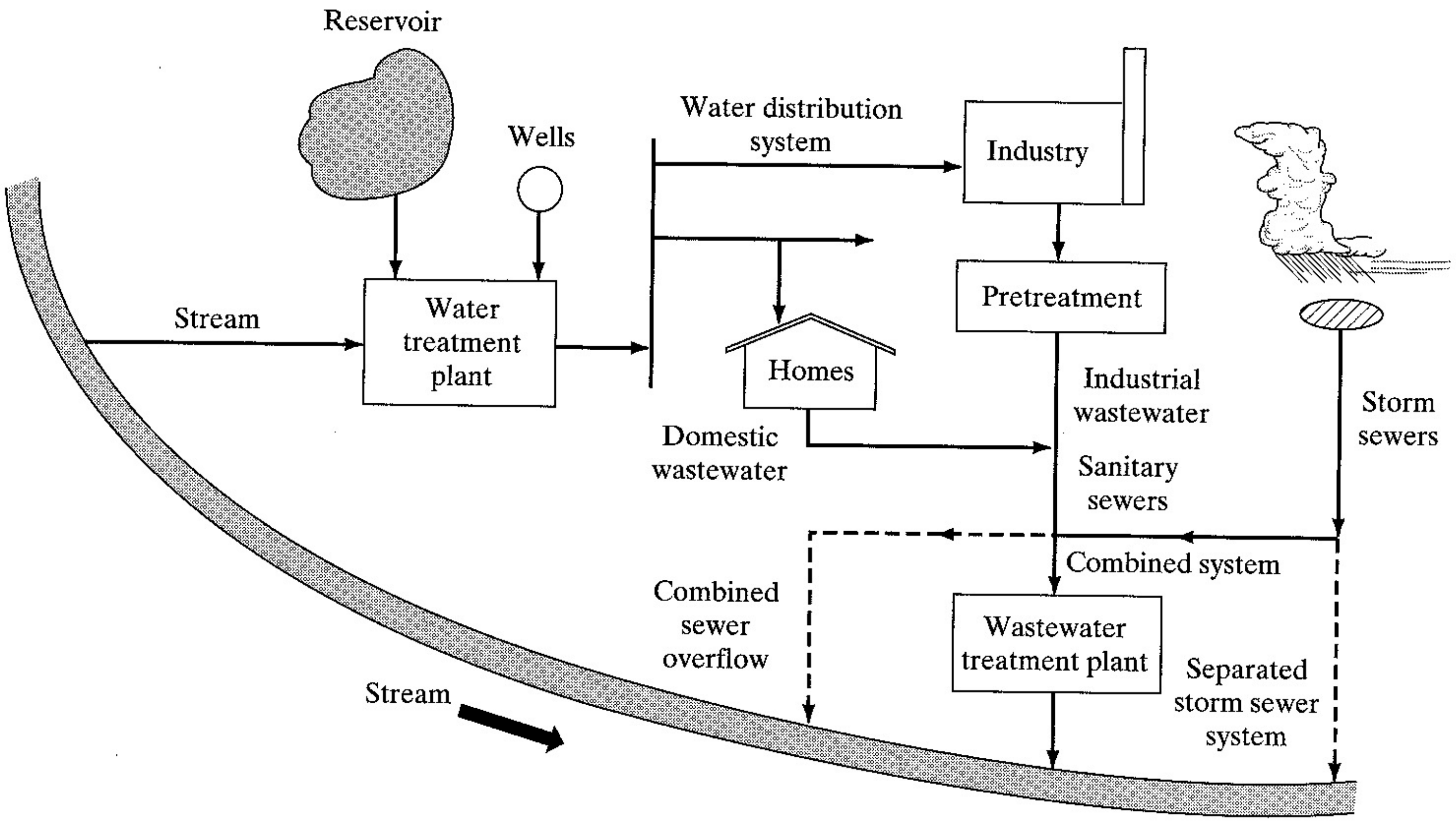
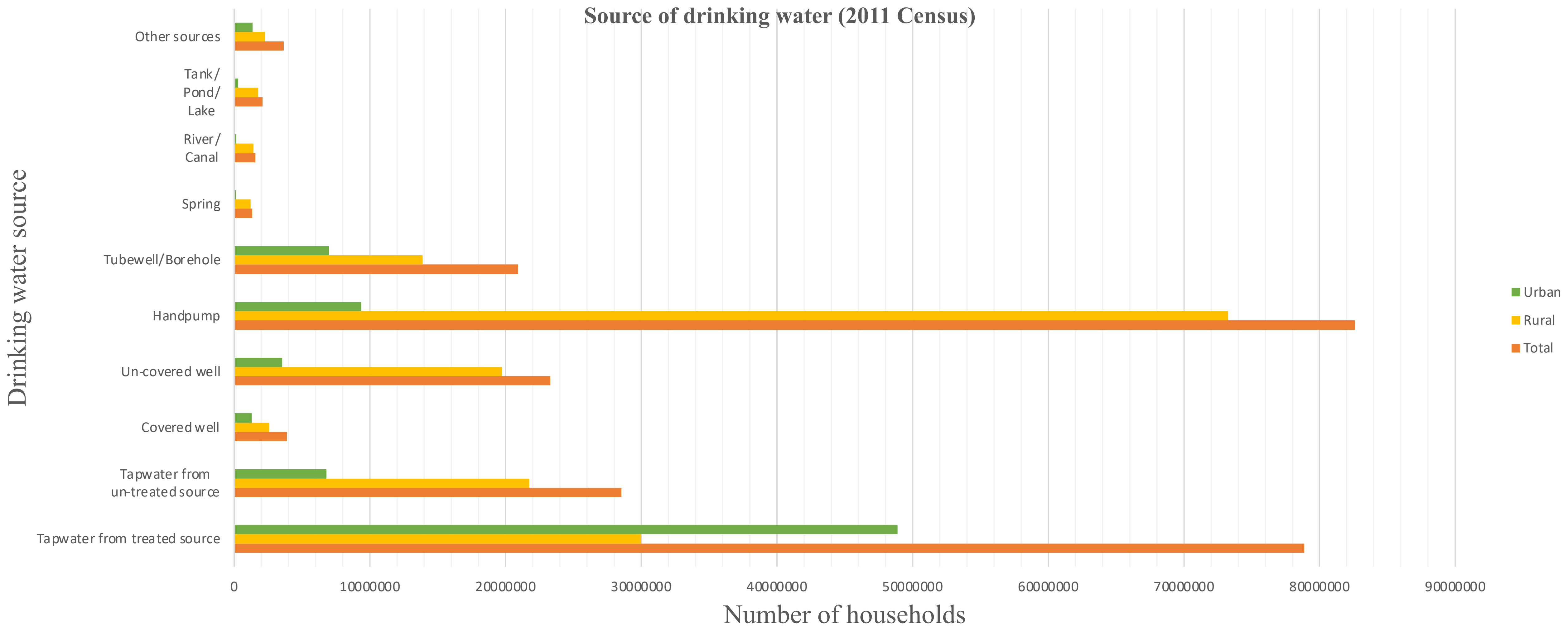
Water and Wastewater treatment

Engineered Water Systems



Predominance of water from untreated sources and reliance on groundwater



http://www.censusindia.gov.in/2011census/Hlo-series/HH06.html

Steps	Surface Water	Hard Groundwater
1	Screening/Microstrainer	Aeration
2	Pre-Sedimentation/Pre-Chlorination	Oxidation/Prechlorination
3	Rapid Mixing (Coagulation Tank)	Rapid Mixing (Lime & Soda Addition
4	Slow Mixing (Flocculation Tank)	Precipitation
5	Sedimentation	Sedimentation
6	Filtration	Recarbonation
7	Adsorption Optional for organics removal for better taste/color/odor)	Filtration
8	Disinfection	Disinfection

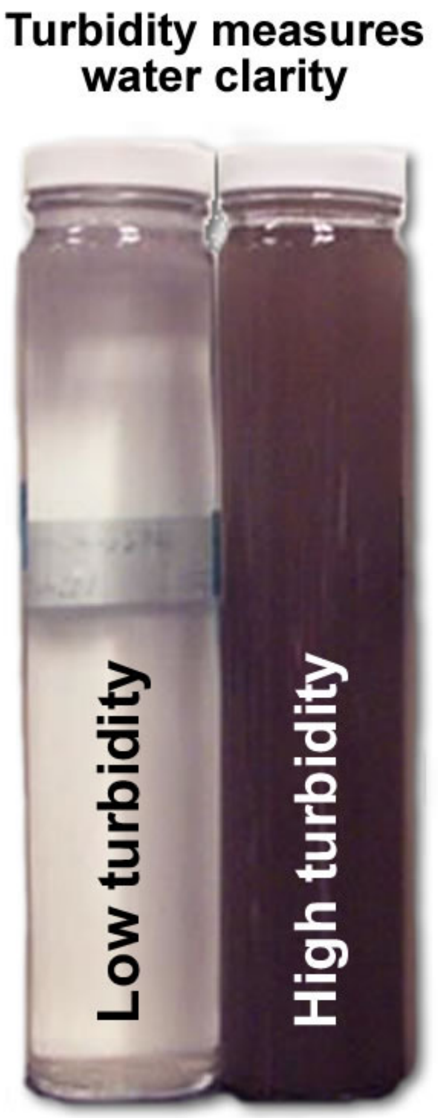
Surface Water Treatment

Primary objectives are to

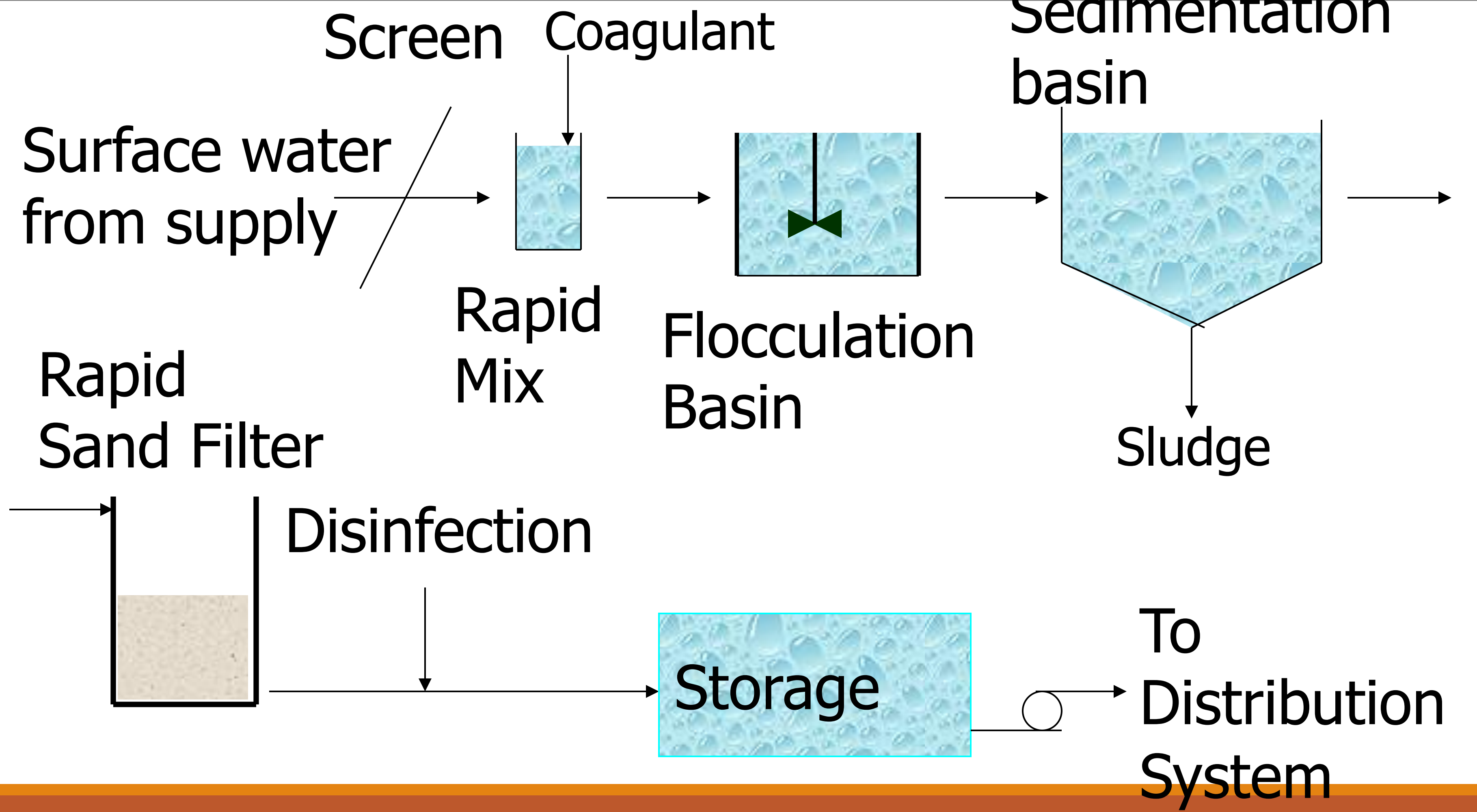
- Remove suspended material (turbidity) and color
- Eliminate pathogenic organisms
- Also, quite a few Indian rivers have such high organic content from human act remove considerable levels of organic content (E.g. Yamuna, d/s of Delhi) too

Treatment technologies largely based on

- Coagulation and flocculation
- Sedimentation
- Filtration
- Disinfection



Surface Water Treatment



Coagulation/Flocculation/Physical Removal

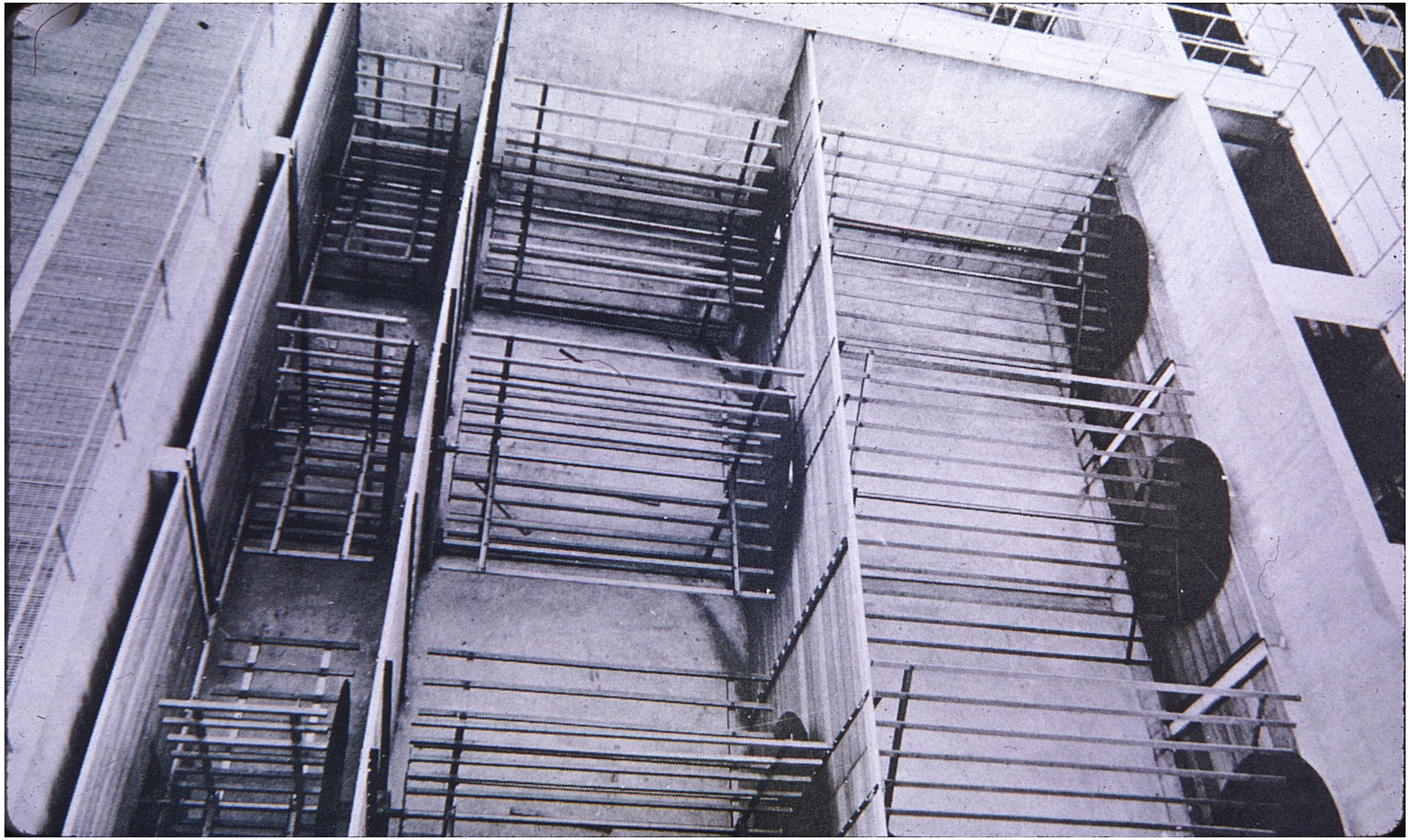
Designed to remove

- Microorganisms
- Toxic compounds that are sorbed to particles
- NOM (because it is a precursor of DBPs)

Designed to make the water more palatable

Coagulation = Charge reduction

Flocculation = Contact of particles



Paddle Mixers in Left Chamber
and Flocculators in Right Two Chambers

Coagulation and Flocculation

Goal: To alter the surface charge of the particles that contribute to color and turbidity so that the particles adhere to one another and are capable of settling by gravity

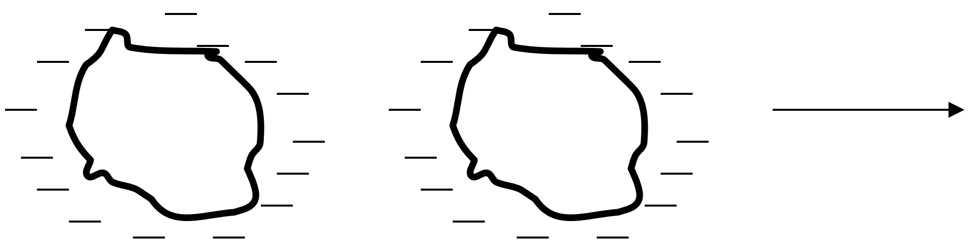
Colloids

Small particles (0.001 to 1 μm)

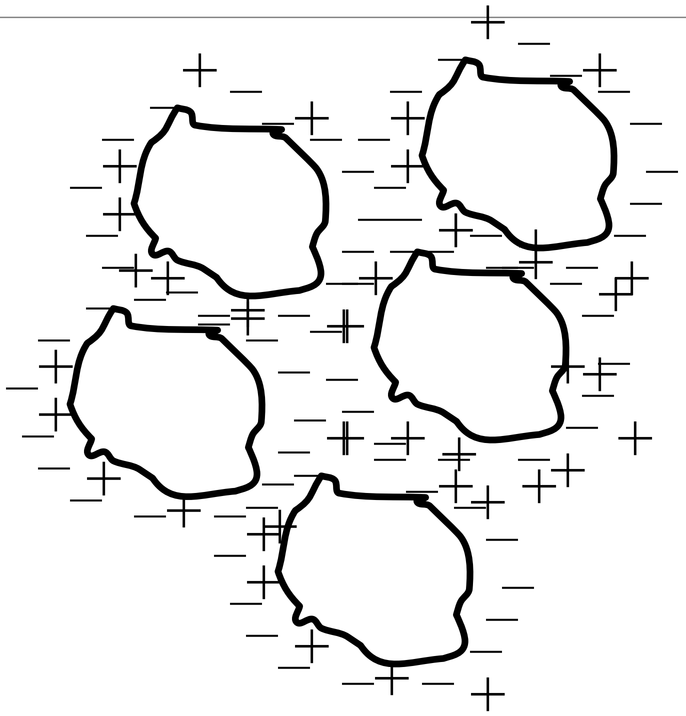
Usually negatively charged

Particles repel so suspension is considered stable

Coagulation and Flocculation



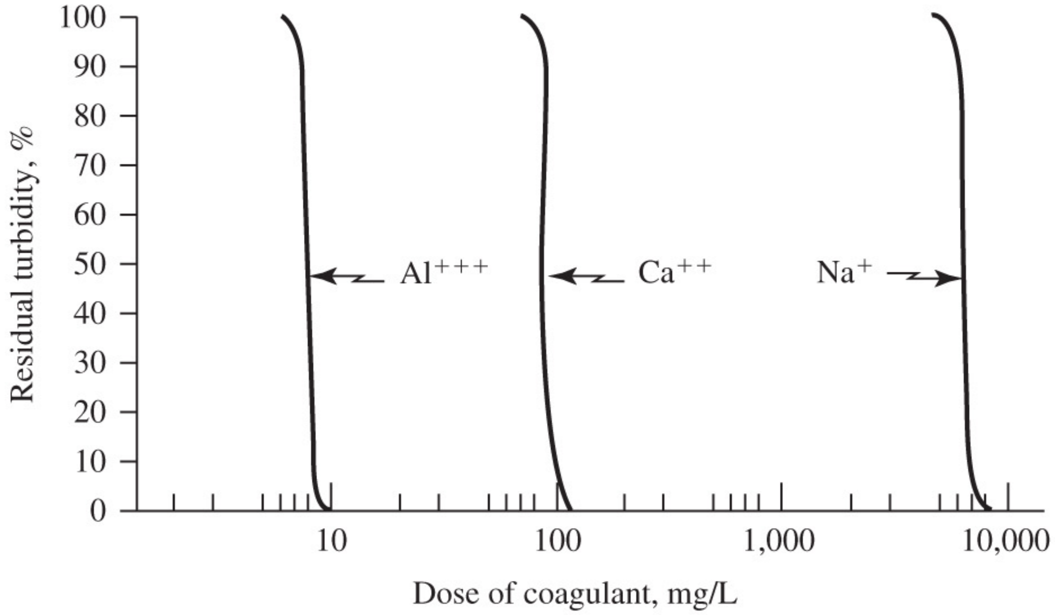
Colloidal particles
(0.001 - 1 μm)

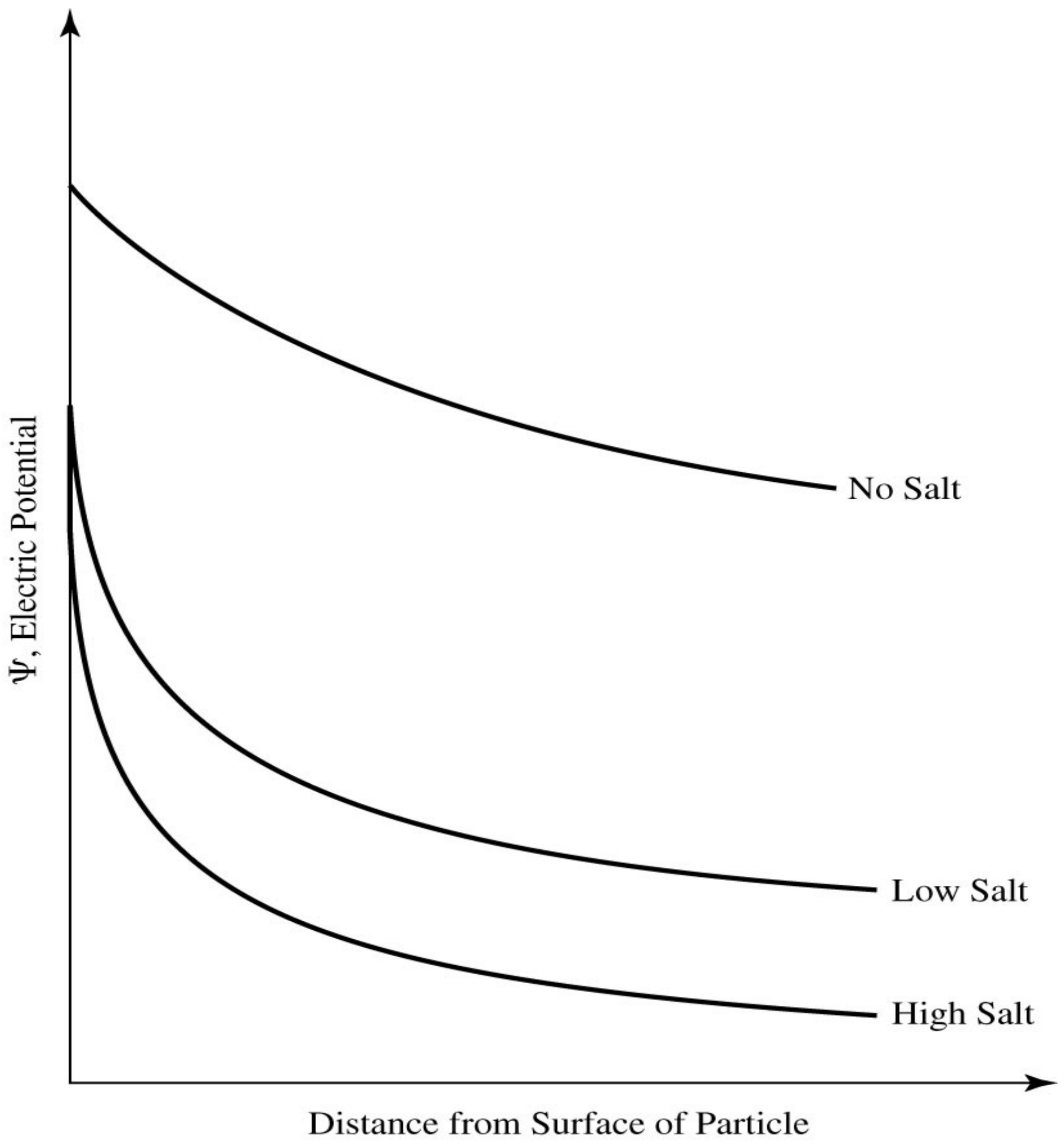


floc
(1 - 100 μm)

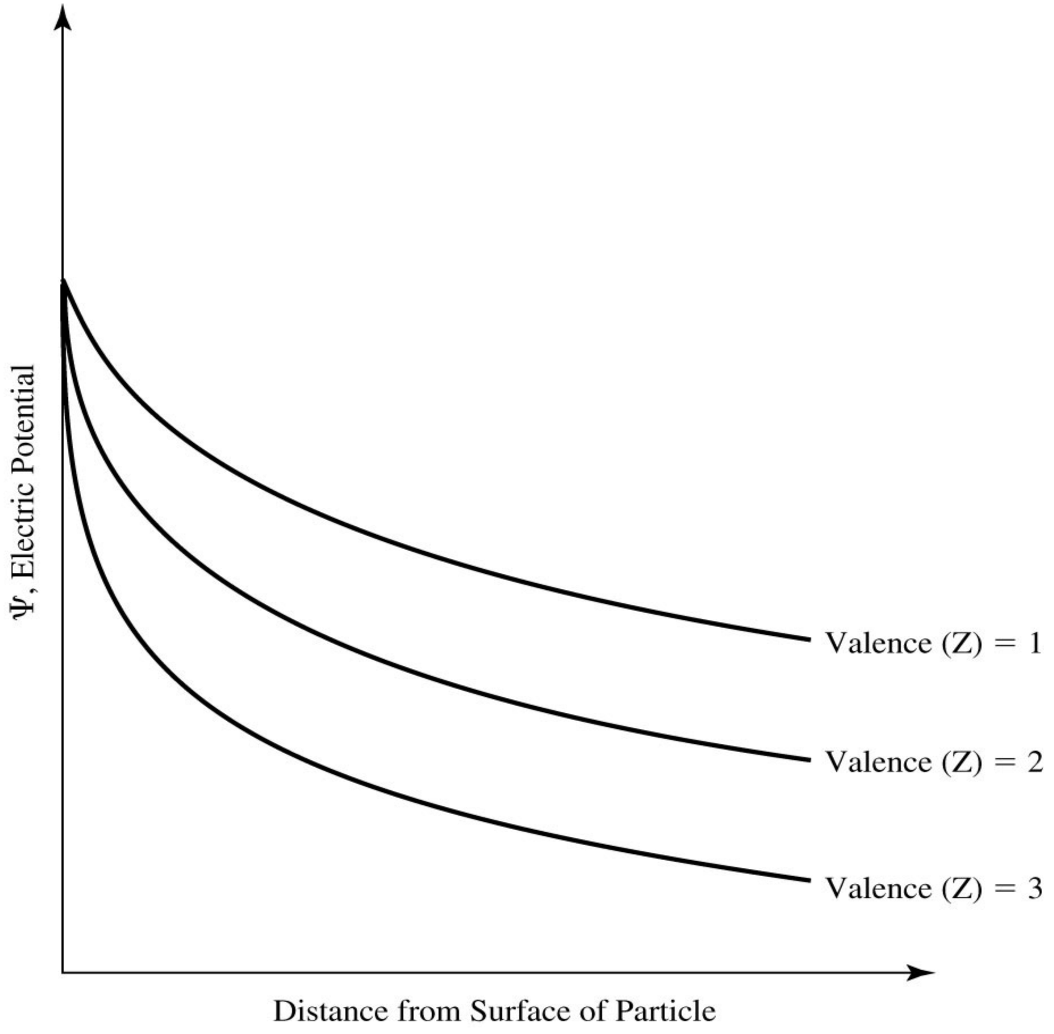
Coagulant

- Non-toxic and relatively inexpensive
- Insoluble in neutral pH range - do not want high concentrations of metals left in treated water.
- High Charge density
- Common coagulants
  - Alum: $Al_2(SO_4)_3 \cdot 14H_2O$,
  - Ferric chloride: $FeCl_3$,
  - Ferric sulfate: $FeSO_4$,
  - Polyelectrolyte

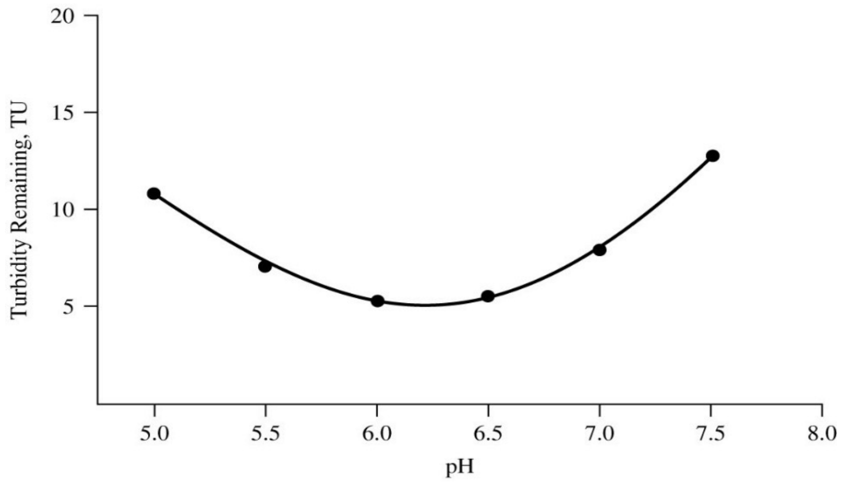


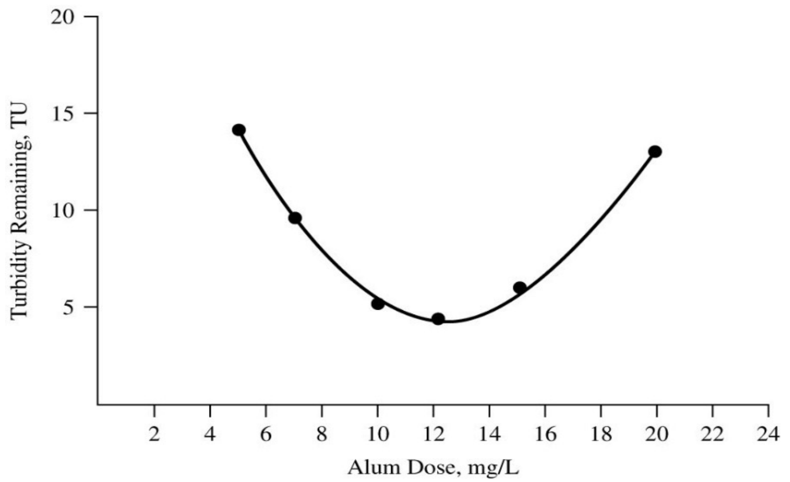


Effect of salt concentration on electric potential



Effect of valence on electric potential





Results from jar test

Rapid Mixing

Used to blend chemicals and water being treated

Retention time from 10 - 30 sec.

Mechanical mixing using vertical-shaft impeller in tank with baffles

Flocculation

Paddle units rotate slowly, usually <1 rpm

Velocity of water: 0.5 - 1.5 ft/sec

Detention time of at least 20 min

Sedimentation/Settling

Following flocculation, the water then flows into the settling basins

Water is nearly quiescent – low flow with little turbulence

Water resides for at least 3 hours and the flocs settle out and collect at the bottom.

Filtration

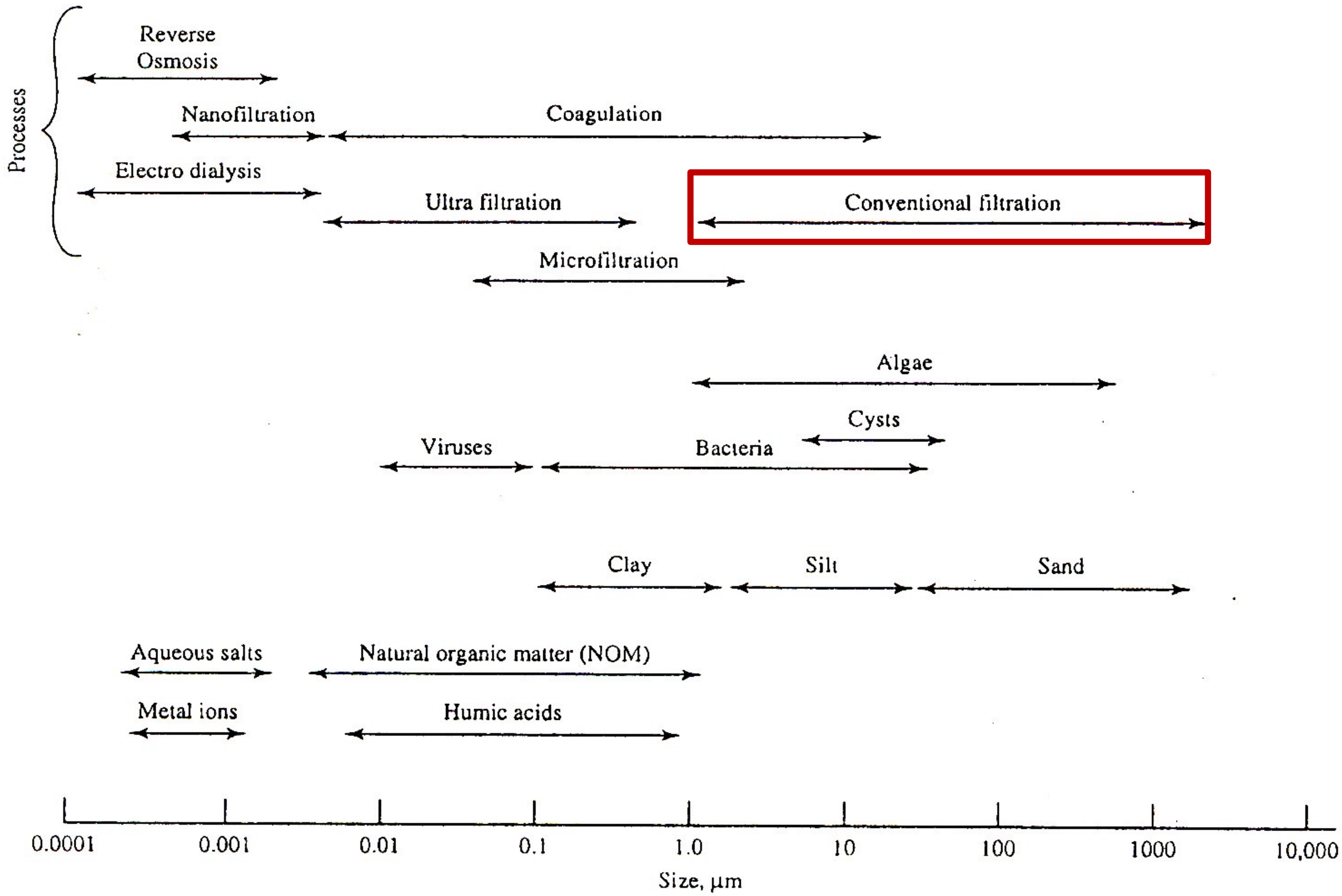
The final step in removing particles is filtration.

Removal of those particles that are too small to be effectively removed during sedimentation

Multiple removal mechanisms depending on design

Sedimentation effluent: 1 - 10 NTU

Desired effluent level: <0.3 NTU



Processes
Reverse Osmosis
Nanofiltration
Coagulation
Electro dialysis
Ultra filtration
Conventional filtration
Microfiltration
Algae
Cysts
Viruses
Bacteria
Clay
Silt
Sand
Aqueous salts
Natural organic matter (NOM)
Metal ions
Humic acids
0.0001
0.001
0.01
0.1
1.0
10
100
1000
10,000
Size, μm

Removal Mechanism of filtration

Mechanical Straining of particles. Size of particle > void space (slow sand filter)

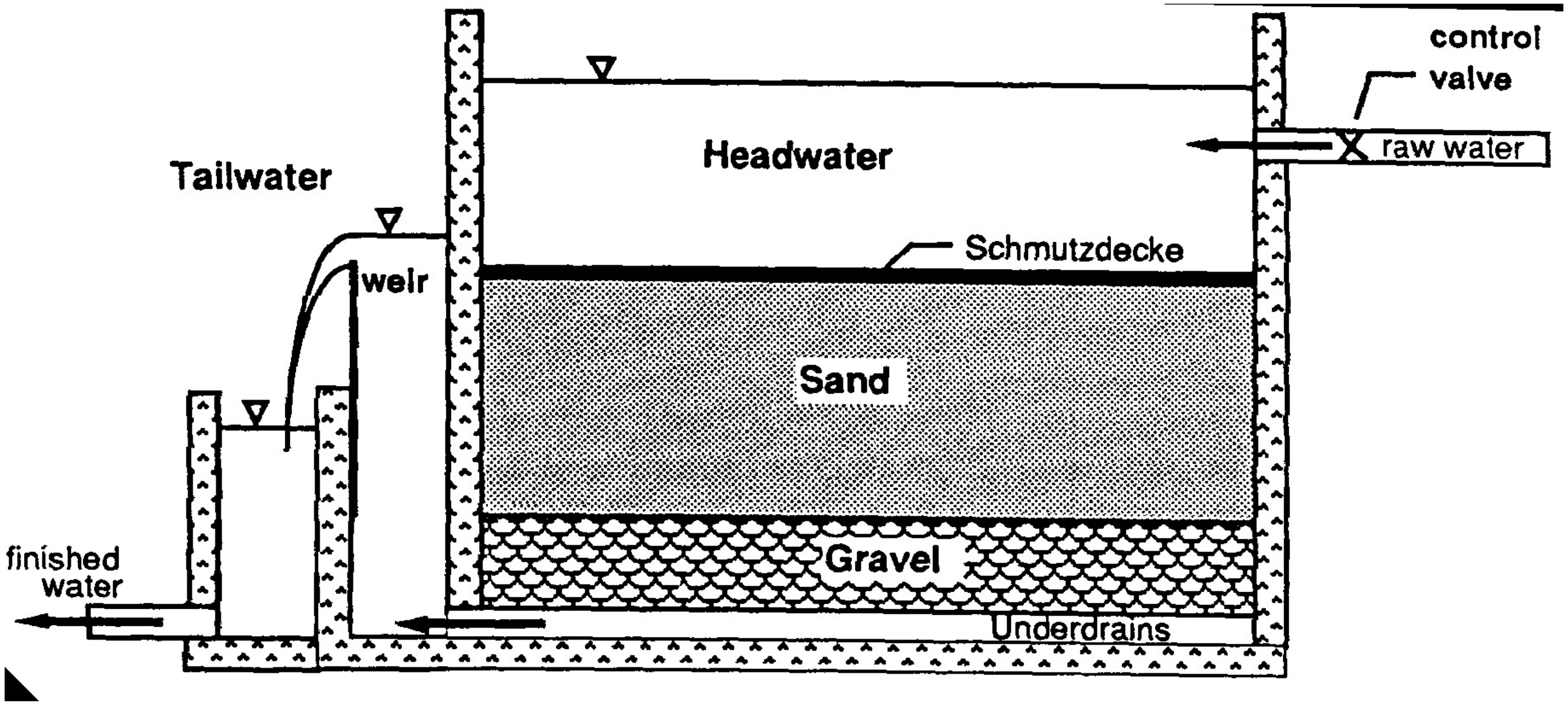
Biological mechanism: impurities removal by microorganisms on the top filter layer (slow sand filter)

Adsorption to filter media

Sedimentation on filter media

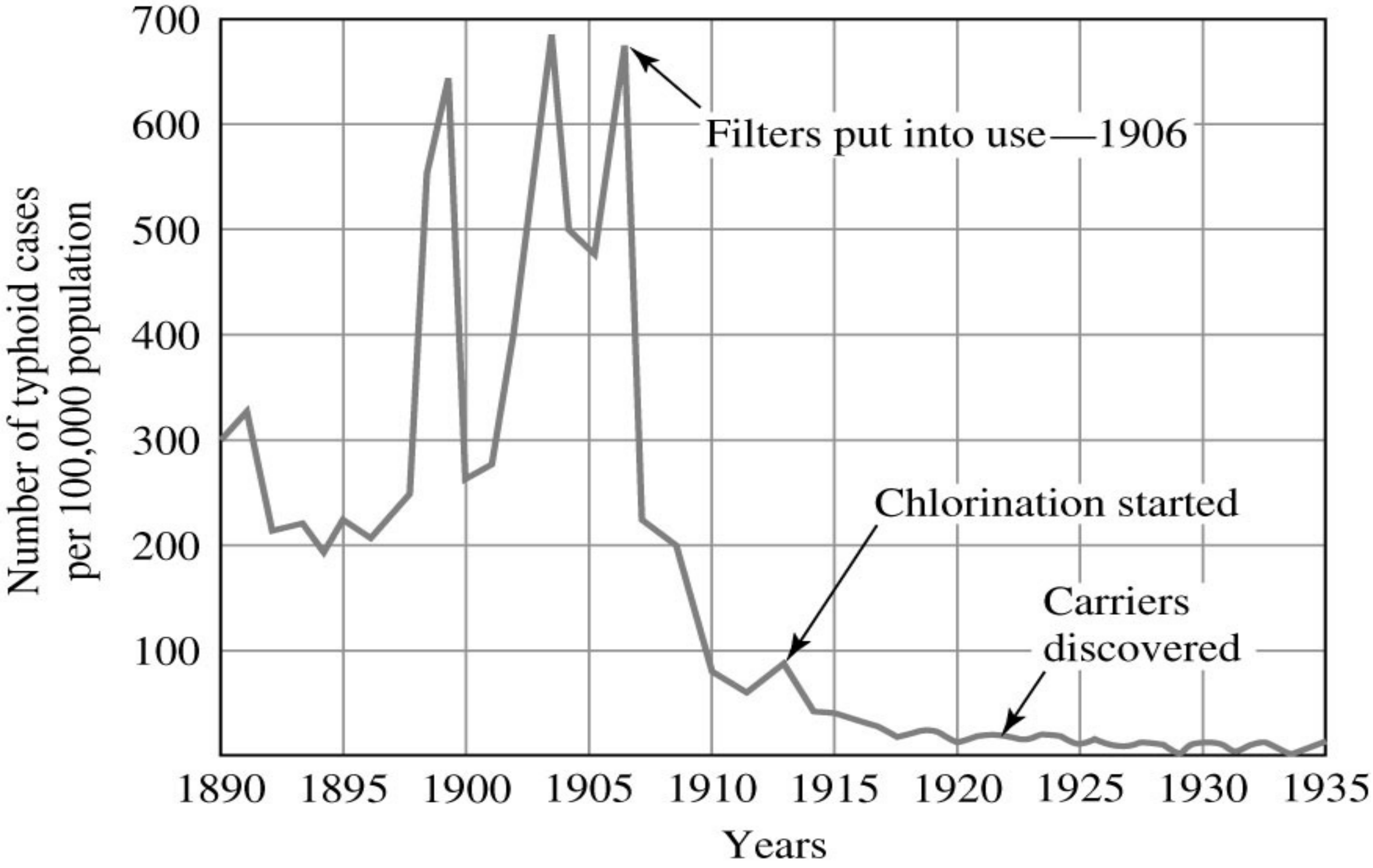
Slow sand filtration

- Gravity feed
- Sieving and some biological degradation
- Inexpensive compared to deep filtration



Disinfection

Huge, immediate impact on human health



Typhoid fever cases per 100,000 population from 1890 to 1935, Philadelphia

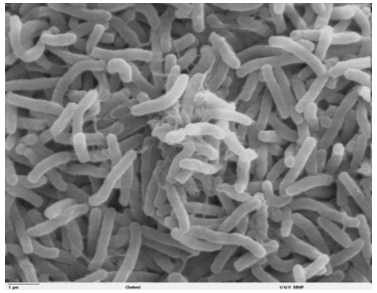
Human enteric pathogens

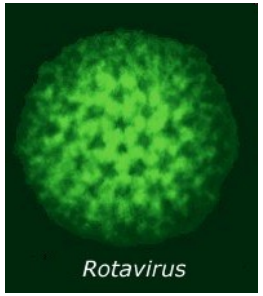
Bacteria
- E. coli O157
- Vibrio cholera

Viruses

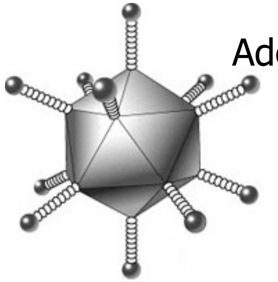
Protozoa
- Cryptosporidium spp.
- Giardia

Amebic cysts

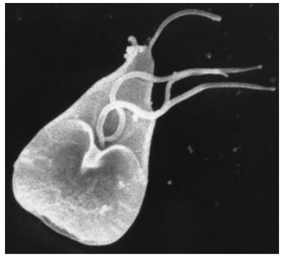

Vibrio cholera

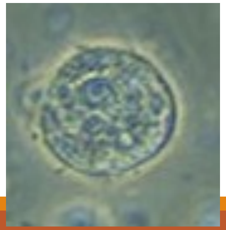


Adenovirus



Giardia




Entamoeba histolytica

Major Goals for Disinfection

According to Indian Standard DRINKING WATER — SPECIFICATION*(Second Revision)*

- *E. coli* or thermotolerant coliform bacteria
  - Shall not be detectable in any 100 ml sample
- Total coliform bacteria
  - Shall not be detectable in any 100 ml sample
- Trihalomethanes (THMs):
  a) Bromoform, 0.1 mg/l
  b) Dibromochloromethane, 0.1 mg/l
  c) Bromodichloromethane, 0.06 mg/l
  d) Chloroform, 0.2 mg/l

Indian scenario

- Treated water entering the distribution system after treatment at WTPs typically meets the E coli and total coliform related standard.
  - Standards for THMs are mostly not met
  - Adverse effect of THMs: Long term

- Water from the distribution network at the consumer end often does not meet the standard E coli and total coliform standard.
  - Contamination of drinking water distribution network

Properties of Disinfectants

- For wastewater:
  - Does not produce carcinogenic compounds which can be released to water body
  - Kills pathogens
  - Nontoxic to fish
  - Often used with dechlorination to remove residual chlorine

In India, chlorine is typically used for disinfection of treated wastewaters

- Treated waste waters too have significant organic content
- Chlorination leads to formation of DBPs and other compounds that are acutely toxic to both humans and the aquatic life.
- No dechlorination is done in India

Typical disinfectants

- Chlorine and other forms of chlorine (usually used in India)
  - Cl_2 (gas)
  - NaOCl (liquid)
  - $Ca(OCl)_2$ (solid)
- Ozone and UV
  - Relatively less disadvantages
  - More effective disinfectants
  - Costly

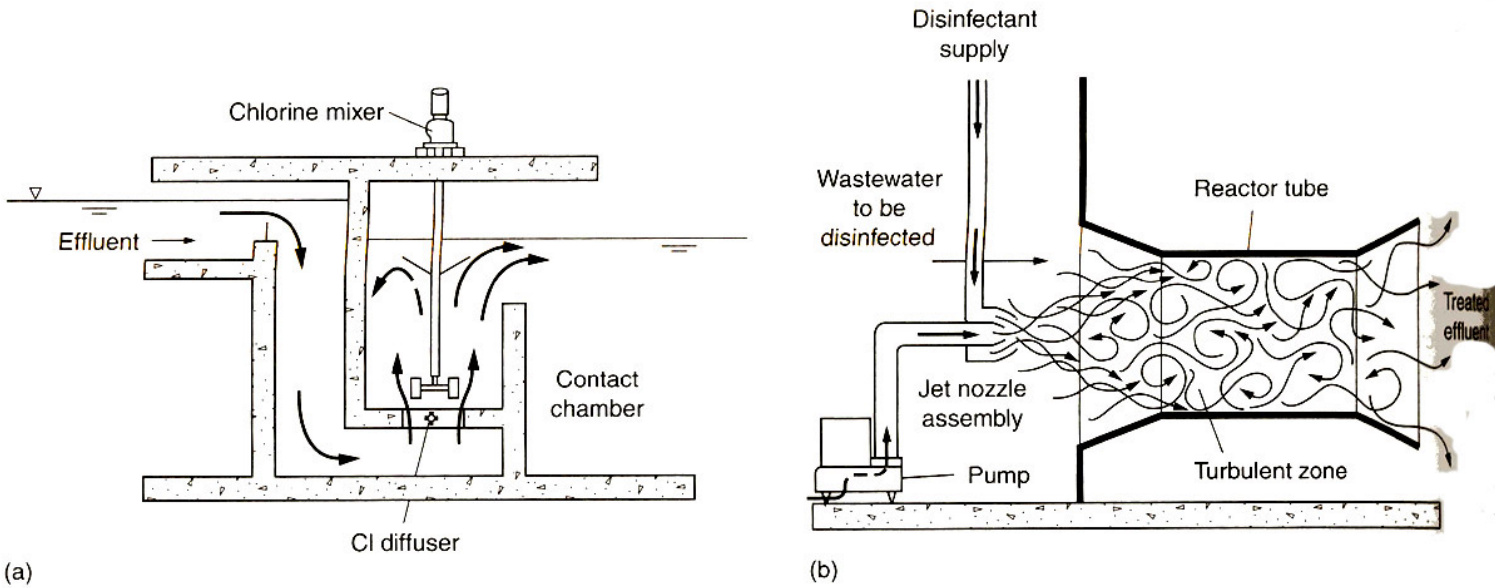
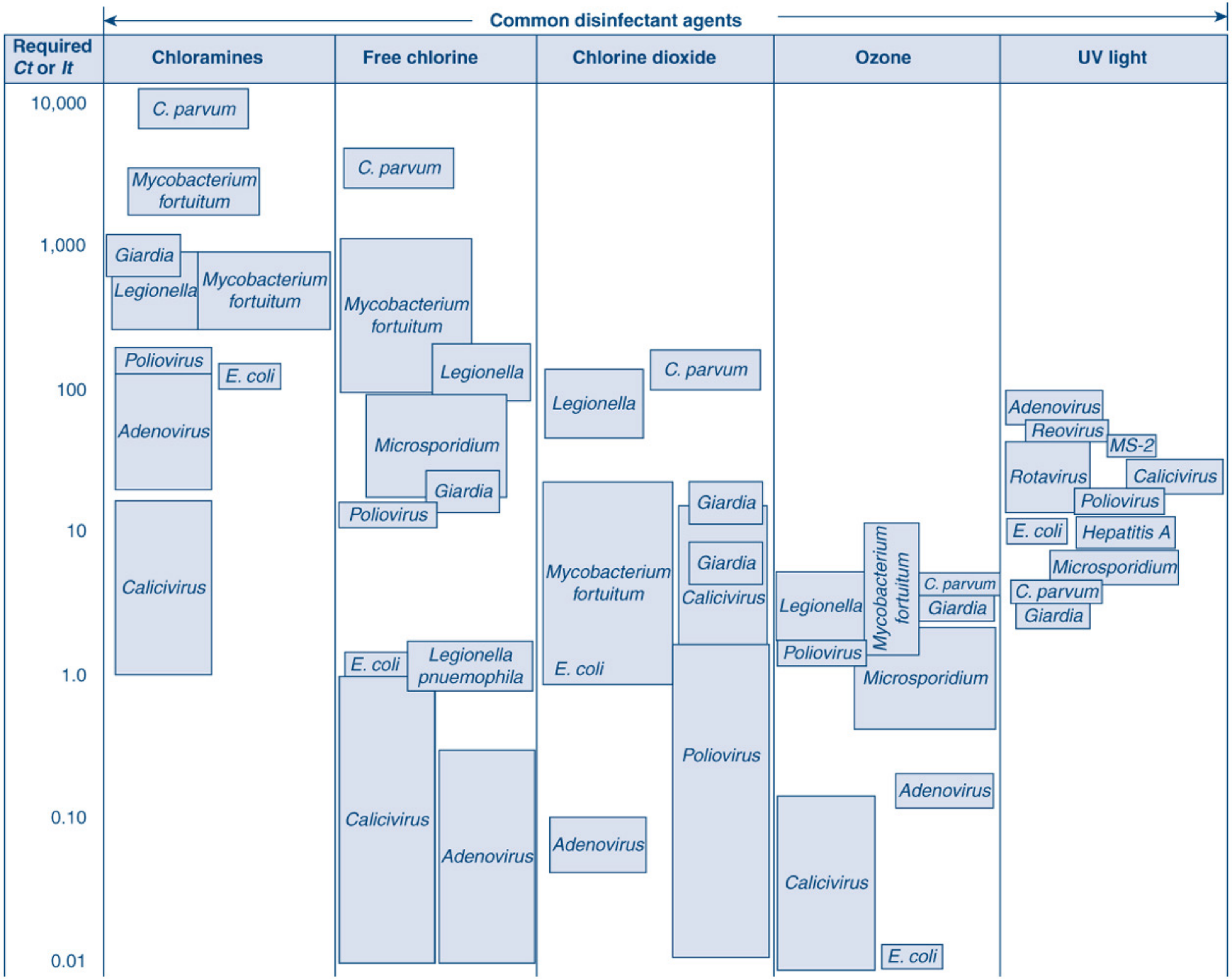


Figure 12–22

Typical mixers for the addition of chlorine: (*a*) in-line turbine mixer and (*b*) injector pump type. *(From Pentech-Houdaille.)* For additional types of chlorine mixers see Fig. 5–14 in Chap. 5.

Dose=Intensity or concentration*time



When Cl_2 gas is added to water during the disinfection of drinking water, it hydrolyzes to form HOCl. The p*Ka* for HOCl is 7.5. (a) What % of the total acid (i.e., $HOCl + OCl^-$) exists in the acid form at a pH = 6? (b) At pH = 7?

At pH 6

$$K_a = 10^{-7.5} = \frac{[OCl^-][H^+]}{[HOCl]} = \frac{[OCl^-]][10^{-6}]}{[HOCl]}$$

$$[OCl^-] = 0.032[HOCl]$$

$$\frac{[HOCl]}{[OCl^-]+[HOCl]}*100\% = 97\%$$

At pH 7

$$K_a = 10^{-7.5} = \frac{[OCl^-][H^+]}{[HOCl]} = \frac{[OCl^-]][10^{-7}]}{[HOCl]}$$

$$[OCl^-] = 0.32[HOCl]$$

$$\frac{[HOCl]}{[OCl^-]+[HOCl]} * 100\% = 76\%$$

Considering that the disinfection power of the acid HOCl is 88 times better than its conjugate base, OCl^-, we see that pH has a considerable effect on the efficiency of disinfection

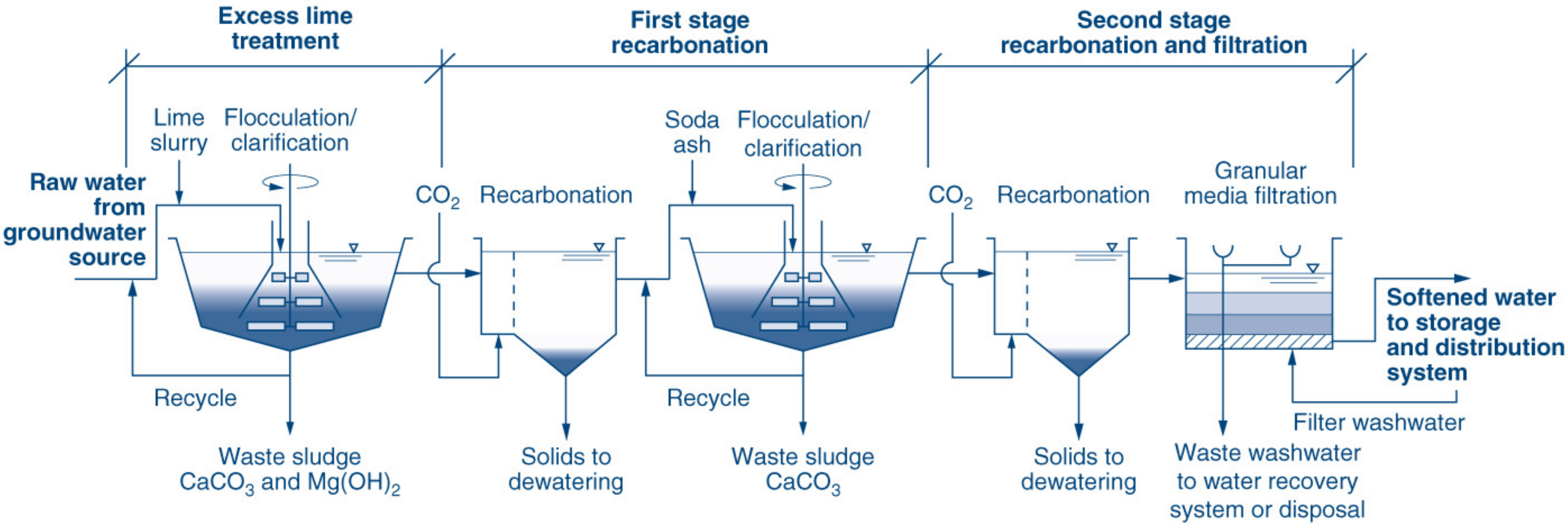
Groundwater Treatment

Primary objectives

1. Remove hardness and other minerals
2. Eliminate Bacteria or Ensure Residual Disinfectant in water
   1. Ground water will rarely have bacteriological contamination
3. In India, ground water is rarely treated.
   1. Typically distributed after ensuring residual disinfection
   2. Residual disinfection is required to account for the contamination of water during distribution

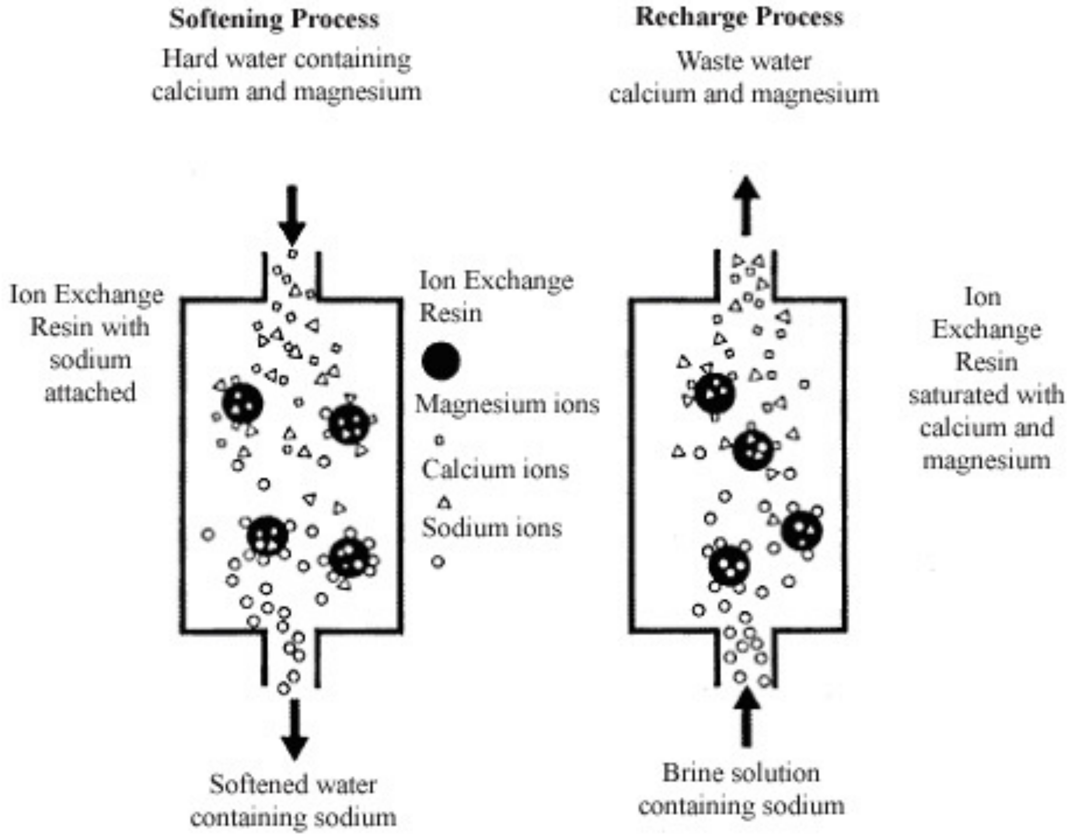
Treatment technologies largely based on precipitation

Groundwater Treatment



Ion exchange for hardness removal

For industrial operations and waters with mostly non carbonate hardness, cation exchangers are used.



20-35 mesh (500 to 900 mm) diameter ion exchange resin beads

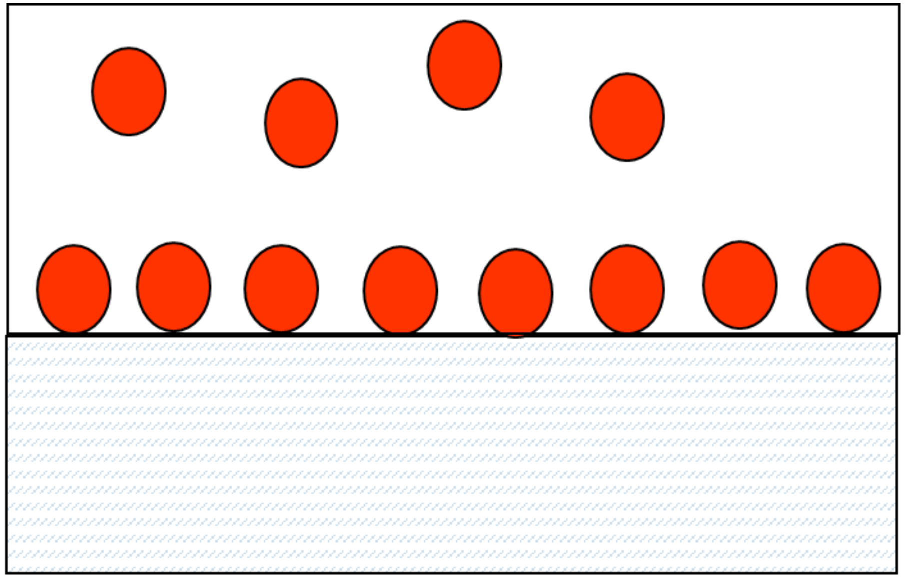
Ion exchange for hardness removal

Arsenic and Fluoride removal

- Many options available
- Implementation on the ground depend on costs, and ease of use
- Most of widely used techniques:
  - Surface complexation and adsorption
    - Most widely used is activated alumina (WHO recommended); low cost
  - Ion exchange

PHASE I

"PHASE" 2



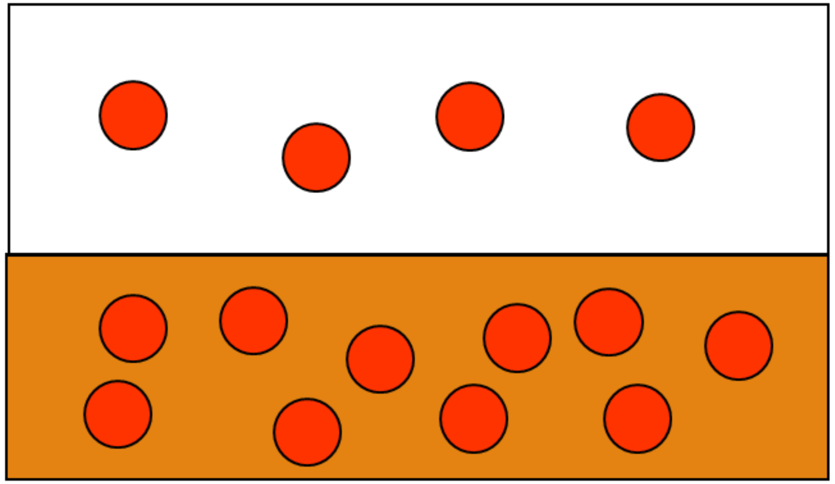
Adsorption

$q=KC^{1/n}$

Example of a model to "explain" adsorption

PHASE I

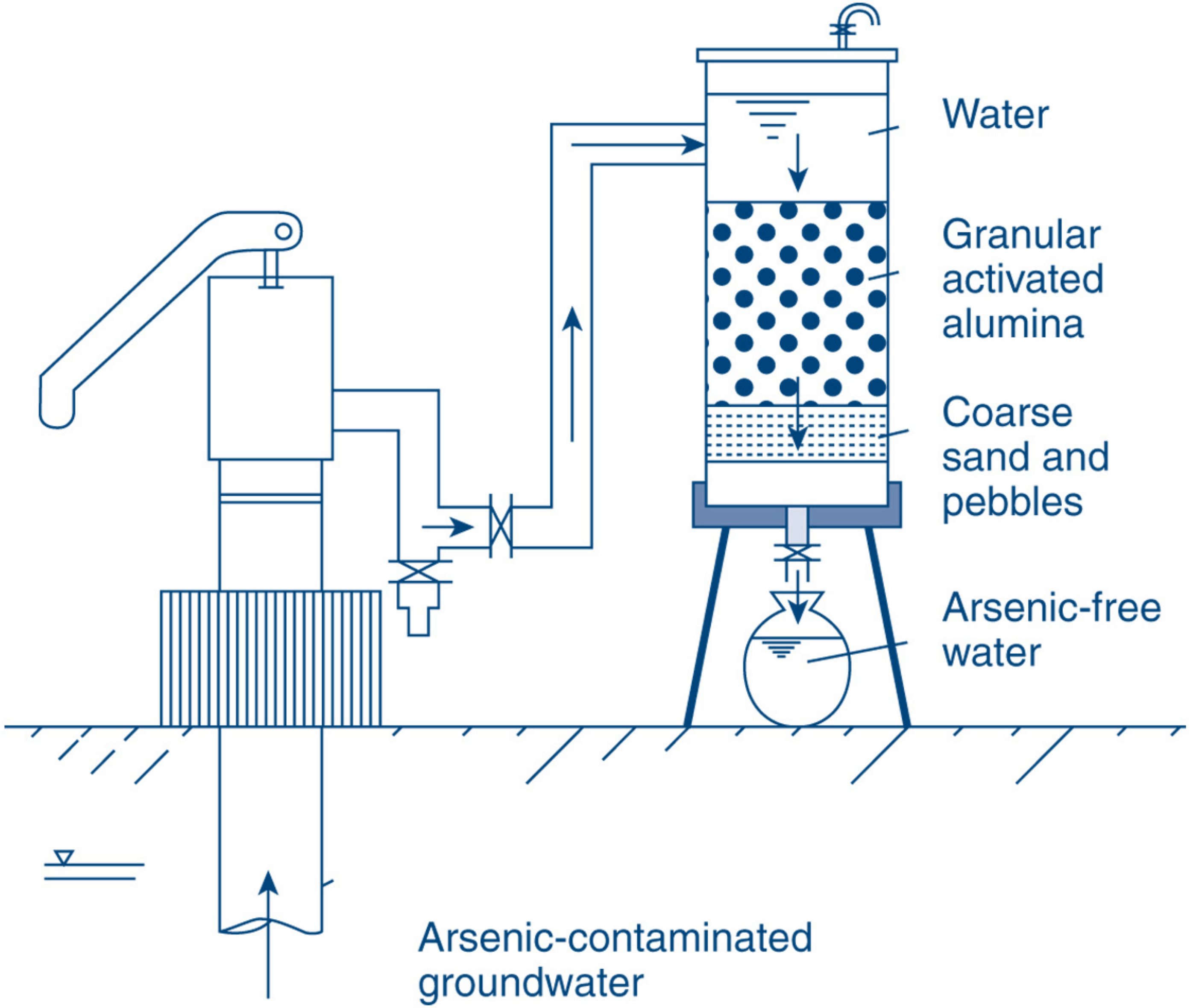
PHASE 2



Absorption ("partitioning")

$$P_{gas} = K_H c_{aq}$$

Henry's Law


Water
Granular
activated
alumina
Coarse
sand and
pebbles
Arsenic-free
water
Arsenic-contaminated
groundwater

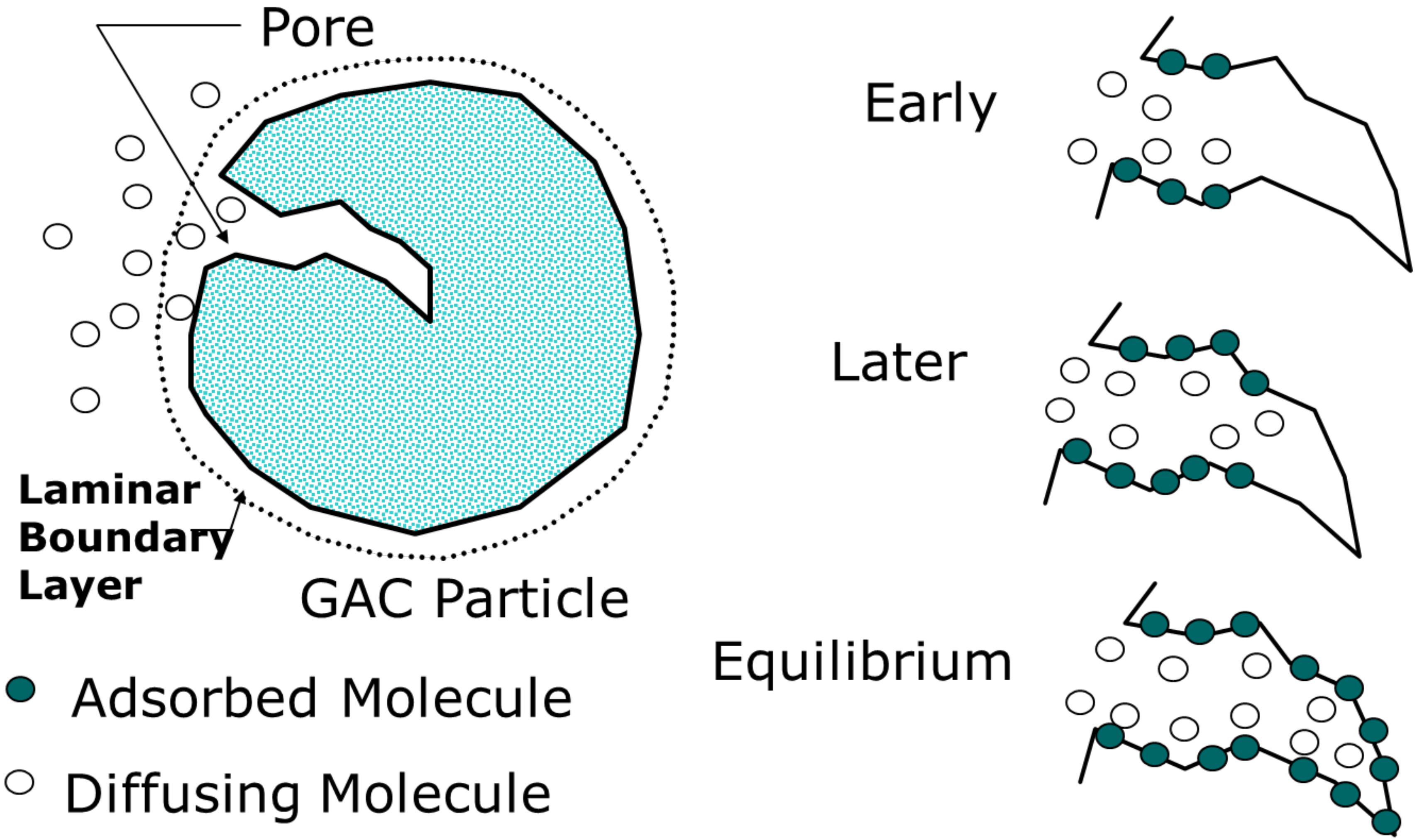
Granular Activated Alumina

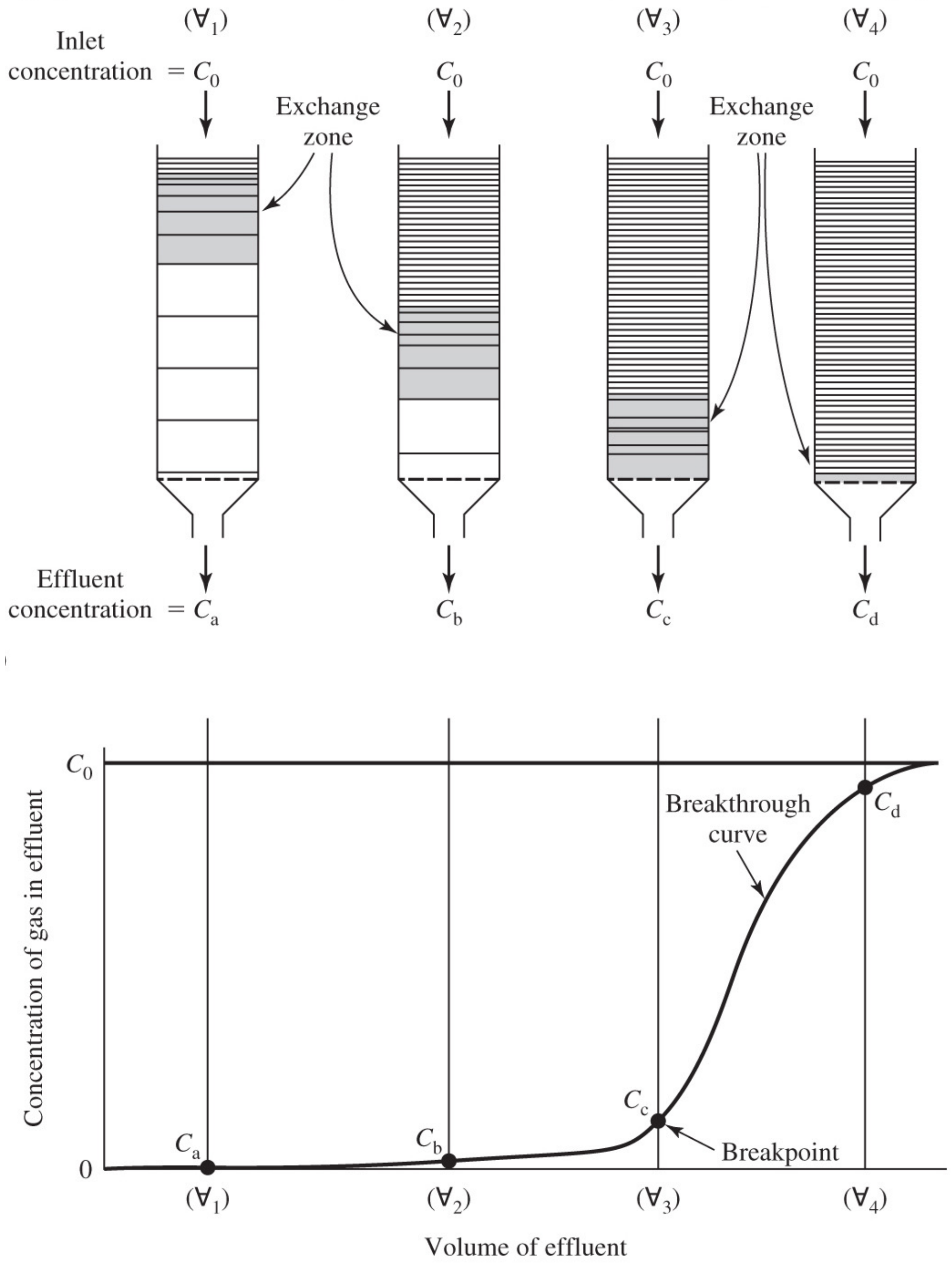
- AA has been used since the 1940s as an effective adsorptive media for fluoride removal. It is a mixture of amorphous and gamma aluminum oxide (γ-Al2O3) prepared by low-temperature (300 to 600ºC) dehydration of $Al(OH)_3$ precipitates. The material is highly porous and has a high average surface area per unit weight of 350 m^2/g of media. Adsorption occurs at both internal and external surfaces of AA.

- The adsorptive capacity for fluoride by AA is pH-dependent, with fluoride best adsorbed below a pH of 8.2 – a typical zero point of charge (ZPC) – where alumina surface has a net positive charge.

- The useful AA bed life is usually measured by the number of bed volumes (BV) of water treated before breakthrough of fluoride at a target level (e.g., 1.5 mg/L). Depending on the water quality and operating conditions, an AA bed can last from several hundred to a few thousand BV before media regeneration is required.

Adsorptive Equilibration





Breakpoint = Breakthrough
Arbitrarily set based on design criteria

$C_{exhaustion} = 0.95\ C_o$

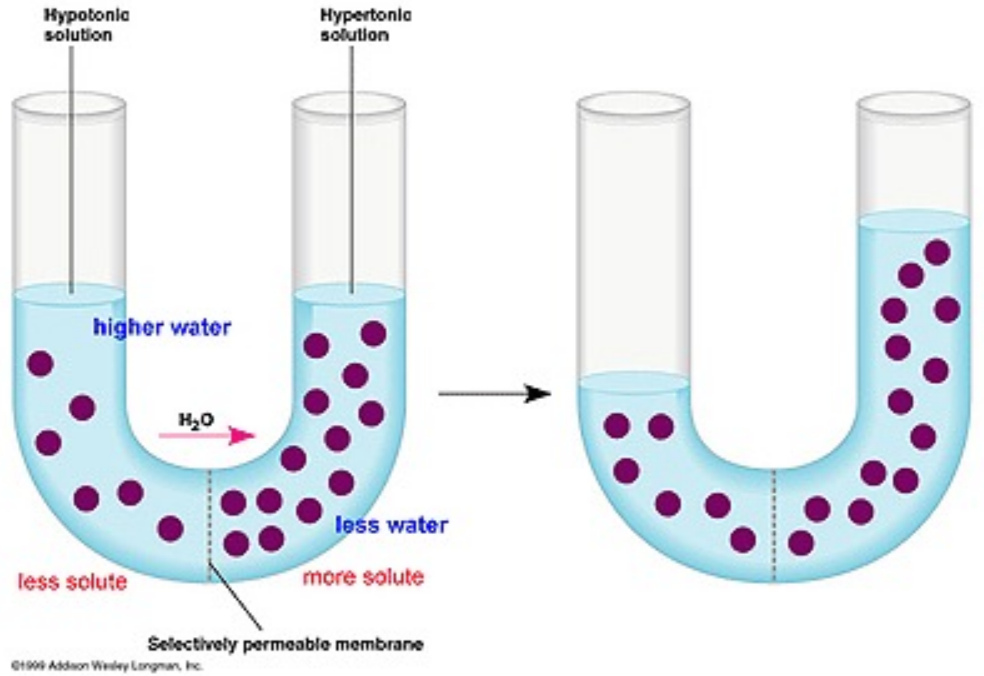
Practical challenges

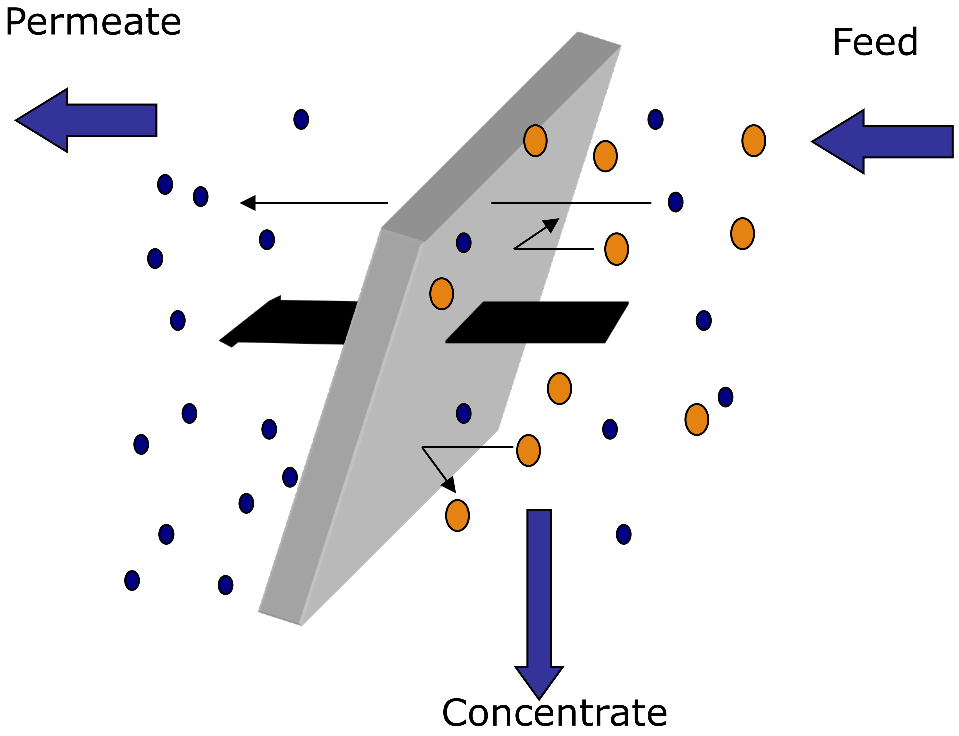
- The lay man is unable to estimate when the AA column/bed has been exhausted and needs regeneration.
  - Most media suppliers recommend an empty bed contact time (EBCT) of 5 min (equivalent to 1 ft^3 of media per 1.5 or 1.0 gpm of treated water flowrate)
- Lay man is unable to maintain the required Empty bed contact time (EBCT)
  - EBCT: approximation of time that the water is in contact with the media
- Regeneration of exhausted media
- Disposal of backwash or spent regenerant

Home Water purification systems

- Most are based on Reverse Osmosis (RO)
  - High capital and maintenance costs
    - High pressures required to drive reverse osmosis
  - Considerable wastage of high TDS water as reject
  - Preceded by micro and ultra filtration
    - Improves the life of RO

Osmosis vs. Reverse Osmosis





Driving Force (ΔC, ΔP)

Osmosis is the net movement (diffusion) of a solvent from a region of higher water concentration to a region of lower concentration

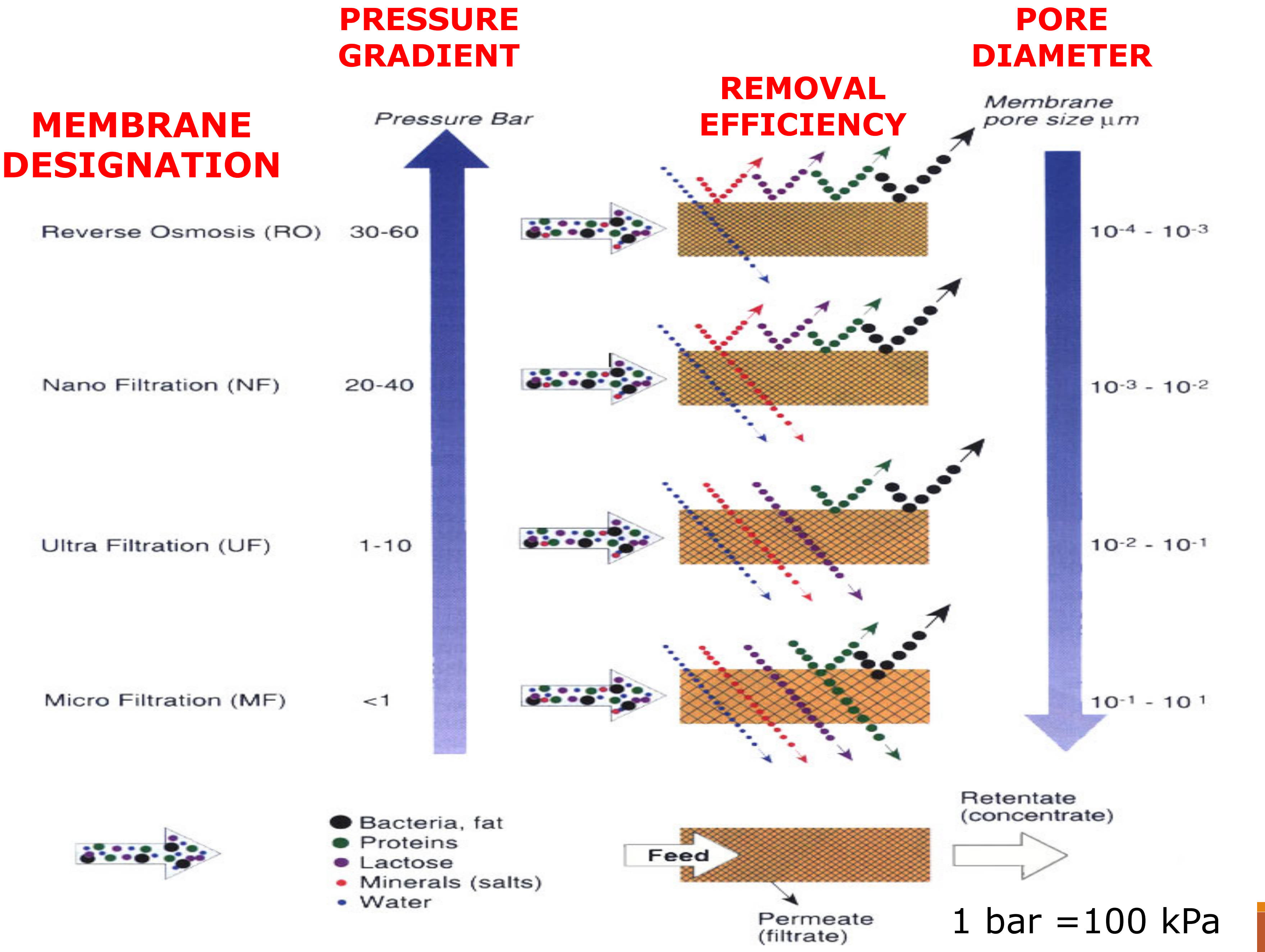
Reverse osmosis is the net movement (diffusion) of a solvent (water) from a region of higher salt concentration to a region of lower water concentration

Reverse osmosis

Recovery $r = \frac{Q_p}{Q_F}$

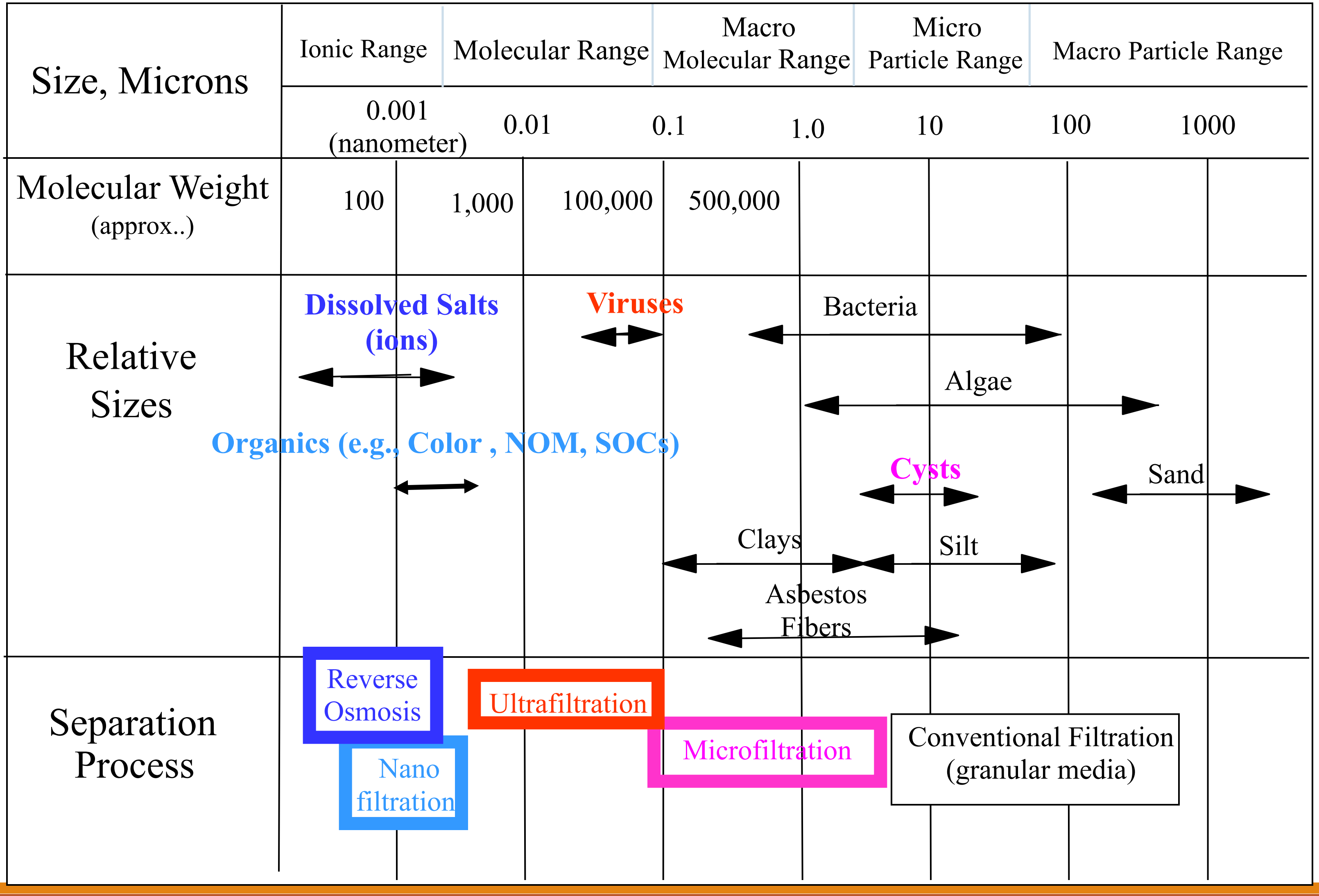
Rejection $= \left[1 - \frac{C_P}{C_F}\right] \times 100\%$

- RO systems typically run anywhere from 50% to 85% recovery
- Considerable wastage of water during daily usage of water purification systems
  - Is such treatment required for most ground waters, or treated surface waters?
- TDS in reject water varies from 35,000 ppm to higher, based on type of influent water


MEMBRANE DESIGNATION
PRESSURE GRADIENT
REMOVAL EFFICIENCY
PORE DIAMETER
Pressure Bar
Membrane pore size µm
Reverse Osmosis (RO)
30-60
10^{-4} - 10^{-3}
Nano Filtration (NF)
20-40
10^{-3} - 10^{-2}
Ultra Filtration (UF)
1-10
10^{-2} - 10^{-1}
Micro Filtration (MF)
<1
10^{-1} - 10^{1}
Bacteria, fat
Proteins
Lactose
Minerals (salts)
Water
Feed
Retentate (concentrate)
Permeate (filtrate)

1 bar =100 kPa

Membrane Separation



RO plants in Chennai

- Seawater has Total Dissolved Solids (TDS) close to 35,000 parts per million (ppm)
  - An effective RO plant will bring this down to about 200 ppm
- Years of water crises in **Chennai** saw the government set up two desalination plants between 2010 and 2013.
  - Each supplies 100 million litres a day (MLD);
  - together they meet little under a fourth of the city's water requirement of 830 MLD
  - The city's water authorities are planning to install two more plants with capacities of 150 MLD (to be operational by 2021) and 400 MLD, at a cost of around ₹1,260 crore (funded by the German agency, KfW) and ₹4,000 crore (funded by the Japan International Cooperation Agency), respectively.
- Highly desalinated water has a TDS of less than 50 milligrams per litre, is pure, but does not taste like water. Anything from 100 mg/l to 600 mg/l is considered as good quality potable water.
  - desalinated water is shorn of vital minerals such as calcium, magnesium, zinc, sodium, potassium and carbonates
- Most RO plants, including the ones in Chennai, put the water through a 'post-treatment' process whereby salts are added to make TDS around 300 mg/l.

https://www.thehindu.com/sci-tech/is-desalination-realistically-a-help-in-harnessing-potable-water-from-the-sea/article28306470.ece

RO plants in Chennai

- Ever since the Chennai plants have started to function, fishermen have complained that the brine being deposited along the seashore is triggering changes along the coastline and reducing the availability of prawn, sardine and mackerel.
- Hyper salinity along the shore affects plankton, which is the main food for several of these fish species
- High pressure motors needed to draw in the seawater end up sucking in small fish and life forms, thereby crushing and killing them — again a loss of marine resource
- On an average, it costs about ₹900 crore to build a 100 MLD-plant and, as the Chennai experience has shown, about five years for a plant to be set up. To remove the salt required, there has to be a source of electricity, either a power plant or a diesel or battery source. Estimates have put this at about 4 units of electricity per 1,000 litres of water. Therefore, each of the Chennai plants needs about 400,000 units of electricity. It is estimated that it costs ₹3 to produce 100 litres of potable water.
- Sustainable?
- With average annual rainfall of 140 cm, Chennai doesn't need desalination plants, which are more suited to arid areas with limited fresh water.
  - Restoration of existing freshwater sources.
  - The use of treated sewage is another option.
  - Rain water harvesting and ground water recharge

Further reading

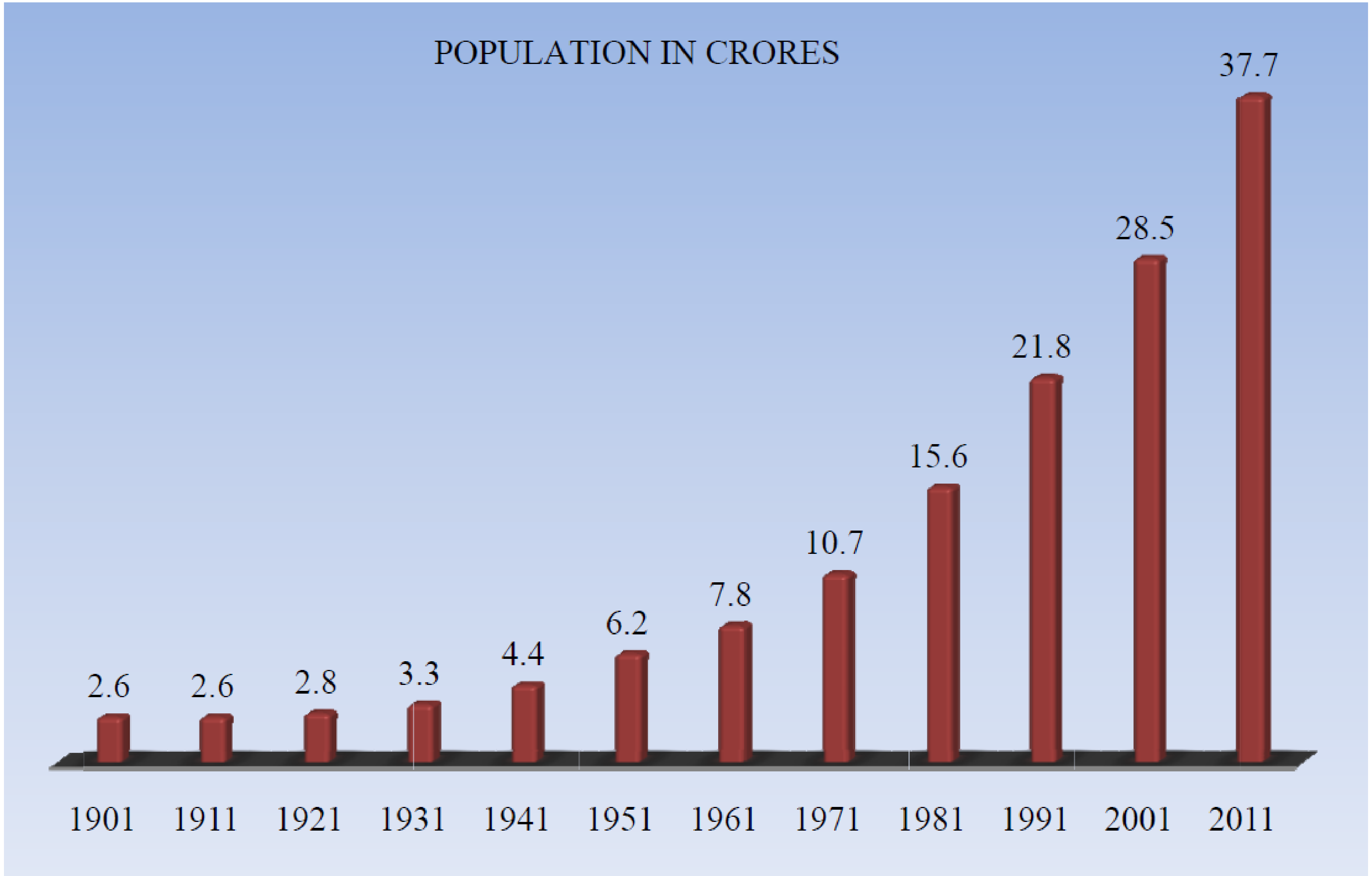
https://www.thehindu.com/news/national/tamil-nadu/disturbed-by-desalination/article25147892.ece

https://www.thehindubusinessline.com/specials/clean-tech/from-drought-stricken-to-water-capital-the-chennai-transformation/article29271457.ece

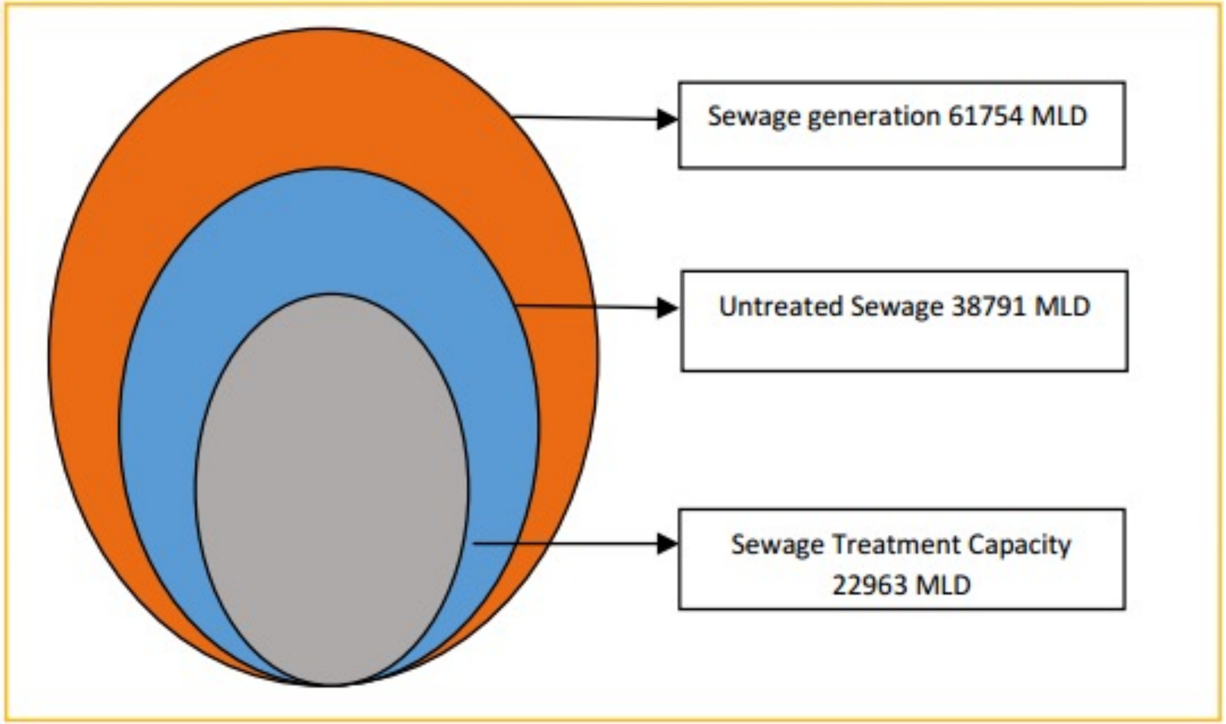
Wastewater Treatment

CHARACTERISTICS AND SYSTEMS

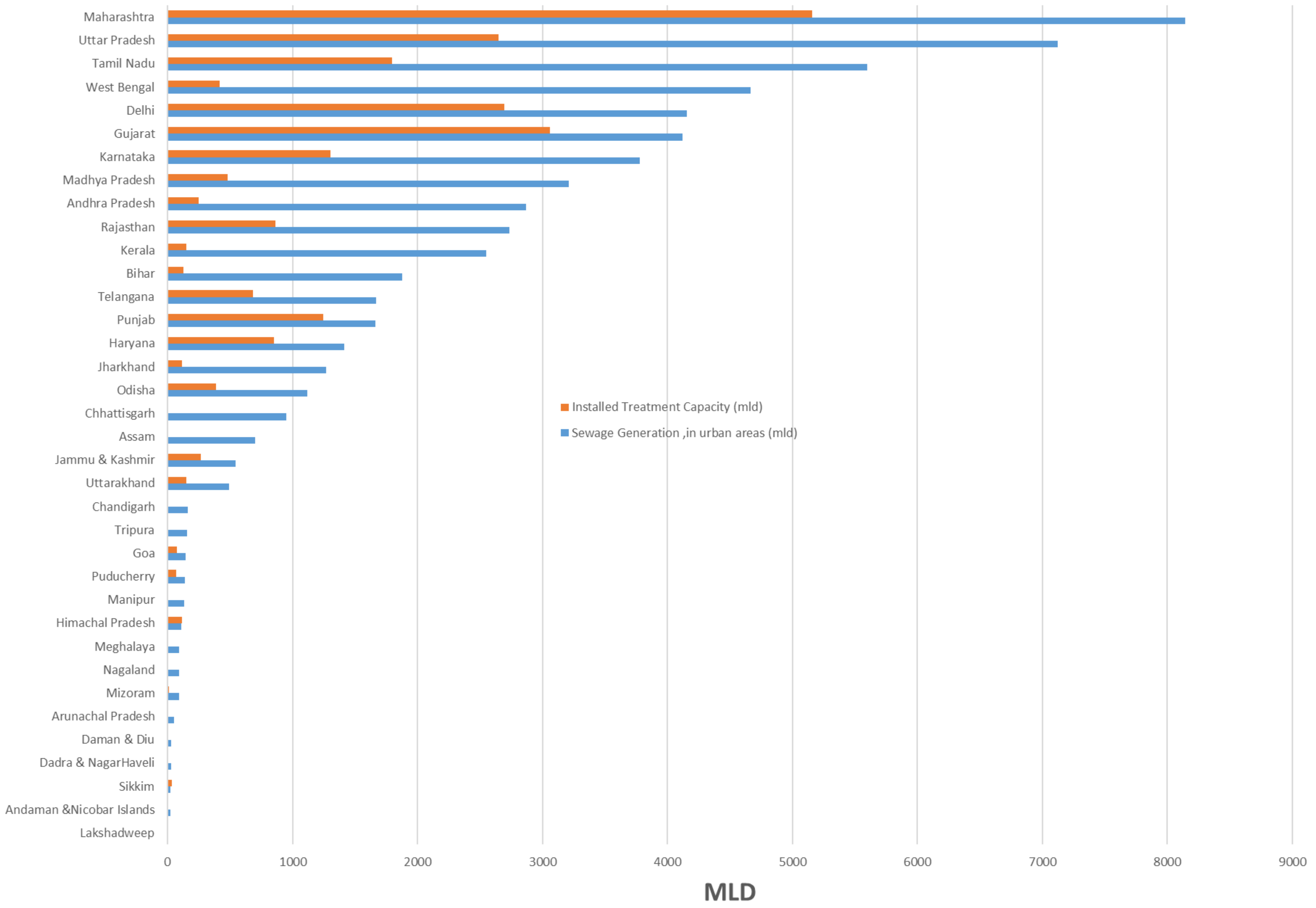
Urban population, India

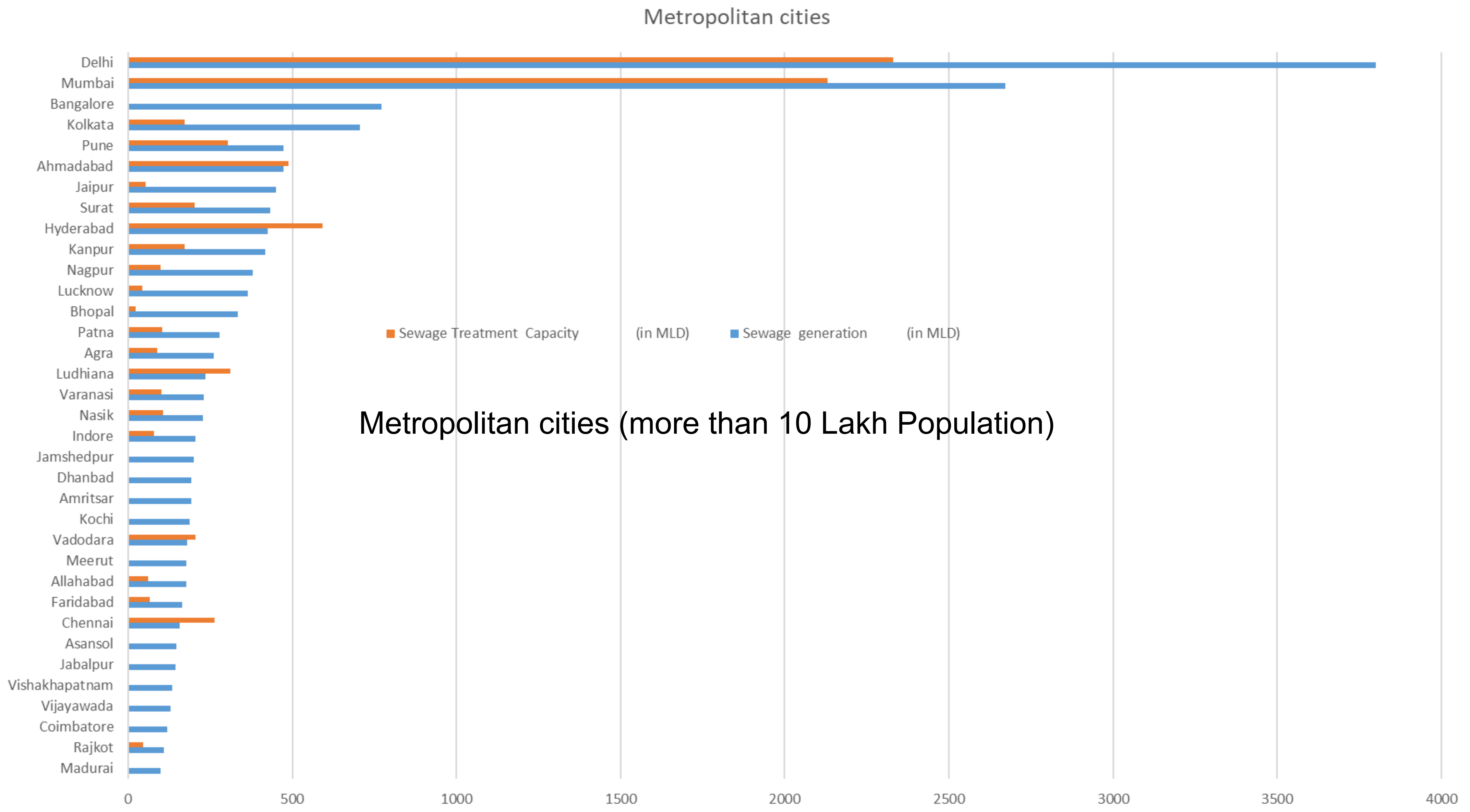


Urban population, as % of total, increased from 13.85 % in 1941 to 31.16 % in 2011



http://www.sulabhenvis.nic.in/database/stst_wastewater_2090.aspx


Maharashtra
Uttar Pradesh
Tamil Nadu
West Bengal
Delhi
Gujarat
Karnataka
Madhya Pradesh
Andhra Pradesh
Rajasthan
Kerala
Bihar
Telangana
Punjab
Haryana
Jharkhand
Odisha
Chhattisgarh
Assam
Jammu & Kashmir
Uttarakhand
Chandigarh
Tripura
Goa
Puducherry
Manipur
Himachal Pradesh
Meghalaya
Nagaland
Mizoram
Arunachal Pradesh
Daman & Diu
Dadra & NagarHaveli
Sikkim
Andaman &Nicobar Islands
Lakshadweep
Installed Treatment Capacity (mld)
Sewage Generation ,in urban areas (mld)
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
MLD



Metropolitan cities (more than 10 Lakh Population)

Class I cities (MLD)
50,000
40,000
30,000
20,000
10,000
0
1978
1988
1995
2006
2009
8,638
15,190
20,607
29,782
44,769
7,007
12,148
18,882
23,826
35,558
2,756
2,495
4,037
6,955
11,554
Water supply
Wastewater
Treatment

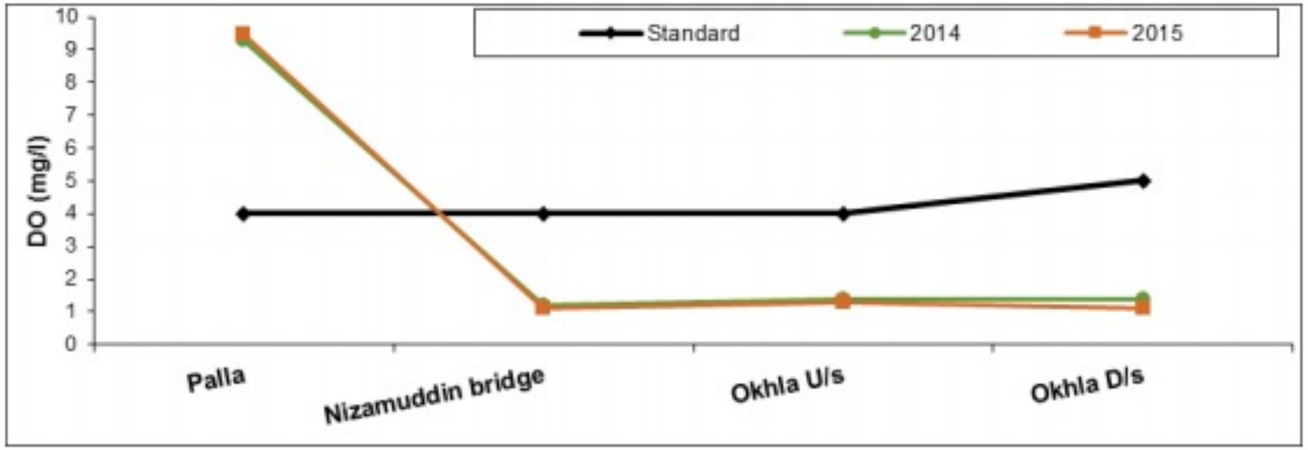
Class II cities (MLD)
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1978
1988
1995
2006
2009
1,533
1,622
1,936
3,035
3,325
1,226
1,280
1,650
2,428
2,697
67
27
62
89
324
Water supply
Wastewater
Treatment

Table 3.2: Percentage of households with the drainage system and distribution of households by type of disposal of household waste water during 2012

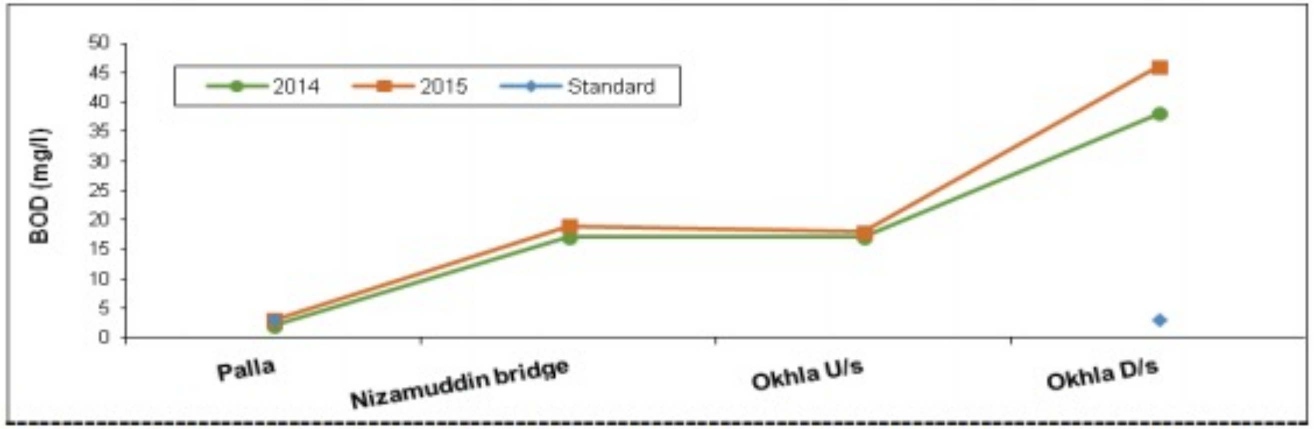
Drainage system of the household	Percentage distribution of households with the drainage system	Type of disposal of household waste water							
		Safe re-use after treatment	Disposed of without treatment to				Disposed of with or without treatment to other places	Not known	All (incl. n.r.)
			Open low land areas	Ponds	Nearby river	Drainage system			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Rural									
Underground	8.5	0.0	25.0	12.3	2.5	50.7	8.8	0.7	100.0
Covered pucca	6.4	0.0	33.8	6.9	2.0	43.3	13.9	0.1	100.0
Open pucca	16.8	0.0	28.6	17.3	3.0	43.6	6.7	0.7	100.0
Open katcha	18.4	0.0	64.0	7.1	1.9	15.0	11.7	0.3	100.0
No drainage	49.9	0.1	75.9	3.1	0.5	0.6	19.5	0.4	100.0
All (incl. n.r.)	**100.0**	**0.0**	**58.7**	**7.3**	**1.4**	**17.4**	**14.6**	**0.4**	**100.0**
Urban									
Underground	45.2	0.1	2.7	0.6	0.7	92.4	2.7	0.9	100.0
Covered pucca	14.9	0.0	10.9	1.4	1.1	78.1	7.8	0.7	100.0
Open pucca	22.4	0.0	11.5	2.5	1.2	78.3	4.2	2.3	100.0
Open katcha	5.0	0.0	45.6	5.2	0.8	37.4	10.5	0.5	100.0
No drainage	12.5	0.0	65.8	3.4	0.8	3.8	25.6	0.5	100.0
All (incl. n.r.)	**100.0**	**0.0**	**15.9**	**1.7**	**0.9**	**73.3**	**7.0**	**1.1**	**100.0**

n.r.: Not reported

Yamuna: ecologically dead downstream (d/s) of Delhi until its confluence with Ganga



Water quality of river Yamuna in terms of DO



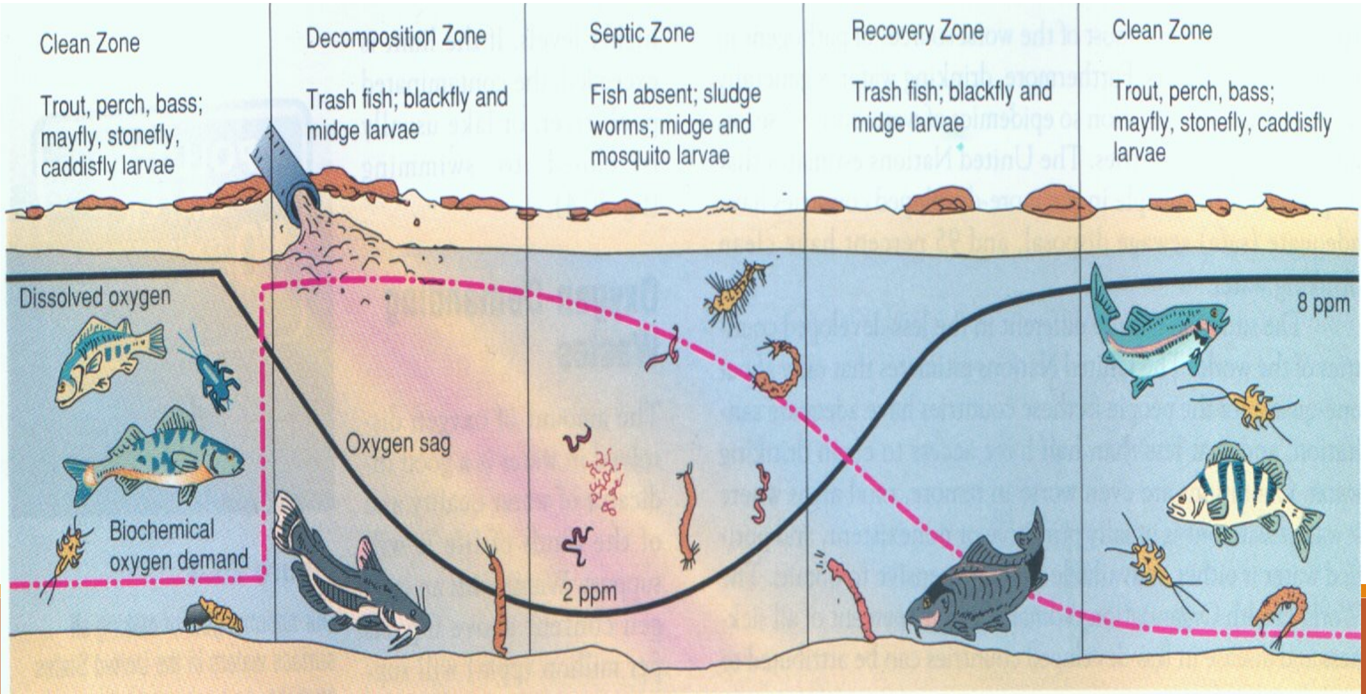
http://www.sulabhenvis.nic.in/Database/WaterQualityStatus_6984.aspx

Discharge of untreated/partially treated waste into Yamuna

- At Delhi Yamuna traverses a distance of about 46 Km.
- Though stretch of Yamuna between Wazirabad barrage to downstream Okhla barrage is less than 2% of the entire river stretch, it receives around 70% of the total pollution (BOD) load that is received by the river, causing severe pollution.
- Total Coliform (TC) was found meeting the standard of 5000 MPN/100 ml at Palla in 14 out of 22 rounds of analysis and its values ranged between 450 – 43,000 MPN/100 ml.
- At Okhla d/s, TC with significantly high counts i.e. 3,30,000 – 16,00,00,000 MPN/100 ml.
- Need to treat the water before discharge to surface water bodies

OBJECTIVES


BOROSIL®
1000ml
1000
APPROX. VOL.
800
600
400
200


Clean Zone
Trout, perch, bass; mayfly, stonefly, caddisfly larvae
Decomposition Zone
Trash fish; blackfly and midge larvae
Septic Zone
Fish absent; sludge worms; midge and mosquito larvae
Recovery Zone
Trash fish; blackfly and midge larvae
Clean Zone
Trout, perch, bass; mayfly, stonefly, caddisfly larvae
Dissolved oxygen
8 ppm
Oxygen sag
2 ppm
Biochemical oxygen demand

FINAL GOAL

The Environment (Protection) Rules, 1986 **[SCHEDULE – VI]** (rule 3A)

https://cpcb.nic.in/uploads/GeneralStandards.pdf

GENERAL STANDARDS FOR DISCHARGE OF ENVIRONMENTAL POLLUTANTS **PART-A : EFFLUENTS**	**BOD, COD, pH, Heavy metals, etc**
WASTE WATER GENERATION STANDARDS - PART-B	
LOAD BASED STANDARDS - PART-C	
GENERAL EMISSION STANDARDS - PART-D	
NOISE STANDARDS - PART-E	

Significance of Wastewater Contaminants

Suspended solids – can cause sludge deposits and anaerobic conditions in the environment

Biodegradable organics – can cause anaerobic conditions in the environment

Pathogens – transmit disease

Nutrients – can cause eutrophication

Heavy metals – toxicity to biota and humans

Refractory organics – toxicity to biota and humans

Dissolved solids – interfere with reuse

Characteristics of Domestic Wastewater

Typical Composition of Untreated Domestic Wastewater

Constituent	Weak	Medium	Strong
	(all $mg \cdot L^{-1}$ except settleable solids)		
Alkalinity (as $CaCO_2$)[a]	50	100	200
BOD_5 (as O_2)	100	200	300
Chloride	30	50	100
COD (as O_2)	250	500	1000
Suspended solids (SS)	100	200	350
Settleable solids (in $mL \cdot L^{-1}$)	5	10	20
Total dissolved solids (TDS)	200	500	1000
Total Kjeldahl nitrogen (TKN) (as N)	20	40	80
Total organic carbon (TOC) (as C)	75	50	300
Total phosphorus (as P)	5	10	20

[a]This amount of alkalinity is the contribution from the waste. It is to be added to the naturally occuring alkalinity in the water supply. Chloride is exclusive of contribution from water-softener backwash.

Characteristics of Raw sewage at inlet of STP at IIT Roorkee

S. No.	Inlet Parameters of Raw Sewage	IIT R (before sewerage network, 2016)	IITR (after sewerage for network,2019)	Typical	Effluent quality (CPHEEO guidelines)
1	pH	**6.5**	**7.35**	6.5 - 8	6.5–8.5
2	Biochemical Oxygen Demand (BOD5) at 20°C, mg/L	**48**	**270**	50-130	≤ 10
3	Chemical Oxygen Demand (COD) , mg/L	**140**	**535**	100-350	≤ 50
4	Total Suspended Solids (TSS) , mg/L	**580**	**250**	100-400	≤ 10
5	Total dissolved solids(TDS), mg/l	**753**	**-**	36	
6	Nitrogen, mg/l	**1.25**	**29**	40	≤ 10
7	NH_4-N,mg/l	**-**	**12**	12 to 25	
8	NO3-, mg/L		**6.8**		
9	Phosphorous-P, mg/L	**7.9**	**12**	2 to 4	≤ 2
10	Total Coliform, MPN/100 ml	**<10^7**		<10^7	
11	Fecal Coliform, MPN/100 ml	**<10^5**		<10^5	< 100
12	Free/Residual Chlorine (at treated outlet)				0.3-0.5

On-Site Disposal Systems

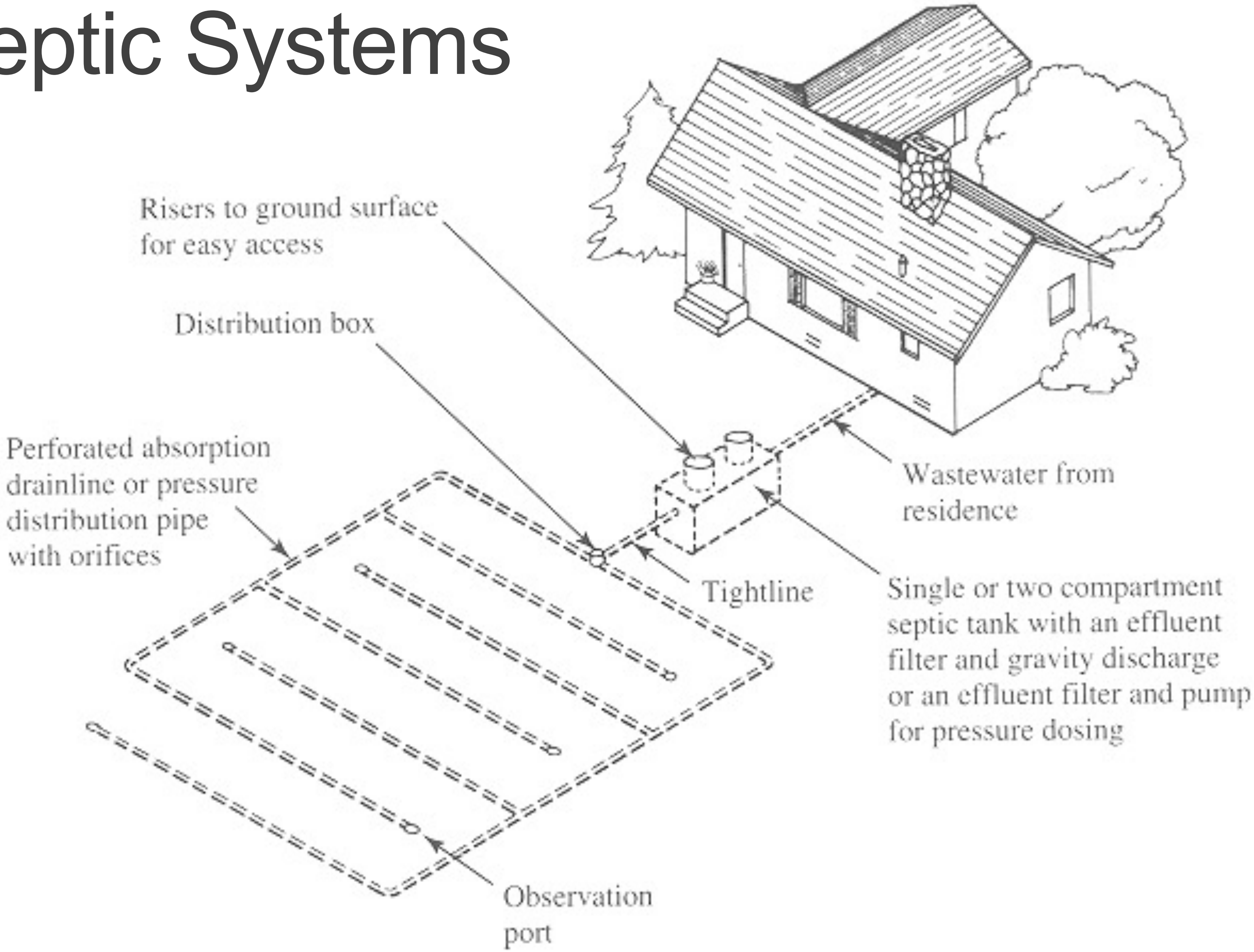
In locations where sewers and a centralized wastewater treatment system are not available, on site disposal must be used

Septic systems most common for individual residences

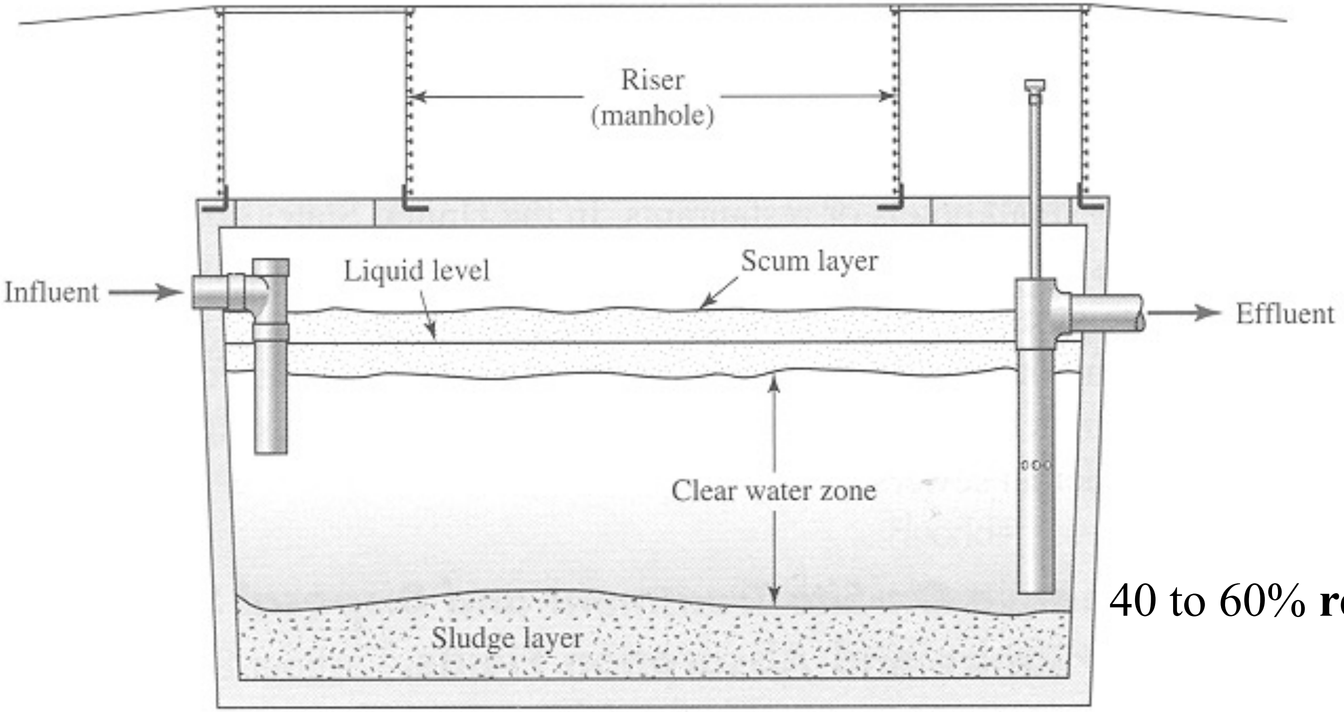
“Engineered systems” used for unfavorable site conditions

Larger systems required for housing clusters, rest areas, commercial and industrial facilities

Septic Systems

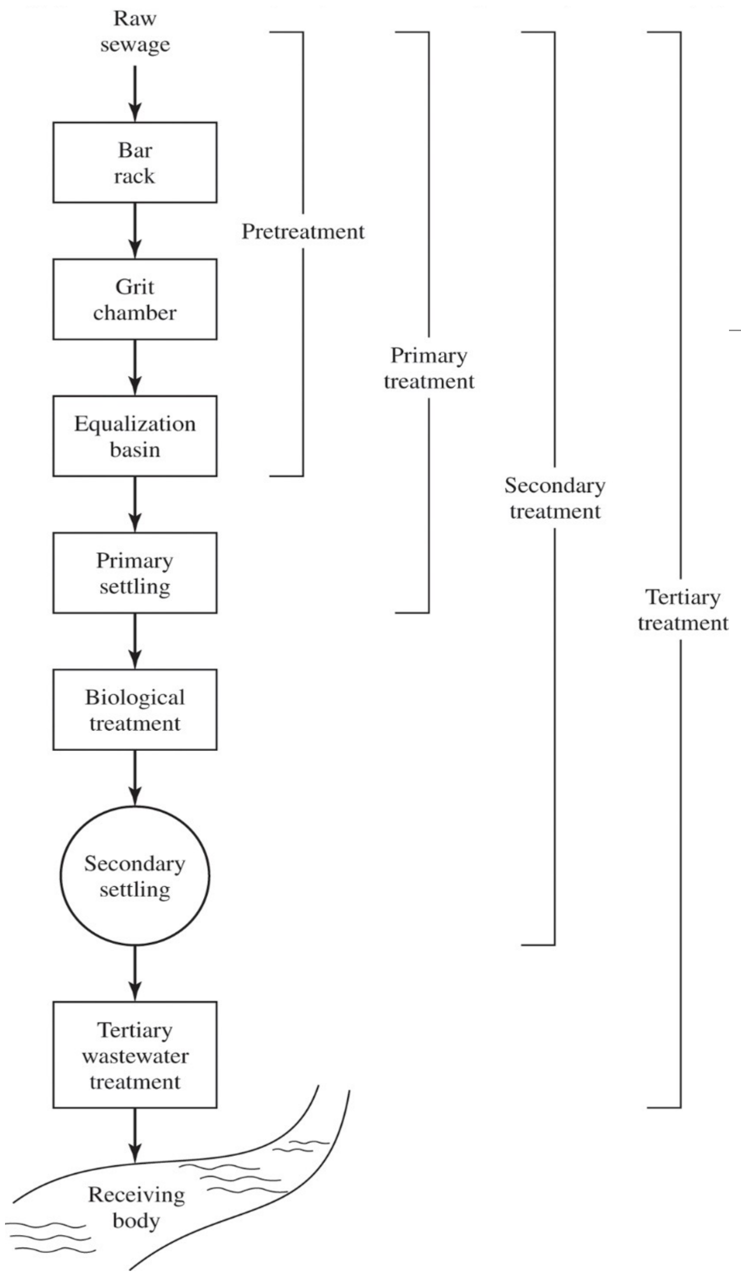


Septic Systems



40 to 60% **removal** of both $\mathbf{BOD_5}$ and **TSS**

Septic Tank – settling, flotation and anaerobic degradation



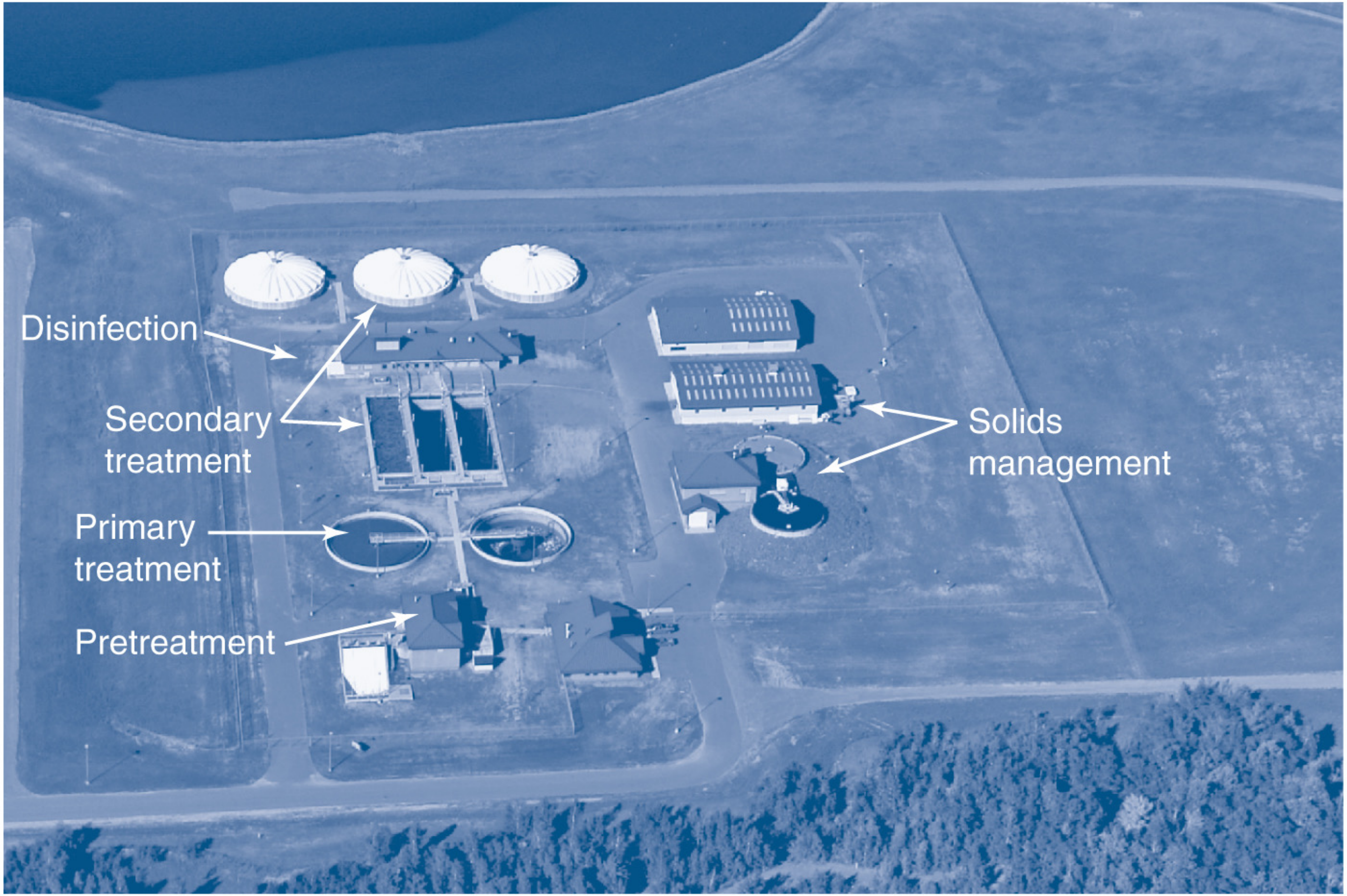
Municipal Wastewater Treatment Systems

Pretreatment – removes materials that can cause operational problems, equalization optional

Primary treatment – remove ~60% of solids and ~35% of BOD

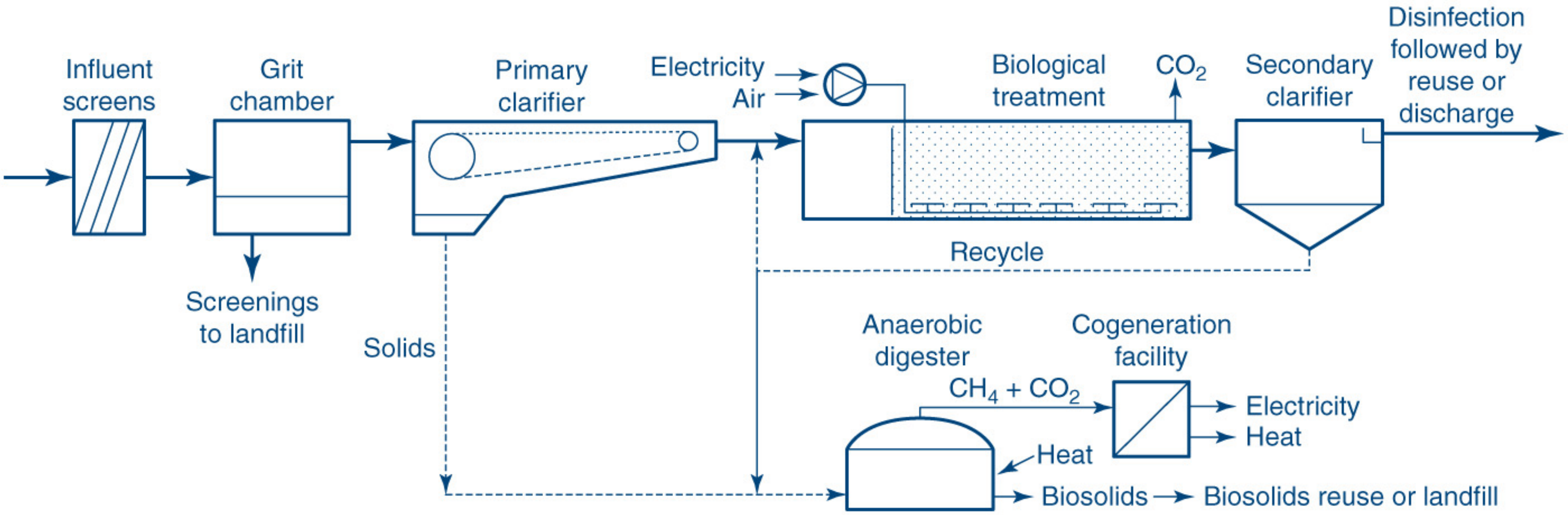
Secondary treatment (Biological Treatment)– remove ~85% of BOD and solids

Tertiary treatment – varies: 95+ % of BOD and solids, N, P, emerging contaminants


Disinfection
Secondary treatment
Primary treatment
Pretreatment
Solids management

MUNICIPAL WASTEWATER TREATMENT PLANT

Typical STP



Influent screens
Grit chamber
Primary clarifier
Electricity
Air
Biological treatment
CO_2
Secondary clarifier
Disinfection followed by reuse or discharge
Screenings to landfill
Solids
Recycle
Anaerobic digester
Cogeneration facility
$CH_4 + CO_2$
Electricity
Heat
Heat
Biosolids
Biosolids reuse or landfill

Pretreatment of Industrial Wastewaters

Industrial wastewaters must be pretreated prior to being discharged to Common Effluent Treatment Plants

Local authority must monitor and regulate industrial discharges

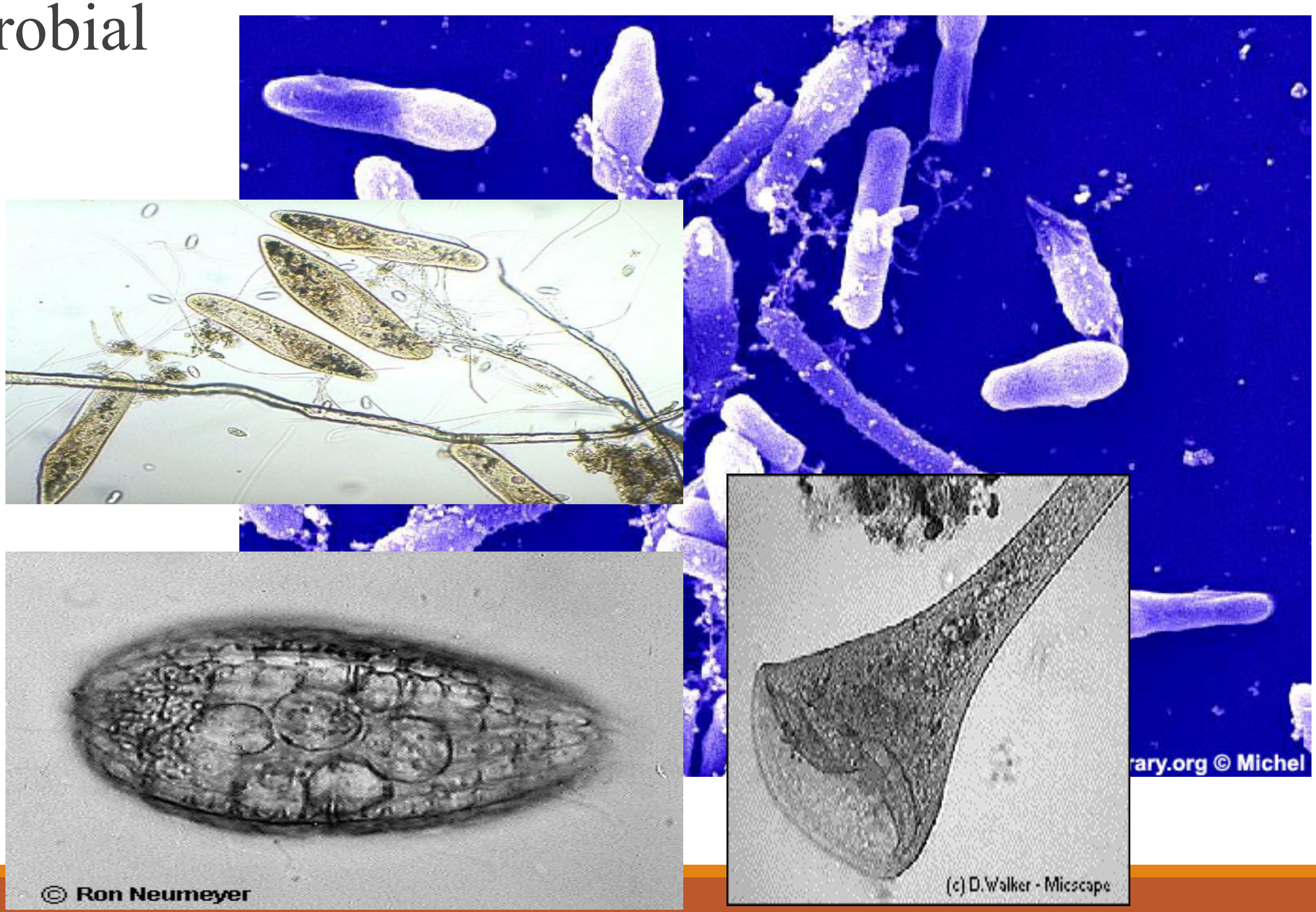
Pretreatment requirements set by MoEF, Govt. of India

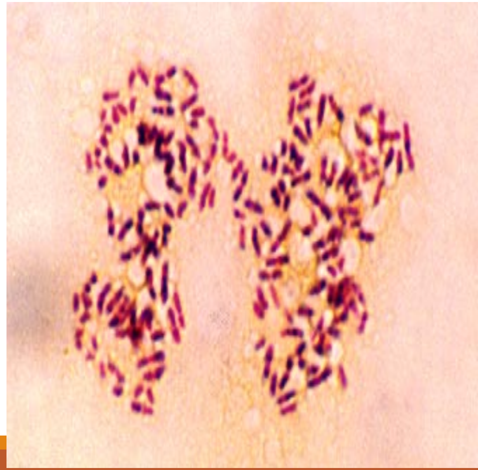
Secondary Treatment

- Provide BOD removal beyond what is achieved in primary treatment
  - removal of soluble BOD
  - additional removal of suspended solids
- Basic approach is to use *aerobic* biological degradation:
- organic carbon + $O_2 \rightarrow CO_2$
- Objective is to allow the BOD to be exerted in the treatment plant rather than in the stream
- Microbes release enzymes, which act as catalysts for oxidation of organic carbon

How is this accomplished?

Create a very rich environment for growth of a diverse microbial community





Basic Ingredients

High concentration of microorganisms (keep organisms in system)

Good contact between organisms and wastes (provide mixing)

Provide satisfactory levels of oxygen (aeration)

Favorable temperature, pH, nutrients (design and operation)

Limited or no concentration of toxic chemicals present (control industrial inputs)

Biological Treatment

- Aerobic:
  - Activated Sludge Process (ASP)
  - Sequencing Batch Reactor (SBR)
- Anaerobic Process
  - Up-flow Anaerobic Sludge Blanket (UASB) Reactor
    - Rarely used for municipal waste water treatment

Activated Sludge process

Process in which a mixture of wastewater and microorganisms (biological sludge) is agitated and aerated

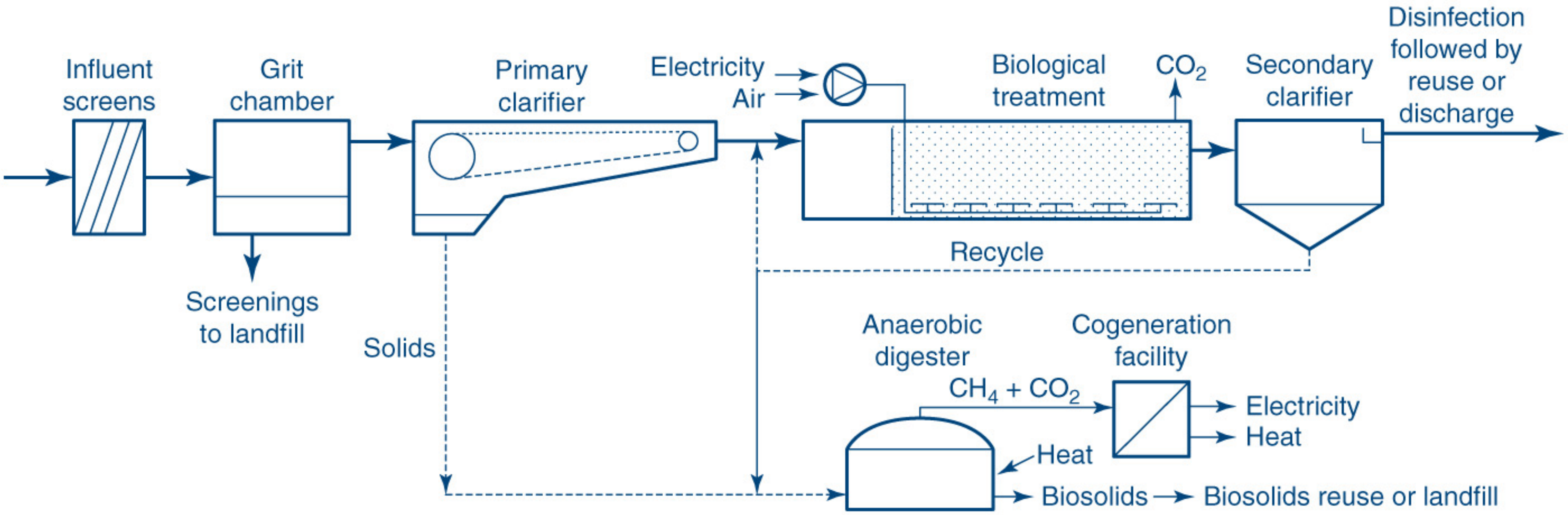
Leads to oxidation of dissolved organics

After oxidation, separate sludge, which is heavier and settles down, from wastewater

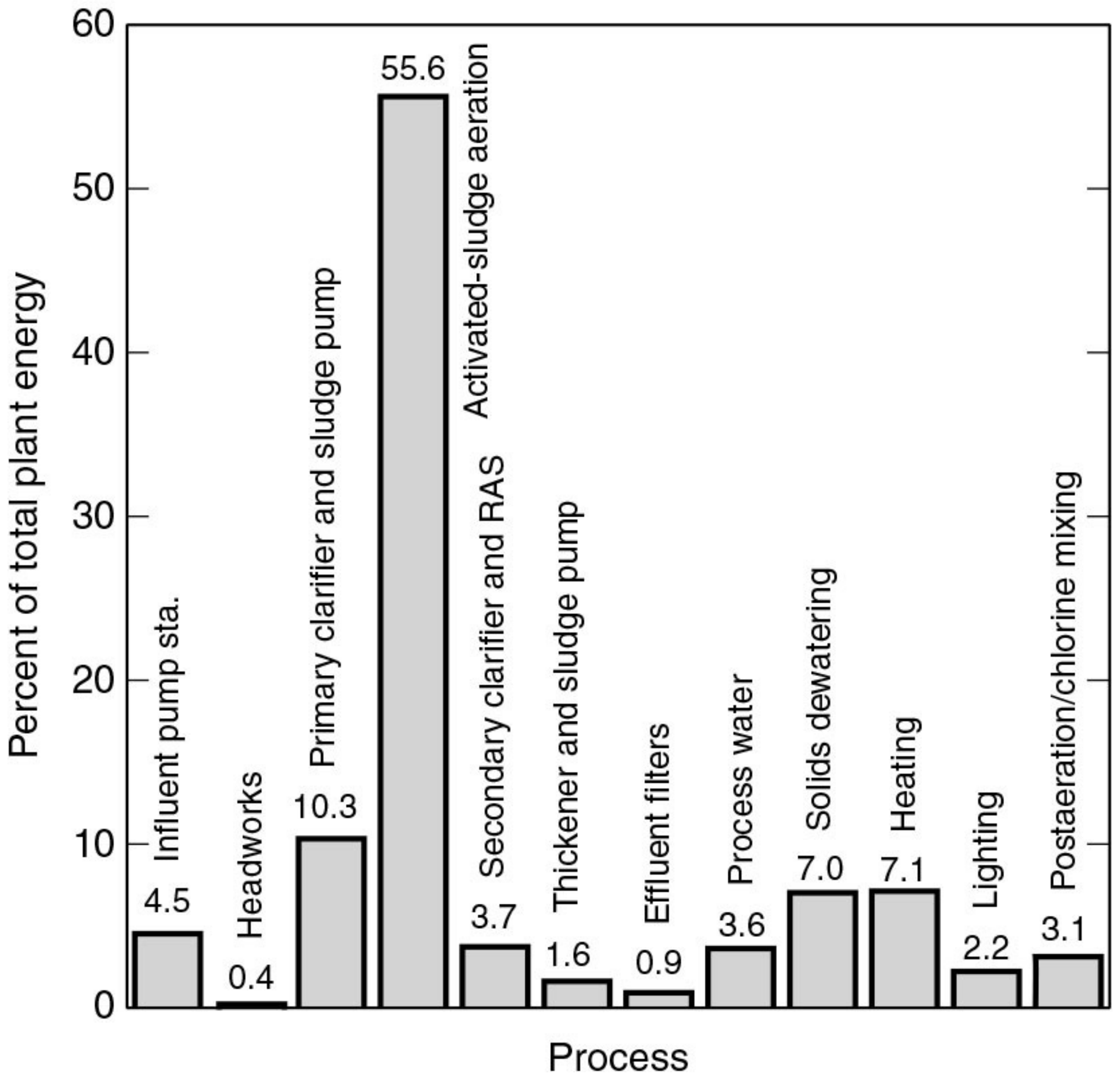
Overview: Primary settling tanks in foreground, activated sludge aeration tanks and circular secondary settling tanks at top.

The flow pattern in this plant is sinusoidal through the three tanks so that the tanks approximate a plug flow reactor.

Typical STP

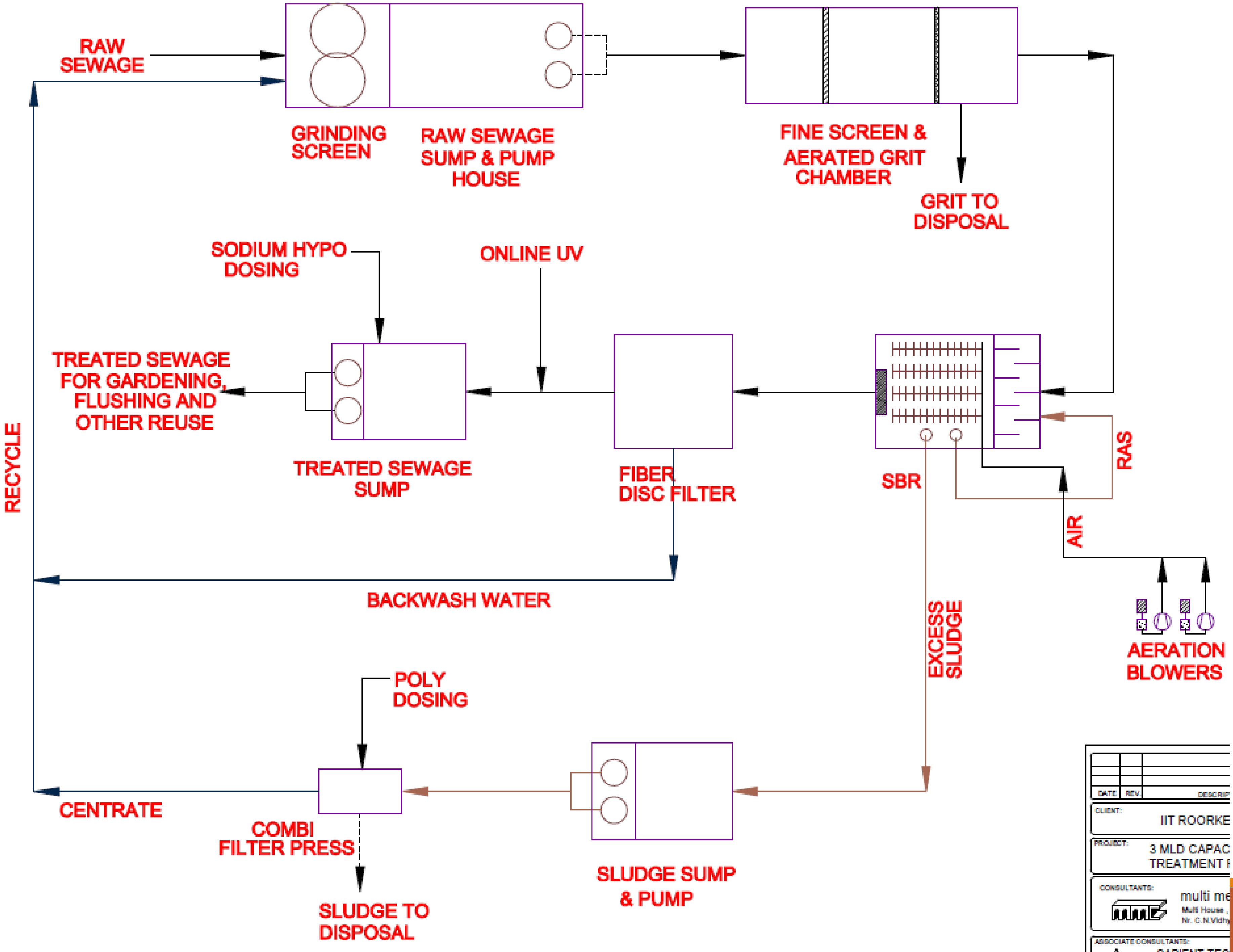


Influent screens
Grit chamber
Primary clarifier
Electricity
Air
Biological treatment
CO_2
Secondary clarifier
Disinfection followed by reuse or discharge
Screenings to landfill
Solids
Recycle
Anaerobic digester
Cogeneration facility
$CH_4 + CO_2$
Electricity
Heat
Heat
Biosolids
Biosolids reuse or landfill


Percent of total plant energy
60
50
40
30
20
10
0
Process
Influent pump sta.
4.5
Headworks
0.4
Primary clarifier and sludge pump
10.3
Activated-sludge aeration
55.6
Secondary clarifier and RAS
3.7
Thickener and sludge pump
1.6
Effluent filters
0.9
Process water
3.6
Solids dewatering
7.0
Heating
7.1
Lighting
2.2
Postaeration/chlorine mixing
3.1

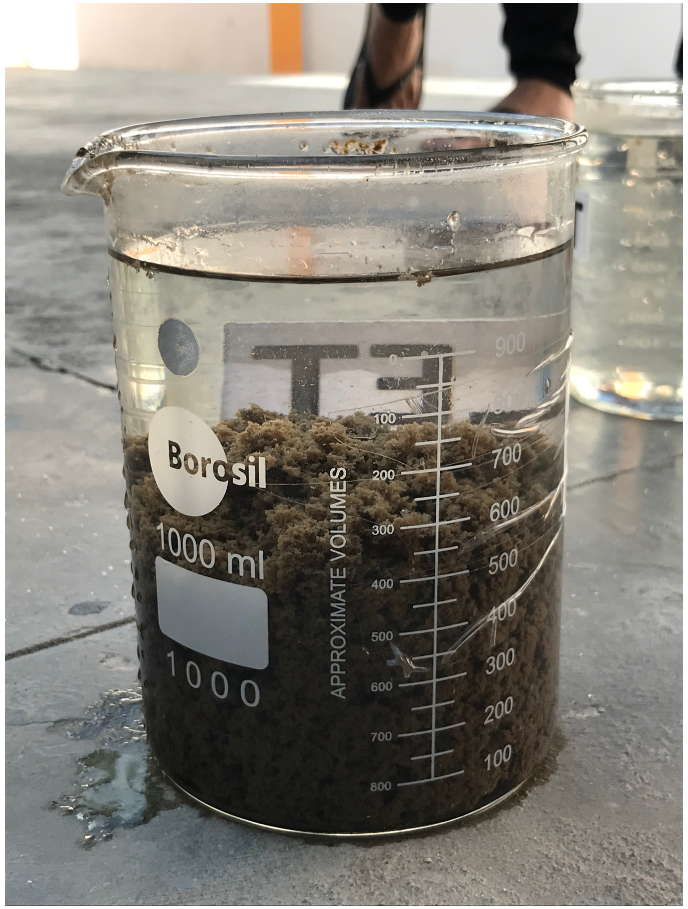
STP at IIT R

SBR: 3 MLD


RAW SEWAGE
GRINDING SCREEN
RAW SEWAGE SUMP & PUMP HOUSE
FINE SCREEN & AERATED GRIT CHAMBER
GRIT TO DISPOSAL
SODIUM HYPO DOSING
ONLINE UV
TREATED SEWAGE FOR GARDENING, FLUSHING AND OTHER REUSE
TREATED SEWAGE SUMP
FIBER DISC FILTER
SBR
RAS
AIR
RECYCLE
BACKWASH WATER
EXCESS SLUDGE
AERATION BLOWERS
POLY DOSING
CENTRATE
COMBI FILTER PRESS
SLUDGE TO DISPOSAL
SLUDGE SUMP & PUMP
DATE
REV
CLIENT:
IIT ROORKE
PROJECT:
CONSULTANTS:
ASSOCIATE CONSULTANTS:

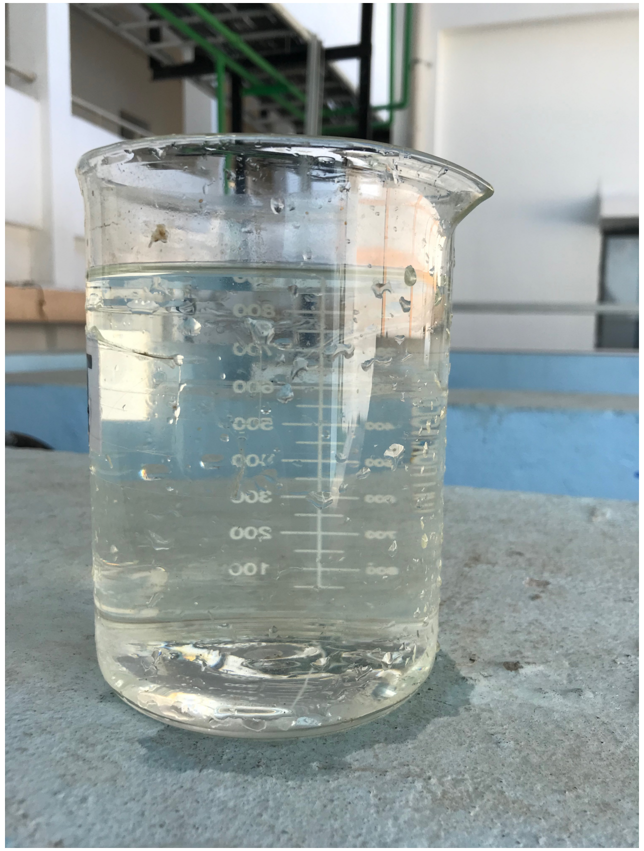
Inlet at IITR SBR based STP

Settling of floc after aeration



After final treatment

Inlet

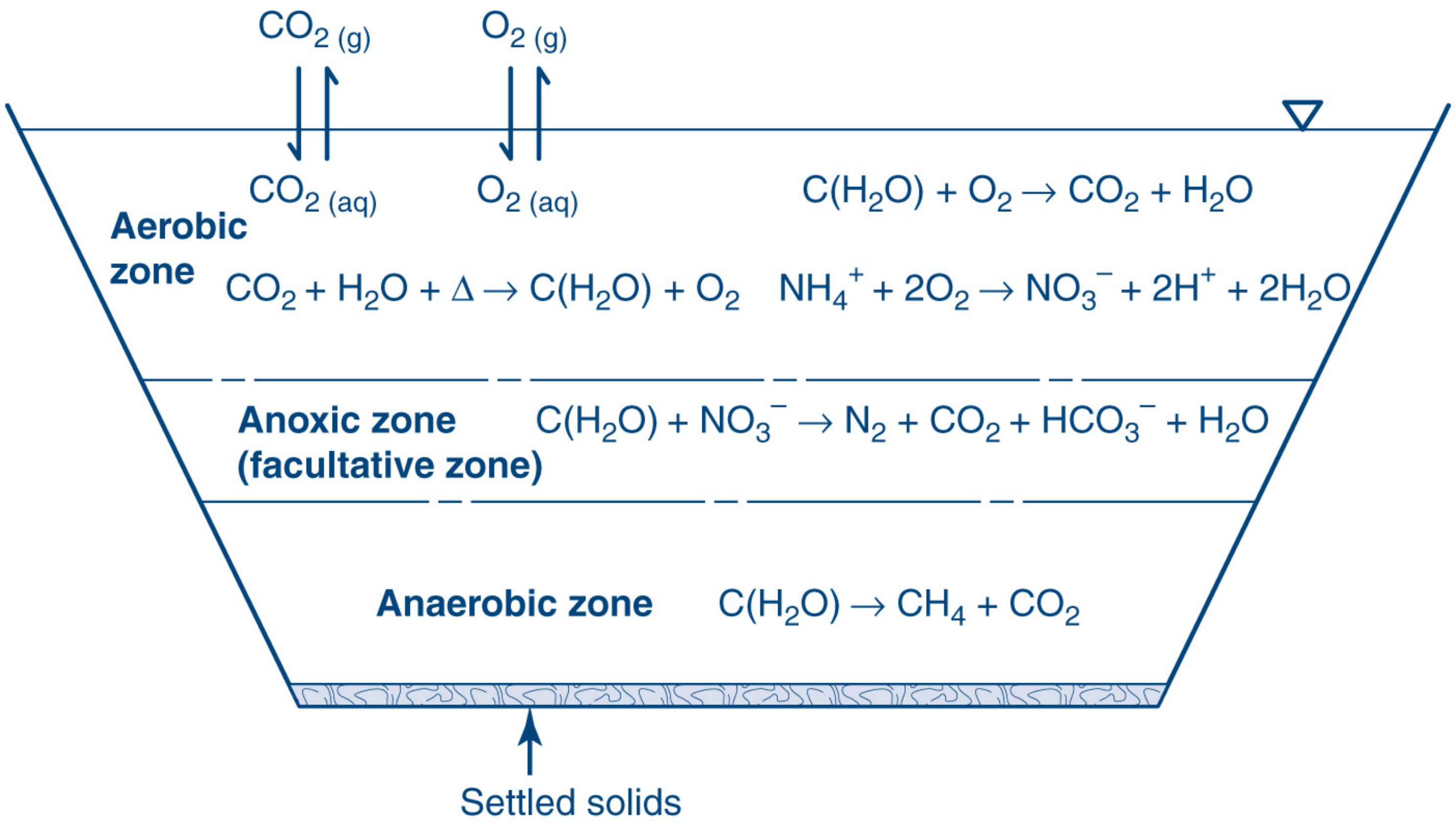


Outlet

Currently being discharges into Ganga Canal. Plan is to reuse the water for lawn and ground maintenance, after laying the distribution network.

Dewatered sludge

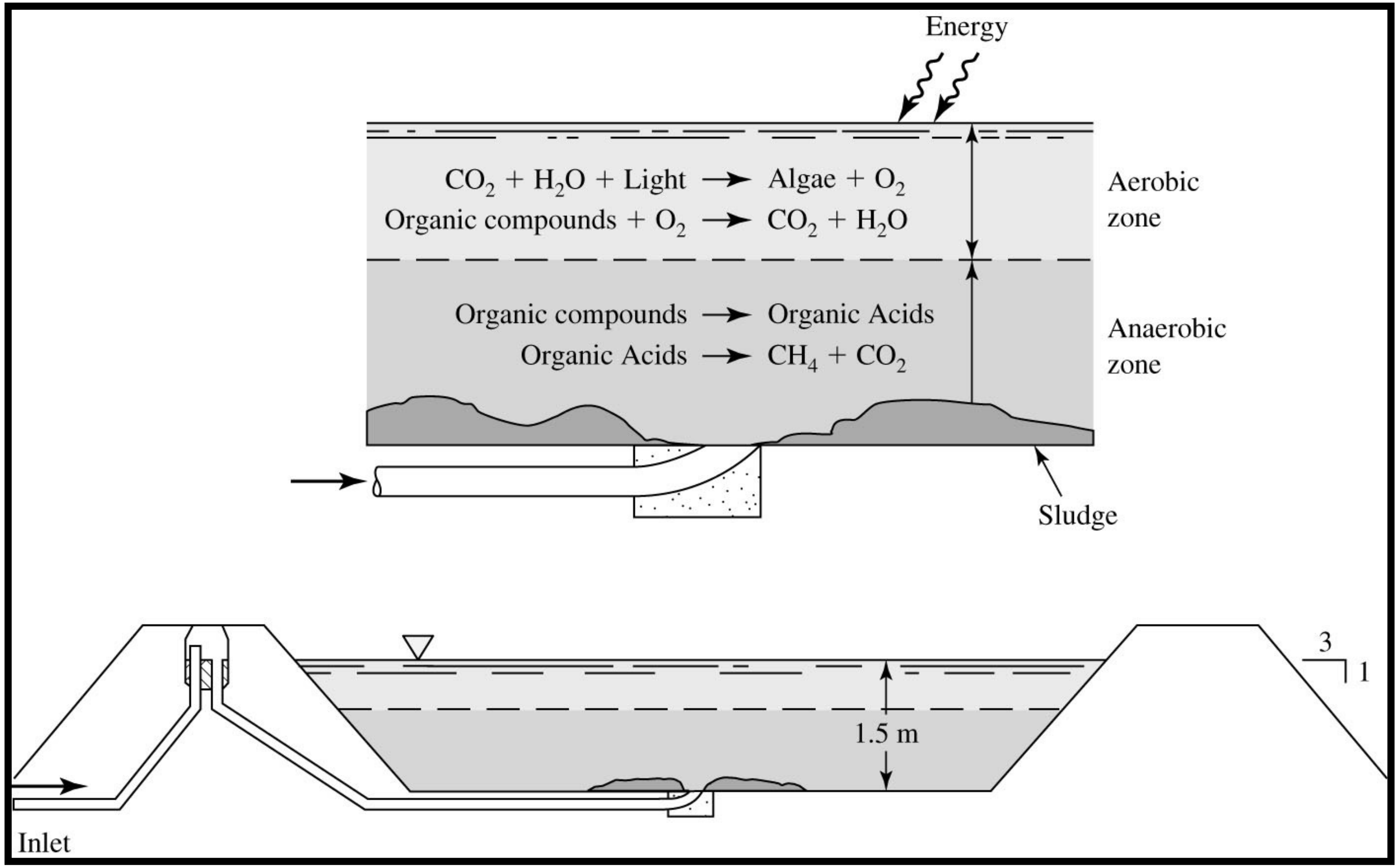
Low-tech solutions (Waste Stabilization Pond)



- Ponds 1 - 2.5 m deep
- θ = 30 - 180 d (HRT)
- not easily subject to upsets due to fluctuations in Q, loading
- low capital, O&M costs

Low efficiency. Large area requirement. No new plants being constructed in Urban areas.

Schematic diagram of facultative lagoon pond relationships



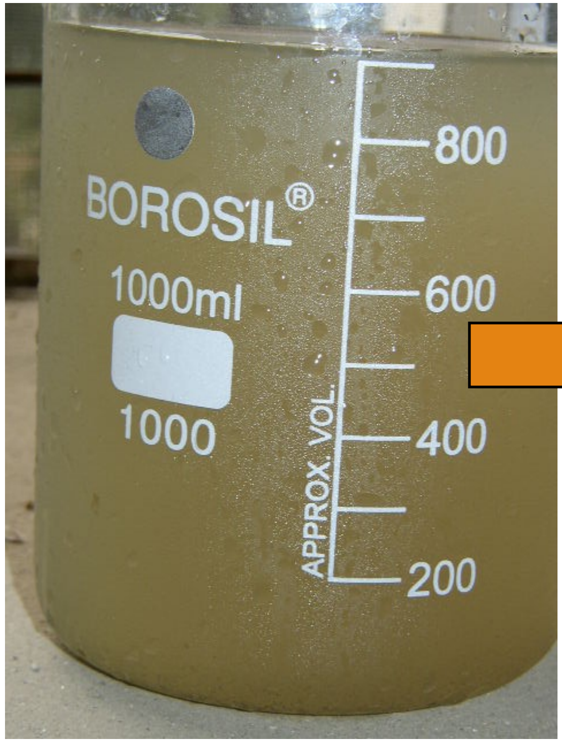
WASTE STABILIZATION POND

The miracle of Kolkata's wetlands – and one man's struggle to save them

The wetlands are this Indian city's free sewage works, a fertile aquatic garden and, most importantly, a flood defence – but they're under threat from developers. One environmentalist is leading the resistance

The wetlands serve two functions: they are the city's free sewage works and they are also a fertile aquatic market garden. As well as fish, wastewater is used in paddy fields and vegetables are grown on the verdant banks and on a long, low hill created by Kolkata's organic waste. This recycling makes Kolkata the cheapest major city in India.

Carried by long channels towards the ponds, effluent was broken down by UV rays from the sun. This nutrient-rich water is channelled into ponds where algae and fish thrive. The algae is removed by fishermen and fed to the fish that grow quickly in these nutrient-rich ponds.



BOD: 30 mg/L, SS : 50 mg/L