WATER

- ✓ Water is by far the most common liquid on the Earth's surface.
- ✓ Its unique properties enable life to exist.
- ✓ In chemical terms it is a dilute solution of various compounds. It can also hold suspensions.
- ✓ Water is the medium for almost all the reactions and processes that are essential for life.
- ✓ To understand water pollution, and also water and wastewater related environmental engineering practices it is first necessary to have an appreciation of chemical phenomena that occur in water.

WATER

- ✓ Water availability and demand in Turkey
- ✓ Water availability in the world
- ✓ Chemical structure of water
- ✓ Unique properties of water (Fundamental and Engineering Properties of Water

Water availability and Demand in Turkey

Is Turkey a

- water rich country?
- water scarce country?
- water poor country?

Water rich country: 8000 m^3 - 10000 m^3 of water per inhabitant per year

Water scarce country: Less than 2000 m^3 of water per inhabitant per year

Water poor country: Less than 1000 m^3 of water per inhabitant per year

In an average year, 1 000 m^3 of water per inhabitant can be considered as a minimum to sustain life and ensure agricultural production in countries with climates that require irrigation for agriculture.

REVIEW OF WORLD'S WATER RESOURCES BY COUNTRY

A country may have a relatively high availability of water, but it may still suffer high water stress if withdrawal is high. Conversely, a country may have relatively low water availability, but may not suffer water stress if withdrawal is low. Examples in the first category could be found in industrialised countries where demand for water per person is high. Examples in the second category could be found in developing countries where demand for water is low.

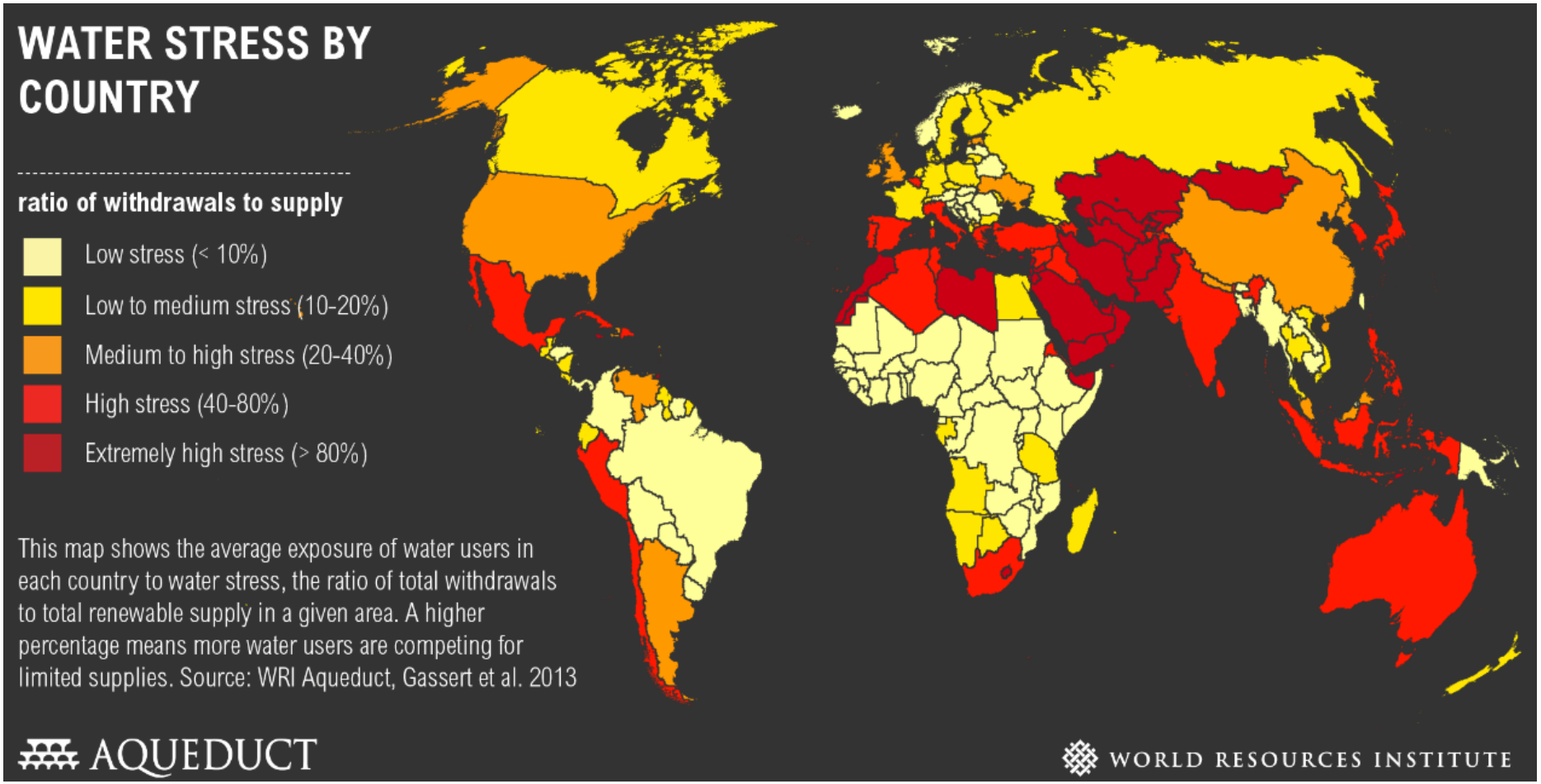
4. Su Alanında Türkiye'deki Genel Görünüm

En hayati ihtiyacımız olan su, bütün toplumsal faaliyetlerimizi yürütmemiz açısından kritik bir öneme sahiptir. Türkiye, su kaynakları açısından zengin bir ülke olmadığı gibi, mevcut su kaynaklarının ülke geneline dağılımı da eşit değildir.[8] DSİ'nin çalışmalarına göre ülkemizde mevcut durumda toplam 234 milyar m^3'lük kullanılabilir su kaynağı olmasına rağmen ekonomik ve teknik sebeplerle bu miktarın 112 milyar m^3'lük kısmı kullanılabilmektedir. DSİ ayrıca 2030 yılında ülkemizdeki su tüketiminin yaklaşık 112 milyar m^3 olacağını öngörmektedir. Bu veriler ve tahminlerden yola çıkıldığında gerek su kaynaklarının temini gerekse de kullanılmış suyun arıtımına yönelik Ar-Ge ve Yenilik çalışmaları yapılmasının son derece gerekli olduğu görülmektedir.

Türkiye'de kişi başına düşen yıllık kullanılabilir su miktarı 1.586 m^3, tür ve bu sayı su zengini ülkelerde kişi başına düşen su miktarının beşte birine denk gelmektedir.[9] Ülkemiz su azlığı yaşayan bir ülke konumundadır. 2030 yılı için nüfus artışıyla birlikte mevcut kaynakların tahrip edilmeden aktarılacağı varsayılarak yapılan öngörüde kişi başına düşen kullanılabilir su miktarı su fakirliği sınırında bulunan 1.120 m^3/yıl olarak hesaplanmıştır.[10]

Ülkemizdeki toplam su tüketiminin yıllara ve sektörlere göre dağılımına bakıldığında toplam su kullanımının 2004 yılından 2030 yılına kadar yaklaşık 3 kat artacağı görülmektedir.[11] Sulama, su tüketiminde en büyük paya sahip sektör olarak dikkat çekmektedir (Tablo 1).

EK 2-ULUSAL SU AR-GE VE YENİLİK STRATEJİSİ – TÜBİTAK Aralık 2011



World's 36 Most Water-Stressed Countries

by  Paul Reig, Andrew Maddocks and Francis Gassert - December 12, 2013

Tablo 1. Türkiye'de Sektörler Tarafından Kullanılan Su Miktarı[12]

Yıl	Toplam Su Tüketimi		Sektörler					
			Sulama		İçme-Kullanma		Sanayi	
	km^3	%	km^3	%	km^3	%	km^3	%
1990	31	28	22	72	5	17	3	11
2004	40	36	30	74	6	15	4	11
2030	112	100	72	64	18	16	22	20

Tablo 2. Bazı ülkeler ile Türkiye'nin yıllık yağış miktarı ve sektörlere göre su kullanımı (km^3)[15]

Ülke	Yıllık Ortalama Yağış miktarı	Sulama	İçme suyu	Endüstri	Veri tarihi
Türkiye[14]	501	34	7	5	2008
Hindistan	3.560	688	56	17	2007-2010
Güney Kore	127	16	7	3	2002
ABD	6.887	192	65	221	2005-2008
Çin	6.191	358	68	129	2005-2007

The Hydrologic Cycle

- Over 71% of the earth's surface is covered by water:
  - Oceans contain 97%.
  - Polar ice caps and glaciers contain 2%.
  - Freshwater in lakes, streams, and ground water make up less than 1%.

The Water Resources of Earth

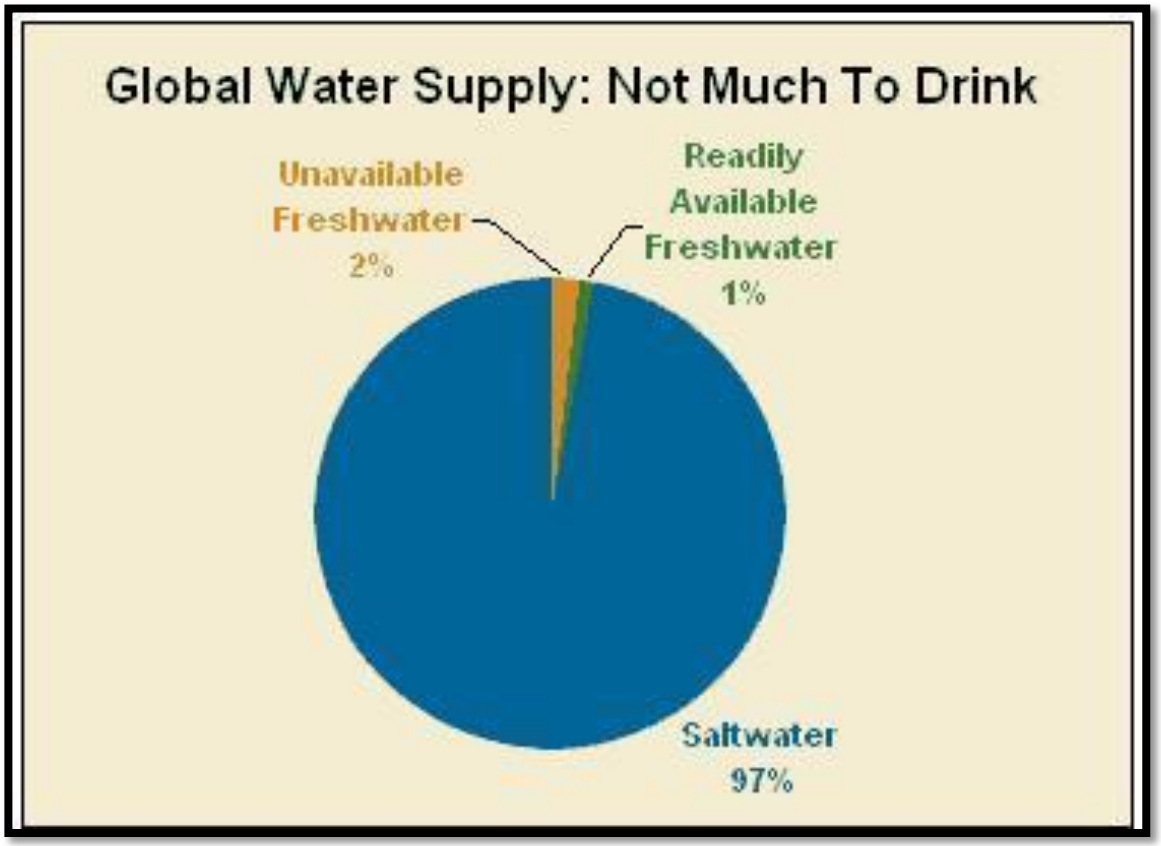
Abundancy versus availability

- 97.13% of all water on Earth is salt water.
- About 2.5% is fresh water .
  - Nearly 70% of that fresh water is frozen in the icecaps of *Antarctica* and *Greenland*.
  - Most of the remainder lies in deep underground aquifers as groundwater not accessible to human use.

71 % of our Earth's surface is covered by water.

Water Available for Direct Human Use

- < 1% of the world's fresh water (~0.007% of all water on earth) is accessible for direct human uses.
- This is the water found in *lakes, rivers, reservoirs and those underground sources* that are shallow enough to be tapped at an affordable cost.
- Only this amount is regularly renewed by rain and snowfall, and is therefore available on a sustainable basis.


Global Water Supply: Not Much To Drink
Unavailable Freshwater 2%
Readily Available Freshwater 1%
Saltwater 97%

- Oceans 97.13%

  – approximately 1.1 M solution of cations and anions.

  TDS=35,000 mg/L, mostly Na^+ and Cl^-.

Fresh water can be defined as water with less than 500 parts per million (ppm) of dissolved salts.

Water salinity based on dissolved salts in parts per thousand (ppth)			
Fresh Water	**Brackish water**	**Saline Water**	**Brine**
< 0.5	**0.5 – 30**	**30 – 50**	**> 50**

Rainwater

- Most dilute of all waters. Equilibrates with the gases in the atmosphere.
- No buffering agents ⟹ rapid pH changes
- When absorbs SO_2 ⟹ acid rain
- The major atmospheric constituents, N_2 and O_2 are sparingly soluble in water.
- Minor constituents such as SO_2 and CO_2 are however, very soluble.
- When rainwater falls onto the land surface and comes in contact with rocks, sediments, and soils giant global acid-base titrations occur.

Groundwater

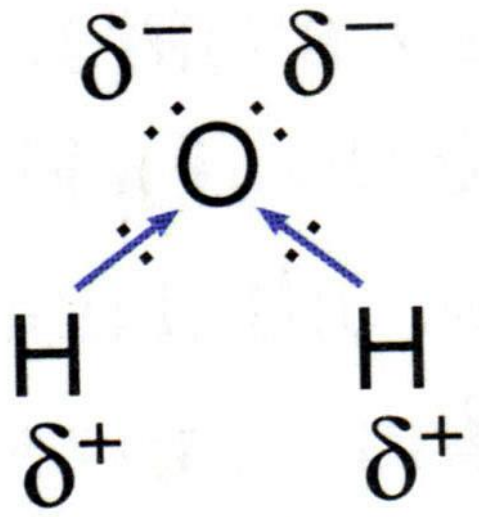
- Ground water is a result of precipitation falling on porous ground where spaces between the soil particles allows water to seep and then flow beneath Earth's surface.
- Earth has 40 times more water underground than is found in lakes, rivers, and streams as surface water.
- GW usually contains more dissolved solids than surface waters because of longer contact time between water, rocks and soils in the ground. Microbiological activities in soil produce CO_2, pH drops, more corrosive.
- Usually softening is required for drinking water purposes.

Surface water

- Contains various degrees of hardness.
- When in contact with granite (SiO_2), low TDS,
- Contact with calcite ($CaCO_3$), high TDS.

The Water Molecule

The water molecule is made up of two hydrogen atoms bonded to an oxygen atom.



The three atoms are not in a straight line; instead, they form an angle of 105°. Because of water's bent structure and the fact that the oxygen atom attracts the negative electrons more strongly than do the hydrogen atoms, the water molecule behaves like a dipole having opposite electrical charges at either end.

The Water Molecule

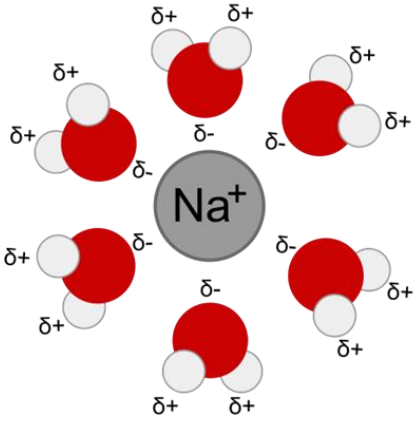
Atoms of electropositive elements can give up one or more electrons easily, such as H atom.

Atoms of electronegative elements can gain electrons easily, such as O atom.

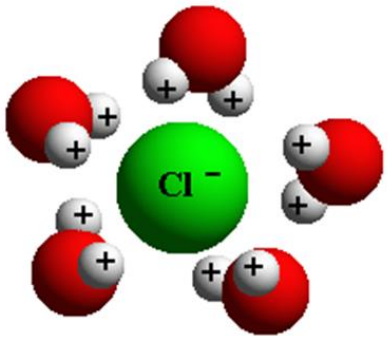
The Water Molecule

The water dipole may be attracted to either positively or negatively charged ions.

This kind of attraction for ions is the reason why water dissolves many ionic compounds and salts that do not dissolve in other liquids.



Polar water molecules surrounding Na^+ ion.



Polar water molecules surrounding Cl^- ion.

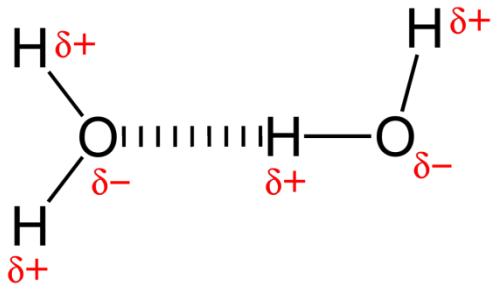
Hydrogen Bonds

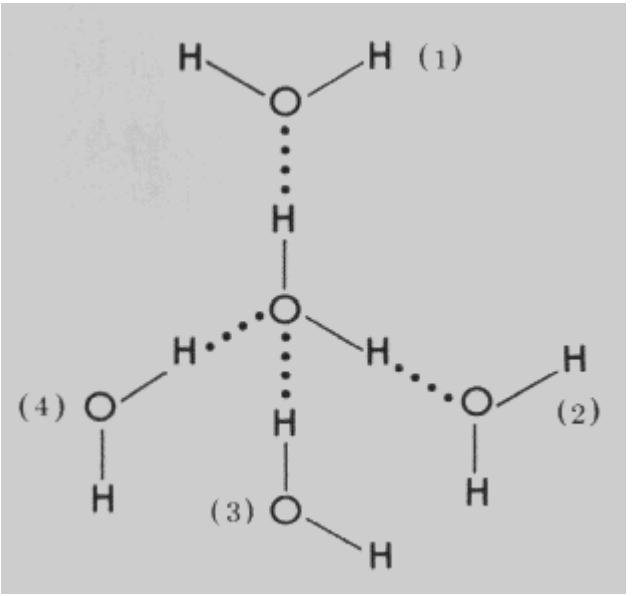
- Hydrogen bonding is a special type of bond that occurs when a H atom in one molecule is attracted to an electronegative atom such as F, O or N in a neighboring molecule.

- Hydrogen bonding causes stronger attractive forces between water molecules than the molecules of most other liquids and is responsible for many of the unique properties of water.

Hydrogen Bonds

- attraction between the hydrogen in one water molecule and the oxygen in another water molecule.
- takes place because the oxygen has a partial negative charge and the hydrogen a partial positive charge.
- hydrogen bonds, shown in figure as dashed lines, hold the water molecules together in large groups.

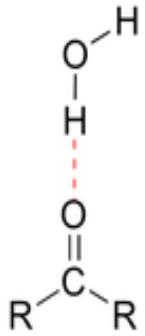




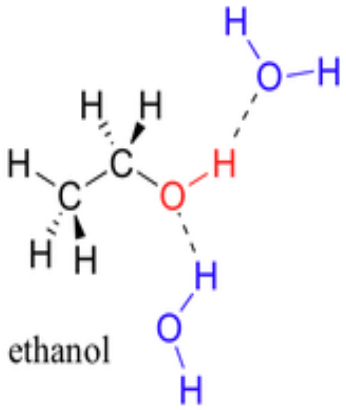
Hydrogen Bonds

- Hydrogen bonds also help to hold some solute molecules or ions in solution.
- This happens when hydrogen bonds form between the water molecules and hydrogen, nitrogen, or oxygen atoms on the solute molecule.
- Hydrogen bonding also aids in retaining extremely small particles called *colloidal particles* in suspension in water.

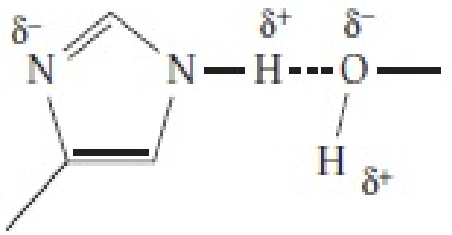
Hydrogen bonds holding organic molecules ions in solution.



hydrogen bonding between a ketone (acceptor) and water (donor)



ethanol



imidazole group of a protein can bond to an OH group of water

Hydrogen Bonds

H_2O (18) – Replace Oxygen by some heavier molecules, sulfur, selenium, tellurium

- H_2S (66) – is a colorless, toxic, flammable gas. b.p. -60.3 ^oC
- H_2Se (81) – Hydrogen Selenide is a colorless, flammable, extremely toxic gas. b.p. -42 ^oC
- H_2Te (130) – b.p. -2 ^oC

The Water Molecule

Extremely high dielectric constant

(Measure of the ability of a solvent to maintain a separation of charges.)

Excellent solvent properties

*Water is called the **Universal Solvent** because it dissolves more different kinds of materials than any other liquid.*

Water is the basic transport medium for nutrients and waste products in life processes.

Water

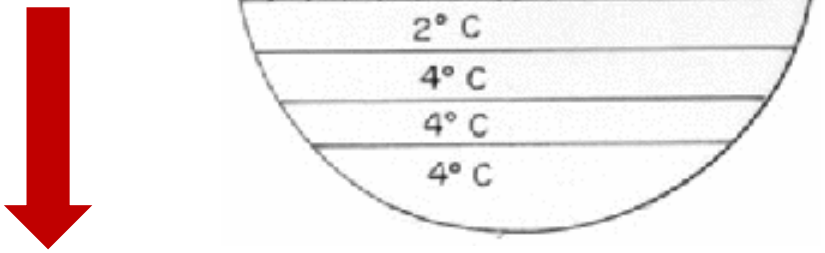
- Has the highest heat capacity of any liquid or solid with one exception, NH_3. **1 cal.g^{-1}/deg^{-1}**.
- Has extremely high heat of vaporization of water, **585 cal/g** at 20°C.

– has a stabilizing effect upon the temperature of nearby geographic regions.

– prevents sudden large changes of temperature in large bodies of water and thereby protects aquatic organisms from the shock of abrupt temperature variations.

Water

- Water has its maximum density at 4°C, a temperature above its freezing point.



  - Ice floats and few large bodies of water ever freeze solid.
  - the pattern of vertical circulation of water in lakes, a determining factor in their chemistry and biology, is governed largely by the unique temperature-density relationship of water.

Water

- ✓ The excellent ability of water to dissolve so many substances allows our cells to use valuable nutrients, minerals, and chemicals in biological processes.
- ✓ Water's "stickiness" (from surface tension) plays a part in the body's ability to transport these materials throughout our bodies.
- ✓ The carbohydrates and proteins that our bodies use as food are metabolized and transported by water in the bloodstream.
- ✓ No less important is the ability of water to transport waste material out of our bodies.

For all of these reasons, and for many others, we can truly say that water is special, strange, and different.

Table 2-1
Engineering properties of water

Property	Symbol	Unit		Value[a]		Definition/Notes
		SI	U.S. Customary	SI	U.S. Customary	
Boiling point	bp	°C	°F	100	212	Temperature at which vapor pressure equals 1 atm; high value for water keeps it in liquid state at ambient temperature.
Conductivity	κ	μS/m	μS/m	5.5	5.5	Pure water is not a good conductor of electricity; dissolved ions increase conductivity.
Density	ρ	kg/m^3	$slug/ft^3$	998.2	1.936	
Dielectric constant	ε_r	unitless	unitless	80.2	80.2	Measure of the ability of a solvent to maintain a separation of charges; high value for water indicates it is a very good solvent.
Dipole moment	p	C•m	D (debye)	6.186×10^{-30}	1.855	Measure of the separation of charge within a molecule; high value for water indicates it is very polar.

(*continues*)

Table 2-1 *(Continued)*

Property	Symbol	Unit		Value[a]		Definition/Notes
		SI	U.S. Customary	SI	U.S. Customary	
Enthalpy of formation	ΔH_f	kJ/mol	btu/lb_m	−286.5	−6836	Energy associated with the formation of a substance from the elements.
Enthalpy of fusion[b]	ΔH_{fus}	kJ/mol	btu/lb_m	6.017	143.6	Energy associated with the conversion of a substance between the solid and liquid states (i.e., freezing or melting).
Enthalpy of vaporization[c]	ΔH_v	kJ/mol	btu/lb_m	40.66	970.3	Energy associated with the conversion of a substance between the liquid and gaseous states (i.e., vaporizing or condensing); high value for water makes distillation very energy intensive.
Heat capacity[d]	c_p	J/mol•°C	btu/lb_m•°F	75.34	0.999	Energy associated with raising the temperature of water by one degree; high value for water makes it impractical to heat or cool water for municipal treatment purposes.
Melting point	mp	°C	°F	0	32	

http://www.worldometers.info/water/

- Worldwide, agriculture accounts for 70% of all water consumption, compared to 20% for industry and 10% for domestic use.
- In industrialized nations, however, industries consume more than half of the water available for human use.
- Belgium, for example, uses 80% of the water available for industry.

- Freshwater withdrawals have tripled over the last 50 years.
- Demand for freshwater is increasing by 64 billion m^3/year.
- The world's population is growing by roughly 80 million people each year.
- Changes in lifestyles and eating habits in recent years are requiring more water consumption per capita.

What's the problem?

- The population is growing rapidly, putting more pressure on our water supply (demand is increasing)
- The amount of water is effectively reduced by pollution and contamination (supply is decreasing).
- What does the future hold? We can best explore this question by looking carefully at the world's water resources.