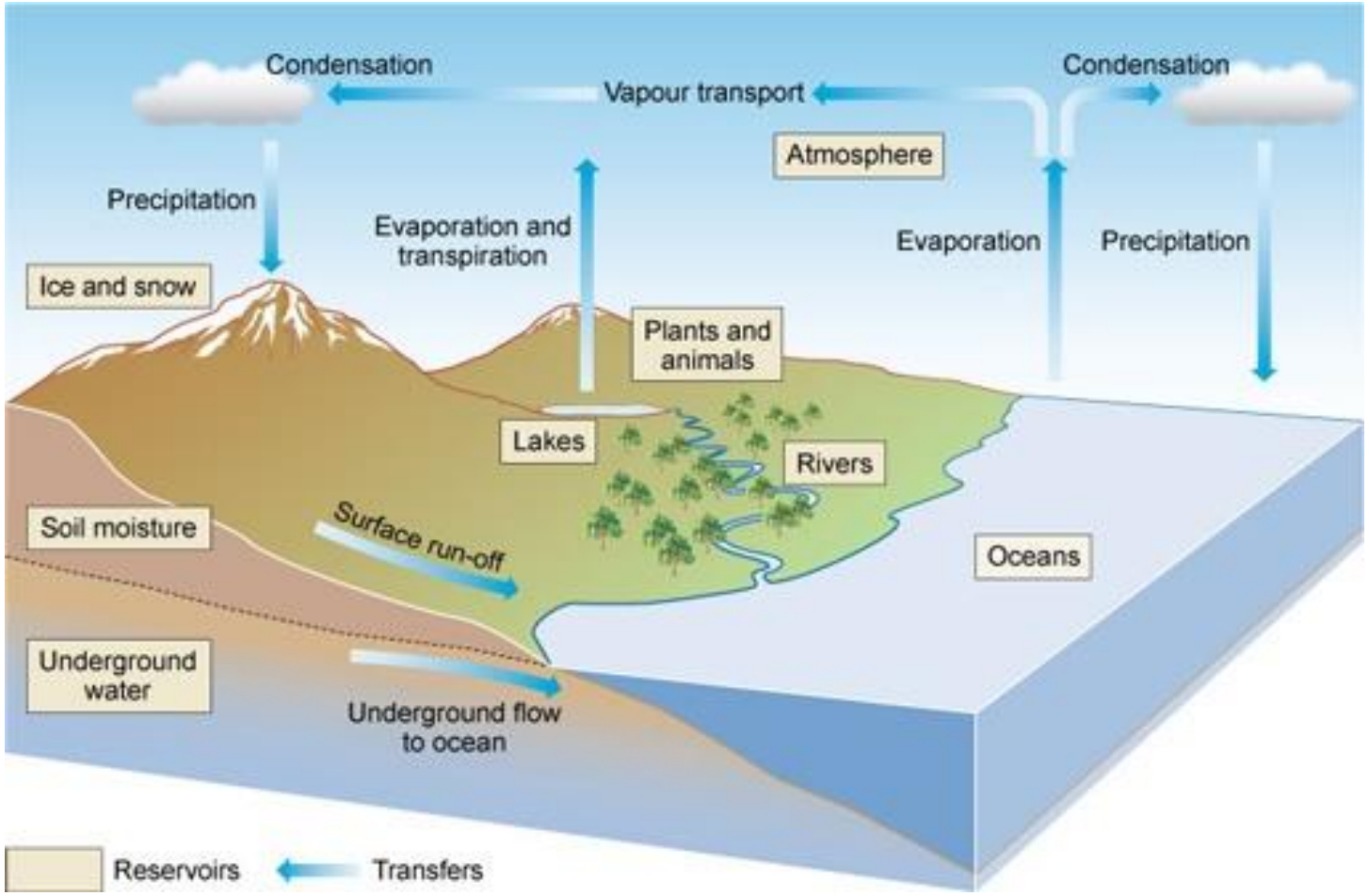
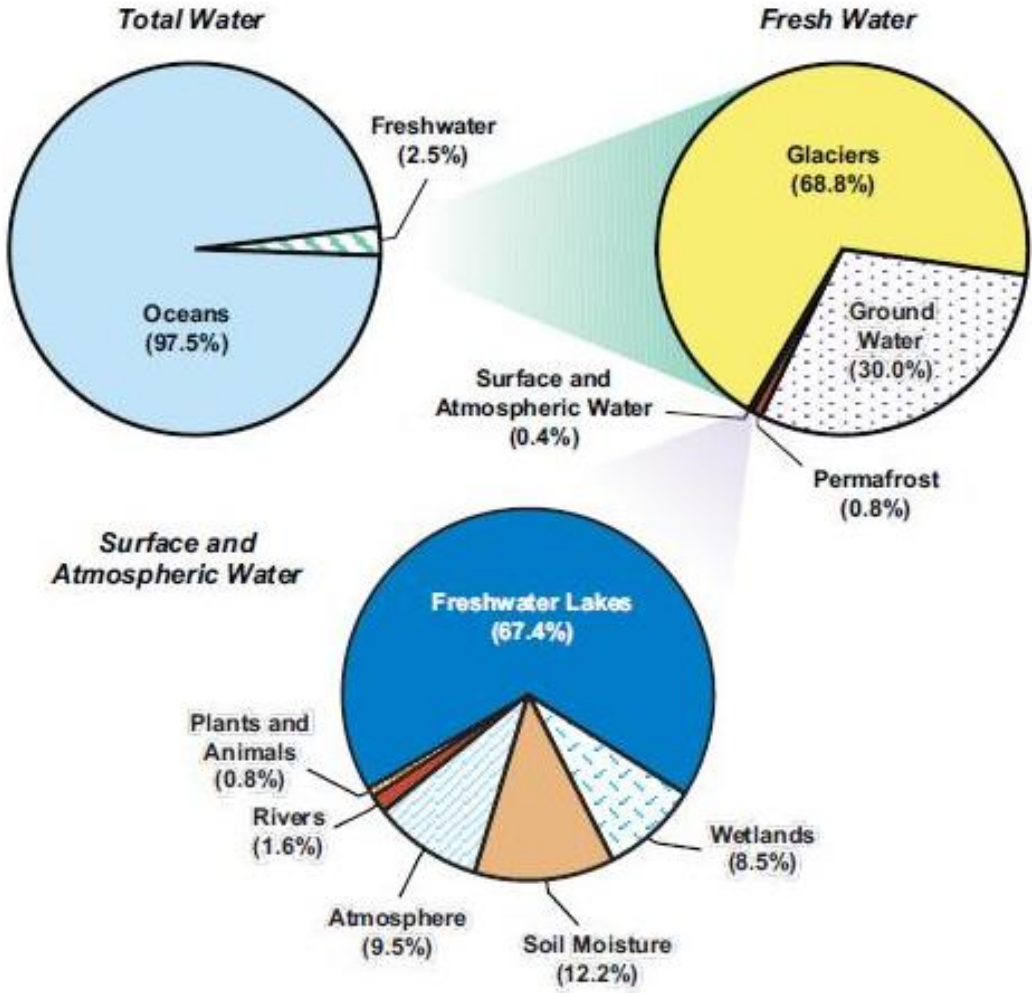
Sources of Water





- Water has different physical, chemical and biological Impurities which can cause **problems in both domestic and industrial applications**.

Impurities in water

- Physical: - Inorganic such as clay, sand
  - Organic such as oil globules, vegetable/animal matter
  - Colloidal such as $Fe(OH)_3$, Complex proteins, amines

- Chemical: - **Anions such as Cl^-, SO_4^{2-}, CO_3^{2-},HCO_3^-, NO_3^-**
  - **Cations such as Ca^{2+}, Mg^{2+}, Na^+, K^+, Fe^{3+}, Al^{3+}**
  - **Dissolved gases such as O_2, N_2, CO_2, H_2S, NH_3**

- Biological: - Microorganisms such as algae, fungi, bacteria (Pathogenic causing Malaria, diarrhoea, typhoid etc.)

❑ Hardness of Water

- Hardness of water is the characteristic of preventing lather formation of water with soap.
- This is a common quality of water which contains dissolved compounds of **calcium and magnesium** and, sometimes, other divalent and trivalent metallic elements

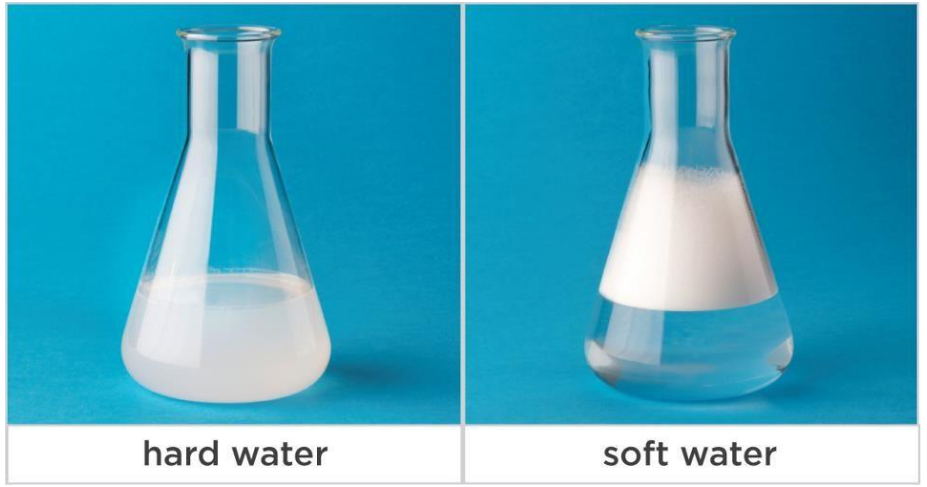
- **Symptoms of Hard Water include**
  - Stiff, dingy laundry
  - Mineral deposits on dishes and glassware
  - High energy costs, possibly due to scale build-up in pipes and on appliances
  - Scale build up in sinks, tubs, faucets etc.

Hard water

- Hard water on treatment with soap (Stearic or palmitic acid salts of sodium or potassium) causes white **precipitate formation** of calcium or magnesium stearate or palmitate. Precipitation of the soap prevents lathering at first.

$$2C_{17}H_{35}COONa + CaCl_2 \longrightarrow (C_{17}H_{35}COO)_2Ca + 2NaCl$$

Sodium stearate (soap) — Calcium stearate (insoluble)



Types of Hardness

a) **Temporary** :

- Due to dissolved **bicarbonates** of calcium and magnesium and **carbonates** of iron and other heavy metals. Hence it is also called as **carbonate hardness**.
- Can be easily removed by boiling where CO_2 gas gets expelled removing the hardness.

$$Ca(HCO_3)_2 \xrightarrow{Heat} CaCO_3\downarrow + H_2O + CO_2$$

$$Mg(HCO_3)_2 \xrightarrow{Heat} Mg(OH)_2\downarrow + CO_2$$

b) **Permanent:**

- Due to dissolved **chlorides and sulphates** of calcium and magnesium. Also called as **non-carbonate hardness**.
- Can be removed through zeolite, Lime-soda, ion-exchange processes.

Hardness Scale

mg/L & ppm	*Classification*
Less than 17.1	Soft
17.1 - 60	Slightly Hard
60 - 120	Moderately Hard
120 - 180	Hard
over 180	Very Hard

Measurement of hardness of water

- Hardness of water is measured in parts per millions (**ppm**) **as calcium carbonate equivalents**.
- Reasons for expressing hardness in $CaCO_3$ equivalents:
  - its molecular weight is 100; equivalent weight is 50.
  - it is the most common insoluble impurity in water.

$$\text{Hardness in terms of Equivalents of } CaCO_3 = \frac{\text{Mass of Hardness Producing Substance} \times \text{Equivalent Weight of } CaCO_3}{\text{Equivalent Weight of hardness-producing substance}}$$

Calculate the temporary hardness in terms of calcium carbonate equivalents in a water sample containing 12.2 mg $Ca(HCO_3)_2$. Given that at. Wt. of Ca=40 amu, O=16 amu, C=12 amu, H=1 amu. **(Ans.: 7.53 mg)**