

How Do You Clean Your Water?

An Investigation of Point of Use Water Purification and Filtration Systems

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Abstract:

- There are many different water filtration and purification products available that are used to give us potable water that we can drink moments after taking it from the source. However, certain products are used for particular reasons, and the right product will vary based on what the source of water is, who is using it, and what they need it for. This project takes a closer look at some of these products to see what they are really doing to clean the water, how they do it, and how effective they really are.

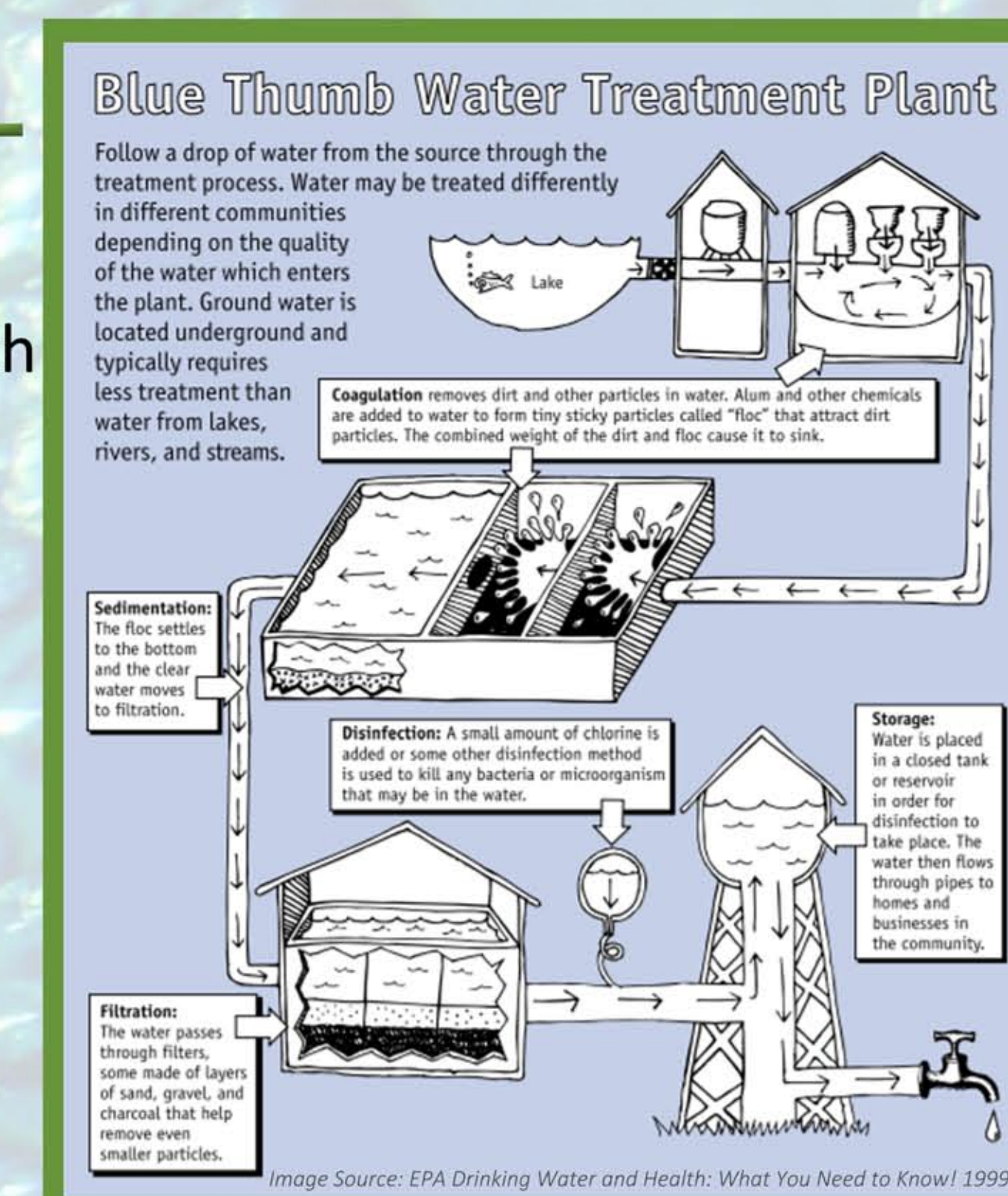
Overview of Water Treatment Process:

- There are over 100 contaminants that can be found in fresh water that the EPA lists as hazardous to human health that water suppliers must remove before distribution.
- There are also over a dozen aesthetic impurities that are not hazardous to human health but may not be suitable for consumers' tastes.

Contaminant	MCL or TT ¹ (mg/L) ²	Potential health effects (see table for details) ³	Common sources of contaminant in drinking water	Public Health Goal (mg/L) ⁴
Arsenic	0.05	Brain damage or problems with circulatory system, and may have increased risk of getting cancer	Discharge of natural arsenic, leach from old cans, runoff from glass & aluminum production waste	0
Asbestos (fibers >10 micrometers)	7 million fibers per liter (MFL)	Increased risk of developing benign intestinal polyps	Decay of asbestos cement in water mains, erosion of natural deposits	7 MFL
Barium	2	Increase in blood pressure	Discharge of drilling wastes, discharge from metal refineries, erosion of natural deposits	2
Benzene	0.005	Acute: decrease in blood platelets, increased risk of cancer	Discharge from factories, leaching from gas storage tanks and landfills	zero
Benzopyrene (BaP)	0.0002	Reproductive difficulties, increased risk of cancer	Leaching from linings of water storage tanks and distribution lines	zero
Beryllium	0.004	Intestinal lesions	Discharge from metal refineries and coal-burning factories, discharge from electrical, aerospace, and defense industries	0.004
Carbon tetrachloride	0.005	Liver problems, increased risk of cancer	Discharge from chemical plants and other industrial activities	zero
Chlorine (as Cl ₂)	MCL=4.0	Eye/nose irritation, stomach discomfort	Water additive used to control microbes	MRDLG=4
Chlorine dioxide (as ClO ₂)	MRDLG=8	Asthenia, infants, young children, and fetuses of pregnant women: nervous system effects	Water additive used to control microbes	MRDLG=8
Copper	TT: Action Level=1.3	Short-term exposure: Gastrointestinal distress, Long-term exposure: liver or kidney damage. People with Wilson's Disease should avoid use of copper in their water exceeds the action level	Corrosion of household plumbing systems, erosion of natural deposits	1.3
Cryptosporidium	TT ¹	Short-term exposure: Gastrointestinal distress (e.g., diarrhea, vomiting, stomach pain)	Human and animal fecal waste	zero
Cyanide (as free cyanide)	0.2	Nerve damage or thyroid problems	Discharge from steel/metal facilities, discharge from plastic and fertilizer factories	0.2
Fluoride	4.0	Bone disease (pain and tenderness of the bones, children may get dental fluorosis)	Water additive which promotes strong teeth, erosion of natural deposits, discharge from fertilizer and aluminum factories	4.0
Giardia lamblia	TT ¹	Infants and children: Delay in physical or mental development, children could show signs of malnutrition, loss of weight and learning abilities. Adults: kidney problems, high blood pressure	Human and animal fecal waste	zero
Lead	TT: Action Level=0.05	Children could show signs of malnutrition, loss of weight and learning abilities. Adults: kidney problems, high blood pressure	Corrosion of household plumbing systems, erosion of natural deposits	zero

- To clear the water of these contaminants, it is run through a multi-step treatment process.
- First the water is pumped through a mesh filter to remove large particles
- Then the flocculating agents, Al₂(SO₄)₃ and Ca(OH)₂ are added and the following chemical reaction occurs
$$\text{Al}_2(\text{SO}_4)_3 + 3\text{Ca}(\text{OH})_2 \rightarrow 2\text{Al}(\text{OH})_3 + 3\text{Ca}(\text{SO}_4)$$

- The product Al(OH)₃ is a gel that sits at the top of the water then slowly sinks to the bottom, collecting contaminants as it goes.
- Then the water is passed through another filter that can consist of activated carbon or gravel and sand.
- The antibacterial agent HClO is created by adding Cl₂, NaClO, or Ca(ClO)₂
- A small amount of HClO remains to protect the water as it travels through the pipes



Contaminant	Secondary Maximum Containment Level
Aluminum	0.05 to 0.2 mg/L
Chloride	250 mg/L
Color	15 color units
Copper	1.0 mg/L
Conductivity	Nonconcrete
Fluoride	2.0 mg/L
Foaming Agents	0.5 mg/L
Iron	0.3 mg/L
Manganese	0.05 mg/L
Color	1 household odor number
pH	6.5-8.5
Silver	0.10 mg/L
Sulfate	250 mg/L
Total Dissolved Solids	500 mg/L
Zinc	5 mg/L

Product #1: Brita Pitcher (Standard)

- The standard Brita Pitcher Water filter contains ion exchange resin and activated carbon treated with silver.
- The ion exchange resin is able to reduce the levels of mercury, copper, cadmium, and zinc.
- The silver is an antibacterial agent
- The activated carbon removes VOCs, chlorine, radon, and can reduce mercury levels.



- Activated carbon is a very common filter for water and is even used in large-scale water treatment due to its proven effectiveness
- The Brita Pitcher filter performed better than expected when tested for removing Arsenic (Barnaby et al. 2017)



- It is an inexpensive and readily available solution for removing impurities causing bad tastes and odors
- It is not able to remove harmful viruses and bacteria, benzene, asbestos, iron, fluoride, lead, or nitrates.
- It can be good for home use as long as the water is not heavily contaminated.

Product #2: Iodine Tablets

- Iodine tablets were mainly developed for military use to disinfect water in emergency situations where they had to use untreated water.
- The chemical ingredients in the best water purification tablets are iodine, chlorine, and chlorine dioxide.
- The iodine tablets act like the antibacterial agent used in large-scale water treatment
- Two tablets in a quart of water after a wait of a minimum of 35 minutes is meant to kill parasites, bacteria, and viruses.
- Useful for hikers, backpackers, and world travelers, water purification tablets are inexpensive, less bulky than water filters, and are effective at killing bacteria such as E. coli, salmonella, and cholera.
- However, Iodine tablets have been linked to thyroid problems, have been shown to be ineffective in neutralizing viruses and the Cryptosporidium parvum, a harmful parasite.
- Plus, Iodine tablets can go bad if not stored correctly, can leave a bad taste in the water, do not affect heavy metals or chemicals, and there are no widely circulated testing methods for making sure that the water is safe to drink after using the tablets.
- Using a water filter in addition to Iodine tablets would be safer and more effective than using them alone.



Product #3: LifeStraw

- The LifeStraw is a product created by a European company called Vestergaard Frandsen.
- It is a portable water filter in a tube shape that can be used to filter and purify water by sipping through the LifeStraw straight from the water source.
- This product uses hollow fiber membrane micro filtration to physically remove particulates, bacteria, and protozoan cysts like Cryptosporidium parvum and Giardia lamblia.
- The pores of the hollow fibers have a micron rating of 0.2, thus water goes through but practically everything else is stopped.
- The LifeStraw removes 99.9999% of bacteria and 99.9% of protozoa.
- It also does not require batteries or any pumping, and it does not use chemicals or leave a bad taste.
- Unfortunately, the LifeStraw cannot remove viruses, heavy metals, chemicals or salt.
- Also, its effectiveness can be limited by environmental conditions and exposure to the cold can cause it to break



- Using a larger pre-filter and a chemical treatment for viruses would increase the effectiveness of this product