What is physical treatment? What is chemical treatment?

*Physical*: having material existence and subject to the laws of nature.

*Chemical*: any material used in, or produced by chemistry.

*Chemistry*: is the study of matter (composition, structure, and properties) and the changes it undergoes.

The key is the **change** that the matter undergoes.

In chemical transformation, the original substance turns into an entirely different substance after the transformation.

In physical transformation, the change is only in appearance but not in substance.
Physical treatment of water and wastewater is a process applied to water and wastewater in which no chemical changes occur.

Chemical treatment of water and wastewater is a process applied to water and wastewater in which chemical changes occur.
Process versus Operation?

In **PROCESS** chemical and biological forces are active. (e.g. adsorption, oxidation, activated sludge treatment)

In **OPERATION**, physical forces are active (e.g. mixing, filtration, aeration). Physical treatments are called unit operations.
Removable by plain settling

Removable by coagulation + settling and/or filtration

Need special methods

Settleable solids

1 mm coarse sand

10^{-1} fine sand

10^{-2} silt

Non-settleable solids

10^{-3} clay, bacteria, algae

10^{-4} fine clay, bacteria

Colloidal solids

10^{-5} colloidal clay, virus

10^{-6}

Dissolved solids

10^{-7} molecules

10^{-8} & atoms

- $10^{-2}$: naked eye limit
- $10^{-4}$: ordinary microscope limit
- $10^{-6}$: ultra microscope limit
1. Turbidity

Importance: Less attractive for drinking, swimming, etc. particles protect microorganisms from the effect of disinfectants.

Characteristics: Colloidal particles, e.g. clay, silt, metal oxides, plant fibers, algal cells.

Treatment: Coagulation, sedimentation, filtration.

2. Algae (colloidal size plants)

Importance: Cause taste and odor and turbidity.

Characteristics: Non-settlevable, colloidal microscopic plants.

Treatment: Coagulation, sedimentation, filtration, disinfection.

3. Pathogenic Microorganisms

Importance: Transmission of diseases through water.

Characteristics: Colloidal, bacteria, viruses, protozoa.

Treatment: Disinfection, coagulation, filtration.
4. Iron and Manganese
Importance: Staining, taste.
Characteristics: Dissolved solids.
Treatment: Chemical oxidation by $O_2$ (aeration), $O_3$, $Cl_2$, $KMnO_4$, etc.

5. Sulfides $\rightarrow H_2S$, Mercaptanes (organic S containing comp.)
Importance: Odor, taste, corrosion.
Characteristics: Dissolved solids (usually in groundwater).
Treatment: Stripping (aeration), chemical oxidation to break the bonds and make it a smaller compound.

6. Salts
Importance: Taste, $SO_4$ – laxative.
Characteristics: Dissolved solids ( $Cl^-$, $SO_4^{2-}$, $HCO_3^-$, etc).
Treatment: Ion exchange, membrane processes.
7. **Hardness** ➔ if H₂O is needed for industrial purposes such as boilers or cooling H₂O you have to remove them. For tap water it is not very important.

**Importance**: Scaling, soap precipitation.

**Characteristics**: Dissolved solids (Ca²⁺ & Mg²⁺).

**Treatment**: Precipitation, ion exchange, membrane processes.

*You can bring them down to the solubility of those compounds.*

8. **Heavy Metals**

**Importance**: Toxic, damage nervous system (Hg) brittle bones

**Characteristics**: Dissolved solids.

**Treatment**: Precipitation, oxidation/ppt., ion exchange, magnetic separation, adsorption.
9. Organic Chemicals
Importance: Carcinogenic, toxic, mutagenic.
Characteristics: Have low solubilities and accumulate in the fatty acids of the body.
- Synthetic (pesticides, herbicides, PCBs, PAH, etc.) solvents and other chlorinated organics
- THMs produced in the treatment plant upon chlorination.
- Natural humic substances (association with metals & synthetic organics is of concern). They form complexes.
All are dissolved solids except some colloidal humic.
Treatment: Adsorption (up to 60% can be removed through adsorption), chemical oxidation, coagulation, stripping, biological removal

10. Nitrate
Importance: Interferes with oxygen-carrying capability of blood causing oxygen starvation of cells in infants ➔ “blue babies”
Characteristics: Ion
Treatment: Ion exchange, membrane processes, denitrification (being researched).
11. Sludge

Importance : Created in the treatment plant from coagulation and precipitation processes
   Needs further treatment.

Characteristics : Settleable and colloidal particles.

Treatment : Thickening, dewatering by centrifuge or filter press.
WASTE WATER TREATMENT PROBLEMS

1. Settleable Solids
   Grit chambers, sedimentation, during primary treatment.

2. Dissolved & Colloidal Organics
   Secondary Treatment until biological treatment.
   Exert oxygen demand in receiving waters.
   Biological oxidation (aerobic or anaerobic)
   If you have non-biodegradable, apply chemical oxidation such as (O$_3$, Cl$_2$, KMnO$_4$, UV)
   Coagulation, adsorption.

3. Nitrogen Compounds
   Advanced or Tertiary Treatment
   Nutrient (NH$_3$, NO$_3^-$, amines, amino acids, etc.). Dissolved solids.
   Removal by nitrification/denitrification, NH$_3$ stripping, breakpoint chlorination, ion exchange → in the form of NH$_4^+$ (below pH 9).
4. Phosphorus Compounds
Nutrient (ortho and polyphosphates, org-P). Dissolved solids. Removal by chemical precipitaton, ion exchange → very expensive.

5. Pathogens, Heavy Metals, Synthetic Organics
Same as in water treatment.

6. Sludge → mostly biological sludge
Further treatment thermally or digestion before dewatering.