Appendix B

NanoTreatment Cards

Note: Print these cards on cardstock and laminate them for repeated use.

Water Quality Problem 1

Cleaning water for drinking, cooking, and bathing in a first-world country

What contaminants affect this water?

Bacteria

Pesticides

What other factors do you need to consider?

- Literate population
- Expects clear water = clean water

Water Quality Problem 2

Cleaning water for cooking and drinking in a third-world country

What contaminants affect this water?

Bacteria

Viruses

Cyanide

What other factors do you need to consider?

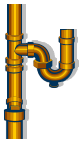
- Illiterate population
- Little to no infrastructure to support large-scale water treatment

Water Quality Problem 3

Cleaning water for irrigation in a second world country

What contaminants affect this water?

Cadmium



Lead

Pesticides

What other factors do you need to consider?

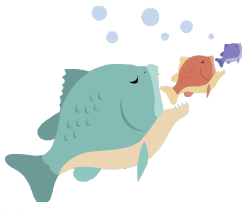
- Semi-literate population
- Intermittent power supply

Water Quality Problem 4

Cleaning water for industrial use in soft drinks

What contaminants affect this water?

Cadmium



Mercury

What other factors do you need to consider?

- Lots of existing systems
- Removal of taste and odor is key

Water Quality Problem 5

Cleaning water for vaccines

What contaminants affect this water?

Viruses

Bacteria

What other factors do you need to consider?

- Lots of existing systems
- No shortage of energy
- Removal of all contaminants is key

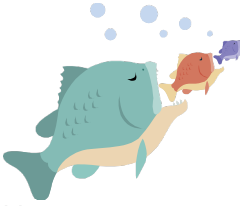
Water Quality Problem 6

Desalinating ocean water to use as drinking water

What contaminants affect this water?

Salt

Bacteria



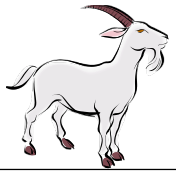
Mercury

What other factors do you need to consider?

- Requires a lot of energy
- We typically extract salt out of the water – is there a way to extract only the water?

Water Quality Problem 7

Treating water for livestock to drink



What contaminants affect this water?

Pesticides

Bacteria

What other factors do you need to consider?

- Electrostatic interactions are sensitive to pH and salt concentrations

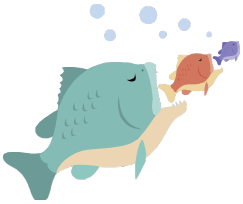
Water Quality Problem 8

Reclaiming water contaminated by industrial use

What contaminants affect this water?

Lead

Cadmium



Mercury

What other factors do you need to consider?

- Lots of existing systems

Nano-Link

Water Contaminant B

Coliform bacteria 

Source: Soils, plants, animals, human sewage, agricultural and storm runoff.

Hazards: Most coliform bacteria do not cause disease, but are an easy way to monitor for more dangerous organisms that cause diarrhea.

Size: 500–2000 nm

Dominant force(s): Gravity, Electrostatic (influenced weakly by charge)

Water Contaminant V

Viruses 

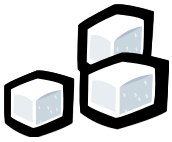
Source: Fecal matter, animal urine

Hazards: Hepatitis, meningitis, colds, gastroenteritis.

Size: 27–35 nm

Dominant force(s): Electrostatic (influenced by charge) electrostatic interactions, which are sensitive to pH and salt concentrations

Water Contaminant S

Salts 

Source: Contact with the ground and oceans in the water cycle

Hazards: Drinking salt water causes dehydration, nausea, weakness, and possible death.

Size: 0.09–0.206 nm

Dominant force(s): Electrostatic, (influenced strongly by charge)

Water Contaminant P

Pesticides 

Source: Runoff from pesticide application, water treatment plants (chlorine), pesticide disposal.

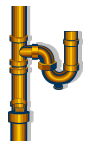
Hazards: Effects depend on type, amount, and duration of exposure, but include cancer, nerve damage, and hormone disruption.

Size: 0.240–0.750 nm

Dominant force(s): Electrostatic (influenced by charge), larger ones are influenced by gravity

Water Contaminant L

Lead
(Pb++ or Pb+)



Source: Lead pipes and solder that is used to connect pipes. Leaded gasoline.

Hazards: Mental and physical development delays in children; high blood pressure and kidney problems in adults.

Size: 0.079–0.143 nm

Dominant force(s): Electrostatic (influenced heavily by charge)

Water Contaminant C

Cadmium
(Cd++)

Source: Corrosion of galvanized pipes; erosion of natural deposits; discharge from metal refineries; runoff from waste batteries and paints.

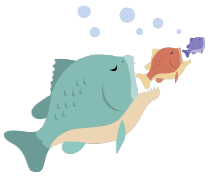
Hazards: Kidney damage

Size: 0.092–0.124 nm

Dominant force(s): Electrostatic (influenced heavily by charge)

Water Contaminant M

Methylmercury



Source: Industrial processing of coal and metals contributes mercury to aquatic systems where it complexes to form methylmercury. It is biomagnified in these food chains.

Hazards: Impaired neurological development in children (for example, thinking, memory, attention, language, and fine motor and visual spatial skills)

Size: 0.110–0.133 nm

Dominant force(s): Electrostatic (influenced by charge)

Water Contaminant Y

Cyanide (CN^-)

Source: Industrial contamination from production of paper, textiles, plastics

Hazards: Lowers B12 levels, prevents cells from using oxygen, disrupts thyroid and nervous system function.

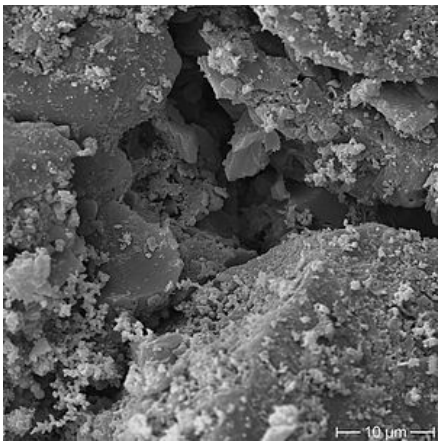
Size: 0.090 nm

Dominant force(s): Electrostatic (influenced heavily by charge)

Nanotechnology: Activated Carbon / Activated Charcoal

Potential

- Effective adsorbent of a variety of non-polar substances—typically taste and odor.



Risks

- Non-toxic
- Does not affect metals, Cyanide, or alcohol; destroyed by high or low pH

Subject to forces: Electrostatic (influenced weakly by charge)

Size: 2–50 nm

Image: Activated Charcoal through a Scanning Electron Microscope

Credit: http://upload.wikimedia.org/wikipedia/commons/thumb/6/65/Activated_Charcoal.jpg/300px-Activated_Charcoal.jpg

Nanotechnology: Solar Water Disinfection

Potential

- Sunlight through clear water for 6+ hours will treat most water for bacterial pathogens.
- This process is sped up by adding a catalyst such as silver and titanium dioxide nanoparticles.

Risks

- Creation of free radicals and silver chloride in the body
- Cellular death
- Accumulation in the liver
- Smaller particles are more reactive than larger ones

Subject to forces: Electrostatic (influenced heavily by charge)

Size: 1–100 nm

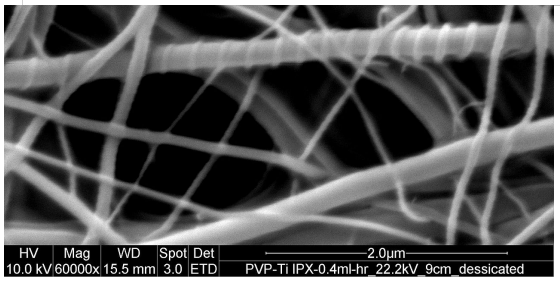
Image: A Solar Water Disinfection table

Credit: http://upload.wikimedia.org/wikipedia/commons/thumb/6/67/Indonesia-sodis-gross.jpg/320px-Indonesia-sodis-gross.jpg

Nanotechnology: Nanobiocides

Potential

- Nanobiocides such as metal nanoparticles and engineered nanomaterials are successfully incorporated into nanofibers showing high antimicrobial activity and stability in water.
- Titanium dioxide nanoparticles break down common organic contaminants such as hormones, pharmaceuticals, or manure—when exposed to light
- Nano-sized Silver is used to kill bacteria.



Risks

- Creation of free radicals and silver chloride in the body
- Cellular death
- Accumulation in the liver
- Smaller particles are more reactive than larger ones

Subject to forces: Electrostatic (influenced heavily by charge)

Size: 1 to 100 nm

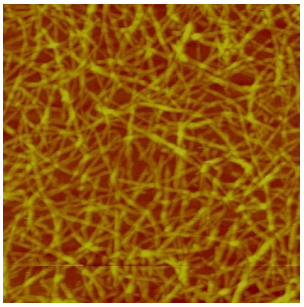
Image: Titanium Dioxide nanofiber spiral

Credit: http://upload.wikimedia.org/wikipedia/commons/thumb/2/25/Titanium_dioxide_nanofiber_spiral.jpg/220px-Titanium_dioxide_nanofiber_spiral.jpg

Nanotechnology: Nano-cellulose filter

Potential:

- From plants or bacteria
- Transparent, electrically conductive, stronger than steel
- Nanocellulose can filter out nitrates in city water, paint dye residues in printing and textiles, and metal ions from industrial waste. It has also been shown to remove virus particles.



https://en.wikipedia.org/wiki/Nanocellulose#/media/File:AFM_Innventia_nanocellulose.JPG

Risks:

- Biodegradable
- Inert
- Non-toxic
- Stable in wide range of pH

Subject to forces:

Size: 5-20 nm x 10 nm to several micrometers

Image: Carboxymethylated nanocellulose

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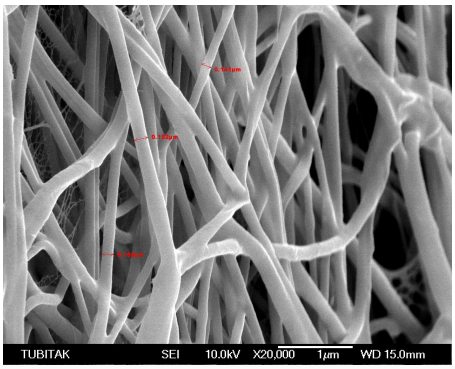
Nanotechnology: Electrospun Nanofibers

Potential

- Useful in filtration—these fibers can be built into membranes with a high surface area. Also, the material being spun can be manipulated to give control over pore size and modification of the surface chemistry.

Risks

- May carry similar risks to manufacturers as asbestos fibers: cancer



Credit: http://upload.wikimedia.org/wikipedia/commons/thumb/d/db/N2_2.kesit.JPG/220px-N2_2.kesit.JPG

Subject to forces: Varies depending on composition.

Size: 10–1,000 nm

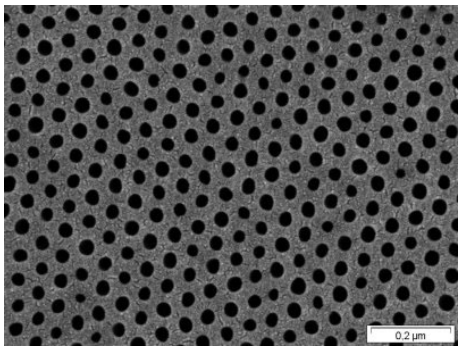
Image: Electrospun Nanofibers

Nanotechnology: Nanoporous membrane

Potential:
These self-assembled membranes are used to desalinate saltwater, and remove molecules such as micro-pollutants and pharmaceutical residues from water.

Risks:

-



www.nanowerk.com/news2/newsid=29282.php

Subject to forces:

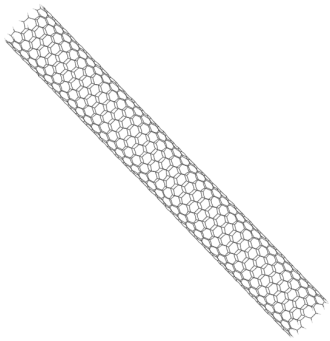
Size: 3 - 15 nm

Image: Nanopore membrane

Nanotechnology: Carbon Nanotubes

Potential

- Water can travel through the tube, while other materials cannot.



Risks

- Can cross the cell membrane.
- May interfere with or damage DNA
- May carry similar risks as asbestos fibers: cancer

Subject to forces: Electrostatic (variably influenced by charge)

Size: 1.0 nm diameter

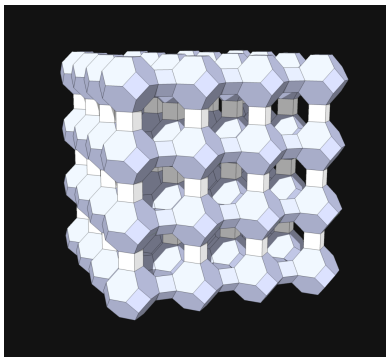
Image: Simulated Carbon NanoTube

Credit: Source=Wikipedia commons |Date=03 03 2007 |Author=User:Gmdm |

Nanotechnology: Zeolyte

Potential

- Utilizes the existence of nanoscopic pores in zeolite to act as a molecular sieve
- Exchanges Na^{+} for other ions, such as K^{+}, $Ca^{+,}$ Mg^{2+}, Cu^{2+}



Risks

- Naturally occurring substance.
- None known when used in processing water. Not recommended to take internally.

Subject to forces: Electrostatic (influenced heavily by charge)

Size: 0.003–0.010 nm

Image: Zeolite

Credit: http://commons.wikimedia.org/wiki/Category:Zeolite#mediaviewer/File:Struttura_molecolare_di_una_zeolite.png

Nano-Link