WAY OF THINKING FOR WATER TREATMENT PLANT

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Introduction

The design of water supply facilities for communities in developing countries should be based upon the proper application of current technologies.

The following technologies are judged to be of merit in considering options for surface water treatment in communities in developing countries,

- **Source**
- **Way of abstracting the water from source**
- **Pretreatment**
- **Chemicals**
- **Chemicals feeder**
- **Hydraulic Rapid mixer or mechanical mixer**
- **Hydraulic Flocculators or mechanical flocculators**
- **Sedimentation basin**
- **Filtration**
- **Disinfection**
- **Storage for distribution**

Basic considerations

In as much as socioeconomic and technical conditions differ sharply between industrial and developing countries, a different set of design would govern the implementation of water supply project in each area.
In the industrial countries, the following general conditions are usually practiced;

A high degree of automation in order to reduce labor costs that are substantially higher than those found in developing countries.

Extensive utilization of equipment and instrumentation that are easily procured from and serviced by variety of proprietors,

Preference for mechanical solutions rather than hydraulic ones.

The water treatment plants constructed with expensive, imported technologies are not economically feasible due to following factors;

Unaffordable to pay high tariff like industrial countries.

There is a shortage of skilled personnel to operate and maintain the treatment plants in the developing world. On the other hand, there is abundance of unskilled labor, which makes labor intensive technologies more attractive.

The water utilities that must administer water system are generally weak and suffer from excessive staff turnover.

The following guides are recommended for the design and construction of water treatment plants in developing countries;

The utilization of mechanical equipment should be limited to that produced or available in local.

Hydraulic based devices that use gravity to do such work as mixing, flocculation, and filter rate control are preferred over mechanized equipment.

Mechanization and automation are appropriate only where operations are not readily done manually, or where they greatly improve reliability.

Design period for construction should be shorter to reduce the financial burden on the present population; design should be for 5 to 10 years rather than 15 to 20 years.

The plant must be design to treat the raw water available. Because all water are different, specific treatment objectives must be determined before initiating the design of plants.

The organization operating and maintaining the facility should have the capacity to recruit, train, and retain the various level of personal required for continuous operation.

Water Quality Criteria

Enteric diseases are the predominant health hazard arising from drinking water in developing countries, standard for water quality should concentrate on microbiological quality.

A safe and portable drinking water should conform to the following water quality characteristics. It should be

Free from pathogenic organism.

Low in concentration of compounds that are acutely toxic or that have serious long term effects such as lead.

Clear.

No saline (salty)

Free of compounds that cause an offensive taste or odor.

Noncorrosive nor should it cause encrustation of piping or staining of clothes.

Choice of Source

The selection of the source determines the adequacy, reliability, and quality of the water supply

The raw water quality dictates the treatment requirements.

The Location of the source also defines the energy requirement for raw water pumping, which can directly affect recurrent operational costs. Furthermore, there will be additional cost for water conveyance system.

Whenever possible, the raw water source of highest quality economically available should be selected, provided that its capacity is adequate to furnish the water supply needs of the community.

The careful selection of the source, and its protection, are the most important measures for preventing the spread of waterborne enteric disease in developing countries.

The American Society of Civil Engineers (1969) has characterized water sources for portable supplies according to water quality, using parameters of biochemical oxygen demand (BOD), coliform, pH, chlorides and fluorides but turbidity is not included because it is easily removed in treatment.

	Excellent Source	Good Source	Poor Source	Reject able Source	Remarks
Average BOD (5 days)mg/L	0.75 to 1.5	1.5 to 2.5	2.5 to 4	> 4	
Average coliform, Most probable Number (MPN) Per 100 ml	50 to 100	100 to 5000	5000 to 20,000	> 20,000	
pH	6 to 8.5	5 to 6 8.5 to 9	3.8 to 5 9 to 10.3	< 3.8 >10.3	
Chloride (mg/L)	<50	50 to 250	250 to 600	>600	
Fluorides (mg/L)	<1.5	1.5 to 3	>3		

Source; Adapted from ASCE, 1969

A sanitary survey of potential drinking water source s for a community is an essential Step in source selection.

The survey should be conducted in sufficient detail to determine

1. **The suitability of each source, based upon its adequacy, reliability, and its actual and potential for contamination.**

2, Treatment required before the water can be considered acceptable. Physical, bacteriological, and chemical analyses can, in additional, be helpful in providing useful information about the source and the conditions under which it will be developed.

CHOICE OF TREATMENT PROCESS

The broad choice available in water treatment make it possible to produce virtually any desired quality of finished water from any but the most polluted source , therefore economic and operational considerations become the limiting constraints in selection of the treatment.

A treatment plant may consist of many processes, including pretreatment, chemical coagulation, rapid mixing, flocculation, sedimentation, filtration and disinfection. However, raw water quality varies from place to place and , in any one place, from season to season and the resources for construction and operation vary from place to place, so the treatment selected must be based on the particular situation;

- Treated water specification
- Raw water quality and its variations.
- Local constraints and limitation of capital.
- Availability of skilled and unskilled labor.
- Availability of local codes, drinking water standards and specifications for materials.

PRETREATMENT

Appropriate pretreatment during periods of excessive turbidity may reduce the load on subsequent treatment units and yield substantial saving on overall operating cost especially for chemicals.

Pretreatment	Turbidity Range (NTU)
Plain Sedimentation	20 to 100
Storage	>1000
Roughing filtration	20 to 150

Conventional Methods of Pretreatment.
Source ; Adapted from Huisman and Wood, 1974

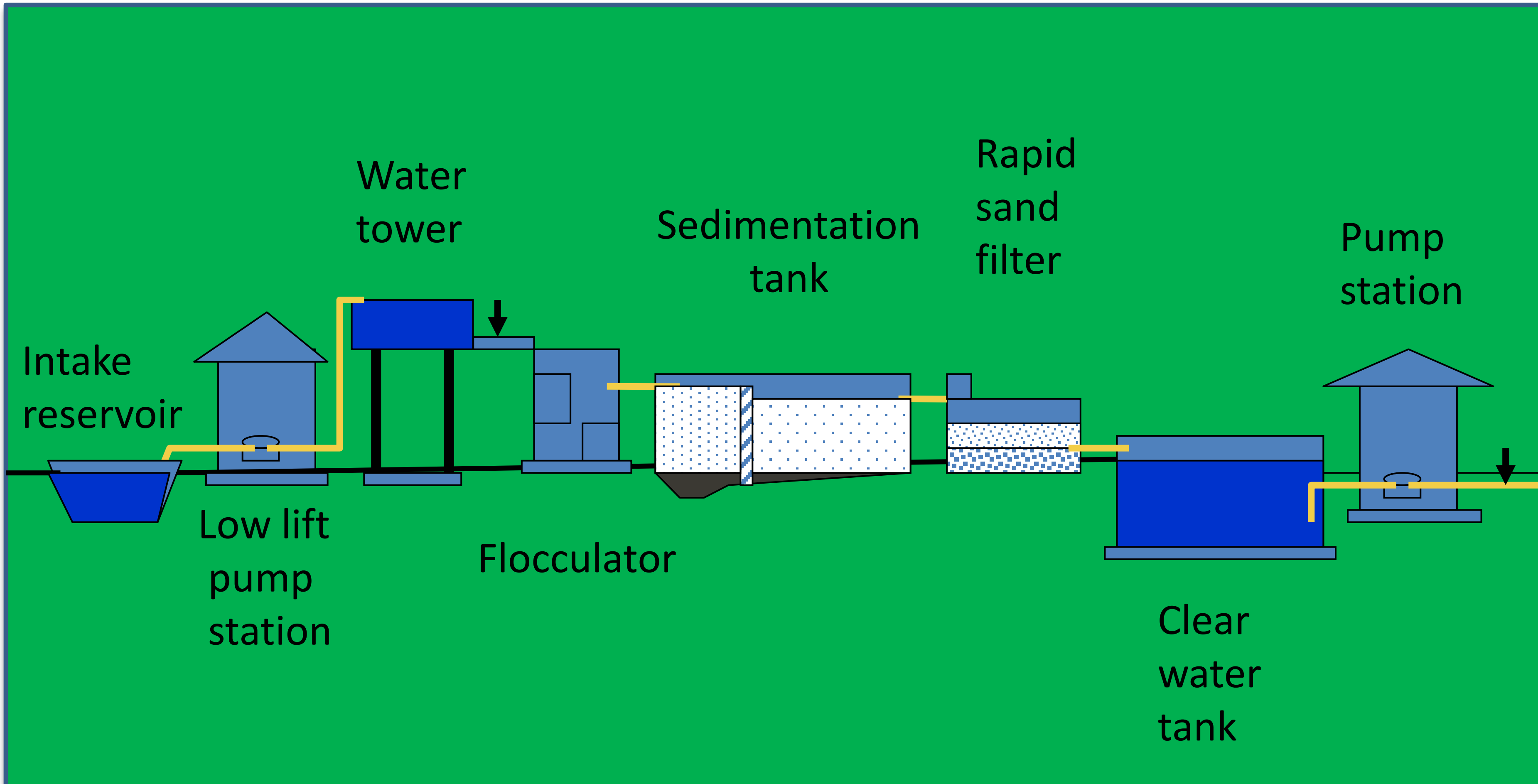
Plain sedimentation is quite effective in tropical developing countries for the following reasons;
The turbidity in rivers can be attributed largely to soil erosion, the silt being settle.
The higher temperatures in these countries improve the sediment process by lowering the viscosity of the water. Experience has shown that water of high turbidity is clarified more effectively than water of low turbidity.

Design Criteria for Plain Sedimentation Basin

Parameter	Range of values
Detention time (hr)	0.5 to 3
Surface loading (m/hr)	20 to 80
Depth of the basin (m)	1.5 to 3.5
Length/width ratio	4:1 to 6:1
Length/depth ratio	5:1 to 20:1

Pre-sedimentation Basin and Low Lift Pump for Aeration and Create Overflow Weir

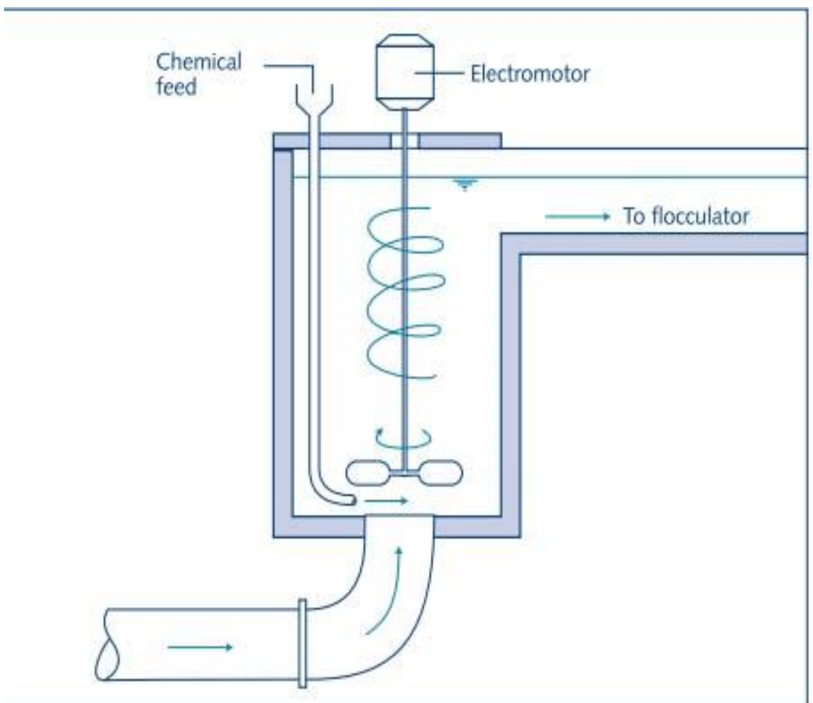
Longitudinal profile of water treatment plant

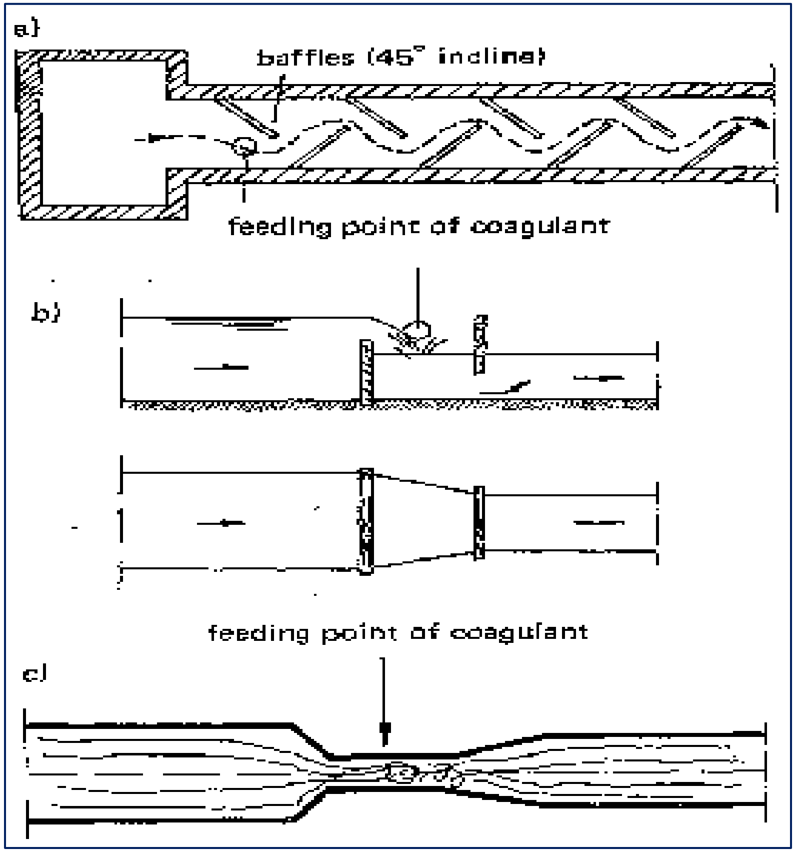


COAGULANT RAPID MIXING DEVICE SELECTION.

The function of a rapid mix system is to disperse the coagulant uniformly throughout the entire mass of water with maximum possible rapidity in order to ensure that coagulation process is as effective as possible. The chemicals must be thoroughly dispersed in the raw water in a fraction of a second, and the stagnant zones of conventional mixers should be avoided.

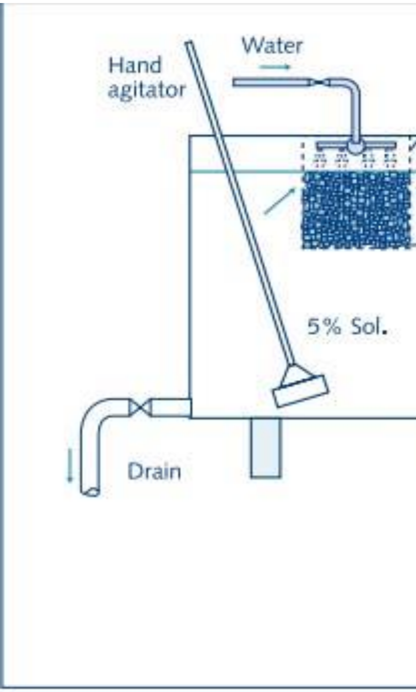
There are two types of rapid mixing devices namely, mechanical and hydraulic rapid mixing.

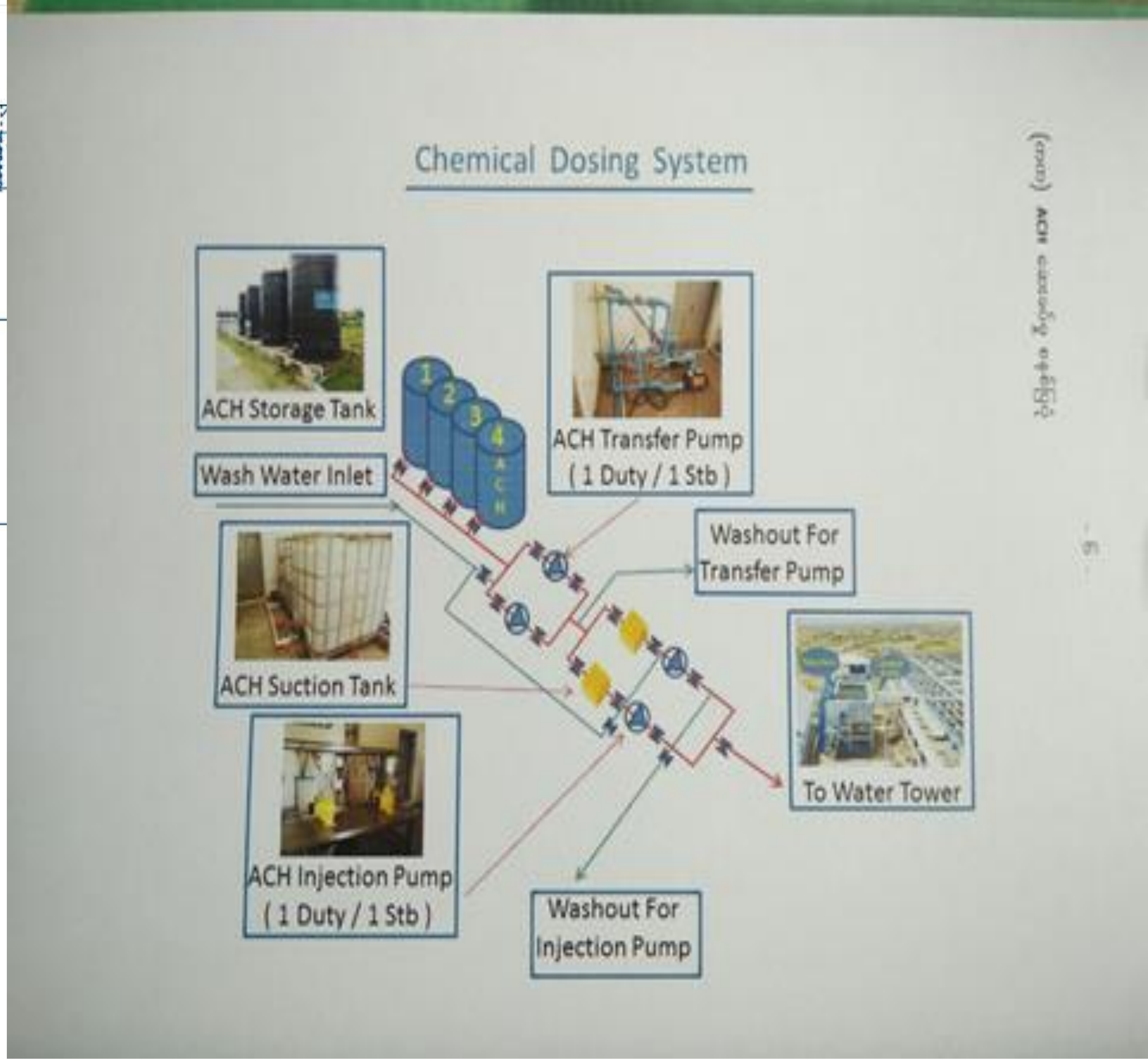




Major technical advantages of mechanical device are that mixing is not a function of flow and they are flexible in adjusting the degree of turbulence to suit particular treatment needs. However, this advantage is of little consequence in place where the equipment cannot be kept in repair and where skilled operators are unavailable to make necessary adjustment.

Hydraulic rapid mixers are design for either of two types of flow conditions namely, open channel flow or pressure flow in pipes. When feasible, open channel flow in gravity channel is preferred, as design eliminate costly pipes and fittings and can reduce the total capital cost of the plant. Moreover, rapid mixer in open channels relatively simple and have their component parts exposed and accessible for easy operation and maintenance.


Hand agitator
Water
5% Sol.
Drain


Chemical Dosing System
ACH Storage Tank
Wash Water Inlet
ACH Suction Tank
ACH Injection Pump
(1 Duty / 1 Stb)
ACH Transfer Pump
(1 Duty / 1 Stb)
Washout For Transfer Pump
To Water Tower
Washout For Injection Pump

Flocculation

Flocculation follows directly after the rapid mix process and it is the process of gentle and continuous agitation, during which suspended particles in the water coalesce into larger masses so that they may be removed from the water in subsequent treatment processes.

There are two kinds of flocculators namely mechanical flocculator and hydraulic flocculator. The principle elements of mechanical flocculators systems agitator impellers, drive motors, speed controllers and reducers, transmission systems, shafts and bearings. The relatively high cost and complexity of mechanical focculator system, particularly with regard to operation and maintenance, render them less suitable for developing countries.

A more practical approach is to use hydraulic flocculators that do not require mechanical equipmentor continuous power supply if gravity flow is available, and which can be built primary from concrete, brick, wood, or masonry by local labor at relative low cost. There are many types of hydraulic flocculators which are suitable to be used depend on the flow capacity, detention time and hydraulic head available. These are;

Baffle channel flocculators (horizontal and vertical flow)

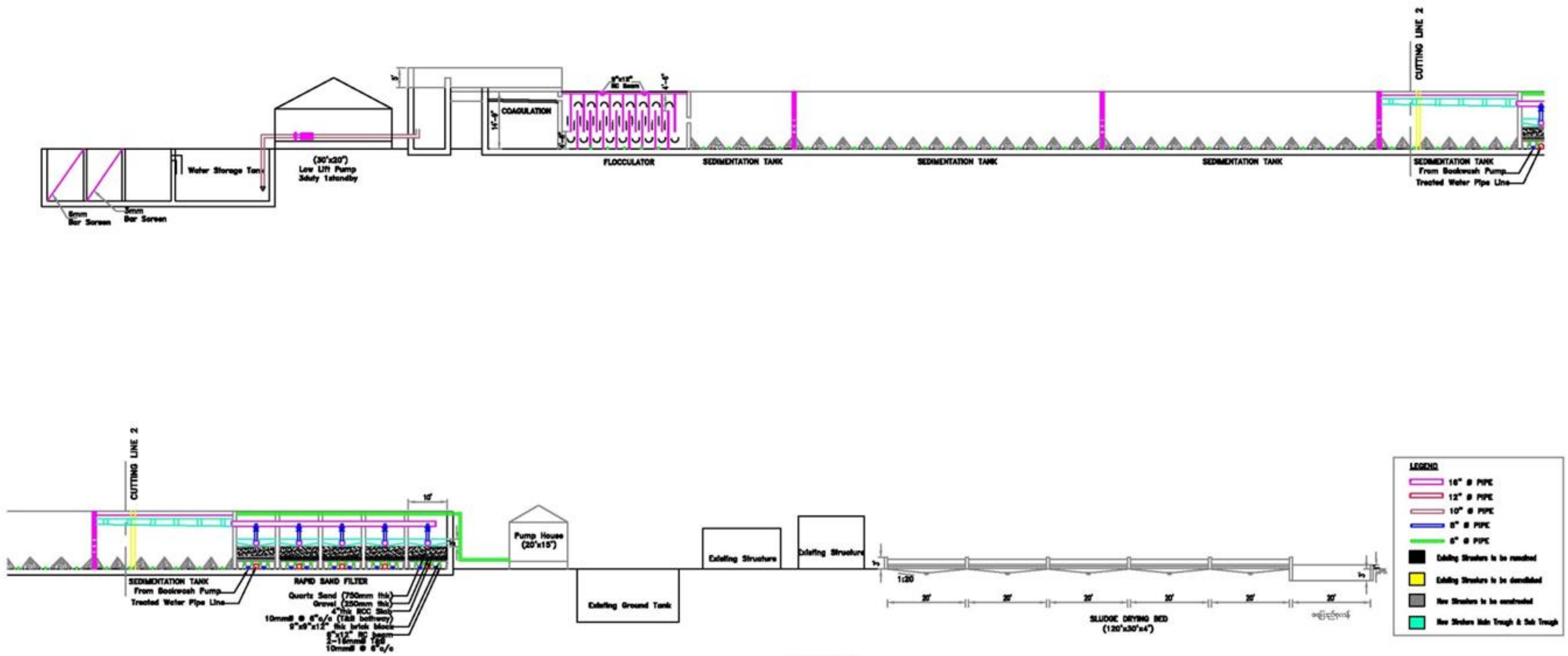
Hydraulic jet action flocculators (Heliocoidal flow, staircase type flocculator, Albama type flocculator, Gravel bed flocculators and surface Contact flocculator

မန္တလေး စည်ပင်သာယာရေးကော်မတီ (လမ်း ၆၀)

ရေတွင်းစက်ရုံအမှတ်(၄)၏လက်ရှိရေသန့်စင်စက်ရုံ အဆင့်မြှင့်တင်ခြင်းလုပ်ငန်း

UPGRADING OF EXISTING WATER TREATMENT PLANT (5MGD)

(COAGULATION, FLOCCULATOR, SEDIMENTTATION, RAPID SAND FILTER)



SECTION

AUTHENTIC WATER & WASTEWATER CO.,LTD			
Project Name	MDY WATER TREATMENT PLANT		
Drawing Title	SECTION		
Designed By	Dr.TTT	Drawn By	YMO
Scale:	1:200	Date	19.10.2016

FILTRATION

Two general types of filters are commonly used in water treatment; The Slow Sand Filter and Rapid Sand Filter.

Slow Sand Filter

Slow sand *filtration* has been an effective water treatment process for preventing the spread of gastrointestinal diseases for over 150 years, having been used first in Great Britain and later in other European countries

The basic principle of the process is very simple. Contaminated *freshwater* flows through a layer of sand, where it not only gets physically filtered but biologically treated.

RAPID FILTRATION

Rapid filters can be classified in various ways. They may be classified according to (1) the type of filter media employed, (2) the type of filter rate-control system employed, (3) the direction of flow through the bed, or (4) water whether they operate under gravity (free-surface) or pressure. In general, pressure filters are not well-suited for developing countries because they generally need to be imported. Furthermore, they require skilled operation and high-quality maintenance because the filter media cannot be monitored.

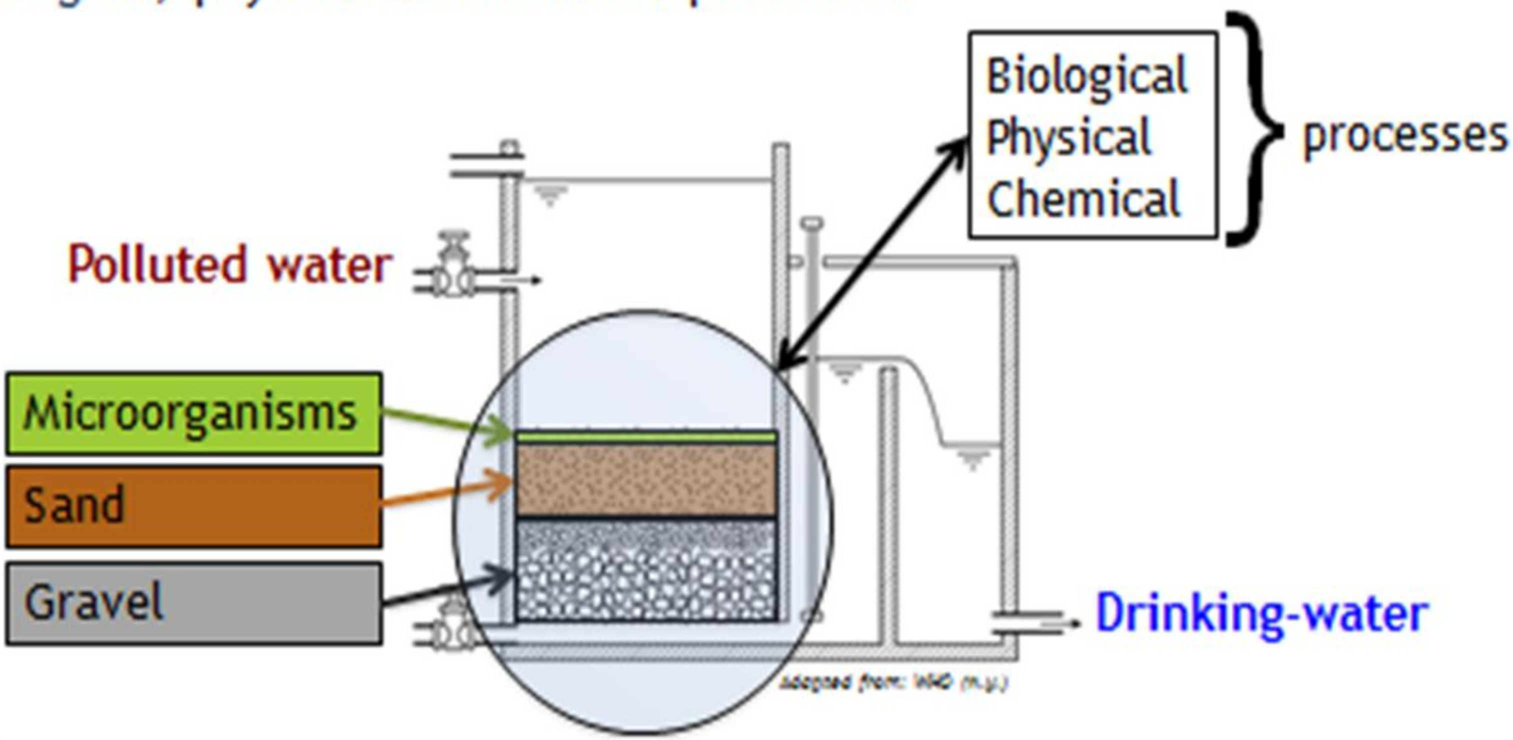
The design variables for rapid filtration include (1) filter media, (2) filter bottoms and under drains, (3) backwashing arrangements, (4) auxiliary scour wash systems, and (5) rate-control systems.

1. Concept

Simple but Effective

Working Principle

Freshwater flows through a sand-bed with a thin layer populated by microorganisms. Hereby, the water gets purified through various biological, physical and chemical processes.



Design Criteria

Recommended Number of Filter Basins

Design Flow	Recommended Number of Basins
<450 gpm	2
450 – 900 gpm	3
900 – 1,400 gpm	4
1,400 gpm – 2,100 gpm	5

Sand Gradation Criteria

Parameter	Recommended Value
Effective Diameter (d_{10})	0.15 – 0.30 mm
Uniformity Coefficient (d_{60}/ d_{10})	< 2.5
% Passing #200 sieve unwashed	< 3%
% Passing #200 sieve washed	< 0.1%

9. Slow Sand Filter Facilities Work

(1) General

One treatment plant (WTP) shall be constructed at Meakhong. The capacity of WTP is shown below.

WTP

Capacity	Gallon/hr	Galllon/day	m3/day
Meakhong Water Treatment Plant	33,750	810,000	3,645
Area of Slow Sand Filters	Length 15 m x Width 10 m x 3 nos		450 sq meters
Filtration rate			8.1 m/d(0.3375m/h)

Revised Area of SSF	Length 22 m x Width 10 m x 3 nos	660 sq meters
Filtration rate of 3 SSF operating		5.5 m/d (.23m/h)
Area of 2 SSF operating while one is under scraping		440 sq meters
Filtration rate of 2 SSF		8.28m/d(0.34 m/h)



2. Rapid sand filter (RSF)

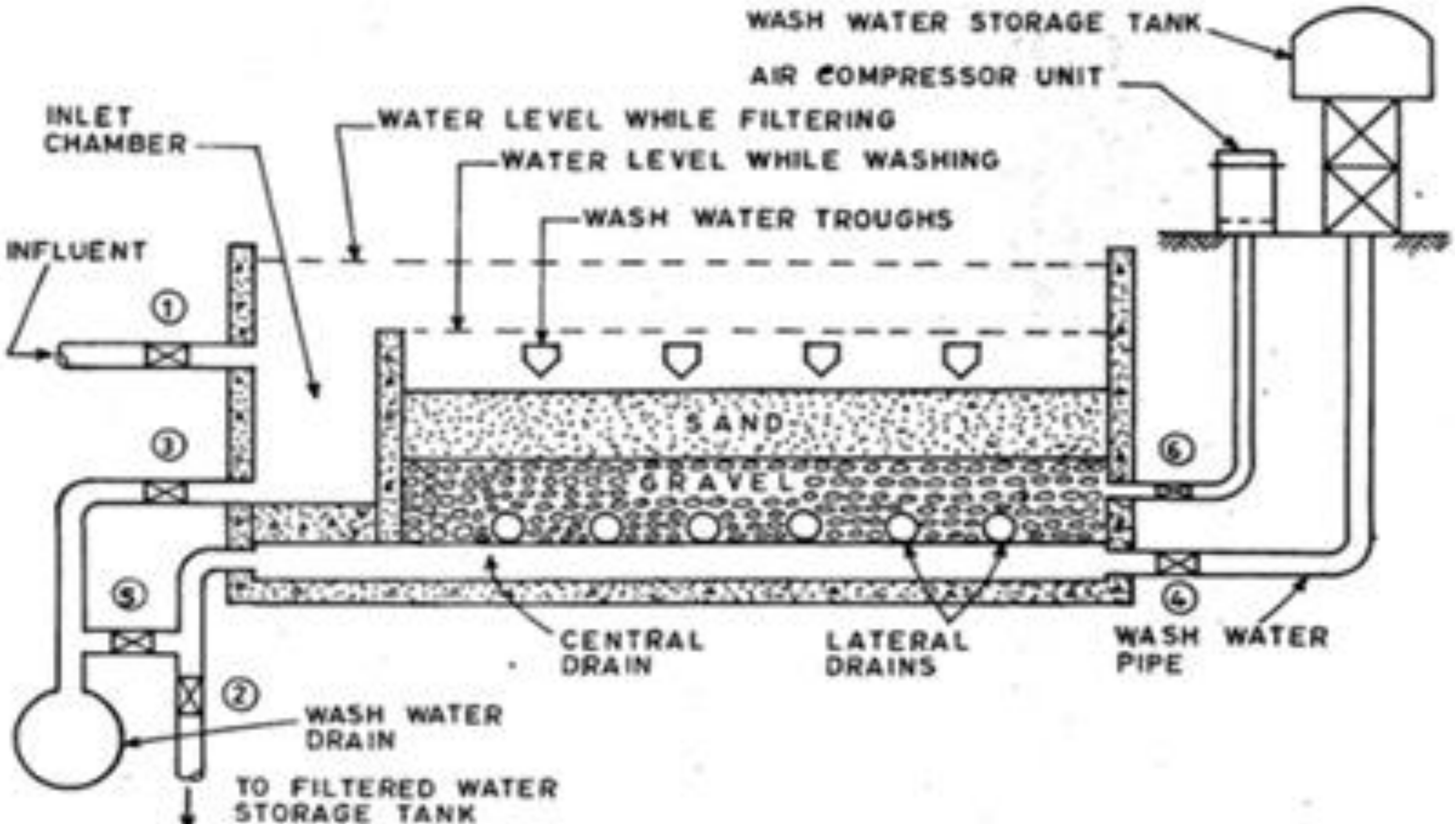


Fig 6.21Section of rapid Sand filter *(Source: Modi, 1998)*

Rapid Sand Filter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Backwash rates and times

Recommended Backwash Rates

Backwash Method	Water Wash Rate (gpm/ft^2)	Water Wash Duration (minutes)	Air Scour Rate ($scfm/ft^2$)	Air Scour Duration (minutes)
Upflow Water Wash (1step)	15–23	3–15	–	–
Upflow Low Rate Water Wash with Initial Air Scour (2 steps)				
(1) Air Scour	–	–	1–2	3–5
(2) Low Rate Water Wash	5–7.5	3–5	–	–
Upflow High Rate Water Wash with Initial Air Scour (2 steps)				
(1) Air Scour	–	–	2–5	3–5
(2) High Rate Water Wash	15–23	3–5	–	–
Concurrent Upflow Water Wash and Air Scour (2 steps)				
(1) Concurrent Air and Water First	6.3–7.5	5–10	6–8	5–10
(2) Water Wash only	6.3–15	5–10	–	–
Upflow Water Wash with Surface Wash (3 steps)				
(1) Surface Wash only	0.5–2.0	1–3	–	–
(2) Low Rate Water Wash*	5–7.5	5–10	–	–
(3) High Rate Water Wash*	15–23	1–5	–	–
*with concurrent surface wash				

(Source: AWWA and ASCE, 1998)

Water Treatment Reservoirs

Water supply sources, such as wells or water treatment plants, operate best at steady, design rates over relatively longer periods of time. However, demand in the water treatment distribution system constantly fluctuates. Most water treatment distribution systems experience short-term peak demands, which exceed the available rate of supply. Service reservoirs provide a suitable reserve of treated water to supply to the shortfall in the water treatment distribution system during the peak demand.

Service reservoirs are provided in the water treatment distribution system for the following functions:

- **To equalize the variation in hourly demand of water by the consumers to a uniform rate of supply from the source either by gravity or pumping,**
- **To maintain the desired minimum residual pressure in the distribution system,**
- **To provide the required contact time for the disinfectant added in order to achieve effective disinfection, and**
- **To facilitate carrying out repairs either to the pumping main or to pump-set without interruption to the supply of water.**

Service reservoirs can be of two types; balancing reservoir and service reservoir. Further they can be either elevated reservoir (ER), also called over head tank (OHT) or ground level reservoir (GLR), also called underground sump. ERs provide the necessary pressure in the distribution system while GLRs serve as suction sumps for pumps.

Volume of Storage Required

Duration of Supply or Pumping	Volume of Storage as percentage of daily requirement
Above 16 to 24 hours	20 to 25%
Above 12 to 16 hours	33.33%
Above 8 to 12 hours	50%
Less than 8 hours	100%

Conclusion

If some body have good Way of Thinking for Water Treatment System, a Treatability Study will be assist to design the Perfect Design of Water Treatment for Certain Situation.

The purpose of a treatability study is to observe and measure the effectiveness of specific treatment methods on samples of water or wastewater to verify that the treatment method is feasible before changing process operations or changing to a new treatment process.

The treatability study results are used to determine or verify the best approach to treatment, such as chemical type and dosage, equipment type and size, or types of treatment process units to purchased or construct.

Treatability studies can be conducted using several treatment options for comparison of results and making cost estimates.

Comparison of Types of intake Structures

Intake Type	Relative Cost	Operational Flexibility	Advantages	Disadvantages
Floating	Low to moderate	Can withdraw with water from a fixed depth below the water surface	Relatively low cost, can be fabricated off-site and assembled on-site. Can operate over a small range of water surface elevations.	Must be securely anchored to prevent damage from wind and wave action. Can only draw water from a fixed depth below the water surface.
Submerged	Low	Can withdraw water from a fixed elevation	Simple, easy, and relatively inexpensive to construct	Can draw water only from a fixed elevation near the bottom where poor quality water is usually located. Grating is inaccessible, so it is difficult to remove lodged debris and perform normal maintenance.
Tower	Moderate to high	With multiple gates can withdraw water from different elevations to obtain optimum water quality.	Can withdraw optimum water quality through multiple gates. Can be located in deep water when constructed prior to reservoir completion. Gates and water conduit can be dewatered and maintained.	More expensive to construct. Located offshore and may be less accessible than shore intakes.
Shore	Moderate to high	With multiple gates can withdraw water from different elevations to obtain optimum water quality.	Accessible for maintenance. If constructed with multiple gates, optimum water quality can be selected. Relatively easy and inexpensive to construct in existing water bodies	More expensive than floating or submerged structured. May require dredging or excavating a channel to deep water.
Pier	Moderate	Can withdraw form a fixed elevation only, unless pumps are set at different depths.	Relatively easy to construct in existing water bodies. Accessible for maintenance.	Can only withdraw water from an elevation fixed by setting depth of pump. May not be able to obtain optimum water quality.

Summary of Various Operations and Processes Considered in the Design of a Water Treatment Plant

Unit No.	Unit Operation and Process	Description and Principal Applications
A	Trash rack (UO)	Provided at the intake gate for removal of floating debris and ice.
B	Coarse screen or fish screen (UO)	Mechanically cleaned screens provided at the intake gate or in the sump well ahead of pumps. Protect fish and remove small solids and frazil ice.
C	Microstrainer (UO)	Removes algae and plankton from the raw water.
D	Aeration (UP)	Strips and oxidizes taste and odor causing volatile organics and gases and oxidizes iron and manganese. Aeration systems include gravity aerator, spray aerator, diffuser, and mechanical aerator. Aeration in the reservoir helps destratification and T & O control.
E	Mixing (UO)	Provides uniform and rapid distribution of chemicals and gases into the water.
F	Pre-oxidation (UP)	Application of oxidizing agents such as ozone, potassium permanganate, and chlorine compounds in raw water and in other treatment units; retards microbiological growth and oxidizes taste, odor and color causing compounds.
G	Coagulation (UP)	Coagulation is the addition and rapid mixing of coagulant resulting in destabilization of the colloidal particle and formation of pin-head floc.
H	Flocculation (UO)	Flocculation is aggregation of destabilized turbidity and color causing particles to form a rapid-settling floc.
I	Sedimentation (UO)	Gravity separation of suspended solids or floc produced in treatment processes. It is used after coagulation and flocculation and chemical precipitation.
J	Filtration (UO)	Removal of particulate matter by percolation through granular media. Filtration media may be single (sand, anthracite, etc.), mixed, or multilayered.

Summary of Various Unit Operations and Processes Considered in the Design of a Water Treatment Plant (continued)

Unit No.	Unit Operation and Process	Description and Principal Applications
K	Chemical precipitation (UP)	Addition of chemicals in water transforms specific dissolved solids into insoluble form. Removal of hardness, iron, and manganese, and many heavy metals is achieved by chemical precipitation.
L	Lime-soda ash (UP)	Lime-soda ash is a chemical precipitation process used for water softening. Excess amounts of calcium and magnesium ions are precipitated from water.
M	Recarbonation (UP)	Restores the chemical balance of water after softening by lime-soda process. Bubbling of carbon dioxide converts supersaturated forms of Ca and Mg into more solute forms. The pH is lowered.
N	Activated carbon adsorption (UP)	Removes taste and odor causing compounds, chlorinated compounds, and many metals. It is used as powdered activated carbon (PAC) at the intake or as a granular activated carbon (GAC) bed after filtration.
O	Activated alumina	Removes certain species from water by hydrolytic adsorption. Fluoride, phosphate, arsenic and selenium have been effectively removed by activated alumina.
P	Disinfection (UP)	Destroys disease-causing organisms in water supply. Disinfection is achieved by ultraviolet radiation and by oxidative chemicals such as chlorine, bromine, iodine, potassium permanganate, and ozone, chlorine being the most commonly used chemical.
Q	Ammoniation (UP)	Ammonia converts free chlorine residual to chloramines. In this form, chlorine is less reactive, lasts longer, and has less tendency to combine with organic compounds, thus reducing taste and odors and THM formation.
R	Fluoridation (UP)	Sodium fluoride, sodium siiicofluoride, and hydrofluosilicic acid may be added in finished water to produce water that has optimum fluoride level for control of tooth decay.

Treatment Desired and Process Selection

Contaminant Removal	Process	Remarks
Turbidity	a. In-line filtration (G + J) b. Direct filtration (G + H + J) c. Conventional (G + H + I + J)	-Applicable to water having low turbidity and color. -Applicable to water having low-to-medium turbidity and low-to-medium color. -Applicable to low and high turbidity and color.
Algae and plankton	a. Microstrainer (C) b. Conventional (G + H + I +J)	- Microstrainers will not handle silt, sand, and other abrasive material. - High population of algae and plankton are difficult to coagulate. They usually float.
Color	a. Oxidation (ozone, chlorine, chlorine dioxide, potassium permanganate) (F) b. Low PH coagulation (G + H) c. Adsorption (N) d. Adsorption (N/GAC) e. Ion-exchange (J + T1)	-Applicable to water having low color. -Applicable to water having low color to high. (Alum performs better than iron salts.) -Applicable to water having low-to-moderate color episodes. -Applicable to water having moderate-to- low-level soluble color for routine color control. -Synthetic resin bed after filtration removes soluble color of industrial origin.
Iron and manganese	a. Oxiation (D + F + I)	-Iron and manganese are removed by oxidation and precipitation.

Treatment Desired and Process Selection (continued)

Contaminant Removal	Process	Remarks
	b. Precipitation (D + K) c. Conventional (G + H + I) d. Ion exchange (T1)	-Iron and manganese are precipitated by aeration at high plumbing pH. Lime is generally used to raise pH. -Iron and manganese are removed by conventional coagulation-flocculation. -Selective ion exchange resins are generally used for removal of fe and Mn for ground waters
Taste and odor (T & O)	a. Oxidation (D or F) b. adsorption (N/PAC or GAC)	-Source control prevents formation and reaching of T& O compounds into the reservoirs. Aquatic weeds and algae control reduce T & O causing compounds. -Aeration in the reservoir, at the head of plant, and in treatment units may reduce T & O. Oxidation with free chlorine may cause THM for mation. -PAC is used for moderate and intermittent T&O episodes. GAC is used for prolonged T&O due to industrial sources.
Hardness	a. Precipitation (L) b. Ion exchange (T1)	-Used for medium-to-hard water. -Zeolite beds remove divalent cations but add Na+. Cation exchangers remove all cations.
Pathogens	a. Disinfection (P)	-Free chlorine enhances THM formation potential.
THM	a. Enhanced coagulation (G + K + H + I)	-Efficient removal of precursors (organics) by low pH coagulation or in conjunction with softening.

Treatment Desired and Process Selection (continued)

Contaminant Removal	Process	Remarks
	b. Adsorption (N) c. Aeration (D) d. Pre-oxidation (F)	-PAC and GAC will remove TOC, precursors, and THM. -Aeration removes organics. -Pre-oxidation of precursors by O_3, H_2, O_2, $KMNO_4$, chloramines, or chlorine dioxide. Avoids excessive free chlorine residual.
Nitrate	a. Denitrification (S) b. Ion exchange (T1) c. Demineralization (T2)	-Biological denitrification provides an effective method of NO_3 removal. -Selective resins are available. -Demineralization with membranes removes NO_3 with other ions. Deionization with RO fluoride. High concentrations of fluoride in drinking water cause fluorosis and toxicity.
Fluoride	a. Activated alumina (O)	-Activated alumina selectively removes F.
Arsenic	a. Enhanced (G + H + I) b. Activated alumina (O) c. Demineralization (T2)	-Removes by precipitation of arsenate As(V), at low pH with coagulation and at high pH with partial softening with lime. -Bed is effective in removing arsenic from groundwater. -Arsenic is removed with other ions by membrane process.


Thank You