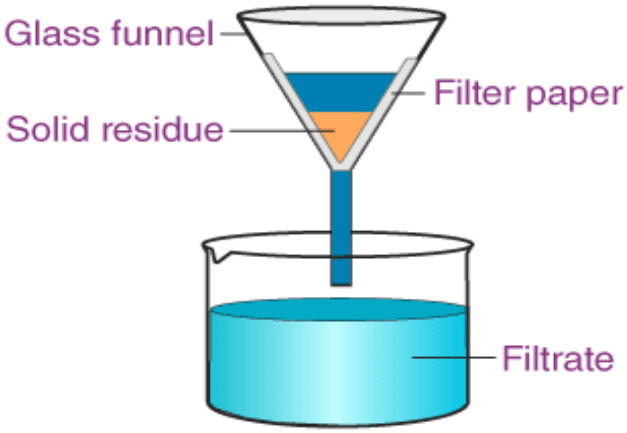
جامعة الإسكندرية
ALEXANDRIA UNIVERSITY
كلية العلوم

Filtration



Filtration process

Name: Dina Mohamed Mohamed Ahmed.
Under supervision of: DR. Nadia Zaki Shabaan.

Definition:

- Filtration is the process in which solid particles in a liquid or gaseous fluid are removed using a filter medium that allows the fluid to pass through while retaining the solid particles.
- Water filtering is a method used to filter out undesired chemical compounds, organic and inorganic materials, and biological contaminants from water. The purpose of water filtration is to provide clean drinking water.
- It may mean the use of a physical barrier, chemical, and/or biological process. The removal of particles takes place with processes including straining, flocculation, sedimentation and surface capture.
- Basic requirements are a filter medium (thin or thick barriers); a fluid with suspended solids; a driving force to cause the fluid to flow; and the filter that holds the filter medium, contains the fluid, and permits the application of force.
- The term "filtration" applies whether the filter is mechanical, biological, or physical. The fluid that passes through the filter is called the filtrate. The filter medium may be a surface filter, which is a solid that traps solid particles, or a depth filter, which is a bed of material that traps the solid.
- Filtration is typically an imperfect process. Some fluid remains on the feed side of the filter or embedded in the filter media and some small solid particulates find their way through the filter. As a chemistry and engineering technique, there is always some lost product, whether it's the liquid or solid being collected.

The basic requirements for filtration are:

(1) a filter medium.

(2) a fluid with suspended solids.

(3) a driving force such as a pressure difference to cause fluid to flow.

(4) a mechanical device (the filter) that holds the filter medium, contains the fluid, and permits the application of force.

- The filter media can be divided into two different classes. One type is the thin barriers usually exemplified as a filtration cloth, filtration screen or the common laboratory filter paper. The second class is the thick barriers which are usually sandfill beds, porous ceramics coke beds, porous metal and a precoat of filter aid that is often used in the filtration of fluids that comprise gelatinous precipitates in the industry.
- The thin filter medium has a single barrier where the openings are smaller compared to the particles to be separated from the fluid. A sand bed may be used in the case of a gelatinous cake that would block the pores of the filtration medium and stop the system from working. A thick filter medium such as a sand bed may be significantly larger than the particles to be separated from the fluid. The particles may move for some distance through the tortuous path of the liquid and through the medium but will eventually be entrapped in the smaller interstices within the particles that make up the filter bed.
- The filtering force drives the fluid to be filtered and makes it pass through the filtrate medium. The filtering force is brought by the force of gravity or by a generated centrifugal force or application of a vacuum below the filter to create the pressure difference. Centrifuges with a bowl with a permeable filter medium can be considered as the centrifugal force replaces the gravitational force which

is significantly greater than gravity. For the case of a laboratory filtration process, a partial vacuum is applied at the bottom to boost the rate of the filtration.

Examples of Filtration:

- While filtration is an important separation technique in a laboratory, it's also common in everyday life.
- The kidneys are an example of a biological filter. Blood is filtered by the glomerulus. Essential molecules are reabsorbed back into the blood.
- Air conditioners and many vacuum cleaners use HEPA filters to remove dust and pollen from the air.
- Belt filters recover precious metals during mining.
- Water in an aquifer is relatively pure because it has been filtered through sand and permeable rock in the ground.
- Brewing coffee involves passing hot water through the ground coffee and a filter. The liquid coffee is the filtrate

Mechanism of Filtration:

1) Straining: The particles which are larger than the pore space of the filtering medium is strained out mechanically. While particles smaller than the pore space are trapped within the filter.
2) Sedimentation: The particles within the filter settle on the filtering medium.
3) Impaction: Heavy particles do not follow the streamlined flow.
4) Interception: The particles are removed during contact with the surface of the filter medium
5) Adhesion: The particles adhere to the surface of the filter medium as they pass

6) Flocculation: It occurs within the interstices of the filter medium.
7) Chemical Adsorption (ie. Bonding, chemical interaction) and Physical adsorption (i.c. Electrostatic force, van der wall force): Once a particle has come into contact with the surface of the filter medium or with other particles, one of these mechanisms, chemical or physical adsorption or both may occur.
8) Biological growth: The biological growth inside the filter reduces the pore volume and improves the removal of particles with any of the previous removal mechanisms.

Applications of Filtration:

1. Particulate filtration includes:

- Vertical plate filter such as those used in Merrill–Crowe process.[clarification needed]
- Nutsche filters typically used in pharmaceutical applications or batch processes that need to capture solids.
- Furnaces use filtration to prevent the furnace elements from fouling with particulates.
- Pneumatic conveying systems often employ filtration to stop or slow the flow of material that is transported, using a baghouse.
- In the laboratory, a Büchner funnel is often used, with a filter paper serving as the porous barrier.
- Air filters are commonly used to remove airborne particulate matter in building ventilation systems, combustion engines, and industrial processes.
- Oil filter in automobiles, often as a canister or cartridge.

2. Combined applications include:

- Compressed breathing air production, where the air passes through a particulate filter before entering the compressor, which removes particles likely to damage the compressor, followed by droplet separation after post-compression cooling, and final product adsorption filtration to remove gaseous hydrocarbons contaminants and excessive water vapor.
- Potable water treatment using biofilm filtration in slow sand filters.
- Wastewater treatment using biofilm filtration using trickling filters.

3. Adsorption filtration includes:

- Carbon dioxide removal from breathing gas in rebreathers and life-support systems using scrubber filters, and activated carbon filters to remove volatile hydrocarbons, odors, and other contaminants from recirculated breathing gas in closed habitats.

Functions of Filtration

- Filtration has many different uses, such as the cleaning of water, like river water, from impurities. It can also be used for sterilization without the use of heat, if the filter's pores are small enough to catch the microorganisms. Keep in mind that this process will not kill the microorganisms since it does not make use of heat.

General steps in purification of drinking water includes:

1. Aeration:

- Raw water is first collected in large aeration tank and the water is aerated by bubbling compressed air through perforated pipes.
- Aeration removes bad odors and CO2. It also removes metal such as iron, manganese by precipitating then as their respective hydroxides.

2. Storage or settling:

- Aerated water is then placed in settling tank and stored for 10-14 days.
- During storage about 90% of suspended solids settle down within 24 hrs. and the water becomes clear. Certain heavier toxic chemicals also settle down during storage.
- Similarly pathogenic bacteria gradually die and bacterial count decreases by 90% in first in first 5-7 days of storage.
- During storage organic matter present in water is oxidized by microorganisms. Similarly, NH3 present is oxidized into nitrate by microorganisms during storage.

3. Coagulation:

- Water from storage tank is then placed in coagulation tank and then some precipitating agents such as alum, lime etc. are added in water and mixed.
- These precipitating agents form precipitate of $Al(OH)_3$ when dissolved in water.
- Suspended solids absorbs on the surface of precipitate, so gradually mass of precipitate becomes heavier and finally settle down.

- This technique is used to remove very light suspended solids that do not settle by themselves during storage. Furthermore, if negatively charged colloidal impurities are present, they are neutralized by Al^{+++} ions and settle down.

4. Filtration:

- Partially clarified water is then passed through sand gravity filter which removes 98 -99% of microorganisms and other impurities.
  - ✓ Sand gravity water filter: Sand filter is a rectangular tank in which filter bed is made up to 3 layers.
  - ✓ Top layer: fine layer of 1 meter thick
  - ✓ Middle layer: 0.3-0.5-meter-thick layer of coarse sand
  - ✓ Bottom layer: 0.3-0.5-meter-thick layer of gravel
- There is a collection tank at the bottom of the filter bed to collect filtered water. During filtration filter bed soon gets covered with a slimy layer called vital layer. Vital layer consists of thread like algae, diatoms, and bacteria.
- During filtration microorganisms presents in vital layer oxidize organic and other matter present in water. For example, if NH3 is present, it is oxidized into nitrate. Vital layer also helps infiltration of microbial cells.

5. Disinfection:

- The filtered water is finally purified by using disinfectants. E.g., Chlorination

  Disinfectant kills pathogenic as well as other microorganism in water.

  After disinfection water is pumped into overhead tank for subsequent domestic distribution.

Types of filtrations:

Which method is used depends largely on whether the solid is a particulate (suspended) or dissolved in the fluid.

1) **General Filtration:** The most basic form of filtration is using gravity to filter a mixture. The mixture is poured from above onto a filter medium (e.g., filter paper) and gravity pulls the liquid down. The solid is left on the filter, while the liquid flows below it.
2) **Vacuum Filtration:** A Büchner flask and hose are used to create a vacuum to suck the fluid through the filter (usually with the aid of gravity). This greatly speeds the separation and can be used to dry the solid. A related technique uses a pump to form a pressure difference on both sides of the filter. Pump filters do not need to be vertical because gravity is not the source of the pressure difference on the sides of the filter.
3) **Cold Filtration:** is used to quickly cool a solution, prompting the formation of small crystals. This is a method used when the solid is initially dissolved. A common method is to place the container with the solution in an ice bath prior to filtration.
4) **Hot Filtration:** the solution, filter, and funnel are heated to minimize crystal formation during filtration. Stemless funnels are useful because there is less surface area for crystal growth. This method is used when crystals would clog the funnel or prevent crystallization of the second component in a mixture.

Type of filtration screen filtration and depth filtration:

➢ Surface filtration (Screen filtration):

- ✓ It is a screening action by which pores or holes of medium prevent the passage of solids.
- ✓ Mechanism involved: straining and impingement.
- ✓ For this, plates with holes or woven sieves are used.
- ✓ Efficacy is defined in terms of mean or maximum pore size.

- Surface filtration involves the removal of material suspended in a liquid using sieving. In this method, the liquid passes through a thin septum (ie, filter material). Materials that have been used as a filter septum include woven wire cloths, cloth fabrics of different fabrics, and a variety of synthetic materials.

➢ Depth filtration:

- In this method, the removal of suspended material from the liquid suspension is performed by passing the liquid through a filter bed composed of a granular or compressible filter medium. The material used for the filter bed is a packed bed of sand, anthracite, or other granular media. Solids (particles) get attached with gradient density structure to the media by adsorption or by physical restriction. This method is used in the treatment of surface waters for potable water supply.
- In this process, the slurry penetrates to a point where the diameter of solid particles is greater than that of the tortuous void or channel.
- Mechanism: Entanglement.
- It is extensively used for the removal of small amounts of contaminants from relatively large volumes of liquids (clarification). These are also used for roughing or prefiltering pharmaceutical solutions. Examples are ceramic filters and sintered (bed) filters.

❖ Difference between the screen and depth filtration:

Screen filtration	Depth filtration
1. The size of partides retained is slightly higher than the mean pore size of medium. 2. Mechanical strength of filter medium is less, unless is made of stainless steel. 3. It has low capacity. 4. The size of partides retained is more predictable.	1. The size of partides retained much smaller than the mean pore size of medium. 2. Mechanical strength of filter medium is high. 3. It has high capacity. 4. The size of partides retained is less predictable.
• It can stop particles and bacteria at its upstream surface. • More common in industrial applications where requirements for particulate-free water are more exacting.	• It can retain particles throughout its whole volume and depth. • **Main advantages:** they can retain large amounts of dirt and debris without clogging and cheap.

✓ Equipment is expensive because equipment as edge clamps is required. • Ex: cellulose membrane filter.	✓ Equipment is cheaper because equipment such as edge clamps is required • Ex: ceramic filter and sintereal filters.