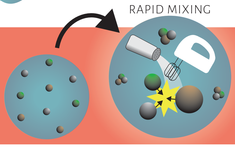
Drinking Water Purification

Conventional Treatment

WATER SOURCE

Coagulation

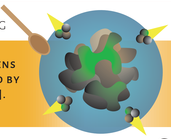
RAPID MIXING



Aluminum or iron salts added to the water remove negative charges from suspended particles, allowing them to stick together.

Flocculation

SLOW STIRRING



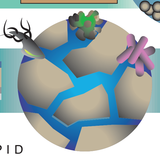
Many pathogens are entrapped by macroflocs [1].

Gentle stirring of water increases collisions between microflocs, forming visible floc particles

Sedimentation

Water is held still in settling basin, floc particles sink to the bottom, and clarified water is drawn from top.

Filtration



Water flows through grains or membrane pores, removing contaminants and making water clear.

Rapid Sand Filter (RSF)

- Filtering bed is 50-75 cm deep, using sand and/or anthracite grains 0.5-1 mm in diameter [2].
- Water is forced through filter using gravity or pressure. Bacteria, parasites, & particles get stuck to or between grains.
- Can achieve flow rates up to 20 meters per hour, but requires daily backwashing to unclog [3]
- Most widely used filtration system in developed countries.

Slow Sand Filter (SSF)

- A layer of safe bacteria and microbes called the "schmutzdecke" eat the bad bacteria & all other pathogens.
- Flow rate 0.1-0.3 m/h [4]
- Requires more land, used more in Europe

Membrane Filters

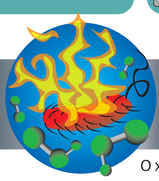
MICROFILTRATION 0.1 - 1 μm
- Removes Bacteria, Parasites, Floc
- Low Pressure System

ULTRAFILTRATION 0.01 - 0.1 μm
- Removes Viruses, Proteins, some man-made compounds like pesticides & endocrine disruptors [5]
- Low Pressure System

NANOFILTRATION 1 - 10 nm
- Removes molecules and some ions such as calcium & magnesium [5]
- High Pressure System

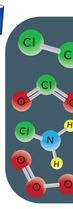
REVERSE OSMOSIS 0.1 - 1 nm
- Removes all dissolved salts & ions
- High Pressure System

Disinfection



The application of an oxidizing agent or UV light inactivates or kills any remaining pathogens. The water is safe to drink.

Oxidizing Agents



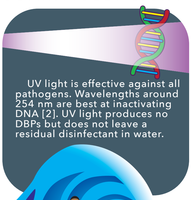
Chlorine is the most common disinfectant. Chlorination forms chlorite ions & hypochlorous acid. The ions damage cell walls, and HOCl passes through them and cripples internal functions [6]. Residual chlorine protects water from recontamination during distribution. Some by-products (DBPs) are hazardous.

Chlorine Dioxide works like chlorine & is just as effective. It produces no DBPs, but its application is more difficult [2].

Chloramines are weaker disinfectants but are sometimes added as a residual to guard against recontamination.

Ozone is even more powerful disinfectant than chlorine. Ozonation is expensive and leaves no residual in the water.

Ultraviolet Light



UV light is effective against all pathogens. Wavelengths around 254 nm are best at inactivating DNA [2]. UV light produces no DBPs but does not leave a residual disinfectant in water.

New Research

UV LEDs (Light-Emitting Diodes)

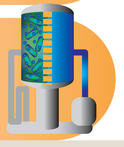
- Wavelength can be selected to disinfect individual pathogens [7].
- Could be installed in distribution systems in the future [7]
- Too expensive right now, but costs are likely to decline [8]
- More efficient, longer lifespans, no mercury, no DBPs [8]

Advanced Oxidation Processes

- Solar disinfection (SODIS) is used in developing countries & requires at least 6 hours of direct sunlight exposure.
- Scientists have accelerated & enhanced SODIS with AOPs using photo-Fenton & peroxymonosulfate. [9]
- Titania photocatalysts have been effective in field tests [10].

Biological Treatment Technologies

- Safe bacteria neutralize contaminants with oxidation.
- These systems can degrade endocrine-disruptors [11].
- Systems that have been researched for drinking water include membrane bioreactors and biologically activated carbon [11].



Developing Countries

Around 500,000 people die of diarrheal, waterborne illness every year [12].

Pathogens in Contaminated Water are Deadly

Point-of-Use Solutions

Household **biosand filtration** is a cheap and effective point-of-use (POU) system. Sand and microbes filter out contaminants. TivaWater biosand filters have provided clean water to over 300,000 people in developing countries [13].

Access to chlorine is limited [5]. **Chlorine** can be produced **locally** through the electrolysis of saltwater, and WATA™ devices can generate 1 liter of solution per hour, which can disinfect 4000 liters of water; WATA™ devices have provided clean water to thousands. [14]

Membrane filtration devices can remove pathogens & turbidity from water using gravity or hand-pumps. LifeStraw® & WATEROAM™ are some providers of these filters. Membrane filtration will likely become the main method of purification in the future [15].

Sources

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