



*Inferior water quality?
Is it the end of the road?*



General

A few definitions

Impurities in water

Processes

My operation? My choice?

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General



We are not all super heroes but we still function

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General



Horses for courses

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A few definitions

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Water purification/treatment

The process of removing undesirable chemicals, biological contaminants, suspended solids, solid waste, liquid waste and gases from contaminated water.

The goal is to produce water fit for a specific purpose.



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solution colloid suspension

smallest ← → largest

Particle size less than 10^{-7} cm	Particle size between 10^{-7} cm and 10^{-5} cm	Particle size Greater than 10^{-5} cm
10^{-7} cm	10^{-5} cm	

True Solution Colloidal Solution Suspensions

Three Types of Solution

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Solutions: *A solution is a homogeneous mixture when 2 or more substances are dissolved together.

Colloids: *A colloid contains particles that are in-between in size. They do not separate into layers. Fog is a colloid. A property of a colloid is a scattering of light.

Suspensions: *A suspension is a heterogeneous mixture, it separates over time. A great example is oil and vinegar or sand and water.

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Impurities in water

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Visible Non visible

Filter medium Membrane

- Sand/clay
- Undissolved organic substances
- Suspended
- Colloidal solutions, cloudiness
- Oil emulsions
- Macromolecules
- Bacteria, cells
- Viruses
- Proteins
- Low-molecular organic compounds
- Multi-charged ions
- Single-charged ions


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Table 6
The priority list of organic contaminants for monitoring in the drinking water value chain

Industrial chemicals (28)	Pesticides (37)	Disinfection by-products (DBPs) (13)	Polymer residues (7)	Cyanotoxins (9)	PPCPs (8)
Benzene	2,4-Dichlorophenoxyacetic acid (2,4-D)	Chloroform*	Arylamides	Seco-cyano*	17β-Estradiol
Chlorobenzene	2,4,5-TP	Bromochloromethane*	Quinoline	2,8-DiA*	Estrol
1,2-Dichlorobenzene	Fenoprop	Chloroacetonitrile*	Diallyldimethylammonium chloride	Arachin-a	Estrore
1,2,4-Trichlorobenzene	MCPA	Formaldehyde	Dimethylamine	Formononetin-a	17α-Ethinodiol
1,4-Dichlorobenzene	Azinph*	Trichloroethylene	Acetamide	Acetamin-a	Diethylstilbestrol (DES)
Perchlorobenzene	Diazin*	Monochloroacetic acid	Monochloroacetic acid	Monoglutin-LR	
p-Chlorophenol	Azinph and metabolites*	Dichloroacetic acid	2,3-Dichloro-1-propanol	Saxitoxin	
2,4-Dichlorophenol	Chlorpyrifos	Bromoacetic acid	3-Chloro-1,2-propanediol	Cylindrocapsin	
2,4,6-Trichlorophenol	Cyfluthrin	Chloroacetic acid		Rebunin	
Permethrin	DDE*	Bromoacetic acid			
D,2-bis(2-ethylhexyl)phthalate	DDE*	Bromochloroacetic acid			
D,2-bis(2-ethylhexyl)phthalate (DEHP)	DDE*	Trichloromethane			
2,3,7,8-Tetrachlorodibenzo-p-dioxin	Endosulfan	Trichloroethylene			
Trichloroacetic acid (TCA)	Endosulfan sulfate				
Benzodiphenyls	β-Endosulfan				
Bisphenol A	Endrin				
Styrene	Endrin*				
p-Dichlorophenol	Heptachlor epoxide				
p-Nonylphenol	Lindane				
Polychlorinated biphenyls	Mecorfenox				
(Aroclor 1016, Aroclor 1248, Aroclor 1254, Aroclor 1260)	Methoxychlor				
Toxane	Permethrin				
Xylene isomers	Permethrin*				
Chloroform	Terbufos				
Dimethyltin	Acetochlor ethanesulfonic acid				
Thiopyrin	Acetochlor				
	Acetochlor oxalic acid				
	Mesochlor ethanesulfonic acid				
	Mesochlor oxalic acid				
	Acidic*				
	Chloroform				
	Chloroform cis trans isomers				
	Hexachlorobenzene (HCB)				
	HCH isomers				
	Cypermethrin				

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Processes of purification or treatment

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Where water treatment is concerned... Size does matter!




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Processes

- Physical – big
 - Flocculation (\$)
 - Filtration
 - Macro filtration (\$\$)
 - Ultra filtration (\$\$\$)
 - Nano filtration (\$\$\$\$\$)
 - Reverse osmosis (\$\$\$\$\$)
 - Sedimentation (\$\$)
- Chemical – small
 - Disinfection/Sanitation
 - Chlorination (\$)
 - Ultraviolet radiation (\$\$)
 - Oxygenation/Aeration (\$\$\$)
 - Ozonation (\$\$\$\$)
 - Peroxide (\$\$\$)
 - Coagulation (\$\$\$\$\$)
 - Cation exchange (\$\$\$\$\$)



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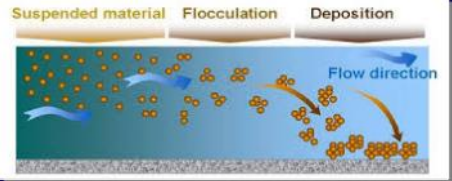


Physical processes

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Flocculation ⁽¹⁾

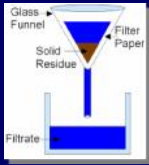

- Wherein colloids come out of suspension and form a flake or flock either spontaneously or due to a clarifying agent
- Colloids flocculated are not dissolved in solution but are in suspension
- Flocculants
 - Polyamides (PAM)
 - Ferri-chloride
- Flocculation with filter is a continuous process
- Flocculation with sedimentation is a batch process



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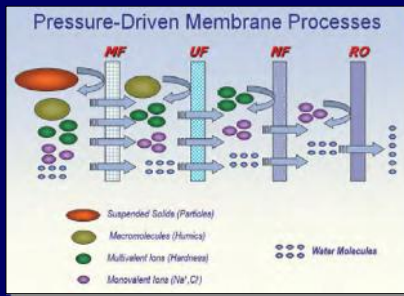
Filtration ⁽¹⁾

- Various processes (mechanical or physical) to separate solids from fluids by interposing a medium through which only a fluid can pass.
- The fluid passing through is referred to as the filtrate
- Filtration or membrane processes
 - Macro filtration
 - Ultra filtration
 - Nano filtration

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Filtration ③



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Filtration ④

1. Membrane filtration

- Fluid passed through sieve-like membrane to separate large compounds or suspended particles
- Macro filtration
 - Soil particles
 - Un-dissolved compounds



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Filtration ⑤

2. Ultra filtration

- Fluid passed through a pore sized membrane to separate micro-organisms from liquid
- Macro
 - Suspended particles
 - Colloidal compounds
 - Oils and emulsions
- Filters
 - Carbon filters
 - Compound
 - Material filters



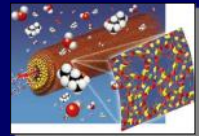
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Filtration ⑥

3. Nano filtration

- Membrane filtration with low TDS water
 - Close to Reverse Osmosis
- Softening (polyvalent cation removal) and removal of disinfection by product precursor
 - Natural organic substances
 - Synthetic organic matter
- Micro
 - Macro molecules
 - Bacteria, cells, viruses, protein



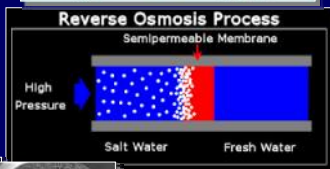
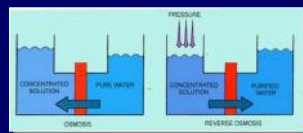
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Filtration ⑦

4. Reverse Osmosis

- Semi-permeable membrane removes ions & molecules through osmosis
- Waste product & membrane replacement
- A membrane process
 - Multi and single charges ions
 - Low molecular



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Reverse osmosis Single and multi charged ions

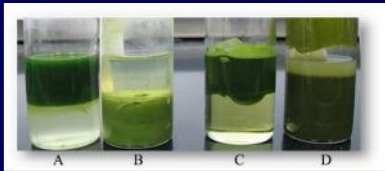
Symbol	Common name	Effect
CaCO ₂	Limestone	Soft scale
Ca(HCO ₃) ₂		Soft scale with CO ₂
CaSO ₄	Gypsum, plaster of paris	Hard scale
CaCl ₂		Corrosion
MgCO ₃		Soft scale
MgSO ₄	Magnesite	Corrosion
Mg(HCO ₃) ₂	Epsom salts	Scale and corrosion
NaCl	Common table salt	Electrolysis
Na ₂ CO ₃	Washing soda	Alkalinity
NaHCO ₃	Baking soda	Priming and foaming
NaOH	Caustic soda	Alkalinity and embitterment
Na ₂ SO ₄	Glauber salts	Alkalinity
SiO ₂	Silica	Hard scale
Fe ²⁺ and Fe ³⁺	Iron compounds	Encrustation, staining of toilet fixtures
Mn ²⁺	Manganese compounds	Encrustation, staining of toilet fixtures
Cl	Chloride compounds	Corrosiveness
F ⁻	Fluoride compounds	Fluorosis

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Sedimentation (3)

- Particles in suspension is settled out of the fluid and retained against a barrier due to existing forces in the fluid
 - Gravity
 - Centrifugal acceleration
 - Electromagnetic
- Sedimentation is transported into a settling area and disposed of
- Disposal and environmental impact



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Chemical processes

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Disinfection/Sanitation (3)

- Antimicrobial agent applied to no living objects to destroy micro organisms living on objects
- Disinfection to remove pathogens

1. Chlorination

- Adding chlorine gas (Cl_2) or hypochlorite (OCl^-) to water to kill bacteria and other microbes
 - Increased ORP (Oxidation reduction potential) – shorting out microbes
- Chlorine highly toxic
- Chlorinate only when low sodium concentration (Sea salt v. table salt)
- Also prevent spread of water born diseases such as cholera, dysentery, typhoid etc



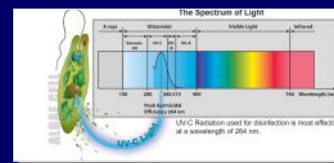
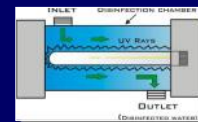
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Disinfection/Sanitation (3)

2. Ultra-violet radiation

- Short wavelength ultra-violet discharged from ultra-violet tubes to kill or inactivate micro organisms such as bacteria, viruses and molds by destroying nucleic acids
- No chemical compounds used although chemical reaction
- Placement of UV system important – specifically on final used water
 - Contact process



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Disinfection/Sanitation (3)

3. Oxygenation or Aeration

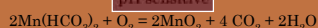
- Air and water is brought into contact to de-carbonate, oxidize iron and manganese and reduce ammonia and hydrogen sulfide



Ferrous bicarbonate converted to ferric hydroxide

(removed through clarification (coagulation and/or flocculation and/or sedimentation) with or without filtration)

pH sensitive



Manganese bicarbonate converted to manganese dioxide

(removed through clarification (coagulation and/or flocculation and/or sedimentation) with or without filtration)

- Waterfall aerator method using spray nozzles breaking down water into small droplets to enhance countercurrent air contact
- Air diffusion method where air is diffused into a receiving vessel containing counter current flowing water creating air bubbles

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Disinfection/Sanitation (3)

- Supplies increased oxygen concentration in water
- Recycling systems – have to cascade water
- Soil water always need aeration – cascading of water
- Important facts
 - Temperature dependant
 - 10% O_2 in water naturally – temperature determines
 - High temperature = between 8 to 10% (water quality dependent)
 - Temperature increased necessary
 - above 24 °C – loss of 1% O_2 for every degree increase – anaerobic conditions follow
 - pH dependant
 - pH < 4 – highly oxidized Mn & Fe
 - Not effective at pH above 5.5

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Disinfection/Sanitation (4)

4. Ozonation

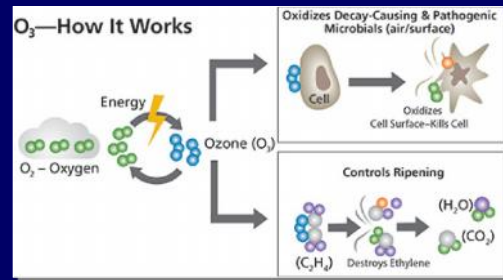
- Dry clean air is passed through a high voltage electric discharge creating ozone of approximately 1% or 10 000 mg.L⁻¹
- Raw water is then passed through a venturi creating a vacuum pulling ozone gas into the water bubbling and treating the water
- As ozone reacts with water metals created in metal oxide forms need to be filtrated
 - Not pH dependant for effectiveness
 - With increase in O₃ slightly decrease in pH
- Disinfection effectiveness against bacteria, viruses (greater than chlorination) and oxidizing properties of ozone make elements like iron, manganese, sulphur plant unavailable or chemically inert



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Disinfection/Sanitation (6)



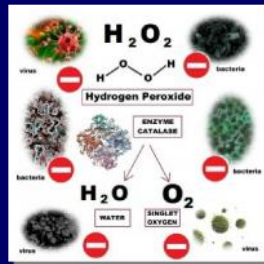
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Disinfection/Sanitation (5)

5. Peroxide treatment

- Hydrogen peroxide breaks down into two extra oxygen atoms (peroxide bond) with two H-O radicals
 - Depresses pH slightly
- Disinfection effectiveness against bacteria, viruses
- System installation important



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Disinfection/Sanitation (7)



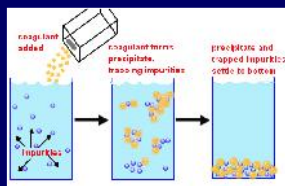
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Coagulation (3)

• Coagulation

- A coagulant (metallic salt) with an opposite charge to colloid is added to water to “destabilize” suspension and cause particles to cling together (agglomerate) and form a micro floc or flake
 - Then filtration and sedimentation of floc or flake



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Cation exchange membranes (4)

• Cation exchange membranes

- Water softening – calcium, magnesium, carbonates and bicarbonate
 - Hard water
- Continuous flow system through cation and then anion reactors
 - Exchange process
- Resin refill or replace
 - Resin chosen based on which cation or anion is removed



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My operation? My choice? (3)

H₂O quality determines class or type of treatment



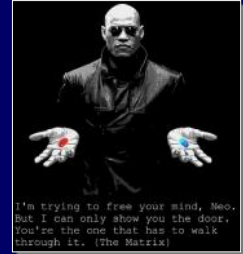
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My operation? My choice? (3)

Your specific problem...

- Physical?
 - Coffee filter paper – if colour does not change – what is in water?
 - If water changes – initial colour
 - Brown = Ferri-chloride (Flocculation/Sedimentation/Filtration)
 - Green = PAM (Flocculation/Sedimentation/Filtration)
 - Sanitize – Yes or no?
- Chemical?
 - Ion exchange



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My operation? My choice? (3)

- Get a specialist not a supplier
 - Expectations and delivery



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My operation? My choice? (3)

Usual problems for a chosen installed system not working

- Common sense
- pH
- Temperature
- Flow direction
- Pipe diameters
- Time

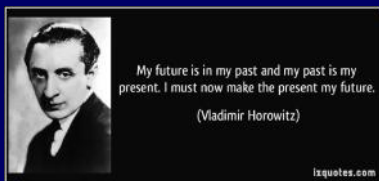


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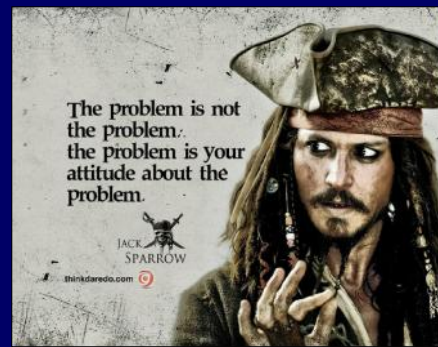


My operation? My choice? (3)

- Water quality changes
 - The only constants are taxes, death and water quality changes
 - Choose carefully!
- Future problems
 - Chemical pollution
 - Increased salt contamination



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Problem? What problem?

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