Standard Operating Procedure

Operation of Mahankalchaur Water Treatment Plant

(As of 2023/12/25)

TABLE OF CONTENTS

1. OVERVIEW OF THE FACILITY

1.1 General Information
1.2 Components of the process

2. BIO FILTER AND CAUSTIC SODA FEEDING EQUIPMENT

2.1 Bio Filter Equipment
2.2 Caustic Soda Feeding Equipment

3. FLOCCULATION AND SEDIMENTATION EQUIPMENT, PAC FEEDING EQUIPMENT, SLAKED LIME FEEDING EQUIPMENT

3.1 Flocculation and Sedimentation Equipment
3.2 PAC Feeding Equipment
3.2.1 General
3.2.2 Process of PAC Solution Preparation and Transfer
3.2.3 Process of Deciding Dosage (Feeding Rate)
3.2.4 PAC Dosing (Feeding) Pump Setting
3.2.5 Floc Formation
3.3 Lime Feeding Equipment
3.3.1 General
3.3.2 Process of Lime Solution Preparation
3.3.3 Process of Deciding Dosage
3.3.4 Dosing Rate Calculation
3.3.5 Lime Dosing Pump Setting

4. RAPID SAND FILTRATION EQUIPMENT

4.1 General
4.2 Operation

5. CLEAR-WATER RESERVOIR AND WATER TRANSMISSION PUMP EQUIPMENT

6. SLUDGE AND DRAINAGE EQUIPMENT

7. CHLORINE FEEDING EQUIPMENT

7.1 Sodium Hypochlorite Generation and Feeding Equipment
7.2 Bleaching Powder Feeding Equipment
7.2.1 General
7.2.2 Outline of Overall Process
7.2.3 Process of Preparing Bleaching Powder Solution
7.2.4 Transferring the Bleaching Powder Solution to Storage Tanks
7.2.5 Dosing (Feeding) the Bleaching Powder Solution to Water
7.2.6 Cleaning Tanks and Pipes
7.2.7 Dosing pump selection

1. Overview of the Facility

1.1 General Information

(1) Facility Name: Water Treatment Plant of the Mahankalchaur Branch

(2) Facility type: Surface and Ground water treatment plant

(3) Establishment: 1994

(4) Water Source: Surface water from Sundarijal (Bagmati river) and ground water from several wells (GK-1, GK-2 & GK-3) in the vicinity of the treatment plant area.

(5) Capacity: 25 MLD (Design)
20.1 MLD (Actual)

(6) Access: 1 km (3 mins drive) from Chabahil, Ring Road

(7) Objective: Removal of turbidity, organic matter, ammonia, bacteria, and other harmful matter

1.2 Components of the process

There are seven (7) unit process in Mahankalchaur WTP as outlined below:

(1) Bio-filter process and caustic soda feeding equipment

(2) Flocculation and sedimentation basin, PAC and slaked lime feeding equipment

(3) Rapid sand filter (RSF)

(4) Clear water reservoir (CWR) and transmission pump equipment

(5) Sludge and drainage equipment

(6) Sodium hypochlorite generator and feeding, bleaching powder feeding equipment

(7) Water quality testing laboratory

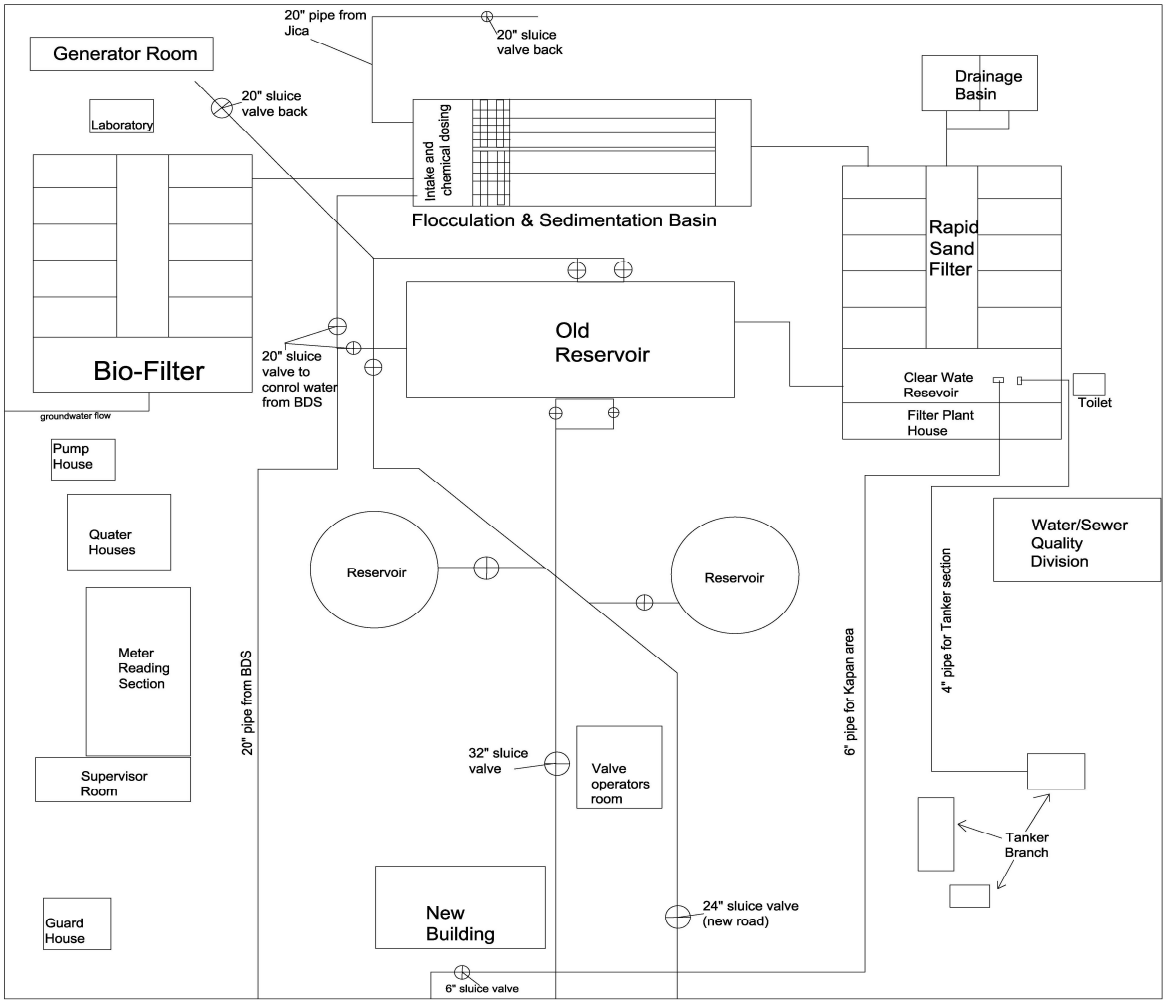


Figure 1: Outline map of Mahankalchaur water treatment plant

(BDS: Bulk Distribution System)

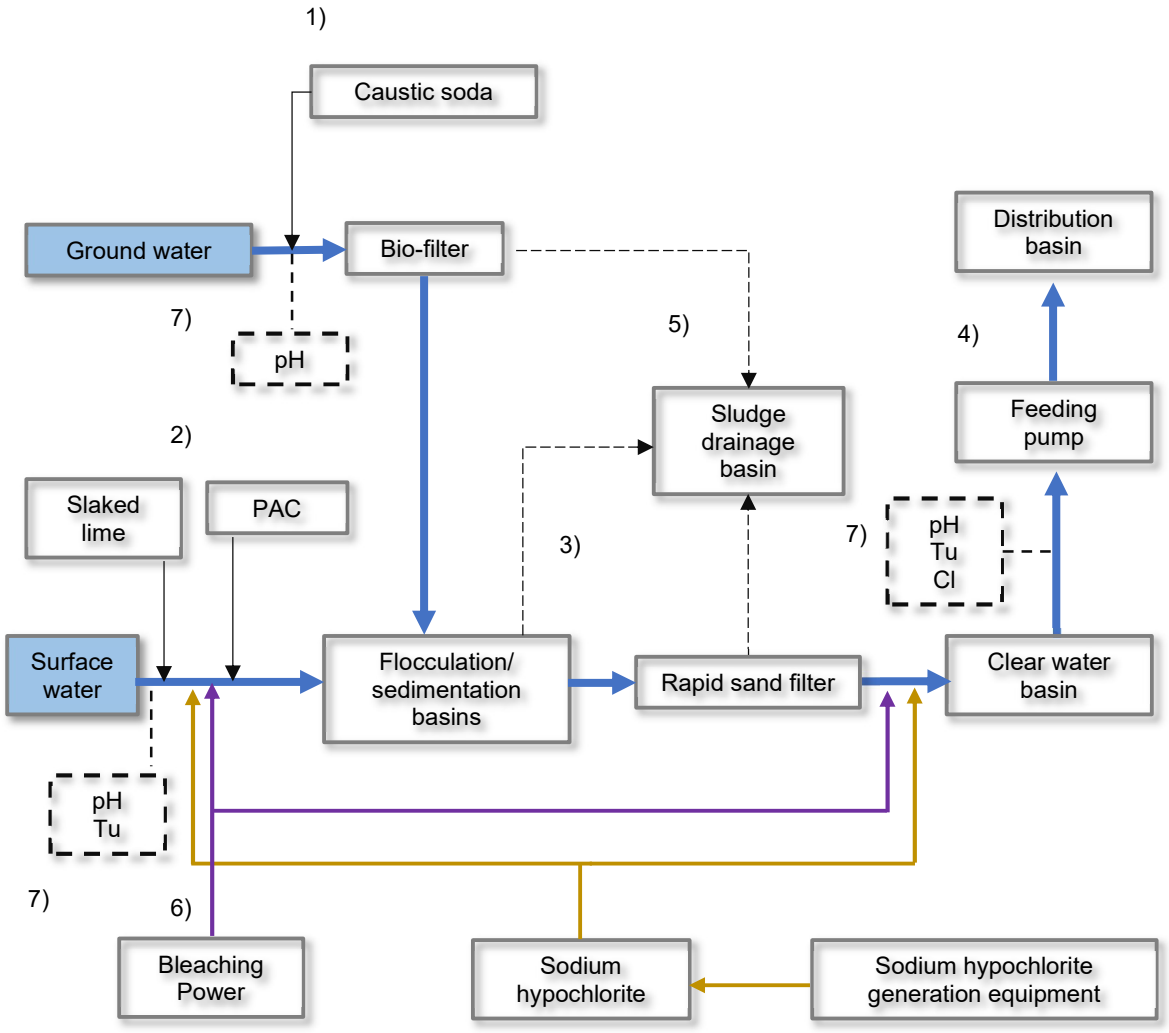


Figure 2: Schematics of Chemical System in Mahankalchaur WTP

Prior to the understanding of operation and maintenance of individual process, it is important to keep daily record of total inflow of water into the system.

(1) Surface water inflow: Measure water depth from the gauge, find out corresponding flow rate and record it.

(2) Groundwater inflow: Record individual pump's inflow rate.

2. Bio filter and Caustic Soda Feeding Equipment

2.1 Bio Filter Equipment

This equipment is not in use.

Purpose: To remove ammonia from the ground water by using nitrification action of aerobic microorganisms.

Mechanism: Filter media is filled into the bio-filter tank for proper propagation of the microorganism. Air blowers provide air under pressure for diffusion of oxygen. Ammonia is nitrified (converted to nitrite and nitrate) by microorganism and removed from water.

Equipment Outline:

Equipment	Type	Size	No of units
Receiving well	Reinforced Cement Concrete	Front well 1.8 m x 2.45 m x approx.5.7 m 2.1 m x 4 m x approx. 5.7 m Rear well 2.1 m x 1.9 m x approx. 5.7 m Capacity: 95.76 m^3 Detention period: 7.2 minutes Incidental equipment: Air diffuser: 1 set Overflow weir: 2.1 m (width) x 0.5 m (length), 1 unit (synthetic lumber)	1 basin
Bio-filter tank	Reinforced Cement Concrete	Filter basin size: 2.46 m (w) x 6.46 m (l) Filter Area: 15.9 m^2/basin Filter medium: Artificial, light, pelleted filter media (pellet dia: 5 – 15 mm, layer depth: 1.3 m) Supporting layer: Gravel (size=10– 30 mm, layer depth 0.2 m) Underdrain: Leopold block (automatically washable), combined type for water and air Washing: Backwashing rate: 1 m^3/m^2/min Backwashing period: 8 min Air washing rate: 0.8 m^3/m^2/min Air washing period: 6 min	10 basins
Make-up water and make up pumps	Submersible pump	Capacity: ϕ 250 x 7 m^3/min x 5.5 m Motor: 200V x 50 Hz x 11 kW	2 pumps

Equipment	Type	Size	No of units
Make up water tanks		2.5 m (w) x 17.5 m (l) x3.5 m (effective water depth) Capacity: V_2 = 2.5 x 16.5 x 3.5 = 144.4 m^3 During normal filtration, a part of the treated water shall be stored in the make-up tanks	
Air blower	Roots blower	Capacity: ϕ 125 x 14.8 m^3/min x 0.6 kg/cm^2 Motor: 400 V x 50 Hz x 30 kW	4 pumps (3 working + 1 spare)

Valves and Air blower Operation

	During filtration	During backwashing	During inspection of the basin
Raw water inflow valve (V1)	Open	Closed	Closed
Water discharge gate (G1)	Closed	Open	Open
Clear water gate (G2)	Open	Open	Closed
Drainage valve (V2)	Closed	Closed	Open
Air supply valve (V3)	Open	Open	Closed
Back washing valve (V4) (air washing)	Closed	Open	Closed
Air blower	Operate 2 units	Operate 3 units	-
Makeup pumps	-	Operate 1 unit	-

Figure 3: Water inflow and drainage valves

Figure 4: Air valve, backwash and water discharge valves

Figure 5: Air blower room

Stopping operation

Close the raw water inflow valve of the respective basin → Close the clear water gate → Close the air supply valve

Operation for draw-off

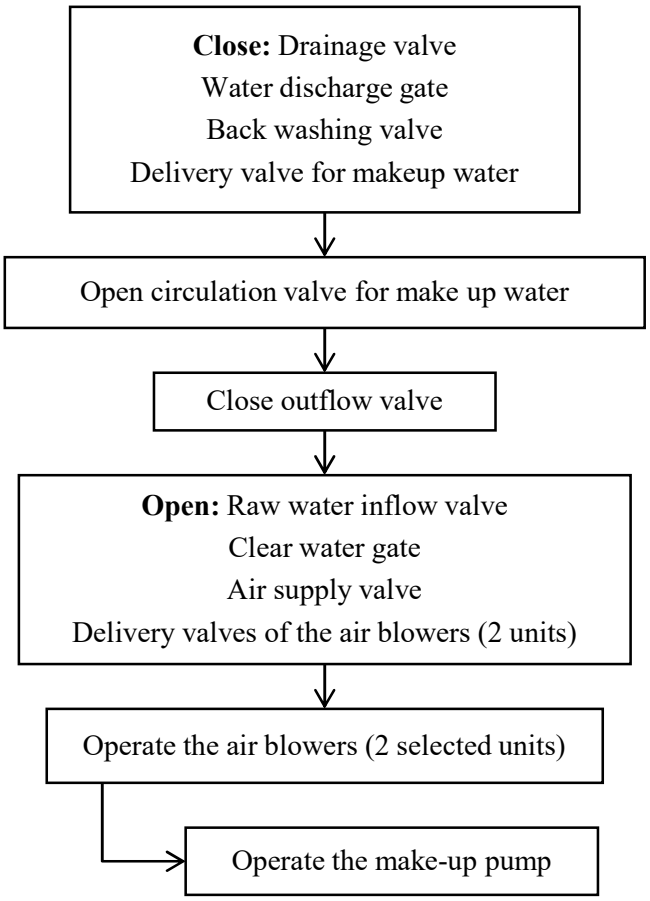
Close the raw water inflow valve → Close the clear water gate → Close the air supply valve → Open the water discharge valve → Open the drainage valve

Draw off	
For receiving well	*For raw water conduit*
Stop inflow of well water → Open the drainage valve of the receiving well	Stop inflow of well water → Open the drainage valve of the raw water conduit

For draw-off of the clear water and outflow conduit

Stop inflow of well water → Stop bio filter basins (all 10) → Close outflow valves → Open drainage valve of the clear water conduit → Open drainage valve of the outflow conduit

Circulation Operation



2.2 Caustic Soda Feeding Equipment

This equipment is not in use.

Purpose: To adjust pH value for the bio-filter tank using caustic soda.

Feeding mechanism: The caustic soda is first dissolved in the dissolution tank, then fed by the transmission pump to the storage tank from where fixed quantities are fed by the feeding equipment at suitable intervals. The caustic soda is fed as a 20% solution from lumps of sodium hydroxide with an NaOH content of 95% -98%. The feeding point is at the inflow of bio-filter tank.

The dosing rate should be based on actual inflow conditions to maintain pH of 7-8.

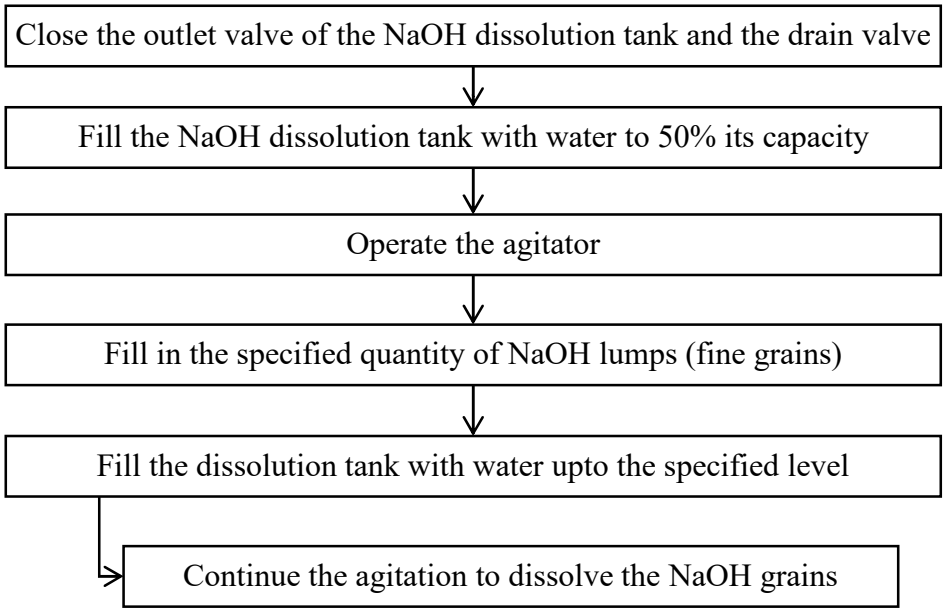
Equipment List

Item	Type	Size/Details	No. of units
Dissolution tanks	Open vertical cylindrical (heat resistant polyethylene)	ϕ approx. 900mm x height 880 mm Capacity: 0.5 m^3 (500 L) Accessories (per tank) Fittings: 1 set; Agitator stand: 1 stand	2 tanks
Agitators	Reciprocal rotary agitator	196 cpm Motor: 0.75 kW x 400 V x 50 Hz	2 units
Transmission pumps	Magnet pump	25 A x 30 L/min x 10m Motor: 0.4 kW x 400 V x 50 Hz	2 units
Caustic soda storage tanks	Closed vertical cylindrical tank (polyethylene)	ϕ approx. 1065 mm x height 1265 mm Capacity: 1 m^3 (1000L) Accessories Fittings: 1 set; Direct-reading liquid level gauge: 1 unit; Manhole: 1 location; Air vent: 1 location; Agitator: 1 set	2 units
Feeding equipment	Diaphragm pump	Capacity a. 15A x 0.9l/min x 3 kg/cm^2 x 1 unit b. 15A x 1.8 l/min x 3 kg/cm^2 x 2 units Motor: 0.2 kW x 400V x 50 Hz Accessories Back pressure valve: 1 piece. Safety valve: 3 pieces; Air chamber: 1 unit; Pressure gauge: 3 pieces	3 units (pump a. supplied as spare)
Piping and valves		Pipes, valves, hard polyvinyl tubes for city water, ball valves, diaphragm valves Bore: 50-15 A	1 set
Instrument panel		MM-2	

Figure 6: Caustic soda storage and feeding room

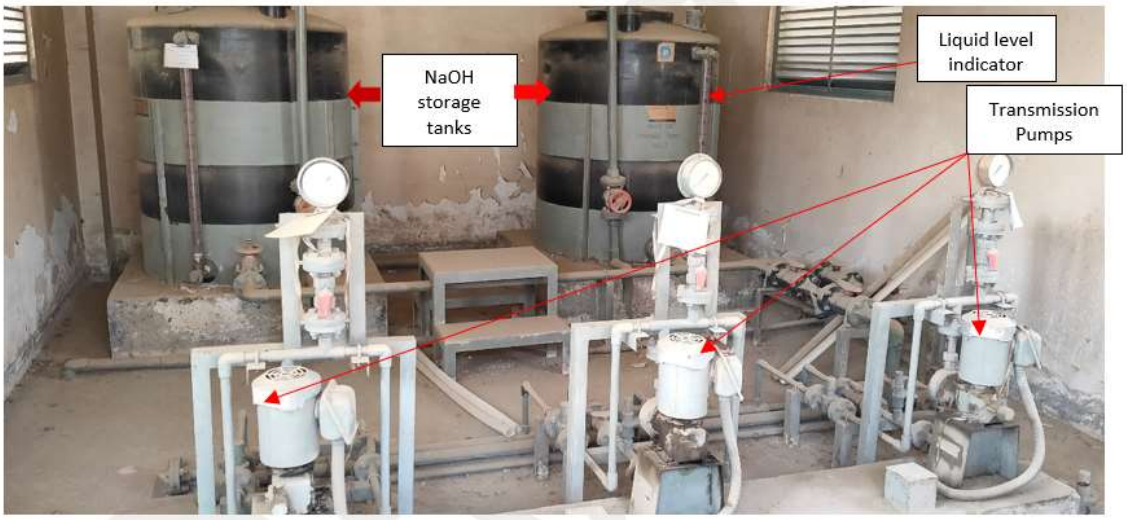
Operation of Caustic Soda Feeding Equipment

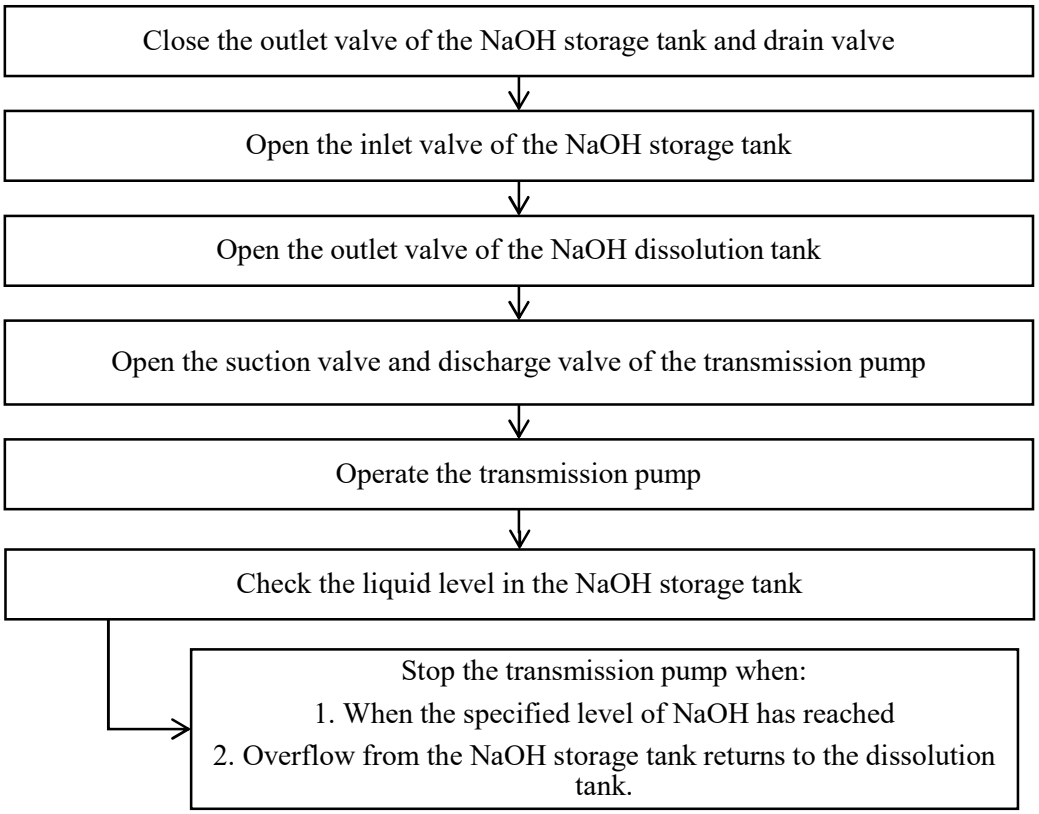
Lumps of NaOH are dissolved to produce a NaOH solution with a concentration of 20%.



Feeding of the NaOH solution

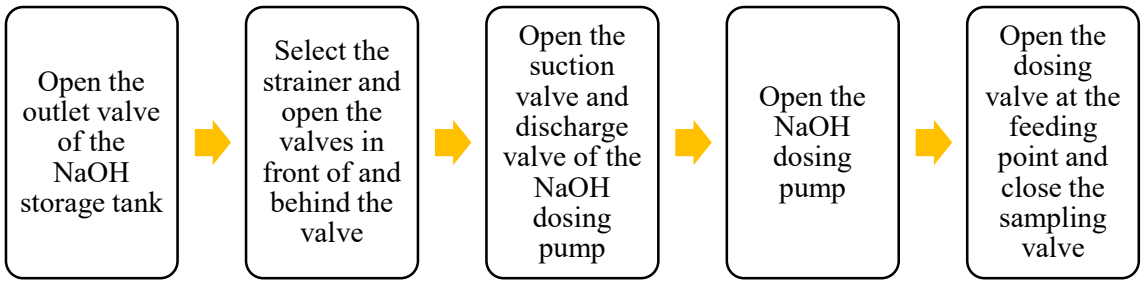
The generated NaOH solution with an NaOH concentration of 20% is fed to the NaOH tank by the transmission pump.





NaOH Feeding

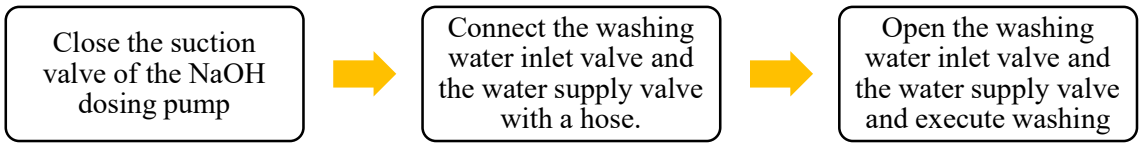
The specified quantity is fed by the NaOH dosing pump at the feeding point.



(For feed confirmation and for checking the dosage, close the dosing valve and open the sampling valve)

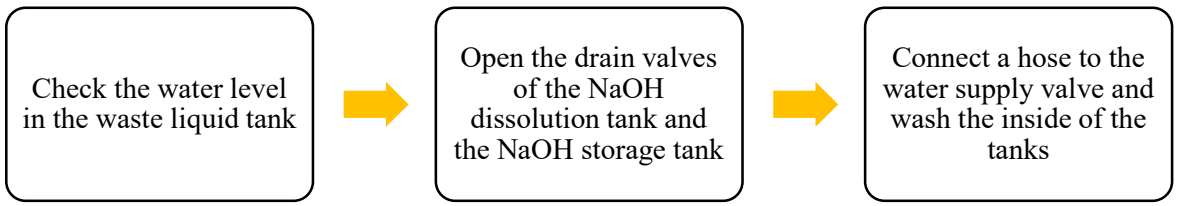
Washing of dosing pump and feed pipe

When feeding is to be stopped for a long time, wash the dosing pump and the feed pipe.



Washing of NaOH dissolution tank and NaOH storage tank

When feeding is to be stopped for a long time, wash the NaOH dissolution tank and the NaOH storage tank.



3. Flocculation and Sedimentation Equipment, PAC feeding equipment, Slaked lime feeding equipment

3.1 Flocculation and Sedimentation Equipment

Purpose: This equipment is used for flocculation and sedimentation of the water in the bio filter of the preceding stage and the surface water.

Mechanism: Flocculation agent and alkali are fed into the raw water flowing in from the receiving well in order to effect rapid mixing.

The gates at the distribution weir shall be opened and closed in order to change the number of basins according to fluctuations in the quantity of the treated water.

Figure 7: Valves and gates to regulate groundwater and surface water

Equipment Outline

Item	Type	Size/Details	No. of units
Receiving well	RCC	2.5 m (w) x 1.8 m (l) x 3.7 m (approx. water depth)	1well
Mixing well	RCC	2.5 m (w) x 2.0 m (l) x 3.7 m (approx. water depth) Effective capacity: 18.5 m^3 Incidental equipment: 1 overflow weir	1 well
Flocculation basin	Horizontal and vertical baffling type	Basin A: 6.0 m (w) x length 7.5 m(l) x water depth approx. 3.1 – 2.8 m	5 basins Basin A x 2,

Item	Type	Size/Details	No. of units
		Basin B: 4.6 m (w) x 9.0 m (l) x water depth approx. 3.1 – 2.8 m Capacity: Basin A: V_A= 6.0 x 7.5 x (3.1 +2.8) x ½ =132.8 m^3 Basin B: V_B= 4.6 x 7.5 x (3.1+ 2.8) x ½ =88.5 m^3 Incidental equipment: 1 set of weir plates Synthetic lumber (FFU) Retention period = 25 to 40 minutes	Basin B x 3
Sedimentation Bain	Horizontal flow type	Basin A: 7.0 m (w) x 43.8 m (l) x water depth approx. 2.8 m Basin B: 4.6 m (w) x 43.8 m (l) x water depth approx. 2.8 m Surface area: Basin A: S_A = 7.0 m x 43.8 m = 306.6 m^2 Basin B: S_b = 4.6 m x 43.8 m = 201.4 m^2 Surface load rate=15-30 mm/min Cross section area: Basin A: S=7.0 m x 2.8 m = 19.6 m^2 Basin B: S= 4.6 m x 2.8 m = 12.88 m^2 Trough: Dimensions: 3.0 m (w) x 2.3 m (l) x 0.3 m (d) Quantity: Basin A x 3 trough, Basin B x 2 trough	5 basins (Basin A x 2, Basin B x 3)

Operation of the Flocculation and Sedimentation Equipment

The treated water quantity differs each month because of the limitation of the biologically treated water (March-June), thus A and B type basins are used in combination.

Figure 8: Flocculation basin

Figure 9: Flocculation and sedimentation basins

Attention: To prevent mixing of ground and surface water, attention should be paid to opening and closing of the conduit gate.

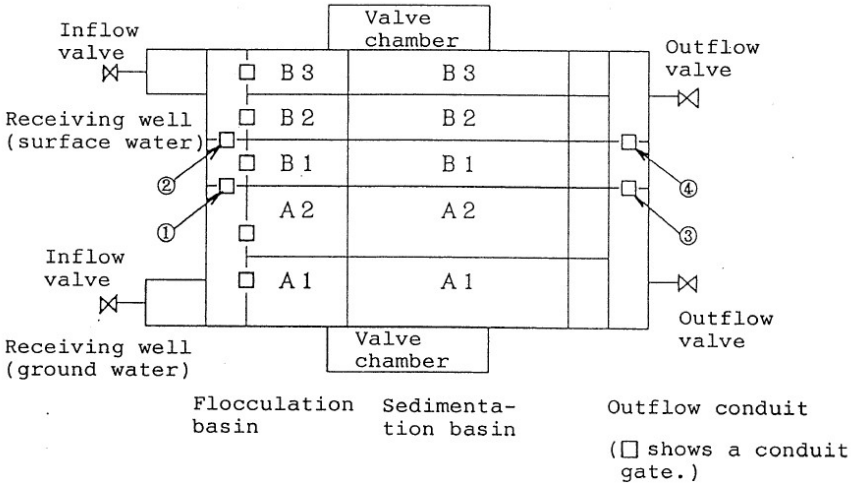


Figure 10: Illustration of the flocculation and sedimentation basin

Sedimentation Basin

Sedimentation basins allow suspended particles as called floc to settle out of water as it flows slowly through the tank. A layer of accumulated solids, called sludge, forms at the bottom of the tanks, and is periodically removed.

To confirm the proper function of sedimentation basins, the followings shall be carried regularly.

a. Check floc formation at inflow of Sedimentation Basin

b. Check floc outflow from Sedimentation Basin (Tough)

c. Sludge removal by sludge valves

d. Check sludge accumulation at the bottom.

Floc Formation

Floc formation at inflow of Sedimentation Basin 3-4 times in a day.

- Morning before chemical dosing adjustment
- 30-40 minutes after of chemical dosing adjustment
- 3-4 hours after in afternoon
- Second time in the afternoon, if possible
-

Jar Test

Floc formation
Floc formation shall be confirmed at inflow of Sedimentation Basin.

Sludge removal Floc Outflow
Floc outflow from Sedimentation Basin (Tough) at the same time when check floc formation.

Inlet of Sedimentation Basin

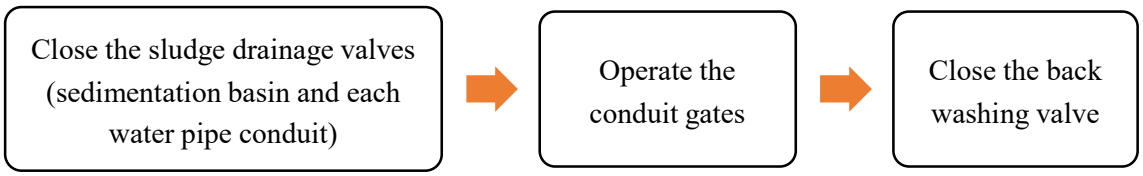
Outlet of Sedimentation Basin

Sludge accumulation at the bottom
Floc outflow from Sedimentation Basin (Tough) at the same time when check floc formation.

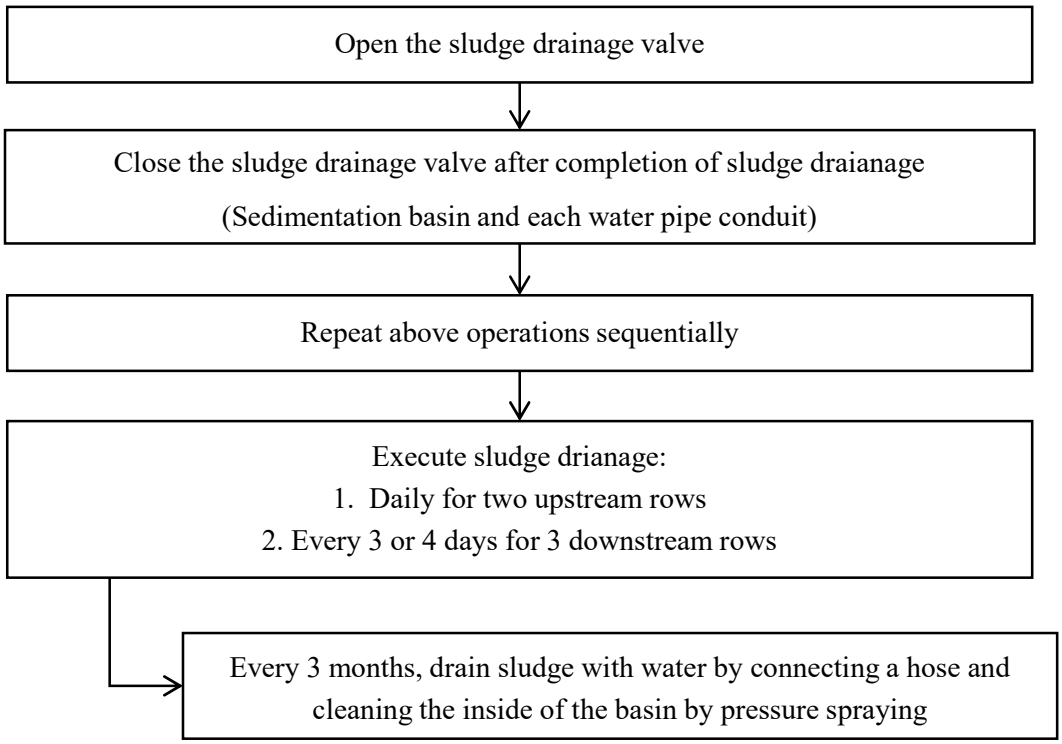
In order to minimize the settled sludge, sludge valves shall be operated.

The valves shall be open and kept for 30 seconds, then close.

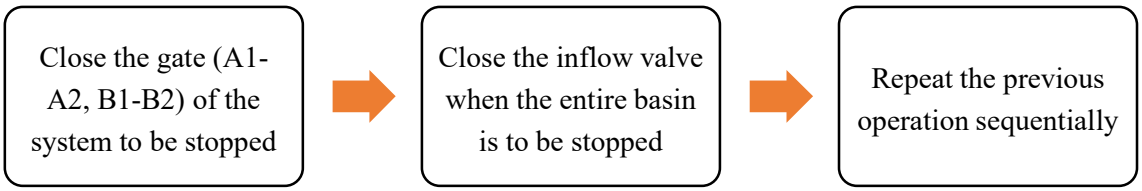
Operation Procedures



Sludge Drain operation

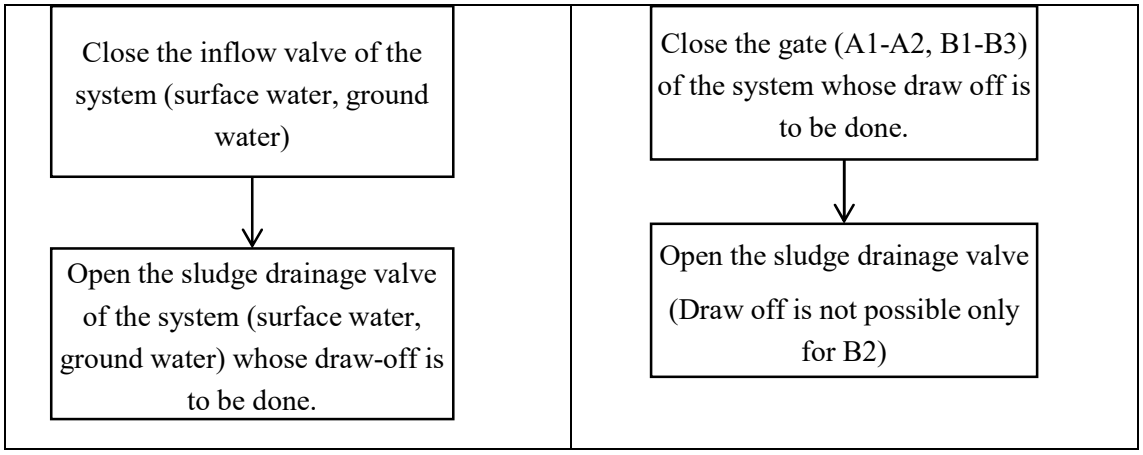


Stop operation



Draw off operation

In case of receiving well	In case of flocculation and drainage basins



Time for sludge drainage

- Sludge drainage time differs according to the inflowing sludge.
- Decide the sludge drainage time according to the time required for change of turbidity of sludge water flowing into the sludge basin. i.e., if the sludge flowing into the sludge basin becomes clear stop the drainage.
- Sludge drainage time will be about 1 minute.

3.2 PAC Feeding Equipment

3.2.1 General

The following section briefly outlines the equipment specifications and main procedures.

Purpose: To dissolve PAC powder which is the coagulant for the flocculation and sedimentation process, and feed to the influent water properly.

Feeding mechanism: PAC powder is dissolved in the dissolution tank to the specified concentration and is pumped by the transmission pump to the storage tank for storage at fixed quantities at suitable intervals.

Equipment Outline

Item	Type	Size/Details	No. of units
Dissolution tank	Open vertical cylindrical tank (polyethylene)	ϕ 900 mm approx. x 1010 mm (h) Capacity: 0.5 m^3 Accessories: Fittings: 1 set Agitator: 1 stand	2 tanks
Agitator	Reciprocating rotary agitator	Reciprocating cycles: 196 rpm Motor: 0.75 kW x 400 V x 50 Hz	2 units
Transmission pumps	Magnet pump	Capacity: 40 A x 30 L/min x 10 m Motor: 0.4 kW x 400V x 50 Hz	2 motors
PAC storage tanks	Closed vertical cylindrical tank (polyethylene)	ϕ 1065 mm approx. x 1265 mm (h) Capacity: 1 m^3 Accessories: Fittings: 1 set Direct sight level gauge: 1 gauge Manhole: 1 location Air vent: 1 location	2 tanks
Feeding equipment	Diaphragm pump	Capacity: a. 15 A x 0.1 L/min x 3 kg/cm^2 b. 15 A x 0.5 L/min x 3 kg/cm^2	4 units (2 units x 2)

Item	Type	Size/Details	No. of units
		Motor: 0.2 kW x 400 V x 50 Hz Accessories: Back pressure valve: 2 units Safety valve: 4 units Air chamber: 2 units Pressure gauge: 4 units	
Piping and valves		Pipes, valves, hard polyvinyl pipes for city water; ball valves, diaphragm valves Diameter: 50 – 15 A	1 set
Instrument panel		MM-3	

Figure 11: PAC dissolution tanks

Figure 12: PAC solution shifting (transferring) pumps

Figure 13: PAC solution storage tanks

Figure 14: PAC feeding equipment

3.2.2 Process of PAC Solution Preparation and Transfer

PAC solution is prepared in such a way that the solution will contain 20% concentration of PAC.

a. Prepare PAC solution containing 20% concentration of PAC as shown below.

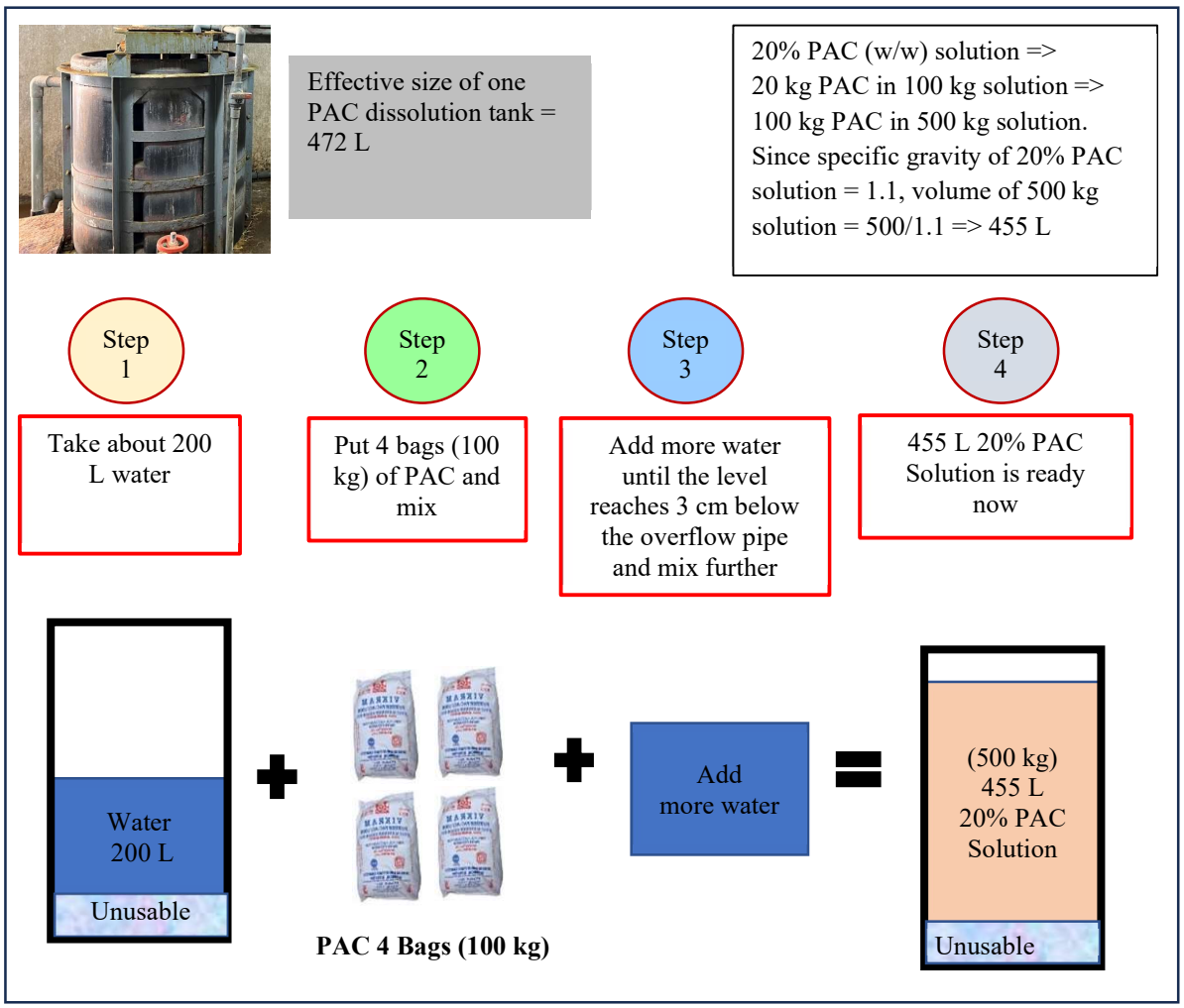


Figure 15: Schematics of 20% concentration PAC solution preparation

Operation procedure

1. Close the outlet valve and the drainage valve of the PAC dissolution tank (LWL)
2. Fill about 50% (200 L) of the tank with water
3. Add 4 bags (100 kg) of PAC
4. Operate the agitator

⇩

5. Add more water until the level reaches about 3 cm below the overflow pipe, continue agitating for about 2-3 hours

b. Transfer PAC solution to PAC storage tanks

Operation procedure

1. Close the outlet valve and the drainage valve of the PAC storage tank

⇩

2. Open the inlet valve of the PAC storage tank

⇩

3. Open the outlet valve of the PAC dissolution tank

⇩

4. Open the suction valve of the transmission pump

⇩

5. Open the delivery valve of the transmission pump

⇩

6. Operate the transmission pump

⇩

7. Check the liquid level of the PAC storage tank and stop the transmission pump if:
Specified level has reached, or
PAC storage tank overflows and the overflow returns to the PAC dissolution tank

3.2.3 Process of Deciding Dosage (Feeding Rate)

PAC dosage (feeding rate) shall be decided in the following manner.

Procedure of deciding PAC dosage (feeding rate)

1. Flow measurement (m^3/day or m^3/hr) (by WTP Engineer)
(Automatic measurement record can be taken when this system is installed and ready)

⇩

2. Find out the required PAC dosing rate by Jar Test (by Central Lab)

⇩

3. Calculate PAC dosage (feeding rate)/ PAC pump setting (by WTP Engineer)

⇩

4. Adjust PAC pump setting (by WTP operator)

⇩

5. Check Floc formation (by Central Lab/WTP)

Calculation

Item	Description
Flow	1,050 m^3/h => 1.05 $\times 10^6$ L/h
PAC Solution	PAC 20% (Al_2O_3 5.6%) => s.g. ≅ 1.1 => 20 kg PAC in 100 kg solution = 100/1.1 = 90.9 L solution => 90.9 L in 20 kg => 220,000 mg/L
Dosing Rate by the Jar Test	10 mg/L as PAC (as an example)
Required PAC dosage	10 mg/L x 1.05 $\times 10^6$ L/h = 10.5 $\times 10^6$ mg/h
Required PAC Solution Feeding Rate	$= \frac{10.5 \times 10^6 \text{ mg/h}}{220{,}000 \text{ mg/L}}$ = 48 L/h (Less than 60 L/h maximum feeding capacity of the pump; OK)
Simplified formula to calculate dosage for PAC 20% solution	$= \frac{1050 \text{ m}^3/\text{h} \times 10 \text{ mg/L}}{220} = 48$ L/h

Estimate from Chart

- Find the PAC dosing rate (mg/L PAC) on the X-axis
- Go up to meet the raw water inflow rate
- Go left to meet the Y-axis

This value on Y-axis is the PAC dosage (feeding rate) for 20% PAC solution.

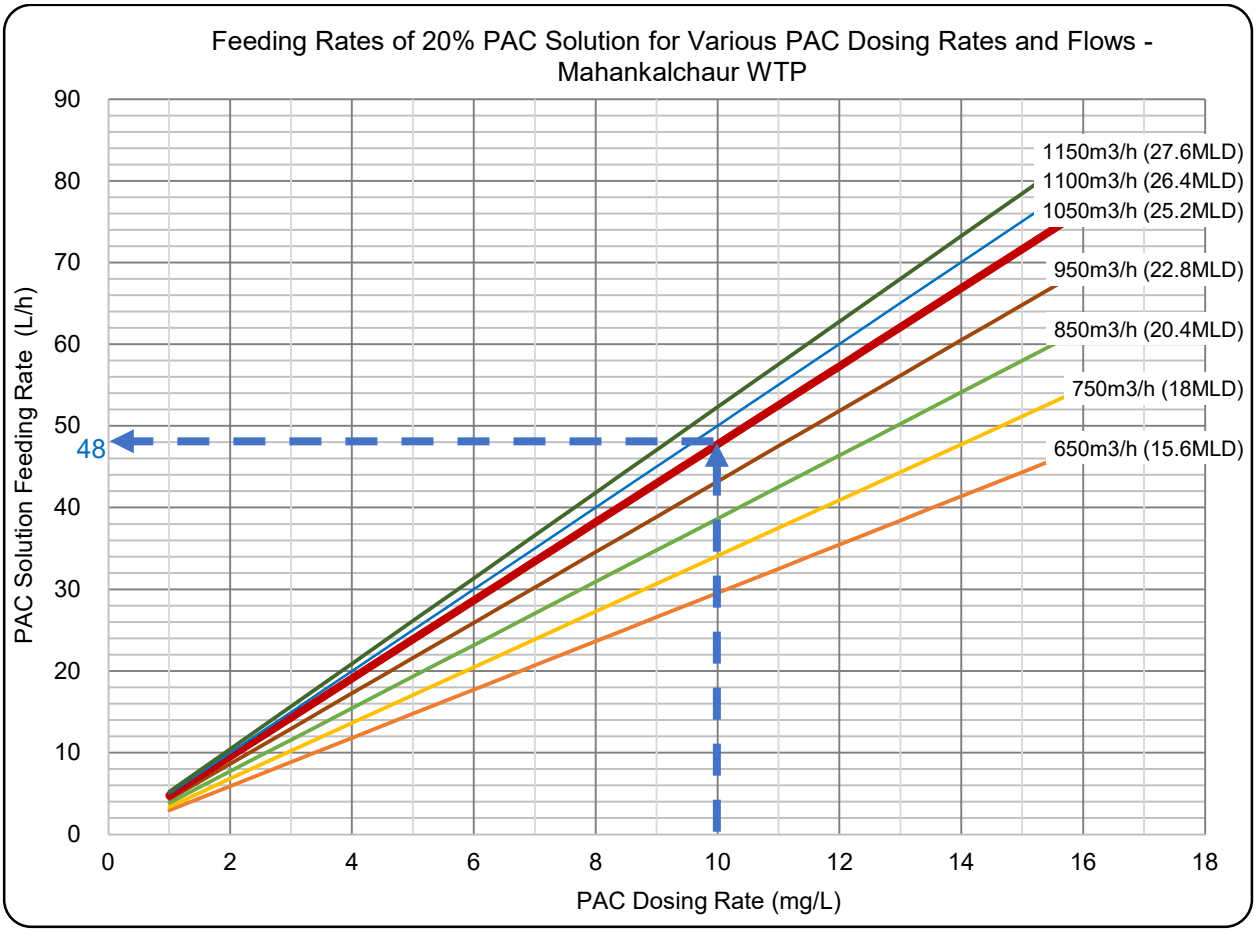


Figure 16: Chart of 20% concentration PAC solution dosages (feeding rates)

Estimate from Table

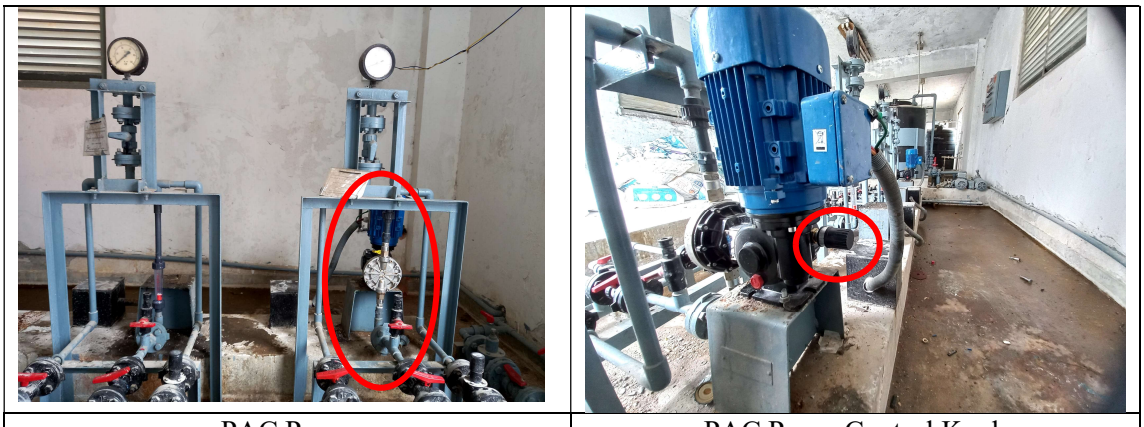
- Find the PAC dosing rate (mg/L PAC) on the first column
- Go right to meet the raw water inflow rate
- The value in that cell is the PAC dosage (feeding rate).

Table 1: Feeding rates of 20% concentration PAC solution for various flows and dosing rates

		PAC Solution Feeding Rates (L/h)											
Dosing Rate (mg/L)	Daily Volume of Solution for 1050 m³/h Flow (L/day)	600 m3/h (14.4MLD)	650 m3/h (15.6MLD)	700 m3/h (16.8MLD)	750 m3/h (18MLD)	800 m3/h (19.2MLD)	850 m3/h (20.4MLD)	900 m3/h (21.6MLD)	950 m3/h (22.8MLD)	1000 m3/h (24MLD)	1050 m3/h (25.2MLD)	1100 m3/h (26.4MLD)	1150 m3/h (27.6MLD)
1	120	3	3	3	3	4	4	4	4	5	5	5	5
2	240	5	6	6	7	7	8	8	9	9	10	10	10
3	336	8	9	10	10	11	12	12	13	14	14	15	16
4	456	11	12	13	14	15	15	16	17	18	19	20	21
5	576	14	15	16	17	18	19	20	22	23	24	25	26
6	696	16	18	19	20	22	23	25	26	27	29	30	31

		PAC Solution Feeding Rates (L/h)											
Dosing Rate (mg/L)	Daily Volume of Solution for 1050 m^3/h Flow (L/day)	600 m3/h (14.4MLD)	650 m3/h (15.6MLD)	700 m3/h (16.8MLD)	750 m3/h (18MLD)	800 m3/h (19.2MLD)	850 m3/h (20.4MLD)	900 m3/h (21.6MLD)	950 m3/h (22.8MLD)	1000 m3/h (24MLD)	1050 m3/h (25.2MLD)	1100 m3/h (26.4MLD)	1150 m3/h (27.6MLD)
7	792	19	21	22	24	25	27	29	30	32	33	35	37
8	912	22	24	25	27	29	31	33	35	36	38	40	42
9	1,032	25	27	29	31	33	35	37	39	41	43	45	47
10	1,152	27	30	32	34	36	39	41	43	46	48	50	52
11	1,272	30	33	35	38	40	43	45	48	50	53	55	58
12	1,368	33	35	38	41	44	46	49	52	55	57	60	63
13	1,488	35	38	41	44	47	50	53	56	59	62	65	68
14	1,608	38	41	45	48	51	54	57	61	64	67	70	73
15	1,728	41	44	48	51	55	58	61	65	68	72	75	78
16	1,824	44	47	51	55	58	62	66	69	73	76	80	84
17	1,944	46	50	54	58	62	66	70	73	77	81	85	89
18	2,064	49	53	57	61	66	70	74	78	82	86	90	94
19	2,184	52	56	61	65	69	73	78	82	86	91	95	99
20	2,304	55	59	64	68	73	77	82	86	91	96	100	105
21	2,400	57	62	67	72	76	81	86	91	96	100	105	110
22	2,520	60	65	70	75	80	85	90	95	100	105	110	115
23	2,640	63	68	73	78	84	89	94	99	105	110	115	120
24	2,760	66	71	76	82	87	93	98	104	109	115	120	126
25	2,856	68	74	80	85	91	97	102	108	114	119	125	131
26	2,976	71	77	83	89	95	101	106	112	118	124	130	136
27	3,096	74	80	86	92	98	104	111	117	123	129	135	141
28	3,216	76	83	89	96	102	108	115	121	127	134	140	147
29	3,336	79	86	92	99	106	112	119	125	132	139	145	152
30	3,432	82	89	96	102	109	116	123	130	137	143	150	157

3.2.4 PAC Dosing (Feeding) Pump Setting



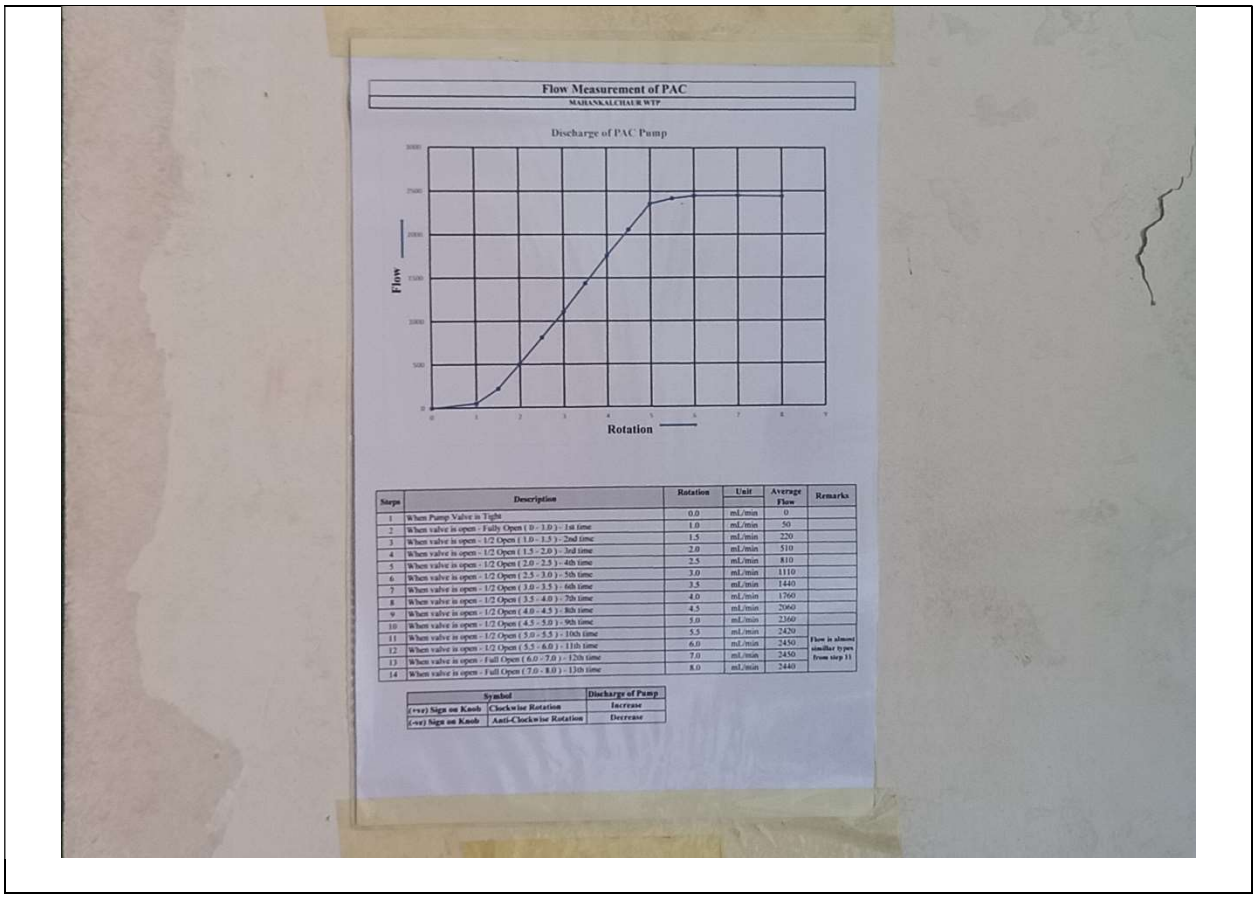
PAC Pump | PAC Pump Control Knob

Photo 1: PAC dosing pump setting methods

- Refer to the pump 'Rotation' versus 'Flow' chart given below

- Locate the Flow on the Y-axis
- Go to right to meet the line
- Go down to meet the X-axis. This gives the number of rotation required
- Set the pump rotation to this value.

For example, for 48 L/h, the required number of rotation is about 2.6.



Steps	Description	Rotation	Unit	Average Flow	Remarks
1	When Pump Valve is Tight	0.0	mL/min	0	
2	When valve is open - Fully Open (0 - 1.0) - 1st time	1.0	mL/min	50	
3	When valve is open - 1/2 Open (1.0 - 1.5) - 2nd time	1.5	mL/min	220	
4	When valve is open - 1/2 Open (1.5 - 2.0) - 3rd time	2.0	mL/min	510	
5	When valve is open - 1/2 Open (2.0 - 2.5) - 4th time	2.5	mL/min	810	
6	When valve is open - 1/2 Open (2.5 - 3.0) - 5th time	3.0	mL/min	1110	
7	When valve is open - 1/2 Open (3.0 - 3.5) - 6th time	3.5	mL/min	1440	
8	When valve is open - 1/2 Open (3.5 - 4.0) - 7th time	4.0	mL/min	1760	
9	When valve is open - 1/2 Open (4.0 - 4.5) - 8th time	4.5	mL/min	2060	
10	When valve is open - 1/2 Open (4.5 - 5.0) - 9th time	5.0	mL/min	2360	
11	When valve is open - 1/2 Open (5.0 - 5.5) - 10th time	5.5	mL/min	2420	
12	When valve is open - 1/2 Open (5.5 - 6.0) - 11th time	6.0	mL/min	2450	Flow is almost similar types from step 11
13	When valve is open - Full Open (6.0 - 7.0) - 12th time	7.0	mL/min	2450	
14	When valve is open - Full Open (7.0 - 8.0) - 13th time	8.0	mL/min	2440	

Symbol		Discharge of Pump
(+ve) Sign on Knob	Clockwise Rotation	Increase
(-ve) Sign on Knob	Anti-Clockwise Rotation	Decrease

Photo 2: PAC solution flow adjusting dial graph on chemical building wall

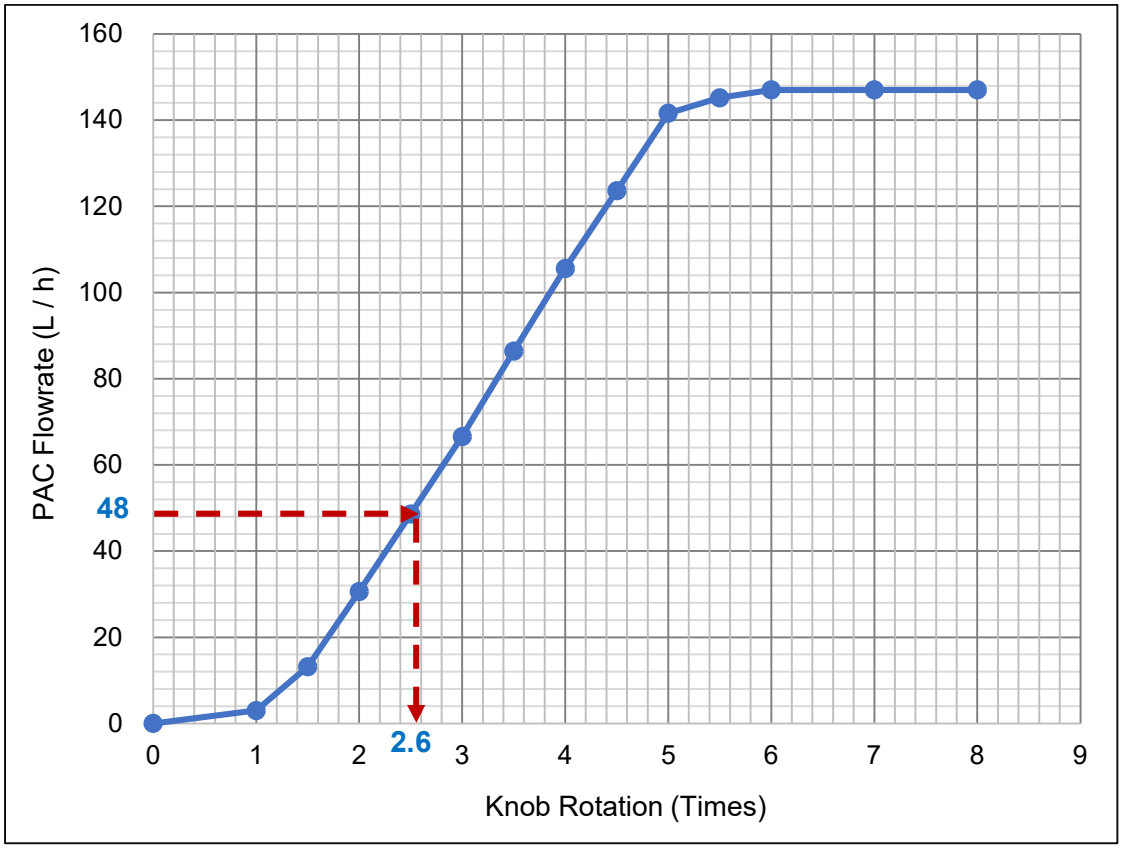


Figure 17: PAC solution flow adjusting dial graph

(Showing example of 48 L/h flow and required number of rotation to achieve that flow)

Symbol		Discharge of Pump
(+ve) Sign on Knob	Clockwise Rotation	Increase
(-ve) Sign on Knob	Anti-Clockwise Rotation	Decrease

Table 2: PAC flowrate adjustment by knob rotation

Steps	Description	Rotation	Discharge of Pump (L/h)	Remarks
1	When Pump Valve is Tight	0.0	0.0	
2	When valve is open - Fully Open (0 - 1.0) - 1st time	1.0	3.0	
3	When valve is open - 1/2 Open (1.0 - 1.5) - 2nd time	1.5	13.2	
4	When valve is open - 1/2 Open (1.5 - 2.0) - 3rd time	2.0	30.6	
5	When valve is open - 1/2 Open (2.0 - 2.5) - 4th time	2.5	48.6	
6	When valve is open - 1/2 Open (2.5 - 3.0) - 5th time	3.0	66.6	
7	When valve is open - 1/2 Open (3.0 - 3.5) - 6th time	3.5	86.4	
8	When valve is open - 1/2 Open (3.5 - 4.0) - 7th time	4.0	105.6	

9	When valve is open - 1/2 Open (4.0 - 4.5) - 8th time	4.5	123.6	
10	When valve is open - 1/2 Open (4.5 - 5.0) - 9th time	5.0	141.6	
11	When valve is open - 1/2 Open (5.0 - 5.5) - 10th time	5.5	145.2	Flow is almost similar from step 11 onward
12	When valve is open - 1/2 Open (5.5 - 6.0) - 11th time	6.0	147.0	
13	When valve is open - Full Open (6.0 - 7.0) - 12th time	7.0	147.0	
14	When valve is open - Full Open (7.0 - 8.0) - 13th time	8.0	147.0	

Due to the difference in the specific gravity between water (1.0) and PAC solution (1.1), PAC solution is thicker than water, a float in the Rotameter indicates the water flow (Rotameter indication), but PAC flow (Actual Flow) is less.

PAC dosage (feeding rate) using Rotameter shall be decided referring to the following graph.

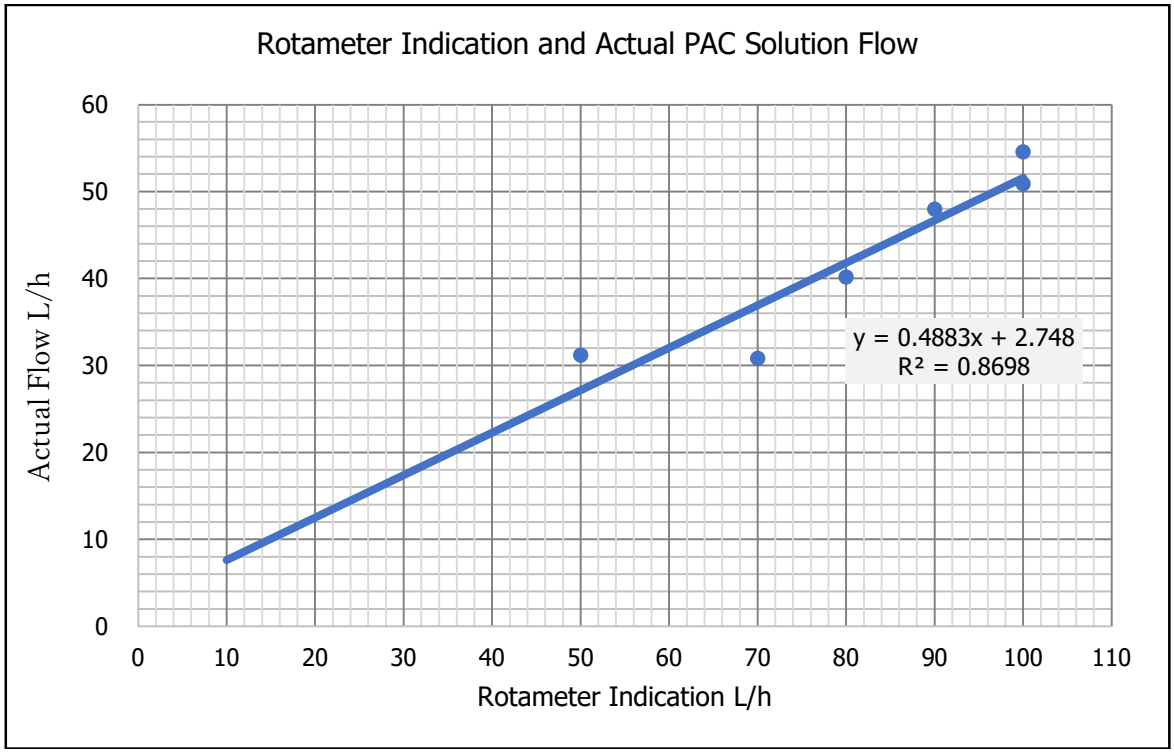


Figure 18: Rotameter indication and actual PAC solution flow rate

To set the Rotameter, use the following chart or table.

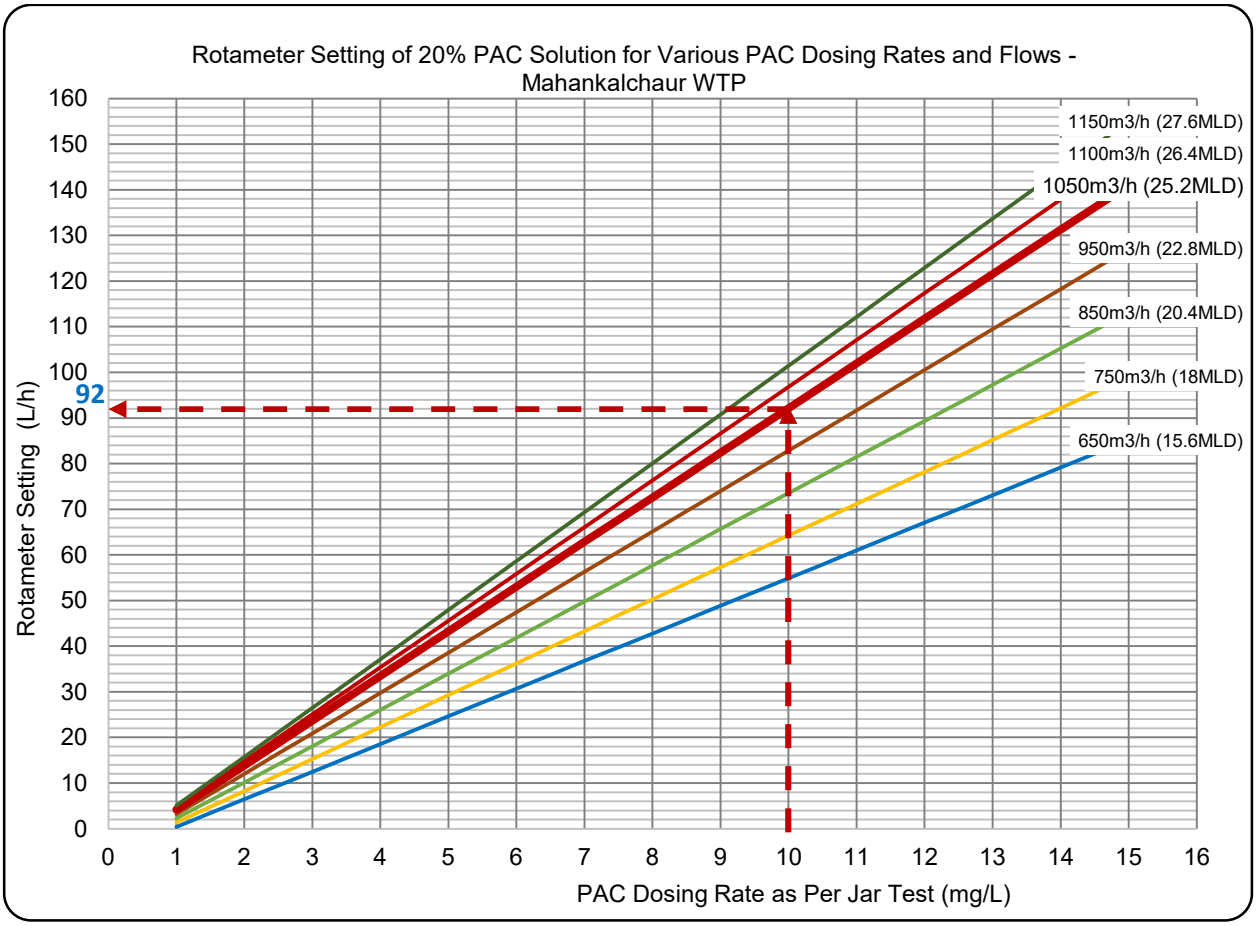


Figure 19: Rotameter setting for various PAC dosing rates

Table 3: Dosing rate of 20% PAC solution and corresponding Rotameter setting

Dosing Rate (mg/L)	Rotameter Setting (L/h)											
	600m3/h (14.4MLD)	650m3/h (15.6MLD)	700m3/h (16.8MLD)	750m3/h (18MLD)	800m3/h (19.2MLD)	850m3/h (20.4MLD)	900m3/h (21.6MLD)	950m3/h (22.8MLD)	1000m3/h (24MLD)	1050m3/h (25.2MLD)	1100m3/h (26.4MLD)	1150m3/h (27.6MLD)
1	0	0.4	0.9	1.4	1.8	2.3	2.8	3.2	3.7	4.2	4.6	5.1
2	5.6	6.5	7.4	8.3	9.3	10.2	11.1	12.1	13	13.9	14.9	15.8
3	11.1	12.5	13.9	15.3	16.7	18.1	19.5	20.9	22.3	23.7	25.1	26.5
4	16.7	18.6	20.5	22.3	24.2	26.1	27.9	29.8	31.6	33.5	35.4	37.2
5	22.3	24.7	27	29.3	31.6	34	36.3	38.6	41	43.3	45.6	48
6	27.9	30.7	33.5	36.3	39.1	41.9	44.7	47.5	50.3	53.1	55.9	58.7
7	33.5	36.8	40	43.3	46.6	49.8	53.1	56.3	59.6	62.9	66.1	69.4
8	39.1	42.8	46.6	50.3	54	57.7	61.5	65.2	68.9	72.6	76.4	80.1
9	44.7	48.9	53.1	57.3	61.5	65.7	69.8	74	78.2	82.4	86.6	90.8
10	50.3	54.9	59.6	64.3	68.9	73.6	78.2	82.9	87.6	92.2	96.9	101.5
11	55.9	61	66.1	71.2	76.4	81.5	86.6	91.7	96.9	102	107.1	112.2
12	61.5	67.1	72.6	78.2	83.8	89.4	95	100.6	106.2	111.8	117.4	123
13	67.1	73.1	79.2	85.2	91.3	97.3	103.4	109.5	115.5	121.6	127.6	133.7
14	72.6	79.2	85.7	92.2	98.7	105.3	111.8	118.3	124.8	131.3	137.9	144.4

Dosing Rate (mg/L)	Rotameter Setting (L/h)											
	600m3/h (14.4MLD)	650m3/h (15.6MLD)	700m3/h (16.8MLD)	750m3/h (18MLD)	800m3/h (19.2MLD)	850m3/h (20.4MLD)	900m3/h (21.6MLD)	950m3/h (22.8MLD)	1000m3/h (24MLD)	1050m3/h (25.2MLD)	1100m3/h (26.4MLD)	1150m3/h (27.6MLD)
15	78.2	85.2	92.2	99.2	106.2	113.2	120.2	127.2	134.1	141.1	148.1	155.1
16	83.8	91.3	98.7	106.2	113.6	121.1	128.6	136	143.5	150.9	158.4	165.8
17	89.4	97.3	105.3	113.2	121.1	129	136.9	144.9	152.8	160.7	168.6	176.5
18	95	103.4	111.8	120.2	128.6	136.9	145.3	153.7	162.1	170.5	178.9	187.3
19	100.6	109.5	118.3	127.2	136	144.9	153.7	162.6	171.4	180.3	189.1	198
20	106.2	115.5	124.8	134.1	143.5	152.8	162.1	171.4	180.7	190.1	199.4	208.7
21	111.8	121.6	131.3	141.1	150.9	160.7	170.5	180.3	190.1	199.8	209.6	219.4
22	117.4	127.6	137.9	148.1	158.4	168.6	178.9	189.1	199.4	209.6	219.9	230.1
23	123	133.7	144.4	155.1	165.8	176.5	187.3	198	208.7	219.4	230.1	240.8
24	128.6	139.7	150.9	162.1	173.3	184.5	195.6	206.8	218	229.2	240.4	251.6
25	134.1	145.8	157.4	169.1	180.7	192.4	204	215.7	227.3	239	250.6	262.3

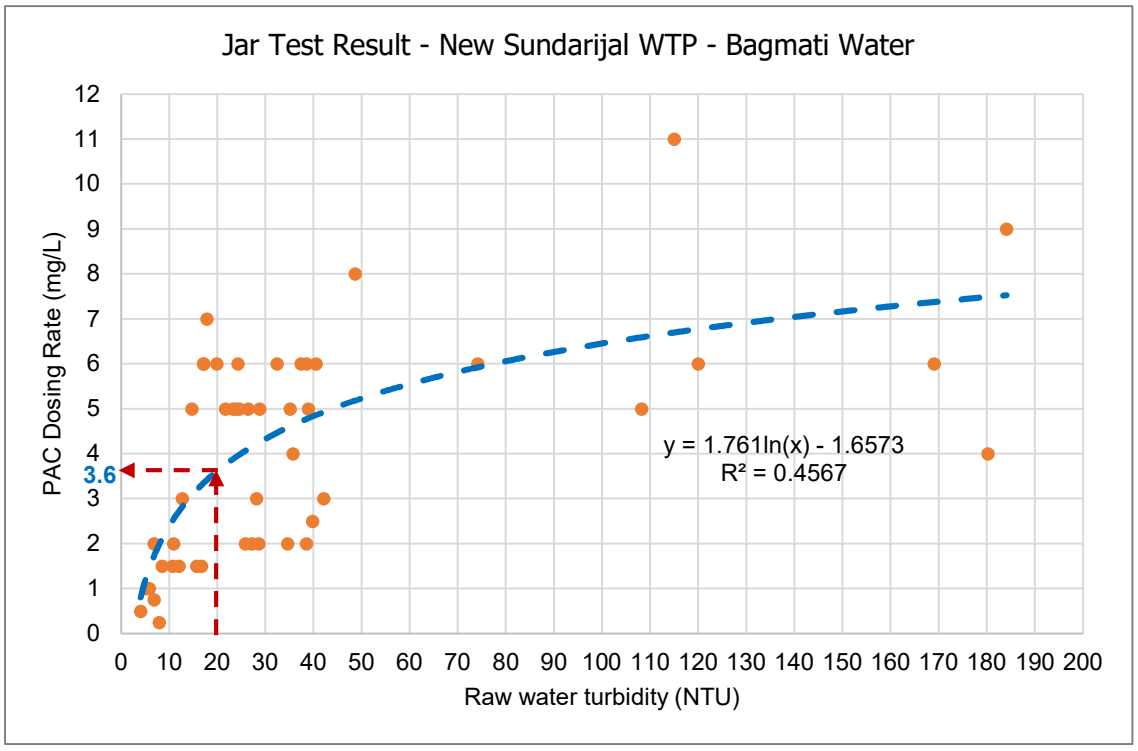


Figure 20: Jar Test Result of Bagmati River water done at New Sundarijal WTP

(The example shows if the turbidity is 20 NTU, the required PAC dosing rate is about 3.6 mg/L)

Dosing pump switching (operating one or more pumps in combination)

Dosing pump capacity a. 0.14 L/min (8.4 L/h) x 2 units

b. 0.46 L/min (27.6 L/h) x 4 units

Pump combination becomes necessary depending on the treated water quantity, dosing rate, and dosing pump capacity.

Refer to the above tables of feeding rates and decide the type (a or b) and number of pumps necessary to feed the required volume of solution.

For example, if the dosing rate is 8 mg/L and the water flow rate is 1000 m^3/h (24 MLD), then the required volume of 20% PAC solution is 36 L/h. Thus, the potential combinations will be: One pump (a) + one pump (b) which will give 8.4 + 27.6 = 36.0 L/h.

3.2.5 Floc Formation

Floc formation at inlet of Sedimentation Basin and no floc leakage at outlet of Sedimentation Basin shall be checked and confirmed.

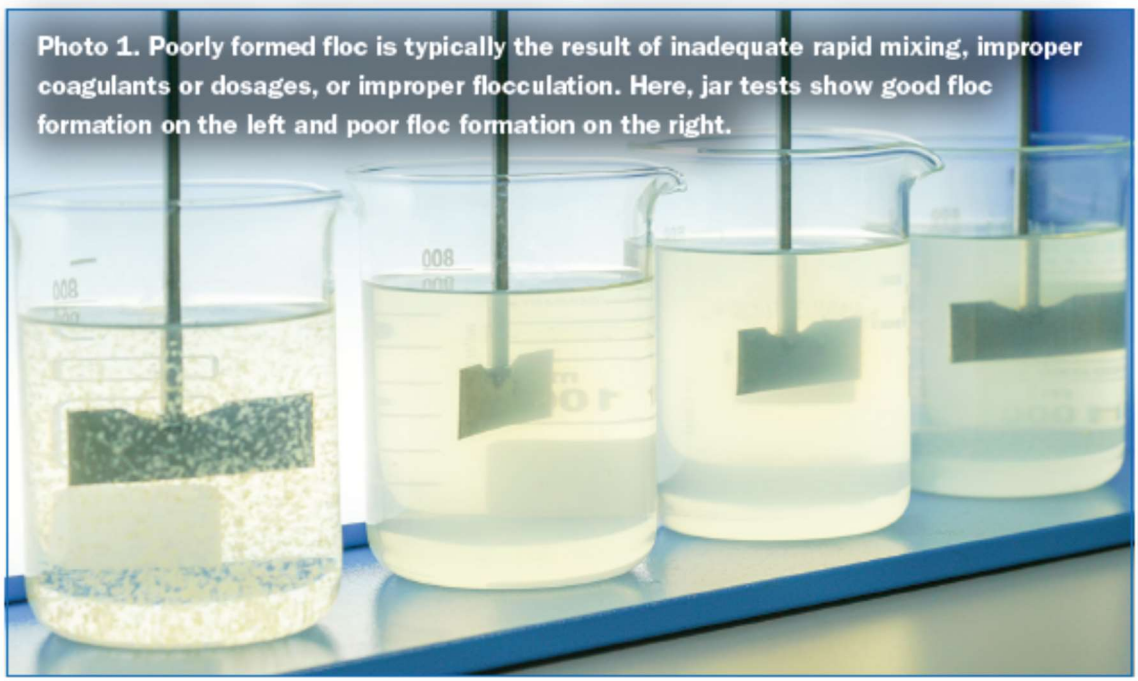


Photo 3: Example of well-formed and poorly formed flocs (Source: AWWA, Opflow, March 2022)

3.3 Lime Feeding Equipment

3.3.1 General

The following section briefly outlines the equipment specifications and main procedures.

Purpose: To adjust the pH of the surface water.

Mechanism: Slaked lime is dissolved to a desired concentration of solution and then transferred by transmission pump to the storage tank and fed at suitable intervals by the feeding equipment at the inlet of the flocculation and sedimentation tank.

Equipment outline

Item	Type	Size/Details	No. of units
Dissolution tank	Open vertical cylindrical tank (polyethylene)	ϕ 900 mm x 900 mm (h) Capacity: 0.5 m^3 Accessories: Fittings: 1 set Agitator: 1 stand	2 tanks
Agitator	Reciprocating rotary agitator	Reciprocating cycles: 196 cpm Motor: 0.75 kW x 400 V x 50 Hz	2 units
Transmission pumps	Magnet pump	Capacity: 25 A x 30 L/min x 20m Motor: 2.2 kW x 400V x 50 Hz	2 pumps
Slaked lime storage tanks	Open vertical cylindrical tank (polyethylene)	Approx. ϕ 1425mm x 1570mm (h) Capacity: 2 m^3 Accessories (per tank) Fittings – 1set Direct reading level gauge – 1 gauge Manhole – 1 location Air vent– 1 location; Agitator stand and agitator– 1 set	2 tanks
Feeding equipment	Diaphragm pump	Capacity: a. 15 A x 0.49 L/min x 3 kg/cm^2 (2 units) b. 15 A x 1.8 L/min x 3 kg/cm^2 (2 units) Motor: 0.2 kW x 400 V x 50 Hz Accessories: Back pressure valve - 2 units	4 units (2 units x 2)

Item	Type	Size/Details	No. of units
		Safety valve - 4 units Air chamber – 2 units Pressure gauge – 4 units	
Piping and valves		Pipes, valves, hard polyvinyl pipes for city water; ball valves, diaphragm valves, etc. Diameter: 50 – 15 A	1 set
Instrument panel		MM-4	

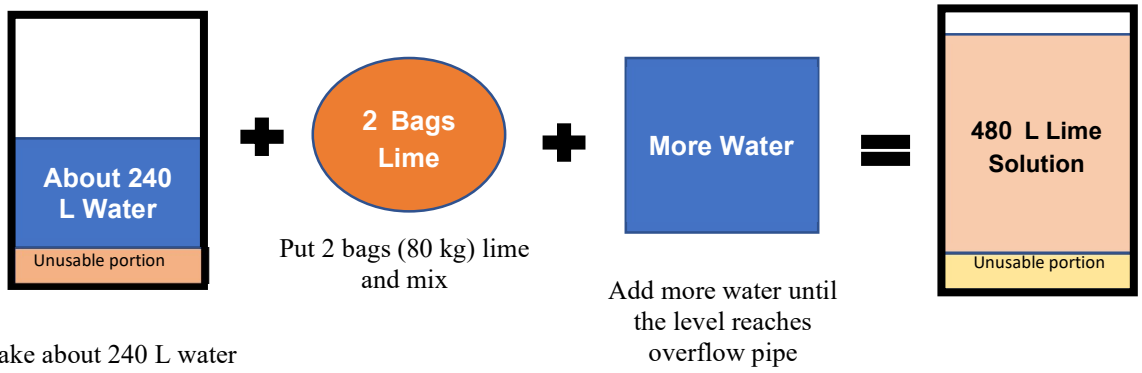
Figure 21: Lime dissolution tanks

Figure 22: Lime solution storage tanks (2 Nos.)

3.3.2 Process of Lime Solution Preparation

Method of lime solution preparation is as below.

Effective volume of the lime dissolution tank = 480 L.



Take about 240 L water

Put 2 bags (80 kg) lime and mix

Add more water until the level reaches overflow pipe

3.3.3 Process of Deciding Dosage

Lime solution dosing rate shall be in the following manner:

1. Flow measurement (m^3/day or m^3/hr) (by WTP Engineer)
(Automatic measurement record can be taken when this system is installed and ready)

⇩

2. Find out the required Lime dosing rate by Jar Test (by Central Lab)

⇩

3. Calculate Lime dosage (feeding rate)/ Lime pump setting (by WTP Engineer)

⇩

4. Adjust Lime pump setting (by WTP operator)

⇩

5. Check pH and floc formation (by Central Lab/WTP)

3.3.4 Dosing Rate Calculation

Item	Description
Flow	1,050 m^3/h => 1.05 ×10^6 L/h
Lime Solution	=> 2 bags (80 kg) Lime in 480 L solution => 80 ×10^6/480 => 167,000 mg/L

Dosing Rate	10 mg/L as CaO (as an example)
Required Lime Dosage	10 mg/L x 1.05 ×10^6 L/h = 10.5 ×10^6 mg/h
Required Lime Solution Feeding Rate	$= \frac{10.5\times10^6 \text{ mg/h}}{167000 \text{ mg/L}}$ = 62.9 L/h = 1.05 L/min
Simplified formula	$= \frac{1050 \text{ m}^3/\text{h} \times 10 \text{ mg/L}}{167}$ = 62.9 L/h

Reference chart and table for Lime solution dosage (feeding rate) calculation:

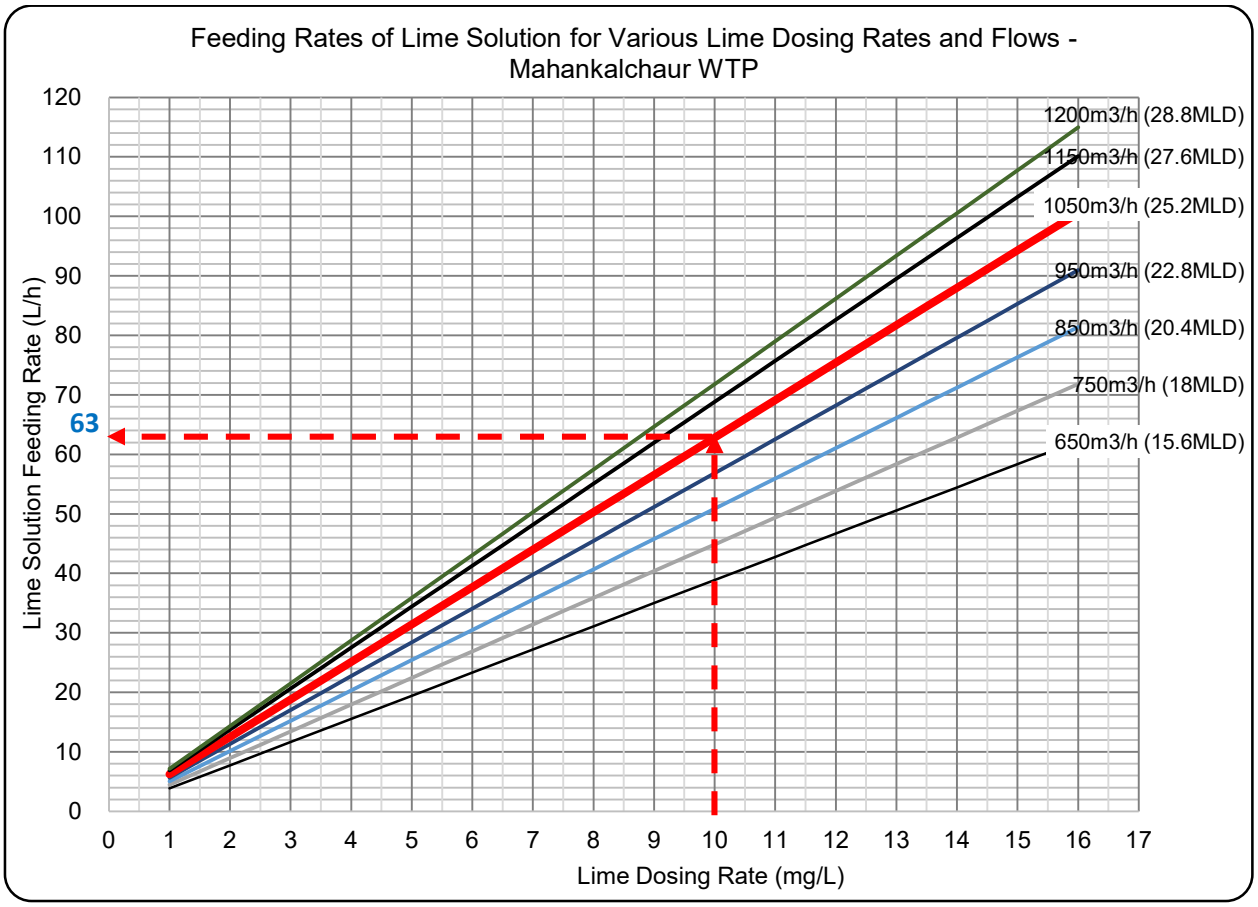


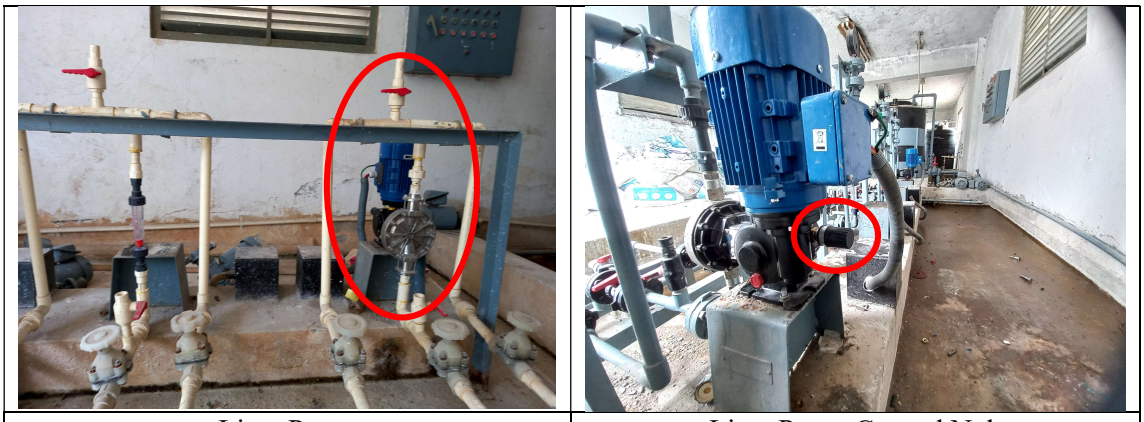
Figure 23: Chart of lime solution dosages (feeding rates)

The feeding rates can also be calculated from the following Table.

Table 4: Lime solution dosages (feeding rate)

Dosing Rate (mg/L)	Daily Volume of Solution for 1050 m^3/h Flow (L/day)	Feeding Rate (L/h)											
		650m3/h (15.6MLD)	700m3/h (16.8MLD)	750m3/h (18MLD)	800m3/h (19.2MLD)	850m3/h (20.4MLD)	900m3/h (21.6MLD)	950m3/h (22.8MLD)	1000m3/h (24MLD)	1050m3/h (25.2MLD)	1100m3/h (26.4MLD)	1150m3/h (27.6MLD)	1200m3/h (28.8MLD)
1	144	4	4	4	5	5	5	6	6	6	7	7	7
2	312	8	8	9	10	10	11	11	12	13	13	14	14
3	456	12	13	13	14	15	16	17	18	19	20	21	22
4	600	16	17	18	19	20	22	23	24	25	26	28	29
5	744	19	21	22	24	25	27	28	30	31	33	34	36
6	912	23	25	27	29	31	32	34	36	38	40	41	43
7	1,056	27	29	31	34	36	38	40	42	44	46	48	50
8	1,200	31	34	36	38	41	43	46	48	50	53	55	57
9	1,368	35	38	40	43	46	49	51	54	57	59	62	65
10	1,512	39	42	45	48	51	54	57	60	63	66	68.9	72
11	1,656	43	46	49	53	56	59	63	66	69	72	76	79
12	1,800	47	50	54	57	61	65	68	72	75	79	83	86
13	1,968	51	54	58	62	66	70	74	78	82	86	90	93
14	2,112	54	59	63	67	71	75	80	84	88	92	96	101
15	2,256	58	63	67	72	76	81	85	90	94	99	103	108
16	2,424	62	67	72	77	81	86	91	96	101	105	110	115
17	2,568	66	71	76	81	87	92	97	102	107	112	117	122
18	2,712	70	75	81	86	92	97	102	108	113	119	124	129
19	2,856	74	80	85	91	97	102	108	114	119	125	131	137
20	3,024	78	84	90	96	102	108	114	120	126	132	138	144
21	3,168	82	88	94	101	107	113	119	126	132	138	145	151
22	3,312	86	92	99	105	112	119	125	132	138	145	151	158
23	3,480	90	96	103	110	117	124	131	138	145	151	158	165
24	3,624	93	101	108	115	122	129	137	144	151	158	165	172
25	3,768	97	105	112	120	127	135	142	150	157	165	172	180

3.3.5 Lime Dosing Pump Setting



Lime Pump	Lime Pump Control Nob

Photo 4: Lime dosing pump setting method

Symbol		Discharge of Pump
(+ve) Sign on Knob	Clockwise Rotation	Increase
(-ve) Sign on Knob	Anti-Clockwise Rotation	Decrease

Table 5: Number of rotation and average flowrate of Lime dosing pump

Steps	Description	Rotation	Average Flow (L/h)	Remarks
1	When Pump Valve is Tight	0.0	0	
2	When valve is open - Fully Open (0 - 1.0) - 1st time	1.0	0.9	
3	When valve is open - 1/2 Open (1 - 1.5) - 2nd time	1.5	12.1	
4	When valve is open - Full Open (1.5 - 2.0) - 3rd time	2.0	33.8	
5	When valve is open - 1/2 Open (2.0 - 2.5) - 4th time	2.5	57.2	
6	When valve is open - 1/2 Open (2.5 - 3.0) - 5th time	3.0	81.5	
7	When valve is open - 1/2 Open (3.0 - 3.5) - 6th time	3.5	105.9	
8	When valve is open - 1/2 Open (3.5 - 4.0) - 7th time	4.0	131.6	
9	When valve is open - 1/2 Open (4.0 - 4.5) - 8th time	4.5	153.9	
10	When valve is open - 1/2 Open (4.5 - 5.0) - 9th time	5.0	167.9	
11	When valve is open - 1/2 Open (5.0 - 5.5) - 10th time	5.5	174.9	Flow is almost similar from step 11 onward
12	When valve is open - 1/2 Open (5.5 - 6) - 11th time	6.0	174.9	
13	When valve is open - Full Open (6.0 - 7.0) - 12th time	7.0	174.9	

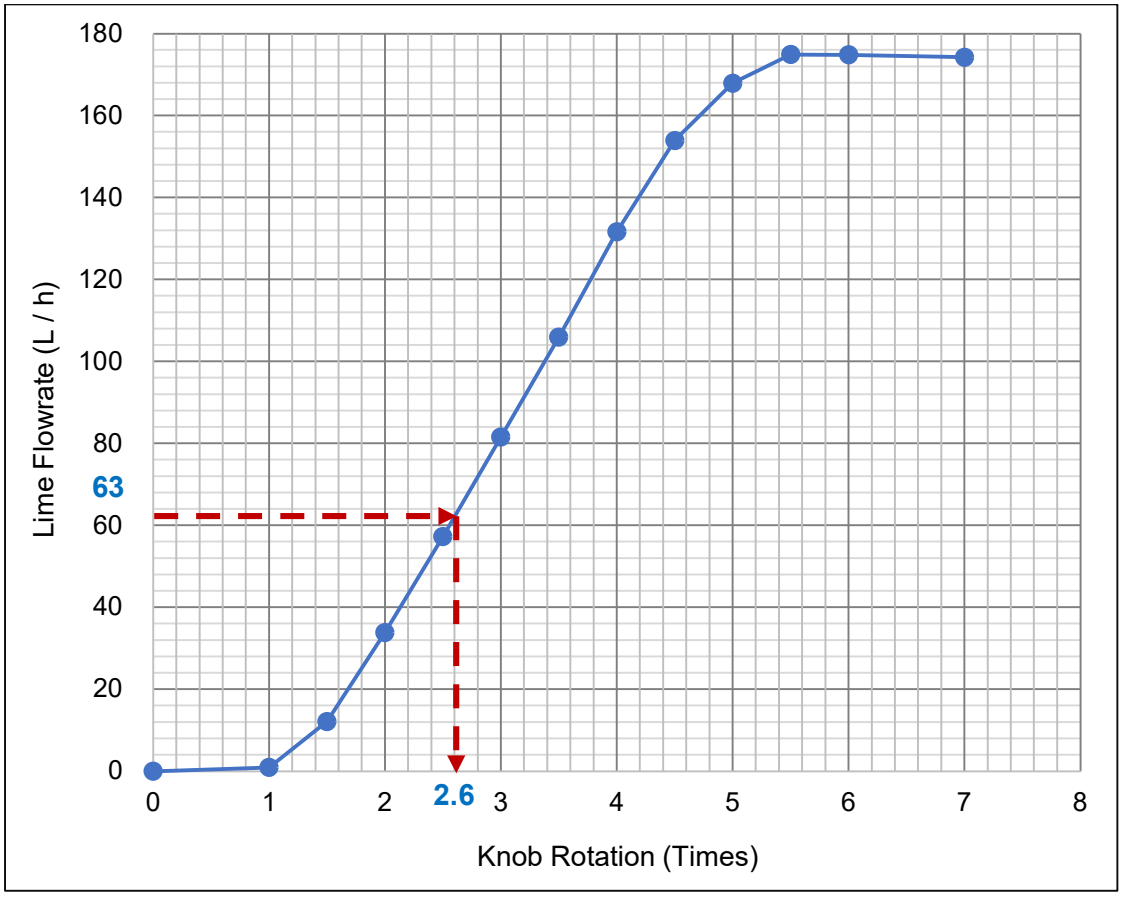
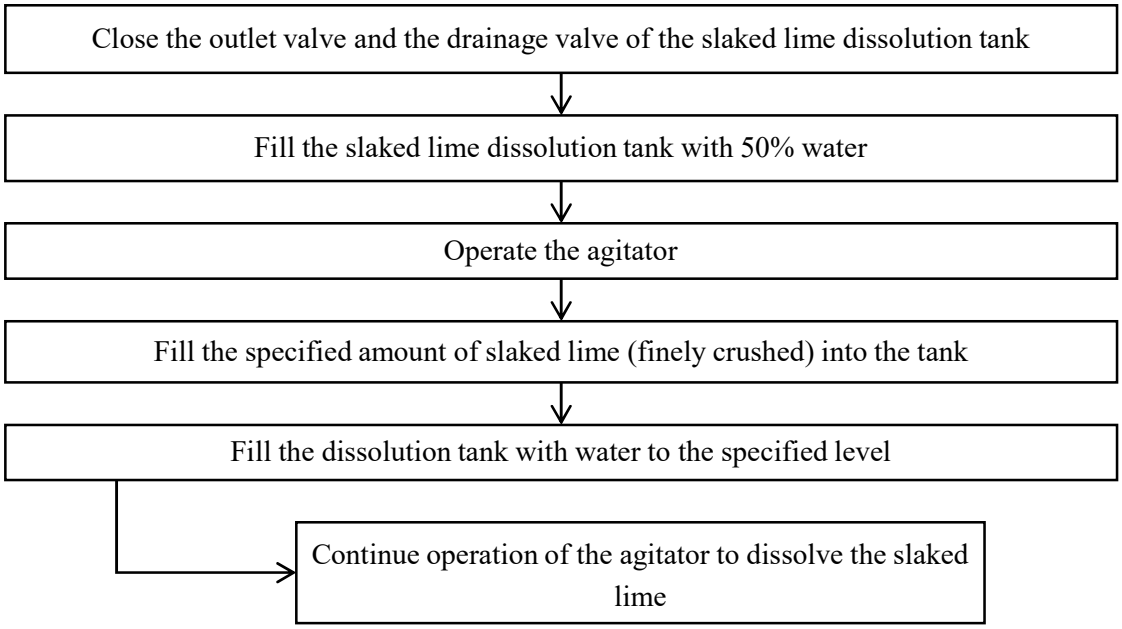
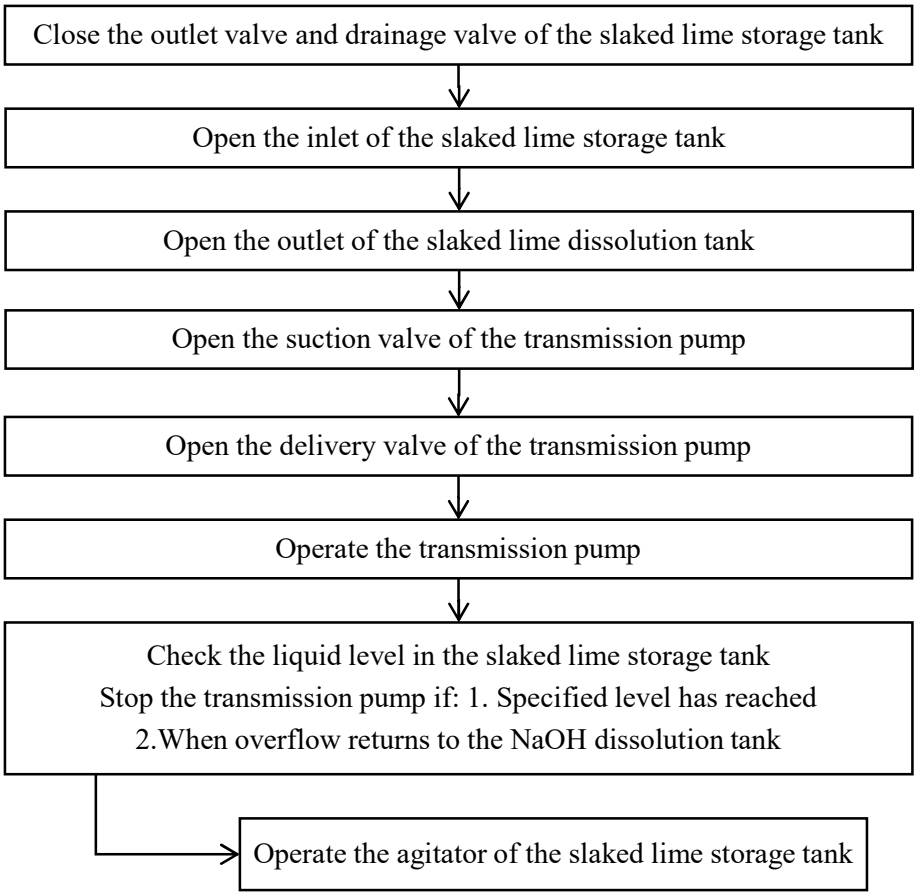


Figure 24: Lime flowrate and number of rotations

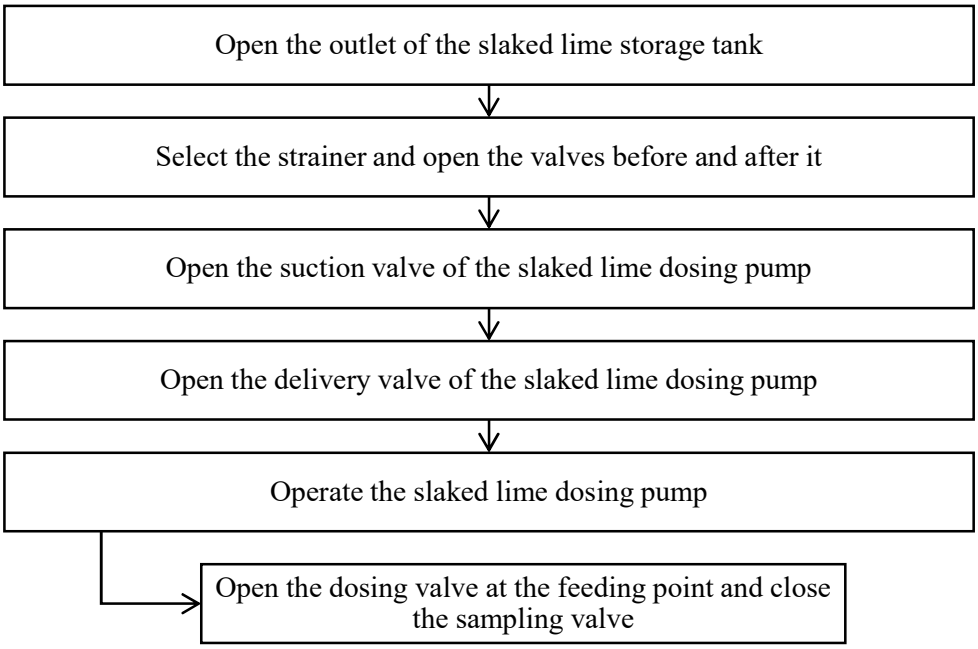
Procedure of preparing lime solution



Process of transferring the slaked lime solution to storage tanks



Process of lime solution feeding

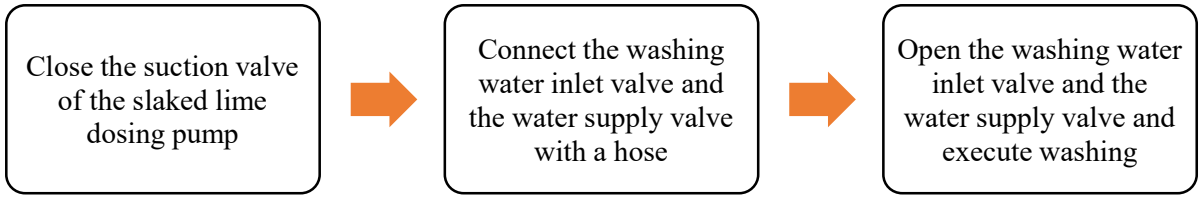


(Note: For feeding confirmation and measuring of the dosage, close the dosing valve and open the sampling valve)

The slaked lime feeding pipe may become clogged by calcium carbonate. Clean the feeding pipe periodically.

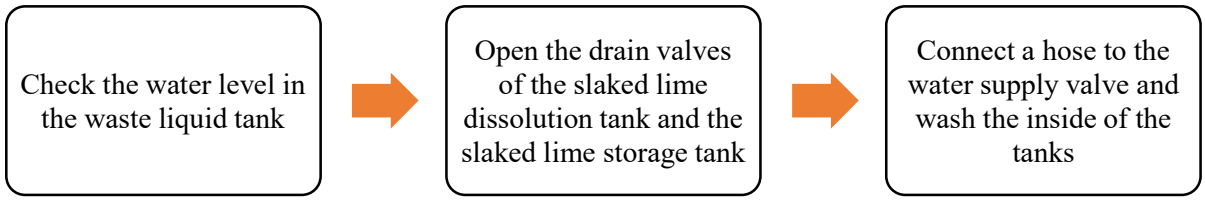
Washing of the dosing pump and feeding pipe

When feeding is to be stopped for long time, wash the dosing pump and the feeding pipe.



Washing of slaked lime dissolution tank and slaked lime storage tank

When feeding is to be stopped for a long time, wash the slaked lime dissolution tank and the slaked lime storage tank.



Dosing pump switching

There are 4 sets of lime dosing pumps as below.

a. 0.49 L/min (29.4 L/h) x 2 units

b. 1.80 L/min (108.0 L/h) x 2 units

Pump should be switched depending on the treated water quantity and the dosing rate. Refer to the above tables for deciding lime solution feeding rates (

Table 4) and selection and use of dosing pumps based on the required rate.

For example, according to the above table, if the dosing rate is 20 mg/L and the water flow rate is 25.2 MLD, then the required lime solution flow rate is 126 L/h.

Then use:
One pump (a) + one pump (b).

4. Rapid Sand Filtration Equipment

4.1 General

Purpose: The Rapid Sand Filter (RSF) is used to remove turbidity, iron, and manganese from the raw water which is subjected to flocculation and sedimentation.

Equipment Outline

<table>
<tr><th>Item</th><th>Type</th><th>Size/Details</th><th>No. of units</th></tr>
<tr><td>Filter basins</td><td>Open natural gravity</td><td>2.65 m (w) x 7.1 m (l)
Area: 18.8 m^2
Filter media:
<table>
<tr><td>Media</td><td>Diameter (mm)</td><td>Depth (mm)</td></tr>
<tr><td>Sand</td><td>0.6</td><td>600</td></tr>
<tr><td rowspan="3">Gravel (for support)</td><td>2-4</td><td>50</td></tr>
<tr><td>4-6</td><td>50</td></tr>
<tr><td>6-10</td><td>50</td></tr>
</table></td><td>10 basins</td></tr>
<tr><td>Surface washing pumps – 2 nos.</td><td>Suction volute</td><td>Capacity: ϕ200 x ϕ150 x 4 m^3/min x 25 m
Motor: 30 kW x 400 V x 50 Hz</td><td>2 pumps</td></tr>
<tr><td>Make up pumps - 2 nos.</td><td>Centrifugal</td><td>Capacity: ϕ100 x 1.2 m^3/min x 7 m
Motor: 2.2 kW x 400 V x 50 Hz</td><td>2 pumps</td></tr>
<tr><td>Water discharge trough</td><td>Basin</td><td>300 (w) x 300 (d) x 2900 (l)</td><td>4 nos.</td></tr>
<tr><td>Raw water inflow valve (V1)</td><td>Valve</td><td>ϕ 350</td><td></td></tr>
<tr><td>Water discharge gate (G1)</td><td>Gate</td><td>ϕ 450</td><td></td></tr>
<tr><td>Clear water gate (G2)</td><td>Gate</td><td>ϕ 450</td><td></td></tr>
<tr><td>Drainage valve (V2)</td><td>Valve</td><td>ϕ 150</td><td></td></tr>
<tr><td>Surface washing valve (V3)</td><td>Valve</td><td>ϕ 250</td><td></td></tr>
</table>

*: All units are in mm unless specified

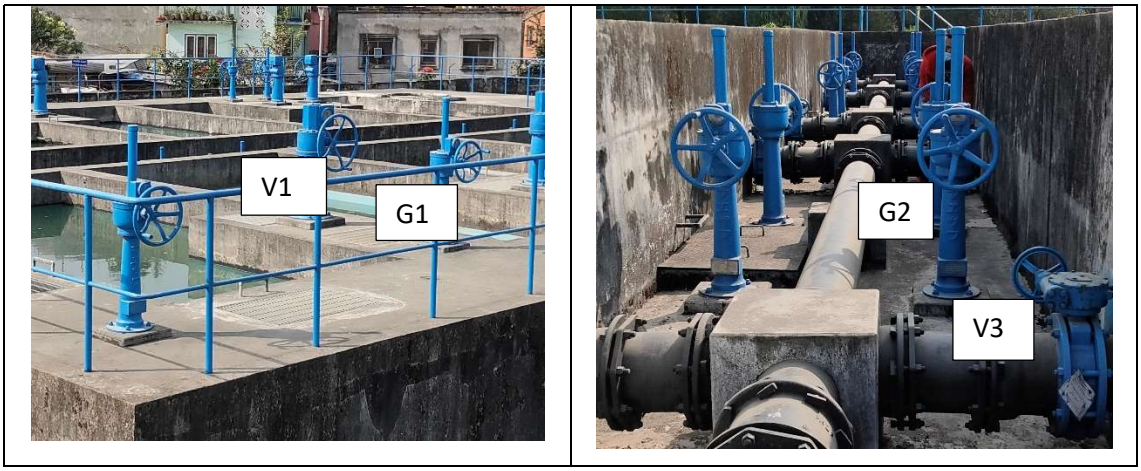


Figure 25: Layout of valves and gates

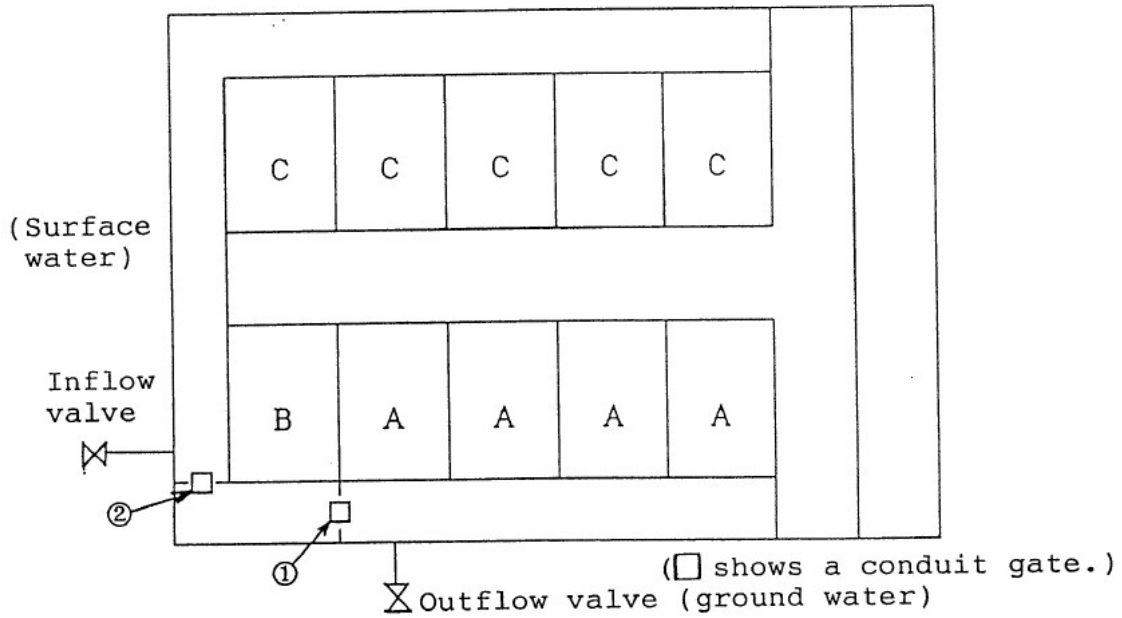


Figure 26: Schematics of rapid sand filtration basins

4.2 Operation

The inflow of the biotreated water is limited to the period from March to June and as the quantity of water differs according to the month, the equipment is divided into 10 filters which are used in combination. Attention should be paid to the opening and closing of the conduit gates to prevent mixing of ground and surface water.

Open/closed condition of the conduit gates

The open/closed condition of the conduit gates according to the operation condition of the RSF is shown in the following table. Surface and ground water should not be mixed.

Open/closed condition of valves and air blower operation

Equipment	During filtration	During washing	During inspection in the basin
Raw water inflow valve (V1)	Open	Closed	Closed
Water discharge gate (G1)	Closed	Open	Open
Clear water gate (G2)	Open	Open	Closed
Drainage valve (V2)	Closed	Closed	Open
Surface washing valve (V3)	Closed	Open	Closed
Surface washing pump	-	Operation of 1pump	-
Make up pump	-	Operation of 1pump	-

Operation procedure

Filtration operation

Close the drainage valve (For RSFs and each pipe conduit)

↓

Close the water discharge gate

↓

Close the surface washing valve

↓

Open the raw water inflow valve

→ Open the clear water gate

Stopping operation

Close the raw water inflow

↓

Close the clear water inflow valve

Back washing operation

Close the raw water inflow

↓

Open the draianage valve

↓

Open the surface washing valve

↓

Operate the surface wash pump

↓

Operate the make up pump

↓

Close the surface washing valve and stop the surface wash pump after a fixed time

↓

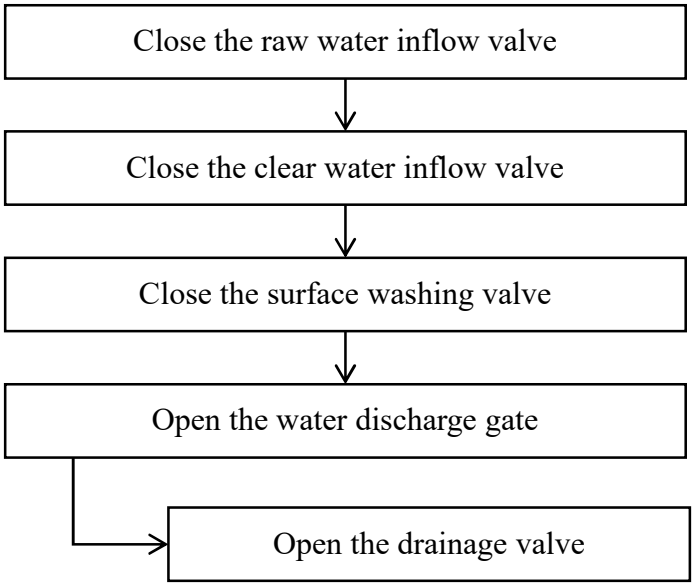
Stop the make up pump after a fixed time

↓

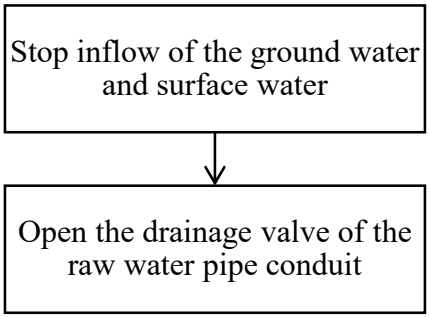
Close the water discharge gate after a fixed time

→ Open the raw water inflow gate

Draw-off operation



In case of draw off for the raw water pipe conduit



In case of draw off for the clear water conduit and the outflow conduit

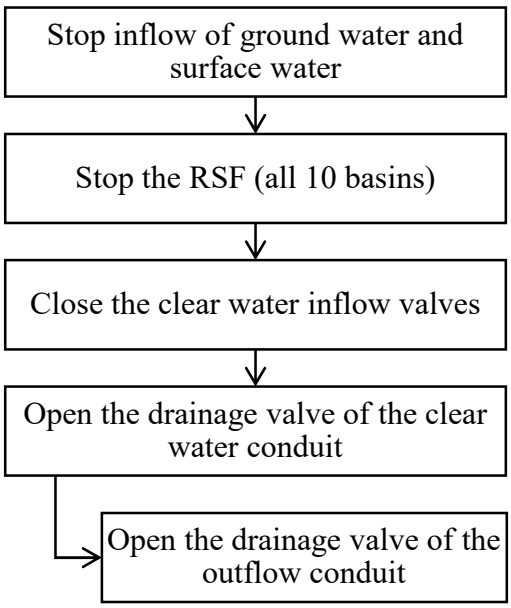


Illustration of water inside the RSF during backwash

Dirty water (initially)	Clear water (completion of backwash)
	

Figure 27: Condition of RSF bed level before and after backwash

5. Clear-Water Reservoir and Water Transmission Pump Equipment

Purpose

Clear water reservoir: To act as a balancing storage, i.e., to store filtered water when the filtered water production rate is more than supply water rate, and to provide extra water for supply when the filtered water rate is less than supply water rate. The reservoir also stores water for backwashing operation of the filters.

Transmission pumps: To transmit water to other reservoirs.

Equipment outline

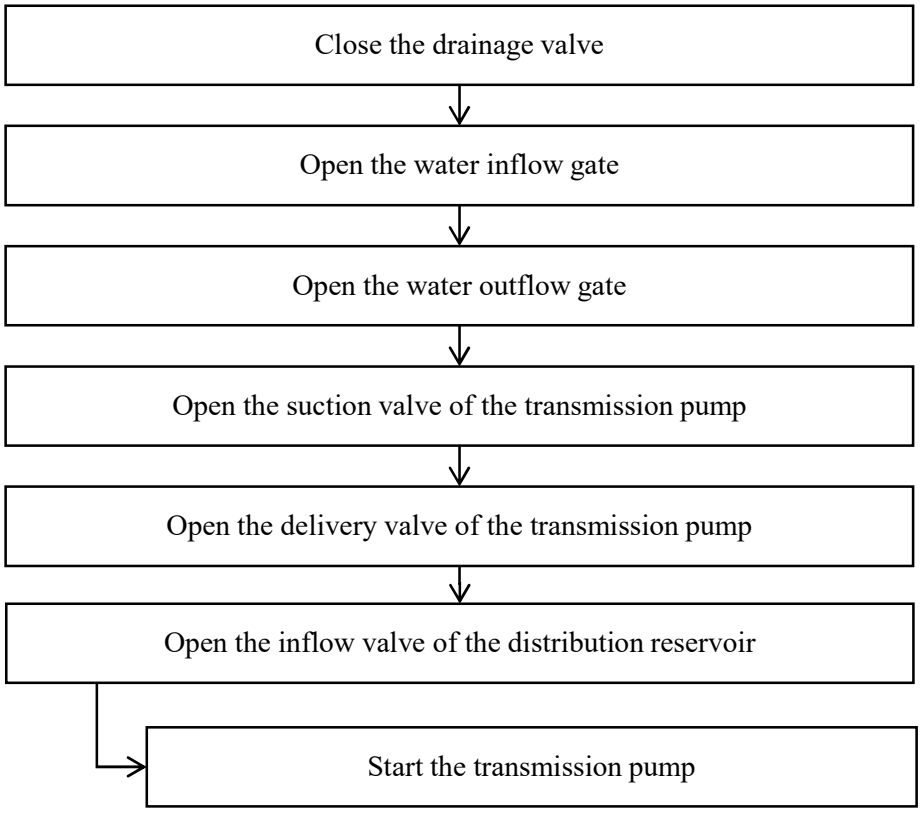
Item	Type	Size/Details	No. of units
Basins	Reinforced Cement Concrete	Dimensions: a. 3.7 m (w) x 8.25 m (l) x 3.3 m (d) b. 3.7 m (w) x 9.7 m (l) x 3.3 m (d) x 4 c. 3.7 m (w) x 3.55 m (l) x 3.3 m (d) Effective capacity: 1235.6 m^3 Retention time: 65 minutes	2 basins
Transmission pumps	Suction volute pump	Capacity: ϕ300 x ϕ200 6.5 m^3/min x 9 m Motor: 15 kW x 400 V x 50 Hz	4 pumps
Water supply pumps	Pressure type automatic supply unit	Capacity: ϕ50 x ϕ65 x 0.6 m^3/min Motor: 3.7 kW x 400 V x 50 Hz	1 set (2 pumps)
Bed drainage pumps	Submersible pumps for soil water	Capacity: ϕ50 x 0.1 m^3/min x 10 m Motor: 0.4 kW x 400 V x 50 Hz	1 set (2 pumps)

Note on operation:

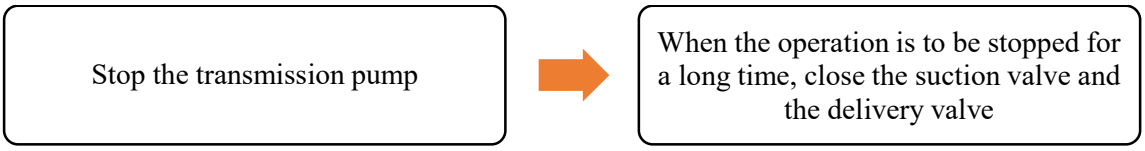
1. Confirm the open/closed condition of the conduit gate.
2. The CWR consists of two basins, and operation with one basin is possible. In case of operation of one basin, operate the inflow and the outflow gate of the respective basin.

Figure 28: Transmission pumps and drainage pumps

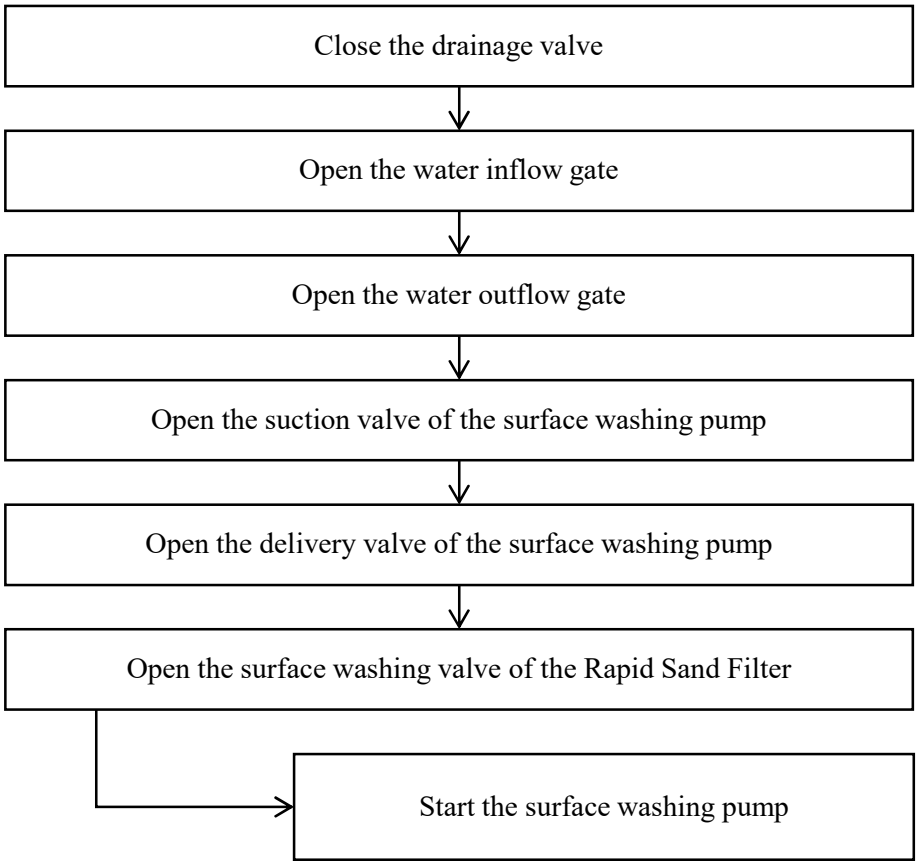
Transmission pump operation procedure



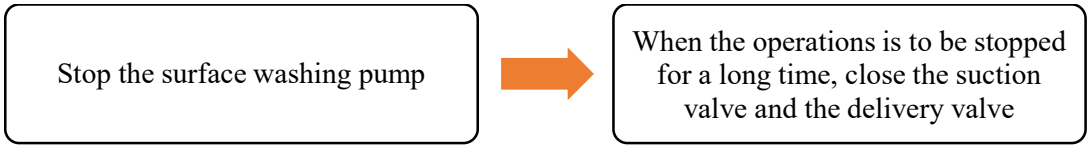
Stopping of the transmission pump



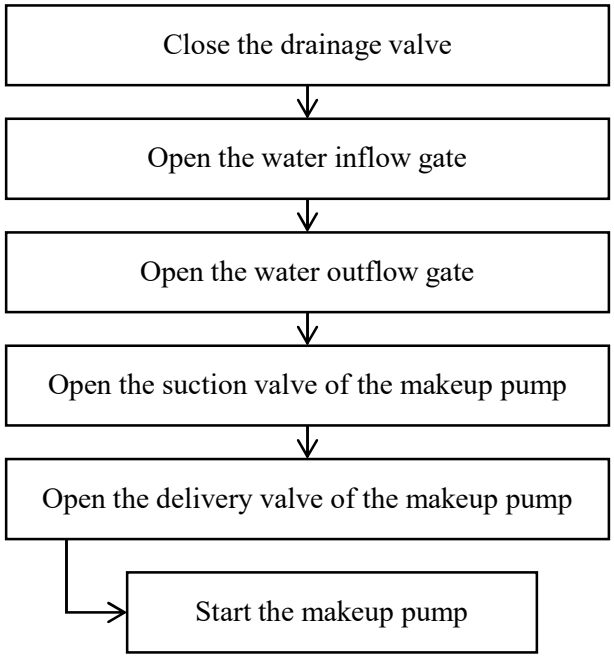
Operating process of the surface washing pump



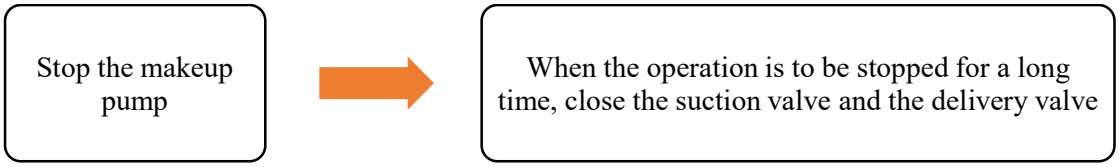
Stopping of the surface washing pump



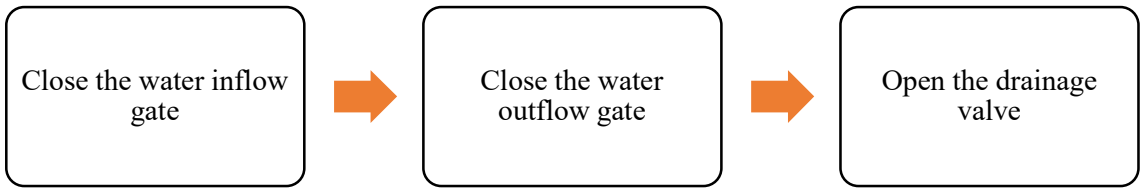
Operating process of the makeup pump



Stopping of the makeup pump

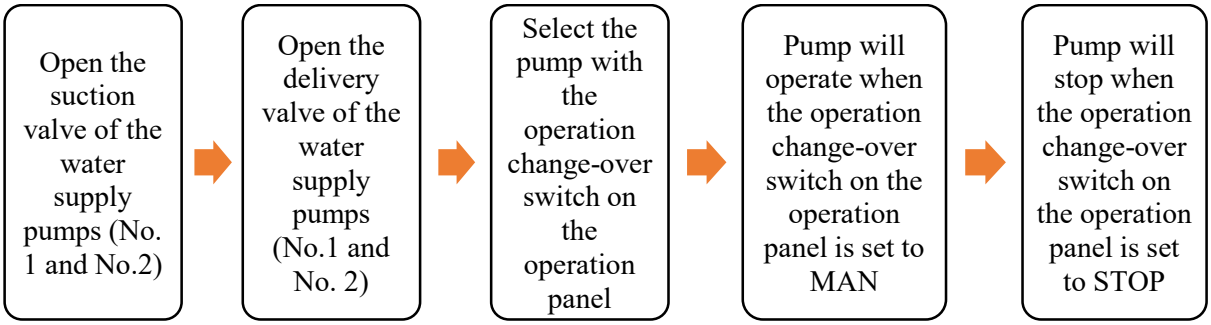


Draw off process for the CWR

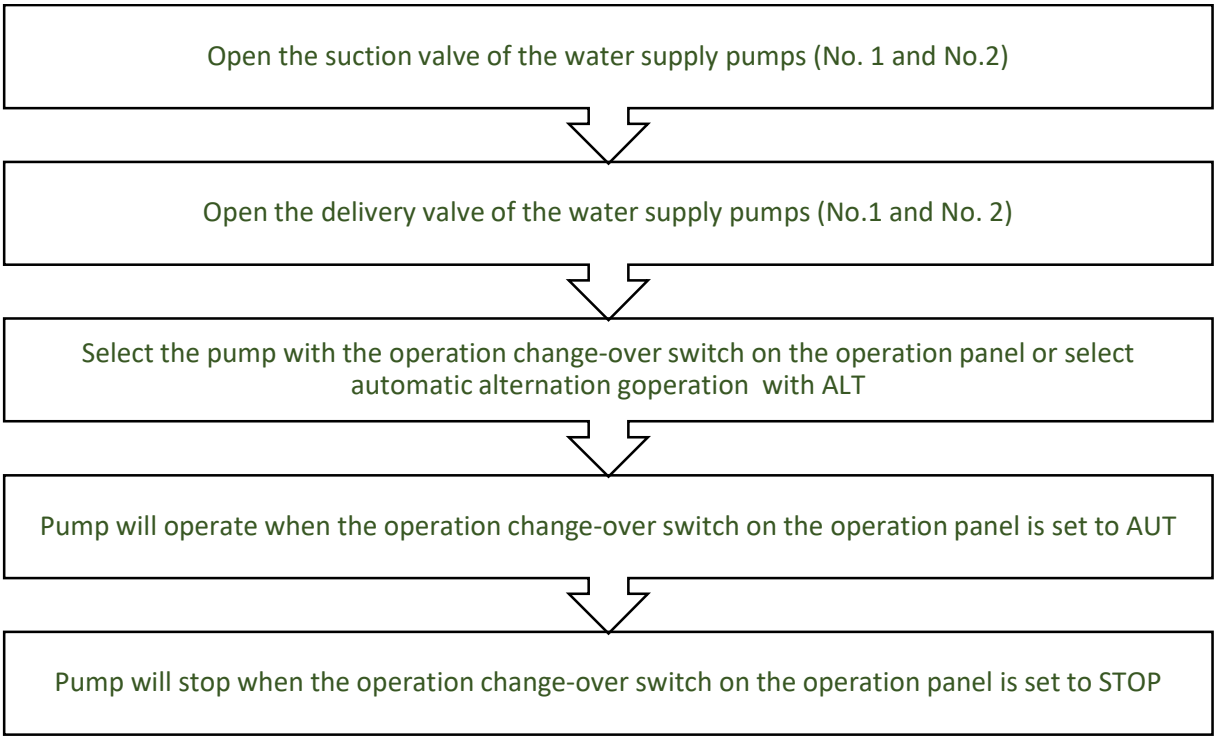


(Note: Do not execute draw off operation for the CWR when washing operation, sludge drainage, or draw off operation is being executed for the bio filter equipment or the RSF equipment)

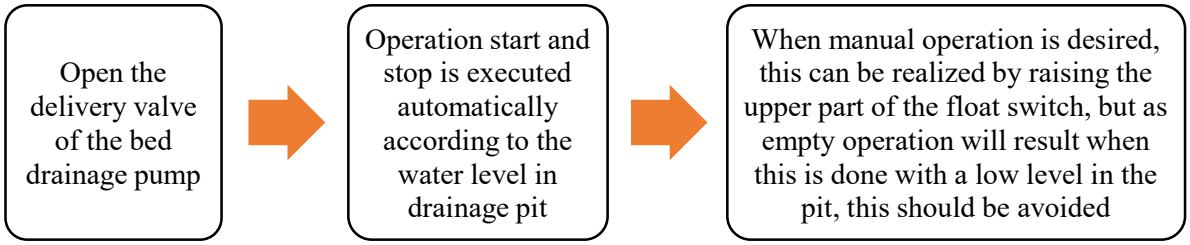
Manual operation of the water supply pump



Automatic operation of the water supply pump



Operation of the bed drainage pump



6. Sludge and Drainage Equipment

Purpose: To receive a large quantity of drainage in a short time when the rapid sand filter is being washed or the sludge from the sedimentation basins is removed.

Equipment Outline

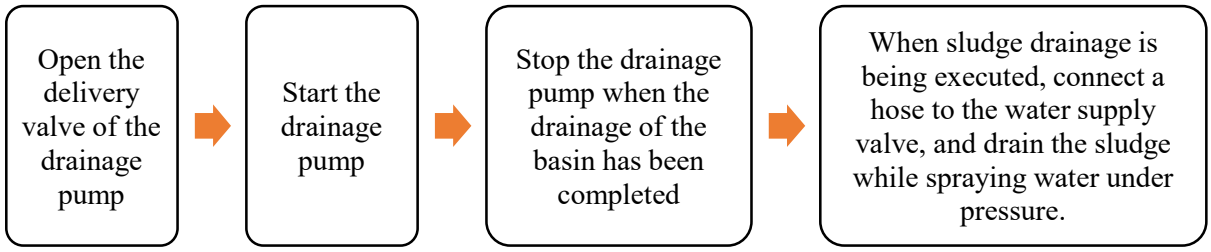
Item	Type	Size/Details	No. of units
Sludge and Drainage Basins	RCC	8 m (w) x 10 m (l) x 3.5 m (d) Effective capacity: 224 m^3/basin x 2 = 448 m^3	2 basins
Drainage pumps	Submersible sewage pump	Capacity: ϕ100 x 2.0 m^3/min x 12 m H Motor: 7.5 kW x 400V x 50 Hz	2 pumps

Figure 29: Sludge drainage basins

Checking the state of the conduit gates

There are 2 sludge and drainage basins. Operation with a single basin is possible. In case of operation of a single basin, operate the water inflow valve of the respective basin.

Operation of the drainage pump



7. Chlorine Feeding Equipment

7.1 Sodium Hypochlorite Generation and Feeding Equipment

This equipment is not in use.

7.2 Bleaching Powder Feeding Equipment

7.2.1 General

① Bleaching powder dissolution tanks

Type: Vertical open cylindrical type (made of PE)

Dimensions: ϕ 1150 mm x height 1200 mm

Capacity: 1.0 m^3

Quantity: 2 tanks

Accessories (per tank)

Fittings 1 set

Agitator stand 1 stand

② Agitators

Type: Reciprocating rotary agitator

Reciprocating cycles: 200 cpm

Motor: 0.75 kW x 400 V x 50 Hz

Quantity: 2 units

③ Transmission pumps

Type: Magnet pump

Capacity: 40 A x 30 L/min x 10 m

Motor: 0.4 kW x 400 V x 50 Hz

Quantity: 2 pumps

④ Bleaching powder storage tanks

Type: Vertical enclosed cylindrical type (made of polyethylene)

Dimensions: ϕ 1425 mm x height 1570 mm

Capacity: 2.0 m^3

Quantity: 2 tanks

Accessories (per tank)

Fittings 1 set

Direct-reading level meter 1 unit

Manhole 1 location

Air vent 1 location

⑤ Feeding equipment

Type: Diaphragm pump

Capacity:

(for oxygenation)

a. 15 A x 0.46 L/min x 3 kg/cm^2 x 2
b. 15 A x 1.8 L/min x 3 kg/cm^2 x 2

(for sterilization)

c. 15 A x 0.23 L/min x 3 kg/cm^2 x 1
d. 15 A x 0.9 L/min x 3 kg/cm^2 x 1

Motor: 0.2 kW x 400 V x 50 Hz

Quantity: 6 units

Accessories:

Back-pressure valve	3 units
Safety valve	6 units
Air chamber	3 units
Pressure gauge	6 units

⑥ Piping and valves

Pipes, valves, hard polyvinyl pipe for city water, ball valves, diaphragm valves, etc.

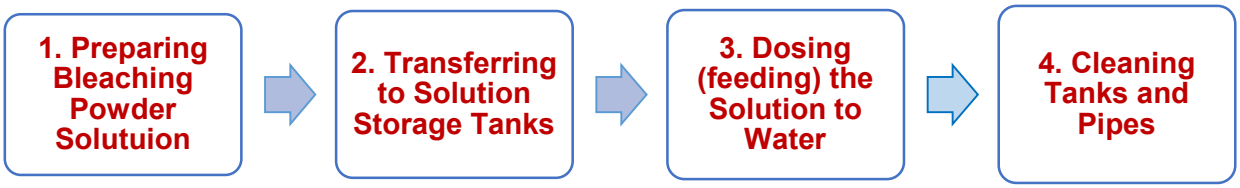
Diameter: 50 ~ 15 A

Quantity: 1 set

⑦ Instrument panel: BM-6

7.2.2 Outline of Overall Process

Main steps



7.2.3 Process of Preparing Bleaching Powder Solution

Effective size of bleaching powder dissolution tank = 480 L.

Desired concentration of chlorine in bleaching powder solution is about 5% Cl_2.

Prepare bleaching powder solution following the schematics and details shown below.

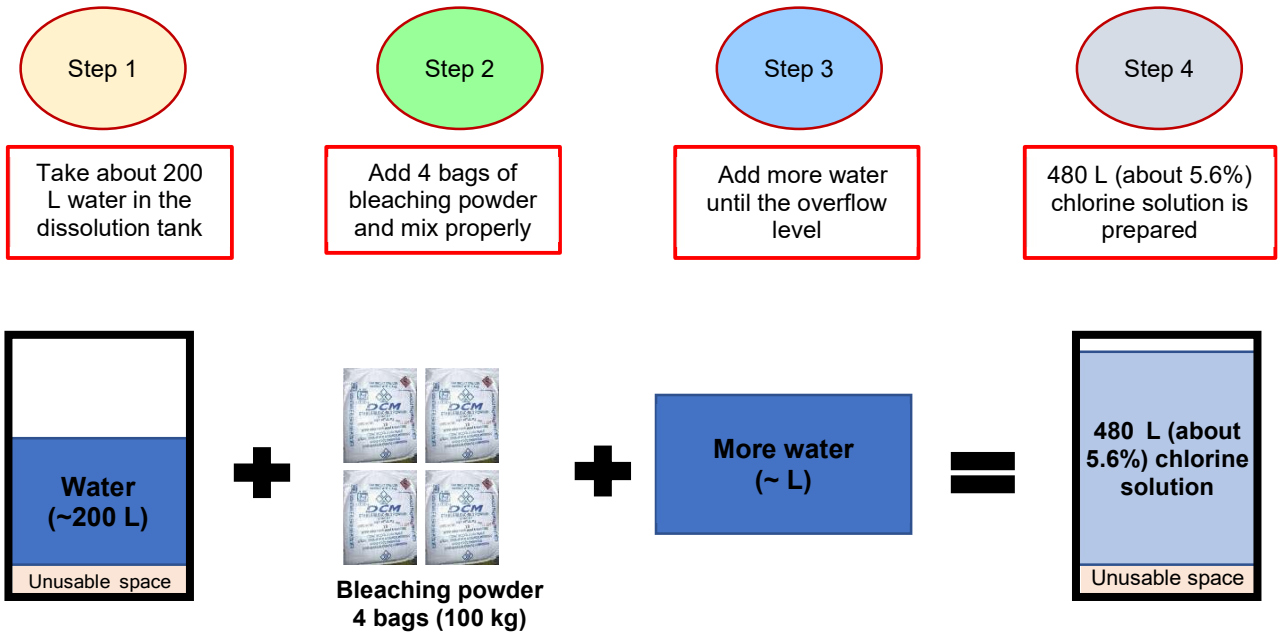


Figure 30: Schematics of chlorine solution preparation using bleaching powder in Mahankalchaur WTP

Operation procedure

1. Close the outlet valve and the drainage valve of the dissolution tank
2. Add about 200 L water (about half way to the tank)
3. Add 4 bags (100 kg) of bleaching power
4. Operate the agitator
5. Add water until the level reaches overflow level, continue agitating for about 20 minutes

⇩

6. Allow 30 minutes to settle

⇩

7. Transfer the solution to the storage tank with the transmission pump

⇩

8. Repeat the Steps 1-7 in another tank or in the same tank after cleaning it

7.2.4 Transferring the Bleaching Powder Solution to Storage Tanks

Operation procedure

1. Close the outlet valve and the drainage valve of the bleaching powder storage tank

⇩

2. Open the inlet valve of the bleaching powder storage tank

⇩

3. Open the outlet valve of the bleaching powder dissolution tank

⇩

4. Open the suction valve of the transmission pump

⇩

5. Open the delivery valve of the transmission pump

⇩

6. Operate the transmission pump

⇩

7. Check the liquid level of the storage tank and stop the transmission pump when the maximum storage level has been reached or liquid in the dissolution tank has been finished

7.2.5 Dosing (Feeding) the Bleaching Powder Solution to Water

Process flow

1. Find out chlorine demand (how many mg of chlorine to be dosed per L of water) from lab test

⇩

2. Calculate the required chlorine dosing rate (mg/L) = Chlorine demand (mg/L) + Desired residual chlorine (mg/L) = D mg/L,

OR

Measure the residual chlorine of treated water and decide dosing rate.

⇩

3. Check the raw water inflow quantity or find out daily filtered water volume Q (m^3/day or m^3/h)

⇩

4. Calculate dosage (feeding rate) for 5% Cl_2 solution according to Formula, Chart, or Table

⇩

5. Adjust the dosage (feeing rate) as per calculated feeding rate

⇩

6. Measure residual chlorine (minimum FRC should be 1 ppm) after about 30 minutes and adjust the dosage (feeding rate) if required so that the required FRC is obtained

a) Methods of calculating chlorine dosage (feeding rate)

Three methods; (1) By using formula, (2) By using Chart, or (3) From the Table

(1) By using formula

You can use the following formula:

$$\text{Bleaching powder solution feeding rate} = \frac{Q\ m^3/h \times D\ mg/L}{62.5}\ L/h$$

As an example, if the inflow is 1050 m^3/h and the dosing rate is 3 mg/L, then the dosage (feeding rate) =

$$\text{Bleaching powder solution feeding rate} = \frac{1{,}050\ m^3/h \times 3\ mg/L}{62.5} = 50.4\ L/h$$

Details of calculations for understanding:

The bleaching powder contains 30% chlorine. That means 100 kg bleaching powder will have 30 kg Cl_2 → 30 kg Cl_2 is in 480 L solution => Strength of the solution = 30,000,000 mg/480 L = 62,500 mg/L Cl_2.

(2) By using Chart

Refer to the following Chart to determine dosage (feeding rate) of bleaching powder solution for various flows and chlorine dosing rates.
First read the Cl_2 dosing rate (mg/L) along the X-axis → go up to the daily flow line → go left to Y-axis and read the dosage (feeding rate).

For example, if the Cl_2 dosing rate is 3 mg/L and the daily water flowrate is 1050 m^3/h, the dosage (feeding rate) comes out to be about 50.4 L/h.

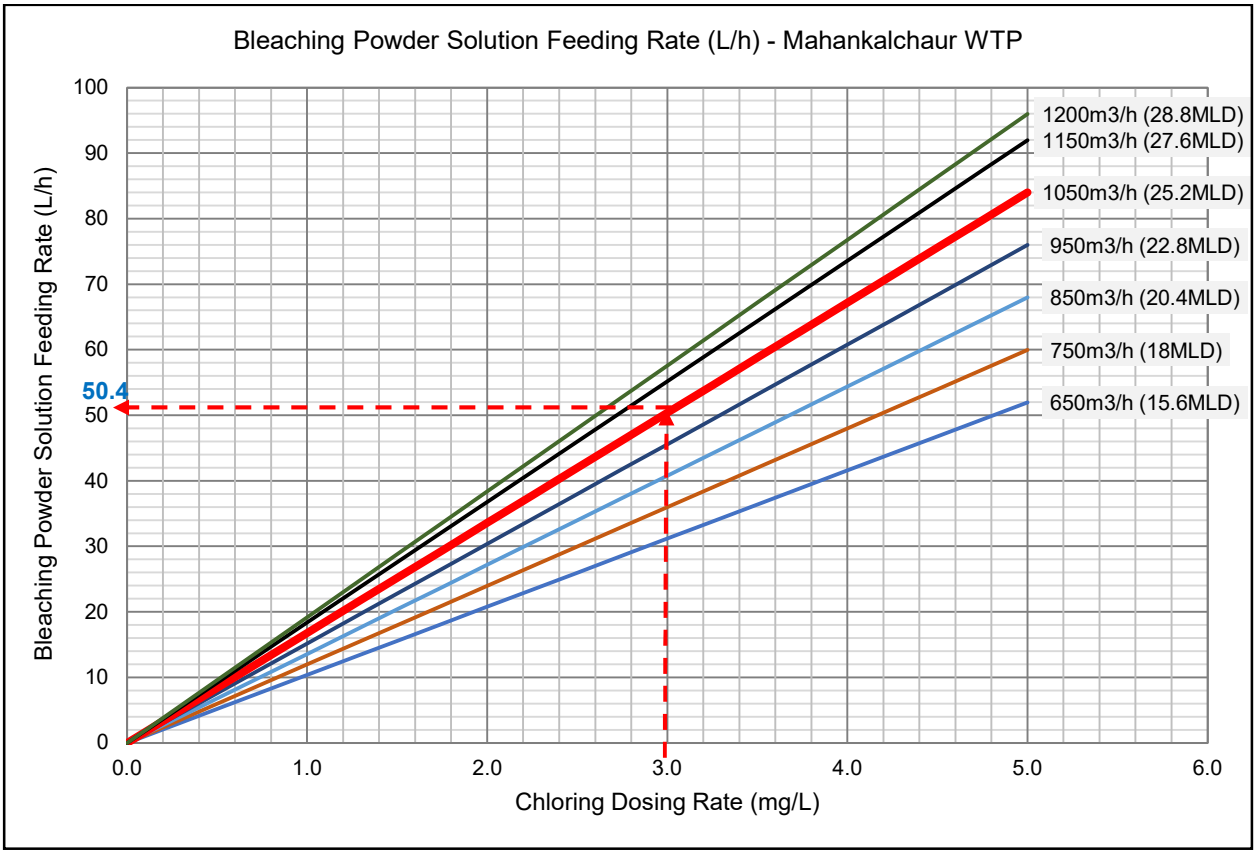


Figure 31: Chart of bleaching powder solution dosages (feeding rates)

(3) By using Table

Find the row of dosing rate from the leftmost column → Go right on that row until meeting the water flow rate → The value in intercepting cell is the feeding rate.

Table 6: Dosages (feeding rates) of bleaching powder solution

Cl_2 Dosing rate (mg/L)	Bleaching Powder Solution Feeding Rate (L/h)											
	650m3/h (15.6MLD)	700m3/h (16.8MLD)	750m3/h (18MLD)	800m3/h (19.2MLD)	850m3/h (20.4MLD)	900m3/h (21.6MLD)	950m3/h (22.8MLD)	1000m3/h (24MLD)	1050m3/h (25.2MLD)	1100m3/h (26.4MLD)	1150m3/h (27.6MLD)	1200m3/h (28.8MLD)
0.0	0	0	0	0	0	0	0	0	0	0	0	0
1.0	10	11	12	13	14	14	15	16	17	18	18	19
1.5	16	17	18	19	20	22	23	24	25	26	28	29
2.0	21	22	24	26	27	29	30	32	34	35	37	38
2.5	26	28	30	32	34	36	38	40	42	44	46	48
3.0	31	34	36	38	41	43	46	48	50.4	53	55	58
3.5	36	39	42	45	48	50	53	56	59	62	64	67
4.0	42	45	48	51	54	58	61	64	67	70	74	77
4.5	47	50	54	58	61	65	68	72	76	79	83	86
5.0	52	56	60	64	68	72	76	80	84	88	92	96
5.5	57	62	66	70	75	79	84	88	92	97	101	106
6.0	62	67	72	77	82	86	91	96	101	106	110	115
6.5	68	73	78	83	88	94	99	104	109	114	120	125

b) Chlorine dosing location

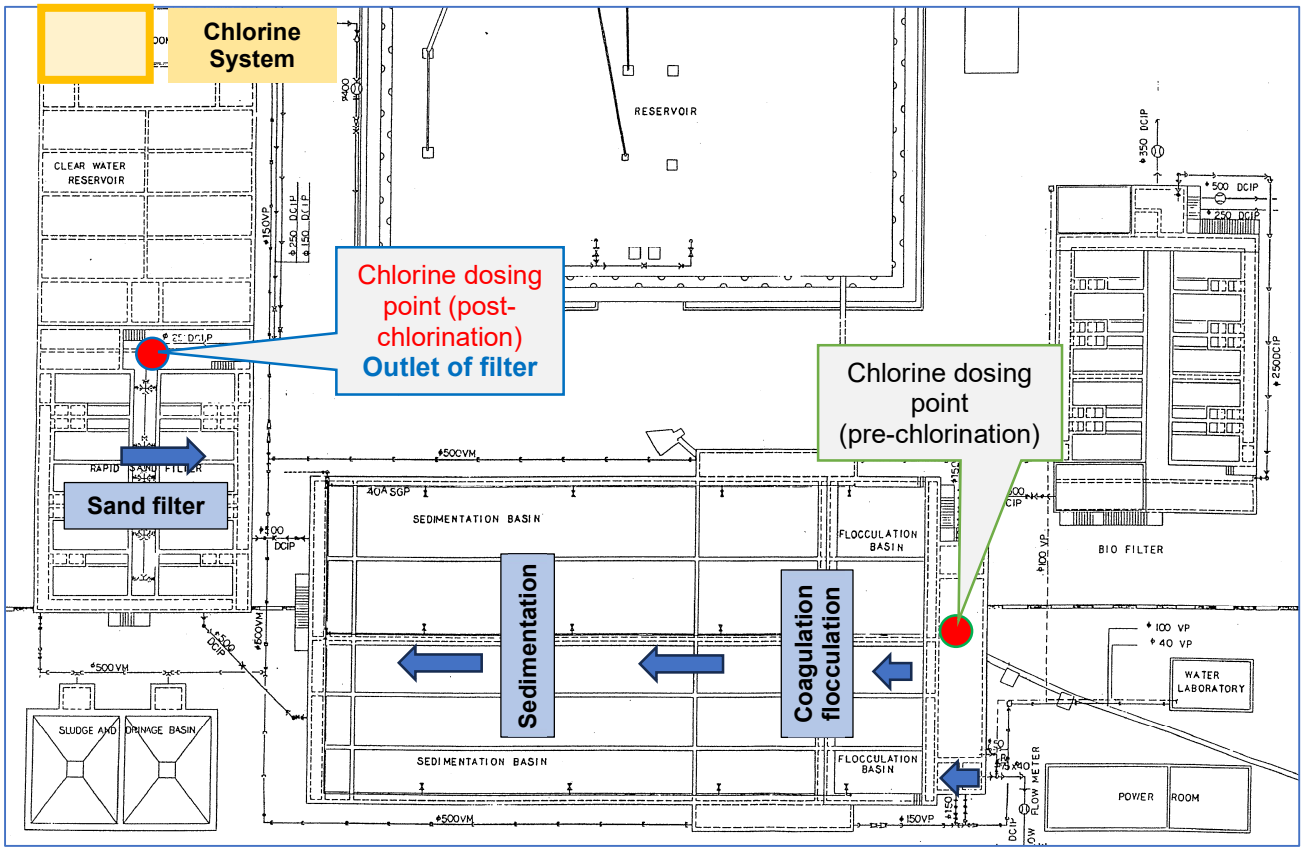


Figure 32: Chlorine dosing location (post-chlorination) – Mahankalchaur WTP

c) Operation procedure of bleaching powder solution feeding system

The specified quantity (as determined above) is fed by the chlorine dosing pump at the feeding point with the following process.

Operation procedure

1. Close the outlet valve of the bleaching powder solution storage tank
⇩
2. Select the strainer and open the vales before and after it
⇩
3. Open the suction valve of the bleaching powder solution feeding pump
⇩
4. Open the delivery valve of the bleaching powder solution feeding pump
⇩
5. Operate the bleaching powder feeding pump
⇩
6. Open the feeding valve at the feeding point and close the sampling valve

d) Operation procedure for adjusting the dosage (feeding rate)

Operation procedure

1. Adjust the pump stroke according to feeding pump characteristic curve to obtain the required feeding rate
⇩
2. Or, adjust the rotameter to obtain the required feeding rate
⇩
3. Check residual chlorine level and adjust the feeding rate if necessary

7.2.6 Cleaning Tanks and Pipes

a) Washing of dosing pump and the feed pipe

When feeding is to be stopped for a long time, wash the dosing pump and the feed pipe.

Operation procedure

1. Close the suction valve of the bleaching powder feeding pump

⇩

2. Connect the washing water inlet valve and the water supply valve with a hose

⇩

3. Open the washing water inlet valve and the water supply valve and execute washing

b) Drainage of bleaching powder dissolution tank

Undissolved material remaining at the bottom of the tank does not contain any chlorine. It should be drained out.

The clear water drainage pipe is used for drainage.

Operation procedure

1. Check the water level of the clear water basin

⇩

2. Open the drainage valve of the bleaching powder dissolution tank

⇩

3. Connect a hose to the water supply valve and execute drainage while washing the inside of the tank with water

⇩

4. Open the clear water basin drainage valve

⇩

5. Open the drainage valve connected to the clear water basin drainage pipe

c) Washing of bleaching powder dissolution tank and the solution storage tank

When feeding is to be stopped for a long time, wash the bleaching powder dissolution tank and the solution storage tank.

Operation procedure

1. Check the water level of the clear water basin

⇩

2. Open the drainage valve of the bleaching powder dissolution tank

⇩

3. Connect a hose to the water supply valve and execute drainage while washing the inside of the tank with water

⇩

4. Open the clear water basin drainage valve

⇩

5. Open the drainage valve connected to the clear water basin drainage pipe

Photo 5: Bleaching powder dissolution and storage tanks in Mahankalchaur WTP

7.2.7 Dosing pump selection

Depending on capacity and number of dosing pumps, treated water quantity, and the dosage (feeding rate), different pump combinations may be required.

Existing dosing pump capacity at Mahankalchaur WTP:

a. 0.9 L/min x 1 unit

b. 1.8 L/min x 2 units

Possible various combinations are as follows:

(1) Use of one pump a.

(2) Use of one pump b.

(3) Use of one pump a and one pump b.

(4) Use of two pumps b.

(5) Use of one pump a and two pumps b.

For example, if the required dosage (feeding rate) is 50.4 L/h (0.83 L/min), then case '(1) Use of one pump a' will be required.

End of the SOP.