

1 **Water Use and Management**

EVPP 111 Lecture

Dr. Largen

2 **Outline**

- **World's Water Supply**
- **Hydrologic Cycle**
- **Types of water**
- **Water Use**
- **Water Pollution**
- **Wastewater Treatment**
- **Water Use Planning**

3 **Outline**

- **World's Water Supply**
- **Hydrologic Cycle**
- **Types of water**
- **Water Use**
- **Water Pollution**
- **Wastewater Treatment**
- **Water Use Planning**

4 **Water Use and Management**

- **World's water supply**
 - **Importance of water**
 - Life
 - Physical properties:

5 **Water Use and Management**

- **World's water supply**
 - **Distribution of Water**
 - ~75% earth's surface is covered by water
 - ~97.5% - seawater
 - ~ 2.5% - fresh water
 - » ~1.97% - ice caps and glaciers
 - » ~0.53% - lakes, rivers, soils, moisture, atmosphere
 - >99% unavailable to humans

– <1% accessible to humans

6 

7 

8  **Water Use and Management**

World's water supply


Distribution of Water

- global variations in water supply
 - differences in annual precipitation
- vulnerability to water shortages
 - high annual precipitation = low vulnerability
 - low annual precipitation = high vulnerability

9  **Fig. 16.2**

10  **Outline**

- World's Water Supply**
- Hydrologic Cycle**
- Types of water**
- Water Use**
- Water Pollution**
- Wastewater Treatment**
- Water Use Planning**

11  **Water Use and Management**

Hydrologic cycle

- constant water recycling process
 - precipitation
 - evaporation
 - evapotranspiration
 - condensation
 - infiltration
 - runoff

12 

13  **Outline**

- World's Water Supply**
- Hydrologic Cycle**
- Types of water**
- Water Use**
- Water Pollution**
- Wastewater Treatment**

» Water Use Planning

14 ☐ Water Use and Management

» Types of water

- Surface water
- Ground water

15 ☐ Water Use and Management

» Types of water

- Surface water
- Ground water

16 ☐ Water Use and Management

» Types of water

- Surface water
 - fresh water on earth's surface
 - streams, rivers, lakes, ponds, reservoirs, wetlands
 - replenished by runoff
 - considered renewable, though finite, resource

17 ☐ Water Use and Management

» Types of water

- Surface water
 - drainage basin
 - area of land drained by single river
 - watershed
 - area of land drained by a river and all its tributaries

18 ☐ Water Use and Management

» Types of water

- Surface water
- Ground water

19 ☐ Water Use and Management

» Types of water


- ground water
 - water that fills spaces in soil and subsurface material
 - moves downward until it reaches an impervious layer of rock
 - accumulates in porous strata called an **aquifer**
 - » that becomes saturated with water

20 ☐ Water Use and Management

» Types of water

- ground water


- **aquifer**
 - two types
 - » **unconfined aquifer**
 - » **confined aquifer**

21  **Water Use and Management**

» **Types of water**


- **ground water**
 - **unconfined aquifer**
 - usually near land's surface
 - lower boundary is impermeable layer of clay or rock
 - upper limit, below which ground is saturated with water, is **water table**
 - atmospheric pressure
 - recharged by rainfall and percolation
 - flows in direction of water table's slope
 - **vadose zone**
 - » below surface, above water table, not saturated with water

22 

23  **Water Use and Management**

» **Types of water**


- **ground water**
 - **confined aquifer**
 - bounded on top and bottom by impermeable layer
 - water is trapped, often stored under high pressure
 - water is recharged from a geologic recharge zone
 - » land from which water percolates to replace the groundwater

24  **Water Use and Management**

» **Types of water**

- **ground water**
 - **confined aquifer**
 - **artesian well**
 - » non-flowing artesian well
 - » flowing artesian well

25 

26  **Water Use and Management**

» **Types of water**

- **ground water**
 - most is considered nonrenewable resource
 - takes hundreds or thousands of years to accumulate
 - only small portion is replaced each year by percolation or precipitation

27  **Outline**

- » **World's Water Supply**
- » **Hydrologic Cycle**

- **Types of water**
- **Water Use**
- **Water Pollution**
- **Wastewater Treatment**
- **Water Use Planning**

28 **Water Use and Management**

➤ **Water use**

- varies considerable around the world
 - depending on
 - availability of water
 - degree of industrialization
- non-consumptive (water withdrawal)
 - withdrawing water, returning to original source.
- consumptive (water consumption)
 - withdrawing water and incorporating it into a product, or otherwise moving it to another area so it does not make it back to its original source.

29 **Water Use and Management**

➤ **Water use**

- four broad use categories
 - **domestic**
 - **agricultural**
 - **industrial**
 - **in-stream uses**

30 **Water Use and Management**

➤ **Water use**


- four broad use categories
 - **domestic**
 - **agricultural**
 - **industrial**
 - **in-stream uses**

31 **Water Use and Management**

➤ **Water use**

- **domestic** water use
 - accounts for
 - ~12% of total water use in North America
 - » ~100 gallons per person per day
 - ~7% of total water use world wide

32 

33  **Water Use and Management**


Water use

- **domestic** water use
 - ~8% of global freshwater is withdrawn for
 - more domestic water is wasted than consumed
 - ~ 60% of domestic water returned to rivers as wastewater
 - major source of loss is public attitude
 - as long as water is considered limitless & cheap, little effort will be made to conserve it

34 


35 

36 

37  **Water Use and Management**

Water use

- four broad use categories
 - **domestic**
 - **agricultural**
 - **industrial**
 - **in-stream uses**


38  **Water Use and Management**

Water use

- **agricultural** water use
 - major consumptive use of water in most parts of world
 - accounts for
 - ~40% of total water use in North America (text has typo)
 - ~70% of total water use world wide


39 


40 


41  **Water Use and Management**

Water use

- **agricultural** water use
 - irrigation
 - requires large amount of energy
 - many methods are wasteful
 - » increasing water costs will stimulate conservation - i.e. trickle irrigation
 - increasing water costs or a water shortage can lead to devaluation of land

42  Fig. 16.10a

43  Fig. 16.10b

44  **Water Use and Management**

 ➤ **Water use**

- four broad use categories
 - **domestic**
 - **agricultural**
 - **industrial**
 - **in-stream uses**


45  **Water Use and Management**

 ➤ **Water use**

- **industrial water use**
 - accounts for
 - ~48% of total water use in North America
 - ~23% of total water use world wide
 - ~90% of water is used for cooling
 - returned to source
 - little actually consumed
 - to dissipate and transport waste materials.
 - results in stream and lake degradation


46 

47 

48  **Water Use and Management**

 ➤ **Water use**

- four broad use categories
 - **domestic**
 - **agricultural**
 - **industrial**
 - **in-stream uses**

49  **Water Use and Management**

 ➤ **Water use**


- **in-stream water use**
 - does not remove water but makes use of it in its channels and basins
 - all are non-consumptive
 - major in-stream uses are
 - **hydroelectric power**
 - **recreation**
 - **navigation**

50  **Water Use and Management**

 ➤ **Water use**

- **in-stream water use**
 - **hydroelectric power**


- produce ~13% of electricity generated in US
- does not consume water
- does not add waste to water
- controls flooding and creates electricity
- has drawbacks.
 - » high construction costs
 - » habitat destruction
 - » retard stream flow and silt deposition
 - » impounded water has high evaporation rate

51  **Fig. 16.11a**

52  **Water Use and Management**

» **Water use**

- **in-stream water use**
 - **recreation**
 - often associated with reservoirs created by dams
 - requires water of reasonably good quality
 - overuse or inconsiderate use can cause degradation

53  **Water Use and Management**

» **Water use**

- **in-stream water use**
 - **navigation**
 - US has 40,000km (25,000mi) of commercially navigable waterways
 - must have sufficient depth
- in past, economical aspects of navigation projects often outweighed environmental concerns

54  **Outline**

- » **World's Water Supply**
- » **Hydrologic Cycle**
- » **Types of water**
- » **Water Use**
- » **Water Pollution**
- » **Wastewater Treatment**
- » **Water Use Planning**

55  **Water Use and Management**

» **Water pollution**

- occurs when something enters water that
 - changes natural ecosystem

- interferes with water use by segments of society
- in industrialized societies
 - not feasible to maintain completely unpolluted water

56 ☐ Water Use and Management

☛ Water pollution

- **water pollutants** can be divided into several categories
 - toxic chemicals
 - dissolved organic matter
 - disease-causing organisms
 - nutrients
 - physical particles

57 ☐ Water Use and Management

☛ Water pollution

- **water pollutants**
 - **toxic chemicals**
 - kill organisms
 - make water unfit for human use
 - persistent
 - » bioaccumulate in some individual organisms
 - » biomagnify in some food chains

58 ☐ Water Use and Management

☛ Water pollution

- **water pollutants**
 - **dissolved organic matter**
 - decays in water
 - microorganisms naturally present in water break down organic matter, use up available dissolved oxygen from water
 - if too much dissolved oxygen is used, aquatic organisms may die
 - **biochemical oxygen demand (BOD)**
 - » amount of oxygen required to decay a certain amount of organic matter

59 ☐ Water Use and Management

☛ Water pollution


- **water pollutants**
 - **disease-causing organisms**
 - found in untreated or inadequately treated human or domesticated animal waste
 - reduced by sewage and drinking water treatment systems in developed world

60 ☐ Water Use and Management

☛ Water pollution


- **water pollutants**
 - **nutrients**
 - in form of nitrogen and phosphorous compounds
 - » generally present in limited amounts in unpolluted freshwater
 - » are a **limiting factors** for aquatic plants and algae
 - cause increase in rate of growth of aquatic plants and algae

» upon their decay, BOD can increase

61  **Water Use and Management**


» **Water pollution**

- **water pollutants**
 - **physical particles**
 - alter clarity
 - cover spawning sites
 - act as abrasive that injure organisms
 - carry toxic materials
 - contribute to changes in other physical characteristics of waterway

62  **Water Use and Management**


» **Water pollution**

- **sources of pollution**
 - classified as
 - **point**
 - **nonpoint**

63  **Water Use and Management**


» **Water pollution**

- **sources of pollution**
 - classified as
 - **point**
 - » source can be readily identified
 - » has definite place where it enters water
 - » such as waste discharge pipes

64  **Water Use and Management**


» **Water pollution**

- **sources of pollution**
 - classified as
 - **nonpoint**
 - » diffuse pollutants
 - » source cannot be readily identified
 - » such as agricultural land, urban paved surfaces, acid rain, runoff, urban lawns

65  **Water Use and Management**

» **Water pollution**


- **categories of pollution**
 - municipal
 - agricultural
 - industrial
 - groundwater

66  **Water Use and Management**

» **Water pollution**

- **categories of pollution**
 - municipal

- agricultural
- industrial
- groundwater

67  **Water Use and Management**

» **Water pollution**


- **municipal pollution**
 - municipalities must provide
 - suitable drinking water
 - dispose of wastes
 - municipal wastes include
 - storm water runoff
 - industrial wastes
 - residential wastes
 - commercial wastes

68  **Water Use and Management**

» **Water pollution**


- **municipal pollution**
 - residential wastes include
 - garbage
 - food preparation
 - cleaning (clothes, dishes, etc.)
 - human wastes
 - » fecal coliform bacteria (generic term for bacteria found in human intestines)

69 

70  **Water Use and Management**

» **Water pollution**


- **categories of pollution**
 - municipal
 - agricultural
 - industrial
 - groundwater

71  **Water Use and Management**

» **Water pollution**


- **agricultural pollution**
 - agricultural activities are primary cause of water pollution problems
 - eutrophication of aquatic habitats
 - » due to excessive use of fertilizers
 - contamination of groundwater
 - » fertilizers
 - » pesticides

- runoff from agricultural feedlots
 - » bacteria from animal waste
- silt

72  **Water Use and Management**


» **Water pollution**

- **categories of pollution**
 - municipal
 - agricultural
 - industrial
 - groundwater

73  **Water Use and Management**


» **Water pollution**

- **industrial pollution**
 - some discharge wastes into municipal waste disposal systems
 - some discharge wastes directly into bodies of water
 - wastes may include
 - organic materials
 - petroleum products
 - metals
 - acids
 - organisms
 - nutrients
 - particulates
 - toxic materials

74  **Water Use and Management**


» **Water pollution**

- **industrial pollution**
 - **thermal pollution**
 - occurs when an industry
 - » removes water from a source
 - » uses water for cooling purposes
 - » returns heated water to its source
 - significant because some aquatic organisms are very sensitive to minor temperature changes

75  **Water Use and Management**

» **Water pollution**

- **categories of pollution**
 - municipal
 - agricultural
 - industrial
 - groundwater

76  **Water Use and Management**

» **Water pollution**

- **groundwater pollution**

- once it occurs, its very difficult to remedy
- major sources include
 - agricultural products
 - underground storage tanks
 - landfills
 - septic tanks
 - surface impoundments

77 ☐ **Water Use and Management**

 ➤ **Water pollution**

- **groundwater pollution**
 - **agricultural products**
 - pesticides
 - » from leaks, spills runoff
 - » 73 pesticides have been detected in groundwater of Canada and US
 - animal-feeding operations
 - fertilizer applications

78 ☐ **Water Use and Management**

 ➤ **Water pollution**

- **groundwater pollution**
 - **underground storage tanks**
 - leaks from tanks containing gasoline and other hazardous substances
 - » 4 liters of gasoline can contaminate water supply for 50,000 people

79 ☐ **Water Use and Management**

 ➤ **Water pollution**

- **groundwater pollution**
 - **landfills**
 - recently constructed landfills have special liners and water collection systems
 - ~90% of landfills in US have no liners
 - ~96% have no system to collect leachate
 - ~60% have no restrictions on waste accepted

80 ☐ **Water Use and Management**

 ➤ **Water pollution**

- **groundwater pollution**
 - **septic tanks**
 - poorly designed and inadequately maintained septic systems have contaminated groundwater with
 - » nitrates, bacteria, toxic cleaning agents
 - ~20 million septic are in use in US
 - » up to 1/3 have been found to be operating improperly

81 ☐ **Water Use and Management**

 ➤ **Water pollution**

- **groundwater pollution**
 - **surface impoundments**

- >225,000 pits, ponds, lagoons are used in North America to store or treat wastes
- 71% of these are unlined
- only ~1% use plastic or other non-soil liners
- 99% have no leak detection system
- 73% have no restrictions on the waste placed in the impoundment

82 

83 

84 


85 

86 

87 


88  **Outline**

- **World's Water Supply**
- **Hydrologic Cycle**
- **Types of water**
- **Water Use**
- **Water Pollution**
- **Wastewater Treatment**
- **Water Use Planning**

89  **Water Use and Management**

- **Wastewater treatment**
 - wastewater treatment facilities
 - maintained by most companies and municipalities in developed world
 - percentage of sewage treated varies greatly throughout world
 - treatment of sewage is classified as
 - primary
 - secondary
 - tertiary

90  **Table 16.3**

91  **Water Use and Management**

- **Wastewater treatment**
 - **primary treatment**
 - primarily physical process
 - removes large particles via filtration
 - pumps remaining water into settling ponds and lakes


- after settling, water is drawn off the top and is either released to
 - environment
 - subsequent stage of treatment

92  **Water Use and Management**

Wastewater treatment

 • **secondary treatment**

- biological process
- involves holding wastewater until organic matter has been degraded by bacteria and other organisms
- combination of primary and secondary treatment is most common in US.
- discharged water must still be disinfected
 - usually via chlorine due to ease and cost

93  **Water Use and Management**

Wastewater treatment

 • **tertiary treatment**

- involves variety of techniques
- additional stage to remove
 - more dissolved pollutants, such as phosphorous and nitrogen
 - » some municipalities use natural or constructed wetlands
 - specific problem materials
- extremely costly


94 

95 

96 

97  **Outline**

- World's Water Supply**
- Hydrologic Cycle**
- Types of water**
- Water Use**
- Water Pollution**
- Wastewater Treatment**
- Water Use Planning**

98  **Water Use and Management**

Water use planning


- metropolitan areas must deal with variety of issues and maintain extensive infrastructure to provide
 - three basic water services
 - water supply for human and industrial needs
 - wastewater collection and treatment

- storm-water collection and management
- failure to provide these services will lead to serious conflicts about water issues causing
 - social, economic, environmental losses at both local and international levels

99  **Water Use and Management**


 ➤ **Water use planning**

- **water diversion**
 - physical process of transferring water from one area to another
 - can differentially affect areas
 - extensive draining can lead to wetland drainage and habitat loss

100  **Water Use and Management**

 ➤ **Water use planning**

- **groundwater mining**
 - refers to removing water from an aquifer faster than it can be replenished.
 - extended periods of mining can lead to
 - land subsidence
 - lowering of the water table
 - salt-water intrusion of wells in coastal areas

101  **Water Use and Management**

 ➤ **Water use planning**

- **salinization**
 - increase in salinity caused by increased salt concentrations in soil
 - primarily a problem in areas where irrigation has been practiced for decades

102 

103  **The End**