Reverse Osmosis (4)

Lecture 7

6. RO Problems

- Below is a summary of common problems in RO system experiences due to lack of proper pretreatment.

1. Fouling.
2. Scaling
3. Chemical attack
4. Mechanical damage

6.1. Fouling

- Fouling occurs when **contaminants** accumulate on the membrane surface effectively **plugging the membrane**.
- There are many **contaminants** in feed water that are obvious to the naked human eye and **harmless** for human consumption, but large enough to **quickly foul** (or plug) an RO system.
- **Fouling** typically occurs in the front end of an RO system and results in a **higher pressure** drop across the RO system and a **lower permeate flow**.

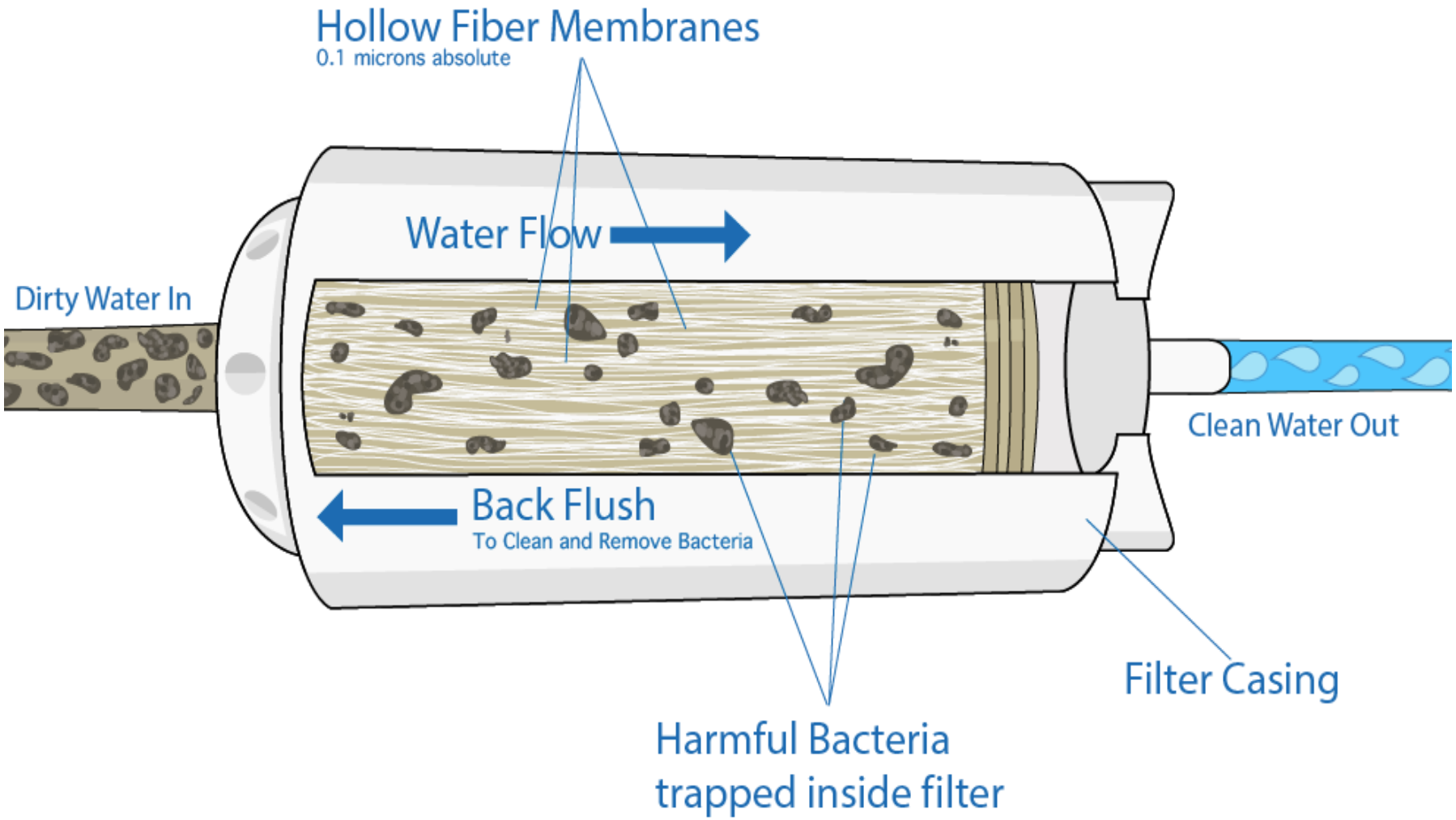
6.1. Fouling

- This translates into **higher operating costs** and eventually the need to **clean** or **replace** the RO **membranes**.
- **Fouling** will take place eventually **to some extent** given the extremely fine pore size of an RO membrane blocking, no matter how effective your pretreatment and cleaning schedule is.
- However, by having **proper pretreatment** in place, you will minimize the need to address fouling related problems on a regular basis.

6.1. Fouling

- Fouling can be caused by the following:
- 1. **Particulate** or colloidal mater (dirt, silt, clay, etc.).
- 2. **Organics** (organic acids, etc)
- 3. **Microorganisms** (bacteria, etc). **Bacteria** present one of the most **common** fouling problems since RO membranes in use today cannot tolerate a disinfectant such as chlorine and therefore microorganisms are often able to **thrive and multiply** on the membrane surface.
- They may produce **bio-films** that cover the membrane surface and result in **heavy fouling**.

6.1. Fouling


Hollow Fiber Membranes
0.1 microns absolute
Water Flow
Dirty Water In
Clean Water Out
Back Flush
To Clean and Remove Bacteria
Filter Casing
Harmful Bacteria
trapped inside filter

6.1. Fouling

- 4. Breakthrough of **filter media** upstream of the RO unit. Granulated Activated Carbon **(GAC)** beds and **softener** beds may develop an **under drain leak** and if there is not adequate post filtration in place the media can foul the RO system.
- By performing **analytical tests**, you can determine if the feed water to your RO has a high potential for fouling.
- To **prevent fouling** of an RO system, **mechanical filtration** methods are used.
- The most popular methods to prevent fouling are the use of **multi-media filters (MMF) or microfiltration (MF).**

6.1. Fouling

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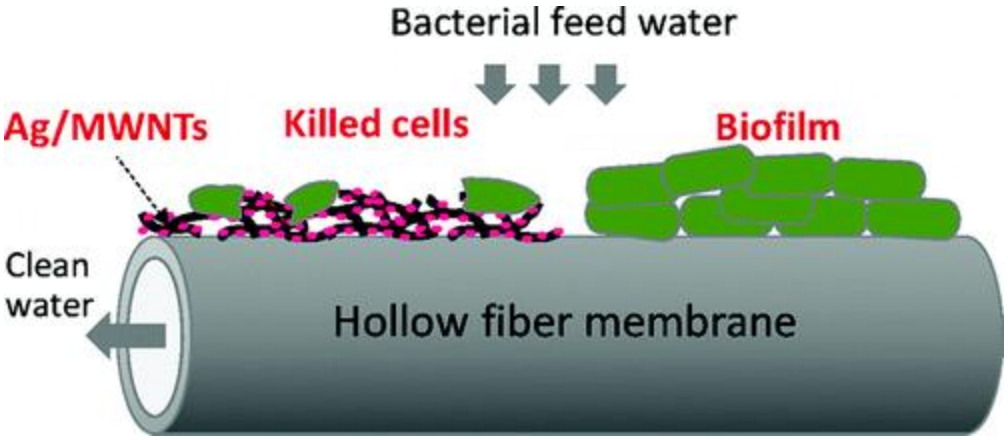
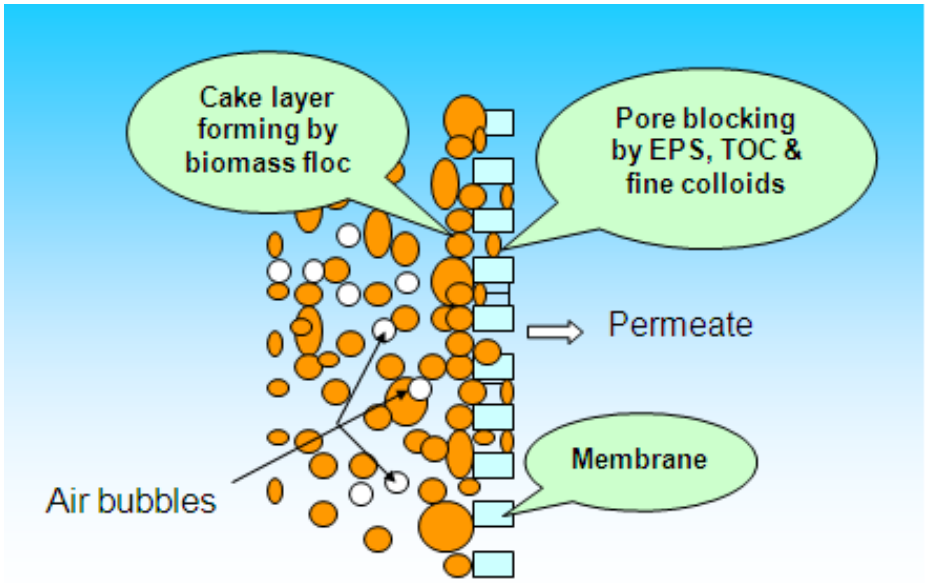

Bacterial feed water
Ag/MWNTs
Killed cells
Biofilm
Clean water
Hollow fiber membrane


Cake layer forming by biomass floc
Pore blocking by EPS, TOC & fine colloids
Permeate
Membrane
Air bubbles

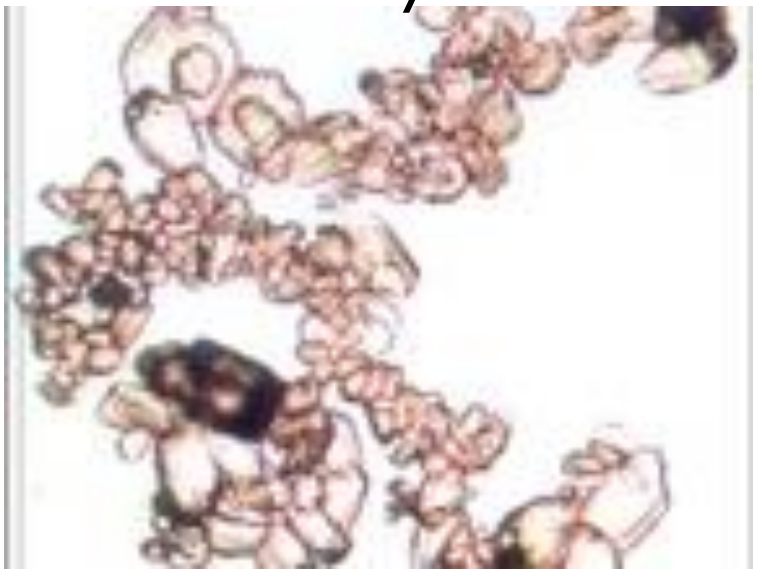
6.2. Scaling

- As certain **dissolved (inorganic) compounds** become more concentrated then scaling can occur if these compounds **exceed their solubility limits and precipitate** on the membrane surface as scale.
- The results of scaling are a **higher pressure drop** across the system, **higher salt passage** (less salt rejection), **low permeate flow** and **lower permeate water quality**.
- An example of a common scale that tends to form on an RO membrane is **calcium carbonate** (CaCO3), **calcium sulfate** ($CaSO_4$), **barium sulfate** ($BaSO_4$), and **strontium sulfate** ($SrSO_4$).
- Less common but equally problematic are **silica** (SiO_2) and **calcium fluoride** (CaF) scales.

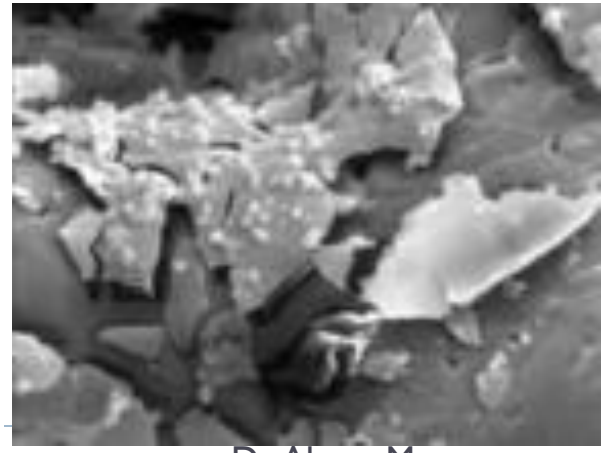
6.2. Scaling

Membrane plugged with scales

Scale crystals



Scanning electron microscope image



6.3. Chemical Attack

- Modern thin film **composite membranes are not tolerant to chlorine.**
- Oxidizers such as chlorine will **'burn' holes** in the membrane pores and can cause **irreparable damage**.
- The result of chemical attack on an RO membrane is a **higher permeate flow** and a **higher salt passage** (**poorer quality permeate water**).
- This is why microorganism growth on RO membranes tends to foul RO membranes so easily since there is no biocide to prevent its growth.

6.4. Mechanical Damage

- Part of the pretreatment scheme should be pre and post RO system plumbing and controls.
- If **'hard starts'** occur, **mechanical damage** to the membranes can occur.
- Likewise, if there is too much **backpressure** on the RO system then mechanical damage to the RO membranes can also occur.
- These can be addressed by using **variable frequency drive motors** to start high pressure pumps for RO systems and by installing **check valve(s) and/or pressure relief valves** to prevent excessive back pressure on the RO unit that can cause permanent membrane damage.

6.4. Mechanical Damage

6.4. Mechanical Damage

Questions

- **Answer with Yes or No and Correct the false ones:**

1. The result of chemical attack on an RO membrane is a higher permeate flow and a higher salt passage.
2. Fouling typically results in a lower pressure drop across the RO system and a lower permeate flow.
3. The results of scaling are a lower pressure drop across the system, lower salt passage.
4. The result of chemical attack on an RO membrane is a lower permeate flow and a higher salt passage.
5. Using variable frequency drive motors to prevent excessive back pressure on the RO unit.

Questions

- **Answer the following questions:**
- 1. Discuss the reasons of fouling of reverse osmosis membranes.
- 2. Reverse osmosis membranes are subjected to mechanical damage, explain the reason for this damage and how can you face these problems.
- 3. Chemical attack is one of the operating problems that facing reverse osmosis unit, discuss this sataement.