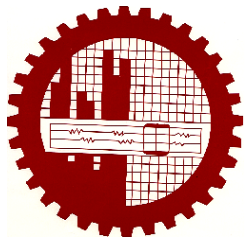


CE 331: Environmental Engineering I

Introduction to the Course



Dr. Tanvir Ahmed

Associate Professor

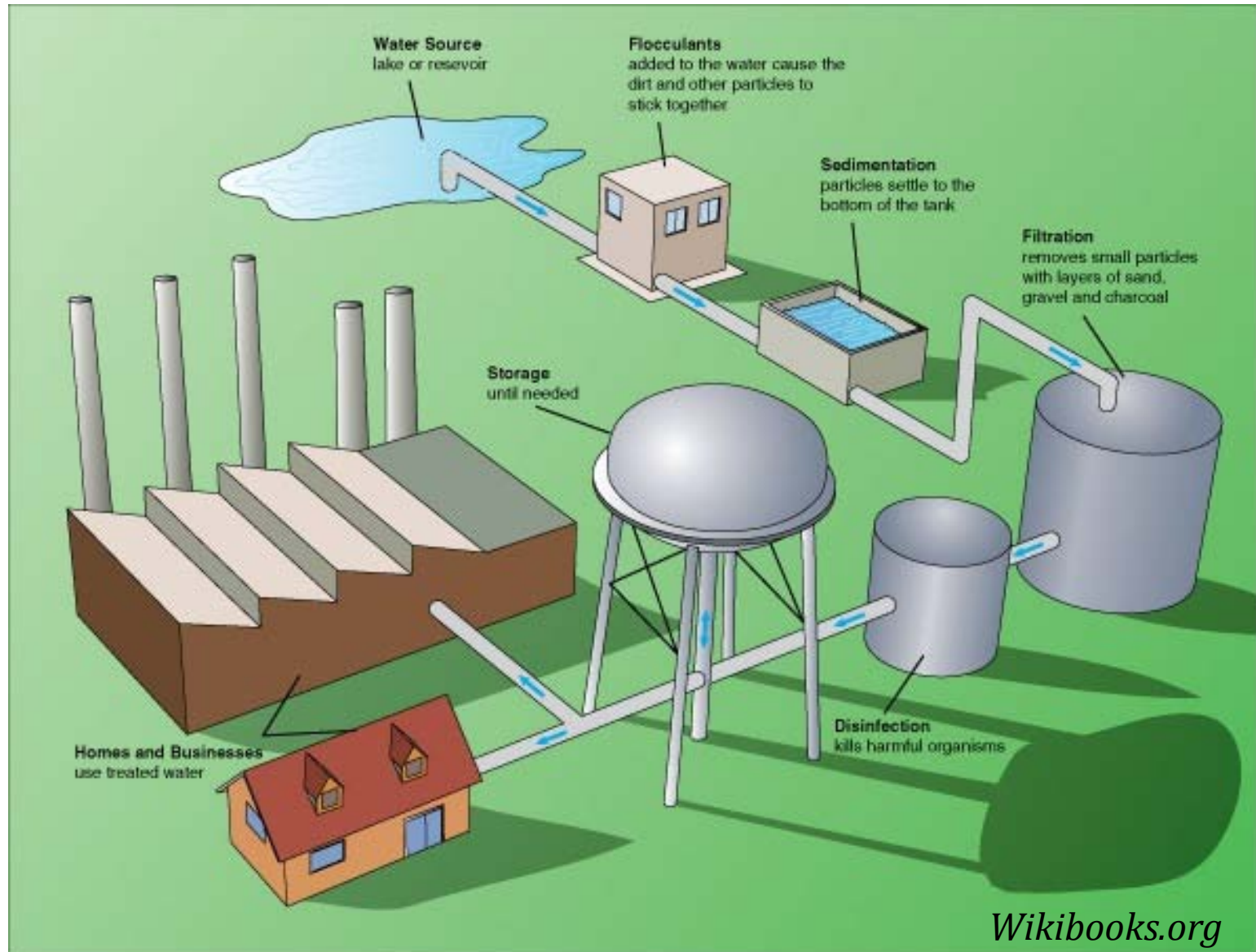
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Environmental Engineering: Definition

“Environmental Engineering is manifest by sound engineering thought and practice in the solution of problems of environmental sanitation, notably in the provision of safe, palatable, and ample public water supplies; the proper disposal of or recycle of wastewater and solid wastes; the adequate drainage of urban and rural areas for proper sanitation; and the control of water, soil and atmospheric pollution, and the social and environmental impact of these solutions. Furthermore it is concerned with engineering problems in the field of public health, such as control of arthropod-borne diseases, the elimination of industrial health hazards, and the provision of adequate sanitation in urban, rural and recreational areas, and the effect of technological advances in the environment.....”

Environmental Engineering Division, ASCE.

Provision for Safe Water Supply



Water Sources: Global View

Location	Volume, 10^{12} m^3	% of total
Land areas		
Freshwater lakes	125	0.009
Saline lakes and inland seas	104	0.008
Rivers (average instantaneous volume)	1.25	0.0001
Soil moisture	67	0.005
Groundwater (above depth of 4000 m)	8,350	0.61
Ice caps and glaciers	29,200	2.14
Total land area (rounded)	37,800	2.8
Atmosphere (water vapor)	13	0.001
Oceans	1,320,000	97.3
Total all locations (rounded)	1,360,000	100

Source: Adapted from Todd. [2-17]

Freshwater amounts to only <3% of the global water.

What is the Role of an Environmental Engineer

Adapt the principles of **natural mechanisms** to **engineered systems**; engineered processes are designed to **amplify and optimize** the operations observed in nature.

Use all available technical tools to design efficient treatment devices that are modeled after natural processes.

Requires understanding of **biological/ chemical reactions and physical processes** involved in natural and engineered systems

History of Water Treatment and Supply

In the Egypt of the Pharaohs it was left standing water in clay pots for several months to allow precipitate particles and impurities, and through a siphon drew water from the top (decanting), at other times incorporating certain minerals and vegetables to facilitate precipitation of particles and clarify the water (coagulation).



History of Water Treatment and Supply

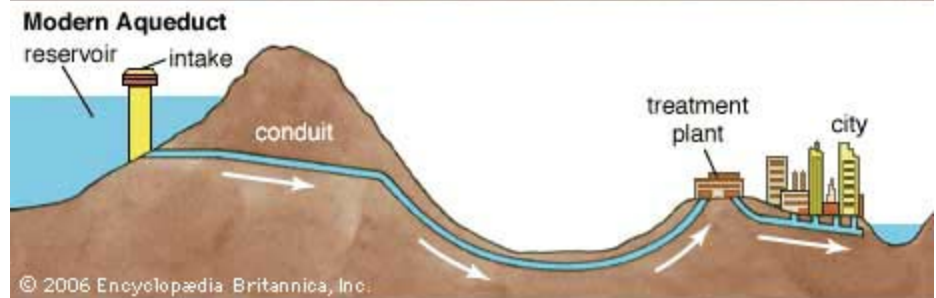
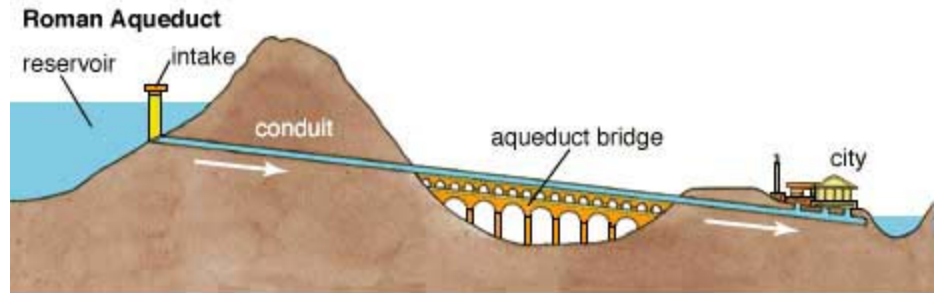
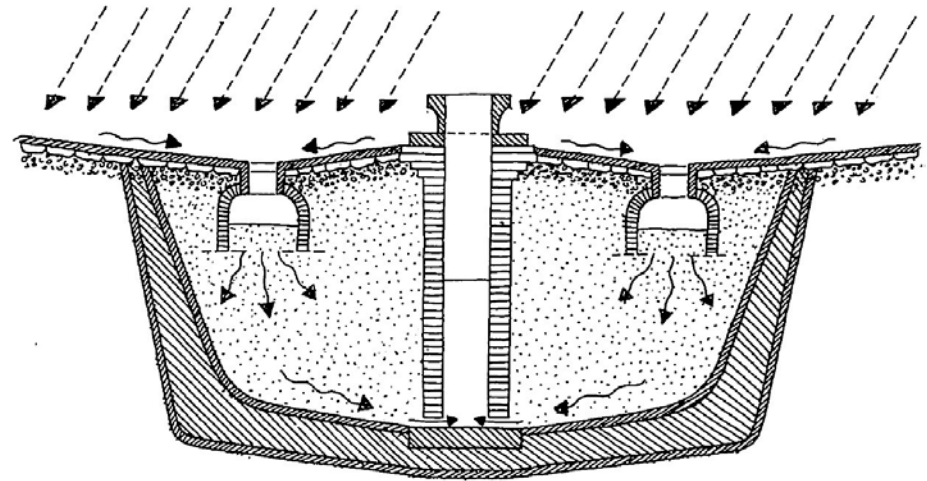
Evidence of water boiling and filtering dates back to 2000 B.C. (sanskrit literature), siphoning and filtering to 1300 B.C. (Egyptian drawings, Greek and Roman literature)

Roman aqueducts had settling basins at headworks (first century) which supplied water to private wells and fountains or reservoirs for general public use.

Rainwater harvesting and sand filtering in Venice (fifth century)

Filtering devices were used in private households, institutions, ships in the 18th Century France and England.

Roman Aqueducts and Venetian water tank



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History of Water Treatment and Supply

19th Century: public water was treated in a large scale. The city of Paisley, Scotland is credited as the first city to have a treated water supply (Settling operations + filtering)

Development of hydraulically cleaned Rapid Sand Filter during the latter part of the 19th Century in America

Motivation of filtration was to improve the aesthetic quality of water

Disinfection practice emerged after the acceptance of germ theory of disease. (Belgium in 1902, Philadelphia in 1913)

Treatment processes developed in the absence of scientific knowledge concerning the basic principles of water treatment.

CE 331 Course Outline

Introduction to Environmental Engineering: ecology and environment; climate change; biodiversity.

Water Supply Engineering: introduction; water demands; water supply sources; ground water exploration: aquifer properties and ground water flow, well hydraulics, water well design, drilling, construction and maintenance; water demand for rural communities; shallow hand tubewells, deep tubewells, deep set pumps and alternative water supplies for problem areas.

Surface water collection and transportation; head works; pumps and pumping machineries; water distribution systems; analysis and design of distribution network; fire hydrants; water meters; leak detection; unaccounted for water.

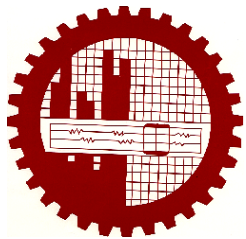
Water quality requirements; water treatment - plain sedimentation, coagulation, flocculation, filtration, disinfection; miscellaneous treatment methods; low cost treatment methods for rural communities; water safety plans.

References Books

- ❑ Peavy, H.S., Rowe, D.R. and Tchonanoglous, G.
Environmental Engineering, McGraw-Hill Publishing
- ❑ Introduction to Environmental Engineering – Davis and
Cornwell. (5th edition). McGraw-Hill Publishing
- ❑ CE 332: Environmental Engineering Sessional Class notes,
BUET.

CE 331: Environmental Engineering I

Water Quality Parameters, Significance and Water Quality Standards

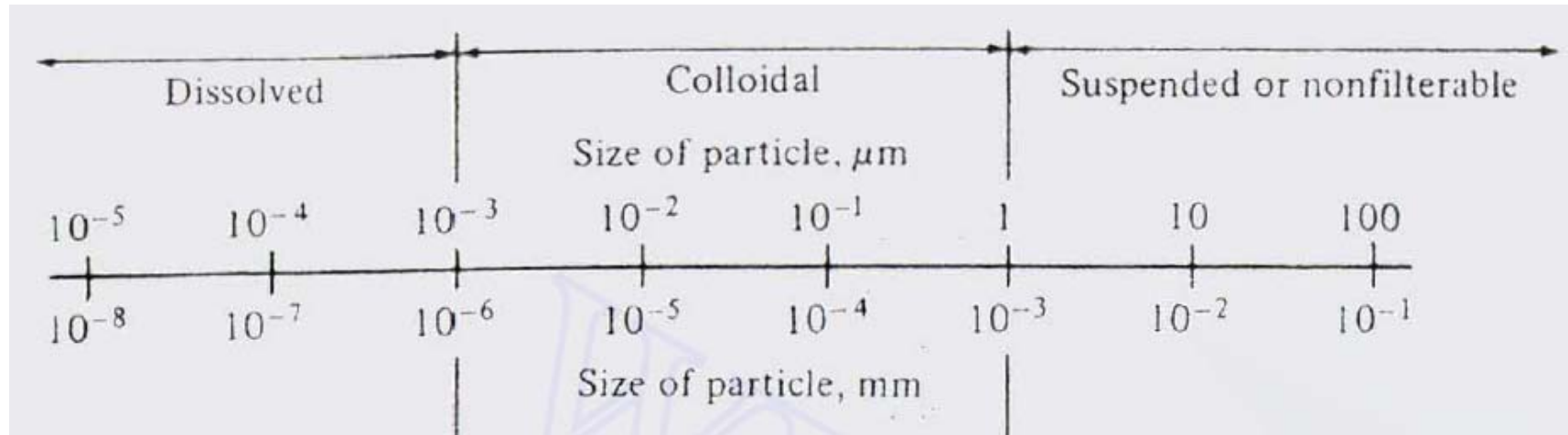


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Associate Professor

Dept. of Civil Engineering, BUET

Impurities in Water



Impurities are added to water in different stages of the water cycle which can affect its intended use.

Water pollution may be defined as the presence in water of impurities in such quantity and of such nature as to impair the use of water for a stated purpose.

Water Quality Parameters

Physical Water Quality Parameters: those characteristics of water that respond to the senses of sight, touch or smell

-Suspended Solids, Turbidity, Color
Taste and odor, Temperature

Chemical Water Quality Parameters: related to solvent capabilities of water

-Total Dissolved Solids, Alkalinity, Hardness
Dissolved Metals, Fluoride, Organics, Nutrients

Biological Water Quality Parameters: Water may serve as a medium for hundreds and thousands of biological species

- Pathogens

Suspended Solids

May consist **inorganic solids** (clay, silt or other soil constituents) or **organic particles** (plant fibers or biological solids) or **immiscible liquids** (i.e. oil and grease)

Domestic wastewater contains large quantities of organic SS, industrial wastewater may contain varieties of impurities of either organic or inorganic nature

Aesthetically displeasing and provides **adsorption sites** for chemical and biological agents.

Biologically active SS may degrade and cause **objectionable by-products**, may include **disease-causing organisms**.

The nature of the SS in water and the secondary effects they produce may be more important than the actual quantity of SS.

Turbidity

A measure of the extent to which **light is either absorbed or scattered** by suspended material in water

Not a direct quantitative measurement of suspended solids but often used as a **proxy for Suspended Solids** in drinking/ potable water supplies

Sources of turbidity: same as suspended solids (erosion of colloidal material such as clay, silt, rock fragments, and metal oxides from soil, vegetable fibres and microorganisms, household and industrial wastewater etc.)

Environmental Significance of Turbidity

Aesthetic quality affected (aesthetically displeasing opaqueness)

In natural waters: may interfere with light penetration and photosynthesis

Increases Filtration cost (SSF operation becomes difficult, RSF operation depends on successful removal of turbidity)

Affects Disinfection (pathogenic organisms encased in particles can be protected from disinfection)

Removal of Turbidity is the first line of defense against disinfection resistant organisms (*Cryptosporidium parvum* and *Giardia lamblia*)

Color (Apparent and True color)

Sources:

- Iron and Manganese in Groundwater (metallic substances)
- Plankton and Weeds
- Humus and Peat
- Colored Wastes

Significance:

- **Aesthetic quality** affected (yellow brownish appearance)
- Organic compounds may exert **chlorine demand**
- **Harmful by-products** formed by the combination of chlorine with color-producing organics (THM, objectionable taste and odor from reaction with phenolic compounds)

Taste and Odor

Sources:

- Inorganics (generally taste unaccompanied by odor): Alkaline materials impart bitter taste, metallic salts give salty/bitter taste
- Organics (both taste and odor): petroleum-based products, biological decomposition of organics (H_2S from reduced products of sulfur), oily substances secreted by algae
- Combination of two products (though neither of them produce taste/odor by itself)

Significance:

- Aesthetic reasons: the consumer typically associates taste and odor with contamination
- Some odor-producing substances are carcinogenic

Temperature

Sources:

- Ambient temperature (surrounding atmosphere)
- Use of water for dissipation of waste heat
- Removal of forest canopies and irrigation return flows

Significance:

- Increased rate of biological activity (an increase in 10°C doubles biological activity), accelerated growth (algal bloom)
- Influences DO levels in water and survival of fish species
- Affects reaction rates and solubility of chemicals
- Viscosity of water increases with decreasing temperature (subtle effect on planktonic organisms in natural water systems)
- Temperature affects density (density stratification in natural waters)

Total Dissolved Solids

Significance:

Many dissolved substances are undesirable, may cause aesthetically displeasing color, taste and odors. (can be both organic and inorganic)

Some TDS can be toxic and carcinogenic

TDS > 500 mg/L → Excessive scaling in water pipes, water heaters and boilers and household appliances

Type of softening procedure depends on TDS

Corrosion control by pH adjustment: pH at stabilization **depends on TDS**, alkalinity and Temperature.

Not all dissolved substances are undesirable. (pure, distilled water has a flat taste, undersaturated water will be “aggressive”)

Total Dissolved Solids and EC

Non-ionized and organic dissolved molecules do not contribute to EC.

Also magnitude of EC is influenced by the valence of the ions in solution, their mobility and relative numbers

Proxy measurement using Electrical Conductivity:

$\text{TDS (mg/L)} \approx (0.55 - 0.90) \times \text{Electrical Conductivity (in } \mu\text{S/cm)}$

To use EC as a quantitative test, sufficient analysis of filterable residue must be run to determine the **conversion factor**

Ions Contributing to TDS

For potable water supplies, the ions contributing to TDS is of importance

Major constituents (1 – 1000 mg/L): Sodium, Calcium, Magnesium, bicarbonate, Sulfate, Chloride



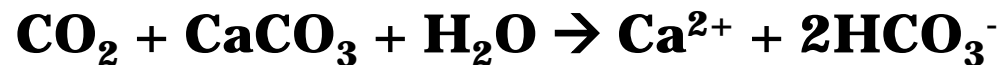
Also called “common ions”, **often sufficient to characterize TDS in natural waters**

Minor constituents (0.01 – 10 mg/L): Iron, Strontium, Potassium, Carbonate, Nitrate, Fluoride, Boron, Silica

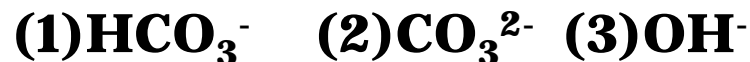
Alkalinity

A measure of **water's capacity to absorb Hydrogen ion** (neutralize acids)

Due to salts of weak acids, strong or weak bases (**bicarbonates** represents major form of alkalinity through the action of CO₂ upon basic materials in soil)



Three major classes of materials causing alkalinity:

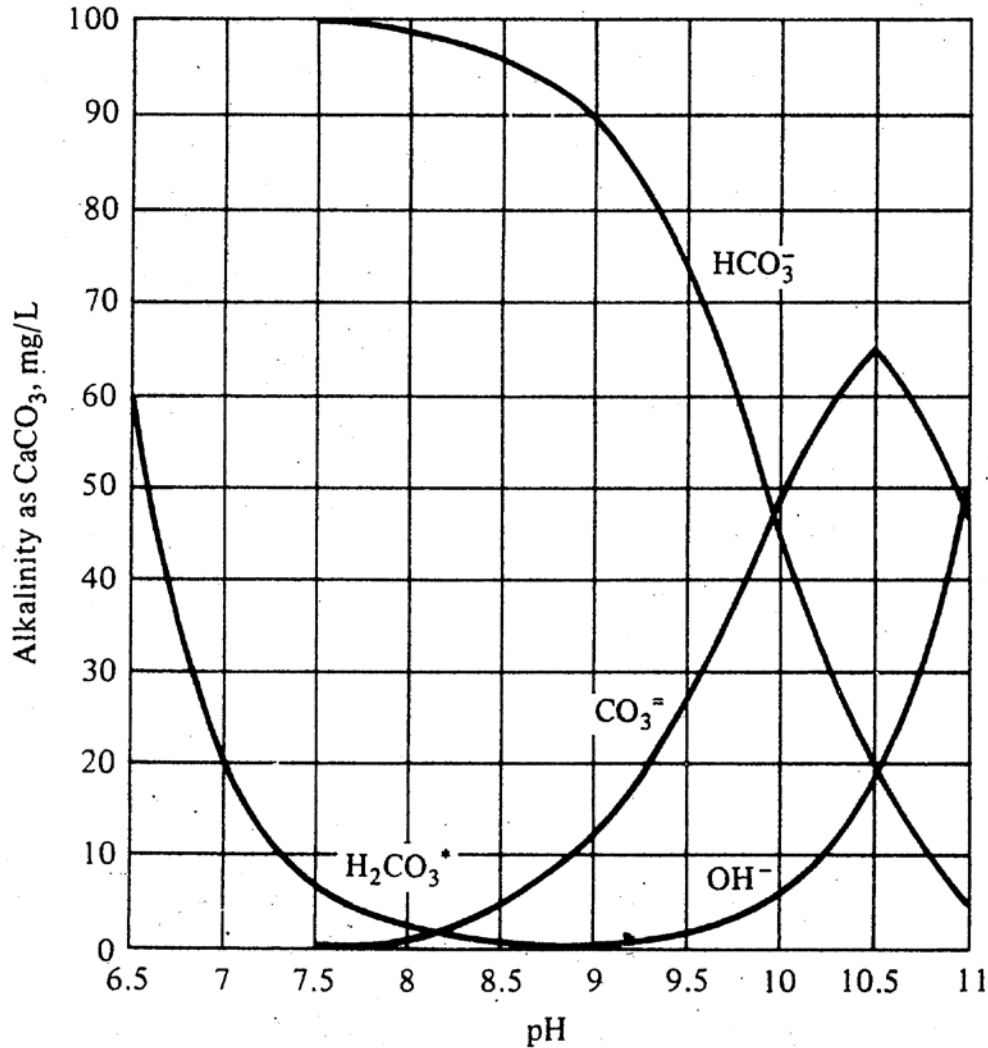


No public health significance (highly alkaline water may be unpalatable, alkalinity causing species react with other cations to result in precipitates which foul pipes)

Alkalinity measures the **buffering capacity** of natural waters

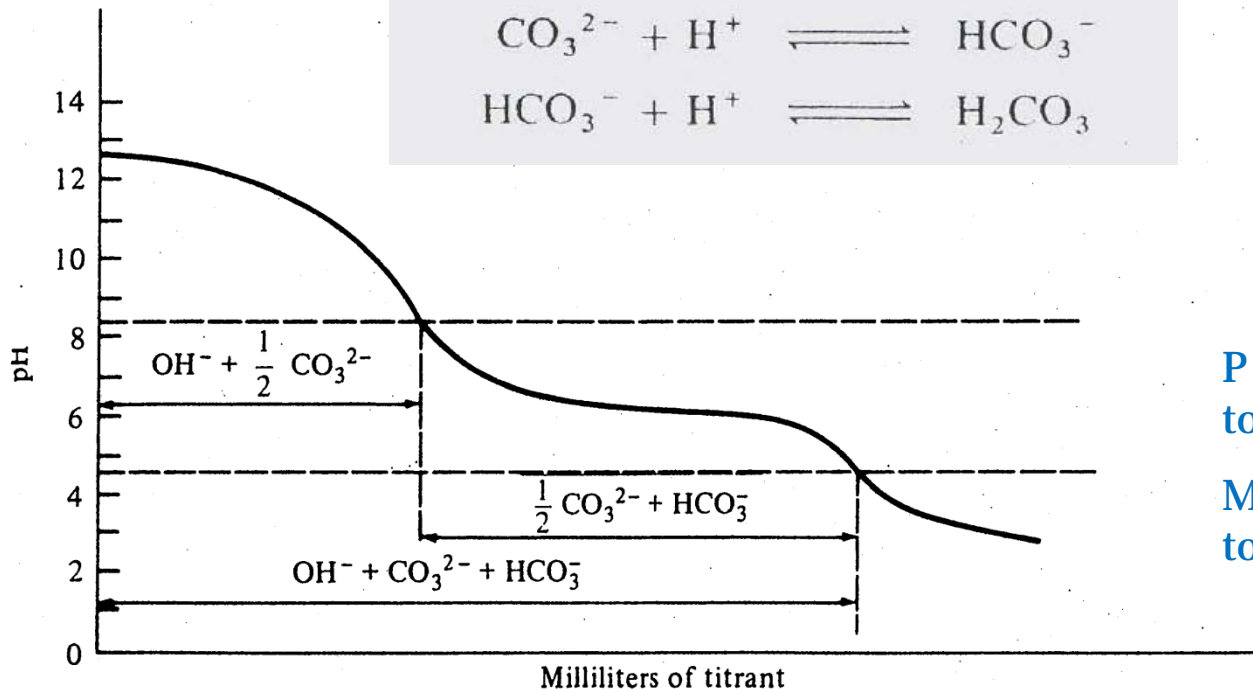
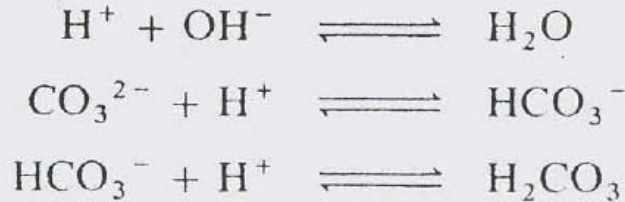
Alkalinity is a **process control variable** in water or wastewater treatment

Alkalinity Species are pH dependent



Determining Total Alkalinity

If 0.02N H_2SO_4 is used in the titration, then 1 ml of the acid will neutralize 1 mg of alkalinity of CaCO_3



P = Amount of acid required to reach pH = 8.3

M = Amount of acid required to reach pH = 4.5

OH^- of samples of $\text{pH} < 9.0$ is insignificant. Therefore CO_3^{2-} would be measured by $2P$ and HCO_3^- would be measured by the remainder ($M - 2P$)

Determining Alkalinity species

If $P = M$, all alkalinity is OH^-

If $P = M/2$, all alkalinity is CO_3^{2-}

If $P = 0$ (initial $\text{pH} < 8.3$), all alkalinity is HCO_3^-

If $P < M/2$, predominant species are HCO_3^- and CO_3^{2-}

If $P > M/2$, predominant species are OH^- and CO_3^{2-}

Ex: A 200 mL sample of water has initial $\text{pH} = 10$. 30 mL of 0.02N H_2SO_4 is reqd. to titrate the sample to $\text{pH} = 4.5$. What is the total alkalinity. Determine the species and quantity of species of alkalinity if the 8.3 equivalence point is reached at 11 mL of acid.

Hardness

Significance:

- Soap consumption issue (not much of a problem nowadays due to availability of detergents)
- Scaling is a problem in industries (fouling of water heater and hot water pipes)
- Laxative effect of Magnesium associated with sulfate
- Drinking hardwater is considered beneficial to cardiovascular system

Cations causing Hardness	Anions
Ca^{2+}	HCO_3^-
Mg^{2+}	SO_4^{2-}
Sr^{2+}	Cl^-
Fe^{2+}	NO_3^-
Mn^{2+}	SiO_3^{2-}

Types of Hardness

Ca^{2+} and Mg^{2+} constitute the major portion of hardness in natural waters

Total Hardness (as mg/L CaCO_3)

= Ca-Hardness (as mg/L CaCO_3) + Mg-Hardness (as mg/L CaCO_3)

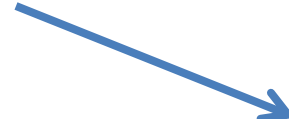


Sometimes needed to calculate the lime requirement in lime soda ash softening

= Carbonate hardness + Non-carbonate hardness



Due to HCO_3^- with Ca^{2+} and Mg^{2+}



Due to SO_4^{2-} , SiO_2^- , Cl^- with Ca^{2+} and Mg^{2+}

When total hardness > alkalinity, **Carbonate Hardness = Alkalinity**

When total hardness < alkalinity, **Carbonate Hardness = Total hardness**

Chloride

Significance:

Not particularly harmful. Can take upto 2000 mg/L without adverse health effects if they are adapted to it

Affects uptake of water through plant roots due to osmotic pressure differences

Used as tracer in some instances where organic dyes are not suitable (e.g. adsorption of dyes on soil particles in GW)

Previously used to detect contamination in water before bacteriological tests were developed (high chloride indicative of sewage pollution)

High chloride concentration usually corrosive to metals

Sources:

Sea Spray, Saltwater intrusion in GW and SW, chloride high in many industrial wastes

Fluoride

Significance:

At optimum levels (around 1 mg/L, minimum limit 0.6 mg/L) beneficial impacts have been observed (less dental caries)

Excessive levels can cause fluorosis (mottling/discoloration) of teeth at concentrations $> 1.5 - 2$ mg/L

Excessive dosage of fluoride (3 – 6 mg/L) can result in bone fluorosis and other skeletal abnormalities

Sources:

Natural, a few sedimentary and igneous rocks, appears in appreciable quantities in GW in a few geographical regions

Sulfate

Significance:

Can be undesirable because of their laxative effects

Sources:

Leaching of natural deposits of magnesium sulfate (Epsom salt) or sodium sulfate (Glauber's salt)

Metals

Non-toxic metals:

Major Hardness ions Calcium and Magnesium, Sodium, Iron, Manganese, Aluminum, copper and Zinc

Sodium is the most abundant non-toxic metal, highly reactive with other elements, excessive concentration cause bitter taste and are a health hazard to cardiac and kidney patients, corrosive to metal surfaces and toxic to plants in large concentrations .

Carbonate and bicarbonate of sodium unite with grease and oil of the skin to form soap, thereby causing the slippery feel of soft alkaline water.

Sodium sulfate may cause foaming of boilers.

Metals

Non-toxic metals:

Iron and Manganese pose no adverse health effects at concentrations typically present in natural waters, in small concentrations can cause color problems, Fe and Mn compounds used as a food source of bacteria resulting in slime growth which creates odor or taste problems

Zinc not detrimental to health, but will impart undesirable taste

Other non-toxic metals are generally found in small quantities and most would cause taste problems before reaching toxic levels

Metals

Toxic metals:

Arsenic, Barium, Cadmium, Chromium, Lead, Mercury and Silver.

These are harmful in small quantities, bioconcentration in the food chain, pose threat to organisms higher in the food chain

Origin of some metals are natural, yet significant concentration in water can be traced to mining, industrial or agricultural sources

Prolonged exposure to Lead (even in small quantities) can lead to death. Lead taken into the body in excess of the low “normal” limits is cumulative poison. Mercury and lead are usually associated with chronic effects on nervous system.

Arsenic occurs naturally in the environment and is also widely used in timber treatment, agri-chemicals (pesticides) etc. Arsenic in drinking water is associated with arsenicosis

Organics

Natural sources: decay products of organic solids

Synthetic organics: wastewater discharges or agricultural practices

Biodegradable or Non-biodegradable



Can be utilized for food by naturally occurring microorganisms, can be determined through BOD test



Resistant to biodegradation (e.g. organic pesticides, tannic and lignic acids)

Can be estimated through COD test, TOC analysis

Nutrients: Nitrogen

Nitrogen species of concern: **Ammonia, Nitrite and Nitrate**

Sources: animal wastes, chemical fertilizers, wastewater discharges

Significance:

Nitrate poisoning in infants (“blue baby” syndrome). Nitrates are reduced in the body to nitrites which react with oxygen receptor sites on the Hemoglobin fraction of the blood and impair its oxygen carrying capacity.

Oxidation of Ammonia (or Ammonium) to nitrite and on to nitrate by aquatic microbes results in an additional biochemical oxygen demand

Nutrients: Phosphorus

Phosphorus species of concern: **Phosphate**

Sources: animal wastes, chemical fertilizers, municipal wastewater discharges (condensed phosphate used as builders in detergents, organic phosphates are constituents of body waste and food residue), industrial waste (phosphate compounds used for boiler conditioning)

Significance:

Non-toxic, do not represent direct threat to human health

Phosphate is often the limiting nutrient in surface water. When phosphate level is increased, eutrophication occurs.

Phosphate can also interfere with treatment processes (as low as 0.2 mg/L interfere with coagulation of turbidity)

Pathogens (Disease causing organisms)

Organisms of concern: **Bacteria, Virus, Protozoa, Helminths**

Test for a specific pathogen is done when there is a reason to suspect its presence. At other times, **indicator organisms** are used.

Significance of indicator organism:

Presence presumes that contamination has occurred and suggests the nature and extent of the contaminant. Ideal pathogen indicator would be (1) applicable to all types of water, (2) always be present/absent when pathogens are present/absent, (3) lend itself to routine quantitative testing without interference from or confusion of results because of extraneous organisms (4) for the safety of laboratory personnel, not be a pathogen itself.



Fecal coliform group (composed of several bacterial strains, notably *E. coli*) nearly meets these requirements as an indicator for waterborne pathogens

Coliform Groups: Fecal and non-Fecal

Fecal coliform group

- Non pathogenic
- Found exclusively in intestinal tracts of warm-blooded animals
- Excreted in large numbers with feces
- Longer survival time outside animal body compared to most pathogens

Coliform of non-fecal origin

- Flourish outside the intestinal tract of animals
- Native to soil and decaying vegetation, often found in water that has recently been in contact with these materials
- Represents life-cycle of some pathogens (i.e. helminths) which includes periods in soil

Total coliform = Fecal coliform + non-fecal coliform

Important: pathogens are not identified by coliform tests. It indicates some portion of the water has recently contacted with soil / decaying vegetation / has been through intestinal tract of warm-blooded animal

Common Waterborne Pathogens

Organism	Disease
Bacteria	
<i>Francisella tularensis</i>	Tularemia (deer fly fever)
<i>Leptospirae</i>	Leptospirosis (Weil's disease, swineherd's disease, hemorrhagic jaundice)
<i>Salmonella paratyphi</i> (A,B,C)	Paratyphoid (enteric fever)
<i>Salmonella typhi</i>	Typhoid fever, enteric fever
<i>Shigella</i> (<i>S. flexneri</i> , <i>S. sonnei</i> , <i>S. dysenteriae</i> , <i>S. boydii</i>)	Shigellosis (bacillary dysentery)
<i>Vibrio comma</i> (<i>Vibrio cholerae</i>)	Cholera (Asiatic, Indian, El Tor)
Viruses	
Enteric cytopathogenic human orphan (ECHO) (ECHO)	Aseptic meningitis, epidemic exanthem, infantile diarrhea
Poliomyelitis (3 types)	Acute anterior poliomyelitis, infantile paralysis
Unknown viruses	Infectious hepatitis
Protozoa	
<i>Entamoeba histolytica</i>	Amebiasis (amebic dysentery, amebic enteritis, amebic colitis)
<i>Giardia lamblia</i>	Giardiasis (<i>Giardia</i> enteritis, lambliasis)
Helminths (parasitic worms)	
<i>Dracunculus medinensis</i>	Dracontiasis (dracunculiasis; dracunculosis; medina; serpent, dragon, or guinea-worm infection)
<i>Echinococcus</i>	Echinococcosis (hydatidosis; granulosis; dog tapeworm)
<i>Schistosoma</i> (<i>S. mansoni</i> , <i>S. japonicum</i> , <i>S. haematobium</i>)	Schistosomiasis (bilharziasis or "Bill Harris" or "blood fluke" disease)

Water Quality Guidelines and Standards

Drinking water quality standards :

acceptable/permissible values/levels of important water quality parameters for implementation or preservation of some desired quality of water for drinking purpose.

Drinking water guideline values (GVs):

concentrations of constituents that do not result in any significant risk to the health of the consumer over lifetime of consumption.

The WHO GV's are recommendations and meant for guidance, **not mandatory for adoption**

Drinking water standards adopted by a country have **legal binding for compliance** within the country.

In-stream Standards

Reflect the beneficial use made of the stream.

More stringent standards are applied to a stream used as a source of water for municipal purposes than to stream used for other purposes

(A) Standards for inland surface water

(ECR 1997)

Best Practice based classification	Parameter			
	pH	BOD mg/l	DO mg/l	Total Coliform number/100
a. Source of drinking water for supply only after disinfecting:	6.5-8.5	2 or less	6 or above	50 or less
b. Water usable for recreational activity :	6.5 – 8.5	3 or less	5 or more	200 or less
c. Source of drinking water for supply after conventional treatment :	6.5 – 8.5	6 or less	6 or more	5000 or less
d. Water usable by fisheries:	6.5 – 8.5	6 or less	5 or more	---
e. Water usable by various process and cooling industries :	6.5 – 8.5	10 or less	5 or more	5000 or less
f. Water usable for irrigation:	6.5 – 8.5	10 or less	5 or more	1000 or less

Drinking Water Quality Standards

Sl. No.	Parameter	Unit	Bangladesh Standards (ECR 1997)	World Health Organization Guidelines (WHO, 2011)
1	Aluminum	mg/l	0.2	--
2	Ammonia (NH ₃)	mg/l	0.5	--
3	Arsenic	mg/l	0.05	0.01
4	Barium	mg/l	0.01	0.7
5	Benzene	mg/l	0.01	0.01
6	BOD ₅ 20°C	mg/l	0.2	--
7	Boron	mg/l	1.0	2.4
8	Cadmium	mg/l	0.005	0.003
9	Calcium	mg/l	75	--
10	Chloride	mg/l	150-600	--
11	Chlorinated alkanes			
	Carbontetrachloride	mg/l	0.01	0.004
	1,1- Dichloroethylene	mg/l	0.001	--
	1,2- Dichloroethylene	mg/l	0.03	0.05
	Tetrachloroethylene	mg/l	0.03	0.04
	trichloroethylene	mg/l	0.09	0.02

Drinking Water Quality Standards

Sl. No.	Parameter	Unit	Bangladesh Standards (ECR 1997)	World Health Organization Guidelines (WHO, 2011)
12	Chlorinated phenols			
	Pentachlorophenol	mg/l	0.03	0.009
	2,4,6- Trichlorophenol	mg/l	0.03	0.2
13	Chlorine (residual)	mg/l	0.2	5
14	Chloroform	mg/l	0.09	0.3
15	Chromium (hexavalent)	mg/l	0.05	--
16	Chromium (total)	mg/l	0.05	0.05
17	COD	mg/l	4	--
18	Coliform (fecal)	Nos/100 ml	0	0
19	Coliform (total)	Nos/100 ml	0	0
20	Color	Hazen unit	15	--
21	Copper	mg/l	1	2
22	Cyanide	mg/l	0.1	--
23	Detergents	mg/l	0.2	--
24	Dissolved Oxygen	mg/l	6	--

Drinking Water Quality Standards

Sl. No.	Parameter	Unit	Bangladesh Standards (ECR 1997)	World Health Organization Guidelines (WHO, 2011)
25	Fluoride	mg/l	1	1.5
26	Hardness (CaCO ₃)	mg/l	200-500	--
27	Iron	mg/l	0.3-1.0	--
28	Kjeldahl Nitrogen (total)	mg/l	1	--
29	Lead	mg/l	0.05	0.01
30	Magnesium	mg/l	30-35	--
31	Manganese	mg/l	0.1	--
32	Mercury	mg/l	0.001	0.006
33	Nickel	mg/l	0.1	0.07
34	Nitrate	mg/l	10	50 (as NO ₃ ⁻)
35	Nitrite	mg/l	<1	3 (as NO ₂ ⁻)
36	Odor	mg/l	Odorless	--
37	Oil and grease	mg/l	0.01	--
38	pH	mg/l	6.5-8.5	--
39	Phenolic compounds	mg/l	0.002	--
40	Phosphate	mg/l	6	--

Drinking Water Quality Standards

Sl. No.	Parameter	Unit	Bangladesh Standards (ECR 1997)	World Health Organization Guidelines (WHO, 2011)
41	Phosphorous	mg/l	0	--
42	Potassium	mg/l	12	--
43	Radioactive materials (gross alpha activity)	Bq/l	0.01	--
44	Radioactive materials (gross beta activity)	Bq/l	0.1	--
45	Selenium	mg/l	0.01	0.04
46	Silver	mg/l	0.02	--
47	Sodium	mg/l	200	--
48	Suspended particulate matters	mg/l	10	--
49	Sulfide	mg/l	0	--
50	Sulfate	mg/l	400	--
51	Total dissolved solids	mg/l	1000	--
52	Temperature	°C	20-30	--
53	Tin	mg/l	2	--
54	Turbidity	JTU	10	--
55	Zinc	mg/l	5	--

Water Sources and Characteristics

Surface water
(rivers, ponds
and lakes)

Exposed to atmosphere, receives pollution from domestic, industrial and agricultural sources,
Microbial pollution
Quality of water of rivers more variable and less satisfactory than lakes and ponds

Groundwater

Generally free from suspended impurities, microbes due to long and slow travel thorough soil, rich in minerals

Rainwater

Free from all impurities except those picked up from the air but can be contaminated from the collection catchment (roof). Rainwater is aggressive due to low mineral content.

Comparison of Surface and Ground Water Quality

Parameter	Surface Water	Ground water
Temperature	Varies with season	Relatively constant
Turbidity and SS	Varies and sometimes high	Usually low or nil
Mineral Content	Varies with soil, rainfall, effluents etc	Relatively constant at high value
Dissolve Fe and Mn	Some	Always high
Aggressive CO ₂	None	Always some
Dissolved Oxygen	Often near saturation, except when polluted	Usually low, requires aeration
Ammonia	Only in polluted water	Levels found to be increasing
Hydrogen sulfide	None	Usually some
Living organisms	May have high levels	Usually none

Water Treatment Process: Groundwater

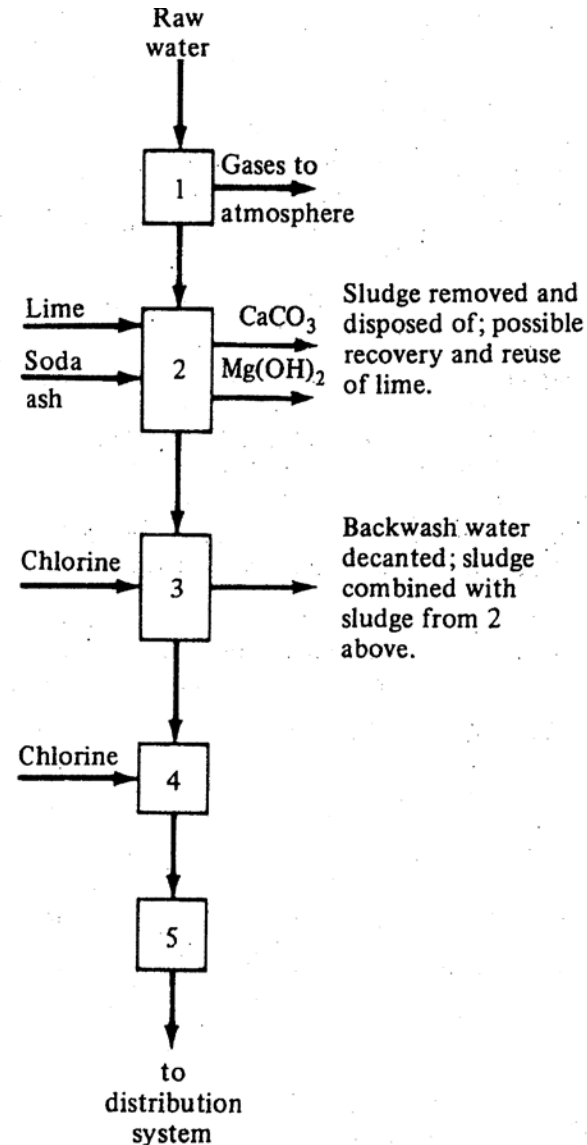
Aeration: Removes undesirable gases and/or oxidation of iron and manganese.

Softening: Removes calcium and/or magnesium hardness; may be done in one or two stages.

Filtration: Removes residual CaCO_3 crystals and Mg(OH)_2 floc left over from softening; disinfectant may be added to prevent biological growth on filter medium.

Disinfection: Destroys pathogens; enough added to provide a residual in the distribution system.

Storage: Provides contact time for disinfection and stores water for peak demands.



Water Treatment Process: Surface water

Presidimentation: May be necessary if water comes from fast-flowing streams. Removes larger suspended solids. Chemicals may be added to oxidize organics or to arrest their biological oxidation.

Mixing, flocculation, settling: Removes turbidity by coagulating colloids and settling them out; may also remove color caused by large organic molecules.

Filtration: Polishes to remove remaining turbidity; disinfectant may be added to prevent biological growth on filter medium.

Adsorption: May be necessary if water contains dissolved organics; may consist of activated carbon columns or activated carbon may be added in powdered form in operation similar to 2 above.

Disinfection: Destroys pathogens; enough added to provide residual in the distribution system.

Storage: Provides contact time for disinfection and stores water for peak demand.

