Why treat water and wastewater?

Reasons for treating:

Protect public health

Protect surface-water quality

Meet legal requirements

Specific concern: Pathogenic organisms

Pathogen = specific agent causing disease

Pathogenic = capable of causing disease

Biological pathogens

Pathogen	Size, µm
Bacteria	$10^{-1} - 10$
Viruses	$10^{-2} - 10^{-1}$
Protozoa	$10 - 10^{2}$
Nematode helminth worms	$1 - 10^{5}$
Trematode helminth worms	$1 - 10^{5}$
Tapeworms	~40 (egg) up 6 m (worm)

Note: filter sand is 100 to 10^3 µm, can strain particles to ~30 µm

Chemical contaminants in drinking water

Organic chemicals

Disinfection byproducts

Inorganic chemicals

Radionuclides

Physical and aesthetic characteristics

"Emerging pollutants"

Organic chemicals

Chemical classes:

- Pesticides and herbicides
- Organic solvents
- Fuel components
- Polynuclear aromatic hydrocarbons

Organic chemical

Health effect of organic chemicals:

Carcinogenicity – cause or suspected to cause cancer

Teratogenicity (terra-tau-genicity) – cause birth

Nervous system impairment

Reproductive impairment

Disinfection byproducts

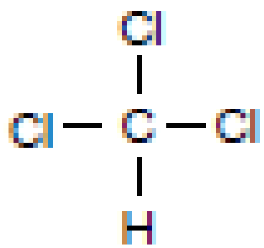
Disinfection with chlorine causes reaction byproducts with organic matter in water

Main classes of chemicals: TTHMs – Total trihalomethanes HAA5 – Five haloacetic acids

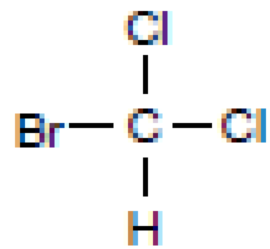
All are suspected human carcinogens

Trihalomethanes

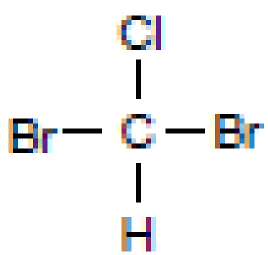
Chloroform



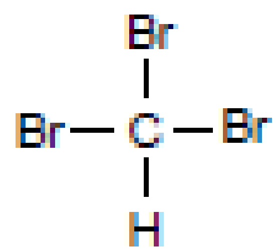
Bromodichloromethane



Chlorodibromomethane

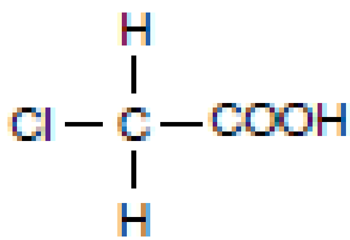


Bromoform

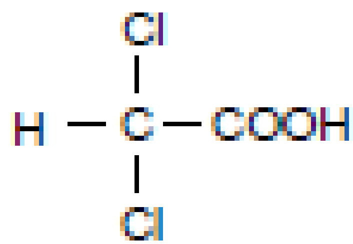


Five haloacetic acids

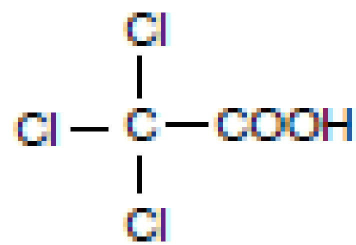
Monochloroacetic acid



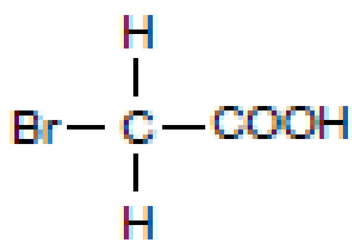
Dichloroacetic acid



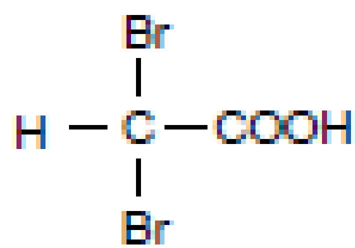
Trichloroacetic acid



Bromoacetic acid



Dibromoacetic acid



Inorganic chemicals

Chemical	Adverse effect
Antimony	Blood disorders
Arsenic	Skin damage, cancer
Barium	Increased blood pressure
Beryllium	Intestinal lesions
Cadmium	Kidney damage
Chromium	Dermatitis
Copper	Gastrointestinal, liver or kidney damage

Inorganic chemicals

Chemical	Adverse effect
Cyanide	Nervous system impairment
Fluoride	Dental fluorosis (staining), bone disease
Lead	Impaired mental development
Mercury	Kidney damage, birth defects
Nitrate	Methemoglobinemia (blue-baby syndrome)
Selenium	Hair loss, circulatory problems
Sodium	High blood pressure
Thallium	Blood, kidney, liver, intestinal effects

Radionuclides

Radioactive decay releases ionizing radiation

Alpha particles – two protons and two neutrons

Beta particles – electrons

Radium-226, Radium-228 – can cause cancer

Uranium – kidney damage, can cause cancer

Alpha radiation, radium and uranium all occur

Physical and aesthetic characteristics

Property	Adverse effect
Turbidity	Harbors bacteria, interferes with treatment
Color, odor	Aesthetic
Silver	Cause argyria (turns skin blue)
Sulfate	Laxative effect
Chloride	Salty taste
TDS	Salty taste, scaling of pipes
Hardness	Cause deposits on bathroom fixtures

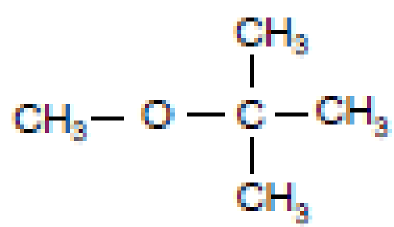
Physical and aesthetic characteristics

Property	Adverse effect
Iron	Stains laundry and fixtures
Manganese	Stains laundry and fixtures
Copper	Stains laundry and fixtures
Detergents	Causes water to foam
pH	Pipe corrosion, impaired taste
Phenols	Taste and odor

Emerging pollutants

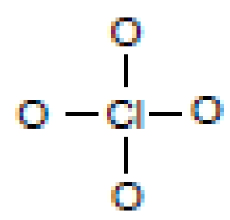
MTBE

Methyl tertiary butyl ether



Perchlorate

ClO_4^-



List of National Secondary Drinking Water Regulations

Contaminant	Secondary Standard
Aluminum	0.05 to 0.2 mg/L
Chloride	250 mg/L
Color	15 (color units)
Copper	1.0 mg/L
Corrosivity	noncorrosive
Fluoride	2.0 mg/L
Foaming Agents	0.5 mg/L
Iron	0.3 mg/L
Manganese	0.05 mg/L
Odor	3 threshold odor number
pH	6.5-8.5
Silver	0.10 mg/L
Sulfate	250 mg/L
Total Dissolved Solids	500 mg/L
Zinc	5 mg/L

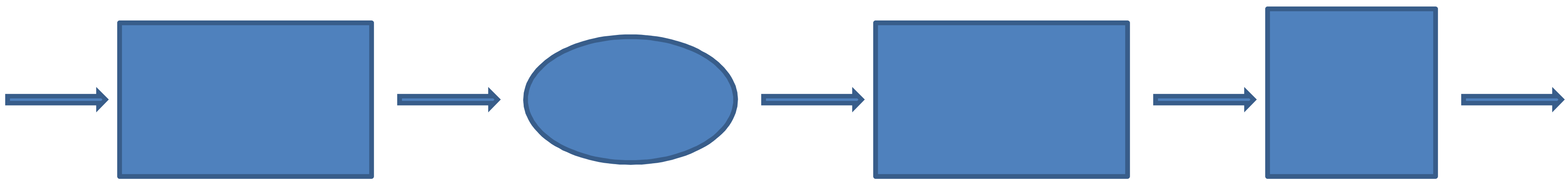
Comparison of standards

Water-quality constituent	Units	U.S. EPA	European Union	World Health Organization
E. coli	number/100 ml	Detected in <5% of samples	0	0
Arsenic	µg/l	10	10	10
Copper	mg/l	1.3	2	2
Lead	µg/l	15	10	10
Nitrate	mg/l as N	10.0	11.3	11.3
TTHM	µg/l	100	100	200/100/100/60[a]
Chloride	mg/l	250	250	250
Iron	µg/l	300	200	No guideline
Benzene	µg/l	5	1	10
Carbon tetrachloride	µg/l	5	4	4
Tetrachloroethylene	µg/l	5	10[b]	40
Trichloroethylene	µg/l	5		70

a Chloroform/bromoform/dibromodichloromethane/bromodichlorodimethane
b Sum of trichloroethylene and tetrachloroethylene

Waste water Screening , Primary treatment

General layout for wastewater treatment plant.



“Headworks” | Primary treatment | Secondary treatment | Disinfection

Screening
Grit removal

Settling

Biological
Treatment

Screening

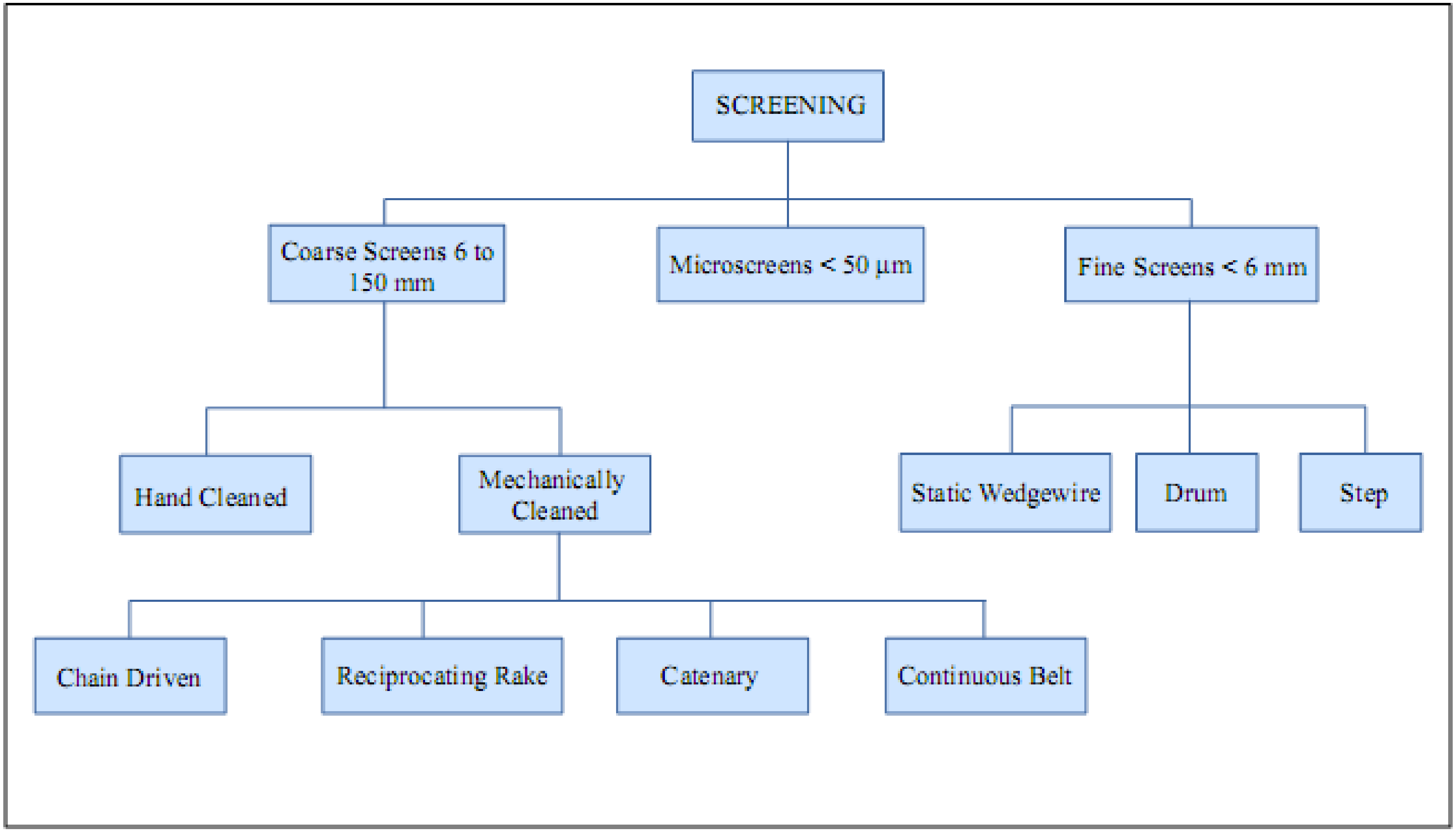
Removes large material to:

1. Protect process equipment.
2. Prevent interference with treatment.
3. Prevent discharge to waterways

Types of Screens

Coarse Screens May be hand raked for small systems.

Most are mechanically cleaned. Often subject to mechanical problems.


SCREENING
Coarse Screens 6 to 150 mm
Microscreens < 50 µm
Fine Screens < 6 mm
Hand Cleaned
Mechanically Cleaned
Static Wedgewire
Drum
Step
Chain Driven
Reciprocating Rake
Catenary
Continuous Belt

❖Design requires minimum velocity-0.4m/s to keep grit suspended –maintained by

❖ Downstream weir or flume.

❖Screenings are disposed by landfilling or incinerations some times passed through grinder

❖ And into waste stream (grinder also called comminutor)

❖Coarse screens usually have nearly 5cm openings.

❖Coarse screens are sometimes followed by fine screens(usually 6mm opening)

Fine screens are expensive, high in maintenance not used commonly for muncipal

wastewater.

Fine screens can remove 10-80% TSS

Average removal = 55%

Grit chambers

Design to remove sand, gravel, cinders, coffee grounds, egg shells, other high density organics and inorganics.

Purposes 1. Protect moving equipment from abrasion.

2. Reduce deposition in pipelines,channels.

3. Reduce frequency of digestor cleaning.

Grit characteristics.

0.004-0.04 m^3grit/m^3 wastewater(higher with combined sewers).

Solids content = 35-80%

Volatile content = 1-55%

Typical density = 1.6 gm/cm^3

Grit chamber design

Design goal- Provide sufficient detention
time for grit to settle.
Maintain constant velocity to scour organics.

Velocity needed to scour organics given by Camp Shields equation (Camp,1942, Grit Chamber
Design, Sewage Works Journal,Vol-14,pp 368-381)

$V_c = 8Kgd\,(\rho_p - \rho_w)/f(\rho_w)$

Vc = Scour velocity [L/T]
g = gravitational acceleration [L/T^2]
d = partical diameter [L]
f = Darey – Weisbach friction factor
0.002 for domestic sewage
ρ_p = particle density [M/L^3]
ρ_w = water density [M/L^3]
K = empirical constant related to stickness of organic particles = 0.04-0.06

Typical V_c = 15 to 30 cm^3 for organic particles.

Challenge in grit chamber is to maintain Vc through fluctuations in flow rate.

One alternative – design outflow weir to maintain velocity in rectangular channel

$$Vc = \frac{Q}{wh} = \text{constant}$$

w = channel width = constant for rest channel
h= elevation above weir crest

$$wVc = \frac{Q}{h} = \text{constant}$$