Filtration Processes

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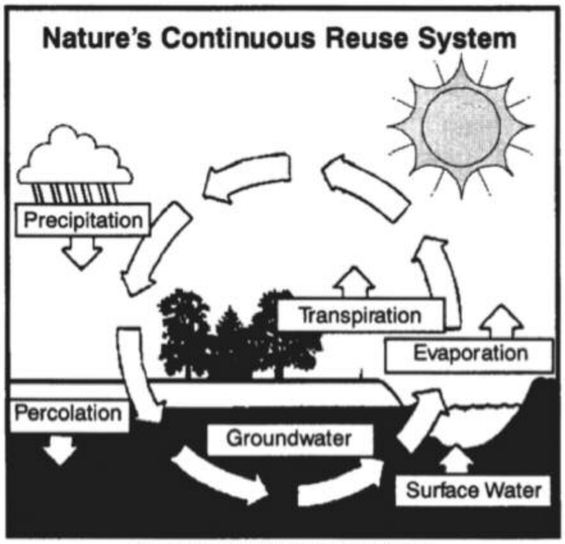
The filtration process is perhaps the most readily understood technique in water treatment, and its results can actually be observed. The basic principles of filtration/separation have been working for eons in our environment. As part of the hydrologic cycle (Figure 1-1), some filtration takes place as water seeps and percolates down through layers of earth. By the time the water has reached the underground aquifer, it is free of any particulate and some of its adsorbed gasses…

Figure 1-1
The Hydrologic Cycle



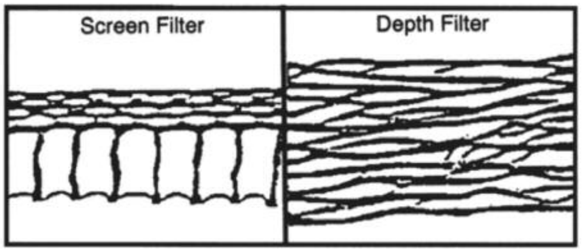
Courtesy: Fresh Water Foundation

Filtration, as such, involves the process or processes of separating suspended matter from a liquid. One of the most common methods of filtration consists of passing water through a bed (column) of granular medium or through various porous media, such as coated paper, membranes, and other special fabrics, to remove undissolved suspended particulates. When these particles result in cloudiness and discoloration, this condition is referred to as "turbidity." Such particulate may be finely divided silt, sand, solid organic matter, precipitated iron, bacteria, or algae, which may be present in both surface or well water sources. Well designed tank-type media filters are capable of removing these suspended solids from water down to about 10.0 micron size.

Particles smaller than 10 microns can be destabilized and then agglomerated together into larger and filterable flocs with the aid of coagulants such as aluminum sulfate (alum). Effective coagulation, mixing, and flocculation prior to media filtration can remove particles down to one micron in size.

In more refined filtration/separation techniques that are used to remove particles not visible to the naked eye (less than 20 microns), special membrane-type media in cartridge-style filters are employed. Two processes are used to remove these extremely fine nonionized species in a sort of "screening out" technique, as shown in Figure 1-2. The first microfiltration involves the removal of species in the 0.06 to 2.00 micron range. The second process is the ultrafiltration membrane method, which is capable of removing particulate matter in the 0.025 to 0.200 micron range and also rejects dissolved macromolecules above the 1,000 molecular weight (MW) cutoff. (This chapter does not cover micro- or ultrafiltration. See *Water Filtration for Point-of-Use Application*, by the Water Quality Association, Lisle, Illinois, 1989.)

Figure 1-2
Examples of Surface (screen) and Depth Filter Media Elements



In its larger technical sense, filtration processes do involve a wide variety of equipment, mechanics, chemicals, devices, and an array of media products in order to "separate" particulates or molecules from fluids. At large industrial, municipal, and specialized commercial water treatment facilities, one or more of the following water rectification modes may be used.

- Simple strainers and sieves
- Granular media-type gravity, pressure, or vacuum filters
- Centrifugation
- Cartridge-type filters
- Precoat filters
- Chemical—coagulation/precipitation
- Filter presses
- Membrane technology…

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THE MECHANICS OF FILTRATION

Home and business filters, for the most part, follow the basic principles of large commercial filtration systems and fall into two broad categories: surface filters and depth filters. Essentially, filtration is accomplished by either surface and depth filters or by electrostatic attraction of undissolved particles in water to certain types of filter media.

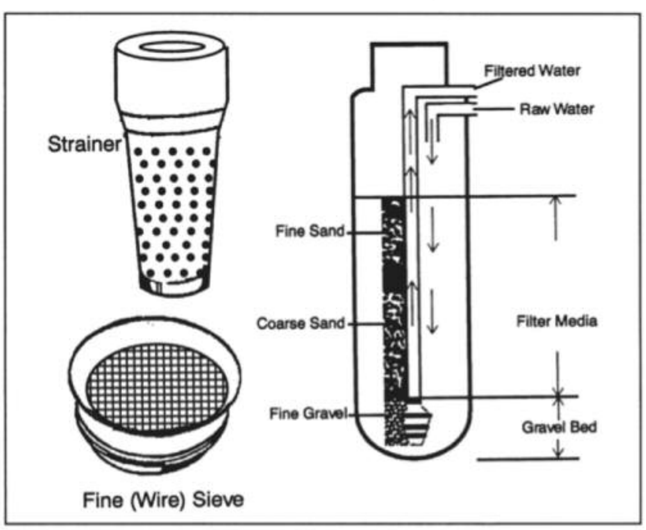
Surface (screen) filtration can be described as a "straining" technique, somewhat akin to the sifting of flour in baking, where a series of holes or perforations (all the same size) in a flat metal or plastic sheeting can remove particulate from a liquid. This series of surface holes holds back solid particles on the basis of size, allowing those of smaller diameter to pass through.[3]

In this "screening out" process, however, a layer usually will build up on the surface filter and become a secondary filter surface. This surface layer then does the actual filtering—and in so doing, establishes a type of "depth filter" element upon the surface filter itself. The problem with surface filtering in home and business situations is that such filters clog easily, much like the debris often observed at the grating of a storm water catch basin.

Surface filters can be either strainers with uniform holes or perforations in a rigid material, or certain membranes with very uniform, tiny openings.

Examples of surface filters (Figure 1-3) include Y-strainers, faucet aerator screens, sump strainers, and basket hair catchers in swimming pool filter systems.

Figure 1-3
Basic Filtration Techniques



Depth filters (or deep-bed filters), on the other hand, are the most common design for domestic purposes. The tank-type filters contain loose media, which form irregular pathways for the water or liquid to pass through. In addition, some media, such as granulated activated carbon, are highly porous particles, offering microfiltration of some microorganic molecules. With the use of more than one layer of medium in filters, the void spaces can be varied even further. Depth filtration is described as "water [liquid] flowing through a mass filter medium or series of media, following a torturous pathway, with many entrapments"[4] – usually of successively decreasing void spaces through the depth of the filtering bed. In deep-bed depth filters, particulate matter is first deposited in the upper inch or two of the bed. Once the layer of particulate is deposited, additional particles can flow through the irregular maze of channels or paths to be entrapped in locations deeper in the media bed.[5] Examples of deep-bed depth filters include anthracite, sand, and garnet mixed media systems.

Depth filtration also includes those string-wound and special fabrics (Figure 1-2) used as part of cartridge-style filter units.

Some undissolved particulates in water carry a very slight charge; thus in certain cases, these particles are separated by electrostatic attraction to the filter medium itself.

TURBIDITY

Turbidity, or cloudiness, in water is caused by very small particles that remain suspended and tend to "float" because of their very low density. The standard analysis measurement for turbidity is reported in Nephelometric Turbidity Units (NTU), which have superseded the Jackson Turbidity Units (JTU) of measurement formerly used in water analysis. Turbidity in potable water cannot exceed 0.5 NTU, according to current US Environmental Protection Agency (EPA) Primary Drinking Water Standards. A reading of 5.0 NTU triggers a mandatory "boil water" alert in public water systems.

Temporary cloudiness in water, such as may be noticed in a freshly drawn glass, is often caused by excess air. This cloudiness disappears rapidly upon standing. Another cause of cloudiness in a glass of drawn hot water can be extremely fine precipitants created during the heating; this condition generally clears itself quickly. Still another form of cloudiness in water may be the rare case of methane gas (CH_4), common in marsh water sources.[6]

Some turbidity (both organic and inorganic in nature) in surface water will settle out when the water is allowed to stand. On the other hand, a portion of this material may be present as finely divided, colloidal matter that cannot be removed by settling. In general, most turbidity in residential water treatment can be removed by passing the water through a bed (tank) of granular-type media in a sediment filter.

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The finer the particle size of a given filter medium, the greater the filter's ability to remove the particulate. Some turbidity and color in water are composed of such small particles that they slip right through the conventional filter medium.

In commercial applications, removal of these extra-fine species usually requires the help of a chemical feed application. Often, a chemical such as alum (aluminum sulfate) is added in low dosages to the stream of water to neutralize the electrical charge or to destabilize the particles, thereby causing them to adhere to one another and, in turn, form larger particles. These particles are then removed first by settling, then filtration.[7]

In the home and on the farm where turbidity and sediment are encountered, a more easily maintained and automatic system is needed. The operation of chemical feed devices is generally more than the average homeowner or businessperson wants to be bothered with. Very often, a small automatic filter can do the task. Most domestic filters are either porous media-type whole-house units or disposable cartridge filters at one or two faucets for drinking water, depending on the amount and type of particulate to be removed. Where softening, demineralization, or reverse osmosis is involved, filtering would be the first (or pretreatment) step so a clear stream of water would be feeding these subsequent treatment modes.

References

3. *Water Filtration for P.O.U.*, Water Quality Association, Lisle, IL, 1989.

4. *Basics of Filtration & Separation*, Nuclepore Corp., Pleasantown, CA, 1978.

5. Ibid.

6. W. McGowan, *Water Processing for Home, Farm and Business*, Water Quality Association, Lisle, IL, 1988.

7. E. Nordell, *Water Treatment for Industry*, 2d ed., Reinhold Press, New York, 1962.

QUIZ 3: "Filtration Processes" (0.25 CPD)

1. **What is the definition of filtration?**
   a. Conversion of dissolved solids into suspended particles
   b. Separation of suspended solids from liquids
   c. Evaporation of liquid to create solid particles
   d. Exchanging of undesirable particles for desirable particles in a liquid
2. **What is the minimum size particle that can be removed by media filters?**
   a. 0.200 microns
   b. 2.00 microns
   c. 10.0 microns
   d. 1,000 atomic mass units
3. **Surface filtration is often described as what type of process?**
   a. Electrostatic attraction
   b. Adsorption
   c. Loose media
   d. Straining
4. **What is a disadvantage of surface filtration?**
   a. Poor attraction between the particles and the surface
   b. Surface clogs easily
   c. High capital costs
   d. Difficult to operate
5. **What is the basic design of depth filtration that is responsible for accomplishing separation?**
   a. Incorporation of a strainer to trap larger particles
   b. Creation of irregular pathways for water with entrapment for particles
   c. Initial deposition of large particles
   d. The ability of small particles to pass through the media bed
6. **What causes turbidity?**
   a. Cloudiness
   b. Color
   c. Large suspended particles
   d. Small suspended particles
7. **What level of turbidity triggers a mandatory "boil water "alert in public water systems?**
   a. 0.05 NTU
   b. 0.5 NTU
   c. 5.0 NTU
   d. 50 NTU
8. **Other than membranes, what can be used to remove turbidity-causing particles too small for separation by conventional filter media?**
   a. Coagulation
   b. Chlorination
   c. Ion Exchange
   d. Settling