NSF NRT-InFEWS: Indigenous Food, Energy, and Water Security and Sovereignty
Presents:

Food, Energy and Water (FEWS) Learning Modules

June 2021

Introduction to Water Within the FEW Nexus

THE UNIVERSITY OF ARIZONA – INDIGE-FEWSS
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PART 2:

Water Treatment Here & Now

LEARNING OBJECTIVES

- Describe and define what chemical and microbial contaminants in water are and how they affect public health
- Describe operational processes of potable water treatment

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PART 2:

Water Treatment Here & Now

AGENDA

- Chemical Contaminants
- Microbial Contaminants
- Water Treatment for Chemical Contaminants
- Water Treatment for Chemical Contaminants

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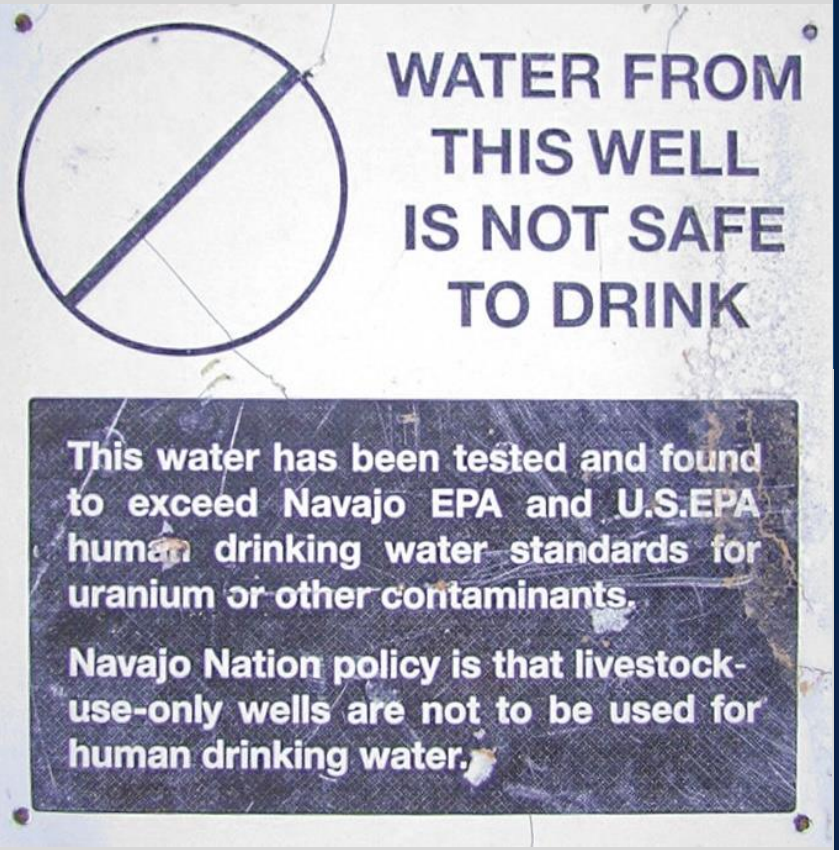
Metric Conversion

Prefix	Abbreviation	Scientific notation	Equal to this many base units
tera	T	1×10^{12}	1,000,000,000,000
giga	G	1×10^{9}	1,000,000,000
mega	M	1×10^{6}	1,000,000
kilo	k	1×10^{3}	1,000
hecto	h	1×10^{2}	100
deka	da	1×10^{1}	10
Base unit	Whatever unit	1	1
deci	d	1×10^{-1}	.1
centi	c	1×10^{-2}	.01
milli	m	1×10^{-3}	.001
micro	μ	1×10^{-6}	.000001
nano	n	1×10^{-9}	.000000001
pico	p	1×10^{-12}	.000000000001

Chemical Contaminants

- Common Contaminants of Concern
- Effects on Human Health
- Sources



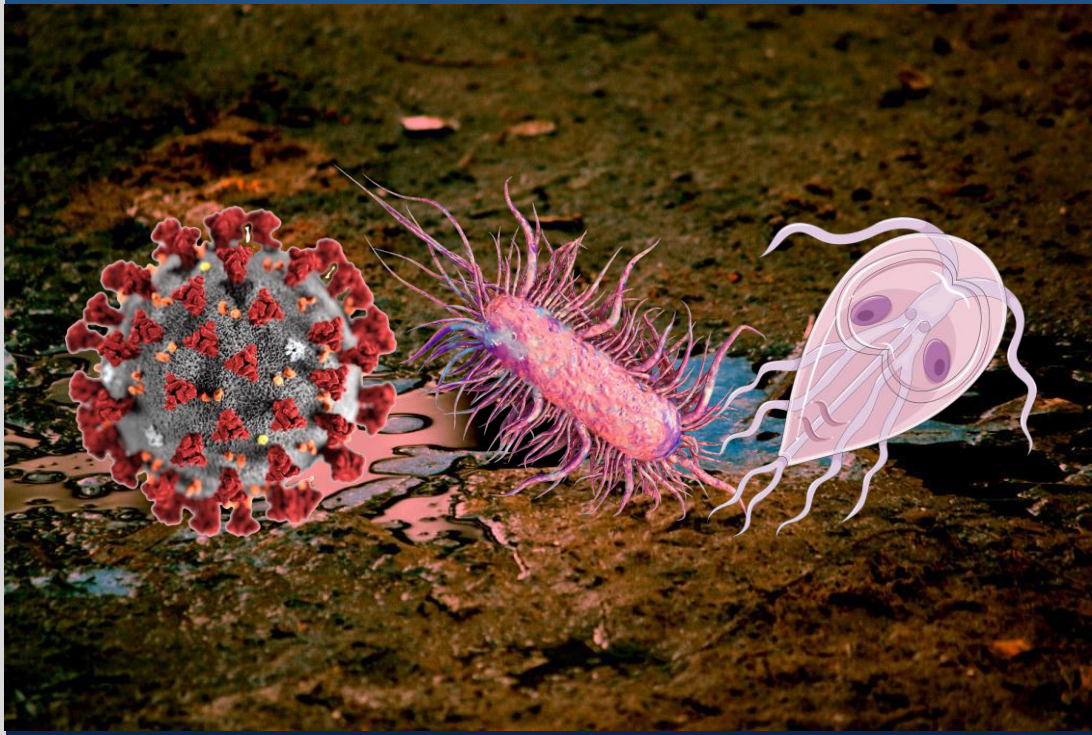
Chemical & Engineering News

Common Contaminants of Concern

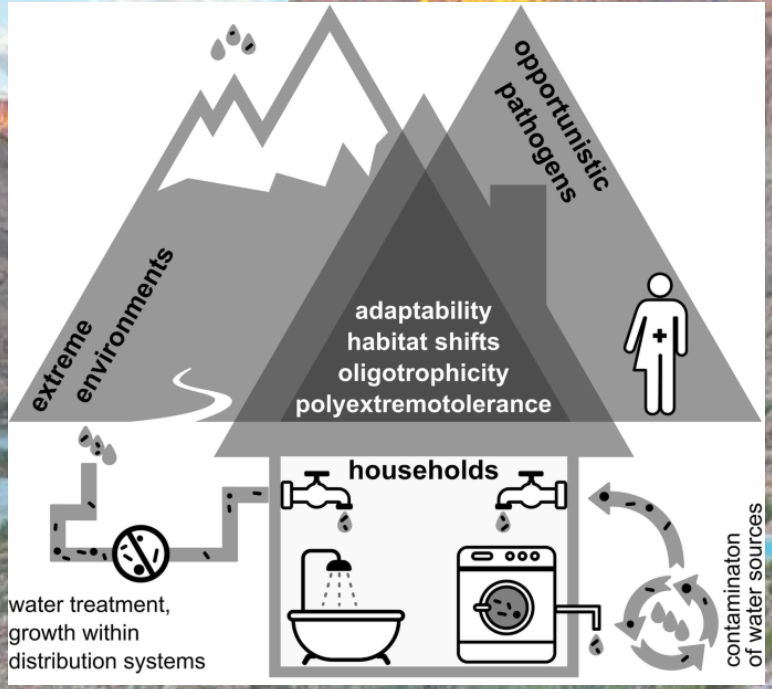
- Heavy Metals
- Organic Molecules
  - Glucose
  - Some carcinogens
- pH
- Conductivity
  - How well water conducts electricity
  - Dependent on dissolved ions and temperature
- Hardness
  - Calcium and Magnesium
- Turbidity (Color)

Microbial Contaminants

- Microbes & Pathogens
- Transmission
- Human Health Effects & Sources



Microbes: To be Pathogenic or not to be?



Not all microbes are bad!

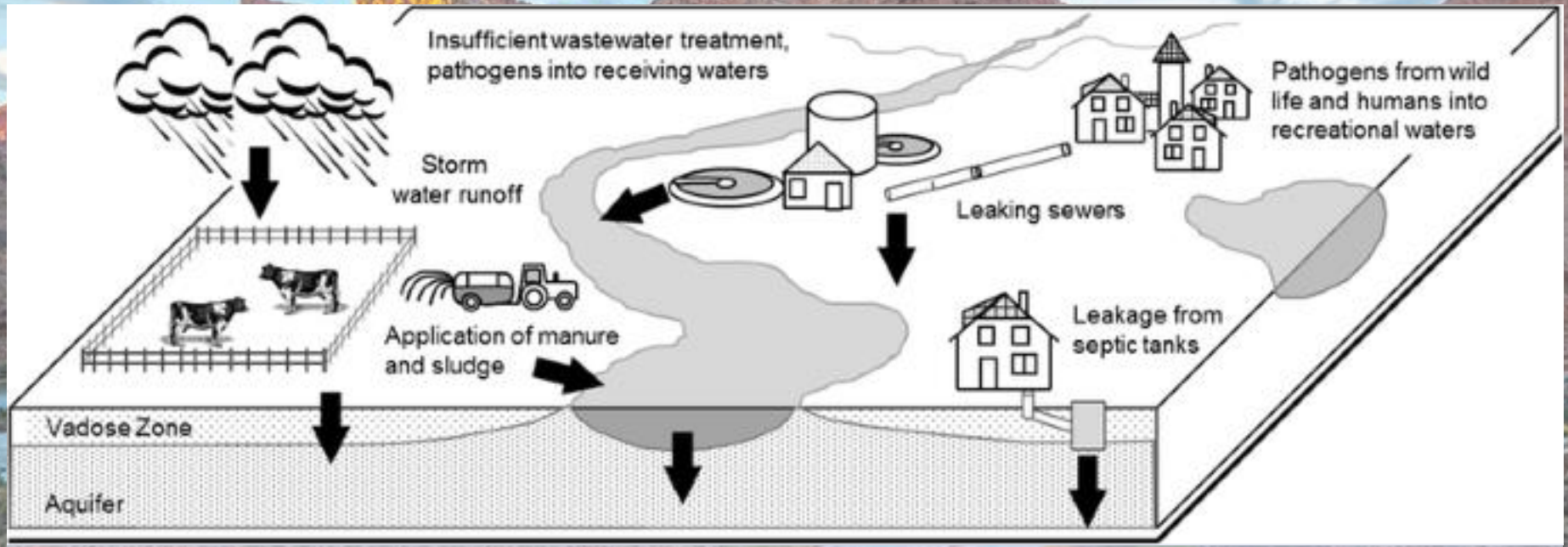
FUN FACT: Less than half of the cells in your body are **human** (~30 trillion) … they are actually **microbes** (~39 trillion)

Pathogenicity: the ability of an infectious agent to cause disease.
Opportunistic Pathogen: a pathogen that causes disease only when host resistance is impaired.
Infectivity: the ability of an infectious agent to infect.
Toxigenicity: the ability for a pathogen to produce a toxin to contribute to development of disease
Virulence: the quantitative ability of an agent to cause disease/death

The Microbes Matrix: Water-based v. Waterborne

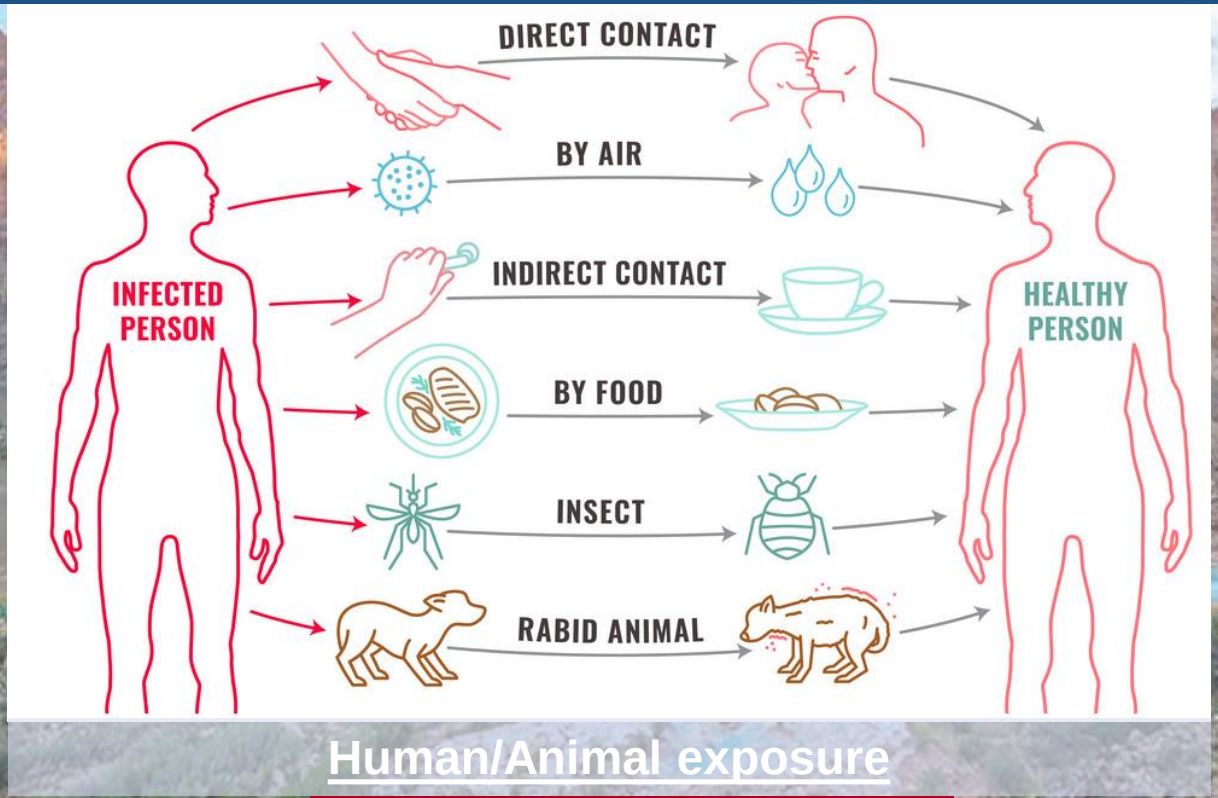
Water-based pathogens	Waterborne pathogens
Originate in water	Originate in fecal matter
Primarily transmitted by direct water contact or inhalation	Primarily transmitted by ingestion
Not transmitted person-to-person	Transmitted person-to-person
Example diseases: respiratory illness, conjunctivitis, Legionellosis, skin and wound infections	Example diseases: diarrhea, vomiting, hepatitis, meningitis, cholera, kidney failure, paralysis, myocarditis
Example pathogens: *Legionella pneumophila, Pseudomonas aeruginosa, Naegleria fowleri,* Mycobacterium	Example pathogens: norovirus, hepatitis A virus, *E. coli* O57:H7, *Campylobacter* species, *Vibrio cholera, Shigella, Salmonella*
Monitored via direct source sampling	Monitored via bacterial indicators (i.e., fecal and total coliforms)
Immunocompromised populations more susceptible to infection and adverse outcome	Infections common in immunocompromised and immunocompetent hosts

Microbes: Where did you come from, where do you go?



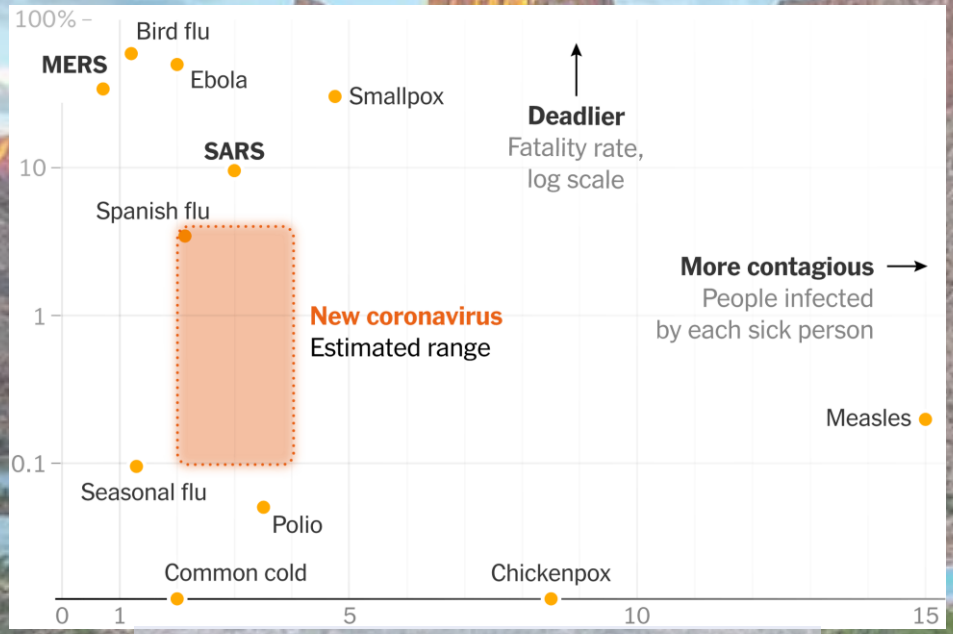
Avenues of environmental contamination

Microbes:
Where did you come from, where do you go?

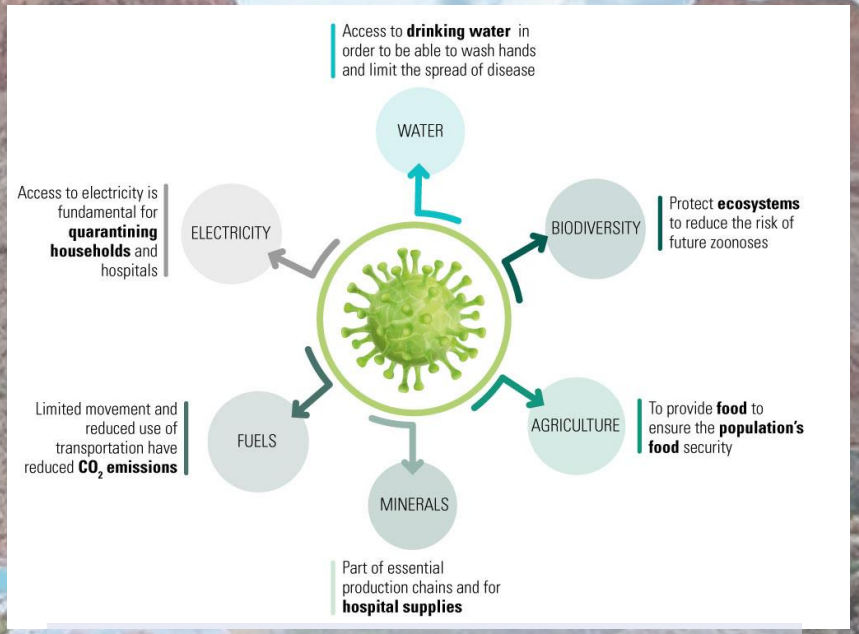


Human/Animal exposure

COVID-19 and Water Quality: Pathogen to Pandemic



Pathogenicity Vs. Virulence



Food-Energy-Water-Pandemic intersection

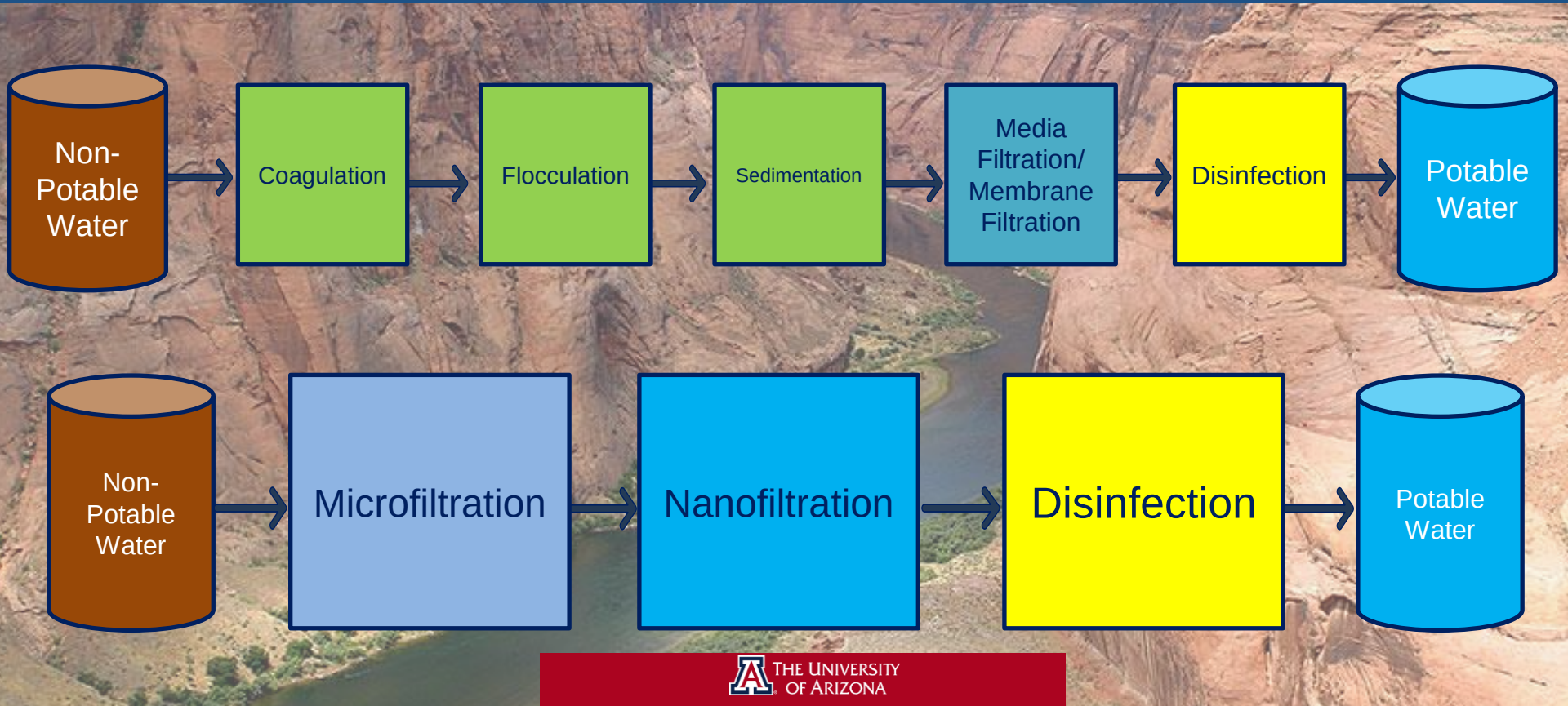
Treatment of Chemical Contaminants

- Coagulation and Flocculation
- Sedimentation
- Granular Media Filtration
- Membrane Filtration

Cutter Lateral Water Treatment Plant

Off-grid Solar Desalination

Examples of Water Treatment Systems



Coagulation and Flocculation

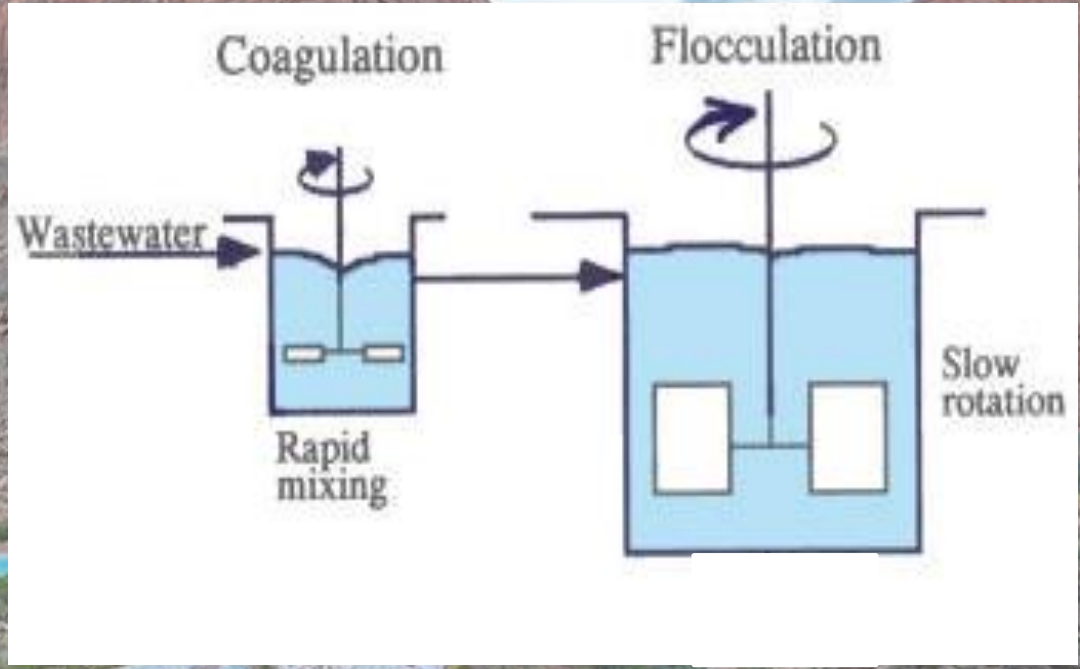
Ideal for removing suspended solids

Coagulation

- Addition of chemicals to destabilize particles for flocculation

Flocculation

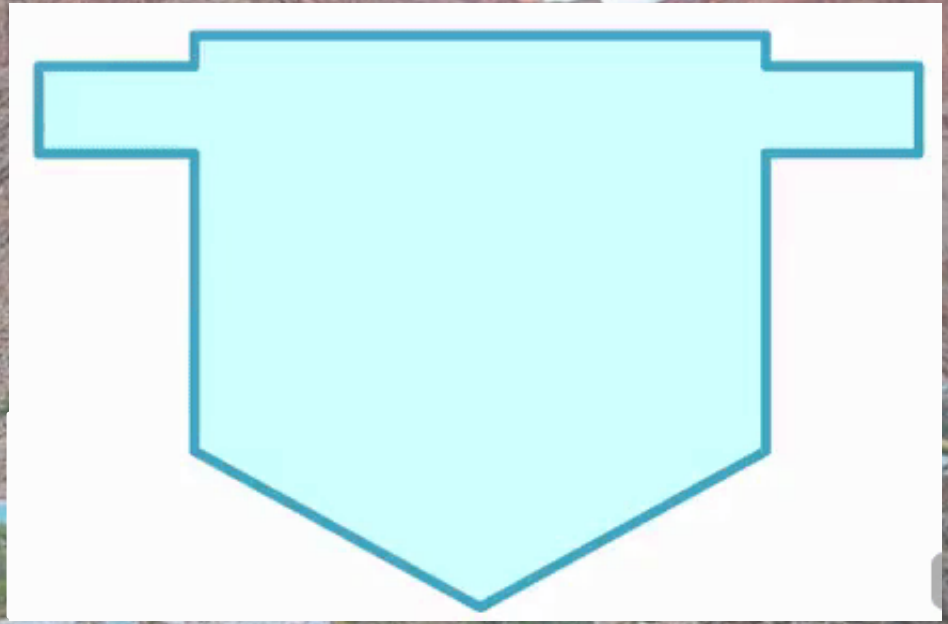
- Process of bringing the particles together so that they aggregate into larger particles



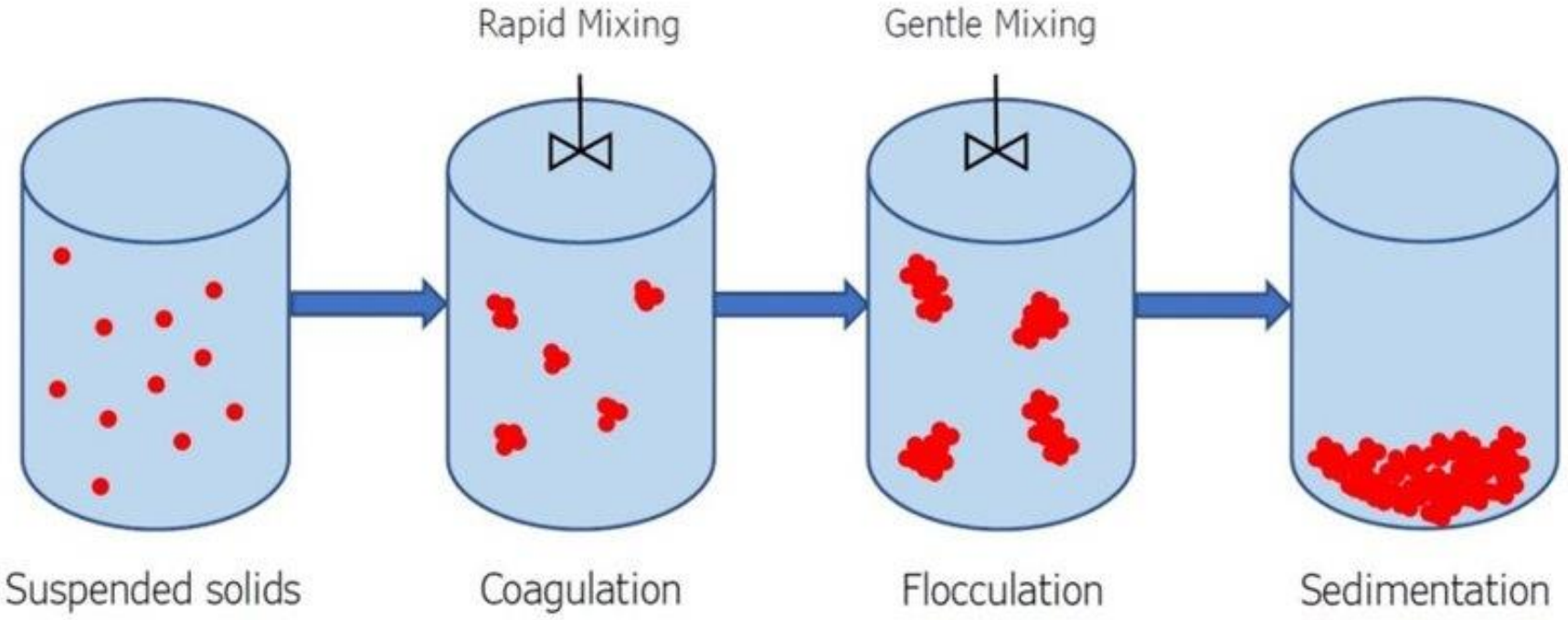
Sedimentation

Occurs after coagulation and flocculation

- Very basic process where particles settle to bottom of a tank because it has very little/no flow or disturbance
- The water resides here for time periods ranging from 2 to 8 hours and flocculated particles settle out as a sludge.
- Can be used in water treatment plants, but also at any scale



Coagulation, Flocculation, and Sedimentation Example



Granular Media Filtration

- Primarily used for organic molecules
- Considered ancient technology
- Improves taste
- Can use a variety of different media, including sand, activated carbon, and anthracite (a kind of coal)

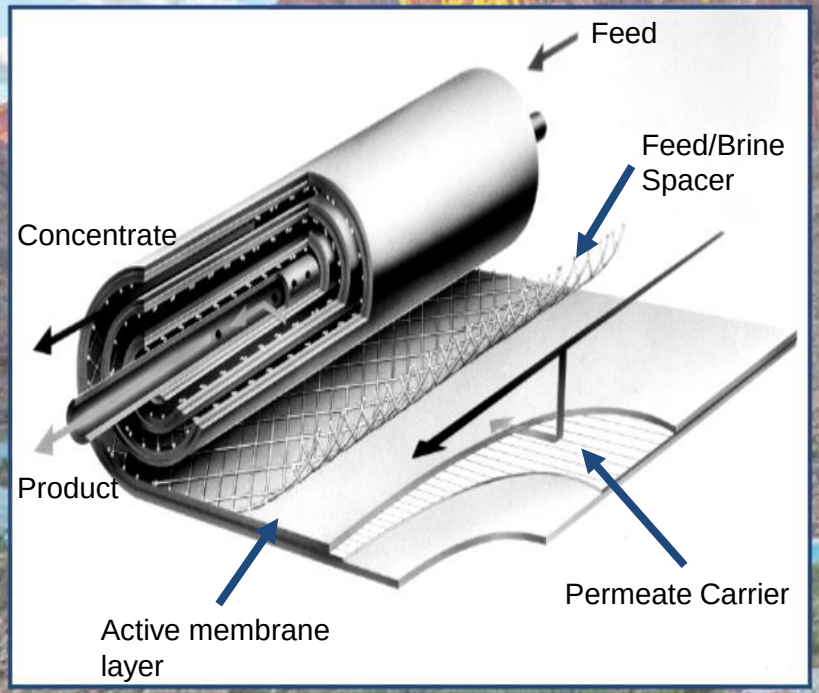






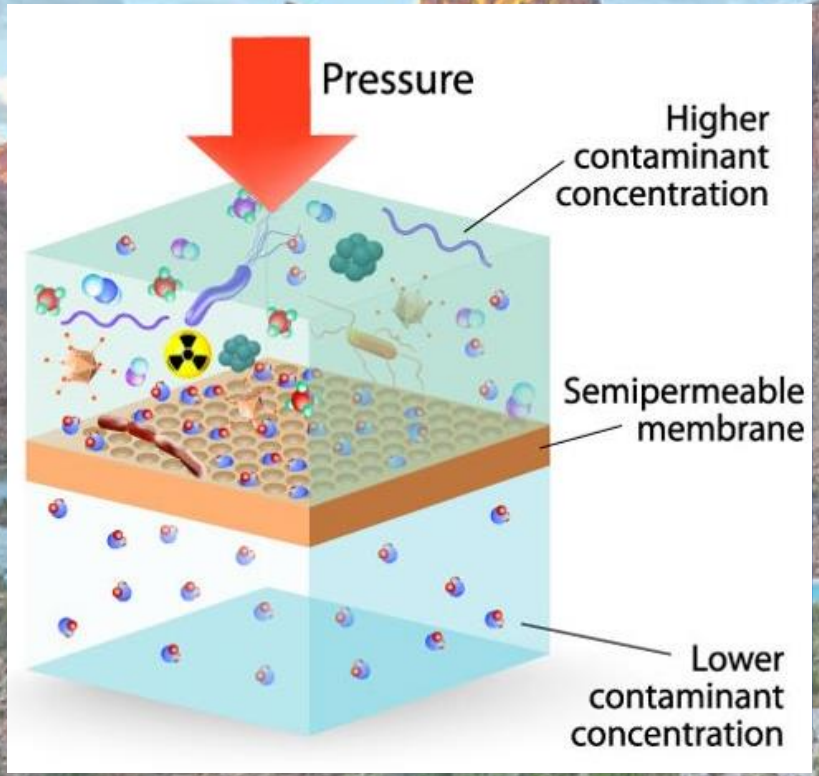
Fernandes, Ana & Gomes, Henrique & Campello, Eduardo M. B. & Pimenta, Paulo. (2017). A Fluid-Particle Interaction Method for the Simulation of Particle-Laden Fluid Problems. 10.20906/CPS/CILAMCE2017-0139.

Membrane Filtration



- Uses Semipermeable membranes
- Separate constituents based on physical properties (ex. size) and chemical properties (ex. charge)
- Used for removing dissolved contaminants that cannot be removed by pervious methods
- Used to remove heavy metals and salts

Membrane Filtration



- Uses Semipermeable membranes
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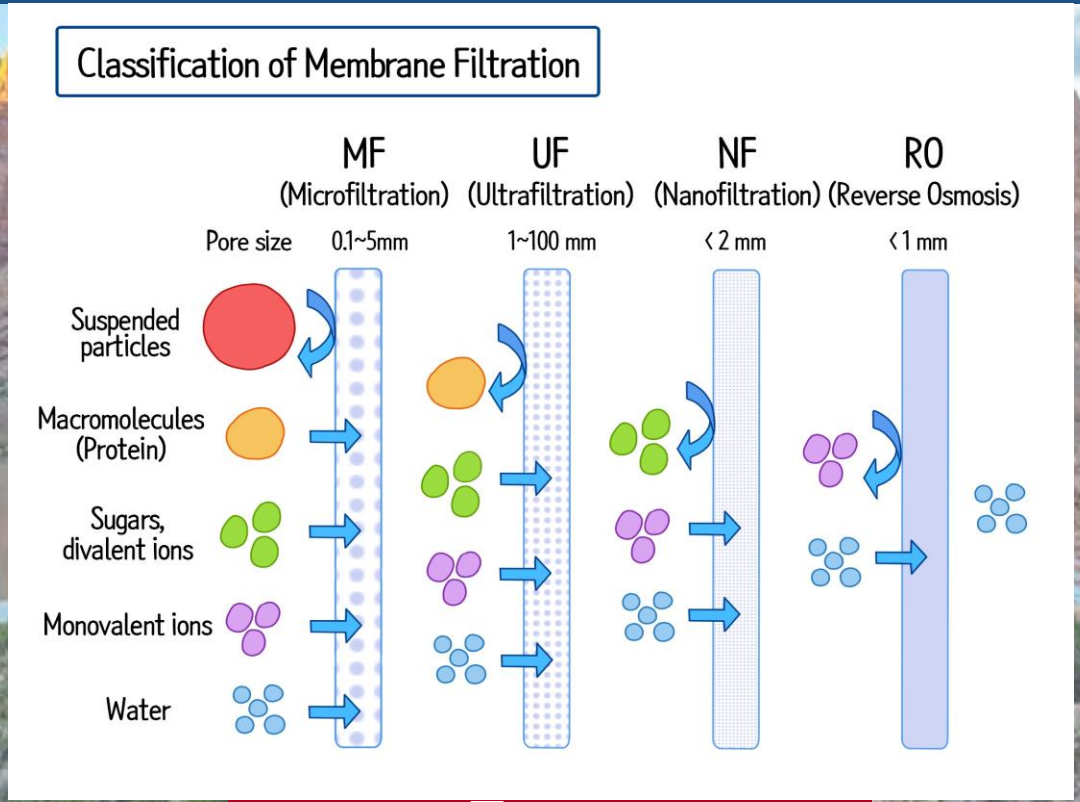
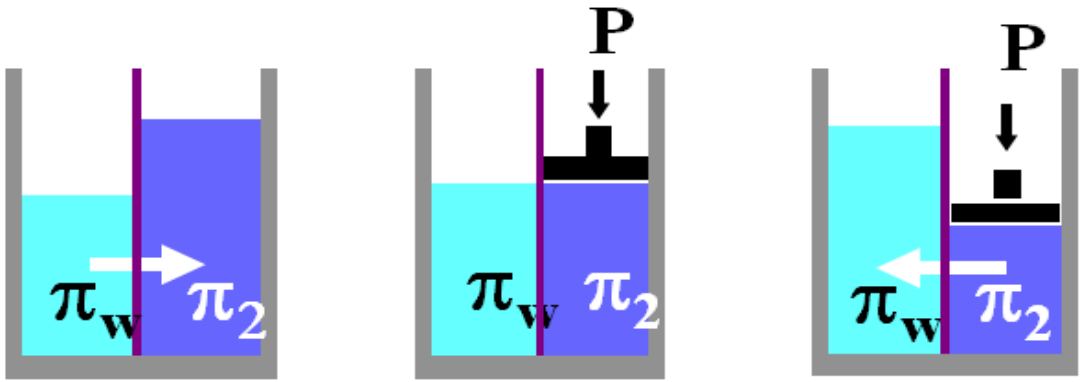
Contaminants removed depend on membrane characteristics



What is *reverse* Osmosis (or nanofiltration)?



osmosis	equilibrium	reverse osmosis
$\pi_w < \pi_2$	$P = \Delta\pi$	$P > \Delta\pi$

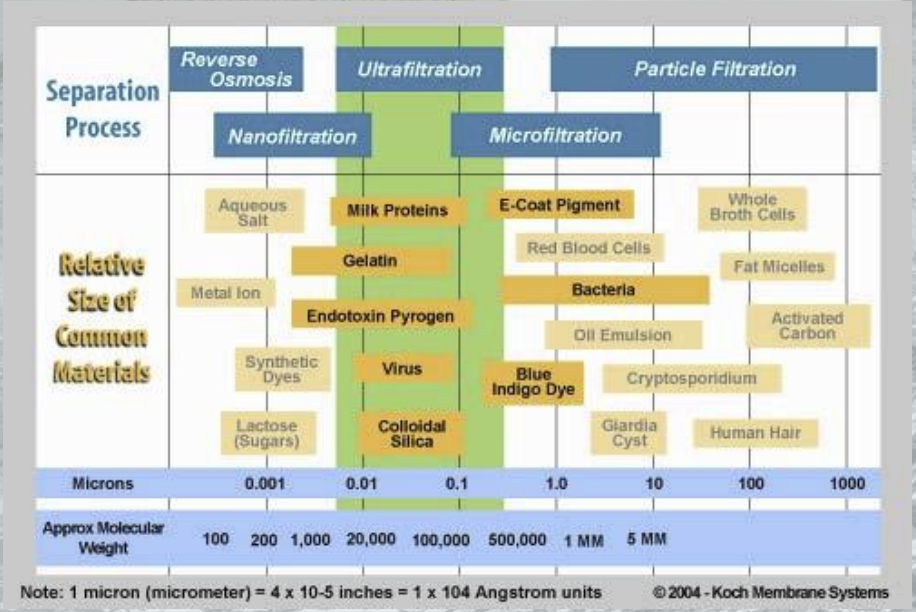
Treatment of Microbial Contaminants

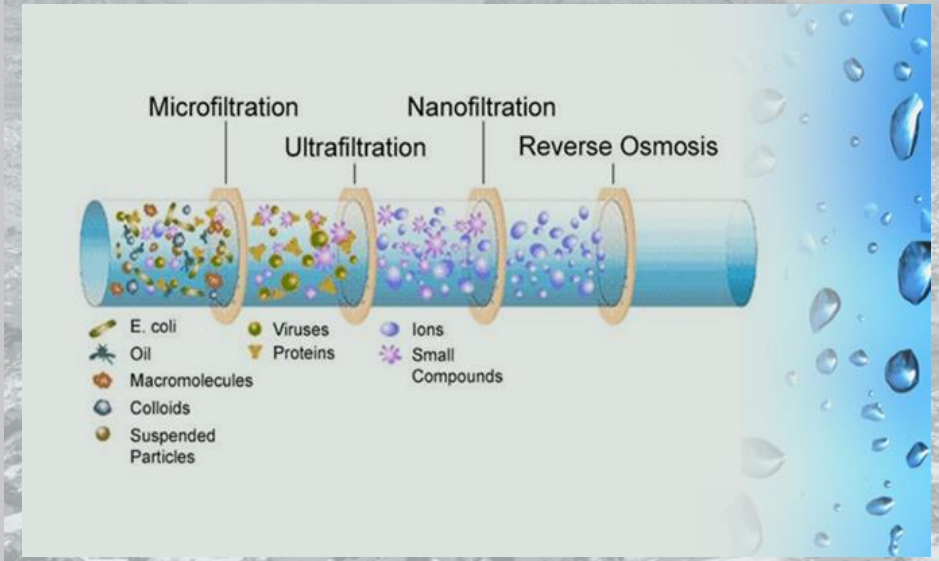
- Size Exclusion
- UV Disinfection
- Chlorine Dose and Time

Cutter Lateral Water Treatment Plan

Off-grid Solar Desalination

Size Exclusion is Inclusive





UV Disinfection

Table 19.3 UV Radiation Advantages and Disadvantages

Advantages	Disadvantages
Excellent germicidal qualities	Turbidity levels affect UV radiation's ability to disinfect, allowing possible microbial survival
Effectively destroys microorganisms	Maintenance includes regular tube cleaning and replacement as needed; periodic acid washing removes chemical buildup
Use in hospitals, biological testing facilities, and many other similar locations for sterilization means effectiveness is well tested	Extremely hazardous to the eyes; requires proper eye protection

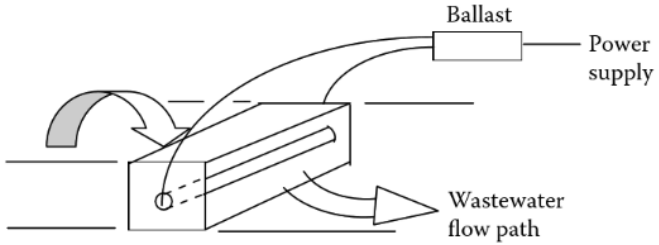
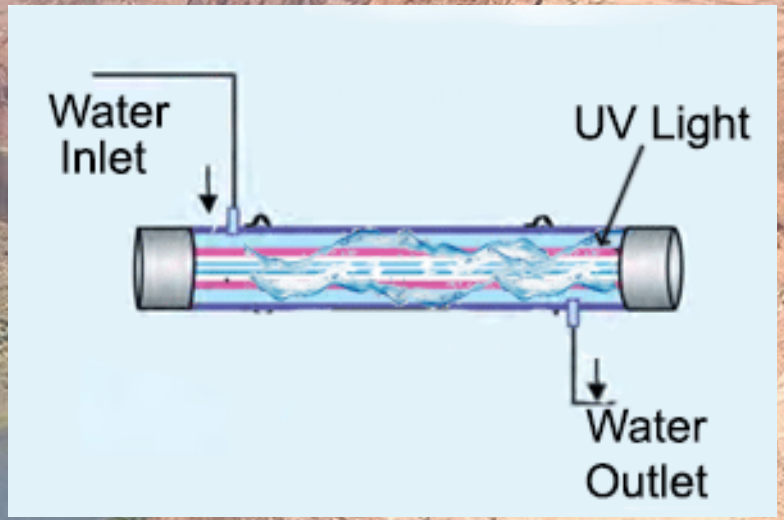
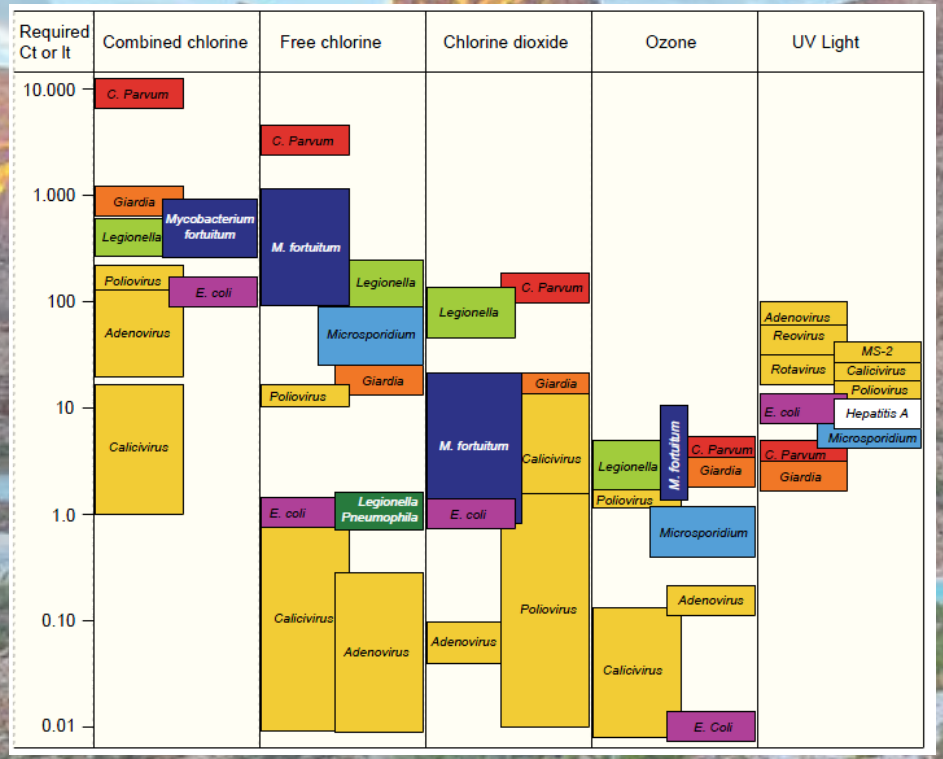


Figure 19.6 UV schematic. (Adapted from USEPA, *Design Manual: Municipal Wastewater Disinfection*, Washington, DC, 1986, p. 158.)



A Mathematical Approach to Dose and Time



CT = concentration x time

Log inactivation:
Log 2 = 99%
Log 3 = 99.9%
Log 4 = 99.99%
Log 5 = ???

What would Log 5 be in percentage(%)?

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