3$ 

Conditions:

Flow rate

1.0 l/min

Power supply

162 W

Losses in equipments

54 W

Net power supply

108 W

Inlet temperature

28 °C

Outlet temperature

33 °C

Settling time, min	Turbidity or color, percent transmission	
	stirrer speed	
	0 rpm	100 rpm, 1 min
0	87.5	87.5
1	90	92.5
2	-	95
5	91.5	97.5
10	92	98
15	93.5	98
20	94.5	98.5
30	95	99
40	95.5	99
60	96.5	99
90	97	99
120	97	99

Test No. 16

Raw water

Characteristic:

Sample 3

Surface water

Turbidity

80% Transmission

pH

7.2

Alkalinity

64 mg/l. as  $\text{CaCO}_3$ 

Conditions:

Flow rate

1.5 l/min

Power supply

294 W

Losses in equipments

54 W

Net power supply

240 W

Inlet temperature

28 °C

Outlet temperature

35 °C

Settling time, min	Turbidity or color, percent transmission
0	81.5
1	84
5	89
10	93.5
15	96.5
20	97.5
30	98.5
40	99
50	99
60	99.5
90	99.5

Test No. 17

Raw water

Characteristics:

Sample 3

Surface water

Turbidity

80% Transmission

pH

7.2

Alkalinity

64 mg/l. as  $\text{CaCO}_3$ 

Conditions:

Flow rate

1.5 l/min

Power supply

162 W

Losses in equipments

54 W

Net power supply

108 W

Inlet temperature

29 °C

Outlet temperature

36 °C

Settling time, min	Turbidity or color, percent transmission
0	82.5
1	87
5	92.5
10	95.5
15	96
20	96.5
30	97
40	97.5
60	98
90	99

Test No. 18

Raw water

Characteristics:

Sample 3

Surface water

Turbidity

80 % Transmission

pH

7.2

Alkalinity

64 mg/l. as  $\text{CaCO}_3$ 

Conditions:

Flow rate

1.5 l/min

Power supply

83 W

Losses in equipments

54 W

Net power supply

29 W

Inlet temperature

29°C

Outlet temperature

34°C

Settling time, min	Turbidity or color, percent transmission
0	82
1	82.5
5	84
10	85.5
15	87.5
20	89
30	91.5
40	93
50	94
60	94.5
90	96



Test No. 19

Raw water

Characteristics:

Samples 4

Surface water

Turbidity

85% Transmission

pH

7.4

Alkalinity

60 mg/l. as  $\text{CaCO}_3$ 

Conditions:

Flow rate

1.5 l/ min

Power supply

162 W

Losses in equipments

54 W

Net power supply

108 W

Inlet temperature

29°C

Outlet temperature

34°C

Stirrer speed, rpm	Turbidity or color, percent transmission						
	Settling time, min						
	0	1	5	10	15	20	30
0	80	84	94	95	96	96.5	97
20	80	89	95.5	96.5	97.5	98	98.5
60	80	86.5	96.5	98	98.5	98.5	99
100	80	82	97.5	98.5	98.5	99	99.5

Test No. 20

Raw water

## Characteristics:

Sample 4

Surface water

Turbidity

85% Transmission

pH

7.4

Alkalinity

54 mg/l. as  $\text{CaCO}_3$ 

Conditions:

Flow rate

1.5 l./min

Power supply

162 W

Losses inequipments

54 W

Net power supply

108 W

Inlet temperature

29 °C

Outlet temperature

36 °C

Stirring time

1 min

Stirrer speed, rpm	Settling time, min				
	Turbidity or color, percent transimssion				
	85	90	92.5	94	95
0	1.00	2.75	3.75	5.35	9.00
20	0.35	1.20	2.00	2.90	3.95
60	0.65	1.35	2.00	2.65	3.25
100	1.00	1.60	2.00	2.45	2.75

Test No. 21

Raw water

Characteristics:

Sample 5	Ground water
Turbidity	82.5% Transmission
pH	6.8
Alkalinity	218 mg/l. as CaCO <sub>3</sub>

Conditions:

Flow rate	1.0 l/min
Power supply	162 W
Losses in equipments	54 W
Net power supply	108 W
Inlet temperature	30 °C
Outlet temperature	36 °C

Settling time, min	Turbidity or color, % transmission
0	73.5
1	76.0
5	94.5
10	97.0
15	97.5
20	98.0
30	98.5
40	98.5
50	98.5
60	98.5
90	99.0

Test No. 22

Raw water

Characteristics:

Sample 5	Ground water
Turbidity	82.5% Transmission
pH	6.8
Alkalinity	128 mg/l. as CaCO <sub>3</sub>

Conditions:

Flow rate	1.7 l./min
Power supply	162 W
Losses in equipments	54 W
Net power supply	108 W
Inlet temperature	30 °C
Outlet temperature	36 °C

Settling time, min	Turbidity or color, % transmission
0	78
1	81
5	91
10	96
15	96.5
20	96.5
30	97
40	97
50	97
60	97.5
90	98

Test No. 23

Raw water

Characteristics:

Sample 5	Ground water
Turbidity	82.5% transmission
pH	6.8
Alkalinity	218 mg/l. as $\text{CaCO}_3$

Conditions:

Flow rate	3.8 l./min
Power supply	126 W
Losses in equipments	54 W
Net power supply	108 W
Inlet temperature	30 °C
Outlet temperature	35 °C

Settling time, min	Turbidity or color, % transmission
0	72.5
1	77.5
5	83
10	89.5
15	91
20	91.5
30	92
40	92.5
50	92.5
60	93
90	93

Test No. 20

Raw water

Characteristics:

Sample 5	Ground water
Turbidity	82.5% Transmission
pH	6.8
Alkalinity	218 mg/l. as $\text{CaCO}_3$

Conditions:

Flow rate	1.5 l./min
Power supply	83 W
Losses in equipments	54 W
Net power supply	29 W

Settling time, min	Turbidity or color, % transmission
0	82
1	88
5	92.5
10	93.5
15	94
20	94.5
30	95
40	95.5
50	96
60	96.5
90	97

Test No. 25

Raw water

## Characteristics:

Sample 5

Ground water

Turbidity

82.5% Transmission

pH

6.8

Alkalinity

218 mg/l. as  $\text{CaCO}_3$ 

Conditions:

Flow rate

1.5 l./min

Power supply

219 W

Losses in equipments

54 W

Net power supply

165 W

Inlet temperature

29°C

Outlet temperature

34°C

Settling time, min	Turbidity or color, % transmission
0	74.5
1	77.5
5	93
10	97.5
15	98
20	98.5
30	98.5
60	98.5
90	98.5

Test No. 26

Raw water

Characteristics:

Sample 5	Ground water
Turbidity	82.5% transmission
pH	6.8
Alkalinity	218 mg/l. as CaCO <sub>3</sub>

Conditions:

Flow rate	1.5 l./min
Power supply	378 W
Losses in equipments	54 W
Net power supply	324 W
Inlet temperature	29 °C
Outlet temperature	35 °C

Settling time, min	Turbidity or color, % transmission
0	74
1	77
5	94
10	97.5
15	98.5
20	98.5
30	98.5
50	99
60	99
90	99



Test No. 27

Raw water

Characteristics:

Sample 5

Ground water

Turbidity

82.5% transmission

pH

6.8

Alkalinity

218 mg/l. as  $\text{CaCO}_3$ 

Conditions:

Flow rate

1.5 l./min

Power supply

162 W

Losses in equipments

54 W

Net power supply

108 W

Inlet temperature

29°C

Outlet temperature

34°C

Settling time, min	Stirrer speed, rpm			
	0	20	60	100
0	70	70	70	70
1	82	85	81	76
3	94	94.5	96.5	97
5	95	96.5	97.5	98
10	96.5	98	98.5	98.5
15	96.5	98.5	98.5	98.5
20	96.5	98.5	99	99
30	97	98.5	99	99

Test No 28

Raw water

Characteristics:

Sample 5	Ground water
Turbidity	82.5% transmission
pH	6.8
Alkalinity	218 mg/l. as CaCO <sub>3</sub>

Conditions:

Flow rate	1.5 l/min
Power supply	162 W
Losses in equipments	54 W
Net power supply	108 W
Inlet temperature	29°C
Outlet temperature	34° C

Stirrer speed, rpm	Settling time, min						
	Turbidity or color, % transmission						
	85	90	91.5	93	94	95	96
0	1.30	2.10	2.30	2.65	3.25	4.50	7.00
20	1.00	1.00	1.70	2.25	2.70	3.10	4.10
60	1.35	1.70	1.90	2.00	2.00	2.30	2.75
100	1.50	1.75	1.90	2.00	2.00	2.10	2.20

Test No. 29

Physical and chemical qualities of sample 3, before and after  
coagulation by electrical means

Conditions:      Flow rate                      1.5 l./min  
                     Power supply                      162 W  
                     Losses in equipments              54 W  
                     Net power supply                      108 W  
                     Inlet temperature                      29°C  
                     Out let temperature                      36°C

Sign No	Parameters	Before coagulation	After coagulation
1	Alkalinity, mg/l. as CaCO <sub>3</sub>	64	51
2	Color, % Transmission	80	99
3	pH	7.2	7.2
4	Total hardness, mg/l.	80	72
5	Total solids, mg/l.	579	531
6	Turbidity, % Transmission	80	99
7	Chloride, mg/l.	28.2	18.7
8	Fluoride, mg/l.	nil	nil
9	Total Iron, mg/l.	0.98	0.09





Test No. 32

Physical and chemical qualities of sample 5, before and after  
coagulation by electrical means

Conditions:	Flow rate	1.0 l./min
	Power supply	162 W
	Losses in equipments	54 W
	Net power supply	108 W
	Inlet temperature	30°C
	Outlet temperature	36°C

Sign No	Parameters	Before coagulation	After coagulation
1	Alkalinity, mg/l. as CaCO <sub>3</sub>	218	153
2	Color, % transmission	82.5	99.0
3	pH	6.8	7.0
4	Total hardness, mg/l.	760	676
5	Total solids, mg/l.	2337	2093
6	Turbidity, % transmission	82.5	99.0
7	Chloride, mg/l.	67	65
8	Fluoride, mg/l.	0.1	0.1
9	Total Iron, mg/l.	0.6	0.04
10	Specific conductivity, millimho	2.87	2.79

Table 2 - Results of Electrical Coagulation

Test no.	Flow rate, l./min	Power supply, W	C, $\text{g}/\text{m}^3$
10-A	0.6	211	3.51
10-B	0.6	211	3.15
11-A	0.8	108	1.35
11-B	0.8	108	1.35
12	1.87	108	0.58
13	3.18	108	0.34
14	1.25	108	0.86
15-A	1.0	108	1.08
15-B	1.0	240	1.08
16	1.5	240	1.08
17	1.5	240	1.60
18	1.5	29	0.19
19	1.5 (0.1 rpm)	108	0.72
19	1.5 (20 rpm)	108	0.72
19	1.5 (60 rpm)	108	0.72
19	1.5 (100 rpm)	108	0.72

Test no.	Flow rate, l./min	Power supply, W	$C_1$ $\text{¥/m}^3$
21	1.0	108	1.08
22	1.7	108	0.63
23	3.8	108	0.28
24	1.5	29	0.19
25	1.5	165	1.10
26	1.5	324	2.16
27	(0 <sup>1.5</sup> rpm)	108	0.72
27	(20 <sup>1.5</sup> rpm)	108	0.72
27	(60 <sup>1.6</sup> rpm)	108	0.72
27	(100 <sup>1.7</sup> rpm)	108	0.72

Remarks:

C - Treatment costs by electrical coagulation



Sample of Calculations:1. Determination of Cost of Alum Coagulation

From Fig. 16.

The optimum  $\text{Al}_2(\text{SO}_4)_3 \cdot 18\text{H}_2\text{O}$  was 30 mg/l., therefore the cost of alum utilized

$$\begin{aligned} &= (30 \text{ mg/l.})(1/1000)(1.380 \text{ ¢ / Kg}) \\ &= 0.041 \text{ ¢ /m}^3 \end{aligned}$$

2. Determination of Cost of Electrical Coagulation

From Test no. 14:

Effluent overflow	= 1.25 l./min
	= 0.075 m <sup>3</sup> /hr
Net Power supply	= 0.108 Kw
Cost of power per Kwhr	= 0.60 ¢
Cost of treatment	= <u>(0.108 Kw) (0.60 ¢ Kwhr)</u>
	(0.075 m <sup>3</sup> /hr)
	= 0.86 ¢/m <sup>3</sup>

3. Correlation of the Equation,  $T = \frac{t}{a+bt} + C$

From the nature of the experimental data it can be seen that the data appear to fall on a hyperbolic curve of the

type  $T = \frac{t}{a+bt} + C$

The curve may be tested empirically by transforming the equation into a straight line. Some point on the plotted curve, preferably a pair of values from the original data  $t_0, T_0$  are selected. These values are substituted into the

equation to obtain  $T_0 = \frac{t_0}{a + bt_0} + C$

$$T = \frac{t}{a + bt} + C$$

Subtracting to obtain

$$\begin{aligned} \frac{t-t_0}{T-T_0} &= \frac{(a+bt)(a+bt_0)}{a} = (a+bt_0) + \frac{b}{a}(a+bt_0)t \\ &= a' + b't \end{aligned}$$

which is a straight line.

Example:

According to the test No. 14 the following results are tabulated

t	T	T-T <sub>0</sub>	$\frac{t - t_0}{T - T_0}$	T <sub>cal</sub>
0	85	-	-	-
1	86	1	1,000	85.8
5	88	3	1,667	88.1
10	90	5	2,000	90.0
15	91	6	2,500	91.4
20	92	7	2,857	92.4
30	94	9	3,333	93.7
40	95	10	4,000	94.6
50	95.5	10.5	4,762	95.2
60	96	11	5,454	95.6
90	96	11	8,182	96.8
120	96.5	11.5	10,435	96.9

Where T = % transmission at time t

t = settling time in minutes

T<sub>cal</sub> = % transmission at time t by calculation

The constants a' and b' in the equation

$$\frac{t - t_0}{T - T_0} = a' + b' t$$

are evaluated by the method

of averages grouping the first five values for  $\frac{t - t_0}{T - T_0}$

along with the corresponding values of  $t$  and the last six values.

$$10.024 = 5a' + 51b'$$

$$36.166 = 6a' + 390b'$$

solving yields  $a' = 1.26$

$$b' = 0.073$$

The constants  $a$ ,  $b$  and  $C$  may be determined by additional computation.

$$(a+bt_0) = a'$$

$$a = a' = 1.260$$

$$\frac{b}{a} (a+bt_0) = b'$$

$$b = b' = 0.073$$

$$T = \frac{t}{1.260 + 0.073t} + C$$

$$\text{at } t = 0, T = 85$$

$$C = 85$$

$$\text{let } T_0 = C$$

$$\text{The final equation is } T = \frac{t}{1.260 + 0.073t} + 85$$

$$\text{Where } \frac{1}{a} = \frac{1}{1.260} = \text{slope at } t = 0$$

$$\text{and } (T_0 + \frac{1}{b}) = 85 + \frac{1}{0.073} = 85 + 13.7 = 98.7$$

= saturation value

## VITA

The writer, Mr. Thamnoon Sittichaimanee, received his Bachelor Degree in Chemical Engineering From Chulalongkorn University in 1970. After graduation he joined the Planning Supply Department, Esso Standard Thailand Co.,Ltd as a professional Industrial Engineer and left in 1971 after when he was admitted to study in the Department of Sanitary Engineering, Graduate School, Chulalongkorn University.