CE 331: Water Supply Engineering
Lecture 2
Overview

• Water Demand
• Hydrologic cycle
• Sources of Water
• Surface water
• Ground water
• Rain water
• Grey water
Water Demand

Quantities that are generally assessed and recorded:

• Total annual volume \((V)\) in litres or million litres.
• Annual average rate of draft in litres per day, \((V/365)\).
• Average rate of draft in litres per day per person (litres per capita day or lcpd), called per capita demand \((q)\).
• Average rate of draft in litres per day per service. \(\{ (V/365)*1/no.of\text{ services} \}\)
• Fluctuations in flows expressed in terms of % ratios of maximum or minimum yearly, monthly, daily or hourly rates to their corresponding average values.
Various Types of Water Demands

• Domestic water demand
• Industrial water demand
• Institutional and Commercial water demand
• Demand for public use
• Fire demand
## World Water Distribution

<table>
<thead>
<tr>
<th>Location-land areas</th>
<th>Volume, ((10^{12} \text{ m}^3))</th>
<th>% of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freshwater lakes</td>
<td>125</td>
<td>0.009</td>
</tr>
<tr>
<td>Saline lakes and inland seas</td>
<td>104</td>
<td>0.008</td>
</tr>
<tr>
<td>Rivers</td>
<td>1.25</td>
<td>0.0001</td>
</tr>
<tr>
<td>Soil moisture</td>
<td>67</td>
<td>0.005</td>
</tr>
<tr>
<td>Groundwater</td>
<td>8350</td>
<td>0.61</td>
</tr>
<tr>
<td>Ice caps and glaciers</td>
<td>29200</td>
<td>2.14</td>
</tr>
<tr>
<td>Total land area</td>
<td>37800</td>
<td>2.8</td>
</tr>
<tr>
<td>Atmosphere (water vapor)</td>
<td>13</td>
<td>0.001</td>
</tr>
<tr>
<td>Oceans</td>
<td>1,320,000</td>
<td>97.3</td>
</tr>
<tr>
<td>Total all locations</td>
<td>1,360,000</td>
<td>100</td>
</tr>
</tbody>
</table>
Hydrologic cycle/Water Cycle

- Role of Water?
  - Terrestrial ecosystems: major factor determining distribution of organisms
  - Aquatic ecosystems: literally matrix that surrounds & serves as environment of aquatic organisms
  - Flows of water are major means for material & energy transfer
  - Water is critical for human activities: agriculture, industry, and municipal use

*Water is the driver of nature.*  
- Leonardo da Vinci
Hydrologic Cycle
Water Cycle: Main Processes

- **Evaporation**: conversion from liquid to vapor (surface to atmosphere)
- **Transpiration**: evaporation of water from leaves
- **Condensation**: conversion of vapor to liquid (ex: water droplets of water on cold soda can)
- **Precipitation**: movement as rain, sleet, hail, & snow (atmosphere to surface)
- **Infiltration**: movement into soil
- **Percolation**: downward flow through soil to aquifers
- **Runoff**: surface flow down slope to ocean, river, or lake.
The Water Cycle

Condensation: conversion of gaseous water vapor into liquid water

Transport overland: net movement of water vapor by wind

Evaporation from the ocean

Evaporation from inland lakes and rivers

Evaporation from the land

Transpiration from plants

Transpiration from plants

Precipitation (rain, sleet, hail, snow, fog)

Precipitation to land

Rivers

Lakes

Oceans

Groundwater movement (slow)

Aquifers: groundwater storage areas

Infiltration: movement of water into soil

Percolation: downward flow of water

Water locked up in snow and ice

Rain clouds

Ocean storage 97% of total water

Precipitation

Evaporation

Evaporation

Evaporation

Evaporation

Evaporation
Sources of Water Supply

• Surface water
  • Ponds and lakes
  • Streams and rivers
  • Storage reservoirs
  • Oceans

• Sub-surface water
  • Springs
  • Infiltration galleries
  • Infiltration wells
  • Wells and tube wells

• Groundwater
Problems in GW development

• Arsenic in groundwater
• Excessive dissolved iron
• Salinity in the coastal areas
• Lowering of groundwater level
• Rock/stony layers in hilly areas
Arsenic in groundwater

• WHO guideline for maximum desirable arsenic concentration in drinking water – 0.01 mg/L
• In Bangladesh – maximum acceptable concentration in drinking water – 0.05 mg/L
• Arsenic toxicity leading to cancer occurs due to excessive intake over a longer period of time.
• Presence of arsenic in Bangladesh was first detected in 1993 at Chapai Nawabganj.
• One in every three shallow tubewells was found to produce arsenic contaminated water above acceptable limits.
Distribution of arsenic concentration in shallow aquifers in Bangladesh
Excessive dissolved iron

- In Bangladesh, the permissible limit of iron in groundwater is 1 mg/L.
- Iron content up to 5 mg/L is acceptable for rural water supply.
- Dissolved iron in shallow tubewell water in about 67% areas of Bangladesh is in excess of 2 mg/L.
- Iron content in deep tubewell water is comparatively lower.
Dissolved iron in shallow tubewell water in Bangladesh
Salinity in coastal areas

• Concentration of dissolved minerals in groundwater is higher than that in surface water
• The coastal belt of Bangladesh is identified as a problem area
• Scarcity of groundwater of acceptable quality at coastal area from shallow depth.
• Low salinity groundwater is not available in many areas at coastal belts within a depth of 1100 ft.
Zoning of coastal area of Bangladesh by tubewell type
Lowering of groundwater level

- A considerable area of the country faces scarcity of groundwater within suction limit in the dry season
- Water level declines due to the over-exploitation of groundwater for irrigation purposes
Rock/stony layers in hilly areas

• Presence of hard formations in the subsurface of hill tracts districts make it difficult to drill tubewells for rural water supply
• Areas – Chittagong, Cox’s bazar, Sylhet, north of Mymensingh, Netrokona, Panchagar districts
• Mechanical drilling rigs used to over the problem and provide potable water
• Installation cost increases as a result
Rainwater

• Being a tropical country, Bangladesh receives heavy rainfall
• Rainwater can be a potential source of water supply
• Areas with high salinity problems harvest rain water (as high as 36% of households) although collection, storage and use are not organized
• The coastal and hilly areas with high source problem intensity lie in the high rainfall areas
• Rainwater harvesting could be a good opportunity for these areas.
• Large rainwater storage reservoirs will be needed due to unequal monthly rainfall distribution
Rainwater Harvesting
Normal annual distribution of rainfall in Bangladesh
Grey Water

- **Greywater** or sullage is defined as wastewater generated from wash hand basins, showers and baths, which can be recycled on-site for uses such as toilet flushing, landscape irrigation and constructed wetlands. Greywater often includes discharge from laundry, dishwashers and kitchen sinks. It differs from the discharge of toilets which is designated sewage or blackwater to indicate it contains human waste.