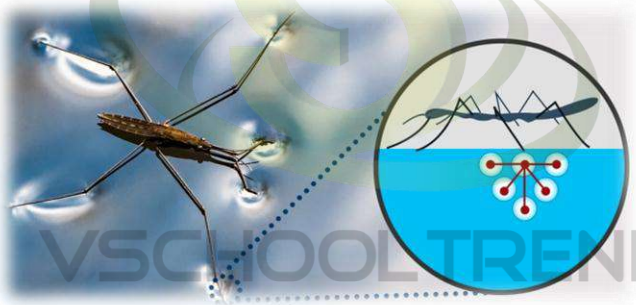
CHAPTER 5 WATER AND SOLUTION

Learning Outcomes:

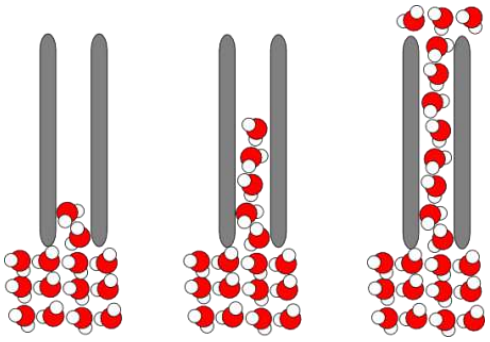
1. To learn about physical characteristics of water
2. To learn about solution and rate of solubility
3. To learn about water purification and water supply

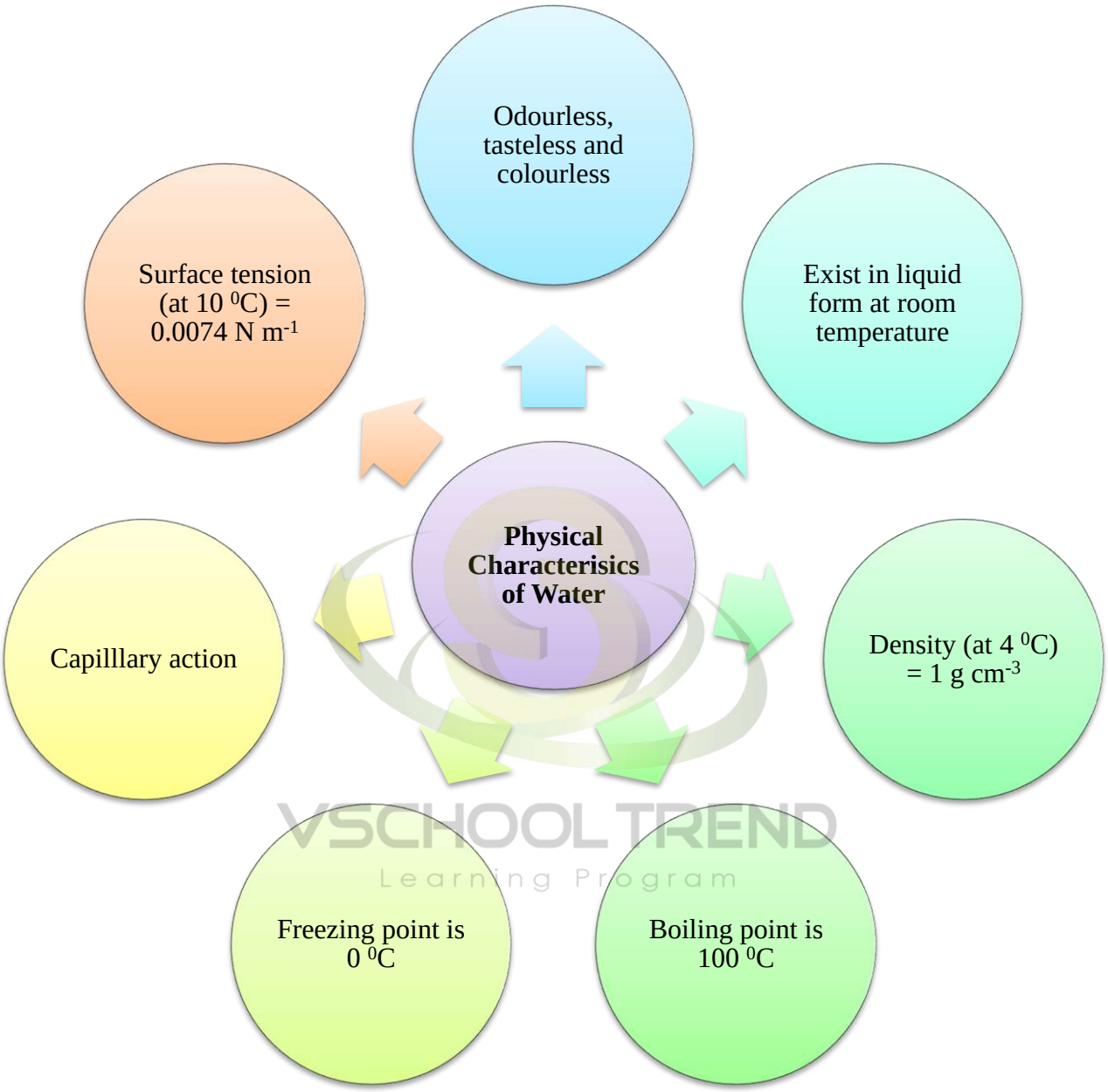
5.1 Physical characteristics of water

1. Water is one of the basic resources for the survival of living things. There would not have life without water.
2. Water is an important medium for many physiological functions, such as:
    a. Regulate body temperature
    b. Facilitate digestion, excretion and transportation of nutrients in the body of animals and humans
    c. Carry out photosynthesis and maintain turgidity of plant cells
3. Surface tension of the water is the cohesive force between water molecules at the surface that causes it to act as an elastic layer of skin. E.g. Water striders can walk on water because of the surface tension of water.



4. The cohesive force among the water molecules and the adhesive force between the water molecules and other molecules **will** cause an **upward** force on the liquid molecules at the edges and **result** in a meniscus which turns **upward**. This phenomenon is known as capillary action.





5. Impurities can change the physical characteristic of water. For example, salt can make the water taste salty; lower the melting point of ice; increase the boiling point and increase the density of water.
6. Water exists in three forms: solid, liquid and gas.

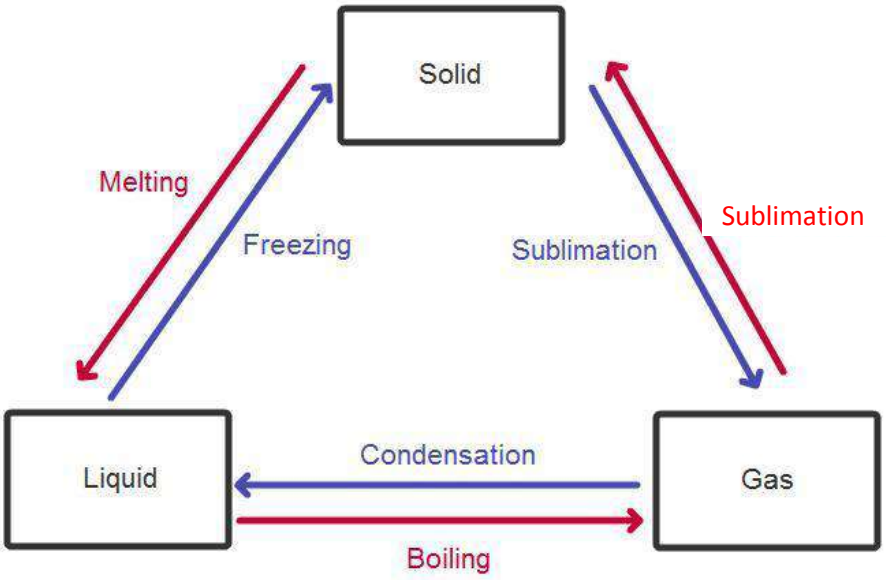
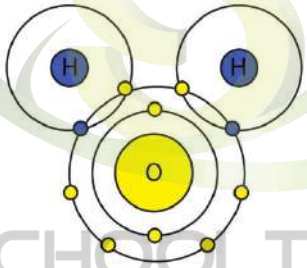


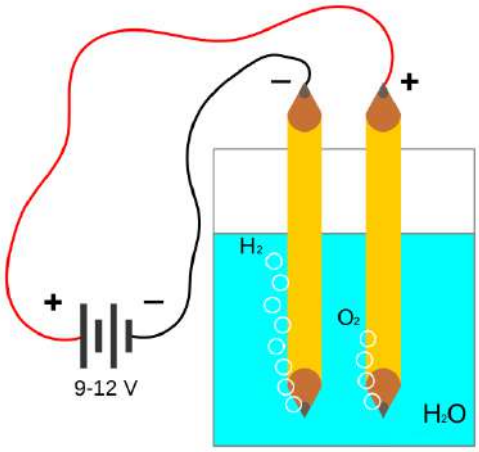
Diagram 5.1 The changes in the forms of water

- **Composition of water**

1. A water molecule consists of two hydrogen atoms and one oxygen atom, which is known as H_2O in chemical formula.



2. Water is a compound which can only be broken down by chemical means. The technique of breaking down water using electrical energy is called **electrolysis**. During electrolysis, oxygen is discharged at the positive electrode (anode) whereby hydrogen is discharged at the negative electrode (cathode).



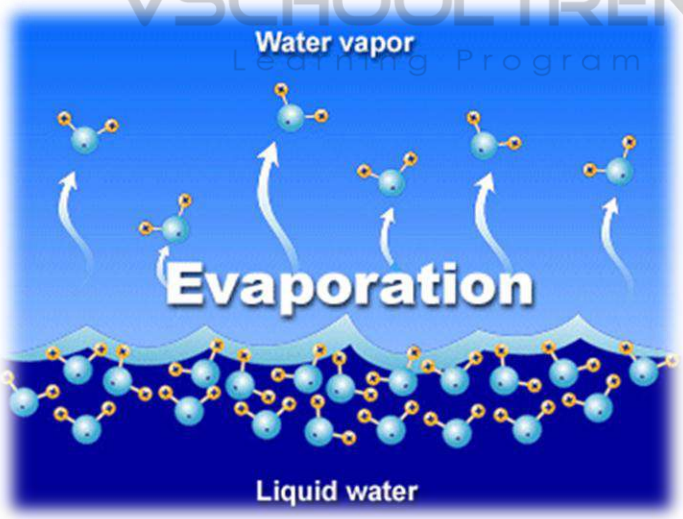
a. The electric current flows through water from anode to cathode.
b. The water is mixed with a few drops of dilute sulphuric acid to increase electrical conductivity and to speed up electrolysis.
c. Gas collected at anode is tested with a glowing wooden splinter, whereby gas collected at cathode is tested with a burning wooden splinter. The observation is recorded in the table below:

Electrode	Observation
Anode	Glowing wooden splinter is lighted up.
Cathode	Burning wooden splinter extinguishes and produces "pop" sound.

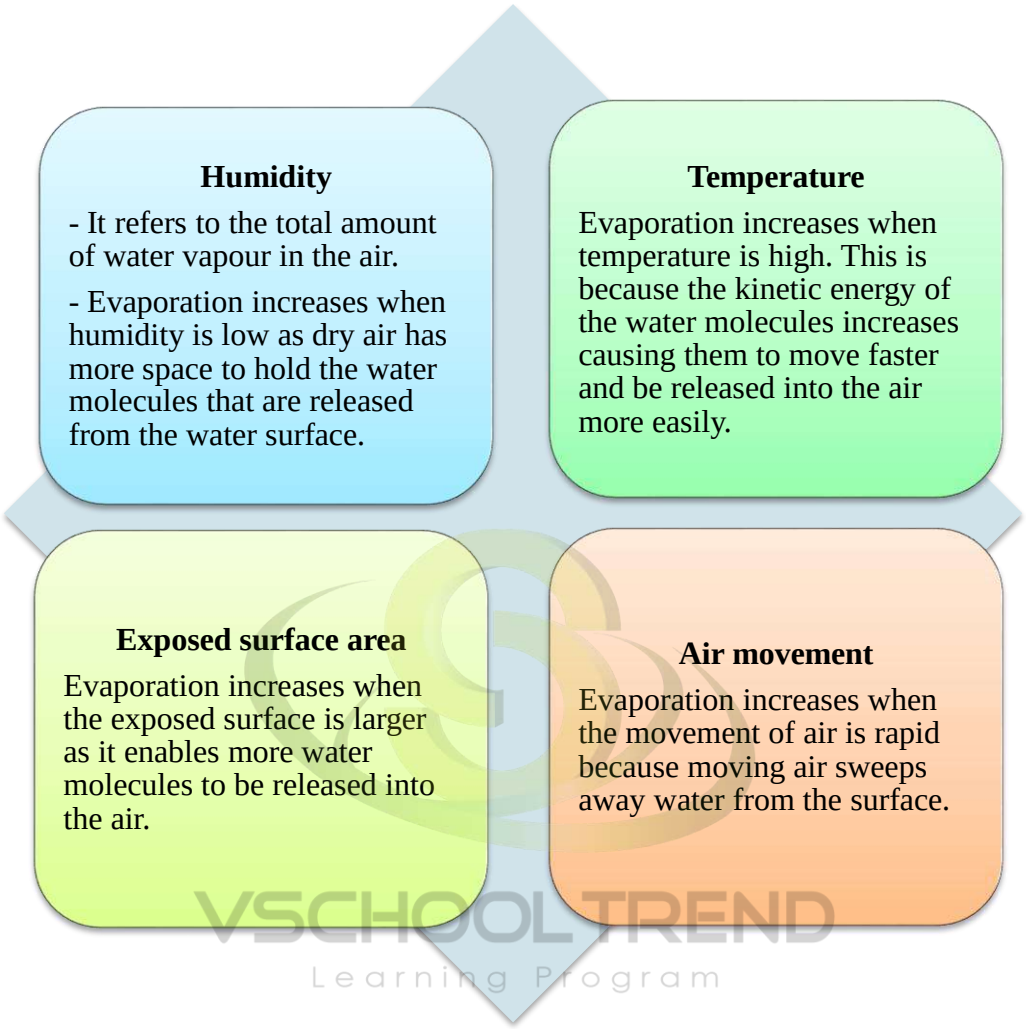
d. The volume of hydrogen is double of the volume of oxygen in the ratio of 2:1.

- **Evaporation of water**

1. Evaporation is a process where liquid changes to gas on the surface of the water at any temperature below its boiling point.
2. Water evaporation occurs slowly because it involves only the water molecules at the exposed surface. The water molecules on the surface gain energy from the surrounding and then escape into the air.
3. When sweat evaporates, heat is absorbed from our body to change the water molecules to gas. Therefore, this process cools our body.



- **Factors affecting the rate of water evaporation**

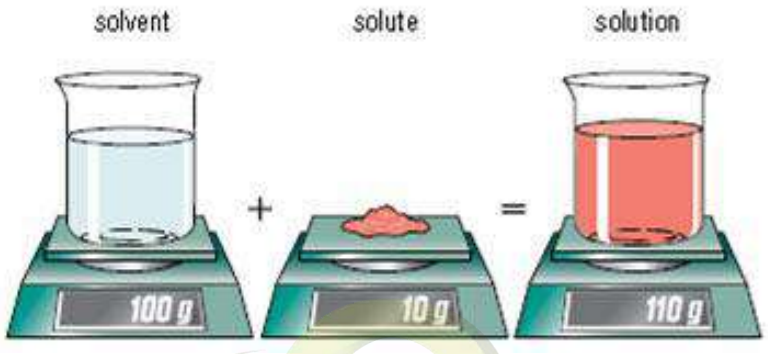


- **Application of water evaporation in daily life**

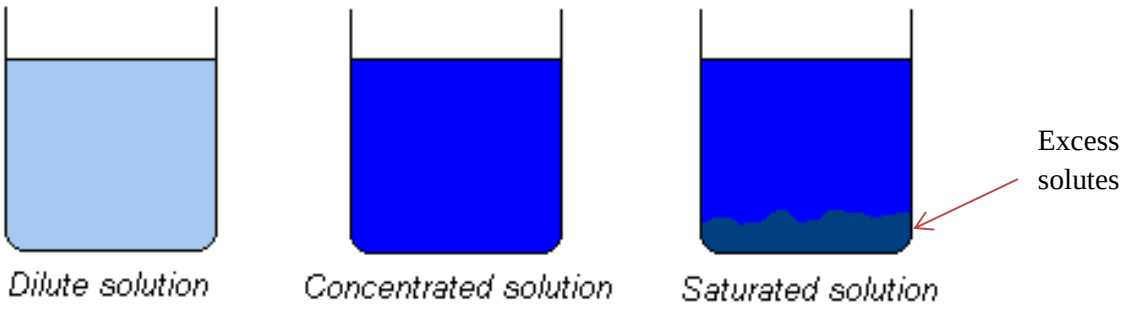
1. Drying of wet laundry
2. The sea water is evaporated to get powdered salt.
3. Drying of seafood such as fish and prawns under the sunshine so that they can be kept longer.
4. Producing evaporated milk from liquid milk.
5. Hair dryer is used to dry wet hair.
6. Wet hands are dried with a hand dryer.

5.2 Solutions and rate of solubility

1. A solution is the mixture formed when solute dissolves in a solvent.
2. A solute is a substance that can be dissolved in liquids.
3. A solvent is a liquid that dissolve solutes.



4. A solution has various concentrations depending on the ratio of solutes to solvent. Hence, a solution can be classified into three types:
   a. Dilute solution
      i. Contains little solute
      ii. Can dissolve more solutes
   b. Concentrated solution
      i. Contains lots of solutes
      ii. Can dissolve only little solute
   c. Saturated solution
      i. Contains the maximum amount of solutes
      ii. Cannot dissolve solutes anymore



Suspension

1. A suspension is a cloudy mixture formed from solutes that is insoluble in solvent. Examples of suspensions are fruit juice, muddy water and salad dressing.
2. The differences between solution and suspension are shown in table below:

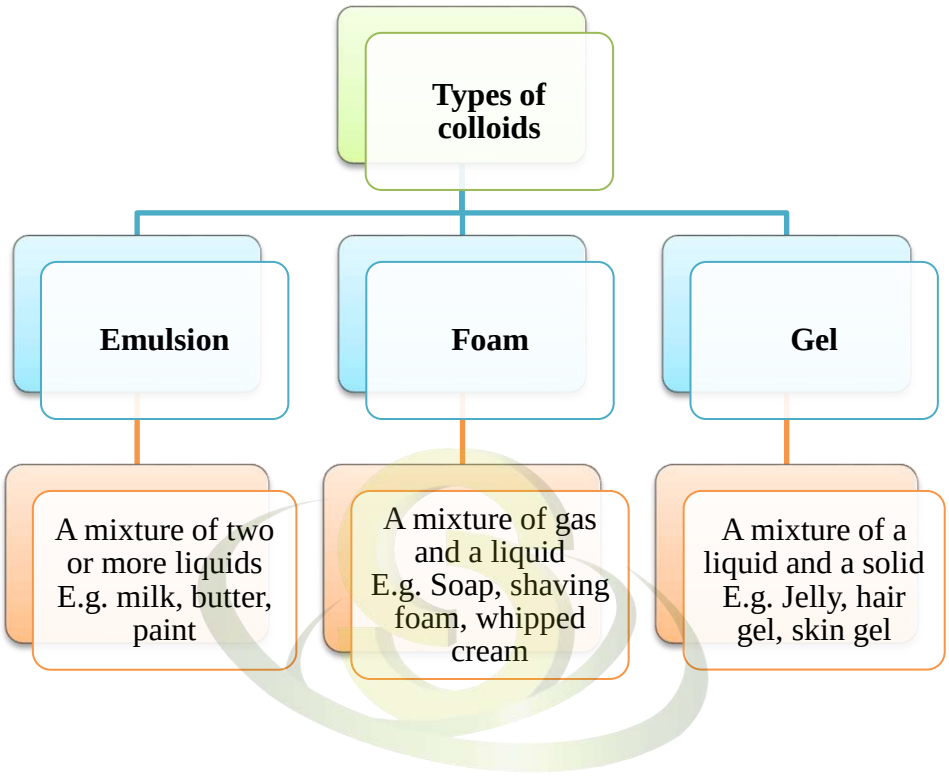
Differences	
Solution	**Suspension**
➢ Solutes are evenly dispersed in solutions.	➢ Solutes are not evenly dispersed in solution.
➢ It is always homogenous in colour and appearance throughout all parts of solution.	➢ Not homogenous in colour and appearance throughout all parts of the solution.
➢ Uniform colour makes the solution to look clear. Precipitate does not form at the base.	➢ Non-uniform colour makes the solution look cloudy. Precipitate forms at the base if left for a while.
➢ It does not leave any waste when filtered.	➢ It leaves waste when filtered.
➢ The tiny solutes particles allow light to pass through, hence the solution is transparent.	➢ The size of the suspension particles is too big to allow the light to pass through.

Solubility

1. Solubility is the maximum amount of solute in gram unit that can dissolve in 100ml solvent at a particular temperature.
2. The solubility rate is influenced by several factors, which include:
    a. Temperature of solvent
        ≈ The rate of solubility increases when the temperature of solvent increases.
    b. The rate of stirring
        ≈ The rate of solubility increases when the rate of stirring increases.
    c. The size of solute particles
        ≈ The rate of solubility increases when the size of solute particles decreases.

Colloid

1. Colloid is mixture of two or more solutes which are evenly dispersed in a solvent.



Water as the universal solvent

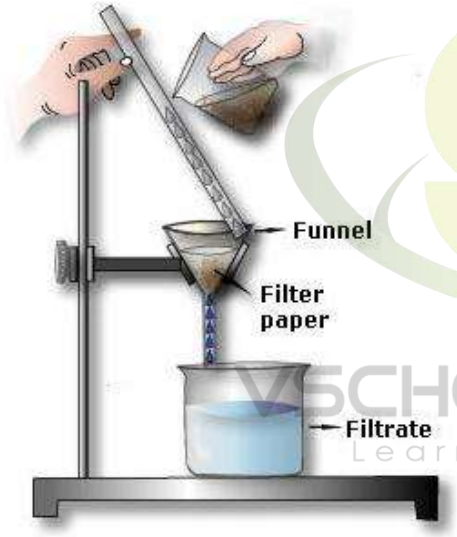
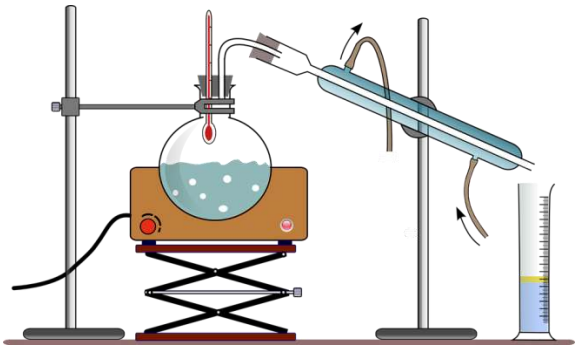
1. Water is known as the universal solvent because it can dissolve almost all substances whether solids, liquids or gases.
2. Solutions that use water as solvent are called aqueous solution. Water is widely used as domestic solvent and also raw material in the manufacturing, agriculture and medical industries.
3. Water is easily available, cheap and safe to manage.
4. The application of water as the universal solvent in daily life includes:
    a. Water dissolves detergents for washing and cleaning.
    b. Water dissolves oxygen for the respiration of aquatic organisms.
    c. Water dissolves nutrients and fertilisers so that plants can absorb them.
    d. Water dissolves chemical substances (e.g. acids and alkalis) in laboratory.
    e. Water dissolves flavours and colourings in food manufacturing industry.

- **Organic solvents**
  1. An organic solvent, or known as non-aqueous solvent, is an organic compound containing carbon elements that can dissolve solutes.
  2. Organic solvents can dissolve substances that cannot be dissolved by water.
  3. Examples of some common organic solvents used in daily life include:
     a. Alcohol
        i. As antiseptic
        ii. To produce perfume, polishing liquid
     b. Kerosene
        i. Dissolves grease and tar
        ii. To produce fuel for light
     c. Acetone
        i. Dissolves resin in nail polish
        ii. To produce cosmetic items like lipsticks
     d. Ether
        i. Dissolves oil
     e. Chloroform
        i. Dissolves alkaloids in poppies to extract morphine
        ii. To stick plastic
     f. Tetrachloroethylene
        i. Use in dry cleaning

5.3 Water purification and water supply

1. Water covers 75% of the Earth's surface but a large part of it cannot be consumed directly by human because it may contain impurities, chemical substances and microorganisms. Hence, water has to be purified and cleaned before use and drink.
2. Water purification methods include:

Method	Description
Chlorination  	- Chlorine is diluted in water to kill harmful microorganisms and to decolorize the water. - It does not eliminate the suspended particles and dissolved substances in the water. - Excessive use will give off an unpleasant smell and cause harm to health. ***Purpose:*** To treat water in swimming pool and public water tanks

Boiling 	- The boiling point of water is 100 ^{0}C at normal atmosphere pressure. - This method can kill harmful microorganisms in the water but does not eliminate suspended particles and dissolved substances. ***Purpose:*** For drinking water
Filtration  	- Filtered water is called filtrate and the waste left is called residue. - This method eliminates insoluble impurities but it does not get rid of dissolved impurities and microorganisms. ***Purpose:*** To filter the incoming water supply at home
Distillation 	- This method produces distilled water that does not contain any impurities, dissolved substances and microorganisms. - It involves the boiling of water into steam and the condensation of the steam into distilled water. - It is not suitable for drinking as it does not contain any mineral salts needed for body. ***Purpose:*** To prepare drugs in hospital and to dilute chemicals in laboratories.

Problems of water supply

1. Some countries experience the shortage of water resource. However, this problem can be overcome by taking recycled sewage water from domestic wastewater. For example, "NEWater Programme" carried out by Singapore successfully produces high quality recycled water.

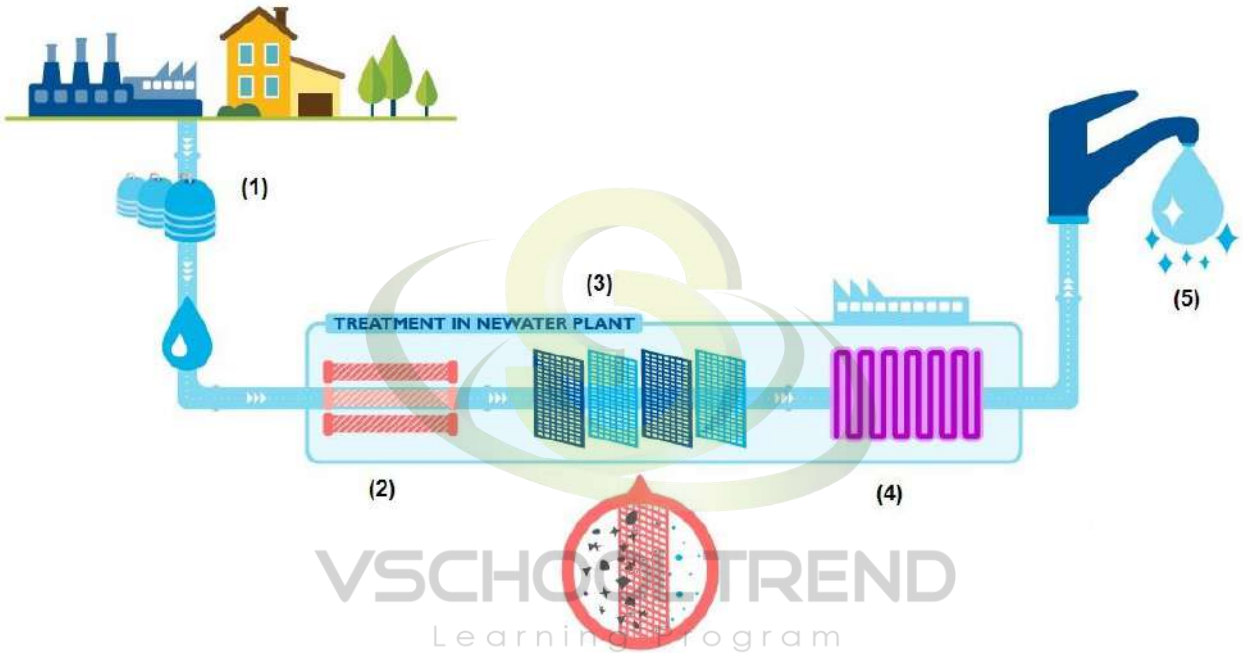


Diagram 5.1 Stages in the NEWater water production

2. There are a few stages in the NEWater water production:

Step (1) – Domestic wastewater is collected and treated.

Step (2) – Microfiltration removes microscopic particles which include bacteria.

Step (3) – Reverse osmosis removes contaminants in the water.

Step (4) – Ultraviolet light kills microorganisms. Chemicals are added to restore pH balance.

Step (5) – NEWater High-grade reclaimed water.

Water supply system

1. Raw water which originates from river water, streams and rain water is the water resource that is mostly used by humans. The water is collected in a reservoir and then purified before it is distributed to our home.

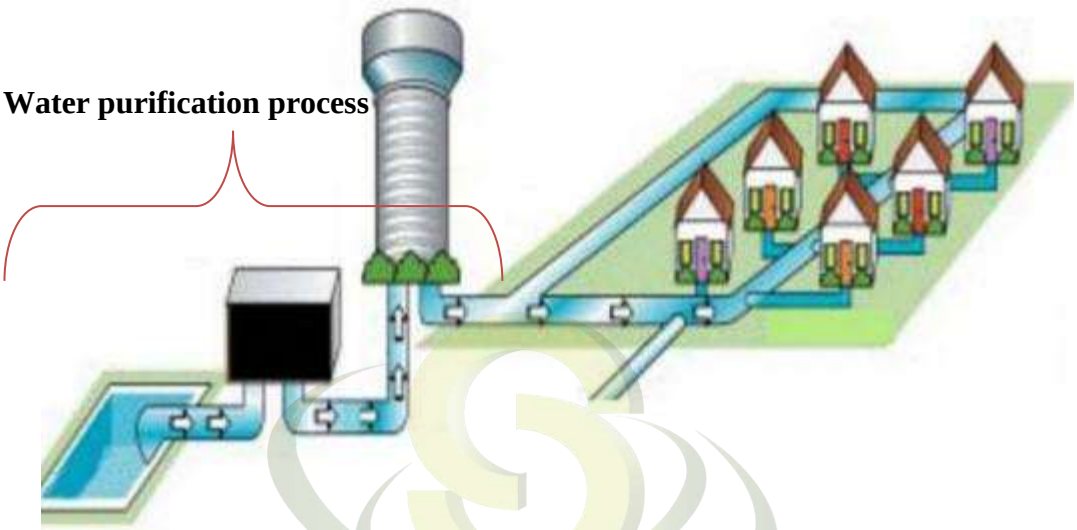


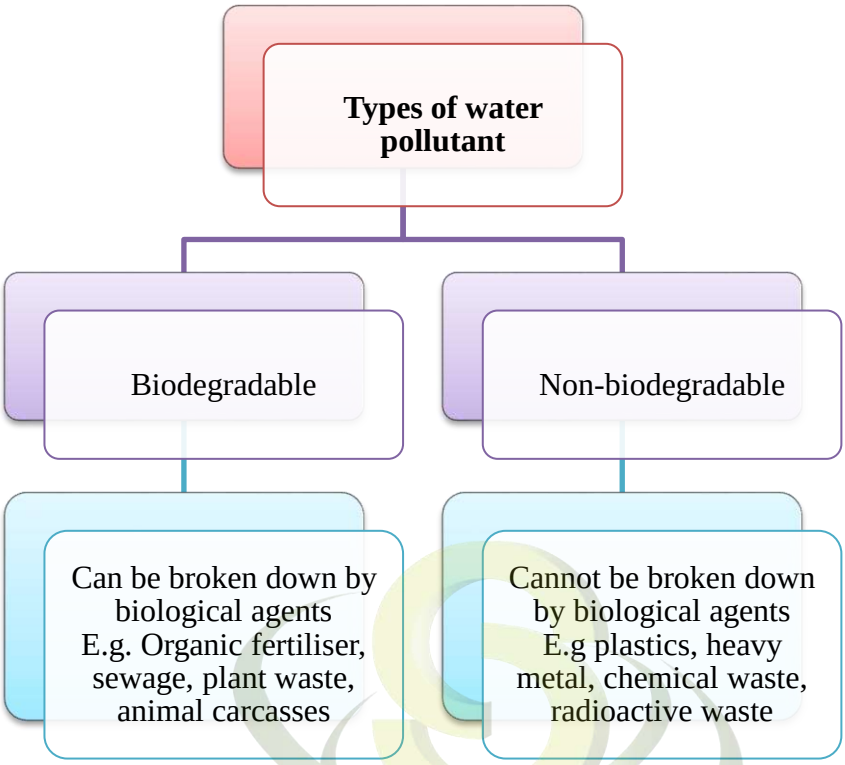
Diagram 5.2 Water supply systems

Process	Function
Screening	Eliminates large suspended particles like leaves, rubbish and fish.
Oxidation	Eliminates the unpleasant smell and taste.
Coagulation	Alum is added to coagulate the suspended particles, whereas slaked lime is added to neutralize the acidity of alum.
Sedimentation	Coagulated suspended particles deposit at the bottom of the tank for removal.
Filtration	Eliminates algae, bacteria and some chemical substances by using a sand filter.
Chlorination	Chlorine kills harmful microorganisms and decolourize the water.
Fluoridation	Prevents the tooth decay.

Table 5.1 Water purification process

Water pollution

1. Water pollution is caused by the presence of water pollutants in large amount due to the discharge of domestic waste, development projects, agriculture and industrialisation.
2. Water pollutants affect the quality of water until it is no longer suitable for use.



Pollutants	Effects on living things	Methods of control
1. Industrial waste • Heavy metal (e.g. mercury, lead) • Chemical waste (e.g. acids, alkalis) • Radioactive waste	• Poisons aquatic life • Accumulation of toxic substances in marine animals that end up as human food	• Enforcement of legislation for the proper handling of industrial wastes • Treating wastes before disposal
2. Agricultural waste • Farm waste (e.g. pesticide, fertiliser, animal waste)	• Excessive algae growth depletes the oxygen in the water and kills the aquatic life	• Use biological control to kill pests • Educate farmers to use chemical fertilisers and pesticides in appropriate amounts

3. Domestic waste • Rubbish • Detergents • Biodegradable materials (e.g. faeces) • Non-biodegradable materials (e.g. plastics)	• Causes water blockage that can lead to flash floods • Cause the spread of infectious disease (e.g. cholera) • Detergents reduce dissolved oxygen in the water and threaten aquatic life.	• Reduce, reuse and recycle • Promote the use of easily biodegradable materials
4. Construction and deforestation • Mud and sand	• Mud and sand that flow into the river will make the river shallow and cause flash flood. • Muddy water prevents the light from penetrating the water and prevents the plant to carry out photosynthesis.	• Reforestation • Proper planning of construction and logging activity
5. Oil spillage • Leakage from oil tanker • Illegal cleaning of ship activities	• Oil prevents the light from penetrating the water and prevents the plant to carry out photosynthesis.	• Clean up ocean oil spills using special bacteria • Continuous surveillance of air and sea should be carried out.

Table 5.2 Effects of water pollution on living things and ways to control water pollution