

ES 200 ENVIRONMENTAL STUDIES

Module-C

Anthropogenic effects on ecosystem, water quality & health, water & wastewater treatment



Lecture-2

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Learning Objectives

Water Resources

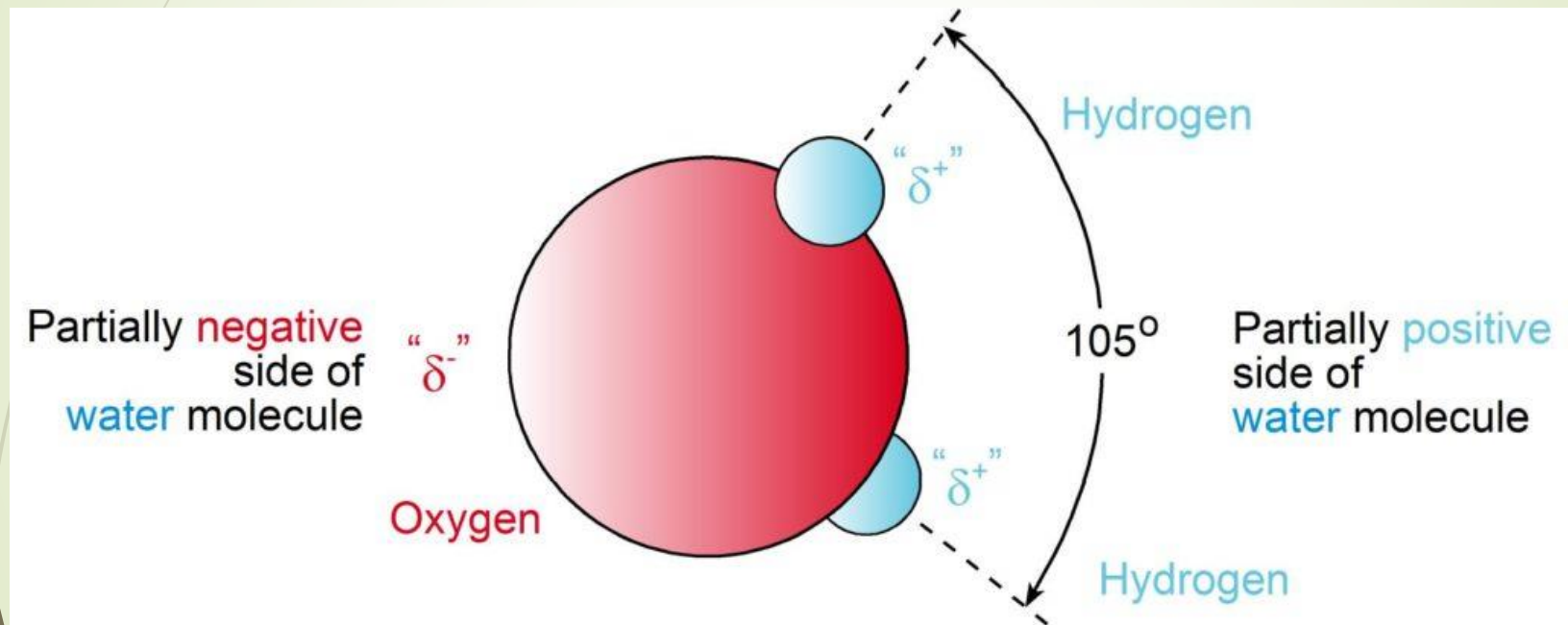
- Why is water so important?
- Hydrologic cycle
- Major water compartments
- Major water issues
- Water management

<https://static.nc-myus.com/images/pub/www/uploads/image/fdf49f3f5bc94699ba9fd4838f56fa05/world-water-infograph.jpg>



http://oregonstate.edu/instruct/css/330/our/images/kiLongGrainRice2ARS_USDA.jpg

What is Water?



http://www.crystalblueent.com/uploads/5/9/9/6/59962767/water-molecule-polarity-1024x406_orig.jpg

Why is Water so Important?

Density

- Maximum density at 4 °C sustains the aquatic life in frozen waters
- Expands when freezes resulting in weathering of rocks and recycling of minerals in significant amount

Melting and Boiling Points

- Unusually high boiling and freezing temperatures for a compound having such a low molecular weight
- Enables it to stay in liquid form over most of the globe

Specific Heat

- Very high heat capacity (4.184 kJ/kg °C)
- Takes longer for water to heat up and cool down than almost anything else
- This makes oceans the major moderating factor in maintaining the temperature of the Earth's surface

Why is Water so Important?

Heat of Vaporization

- The heat required to vaporize water (2258 kJ/kg) is one of the highest of all liquids
- It means that water vapor stores an unusually large amount of energy, which is released when it condenses
- This is important in redistributing the heat across the globe and is a major factor affecting the Earth's climate

Universal Solvent

- Water dissolves more substances than any other common solvent
- Effective medium for transporting dissolved nutrients to organs in the living things as well as eliminating their wastes
- Water also transports dissolved substances throughout the biosphere

Greenhouse Effect

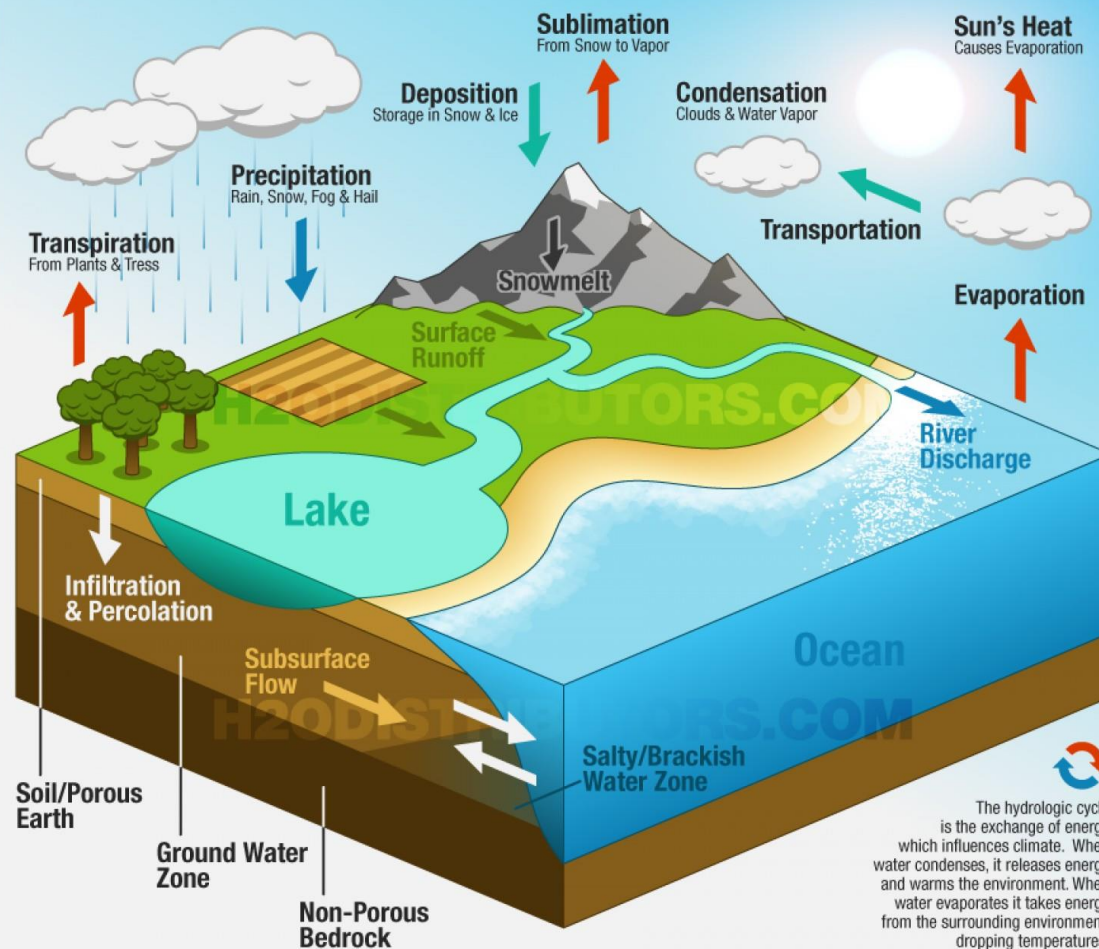
- Water molecule absorbs both incoming solar radiation and infrared radiation leaving Earth's surface
- Such absorptions are the major factors governing the Earth's temperature
- Water vapor is the most important green house gas in the atmosphere

Hydrologic Cycle

The Hydrologic Cycle (also called the Water Cycle) is the continuous movement of water in the air, on the surface of and below the Earth.

Human activities that alter the water cycle:

- Alteration of Atmosphere
- Construction of Dams
- Deforestation and Afforestation
- Water Abstraction from Rivers
- Agriculture
- Industry
- Urbanization



The hydrologic cycle is the exchange of energy which influences climate. When water condenses, it releases energy and warms the environment. When water evaporates it takes energy from the surrounding environment, dropping temperatures.

Process Definitions:

Condensation

The transformation of water vapor to liquid water droplets in the air, creating clouds and fog.

Deposition

Also known as desublimation, is a thermodynamic process, a phase transition in which gas (vapor) transforms into solid (ice).

Evaporation

The transformation of water from liquid to gas phases as it moves from the ground or bodies of water into the overlying atmosphere.

Percolation

Water flows horizontally through the soil and rocks under the influence of gravity.

Precipitation

Condensed water vapor that falls to the Earth's surface. Most precipitation occurs as rain, but also includes snow, hail, fog drip, graupel, and sleet.

Sublimation

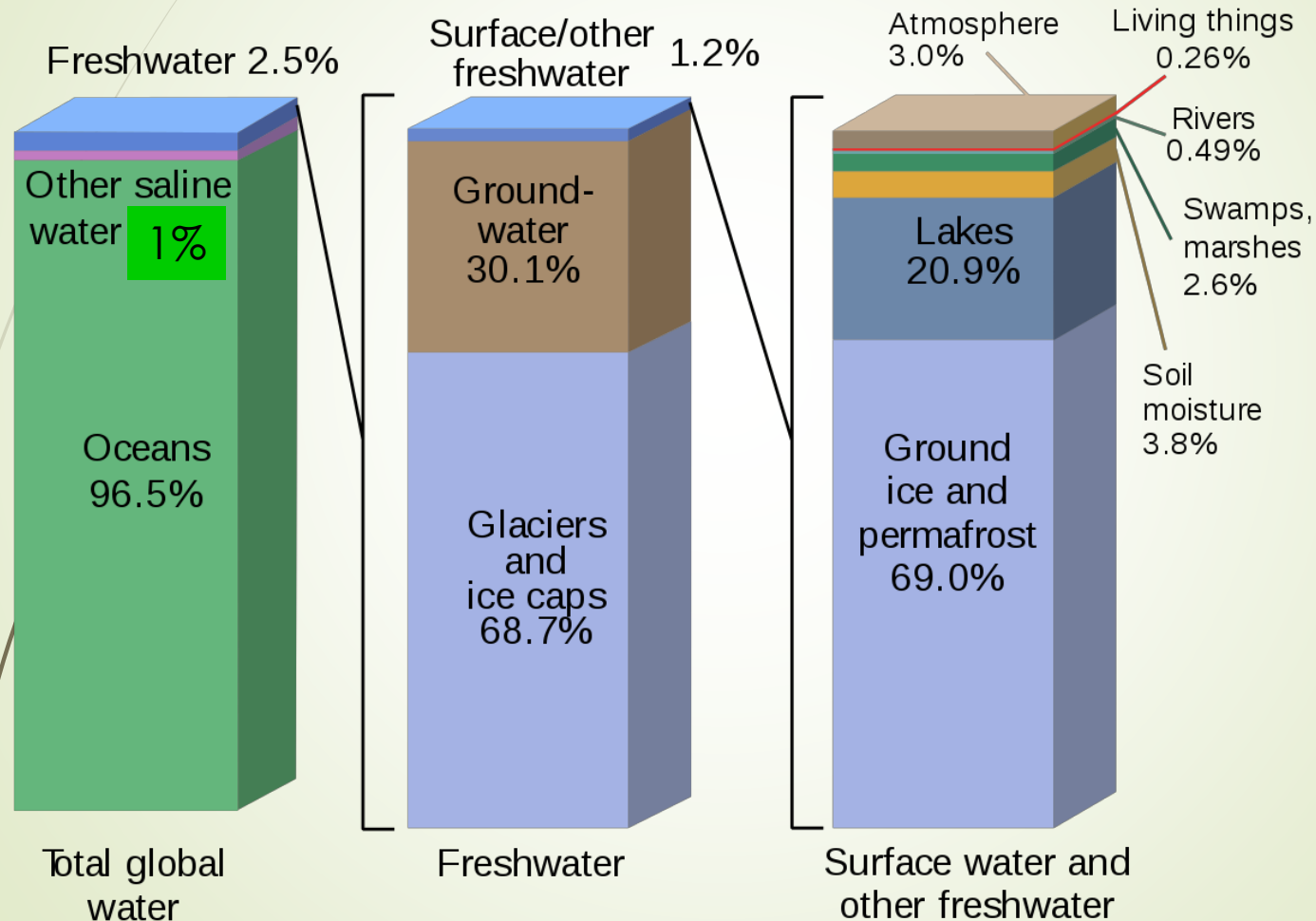
The state change directly from solid water (snow or ice) to water vapor.

Transpiration

The release of water vapor from plants and soil into the air. Water vapor is a gas that cannot be seen.

http://thumbnails.visually.netdna-cdn.com/the-water-cycle_523b5e9dd38c6_w1500.png

Distribution of World's Water



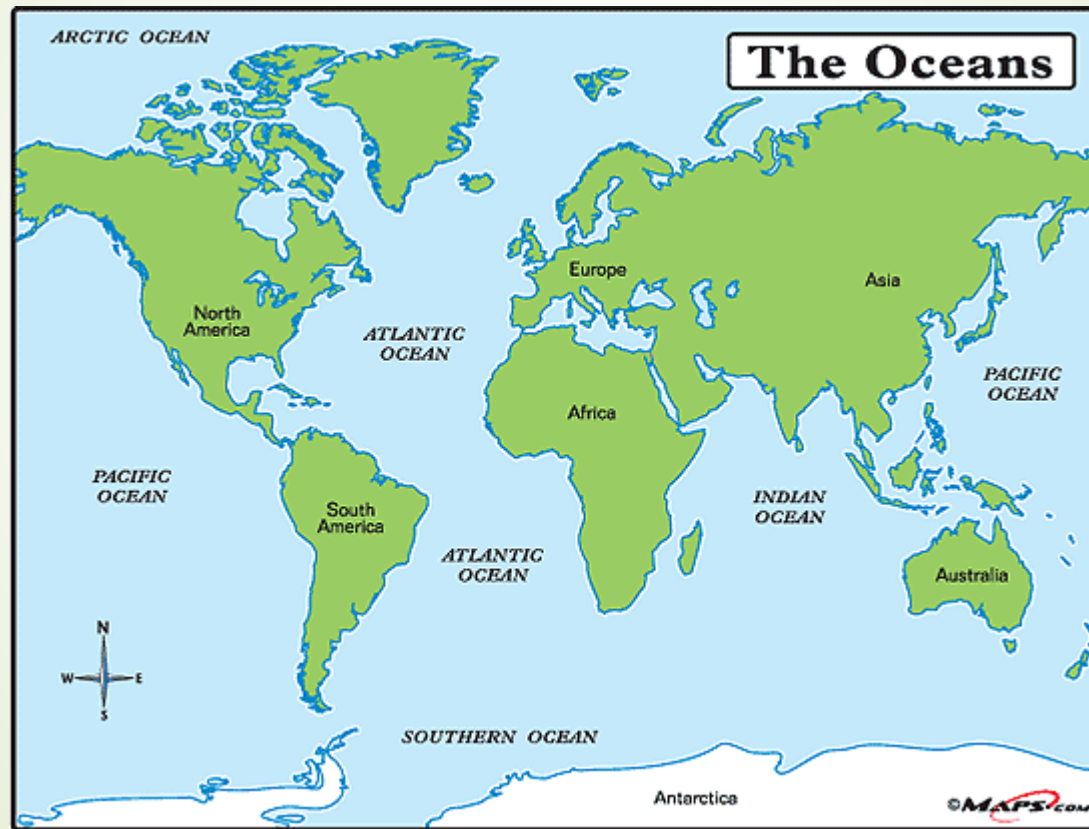
https://upload.wikimedia.org/wikipedia/commons/thumb/5/58/Earth%27s_water_distribution.svg/1200px-Earth%27s_water_distribution.svg.png

Residence Time of a Water Molecule

Reservoir	Residence Time
Living organisms	Hours to days
Atmosphere	5 - 15 days
Rivers	2 weeks
Soil moisture	Months
Large lakes	10 years
Shallow groundwater	10s – 100s of years
World oceans	3000 years
Deep groundwater	Up to 10,000 years
Antarctic ice cap	10,000 – 200,000 years

Major Water Compartments

The Oceans



<https://s-media-cache-ak0.pinimg.com/originals/60/4b/1a/604b1af14e7004825ccc95e0b9f0c2b.gif>

5 Oceans

Major Water Compartments

The Oceans

Oceans are salty!

https://upload.wikimedia.org/wikipedia/commons/thumb/9/98/Water_salinity_diagram.png/1200px-Water_salinity_diagram.png



briny water
brine pools
50+ ppt

saline water
seawater, salt lakes
30-50 ppt

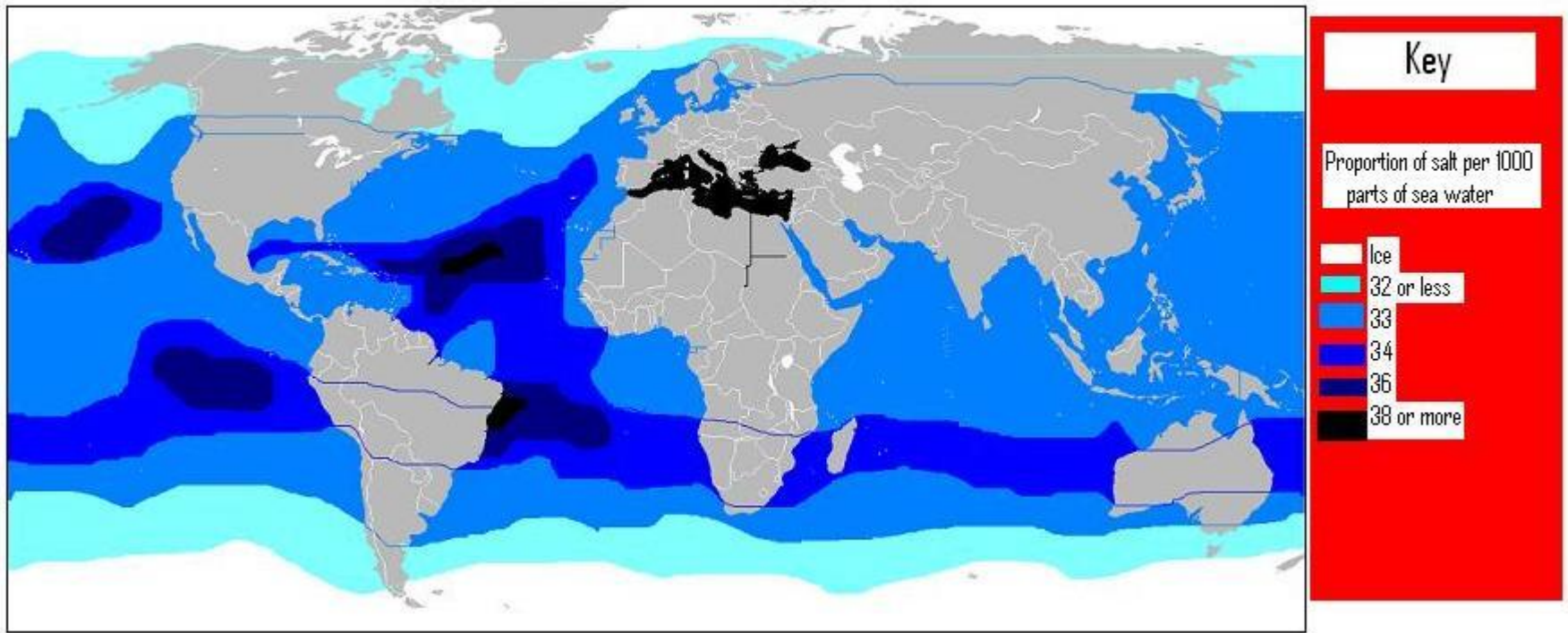
brackish water
estuaries, mangrove swamps,
brackish seas and lake, brackish
swamps
.5-30 ppt

fresh water
ponds, lakes, rivers, streams,
aquifers
0-.5 ppt

Major Water Compartments

The Oceans

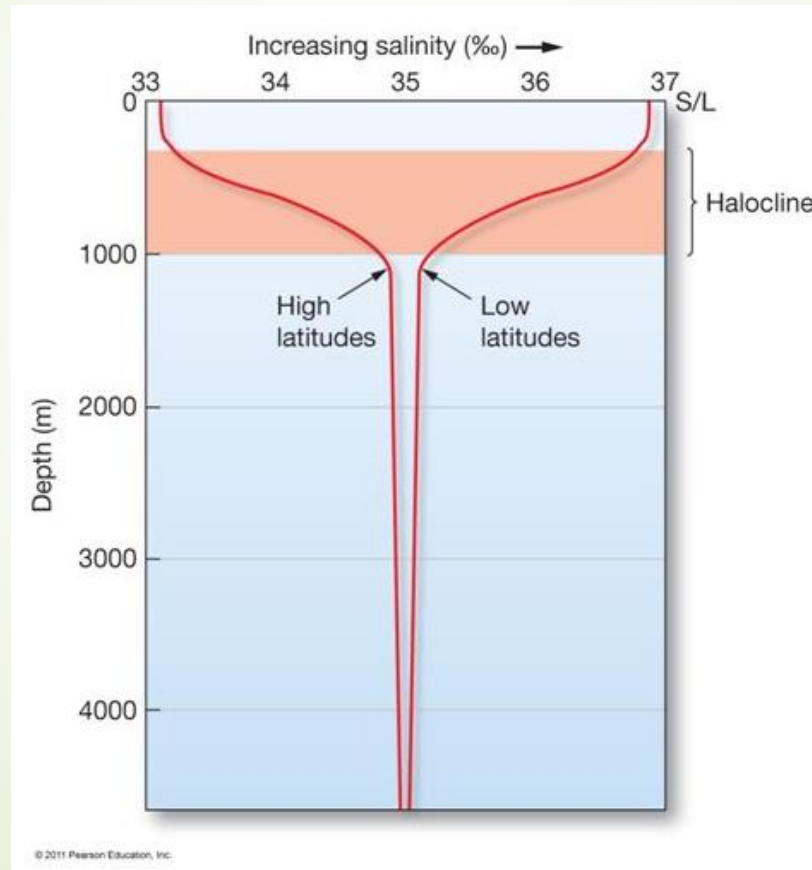
Salinity of the Oceans



https://ehsgeowiki.wikispaces.com/file/view/Salinity_map.JPG/34356979/Salinity_map.JPG

Major Water Compartments

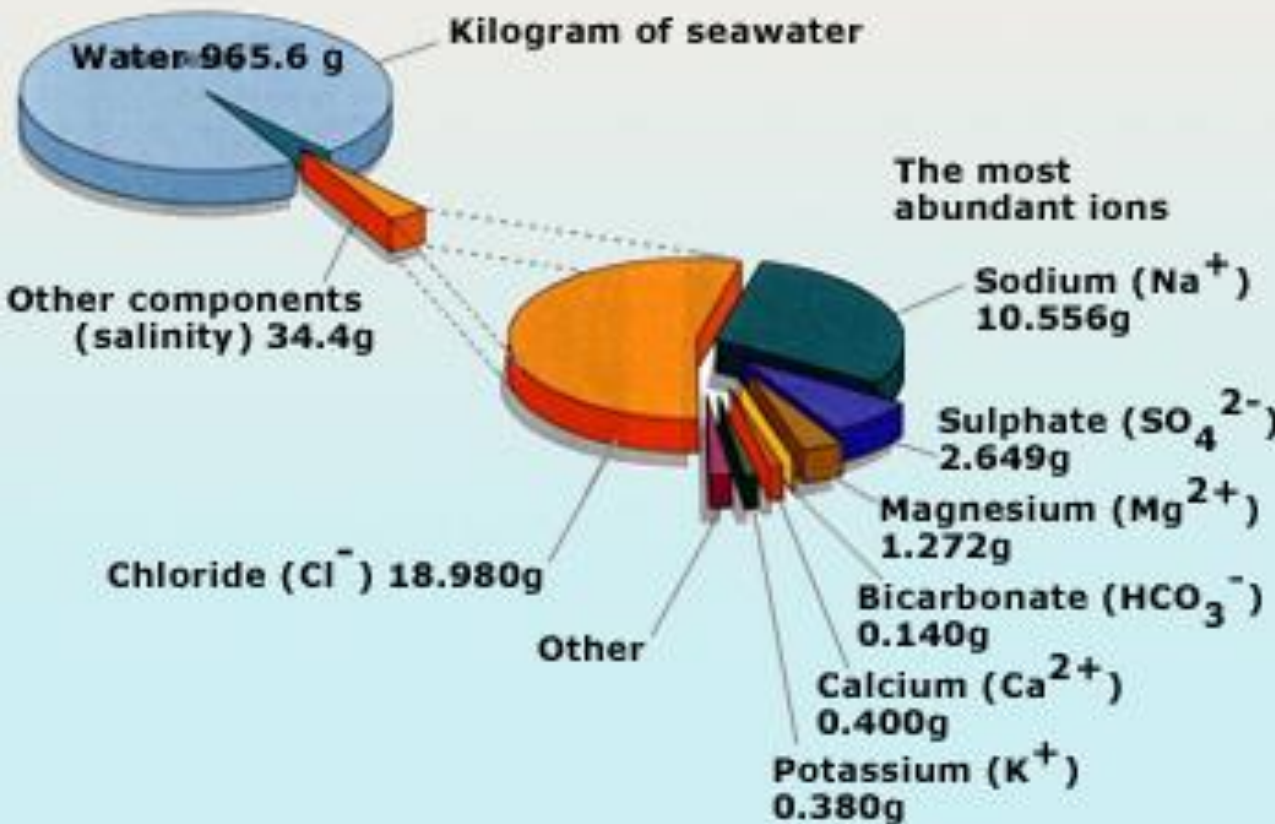
The Oceans



<http://slideplayer.com/slide/6410121/22/images/34/Salinity+Variation+with+Depth.jpg>

Major Water Compartments

The Oceans



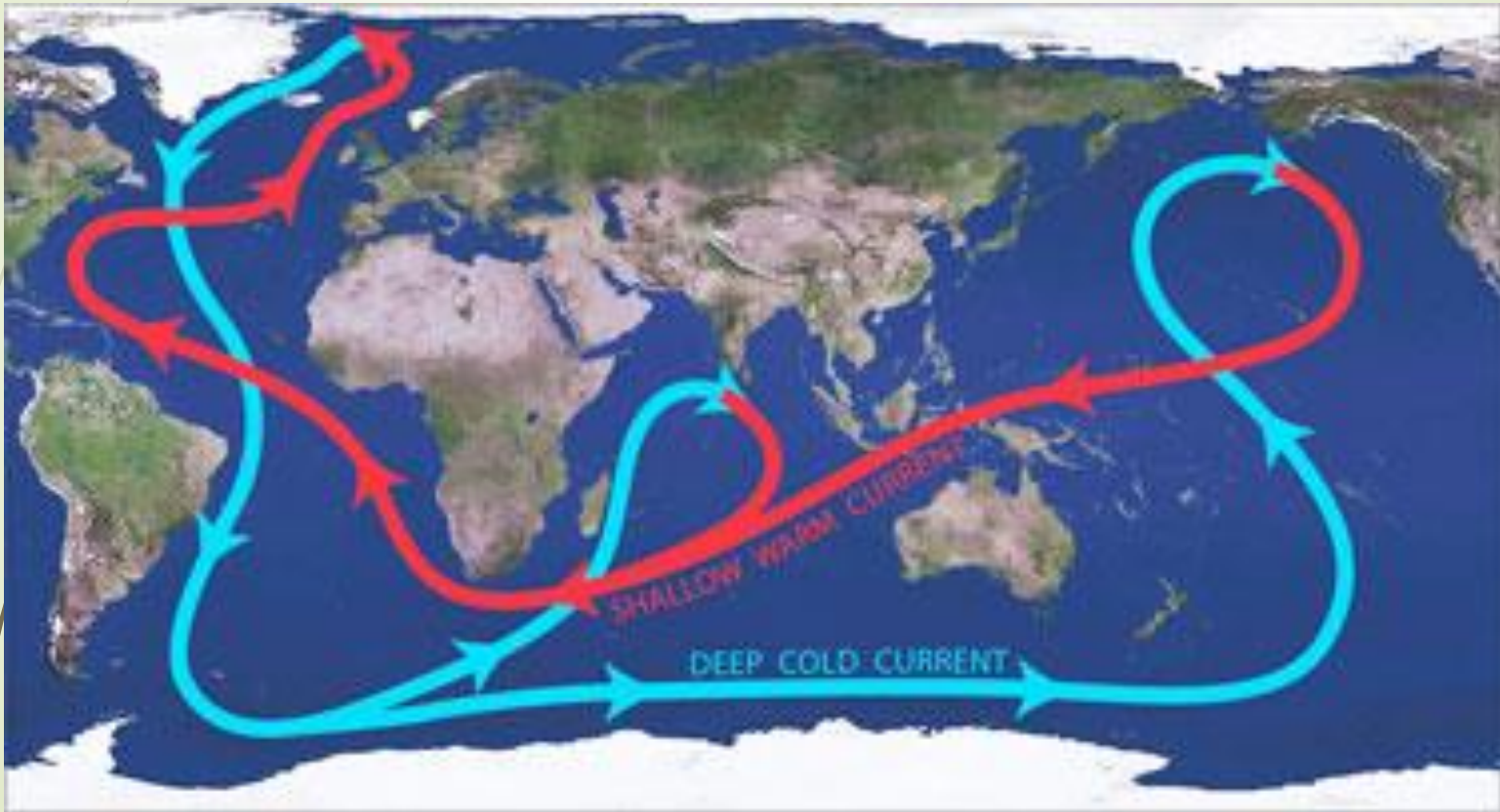
COMPARISON BETWEEN OCEAN WATER AND RIVER WATER

Chemical Constituent	Percentage of Total Salt Content	
	Ocean Water	River Water
Silica (SiO_2)	—	14.51
Iron (Fe)	—	0.74
Calcium (Ca)	1.19	16.62
Magnesium (Mg)	3.72	4.54
Sodium (Na)	30.53	6.98
Potassium (K)	1.11	2.55
Bicarbonate (HCO_3^-)	0.42	31.90
Sulfate (SO_4)	7.67	12.41
Chloride (Cl)	55.16	8.64
Nitrate (NO_3)	—	1.11
Bromide (Br)	0.20	—
TOTAL	100.00	100.00

http://ponce.sdsu.edu/usgs_why_is_the_ocean_salty/charts.gif

Major Water Compartments

The Great Ocean Conveyor Belt

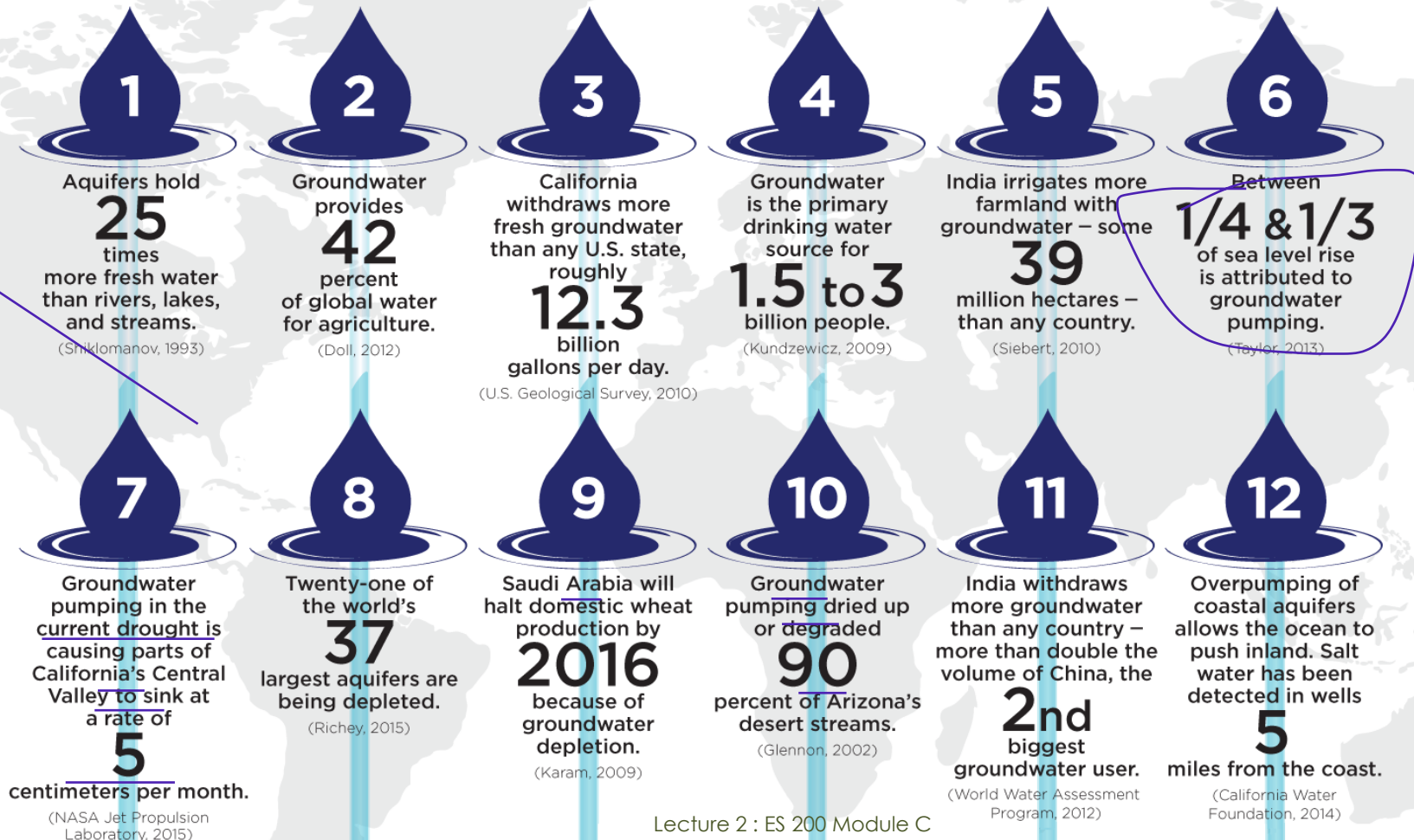


http://stempreacademy.hawaii.edu/sites/default/files/c-more/ocean-conveyor-belt/ocean-conveyor-belt-light_375px.jpg

Major Water Compartments

The Groundwater

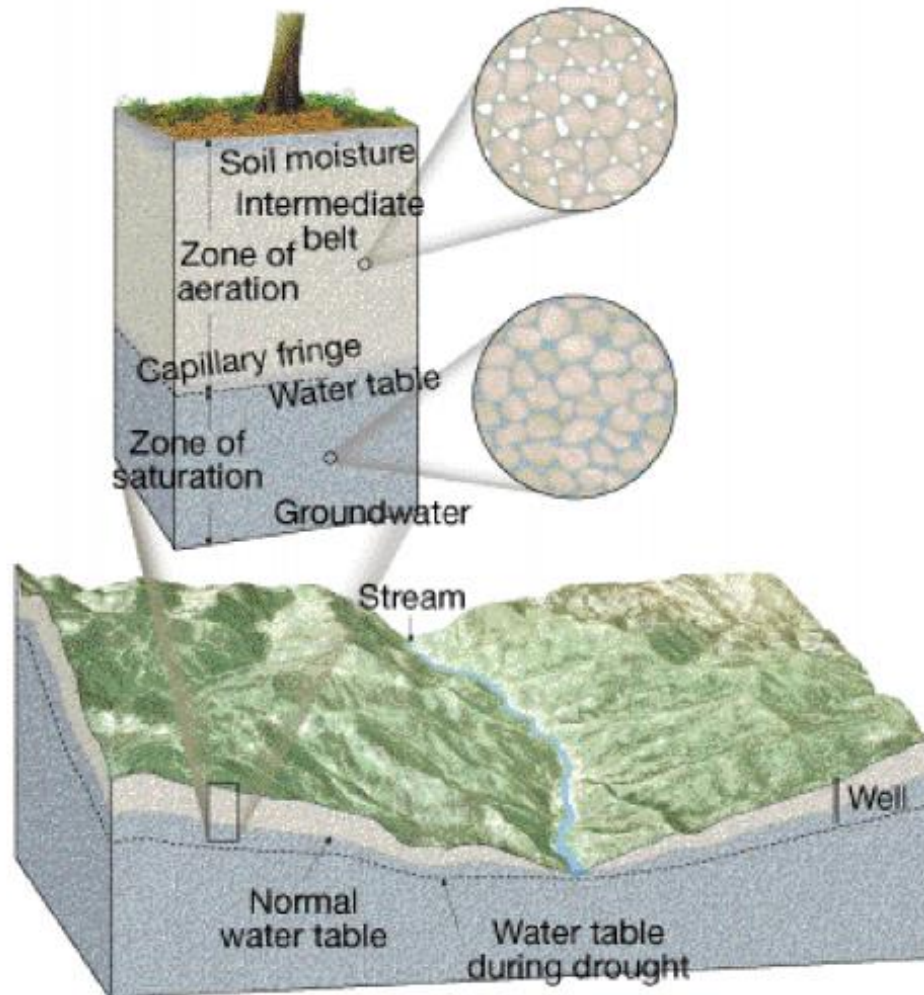
12 THINGS YOU SHOULD KNOW ABOUT GROUNDWATER:



[http://w
ww.circl
eofblue.
org/wp-
content
/upload
s/2016/
01/12-
facts-
about-
ground
water1.
png](http://www.circl eofblue.org/wp-content /upload s/2016/ 01/12- facts- about- ground water1. png)

Major Water Compartments

The Groundwater



[http://web.
arc.losrios.e
du/~boroug
t/Groundwa
ter.gif](http://web.arc.losrios.edu/~boroug/t/Groundwater.gif)

Major Water Compartments

The Groundwater

Physical Properties That Affect Groundwater

▶ Porosity:

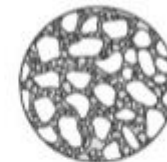
- ▶ The ratio of voids in a rock or sediment to the total volume of material is referred to as porosity and is a measure of the amount of groundwater that may be stored in the material.

▶ Permeability:

- ▶ It measures the transmission property of the media and the interconnection of the pores.
- ▶ It is related to hydraulic conductivity and transmissivity.



HIGH POROSITY
Sediments with uniform grain size



MODERATE POROSITY
Sediments with variable grain size



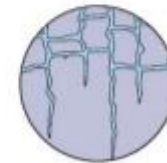
MINIMAL USABLE POROSITY
Cemented sediments of variable grain size



MINIMAL USABLE POROSITY
Fine sediments



LOW POROSITY
Fractured crystalline rock



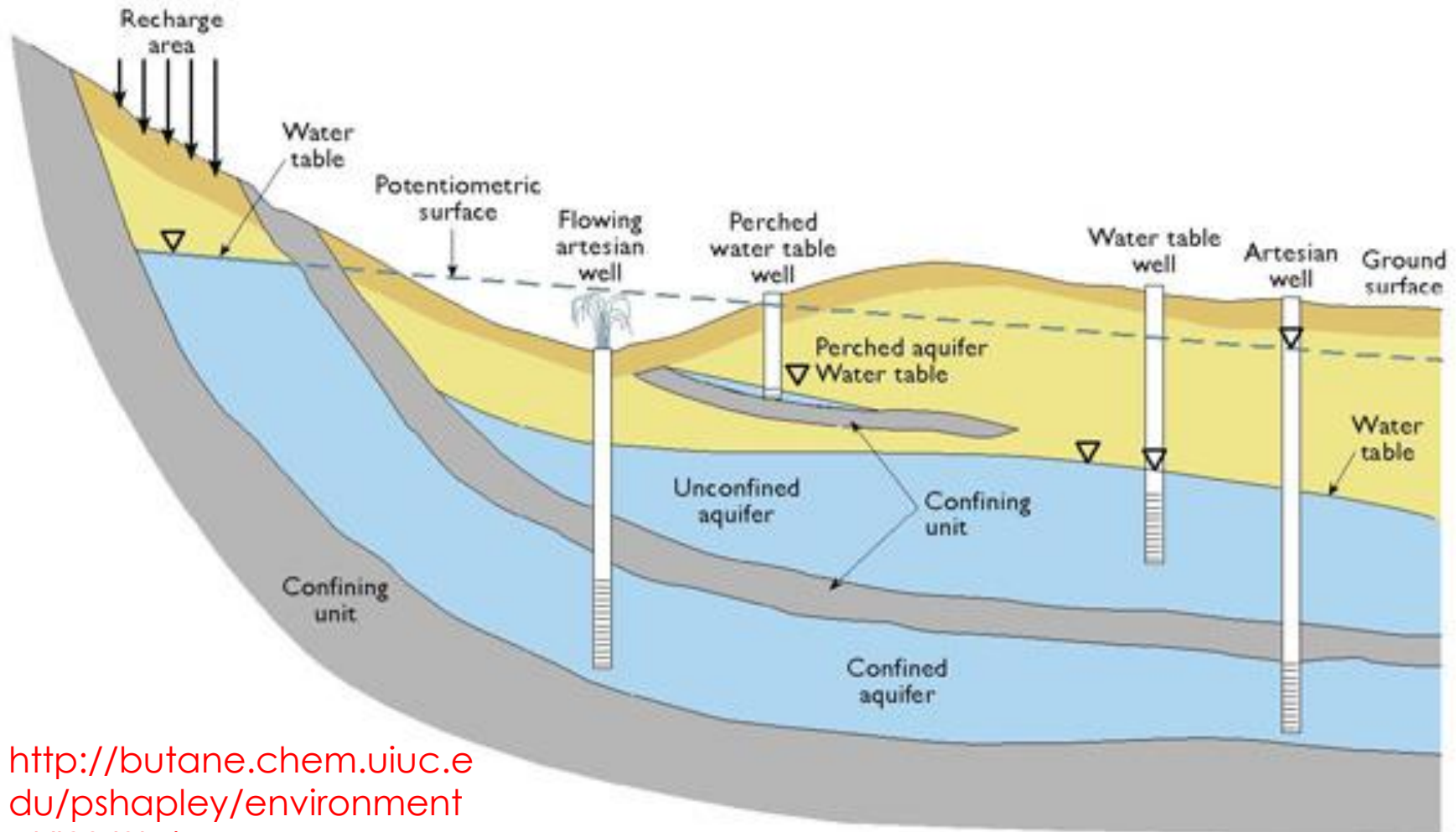
LOW TO HIGH POROSITY
Fractured volcanic rocks

Examples of porosity in sediments and rocks

<https://image.slidesharecdn.com/introductionto-groundwater-hydrology-150316012832-conversion-gate01/95/introduction-to-groundwater-hydrology-13-638.jpg?cb=1426469370>

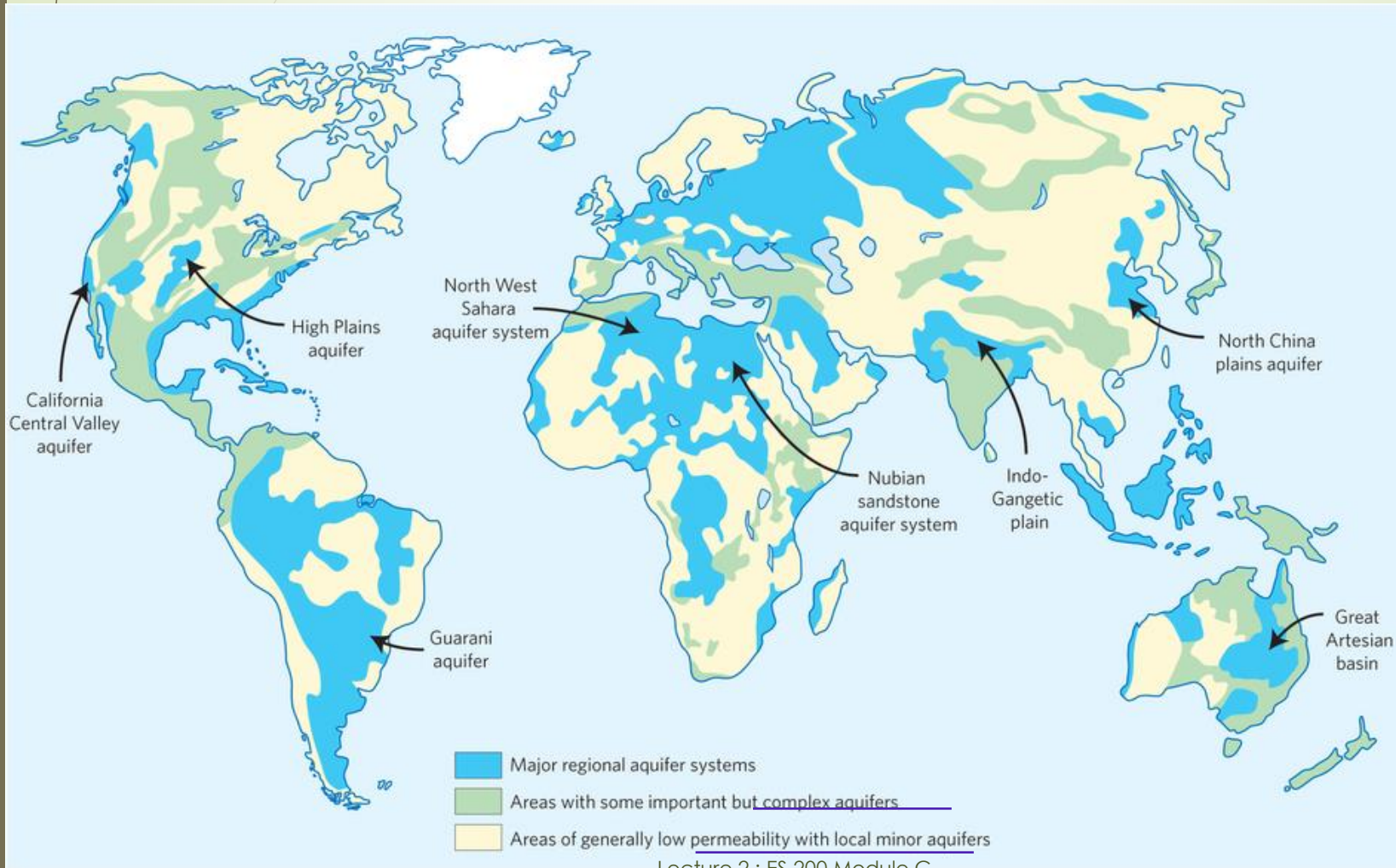
Major Water Compartments

The Groundwater: Aquifers



Major Water Compartments

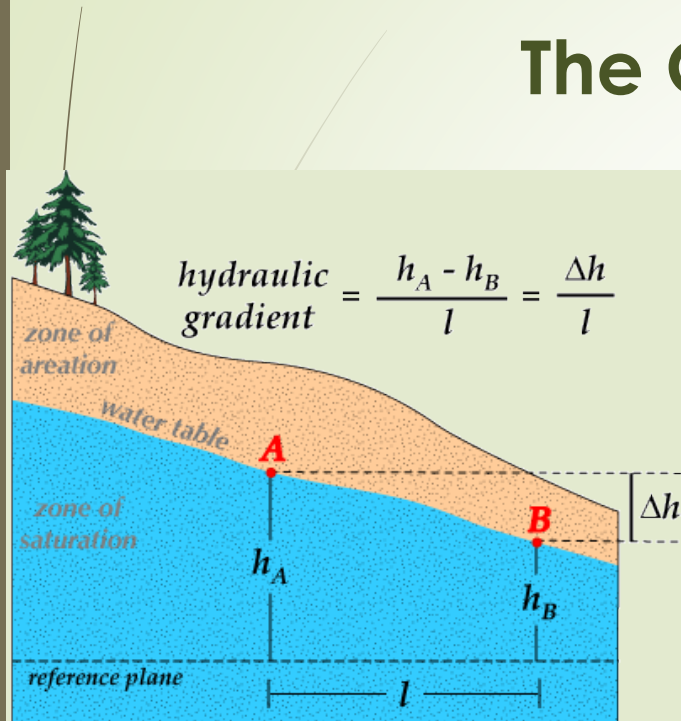
The Groundwater: Major Aquifers



<https://www.nature.com/articles/npg/nclimate/journal/v3/n4/images/nclimate1744-f1.jpg>

Major Water Compartments

The Groundwater: Flow



$$\text{hydraulic gradient} = \frac{h_A - h_B}{l} = \frac{\Delta h}{l}$$

h = hydraulic head

<http://butane.chem.uiuc.edu/pshapley/environmental/I23/3b.jpg>

Masters & Ela
(2008)

Darcy's Law

$$Q = KA \left(\frac{dh}{dL} \right)$$

where

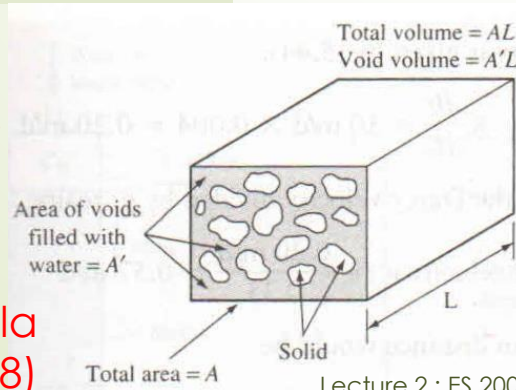
Q = flow rate (m^3/day)

K = hydraulic conductivity, or coefficient of permeability (m/day)

A = cross-sectional area (m^2)

$\left(\frac{dh}{dL} \right)$ = the hydraulic gradient

$$\text{Darcy Velocity, } v = \frac{Q}{A} = \frac{KA \left(\frac{dh}{dL} \right)}{A} = K \frac{dh}{dL}$$



Average linear velocity

$$v' = \frac{\text{Darcy velocity}}{\text{Porosity}} = \frac{v}{\phi} = \frac{K}{\phi} \left(\frac{dh}{dL} \right)$$

Major Water Compartments

The Rivers

The Longest Rivers in the World

Length in kilometers



Source: www.watchmojo.com

Photo: © absolutvision.com

© grafikdienst.com



<https://mossavi.files.wordpress.com/2008/05/3and43.jpg>

TABLE 16.1 World's Largest Rivers Ranked by Discharge

Rank	River	Country	Drainage Area		Average Discharge	
			Square kilometers	Square miles	Cubic meters per sec.	Cubic feet per sec.
1	Amazon	Brazil	5,778,000	2,231,000	212,400	7,500,000
2	Congo	Rep. of Congo	4,014,500	1,550,000	39,650	1,400,000
3	Yangtze	China	1,942,500	750,000	21,800	770,000
4	Brahmaputra	Bangladesh	935,000	361,000	19,800	700,000
5	Ganges	India	1,059,300	409,000	18,700	660,000
6	Yenisei	Russia	2,590,000	1,000,000	17,400	614,000
7	Mississippi	United States	3,222,000	1,244,000	17,300	611,000
8	Orinoco	Venezuela	880,600	340,000	17,000	600,000
9	Lena	Russia	2,424,000	936,000	15,500	547,000
10	Parana	Argentina	2,305,000	890,000	14,900	526,000

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http://images.slideplayer.com/26/8542705/slides/slide_11.jpg

Major Water Compartments

The Rivers

http://pm22100.net/pages/enercoop/01_dossiers/unep-water/04-major-basins.jpg



Source: United Nations Environment Programme (UNEP); World Conservation Monitoring Centre (WCMC); World Resources Institute (WRI); American Association for the Advancement of Science (AAAS); *Atlas of Population and Environment*, 2001.

Major Water Compartments

Reading Assignment

Read about the role of Lakes and Atmosphere as Water Compartments.

The Water Issues

- Quantity of freshwater
- Quality of freshwater
- Inequitable distribution
- Unsustainable use

The Water Issues

Quantity of Freshwater

Recommended per capita Water Supply Levels in India

Classification of Towns/Cities	Recommended Maximum Water Supply Levels (lpcd)
Towns provided with piped water supply without sewerage system	70
Cities provided with piped water supply where sewerage system is existing/contemplated	135
Metropolitan and Mega Cities provided with piped water supply where sewerage system is existing/contemplated	150

Central Public Health and Environmental Engineering Organisation (CPHEEO)
Manual, 1999; IS:1172-1993

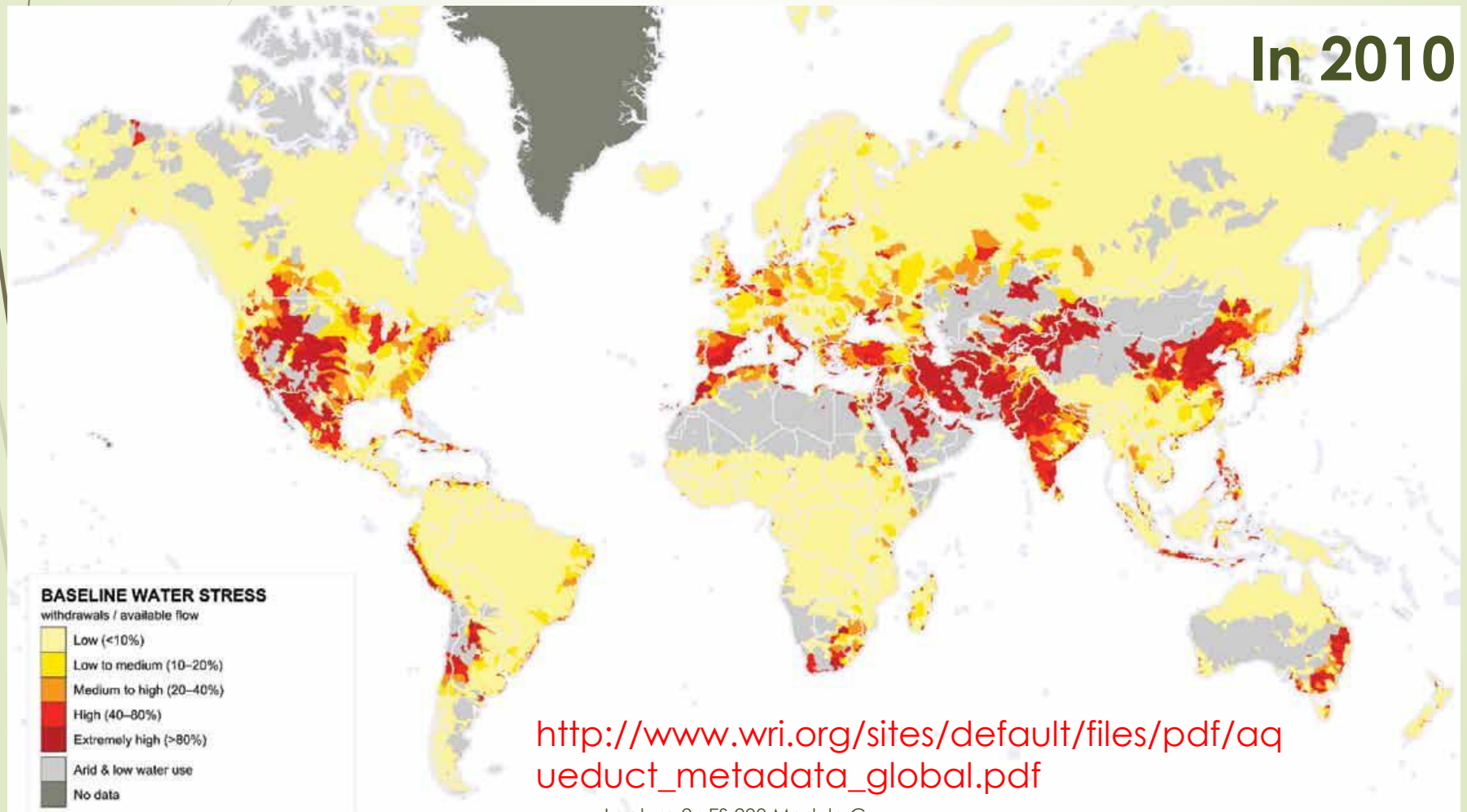
The Water Issues

Quantity of Freshwater

Activity	Demand (lpcd)
Drinking	5
Cooking	5
Bathing	55
Washing of clothes	20
Washing of utensils	10
Cleaning of house	10
Flushing of toilets	30
Total	135

The Water Issues

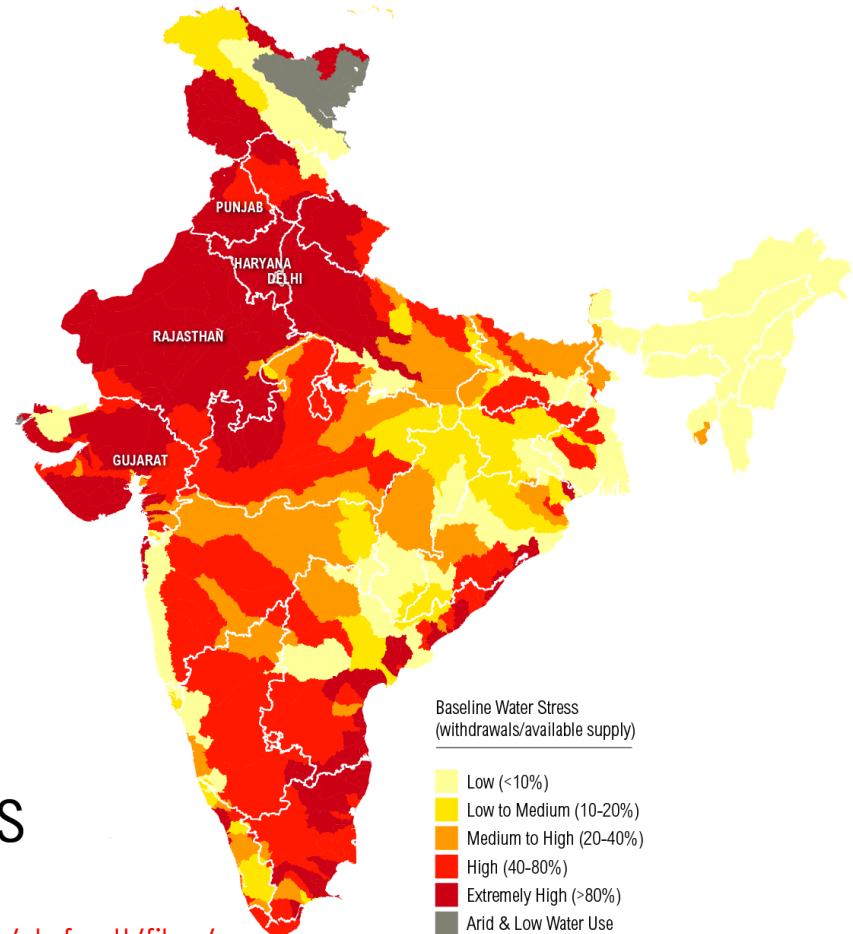
Quantity of Freshwater



The Water Issues

Quantity of Freshwater

54%
of India
Faces
**High to
Extremely
High**
Water Stress

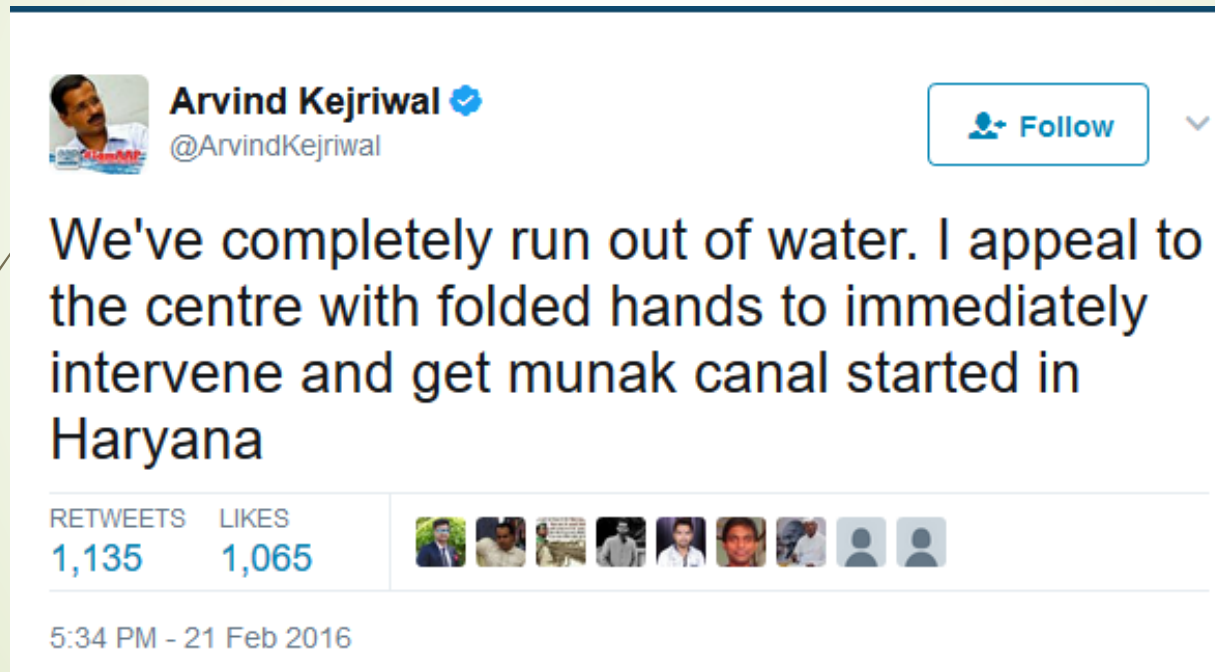


http://www.wri.org/sites/default/files/uploads/India_Water_tool_blog_graphics-01.png

www.indiawatertool.in

The Water Issues

Quantity of Freshwater



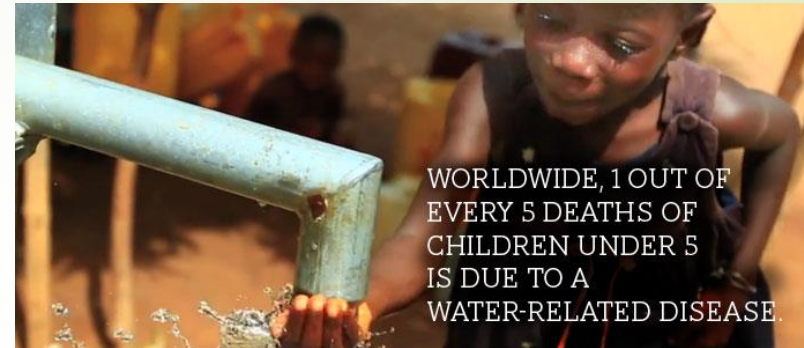
https://twitter.com/ArvindKejriwal/status/701580858428231680?ref_src=twsrc%5Etfw&ref_url=http%3A%2F%2Fwww.huffingtonpost.in%2Famitangshu-acharya%2F5-blind-spots-that-are-bl_b_9483230.html

The Water Issues

Quality of Freshwater



<http://nowfoundation.org.uk/wp-content/uploads/2015/05/NOW-Foundation-Act-Now-Water-7.jpg>



<https://cdn.thewaterproject.org/images/waterstats.jpg>



<https://s-media-cache-ak0.pinimg.com/originals/8c/84/a1/8c84a1c23189ac97041f497a6a70217c.jpg>

The Water Issues

Inequitable Distribution of Freshwater



http://s.wsj.net/public/resources/images/OB-TK844_water0_G_20120619080244.jpg

ts-that-are-bl_b_9483230.html

Solutions To India's Water Crisis

However, fetishizing supply is preferred over regulating demand. From desalinization plants, to interlinking rivers to the promise of 24x7 water supply, our politics legitimize solutions in the name of the common man, but in reality, supply water to the rich. The litigation and conflict surrounding the diversion of water supply [from the city of Pune to the expensive real estate destination, Lavasa City, is case in point](#). In Delhi, the [rich have cornered the bulk of the city's water supply by paying private water tankers, digging illegal bore wells and bribing officials](#).

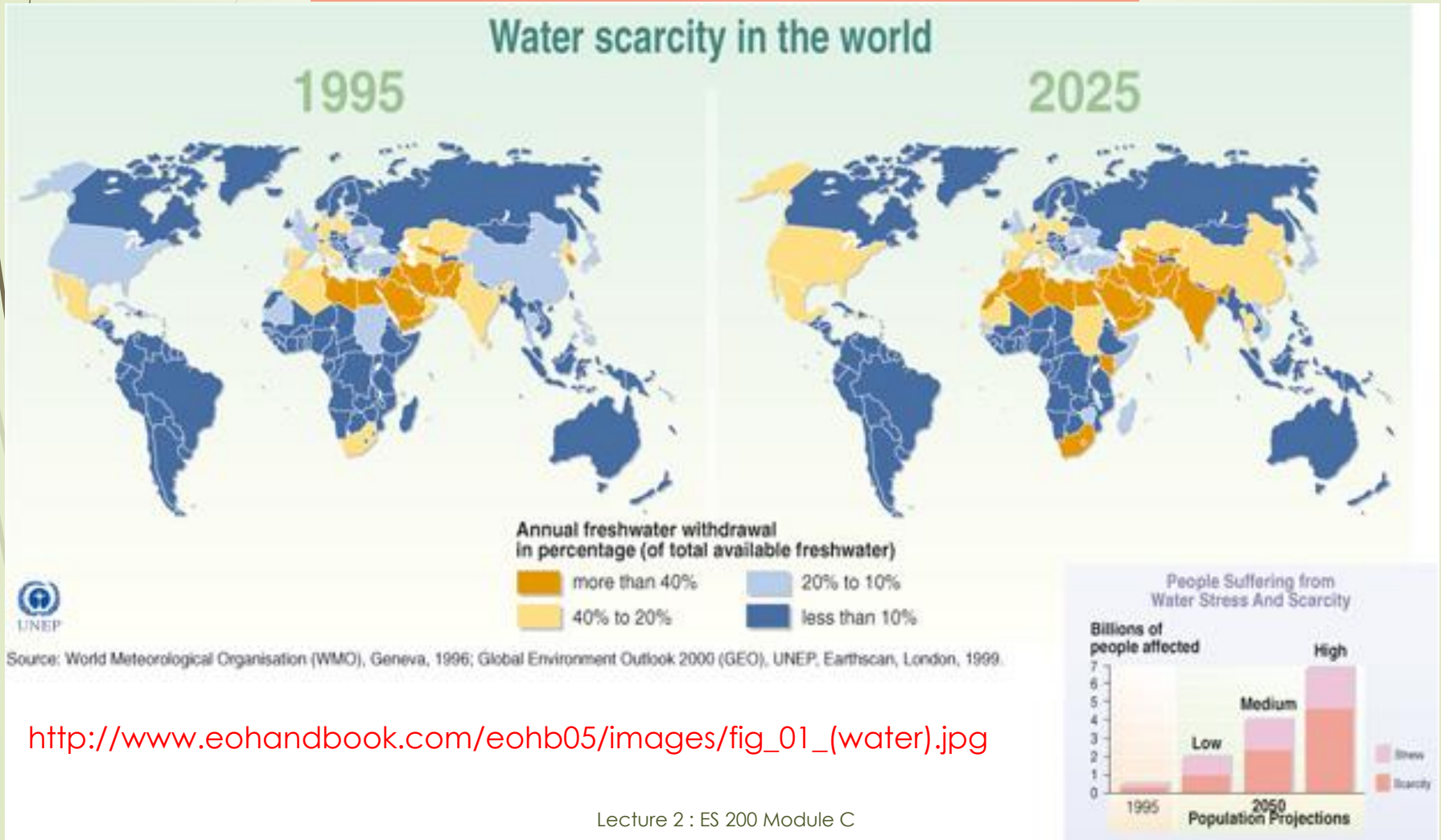
“
The 24x7 water supply system was made operational for some of Delhi's extremely posh colonies... people promptly switched to washing their imported cars three times a day.

Some believe that making the rich pay for their water will solve this problem. Reality disagrees. The 24x7 water supply system was made operational for some of Delhi's extremely posh colonies with the belief that regular supply and volumetric pricing would lead to better water conservation. In fact, as the buzz goes, people promptly switched to washing their imported cars three times a day and watering the lawns more frequently. Such pathology of water consumption by the rich remains unexamined and hence, untreated.

http://www.huffingtonpost.in/amitangshu-acharya/5-blind-spots-that-are-bl_b_9483230.html

The Water Issues

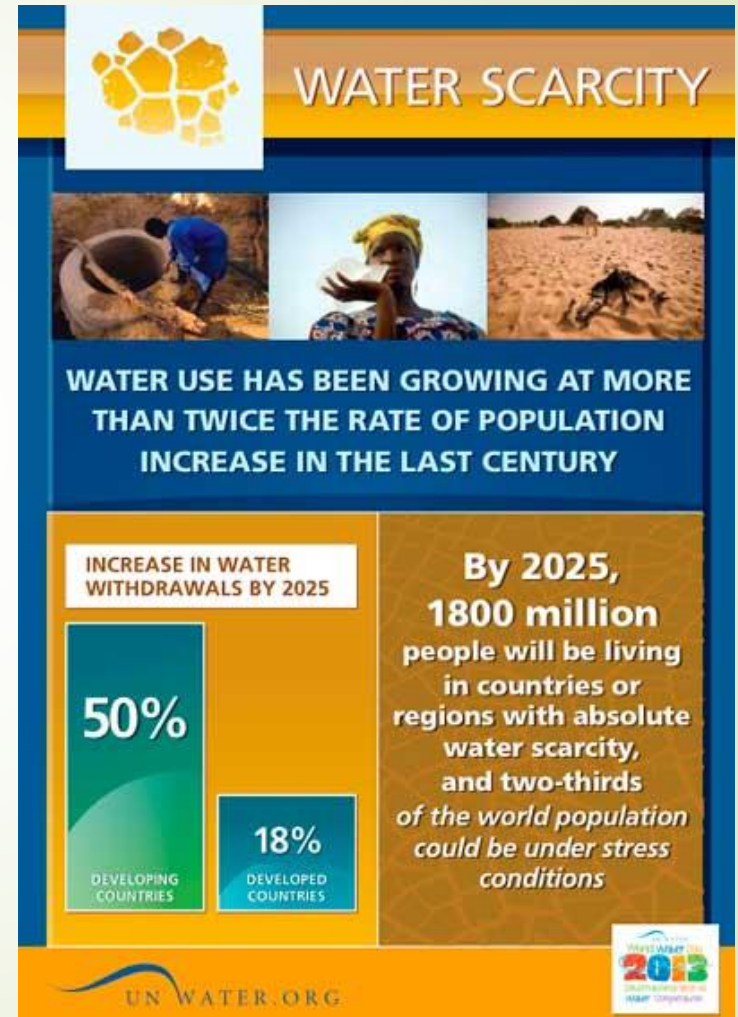
Unsustainable Use of Freshwater



The Water Issues

Unsustainable Use of Freshwater

http://www.un.org/waterforlifedecade/images/scarcity/2014_01_water_scarcity_eng.jpg



The Water Management

Assignment

Write an Essay on “Sustainable Water Management Practices” (1500-2000 words, typed and printed).

Submission: 05 Sep 2017 (Tue) or before **(No late submission)**

Non submission (or plagiarized assignments) will have a **penalty of 4 marks** from your earned marks (Quiz + Final Exam) out of 33 Marks in Module-C.

Example: If you scored 10 marks in Quiz and 20 marks in Final Exam, but did not submit the assignment; then your final marks for Module-C will be: $10+20-4 = 26$ (out of 33).

Important: Submission of the assignment, and having a TA note down that you have actually submitted it, is **YOUR RESPONSIBILITY!!!!**

Next Lecture:

Water Quality & Pollution Sources