EWCE 331
Water Supply Engineering

Lecture 6

Instructor

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Lecture outline

Water Quality Requirements

Topics	References
• **Water impurities** • **Water quality requirements/ standards**	**1. Water and Environmental Engineering** Authors: M. Habibur Rahman, Abdullah Al-Muyeed 1st ed., ITN-BUET **2. Environmental Engineering** Authors: Howard S. Peavy, Donald R. Rowe and George Tchobanoglous International Edition, McGraw Hill Companies **2. Water Supply and Sanitation** Authors: M. Feroz Ahmed, Md. Mujibur Rahman 1st ed., ITN-BUET

Water Impurities

- Pure water is not available in nature nor it is desirable for water supply.

- The impurities present in natural water may be grouped into following categories:
  - ✓ Impurities of mineral origin
  - ✓ Impurities of organic origin
  - ✓ Living impurities
  - ✓ Radioactive impurities

- These impurities may be present in suspensions, solution or pseudo-solution.

Water Impurities

Table 17.4: Effect of impurities present in water

Impurities	Effect on water	Effect on health
Living impurities		
Bacteria	Turbidity at high concentrations	Diseases,
Viruses	--	Diseases
Algae, protozoa, fungi	Turbidity, odour, colour,	Diseases, toxicity
Impurities of mineral & organic origin		
Silt and clay	Turbidity	--
Salt or calcium and magnesium	Hardness, alkalinity, taste, corrosiveness and scale formation	--
Salt of Sodium	Alkalinity, salinity, foaming, taste, scaling,	--
Salt of Sodium	--	Tooth decay
Fluorides	Algal growth	Child disease
Nitrate	Taste, hardness, scaling	--
Iron and manganese	--	Toxicity, diseases
Arsenic, lead, heavy metals	Colour, acidity	Diseases
Vegetable dyes		
Gases		
• Oxygen	Corrosiveness, taste	--
• Carbon dioxide	Acidity, corrosiveness	--
• Hydrogen sulphide	Odour, corrosiveness, acidity	Toxicity
Radioactive impurities	--	Diseases

Water Impurities

- Some of the water quality parameters respond to human senses of sight (turbidity, color), taste (salty, offensive) and smell (odor).

- The presence of pathogens and poisons in drinking water cannot be identified by human senses. These are of greater importance in water supply.

Basic Requirement of Drinking Water

- Be completely free of pathogenic microorganisms that can cause diseases
- Contain no element or compound in concentrations that can cause acute or long term adverse effect on human health
- Be fairly clear and aesthetically acceptable i.e. low turbidity and color

Basic Requirement of Drinking Water

- Not be saline to cause salty taste
- Contain no compounds that can cause an offensive taste and odor
- Not cause corrosion, scale formation discoloration or staining
- Not have a temperature unacceptable to the consumers

Water Impurities – Bacteriological Quality of Water

- The most important parameter of drinking water quality is the bacteriological quality, i.e. presence of pathogens.

- The water-borne diseases are caused by the ingestion of pathogens with drinking water.

- In water supply, the water is examined for specific type of bacteria (*indicator organism*), originating in large numbers from human and animal excreta and whose presence in water is indicative of fecal contamination.

Terminology

- **Potable Water** –
  - ✓ the water which is physically, chemically and bacteriologically acceptable to use.



- **Palatable Water** –
  - ✓ the water is free from turbidity, color, taste, odor and with moderate temperature.
  - ✓ Palatable water is physically acceptable, but not necessary to be accepted as chemically or bacteriologically.



Water Quality Parameters - **pH**

- pH expresses the intensity of the acid or alkaline condition of a solution.

- pH is a measure of the concentration of free hydrogen ions (H^+) in water and expressed as pH = - log (H^+).

- pH of an aqueous system is a measure of acid-base equilibrium achieved by various dissolved compounds and in most natural waters, is controlled by CO_2-HCO_3-CO_3 equilibrium system.

Water Quality Parameters - **pH**

Significance of pH

- pH is important for coagulation, disinfection, water softening and corrosion control.

- In biological treatment of water, pH is very important as the organisms involve din treatment processes operate within a certain pH range.

- Dissolution and mobility of metal in natural waters are also greatly influenced by the pH of the water.

- Drinking water standard for pH is 6.5-8.5.

Water Quality Parameters - **Color**

Source of color

- Color in water is primarily due to the presence of colored organic substances 9humic acids), metals such as Fe, Mn or highly colored industrial wastes (e.g. from pulp and paper and textile industries).

- Limiting the color in potable water means limiting the concentration of undesirable substances that are complexed with or absorbed onto humic substances.

Water Quality Parameters - **Color**

Apparent color

- Caused by suspended matter
- Can be removed by centrifugation or filtration.

True color

- Caused by dissolved matter
- One True Color Unit (TCU) corresponds to the amount of color exhibited under the specific test conditions by a solution containing 1.0 mg of Pt per liter of water in the from of chloroplatinate ion.

Water Quality Parameters - **Turbidity**

Significance of color

- Colored water is not acceptable by the consumers for aesthetic reasons.

- Bangladesh standard and WHO standard for color in drinking water is 15 TCU.

Water Quality Parameters - **Turbidity**

Sources of turbidity

- Turbidity occurs in most surface water due to the presence of suspended clay, silt, finely divided organic and inorganic matters, plankton (algae) and microorganisms.

- Turbidity is an expression of certain light scattering and light absorbing properties of a water sample and depend in a complex manner, on such factors as the number, size, shape and refractive index of the particulate matter present in the water.

Water Quality Parameters - **Turbidity**

Measurement of turbidity

- Current standard method for measurement of turbidity employs the principle of nephelometry and measures the scattering of light from the particles causing turbidity.

- Results are expressed in nephelometric units (NTU).

Water Quality Parameters - **Turbidity**

Significance of turbidity

- A turbidity in excess of 5 NTU is generally objectionable to consumers.

- A turbid water protects microorganisms from disinfectants and hence reduces the effectiveness of disinfection process.

- Turbidity stimulates bacterial growth and exert a significant chlorine demand.

Water Quality Parameters – **Total Dissolved Solids**

- TDS comprises inorganic salts and small amounts of organic matter.

Significance of TDS

- The common dissolved mineral salts are claimed to affect the taste, hardness, corrosion and encrustation.

- Dissolved inorganic substances may exert adverse effects on aquatic animals and plants and may cause irrigation problem.

Water Quality Parameters – **Total Dissolved Solids**

Significance of TDS

- In general, water with total solid content of less than 500 mg/L are most desirable for domestic purpose.

- Water with a higher solid content often have a laxative and sometimes the reverse effects on people.
- Depending on TDS, water can be classified as:
  - ✓ Excellent — TDS < 300 mg/L
  - ✓ Good — 300 - 600 mg/L
  - ✓ Fair — 600 - 900 mg/L
  - ✓ Poor — 900 - 1200 mg/L
  - ✓ Unacceptable — TDS > 1200 mg/L

Water Quality Parameters – **Alkalinity**

- Alkalinity of water is a measure of its capacity to neutralize acids.

Sources of Alkalinity

- Alkalinity is due primarily to salts of weak acids and strong bases.

- Such substances act a s buffers to resist a drop in pH resulting from acidic condition.

- Alkalinity is a measure of the buffer capacity.

Water Quality Parameters – **Alkalinity**

- Most of the alkalinity in natural water is caused by three major classes of materials:
  - ✓ HCO_3^-
  - ✓ CO_3^{2-}
  - ✓ OH^-

- HCO3- represents the most common form of alkalinity since they are formed, in large quantities, from the action of CO_2 upon basic materials in the soil.

- Excessive or insufficient alkalinity interferes with water treatment (coagulation).

Water Quality Parameters – **Hardness**

- Hard waters are generally considered to be those waters –
  - ✓ that require considerable amounts of soap to produce a foam or lather and
  - ✓that also produce scale in hot-water pipes, heaters, boilers, and other units in which the temperature of water is increased substantially.

Water Quality Parameters – **Hardness**

Sources of Hardness

- Hardness is caused by multivalent metallic cations.
- Such cations are capable of reacting with soap to form precipitates and with certain anions present in water to form scale.
- The principal hardness causing cations are the divalent calcium, magnesium, strontium, ferrous iron, and manganous ions.

Water Quality Parameters – **Hardness**

- Hard water generally originates in –
  - ✓ areas with thick topsoil and limestone formations
  - ✓ groundwater rich in H_2CO_3 and DO.

- Groundwater is generally harder than surface water.

Water Quality Parameters – **Hardness**

Significance of Hardness

- Hard water consume too much soap
- It clogs skin, discolors porcelain, make stains, shorten fabrics
- Toughens and discolors vegetables and cooked foods
- Cardiovascular death rates are inversely correlated to hardness of water

Water Quality Parameters – **Hardness**

Significance of Hardness

- Soft water cause corrosion of pipes

- A hardness level of about 100 mg/L of $CaCO_3$ provides a n acceptable balance between corrosion and encrustation.

- Bangladesh drinking water quality standard recommends hardness between 200-5000 mg/L, based on taste and household use consideration.

Water Quality Parameters – **Chloride**

- Chloride is widely distributed in nature in the form of NaCl, KCl and $CaCl_2$.

- Taste thresholds for chlorides are in the range of 200-300 mg/L.

- High chloride concentration is corrosive to metals in the water distribution system, particularly in water of low alkalinity.

- A higher chloride content in inland water usually indicates sewage pollution.

Water Quality Parameters – **Iron**

Sources of Iron

- Dissolution of rocks and minerals, acid mine drainage, landfill lechates, sewage or discharge from iron-related industries.

Significance of Iron

- Iron in surface water is generally present in Fe(III) state.
- Causes hardness, undesirable taste in beverages, staining of clothes and plumbing fixtures, encrustation in water mains and may impart a reddish brown color to water.

Water Quality Parameters – **Arsenic**

Sources of Arsenic (As)

- Most of the As found in water derives from geological formations, industrial discharge, mining operations, use of arsenical insecticides and combustion of fossil fuel.

Significance of Arsenic (As)

- Many As compound are water soluble and thus cause contamination of water.

- The toxicity of As depends on chemical and physical form of As compounds, the route through which it enters the body, the dose and duration of exposure etc.

Water Quality Parameters – **Arsenic**

Significance of Arsenic (As)

- Inorganic As is more toxic than the organic ones.
- As (III) is more hazardous than As (V).
- Severe poisoning may arise from ingestion of arsenic as little as 100 mg arsenic trioxide.
- Chronic effects may result fro accumulation of As in body in low intake level.

Water Quality Parameters – **Arsenic**

Significance of Arsenic (As)

- The recommended allowable limit of As is 0.05 mg/L in Bangladesh.

- As concentration in excess of allowable limit has been found in shallow tubewells of many locations in Bangladesh.

Microbiological Quality Parameters – **TC and FC**

Total Coliform (TC)

- Total coliform bacteria are a collection of relatively harmless microorganisms that live in large numbers in soils, plants and in intestines of warm-blooded animals.

- Coliform aid in the digestion of food.

- There are 16 species of total coliform found in soils, plants and in animal and human waste.

- Characterized broadly by their ability to ferment lactose in culture at 35°C ~ 37°C with the production of acid, gas and aldehyde within 24 or 48 hours

Microbiological Quality Parameters – **TC and FC**

Total Coliform (TC)

- Total coliforms are to be monitored because their presence above the standard indicates problems in treatment or in the distribution system.

- If total coliforms are found, then the public water system must further be analyzed for the total coliform-positive samples to determine whether specific types of coliforms (i.e., fecal coliforms or E. coli) are present or not.

Microbiological Quality Parameters – **TC and FC**

Fecal Coliform (FC)

- A subgroup of total coliform, called fecal coliform bacteria, can grow at higher temperatures and are found only in the fecal waste of warm-blooded animals.

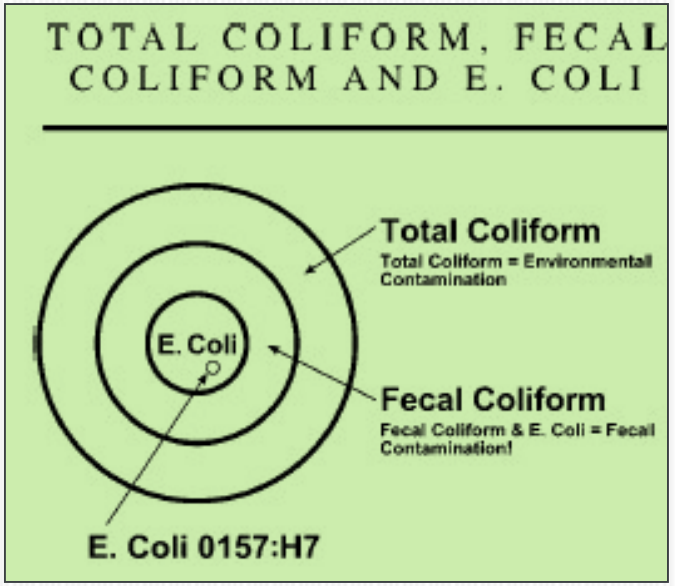
- E. coli is one of the six species of fecal coliform bacteria found in animal and human waste.

- Characterized broadly by their ability to ferment lactose in culture at 44°C ~ 44.5°C.

Microbiological Quality Parameters – **TC and FC**

Fecal Coliform (FC) – E. Coli

- E. coli is a sub-group of the fecal coliform group.



- Most E. coli bacteria are harmless and are found in great quantities in the intestines of people and warm-blooded animals. Some strains, however, can cause illness.

- The presence of E. coli in a drinking water sample almost always indicates recent fecal contamination, meaning there is a greater risk that pathogens are present.

Water Quality Standards

- Water for public water supplies should be drawn from the best available source for cost effective treatment of water.
- The degree and method of treatment to make water potable and acceptable to the consumers depend on the characteristics of the raw water.
- Waters containing hazardous and toxic substances require special and more expensive treatment.

Water Quality Standards

Table 17.7: Drinking water standards

Water quality parameters	Unit	Bangladesh standards	WHO guideline values, 2004
1. Aluminum	mg/l	0.2	0.2**
2. Ammonia (NH_3)	mg/l	0.5	1.5**
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	0.5
8. Cadmium	mg/l	0.005	0.003
9. Calcium	mg/l	75	
10. Chloride	mg/l	150-600*	250**
11. Chlorinated alkenes			
Carbon tetrachloride	mg/l	0.01	0.004
1,1 Dichloroethylene	mg/l	0.001	
1,2 Dichloroethane	mg/l	0.03	0.03
Tetrachloroehylene	mg/l	0.03	
Trichloroethylene	mg/l	0.09	
12. Chlorinated phenols			
Pentachlorophenol	mg/l	0.03	
2, 4, 6 Trichlorophenol	mg/l	0.03	0.2
13. Chlorine (residual)	mg/l	0.2	0.6-1.0
14. Chloroform	mg/l	0.09	0.2
15. Chromium (hexavalent)	mg/l	0.05	
16. Chromium (total)	mg/l	0.05	0.05
17. Chemical oxygen demand)	mg/l	4	
18. Coliform (faecal)	N/100ml	0	0
19. Coliform (total)	N/100ml	0	0
20. Colour	Hazen Unit	15	15
21. Copper	mg/l	1	2
22. Cyanide	mg/l	0.1	0.07
23. Detergents	mg/l	0.2	
24. Dissolved oxygen	mg/l	6	
25. Flouride	mg/l	1	1.5
26. Hardness (as $CaCO_3$)	mg/l	200-500	

Water Quality Standards

Table 17.7: Drinking water standards

Water quality parameters	Unit	Bangladesh standards	WHO guideline values, 2004
27. Iron	mg/l	0.3-1.0	0.3**
28. Kjehldal 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	0.4; 0.1***
32. Mercury	mg/l	0.001	0.001
33. Nickel	mg/l	0.1	0.02
34. Nitrate	mg/l	10	50
35. Nitrite	mg/l	<1	3
36. Odour	mg/l	Odourless	
37. Oil and grease	mg/l	0.01	
38. pH	—	6.5-8.5	
39. Phenolic compounds	mg/l	0.002	
40. Phosphate	mg/l	6	
41. Phosphorus	mg/l	0	
42. Potassium	mg/l	12	
43. Radioactive substances			
Total alfa radiation	Bq/l	0.01	
Total beta radiation	Bq/l	0.1	
44. Selenium	mg/l	0.01	0.01
45. Silver	mg/l	0.02	
46. Sodium	mg/l	200	200**
47. Suspended solids	mg/l	10	
48. Sulphide	mg/l	0	
49. Sulphate	mg/l	400	250**
50. Total dissolved solids	mg/l	1000	1000**
51. Temperature	°C	20-30	
52. Tin	mg/l	2	
53. Turbidity	JTU	10	5
54. Zinc	mg/l	5	3**

* For Coastal Areas of Bangladesh, in case of non-availability of alternative sources value is 1000.

** Value designated only for aesthetic purposes; No health-based guideline value is proposed.

*** Value designated for aesthetic purposes.

Water Quality Standards

Table 17.6: Bangladesh water quality standards for surface water for water supply

Water quality parameters	Unit	Values for water supply by	
		Disinfection only	Conventional treatment
PH	—	6.5 - 8.5	6.5 - 8.5
Biochemical oxygen demand	mg/l	2 or less	3 or less
Dissolved oxygen	mg/l	6 or more	6 or more
Total coliform	number/100ml	50 or less	5,000 or less