

DRINKING WATER PURIFICATION - CHAPT 6

PRIMARY OBJECTIVES

Potable H₂O

Minimum Treatment

SAFE DRINKING WATER ACT

Drinking H₂O stds

Maximum contaminant levels (MCLs)

Primary

Secondary

Sampling

SEDIMENTATION

Detention Time

$$T_D = \frac{V}{Q}$$

Overflow Rate

$$v_o = \frac{Q}{A_s}$$

Sedling Tank Design

Dimensions - Side Wall Depth (SWD)

COAGULATION

Alum or Aluminum Sulfate and polymers

FILTRATION

Filter Types

Filter design

Filter operation

Other Filter types

Disinfection

Chlorination

Other methods

Ozone

Ultraviolet

OTHER TREATMENT PROCESSES

Softening

Aeration

Activated Carbon

Corrosion Control

Fluoridation

Desalination

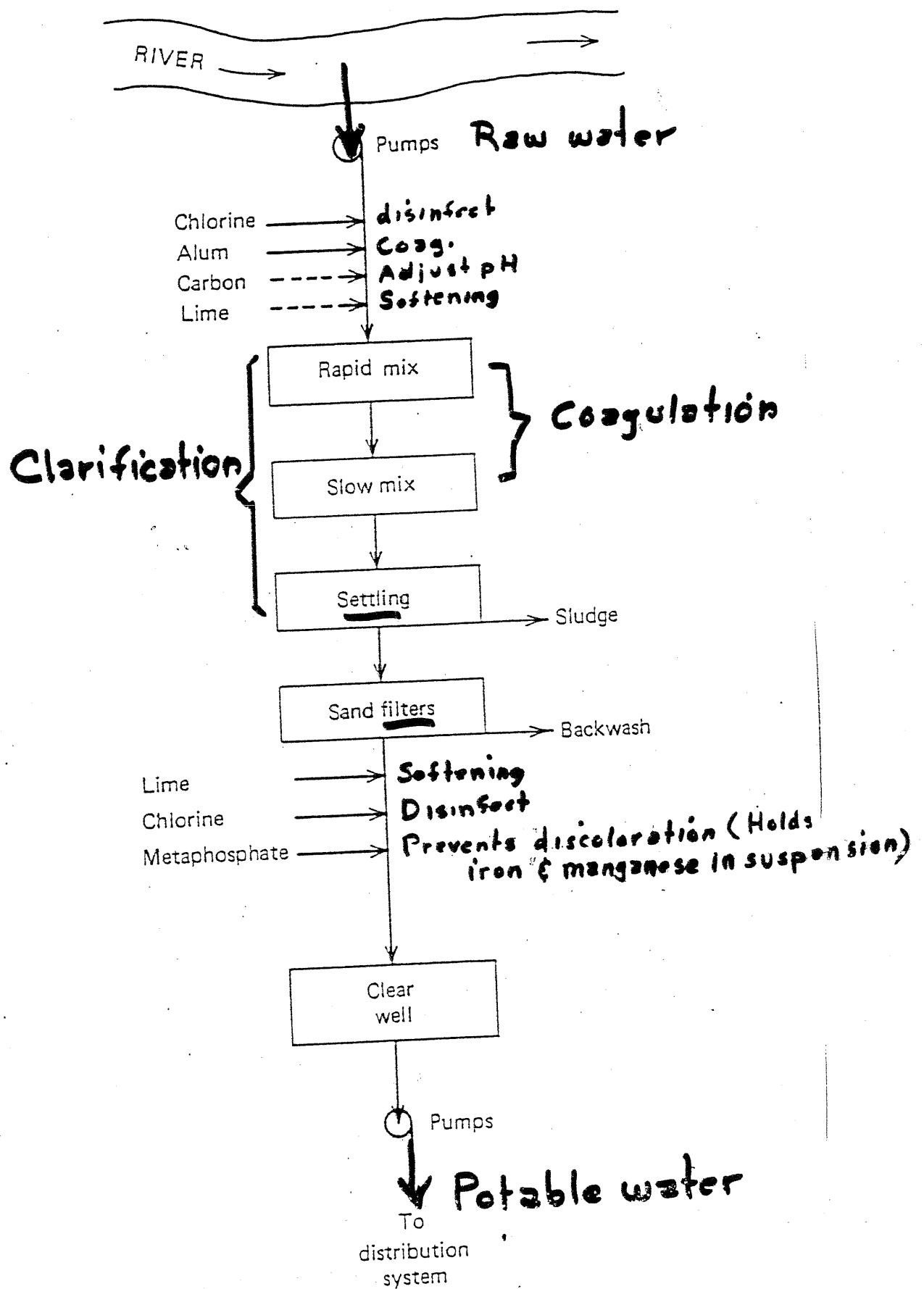


FIGURE 11.2
Flow sheet showing typical municipal treatment facilities for a surface water supply.

TABLE 3.9
Typical Diseases Associated with Water

CATEGORY AND METHOD OF CONTRACTION	DISEASE	CAUSATIVE AGENT	SYMPTOMS
Waterborne: ingesting contaminated water	Amebiasis, (amoebic dysentery)	Protozoan (<i>Entamoeba histolytica</i>)	Prolonged diarrhea with bleeding, abscesses of the liver and small intestine
	Shigellosis (dysentery)	Bacteria (<i>Shigella</i> , 4 spp.)	Severe diarrhea
	Cholera	Bacteria (<i>Vibrio cholerae</i>)	Extremely heavy diarrhea, dehydration, high death rate
	Gastroenteritis	Virus (enteroviruses, parvovirus, rotavirus)	Mild to severe diarrhea
	Giardiasis	Protozoan (<i>Giardia lamblia</i>)	Mild to severe diarrhea, nausea, indigestion, flatulence
	Infective hepatitis	Virus (hepatitis A virus)	Jaundice, fever
	Leptospirosis (Weil's disease)	Bacteria (<i>Leptospira</i>)	Jaundice, fever
	Salmonellosis	Bacteria (<i>Salmonella</i> , - 1700 spp.)	Fever, nausea, diarrhea
	Typhoid fever	Bacteria (<i>Salmonella typhosa</i>)	High fever, diarrhea, ulceration of small intestine
Water-washed: washing with water contaminated	Shigellosis (dysentery)	Bacteria (<i>Shigella</i>)	Mild to severe diarrhea
	Scabies	Mite	Skin ulcers
	Trachoma	Virus	Eye inflammation, partial or complete blindness
Water-based: worm infections involving water as one stage in cycle	Filariasis	Worm	Blocking of lymph nodes, permanent damage to tissue
	Guinea worm	Worm	Arthritis of joints
	Schistosomiasis	Worm (schistosomes)	Tissue damage and blood loss in bladder and intestinal venous drainage

Source: Adapted from Refs. [3.6], [3.10], and [3.19].

CLASSES OF SURFACE WATER

<u>Class</u>	<u>Water is suitable for</u>
A	Primary contact recreation (swimming, etc.).
B	Fish, shellfish, and wildlife. Secondary contact recreation (boating, fishing, etc.)
C	Public water supply after treatment and purification.
D	Agricultural or industrial use.

CRITERIA FOR RAW WATER

- Minimum limits on dissolved oxygen.
 - 5 mg/L for fish maintenance.
 - 8 mg/L for fish spawning.
 - 3 mg/L for Class D water (suffic. for aerobic cond.)
- Maximum coliform levels.
 - 200 per 100 mL for Class A waters (EPA).
(Swimmers don't swallow much water.)
 - 2000 per 100 mL for Class C water (to be purified
prior to use; purification can reduce to less than
1 per 100 mL).

DISINFECTION OF DRINKING WATER

METHODS: Chlorine
Ozone
Ultraviolet

CHLORINATION:

- Most economical method.
- Chlorine toxic as a gas; not when dissolved in water.
- Can react with trace organics to form THMs.
 - THM problem avoided if Cl is added after clarification.
- Cl reacts with water to form:
 - Hypochlorous acid HOCl
 - Hypochlorite radical OCl^-
- Both forms disinfect, work fast, no taste or odor prob.
- Concentration used depends on pH of water.
 - Lower the pH, more Cl used.
- "Chlorine demand" - Cl that reacts with dissolved substances and does not disinfect.
 - The "free available Cl" acts as disinfectant.
 - Reacts with ammonia to form "chloramines".
 - Chloramines also disinfect but:
 - React slower than chlorine.
 - May have an odor problem.
 - Last longer than chlorine.
- Chlorination methods:
 - For large volumes - gaseous form is used.
 - For small volumes - hypochlorite compounds used.
- Effectiveness of chlorination depends on:
 - Chlorine concentration used.
 - Contact time.
- Effectiveness determined by testing for:
 - Presence of coliform bacteria.
 - Chlorine residual test (dye test).

WATER QUALITY STANDARDS

SET LIMITS ON:

- Physical impurities.
- Chemical impurities.
- Microbiological impurities.

STANDARDS INCLUDE RULES AND REGULATIONS FOR:

- Sampling.
- Testing
- Reporting.

TYPES OF WATER QUALITY STANDARDS:

- Stream standards.
- Effluent standards.
- Drinking water standards.

STREAM STANDARDS:

- Classify streams on basis of highest beneficial use.
- Limit pollutants in different classes of streams.
- Intended to prevent further deterioration of streams.

BASIC WATER TREATMENT PROCESSES

- Clarification (coagulation, sedimentation, filtration) to remove suspended solids.
- Disinfection to remove pathogens.

OTHER TREATMENT PROCESSES

- Water softening.
- Aeration.
- Activated carbon.
- Corrosion control.
- Fluoridation.

WATER SOFTENING.

Remove calcium and magnesium salts.

Economic problem, not health problem.

Hardness measured in mg/L of calcium carbonate (CaCO_3).

>300 mg/L is "hard"

>500 mg/L treated at plant.

about 100 mg/l optimum for drinking.

Minerals removed by:

Lime-soda method (precipitation).

"Recarbonation"

Ion-exchange method.

AERATION (air completely mixed with water)

Taste and odor control.

Dissolved gases transferred from water to air ("air stripping").

Removal of iron and manganese.

ACTIVATED CARBON

Used to remove organics causing:

- Taste and odor problems.
- React with Cl to form THMs.

Carbon is very porous:

Attracts and holds many impurities by "adsorption".

CORROSION CONTROL.

Process involves transfer of electrons.

Blocks flow of electrons between water and metal.

Control pH of treated water to prevent corrosion in distribution system.

FLUORIDATION.

To prevent tooth decay.

Done after filtration.

WATER TREATMENT PROCESSES TO MEET DRINKING WATER STANDARDS

CLARIFICATION (to remove suspended solids and many micro-organisms).

Clarification process includes:

- Coagulation and flocculation.
- Sedimentation.
- Filtration.

DISINFECTION (to remove remaining pathogenic bacteria).

Chlorination.

OTHER SPECIAL TREATMENT PROCESSES.

DRINKING WATER STANDARDS

- Established by Safe Drinking Water Act (SDWA) of 1974 to protect public health.
- EPA developed criteria for potable water for *public systems*.
 - Primary Regulations:
 - To protect public health.
 - Are legally enforceable.
 - Secondary Regulations:
 - For substances that affect aesthetic quality.
 - Are not legally enforceable.
 - Are for guidance only.
- Substances controlled under Primary Regulations:
 - Turbidity.
 - Bacteria.
 - Inorganic chemicals.
 - Organic chemicals.
 - Radioactive substances.

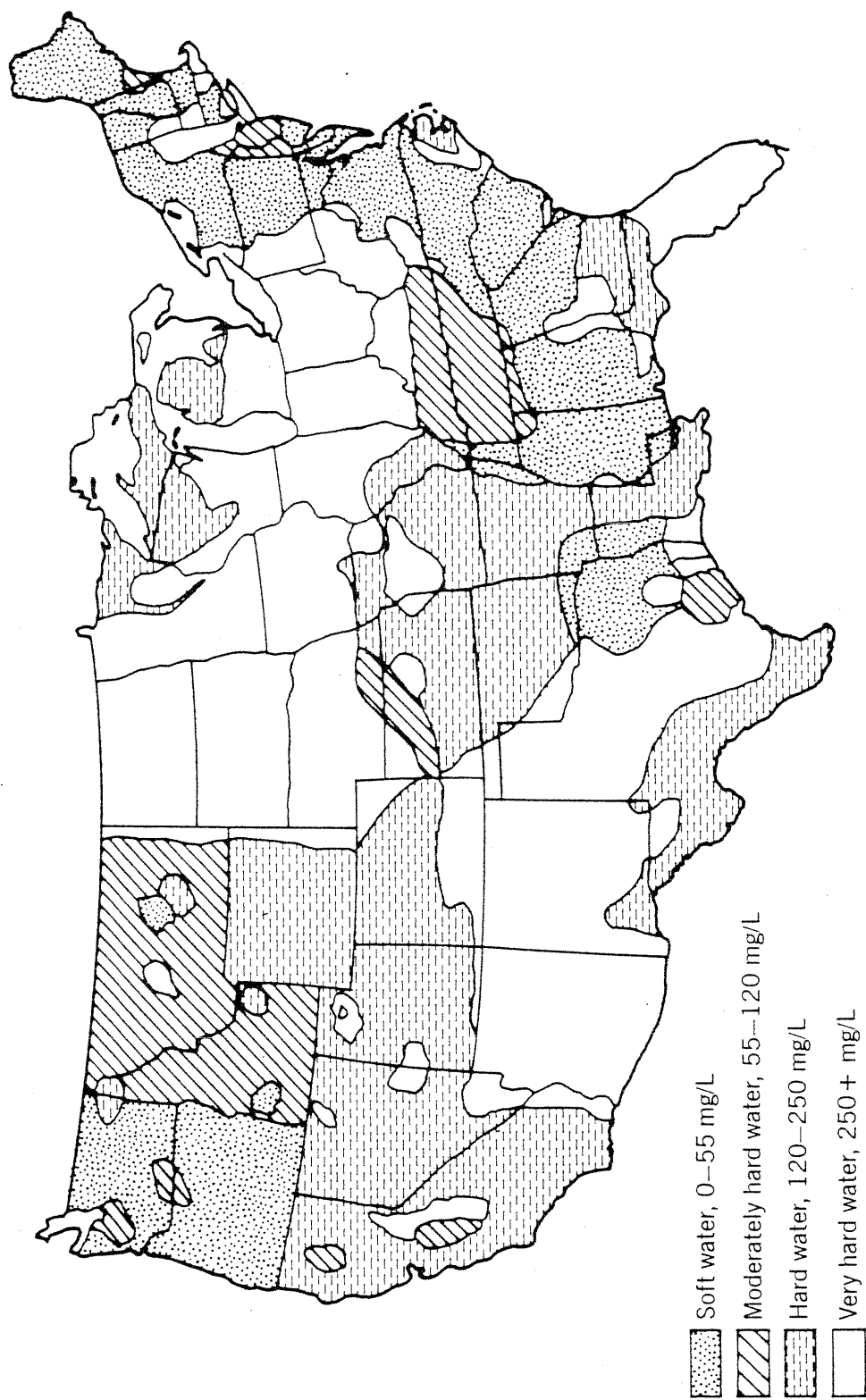


FIGURE 15-14. Distribution of hard water in the United States. The areas shown define approximate hardness values for municipal water supplies. Reprinted with permission from Ciaccio, L. (ed.), *Water and Water Pollution Handbook*, Marcel Dekker, Inc. N.Y. (1971).

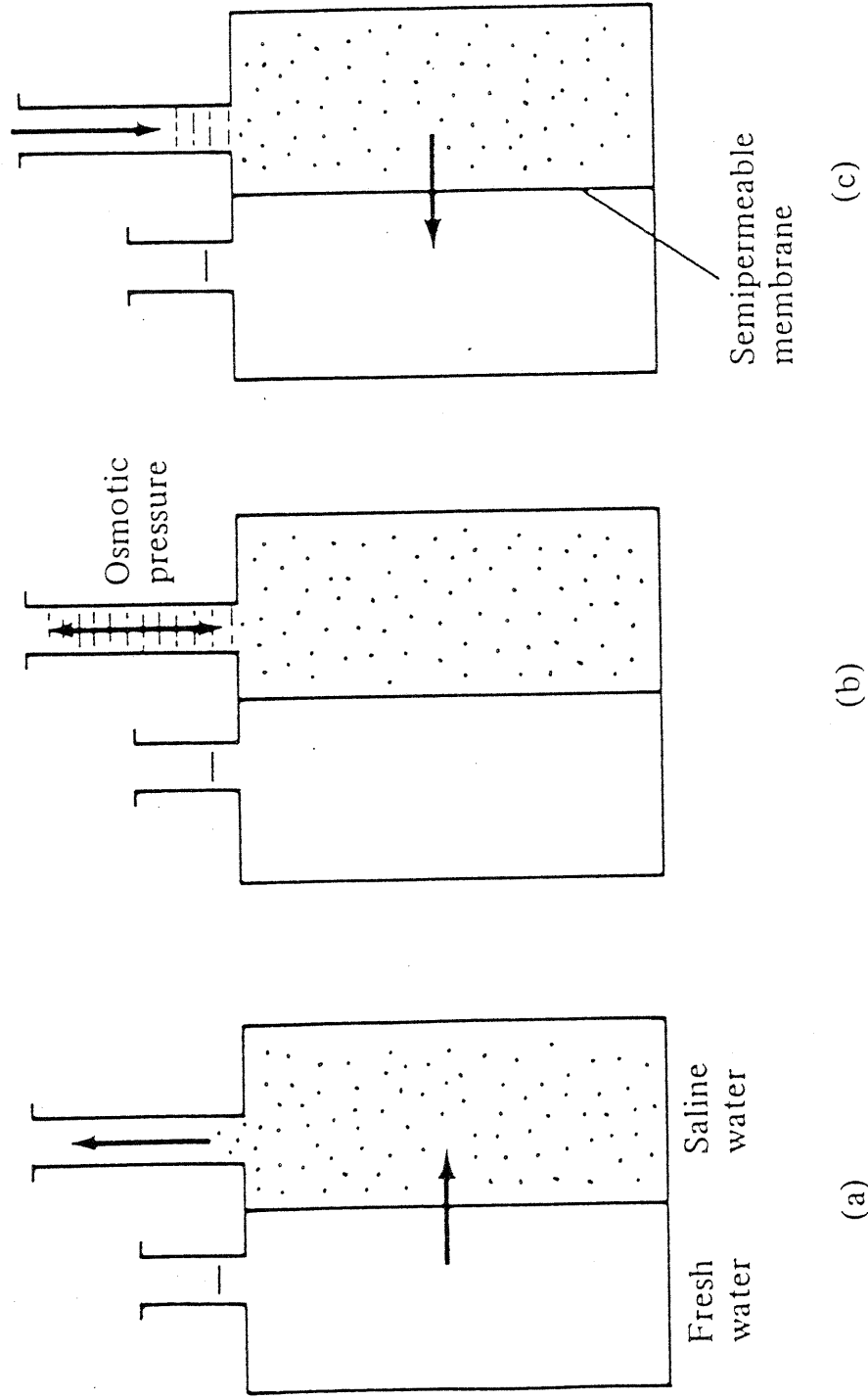


Figure 11.20 Illustrations describing the process of reverse osmosis to remove dissolved salts from water. (a) Direct osmosis. (b) Osmotic equilibrium. (c) Reverse osmosis.