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Drinking Water Standards What Happens At A Water Treatment Plant?

For thousands of years people have treated their drinking water to make it look cleaner and taste better. Medical lore from ancient India to Egypt advised that water should be filtered through sand and coarse gravel. In Greece, Hippocrates, the Father of Medicine, recommended boiling water and straining it through a cloth to remove particles.

Early in the 1800s, scientists began to suspect that diseases could be transmitted by drinking water. Since the discovery of bacteria in the 1870s, treatment to eliminate disease-causing microorganisms has dramatically reduced the incidence of diseases transmitted through water.

Water treatment facilities process water through many steps before it reaches your tap as drinking water for your family. The overall process generally begins with intake at the source, followed by pre-treatment, mixing, coagulation and flocculation, sedimentation, filtration, disinfection, and distribution to the tap. See Figure 1. Other steps may be necessary depending on the quality of the water supply.

Preliminary Treatment Processes

Preliminary treatment processes to purify water depend on the nature of the water supply and the type and the amount of contaminants. Quality may vary

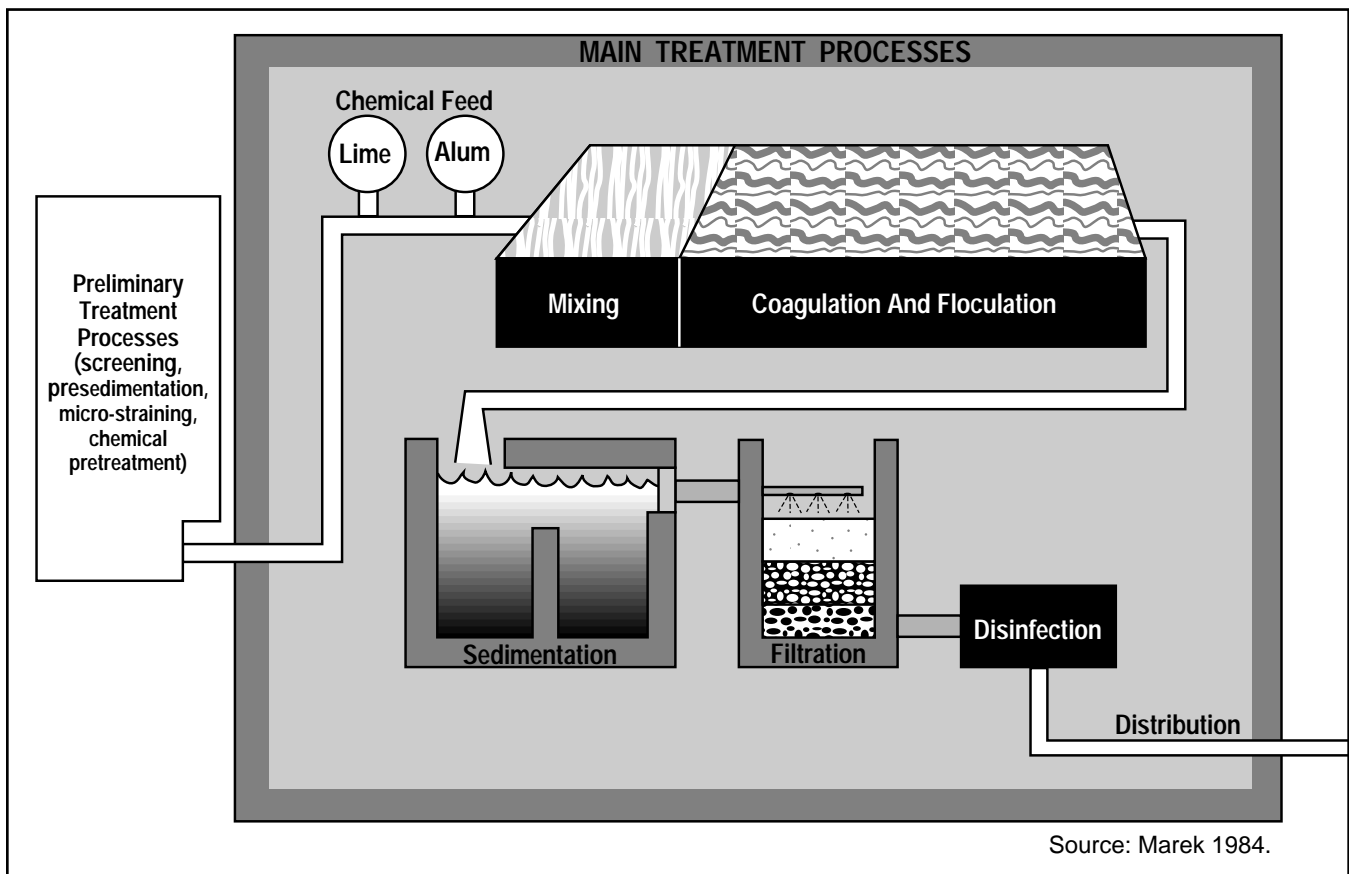


Figure 1. What happens at a water treatment plant.

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seasonally, thus requiring more or less treatment during certain waterflow conditions. Most groundwater in Alabama receives only the disinfection treatment process. All surface water and water from wells susceptible to contamination from surface water receive full treatment through a filter plant. The various preliminary treatment processes may include the following.

Screening. Large objects such as logs, sticks, fish, and plants are usually screened out at the intake or as the water is drawn into the treatment plant from a river, lake, or other surface water source. If the source is groundwater, the screening is done by nature as the water travels under the surface of the earth.

Presedimentation. Gravel, sand, some silt, and other gritty materials may be removed by fine screening.

Micro-straining. In some cases, algae, aquatic plants, and other very small debris may be removed by still finer screening.

Chemical Pretreatment. The water is conditioned for removal of natural organics, primarily algae and other aquatic microorganisms, as well as their by-products. This may precede micro-straining.

Main Treatment Processes

Chemical Feed And Rapid Mix. Chlorine and other chemicals, such as alum or lime, are added to the water to help remove impurities, destroy any taste or odor, raise pH, disinfect, and sometimes remove excess minerals such as iron that may cause rust or staining problems. The water is then mixed rapidly to distribute the chemicals evenly.

Since the early 1900s, chlorine (as a solid, liquid, or gas) has been the primary disinfectant used in the United States because it is effective and inexpensive and can provide a disinfectant residual in the distribution system. Ozone and ultraviolet radiation can also be used as primary disinfectants, but chlorine or an appropriate substitute must also be used as a secondary disinfectant after the main treatment processes to prevent regrowth of microorganisms in the distribution system.

Chemicals may be added to oxidize ferrous iron (Fe^{++}), which is relatively high in some groundwater, to the ferric state (Fe^{+++}). If pH of the water is above 7 (either naturally or by adding lime), the insoluble compound of ferric hydroxide is precipitated.

Softening. Sometimes chemicals are included to reduce the "hardness" or mineral content of drinking water. This usually involves the exchange of sodium for calcium and magnesium and, sometimes, the removal of iron and manganese. However, softening is not as popular as it once was for several reasons. The increased sodium in softened water is unhealthy

for people with high blood pressure. In soft water lead is more easily leached from plumbing. Finally, detergents that clean favorably in hard water are readily available. There are no softening plants in Alabama since total dissolved solids are not excessive.

Coagulation And Flocculation. The water is sent into large basins where the alum clings to other chemicals and impurities in the water (coagulation), causing them to form larger, heavier particles called floc. Gravity causes these larger particles to settle to the bottom.

Sedimentation. The water is allowed to sit undisturbed long enough so that solid particles completely settle to the bottom. This process removes chemical precipitates as well as extremely fine clay and organic particles, including dead microorganisms.

Filtration. After flocs (large, heavy particles) settle to the bottom, the water continues on its trip through filters. Layers of sand, gravel, and sometimes hard coal are used to remove any other impurities that are left in the water. Filtration helps to control biological contamination and turbidity. (Turbidity is a measure of the cloudiness of water caused by the presence of suspended matter.) Turbidity can shelter harmful microorganisms and reduce the effectiveness of disinfection. Removing organics prior to final chlorination of drinking water supplies is important.

Disinfection. After most impurities have been removed from the water, a small amount of chlorine is added to keep the water from developing bacteria as it travels throughout the distribution pipes. The amount of chlorine (usually no more than 3 parts per million) is carefully measured to be the lowest possible amount needed to keep the water free of germs. Residual chlorine at the tap should be near 0.5 parts per million.

A primary health concern with chlorination is the formation of disinfection by-products. When chlorine combines with organic matter in water, such as decaying plants or animals, it forms substances called trihalomethanes (THMs). These have been shown to cause cancer in laboratory animals. Chloroform is a common THM which has been linked to bladder cancer in those who drink from treated public water supplies. There is a drinking water standard for total trihalomethanes (TTHMs) of 0.10 milligrams per liter, but it applies only to those systems that serve more than 10,000 people.

New regulations concerning disinfection by-products will likely be proposed in the near future

Fluoridation. In some places fluoride at concentrations up to 1 part per million is also added to help prevent tooth decay. This is not as common as it once was because of the health concern for excess fluoride.

EPA has established a maximum contaminant level (MCL) of 4 milligrams per liter (4 parts per million) for fluoride in drinking water.

If conventional steps in the main treatment process are not adequate, certain inorganic and organic contaminants must be removed by other methods.

Treatment To Remove Inorganic Contaminants

Reverse osmosis or **ion exchange** are used to remove nonmetal inorganic contaminants. Nitrate and fluoride are the nonmetals of greatest health concern in drinking water. Nitrate is frequently found in groundwater supplies in high-density agricultural areas. Likely sources of groundwater nitrate are nitrogen fertilizers as well as decomposing plant and animal wastes, including human waste from septic systems.

Coagulation and filtration, reverse osmosis, ion exchange, or activated alumina are used to remove metal inorganic contaminants. The metals of greatest health concern in drinking water include mercury, cadmium, selenium, lead, arsenic, chromium, and barium. Industrial sources can contribute rare metals and toxic heavy metals to surface waters.

Controlling corrosion of inorganic chemicals from the distribution or plumbing system is another treatment alternative. Corrosion of plumbing by-products such as copper and lead at the point of use (the consumer's tap) can usually be indirectly eliminated by controlling pH and water hardness.

Lead contamination is the most serious threat from corrosion. Lead usually enters the water from private plumbing where it is found in solder used to

connect copper pipes. Lead can also be corroded from public distribution system pipes and joints.

Aeration effectively strips radon gas from source waters. **Oxidation** and **aeration** will remove hydrogen sulfide gas.

Treatment To Remove Organic Contaminants

Methods to remove organic contaminants include activated carbon filtration and aeration. Special filters may be used at water treatment plants to remove many toxic organic substances such as pesticides and solvents; however, these filter systems are expensive to build and maintain, and they slow down the treatment process. As water passes through carbon filters, organic impurities are trapped inside the filter material. This is called adsorption.

Sources of organic compounds include stormwater runoff and leaching from improperly disposed wastes, accidental spills, leaking fuel storage tanks and pipelines, pesticides from agricultural areas, and industrial effluents.

Testing

Water samples are taken regularly at many points in the treatment process for laboratory testing. These tests let water plant personnel know whether the primary and secondary drinking water standards set by the EPA are being met. The laboratory equipment being used is so sensitive that it can measure substances in parts per million, parts per billion, or even parts per trillion in some cases.

Table 1. Routine Sampling Frequency For Major Contaminant Groups.

Contaminant Group	Surface Water	Groundwater
Inorganics ^a	One time per year	Every 3 years
Organics:		
Herbicides, pesticides, PCBs ^b	Four times per year	Four times per year
TTHMs	Four times per year	One time per year
Turbidity ^c	Continuous monitoring	Once per day
Total Coliform ^d	Monthly	Monthly
Radionuclides	Every 4 years	Every 4 years

^aThe system must be sampled at least once for corrosivity characteristics including pH, calcium hardness, alkalinity, temperature, total dissolved solids, and calculation of the Langlier Index. The system must monitor sodium for reporting purposes. In Alabama, public water systems must sample for asbestos, nitrates, and nitrites more frequently than for other inorganic contaminants.

^bSampling frequency depends on how vulnerable the system is to contamination as determined by the state regulating agency. Under high vulnerability, sampling frequency will increase.

^cMonitoring frequencies depend on the filtration system used by the water treatment plant.

^dSampling frequency may vary somewhat depending on the size of the system and the requirements of the state regulating agency. In Alabama, public water systems must submit a sampling plan to ADEM with the proposed number of samples and sites.

Sources: USEPA 1990^b, and ADEM 1992.

Testing frequency required by the Alabama Department of Environmental Management for different contaminant groups is given in Table 1.

Conclusion

Today we can take a closer look at our drinking water than ever before. With careful monitoring, the ability to detect parts per million—or even trillion—offers the opportunity to spot potential contamination long before the point of danger. Being able to detect potentially harmful substances (whether naturally occurring or synthetic) at concentrations well below

the threshold of danger insures ample time to correct situations that might eventually lead to problems.

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