

INDUSTRIAL CHEMISTRY

SOURCES OF WATER

Although the molecules of water are simple in structure (H_2O), the physical and chemical properties of the compound are extraordinarily complicated, and they are not typical of most substances found on Earth.

Water is vital both as a solvent in which many of the body's solutes dissolve and as an essential part of many metabolic processes within the body. Metabolism is the sum total of anabolism and catabolism.

In anabolism, water is removed from molecules (through energy requiring enzymatic chemical reactions) in order to grow larger molecules (e. g. starches, triglycerides and proteins for storage of fuels and information).

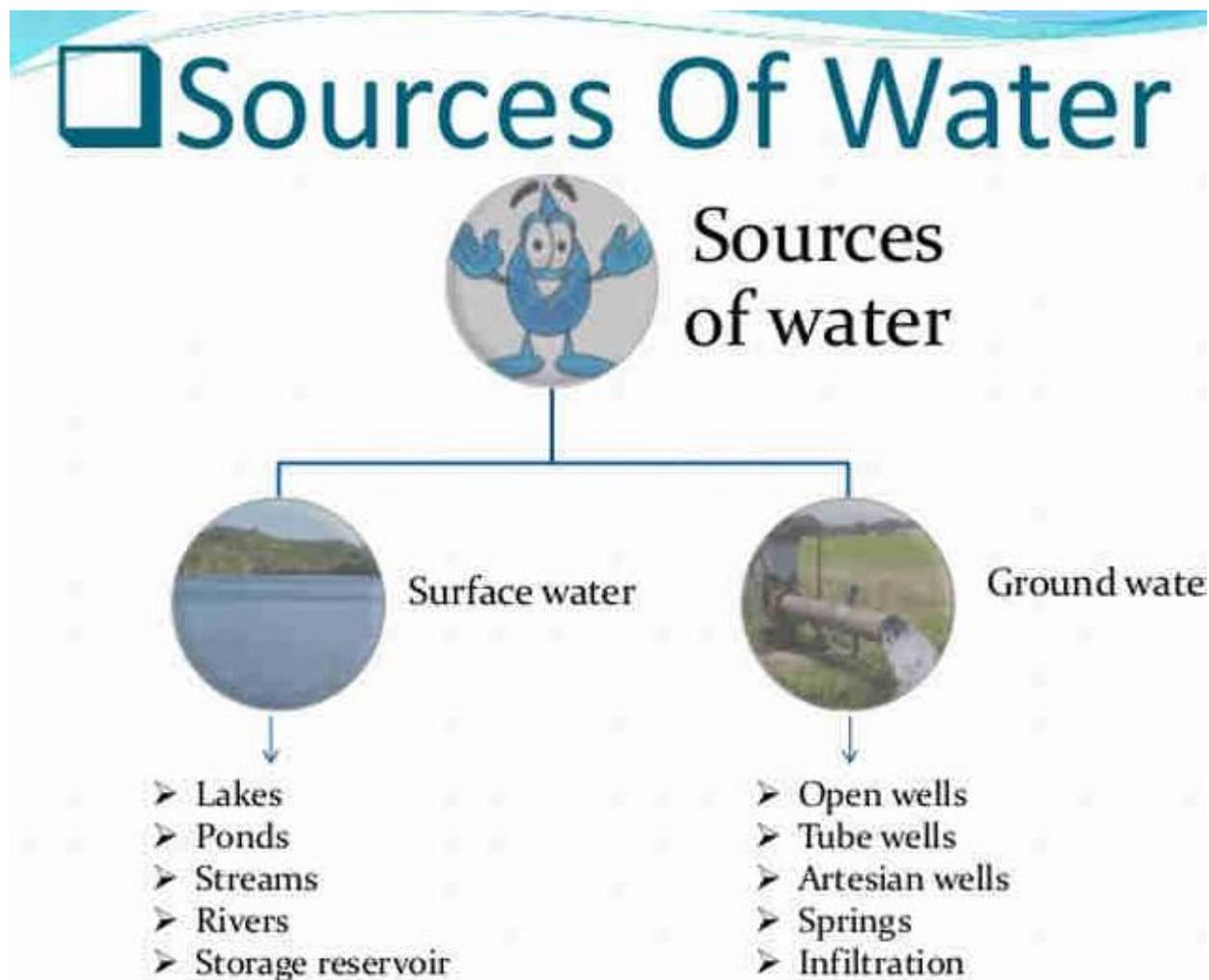
Natural Sources Of Water

Water is one of the vital element needed in our day to day activities as a living being. Water is not just essential to our health, but we also use it for numerous household tasks such as cooking, bathing, cleaning, and drinking; but how often do we think about its source? Where does our water come from? How is it treated? How do we know it is safe to drink? and many other questions we ought to raise.

There are two major **sources of water** which are surface **water** and groundwater. Surface **Water** is found in lakes, rivers, and reservoirs.

Let take a look at each and what supplies these sources.

- Ground **Water**. ...
- Well **Water**. ...
- Rain **Water**. ...
- Surface **Water**. ...
- Snow melt. ...
- Lake And River **Water**. ...
- Salt **water** from oceans.



However, there are two major sources of water which are surface water and groundwater. **Surface Water** is found in lakes, rivers, and reservoirs. **Groundwater** lies under the surface of the land, where it travels through and fills openings in the rocks.

For the benefits of our readers Concise news have splited the sources of water into different places for better understanding. There are a total of eight natural sources of water. Let take a look at each and what supplies these sources.

1. Ground Water

Groundwater is water that is found underground within rocks. Its presence depends primarily on the type of rock. Permeable rocks have tiny spaces between the solid rock particles that allow water and other fluids to pass through and to be held within the rock structure. The layers of rock that hold groundwater are called aquifers.

Groundwater in an aquifer is replenished by rain and other forms of precipitation (any form of water, such as rain, snow, sleet or hail that falls to the Earth's surface. The level of water below ground is called the water table. Groundwater can be extracted from wells or collected from springs.

Advantages And The Disadvantages Of Using Ground Water

Advantages

Likely to be free of pathogenic bacteria

Disadvantages

Often has a high mineral content (i.e. has naturally occurring substances that are not from living organisms)

Usually free of turbidity and colour	such as calcium, magnesium, iron and manganese
Can usually be used without further treatment	Usually requires pumping for extraction
Can often be found in close vicinity to consumers	May have a high level of bicarbonate, carbonate and chloride
Economical to obtain and distribute	Poor in oxygen content
The water-bearing soil or rock provides a natural storage point	Can contain chemical contaminants such as arsenic, fluorides and nitrates
	If it gets polluted, treatment can be difficult to achieve

2. Well Water

Well water as a source of water can be described by their depth, or by the way they are constructed. Most especially they use different types of pump at the surface to raise the water.

The pump is usually used to retrieve water and it go through an extensive filtration or decontamination process either naturally or chemically. There are two major types of well water

Shallow wells

Shallow wells and boreholes usually have a depth of less than 30 m, although they can be as much as 60 m deep, especially in a very dry areas of Ethiopia where the water table is low.

Wells can be excavated by hand if the soil is not too hard or the water table is high. Hand-dug wells have a relatively large diameter because they have to be wide enough for a person to be able to stand inside and dig.

Deep wells

These are wells that have been sunk with drilling machines designed for constructing water extraction boreholes. These machines are able to penetrate through harder material that cannot be tackled by hand digging and can therefore pass through at least one impermeable layer of rock to a productive aquifer underneath.

Deep well typically obtain water from depths ranging from 30 to 60 m, but large urban supply boreholes can be much deeper than this. A casing of metal or plastic pipe is usually necessary to line the borehole and prevent the soil and rock from collapsing into it. The lower part of the casing must have suitable openings to allow water to enter the borehole from the aquifer.

3. Rain Water

Rain water is the source of water that comes from above the clouds, this water is very pure. Until it encounter something on it way down. However if it is stored properly it may relinquish clean drinking water.

In regions where rainfall is abundant and frequent, rainwater can be a good source of water supply for individual, families and some communities. The storage of rainwater is particularly important in areas with a long dry season, or where spring water is difficult to obtain.

The term rainwater harvesting is sometimes used. It simply means collecting, or harvesting, rainwater as it runs off from hard surfaces and storing it in a tank or cistern.

Rainwater has several advantages. It is free, relatively clean and usually reliable, even if it rains only once or twice a year, a rainwater harvesting system can be easily constructed and maintained at low cost. Although mainly found in rural areas.

Apparently, if rainwater is used for water supply, it is important to ensure that it is not contaminated by improper methods of storage, or by bird droppings and leaves from the roof that it is collected from.

Rainwater may also be contaminated by pollution in the air, dust, dirt, paint and other material on the roof or in roofing materials. All of these contaminants can be washed into the storage tank or cistern.

4. Surface Water

Surface water is easily the most abundant supply of natural water. The downside is that most of the surface water on the planet is salt water so it is not ideal for drinking for most living species. Surface water does play an important part in our daily lives in addition to being a source of drinking water.

Surface water is used to produce hydro-electric power as a clean energy source that is also renewable. Surface water is supplied by precipitation, springs and ice melting from higher elevations and glaciers.

5. Snow melt

Melting snow is another natural source of water when melted in great amounts can yield clean drinking water especially once boiled

6. Lake And River Water

Lakes and rivers provide much water to wild animals and if cleaned and filtered properly it could become clean enough to drink for humans. Most countries with access to lakes and rivers use their water for human consumption. This source of water supply is usually regularly replenished by various weather events.

7. Salt water from oceans

Ocean water can effectively be processed for consumption through the de-salinisation process removing excess salt. Without this process the water becomes counter-active and actually dehydrates you.

Careful Use Of Water Sources

Although all the natural sources of water are constantly replenished through weather cycles, we still need to be conservative on how we use water. Fresh water is like a precious gift. We should use it sparingly and do everything in our power to share and protect it for future generations. When we control how we use water, we are helping the planet.

Try to not waste water in your home by using flow regulators and collect rain water for use in your garden. There are several ways to keep the natural water cycle flowing if we are careful in how we use the water we have access to today.

SOFT WATER AND HARD WATER

Hard water... is water that contains an appreciable quantity of dissolved minerals (like calcium and magnesium).

Soft water... is treated water in which the only ion is sodium. As rainwater falls, it is naturally soft. ... On the other hand, soft water tastes salty and is sometimes not suitable for drinking.

Hard water... is water that contains an appreciable quantity of dissolved minerals (like calcium and magnesium).

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As rainwater falls, it is naturally soft. However, as water makes its way through the ground and into our waterways, it picks up minerals like chalk, lime and mostly calcium and magnesium and becomes hard water. Since hard water contains essential minerals, it is sometimes the preferred drinking water. Not only because of the health benefits, but also the flavor. On the other hand, soft water tastes salty and is sometimes not suitable for drinking. So why, then, do we soften our water?

TYPES OF HARDNESS

Hardness is a measure of the resistance to localized plastic deformation induced by either mechanical indentation or abrasion. Some materials (e.g. metals) are harder than others (e.g. plastics, wood). Macroscopic hardness is generally characterized by strong intermolecular bonds, but the behavior of solid materials under force is complex; therefore, there are different measurements of hardness: scratch hardness, indentation hardness, and rebound hardness.

Hardness is dependent on ductility, elastic stiffness, plasticity, strain, strength, toughness, viscoelasticity, and viscosity.

There are three main types of hardness measurements: scratch, indentation, and rebound. Within each of these classes of measurement there are individual measurement scales. For practical reasons conversion tables are used to convert between one scale and another.

Scratch hardness

Scratch hardness is the measure of how resistant a sample is to fracture or permanent plastic deformation due to friction from a sharp object. The principle is that an object made of a harder material will scratch an object made of a softer material. When testing coatings, scratch hardness refers to the force necessary to cut through the film to the substrate. The most common test is Mohs scale, which is used in mineralogy. One tool to make this measurement is the sclerometer.

Another tool used to make these tests is the pocket hardness tester. This tool consists of a scale arm with graduated markings attached to a four-wheeled carriage. A scratch tool with a sharp rim is mounted at a predetermined angle to the testing surface. In order to use it a weight of known mass is added to the scale arm at one of the graduated markings, the tool is then drawn across the test surface. The use of the weight and markings allows a known pressure to be applied without the need for complicated machinery.

Indentation hardness

Indentation hardness measures the resistance of a sample to material deformation due to a constant compression load from a sharp object. Tests for indentation hardness are primarily used in engineering and metallurgy fields. The tests work on the basic premise of measuring the critical dimensions of an indentation left by a specifically dimensioned and loaded indenter.

Common indentation hardness scales are Rockwell, Vickers, Shore, and Brinell, amongst others.

Rebound hardness

Rebound hardness, also known as dynamic hardness, measures the height of the "bounce" of a diamond-tipped hammer dropped from a fixed height onto a material. This type of hardness is related to elasticity. The device used to take this measurement is known as a scleroscope.

Two scales that measure rebound hardness are the Leeb rebound hardness test and Bennett hardness scale.

Ultrasonic Contact Impedance (UCI) method determines hardness by measuring the frequency of an oscillating rod. The rod consists of a metal shaft with vibrating element and a pyramid-shaped diamond mounted on one end.

Common examples of hard matter are ceramics, concrete, certain metals, and superhard materials, which can be contrasted with soft matter.

What causes the temporary and permanent hardness of water

The presence of calcium and magnesium bicarbonates $Ca(HCO_3)_2$ and $Mg(HCO_3)_2$ causes temporary hardness in water. The presence of soluble salts of calcium and magnesium, i.e., sulphates and chlorides of calcium and magnesium cause permanent hardness in water.

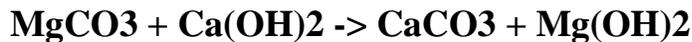
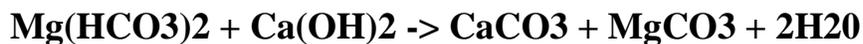
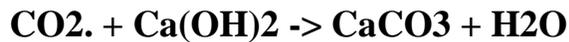
Temporary Hardness	Permanent Hardness
Temporary hardness is due to the presence of bi-carbonates of calcium and magnesium.	It is due to the presence of chlorides of Sulfates of Calcium and Magnesium.
Can be removing by boiling.	Can't be removing by boiling.
Hardness removal is cheap.	Hardness removal is expensive
$H_2O(l) + CO_2(g) + CaCO_3(s) \rightarrow Ca(HCO_3)_2(aq)$	$aq. + CaSO_4(s) \rightarrow Ca^{2+}(aq) + SO_4^{2-}(aq)$

REMOVAL OF HARDNESS BY LIME SODA METHOD

Chemical precipitation is one of the more common methods used to soften water. Chemicals normally used are lime (calcium hydroxide, Ca(OH)_2) and soda ash (sodium carbonate, Na_2CO_3). Lime is used to remove chemicals that cause carbonate hardness. Soda ash is used to remove chemicals that cause non-carbonate hardness. When lime and soda ash are added, hardness-causing minerals form nearly insoluble precipitates. Calcium hardness is precipitated as calcium carbonate (CaCO_3). Magnesium hardness is precipitated as magnesium hydroxide (Mg(OH)_2). These precipitates are then removed by conventional processes of coagulation/flocculation, sedimentation, and filtration. Because precipitates are very slightly soluble, some hardness remains in the water--usually about 50 to 85 mg/l (as CaCO_3). This hardness level is desirable to prevent corrosion problems associated with water being too soft and having little or no hardness.

LIME ADDITION

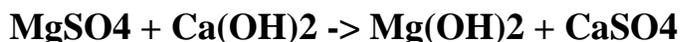
Hardness Lime Precipitate



CO_2 does not contribute to the hardness, but it reacts with the lime, and therefore uses up some lime before the lime can start removing the hardness.

LIME AND SODA ASH ADDITION

Lime



Soda ash Precipitate



CO₂ = carbon dioxide, Ca(OH)₂ = calcium hydroxide or hydrated lime, CaCO₃ = calcium carbonate, Ca(HCO₃)₂ = calcium bicarbonate, Mg(HCO₃)₂ = magnesium bicarbonate, MgCO₃ = magnesium carbonate, Mg(OH)₂ = magnesium hydroxide, MgSO₄ = magnesium sulfate, CaSO₄ = calcium sulfate, H₂O - water. Na₂CO₃ = sodium carbonate or soda ash

For each molecule of calcium bicarbonate hardness removed, one molecule of lime is used. For each molecule of magnesium bicarbonate hardness removed, two molecules of lime are used. For each molecule of non-carbonate calcium hardness removed, one molecule of soda ash is used. For each molecule of non-carbonate magnesium hardness removed one molecule of lime plus one molecule of soda ash is used.

CONVENTIONAL LIME-SODA ASH TREATMENT

When water has minimal magnesium hardness, only calcium needs to be removed. Only enough lime and soda ash are added to water to raise pH to between 10.3 and 10.6, and calcium hardness will be removed from the water (but minimal magnesium hardness will be removed).

EXCESS LIME TREATMENT

When magnesium hardness is more than about 40 mg/l as CaCO₃, magnesium hydroxide scale deposits in household hot-water heaters operated at normal temperatures of 140 to 150° F. To reduce magnesium hardness, more lime must be added to the water. Extra lime will raise pH above 10.6 to help magnesium hydroxide precipitate out of the water.

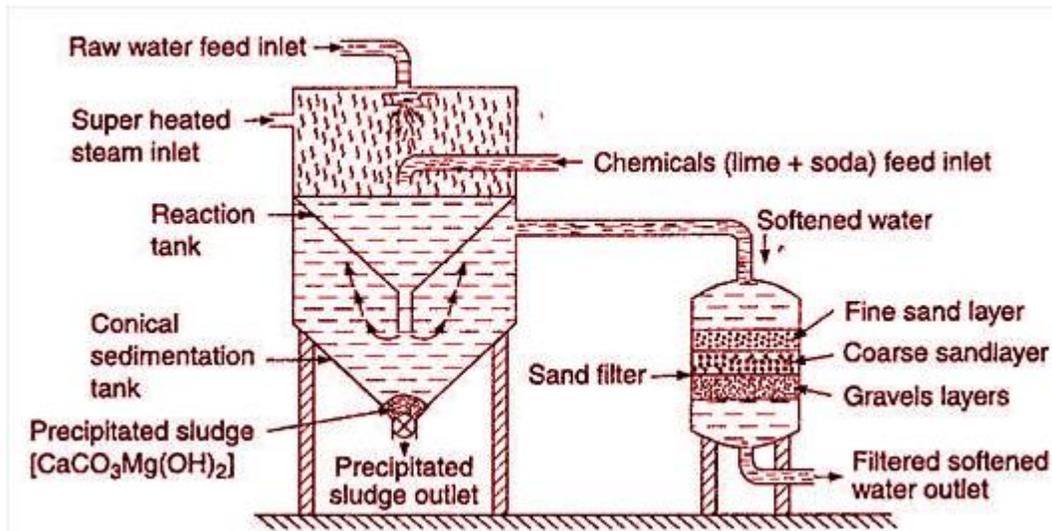
SPLIT TREATMENT

When water contains high amounts of magnesium hardness, split treatment may be used. Approximately 80 percent of the water is treated with excess lime to remove magnesium at a pH above 11, after which it is blended with 20 percent of the source water. Split treatment can reduce the amount of carbon dioxide required to re-carbonate the water as well as offer a savings in lime feed. Since the fraction of the water that is treated contains an excess lime dose, magnesium is almost completely removed from this portion. When this water is mixed with the water that does not undergo softening, the carbon

dioxide and bicarbonate in that water re-carbonates the final blend. Split treatment reduces the amount of chemical needed to remove hardness from water by 20 to 25 percent (a significant savings).

DESIGN CONSIDERATIONS

In lime soda-ash softening plants, the softening process may be carried out by a sequence of rapid mix, flocculation, and sedimentation or in a solids contactor. In the solids contactor the rapid mix, flocculation, and sedimentation occur in a single unit. The process begins with the mixing of the chemicals into the water, followed by violent agitation, termed rapid mixing. This allows chemicals to react with, and precipitate calcium or magnesium hardness in the water.



Sludge Removal Residue created from lime-soda ash softening is normally very high in calcium carbonate or a mixture of calcium carbonate, and magnesium hydroxide. Calcium carbonate sludges are normally dense, stable inert, and dewater readily. Solids content in the sludge range from 5 to 30 total solids with a pH greater than 10.5. Lime-soda ash sludges may be treated with lagooning, vacuum filtration, centrifugation, pressure filtration, recalcination, or land application. The most common method is storage of sludge in lagoons and application to farmland or landfills disposal.

Calculations

There are two methods for calculating lime and soda ash dosages (conventional dosage method and conversion factor method). The conventional method, although much longer, is helpful in understanding the chemical and mathematical relationships involved in softening. The conversion factor method is simpler, quicker, and more practical for daily operations. In both calculation methods, lime and soda ash dosages depends on carbonate and non-carbonate hardness in the water. Lime is used to remove carbonate hardness, and both lime and soda ash are used to remove non-carbonate hardness. If total hardness is less than or equal to total alkalinity, there is no non-carbonate hardness (only carbonate hardness). If total hardness is greater than total alkalinity, non-carbonate hardness equals the difference between total hardness and total alkalinity (and carbonate hardness equals total alkalinity). If total hardness is equal to or less than total alkalinity, then: $\text{Lime Dosage} = \text{the carbon dioxide concentration [CO}_2\text{]} + \text{the total hardness concentration [Total Hardness]} + \text{the magnesium concentration [Mg]} + \text{[Excess]}$ Optimum chemical dosages can be evaluated with a jar test.

Two-Stage Softening

Two-stage softening is sometimes used for treatment of high magnesium water (where excess lime is required). Excess lime is added in the first stage to raise pH to 11.0 or higher for magnesium removal. Following first stage treatment, carbon dioxide is added to reduce the pH to between 10.0 and 10.5, the best value for removal of calcium carbonate. If non-carbonate hardness removal is needed, soda ash will be added at this point. After second stage treatment, the water flows to a secondary recarbonation tank, where pH is reduced to between 8.3 and 8.6.

Single-Stage Softening

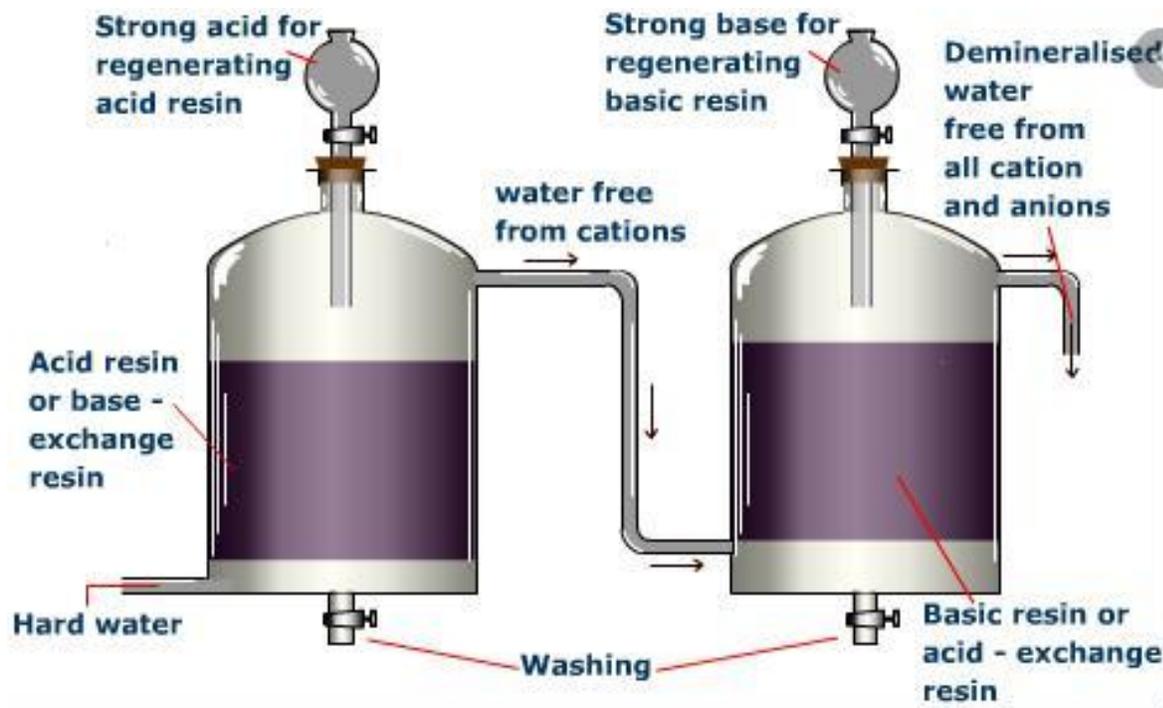
Single-stage recarbonation is the one most commonly practiced (Because of the high capital cost for building this type of two-stage treatment train). There are some benefits to using the twostage method, including reduced operating cost since less carbon dioxide is needed. Better finished water quality is usually obtained through the two-stage process.

Ion-exchange resin method

Conventional water-softening appliances intended for household use depend on an ion-exchange resin in which "hardness ions"—mainly Ca^{2+} and Mg^{2+} —are exchanged for sodium ions. As described by NSF/ANSI Standard 44, ion-exchange devices reduce the hardness by replacing magnesium and calcium (Mg^{2+} and Ca^{2+}) with sodium or potassium ions (Na^+ and K^+).

Ion exchange resins are organic polymers containing anionic functional groups to which the divalent cations (Ca^{2+}) bind more strongly than monovalent cations (Na^+). Inorganic materials called zeolites also exhibit ion-exchange properties. These minerals are widely used in laundry detergents. Resins are also available to remove the carbonate, bicarbonate, and sulfate ions that are absorbed and hydroxide ions that are released from the resin.

When all the available Na^+ ions have been replaced with calcium or magnesium ions, the resin must be recharged by eluting the Ca^{2+} and Mg^{2+} ions using a solution of sodium chloride or sodium hydroxide, depending on the type of resin used. For anionic resins, regeneration typically uses a solution of sodium hydroxide (lye) or potassium hydroxide. The waste waters eluted from the ion-exchange column containing the unwanted calcium and magnesium salts are typically discharged to the sewage system.



DEFINITION OF LUBRICANT

A lubricant is a substance, usually organic, introduced to reduce friction between surfaces in mutual contact, which ultimately reduces the heat generated when the surfaces move. It may also have the function of transmitting forces, transporting foreign particles, or heating or cooling the surfaces. The property of reducing friction is known as lubricity.

In addition to industrial applications, lubricants are used for many other purposes. Other uses include cooking (oils and fats in use in frying pans, in baking to prevent food sticking), bioapplications on humans (e.g. lubricants for artificial joints), ultrasound examination, medical examination. It is mainly used to reduce friction and to contribute to a better and efficient functioning of a mechanism.

Lubricant definition is - a substance (such as grease) capable of reducing friction, heat, and wear when introduced as a film between solid surfaces.

Types of lubricants

Lubricants are generally composed of a majority of base [oil](#) plus a variety of additives to impart desirable characteristics. Although generally lubricants are based on one type of base oil, mixtures of the base oils also are used to meet performance requirements.

Mineral oil

The term "mineral oil" is used to refer to lubricating base oils derived from crude oil. The American Petroleum Institute (API) designates several types of lubricant base oil:^[6]

- **Group I – Saturates < 90% and/or sulfur > 0.03%, and Society of Automotive Engineers (SAE) viscosity index (VI) of 80 to 120**
Manufactured by solvent extraction, solvent or catalytic dewaxing, and hydro-finishing processes. Common Group I base oil are 150SN (solvent neutral), 500SN, and 150BS (brightstock)
- **Group II – Saturates > 90% and sulfur < 0.03%, and SAE viscosity index of 80 to 120**
Manufactured by hydrocracking and solvent or catalytic dewaxing processes. Group II base oil has superior anti-oxidation properties since virtually all hydrocarbon molecules are saturated. It has water-white color.

- **Group III – Saturates > 90%, sulfur < 0.03%, and SAE viscosity index over 120**

Manufactured by special processes such as isohydromerization. Can be manufactured from base oil or slax wax from dewaxing process.

- **Group IV – Polyalphaolefins (PAO)**
- **Group V – All others not included above, such as naphthenics, polyalkylene glycols (PAG), and polyesters.**

The lubricant industry commonly extends this group terminology to include:

- **Group I+ with a viscosity index of 103–108**
- **Group II+ with a viscosity index of 113–119**
- **Group III+ with a viscosity index of at least 140**

Can also be classified into three categories depending on the prevailing compositions:

- **Paraffinic**
- **Naphthenic**
- **Aromatic**

Synthetic oils

Petroleum-derived lubricant can also be produced using synthetic hydrocarbons (derived ultimately from petroleum), "synthetic oils".

These include:

- **Polyalpha-olefin (PAO)**
- **Synthetic esters**
- **Polyalkylene glycols (PAG)**
- **Phosphate esters**
- **Alkylated naphthalenes (AN)**
- **Silicate esters**
- **Ionic fluids**
- **Multiply alkylated cyclopentanes (MAC)**

Solid lubricants

Dry lubricant

PTFE: polytetrafluoroethylene (PTFE) is typically used as a coating layer on, for example, cooking utensils to provide a non-stick surface. Its usable temperature range up to 350 °C and chemical inertness make it a useful additive in special greases. Under extreme pressures, PTFE powder or solids is of little value as it is soft and flows away from the area of contact. Ceramic or metal or alloy lubricants must be used then.

Inorganic solids: Graphite, hexagonal boron nitride, molybdenum disulfide and tungsten disulfide are examples of solid lubricants. Some retain their lubricity to very high temperatures. The use of some such materials is sometimes restricted by their poor resistance to oxidation (e.g., molybdenum disulfide degrades above 350 °C in air, but 1100 °C in reducing environments).

Metal/alloy: Metal alloys, composites and pure metals can be used as grease additives or the sole constituents of sliding surfaces and bearings. Cadmium and gold are used for plating surfaces which gives them good corrosion resistance and sliding properties, Lead, tin, zinc alloys and various bronze alloys are used as sliding bearings, or their powder can be used to lubricate sliding surfaces alone.

Aqueous lubrication

Aqueous lubrication is of interest in a number of technological applications. Strongly hydrated brush polymers such as PEG can serve as lubricants at liquid solid interfaces. By continuous rapid exchange of bound water with other free water molecules, these polymer films keep the surfaces separated while maintaining a high fluidity at the brush–brush interface at high compressions, thus leading to a very low coefficient of friction.

Biolubricant

Biolubricants are derived from vegetable oils and other renewable sources. They usually are triglyceride esters (fats obtained from plants and animals. For lubricant base oil use, the vegetable derived materials are preferred. Common ones include high oleic canola oil, castor oil, palm oil, sunflower seed oil and rapeseed oil from vegetable, and tall oil from tree sources. Many vegetable oils are often hydrolyzed to yield the acids which are subsequently combined selectively to form specialist synthetic esters. Other naturally derived lubricants include lanolin (wool grease, a natural water repellent).

Whale oil was a historically important lubricant, with some uses up to the latter part of the 20th century as a friction modifier additive for automatic transmission fluid.

In 2008, the biolubricant market was around 1% of UK lubricant sales in a total lubricant market of 840,000 tonnes/year.

PURPOSE OF LUBRICATION

The primary function of the **lubrication** is to reduce the friction and wear and tear of the two rubbing parts. Two rubbing parts always produce friction and continuous friction produces heat, which causes wearing of the different parts

of the engine and power loss. This friction can be reduced by proper **lubrication**.

One of the largest applications for lubricants, in the form of motor oil, is protecting the internal combustion engines in motor vehicles and powered equipment.

Lubricant vs. Anti-tack Coating

Anti-tack or anti-stick coatings are designed to reduce the adhesive condition (stickiness) of a given material. The rubber, hose, and wire and cable industries are the largest consumers of anti-tack products but virtually every industry uses some form of anti-sticking agent. Anti-sticking agents differ from *lubricants* in that they are designed to reduce the inherently adhesive qualities of a given compound while lubricants are designed to reduce friction between any two surfaces.

Keep moving parts apart

Lubricants are typically used to separate moving parts in a system. This separation has the benefit of reducing friction, wear and surface fatigue, together with reduced heat generation, operating noise and vibrations. Lubricants achieve this in several ways. The most common is by forming a physical barrier i.e., a thin layer of lubricant separates the moving parts. This is analogous to hydroplaning, the loss of friction observed when a car tire is separated from the road surface by moving through standing water. This is termed hydrodynamic lubrication. In cases of high surface pressures or temperatures, the fluid film is much thinner and some of the forces are transmitted between the surfaces through the lubricant.

Reduce friction

Typically the lubricant-to-surface friction is much less than surface-to-surface friction in a system without any lubrication. Thus use of a lubricant reduces the overall system friction. Reduced friction has the benefit of reducing heat generation and reduced formation of wear particles as well as improved efficiency. Lubricants may contain polar additives known as friction modifiers that chemically bind to metal surfaces to reduce surface friction even when there is insufficient bulk lubricant present for hydrodynamic lubrication, e.g. protecting the valve train in a car engine at startup. The base oil itself might also be polar in nature and as a result inherently able to bind to metal surfaces, as with polyolester oils.

Transfer heat

Both gas and liquid lubricants can transfer heat. However, liquid lubricants are much more effective on account of their high specific heat capacity.

Typically the liquid lubricant is constantly circulated to and from a cooler part of the system, although lubricants may be used to warm as well as to cool when a regulated temperature is required. This circulating flow also determines the amount of heat that is carried away in any given unit of time. High flow systems can carry away a lot of heat and have the additional benefit of reducing the thermal stress on the lubricant. Thus lower cost liquid lubricants may be used. The primary drawback is that high flows typically require larger sumps and bigger cooling units. A secondary drawback is that a high flow system that relies on the flow rate to protect the lubricant from thermal stress is susceptible to catastrophic failure during sudden system shut downs. An automotive oil-cooled turbocharger is a typical example.

Turbochargers get red hot during operation and the oil that is cooling them only survives as its residence time in the system is very short (i.e. high flow rate). If the system is shut down suddenly (pulling into a service area after a high-speed drive and stopping the engine) the oil that is in the turbo charger immediately oxidizes and will clog the oil ways with deposits. Over time these deposits can completely block the oil ways, reducing the cooling with the result that the turbo charger experiences total failure, typically with seized bearings. Non-flowing lubricants such as greases and pastes are not effective at heat transfer although they do contribute by reducing the generation of heat in the first place.

Carry away contaminants and debris

Lubricant circulation systems have the benefit of carrying away internally generated debris and external contaminants that get introduced into the system to a filter where they can be removed. Lubricants for machines that regularly generate debris or contaminants such as automotive engines typically contain detergent and dispersant additives to assist in debris and contaminant transport to the filter and removal. Over time the filter will get clogged and require cleaning or replacement, hence the recommendation to change a car's oil filter at the same time as changing the oil. In closed systems such as gear boxes the filter may be supplemented by a magnet to attract any iron fines that get created.

It is apparent that in a circulatory system the oil will only be as clean as the filter can make it, thus it is unfortunate that there are no industry standards by which consumers can readily assess the filtering ability of various

automotive filters. Poor automotive filters significantly reduces the life of the machine (engine) as well as making the system inefficient.

Transmit power

Hydraulics

Lubricants known as hydraulic fluid are used as the working fluid in hydrostatic power transmission. Hydraulic fluids comprise a large portion of all lubricants produced in the world. The automatic transmission's torque converter is another important application for power transmission with lubricants.

Protect against wear

Lubricants prevent wear by keeping the moving parts apart. Lubricants may also contain anti-wear or extreme pressure additives to boost their performance against wear and fatigue.

Prevent corrosion

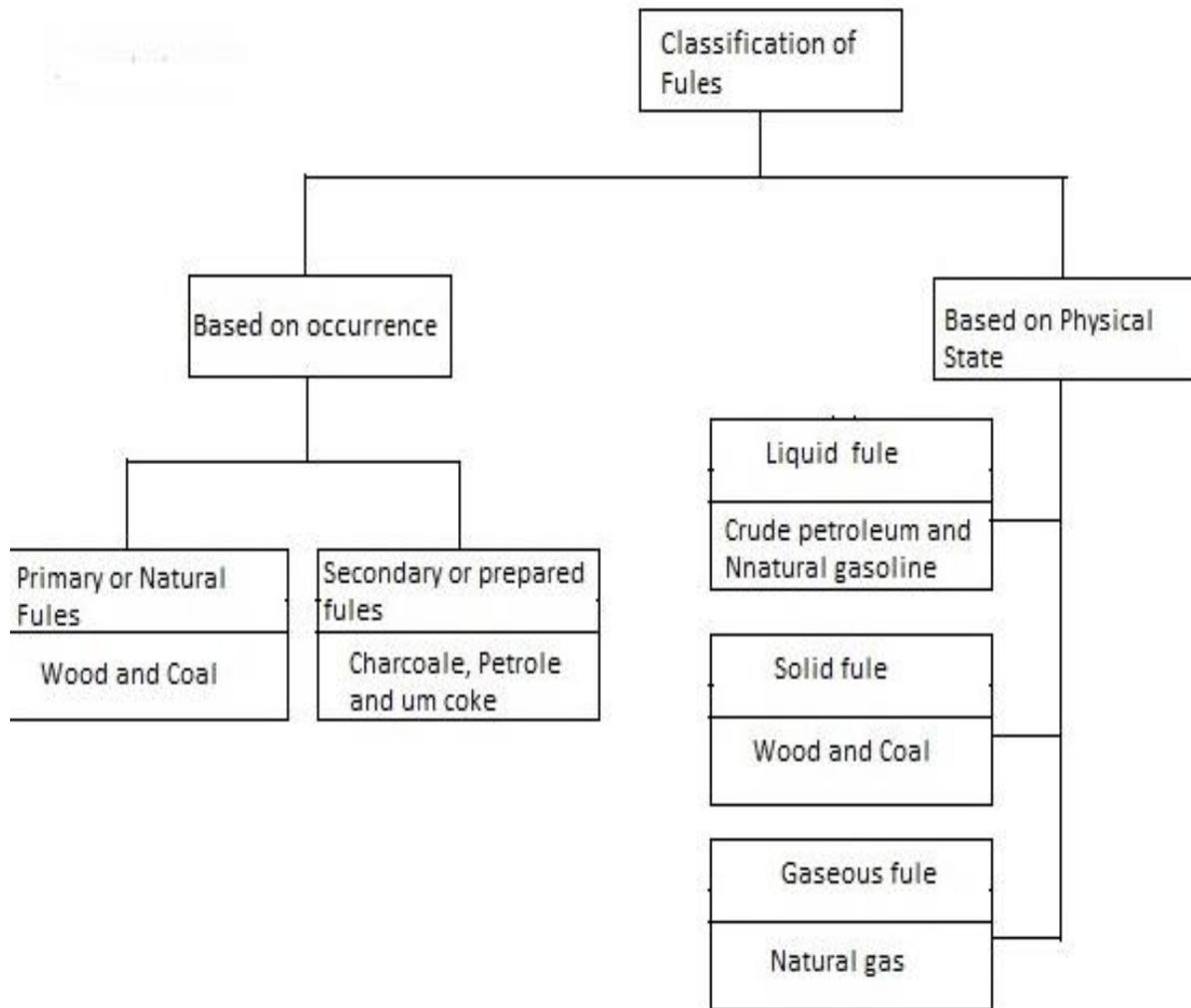
Many lubricants are formulated with additives that form chemical bonds with surfaces or that exclude moisture, to prevent corrosion and rust. It reduces corrosion between two metallic surface and avoids contact between these surfaces to avoid immersed corrosion.

Seal for gases

Lubricants will occupy the clearance between moving parts through the capillary force, thus sealing the clearance. This effect can be used to seal pistons and shafts.

DEFINITION AND CLASSIFICATION OF FUEL

A fuel is a substance which gives heat energy on combustion. A fuel contains carbon and hydrogen as main combustible elements. fuel is any material that can be made to react with other substances so that it releases chemical or nuclear energy as heat or to be used for work. heat energy released by reactions of fuels is converted into mechanical energy via a heat engine. Other times the heat itself is valued for warmth, cooking, or industrial processes, as well as the illumination that comes with combustion. Fuels are also used in the cells of organisms in a process known as cellular respiration, where organic molecules are oxidized to release usable energy.



The based on physical states, fuel can be classified into three types.

Liqued Fuels

Liquid fuels like furnace oil and are predominantly used in industrial applications. Most liquid fuels in widespread use are derived from the fossilized remains of dead plants and animals by exposure to heat and pressure in the Earth's crust. However, there are several types, such as hydrogen fuel (for automotive uses), ethanol, jet fuel and biodiesel which are all categorized as a liquid fuel.

Solid Fuels

Solid fuel refers to various types of solid material that are used as fuel to produce energy and provide heating, usually released through combustion. Coal is classified into three major types; anthracite, bituminous, and lignite. However, there is no clear demarcation between them. Coal is further classified as semi-anthracite, semi-bituminous, and sub-

bituminous. Anthracite is the oldest coal from a geological perspective. It is a hard coal composed mainly of carbon with little volatile content and practically no moisture.

Woods Characteristics

The woods are very easily available and most commonly used solid fuel. The woods are used as fuel from ancient time after the discovery of the fire. The 39 Types of fuels and their Characteristics wood is used in almost every village, town and cities in India. The wood is used for industrial purposes. Constituents of Wood is vegetable tissue of trees and bushes. The wood consists of mainly cellular tissue & lignin. it also consists of lesser parts of fat & tar and sugar.

Coal classification

Coal is classified into three types as follows, even there is no clear demarcation between them:

1. Anthracite
2. Bituminous
3. Lignite.

The Coal is further classified as semi-anthracite, semi-bituminous and sub-bituminous. the anthracite is the oldest coal from a geological perspective. It is a hard coal composed mainly of carbon with little volatile content and without moisture. The lignite is the youngest coal from a geological perspective and it is a soft coal composed mainly of volatile matter(combustible constituents of coal that vaporize when coal is heated). and moisture content with low fixed carbon(carbon in its free state, not combined with other elements).

Gaseous Fuel

Fuel gas is any one of a number of fuels that under ordinary conditions are gaseous. Many fuel gases are composed of hydrocarbons ,hydrogen, carbon monoxide, or mixtures thereof. Such gases are sources of potential heat energy or light energy that can be readily transmitted and distributed through pipes from the point of origin directly to the place of consumption. Fuel gas is contrasted with liquid fuels and from solid fuels, though some fuel gases are liquefied for storage or transport. While their gaseous nature can be advantageous, avoiding the difficulty of transporting solid fuel and the dangers of spillage inherent in liquid fuels, it can also be dangerous.

Types of gaseous fuel

- Natural gas
- Liquefied Petroleum gas (LPG)
- Refinery gases
- Methane from coal mines
- Fuel gases made from solid fuel
- Gases derived from coal
- Gases derived from waste and biomass
- Blast furnace gas
- Gases made from petroleum
- Gases from oil gasification
- Gases from some fermentation process

Natural gas

Natural gas has high calorific value and requiring no storage facilities. It mixes with air readily and does not produce smoke or soot. It did not contains sulphur. It is lighter than air and disperses into air easily in case of leak.

The methane is the main constituent of natural gas and it is about 95% of the total volume. The other components are Ethane, Propane, Butane, Pentane, Nitrogen, Carbon Dioxide, and traces of other gases. In these gases a very small amounts of sulphur compounds are also present. The properties of methane are used when comparing the properties of natural gas to other fuels because methane is the largest component in natural gas.

DEFINITION OF CALORIFIC VALUE OF FUEL

- 1. The amount of energy produced by the complete combustion of a material or fuel. Measured in units of energy per amount of material, e.g. kJ/kg.**
- 2. The amount of energy available from an item of food when digested, mostly from carbohydrates and fats**

choice of a good fuel

A good fuel should satisfy the following requirements:

- 1. It should have a high calorific value i.e., it should evolve a large amount of heat when it is burnt.**

2. Its moisture content should be low so that its heating value should be high.
3. An ideal fuel should have moderate ignition temperature.
4. It should not produce harmful products like CO₂, SO₂, H₂S and other poisonous gases on burning since they pollute the atmosphere.
5. A fuel should have low content of non-combustible matter in the form of ash or clinker.
6. Since the presence of on-combustible matter will enhance the cost of storage, handling and disposal of waste. The combustion of fuel should be controllable so that it can be started or stopped.
7. It should not give any offensive odour.
8. It should have moderate velocity of combustion.

Difference between Thermosetting and Thermoplastic

Difference Between Thermoplastic and Thermosetting Plastic	
Thermoplastic	Thermosetting Plastic
Thermoplastics are usually formed by the addition of polymerization.	Thermosetting plastics are often formed by the condensation polymerization.
It contains long-chain linear polymers and held together by weak Van der Waal forces.	It contains a 3D network structure constructed with strong covalent bonds.
Usually becomes soften on heating and stiffen on cooling.	It does not become soft on heating.
They are expensive.	They are cheap.
Thermoplastic is soluble in organic solvents.	Thermosetting plastics are insoluble in organic solvents.
They are usually soft, weak and less brittle in nature.	They are usually hard, strong and more brittle in nature.
Can be remolded.	They can't be remolded.
An example of thermoplastic is polythene.	An example of Thermosetting plastic is Bakelite.

Definition of Monomer

Polymer means many **monomers**. Sometimes **polymers** are also known as macromolecules or large-sized molecules. Usually, **polymers** are organic (but not necessarily). A **monomer** is a molecule that is able to bond in long chains. ... This linking up of **monomers** is called **polymerization**.

Major Examples	
Monomer	Polymer
Amino Acid	Protein
Monosaccharide (sugar)	Polysaccharide-cellulose, starch, glycogen
Nucleotide	Nucleic acids- RNA and DNA
Fatty Acid	Triglyceride- (glycerol and 3 fatty acids)

EXPLAIN STRUCTURE OF ATMOSPHERE

Earth's atmosphere is divided into five main layers: the exosphere, the thermosphere, the mesosphere, the stratosphere and the troposphere. The atmosphere thins out in each higher layer until the gases dissipate in space. There is no distinct boundary between the atmosphere and space, but an imaginary line about 62 miles (100 kilometers) from the surface, called the Karman line, is usually where scientists say atmosphere meets outer space.

1. The **troposphere** is the layer closest to Earth's surface. It is 4 to 12 miles (7 to 20 km) thick and contains half of Earth's atmosphere. Air is warmer near the ground and gets colder higher up. Nearly all of the water vapor and dust in the atmosphere are in this layer and that is why clouds are found here.

2. The **stratosphere** is the second layer. It starts above the troposphere and ends about 31 miles (50 km) above ground. Ozone is abundant here and it heats the atmosphere while also absorbing harmful radiation from the sun. The air here is very dry, and it is about a thousand times thinner here than it is at sea level. Because of that, this is where jet aircraft and weather balloons fly.

3. The **mesosphere** starts at 31 miles (50 km) and extends to 53 miles (85 km) high. The top of the mesosphere, called the mesopause, is the coldest part of Earth's atmosphere, with temperatures averaging about minus 130 degrees F (minus 90 C). This layer is hard to study. Jets and balloons don't go high enough, and satellites and space shuttles orbit too high. Scientists do know that meteors burn up in this layer.

4. The **thermosphere** extends from about 56 miles (90 km) to between 310 and 620 miles (500 and 1,000 km). Temperatures can get up to 2,700 degrees F (1,500 C) at this altitude. The thermosphere is considered part of Earth's atmosphere, but air density is so low that most of this layer is what is normally thought of as outer space. In fact, this is where the space shuttles flew and where the International Space Station orbits Earth. This is also the layer where the auroras occur. Charged particles from space collide with atoms and molecules in the thermosphere, exciting them into higher states of energy. The atoms shed this excess energy by emitting photons of light, which we see as the colorful Aurora Borealis and Aurora Australis.

5. The **exosphere**, the highest layer, is extremely thin and is where the atmosphere merges into outer space. It is composed of very widely dispersed particles of hydrogen and helium.

Pollutant

A pollutant is a substance or energy introduced into the environment that has undesired effects, or adversely affects the usefulness of a resource. A pollutant may cause long- or short-term damage by changing the growth rate of plant or animal species, or by interfering with human amenities, comfort, health, or property values. Some pollutants are biodegradable and therefore will not persist in the environment in the long term. However, the degradation products of some pollutants are themselves polluting such as the products DDE and DDD produced from the degradation of DDT.

Contamination

Contamination is the presence of a constituent, impurity, or some other undesirable element that spoils, corrupts, infects, makes unfit, or makes inferior a material, physical body, natural environment, workplace, etc.

Receptor

In biochemistry and pharmacology, receptors are chemical structures, composed of protein, that receive and transduce signals that may be integrated into biological systems. These signals are typically chemical messengers which bind to a receptor and cause some form of cellular/tissue response, e.g. a change in the electrical activity of a cell. There are three main ways the action of the receptor can be classified: relay of signal, amplification, or integration.

Definition of water pollution

Water pollution is the contamination of water bodies, usually as a result of human activities. Water bodies include for example lakes, rivers, oceans, aquifers and groundwater. Water pollution results when contaminants are introduced into the natural environment. For example, releasing inadequately treated wastewater into natural water bodies can lead to degradation of aquatic ecosystems. In turn, this can lead to public health problems for people living downstream. They may use the same polluted river water for drinking or bathing or irrigation. Water pollution is the leading worldwide cause of death and disease, e.g. due to water-borne diseases.

Different sources of water pollution

Sewage (Waste Water)

Sewage is another name for waste water from domestic and industrial processes. Despite strict regulatory control, the Environment Agency data shows that the water and sewage industry accounted for almost a quarter of the serious water incidents in England and Wales in 2006.

Agricultural Pollution

The agriculture industry covers 76% of the land area of England and Wales. Agricultural processes such as uncontrolled spreading of slurries and manure, disposal of sheep dip, tillage, ploughing of the land, use of pesticides and fertilisers can cause water pollution. Accidental spills from milk dairies can also affect the quality of water.

Oil Pollution

Every year there are about 3,000 pollution incidents involving oil and fuels in England and Wales. Oil spillages affect water quality in a number of ways. Oil can make drinking water unsafe to drink. A substantial amount of oil released into oceans and seas will destroy wildlife and the ecosystems that sustain them. Oil spills also reduce oxygen supplies within the water environment. The main causes of oil related water pollution are:

- loss from storage facilities**
- spillage during delivery and;**
- deliberate disposal of waste oil to drainage systems**

Radioactive Substances

Radioactive waste is another source of water pollution. Radioactive substances are used in nuclear power plants, industrial, medical and other scientific processes. They can be found in watches, luminous clocks, television sets and x-ray machinery. There are also naturally occurring radioisotopes from organisms and within the environment. If not properly disposed of, radioactive waste can result in serious water pollution incidents.

River dumping

Lots of people dump supermarket trolleys, bicycles, garden cuttings and electronic waste into rivers or river banks. This is illegal and offenders may be charged for fly-tipping if caught. River dumping not only causes water pollution; it also harms wildlife and increases the risk of flooding. Fly-tipping (this includes river dumping) is a criminal offence. In the most severe cases, it can attract a maximum fine of £50,000 or a 5 year jail term.

Marine Dumping

The Worldwide Fund for Nature (WWF) estimates that a staggering amount of waste enters into the sea every year. Part of this is due to deliberate dumping of waste into coastal waters. Other sources of waste at sea include plastics and other materials blown or washed from land. Marine dumping is illegal under international and UK legislation. For more information visit the [Marine Pollution](#) page.

Control of water pollution

Municipal wastewater treatment

In urban areas of developed countries, municipal wastewater (or sewage) is typically treated by centralized sewage treatment plants. Well-designed and operated systems (i.e., with secondary treatment steps or more advanced treatment) can remove 90 percent or more of the pollutant load in sewage. Some plants have additional systems to remove nutrients and pathogens, but these more advanced treatment steps get progressively more expensive.

Nature-based solutions are also being used instead of (or in combination with) centralized treatment plants.

Cities with sanitary sewer overflows or combined sewer overflows employ one or more engineering approaches to reduce discharges of untreated sewage, including:

- utilizing a green infrastructure approach to improve storm water management capacity throughout the system, and reduce the hydraulic overloading of the treatment plant**
- repair and replacement of leaking and malfunctioning equipment**
- increasing overall hydraulic capacity of the sewage collection system (often a very expensive option).**

On-site sanitation and safely managed sanitation

Households or businesses not served by a municipal treatment plant may have an individual septic tank, which pre-treats the wastewater on site and infiltrates it into the soil. This can lead to groundwater pollution if not properly done.

Industrial wastewater treatment

Some industrial facilities generate wastewater that is similar to domestic sewage and can be treated by sewage treatment plants. Industries that generate wastewater with high concentrations of organic matter (e.g. oil and grease), toxic pollutants (e.g. heavy metals, volatile organic compounds) or nutrients such as ammonia, need specialized treatment systems. Some industries install a pre-treatment system to remove some pollutants (e.g., toxic compounds), and then discharge the partially treated wastewater to the municipal sewer system.

Agricultural wastewater treatment

Non point source controls

Sediment (loose soil) washed off fields is the largest source of agricultural pollution in the United States. Farmers may utilize erosion controls to reduce runoff flows and retain soil on their fields. Common techniques include contour plowing, crop mulching, crop rotation, planting perennial crops and installing riparian buffers

Point source wastewater treatment

Farms with large livestock and poultry operations, such as factory farms, are called *concentrated animal feeding operations* or *feedlots* in the US and are being subject to increasing government regulation.

DEFINITION OF AIR POLLUTION

Air pollution is a type of environmental pollution that affects the air and is usually caused by smoke or other harmful gases, mainly oxides of carbon, sulphur and nitrogen.

In other words, air pollution is the contamination of air due to the presence or introduction of a substance which has a poisonous effect.

Many of the world's large cities today have polluted air or low air quality

major air pollutants

The common air pollutants are:

- **Particulate matter (PM10 and PM2.5)**
- **Ozone (O3)**
- **Nitrogen dioxide (NO2)**
- **Carbon monoxide (CO)**
- **Sulphur dioxide (SO2)**

Control of air pollution

- Conserve energy - at home, at work, everywhere.
- Look for the ENERGY STAR label when buying home or office equipment.
- Carpool, use public transportation, bike, or walk whenever possible.
- Follow gasoline refueling instructions for efficient vapor recovery, being careful not to spill fuel and always tightening your gas cap securely.
- Consider purchasing portable gasoline containers labeled “spill-proof,” where available.
- Keep car, boat, and other engines properly tuned.
- Be sure your tires are properly inflated.
- Use environmentally safe paints and cleaning products whenever possible.
- Mulch or compost leaves and yard waste.
- Consider using gas logs instead of wood.

GREENHOUSE EFFECT

The **greenhouse effect** is the process by which radiation from a planet's atmosphere warms the planet's surface to a temperature above what it would be without this atmosphere.

Radiatively active gases (i.e., greenhouse gases) in a planet's atmosphere radiate energy in all directions. Part of this radiation is directed towards the surface, warming it.

The intensity of the downward radiation – that is, the strength of the greenhouse effect – will depend on the atmosphere's temperature and on the amount of greenhouse gases that the atmosphere contains.

Earth's natural greenhouse effect is critical to supporting life, and initially was a precursor to life moving out of the ocean onto land. Human activities, however, mainly the burning of fossil fuels and clearcutting of forests, have accelerated the greenhouse effect and caused global warming.

Depletion of Ozone Layer

Ozone depletion consists of two related events observed since the late 1970s: a steady lowering of about four percent in the total amount of ozone in Earth's atmosphere (the ozone layer), and a much larger springtime decrease in stratospheric ozone around Earth's polar regions. The latter phenomenon is referred to as the **ozone hole**. There are also springtime polar tropospheric ozone depletion events in addition to these stratospheric events.

The main cause of ozone depletion and the ozone hole is manufactured chemicals, especially manufactured halocarbon refrigerants, solvents, propellants and foam-blowing agents (chlorofluorocarbons (CFCs), HCFCs, halons), referred to as **ozone-depleting substances (ODS)**. These compounds are transported into the stratosphere by turbulent mixing after being emitted from the surface, mixing much faster than the molecules can settle