



How Soil Treats Sewage

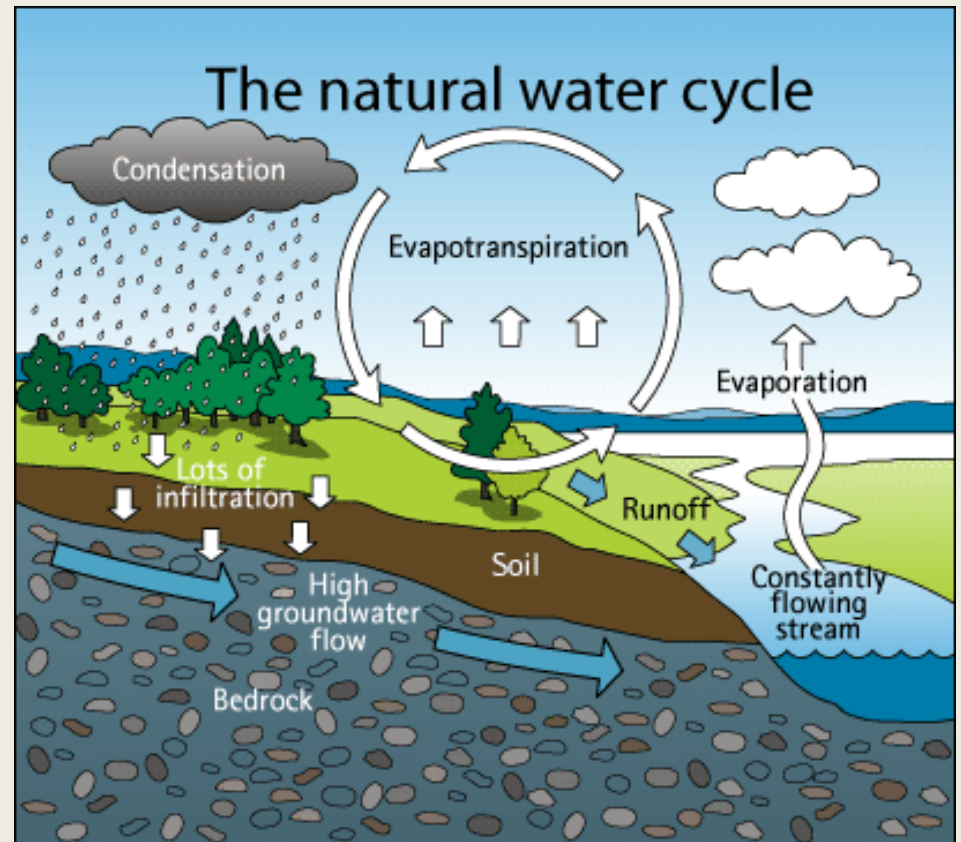


Indiana State
Department of Health

**2017 Plan Review OSS
Designer Workshop
November 7, 2017**

Today's Agenda

- What is effluent?
- What is soil?
- How does the soil treat wastewater?
 - Physical
 - Chemical
 - Biological
 - Environmental





What is Effluent?

Water and contaminants

Pathogens

- Bacteria
- Viruses
- Protozoa
- Helminths
- Fungi

Nutrients

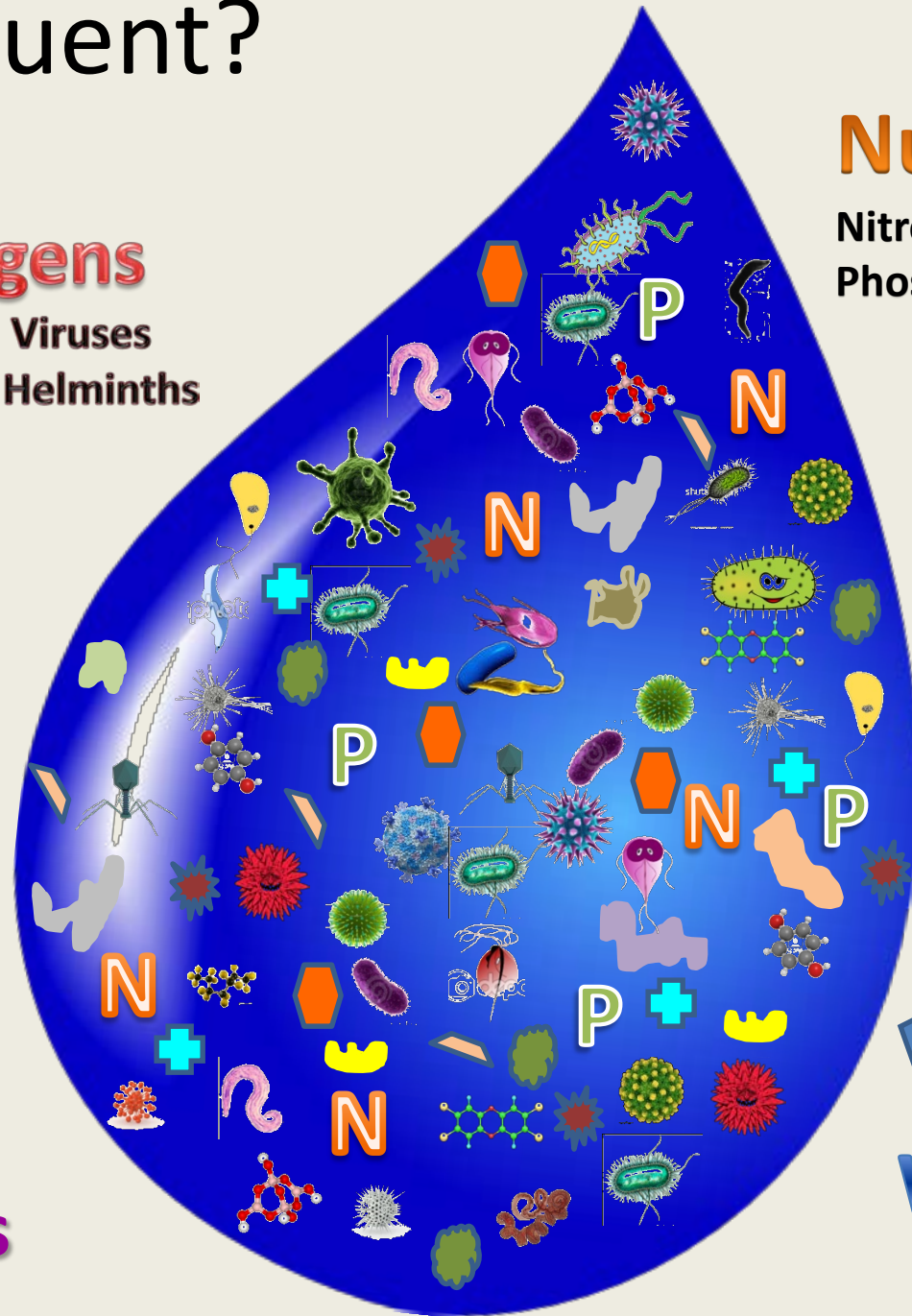
- Nitrogen
- Phosphorus

Total Suspended Solids (TSS)

Biochemical Oxygen Demand (BOD)

Chemicals

Organic Material



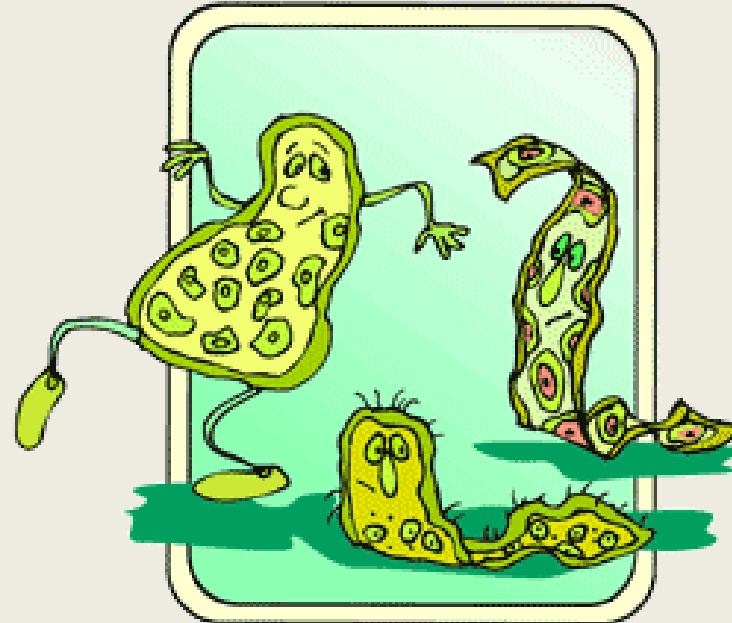
Water

Why do we need to treat contaminants?

Pathogens

Disease causing organisms, including:

- Bacterium
- Viruses
- Helminths
- Protozoa
- Fungus



Can contaminate potable, ground and surface waters

Can cause illness or death in humans and animals

Why do we need to treat contaminants?

Nutrients

Nitrogen (Ammonia)

- Easily converted to nitrate and transported with water
- Nitrates in drinking water can cause methemoglobinemia (blue baby syndrome)



Phosphorus (phosphate)

- Easily transported with water
- Contributes to algal blooms and reduction of oxygen levels in surface water habitats.

Why do we need to treat contaminants?

Chemicals

- Medications
- Cleaners
- Can be carried to surface or drinking waters



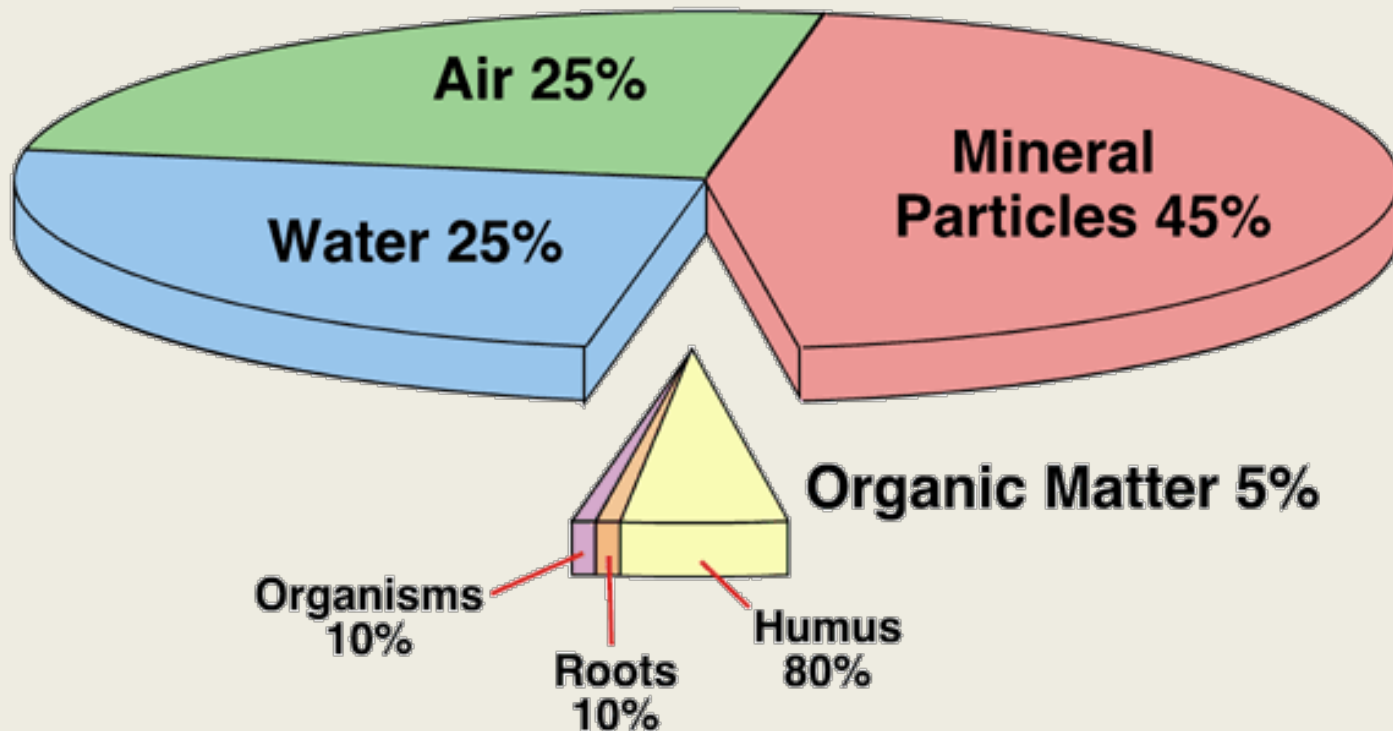
Organic Material

- Suspended Solids
- Can plug soil pores



What is Soil?

- 50% Pore Space
 - Air
 - Water
- 50% Solids
 - Minerals
 - Organic Matter



What do we want soil to do?



- Move water
 - Fast enough....
to get clean water away so that water entering from home use has room to filter through the soil
 - Slow enough...
to have extended detention time for adequate treatment
- Effectively treat contaminants
 - Effluent must travel through small pores
 - Effluent must come into contact with soil particles



What factors affect soils ability to treat wastewater?

- **Physical**

- Soil structure
- Soil texture

- Mechanical Filtration / Straining
- Sedimentation
- Evapotranspiration

- **Chemical**

- Surface Area
- Chemical properties of soil particles

- Adsorption/Adhesion
- Precipitation



What factors affect soils ability to treat wastewater?

- **Biological**

- Soil microbes

- Uptake

- Incorporation

- Predation

- Transformations

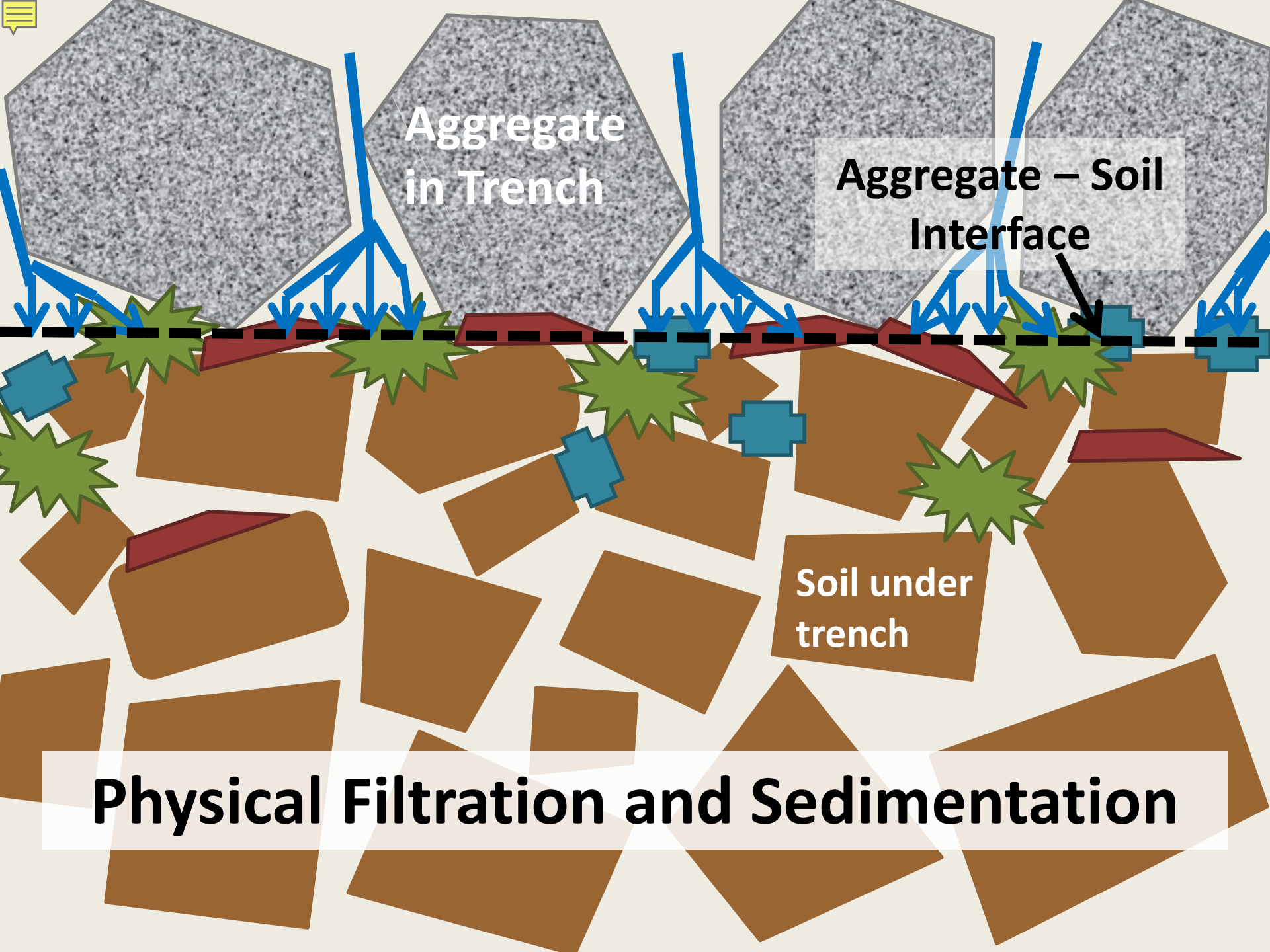
- **Environmental**

- Condition of soil

- Oxygen level

- Temperature

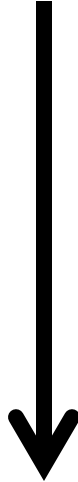
- Moisture content



Physical Filtration and Sedimentation

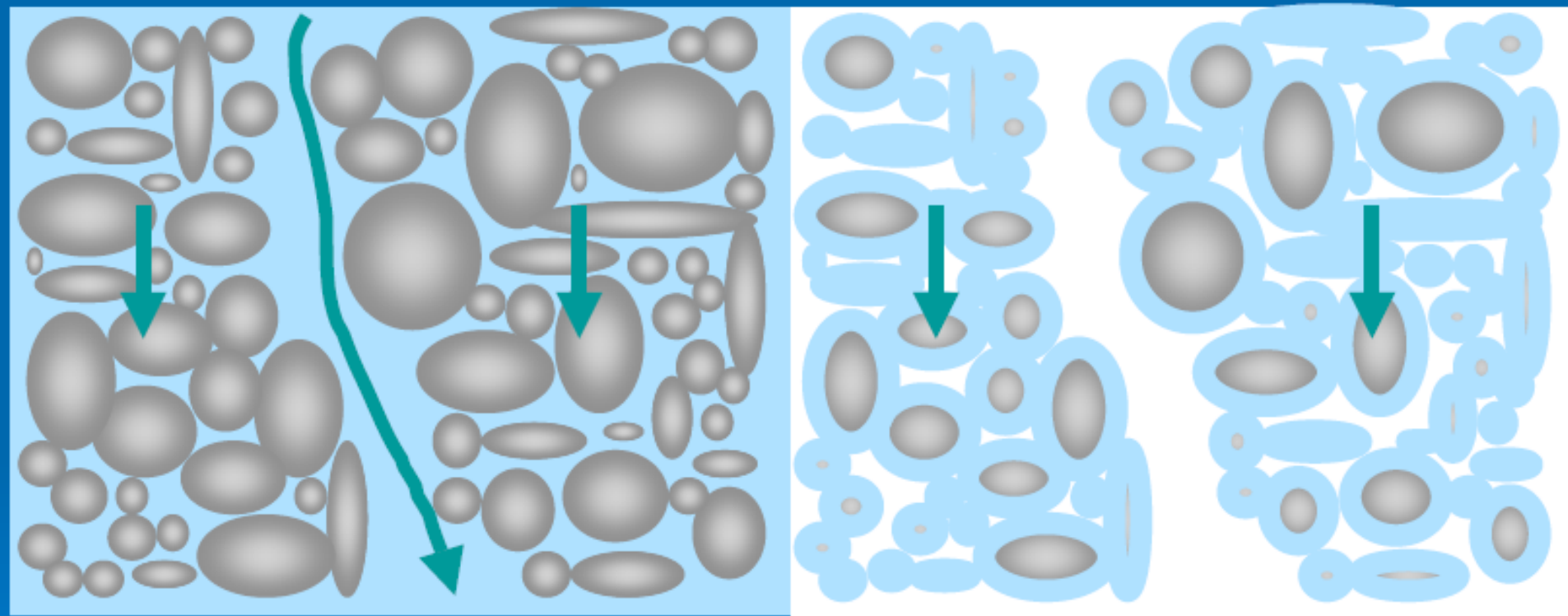
Soil Structure and Porosity

- Structure
 - Granular
 - Angular Blocky
 - Subangular Blocky
 - Prismatic
 - Columnar
 - Platy
- Structureless
- Single Grain
- Massive

Most Porous  Least porous	Granular
	Cube-Like
	Subangular Blocky
	Angular Blocky
	Prism-Like
	Prismatic
	Columnar
	Platy

**SOIL LOADING RATE =
GALLONS / DAY / FT²**

Water Movement



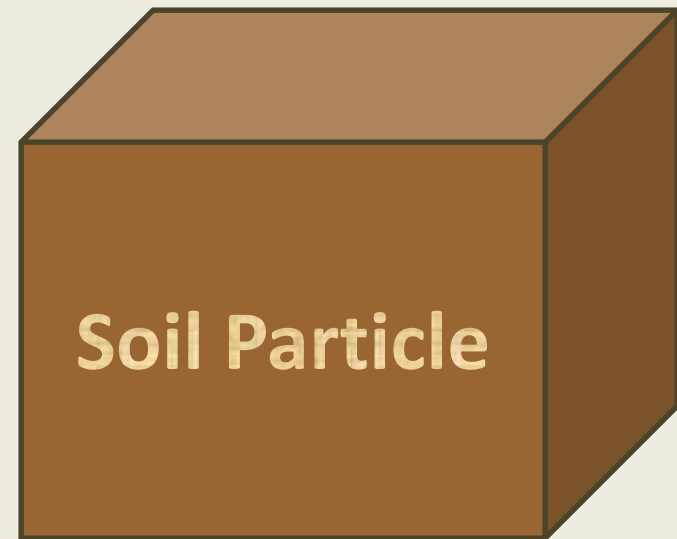
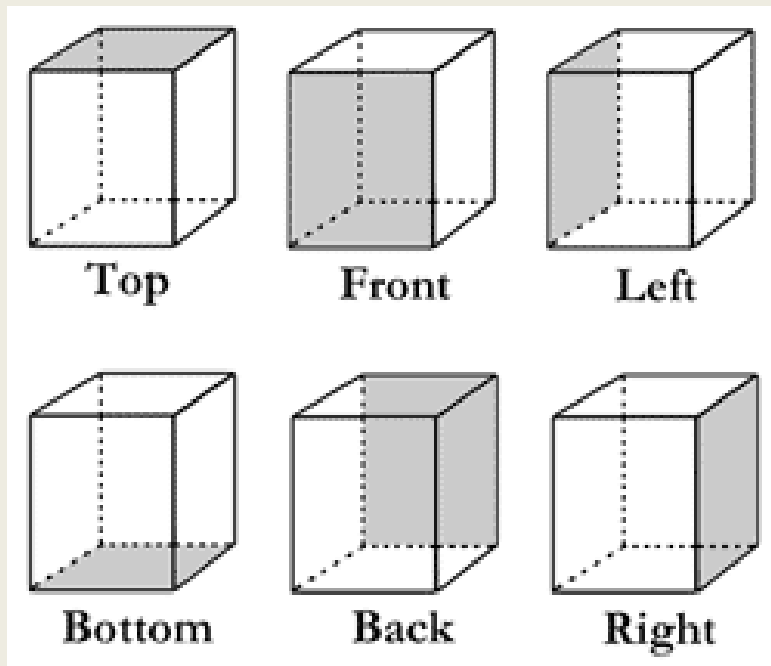
Majority of flow through macropores under saturated conditions

Majority of flow through intrapedal voids under unsaturated conditions

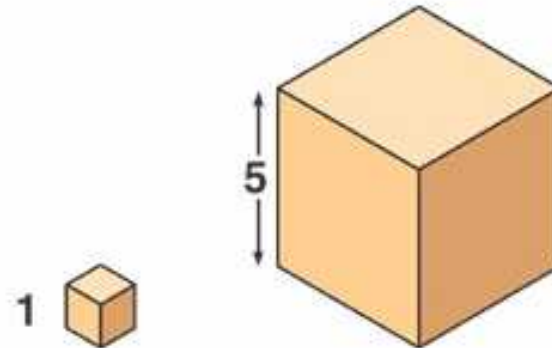
Soil Chemistry

What is needed for chemical reactions?

1. Surface Area
2. Appropriate conditions
3. Reactants

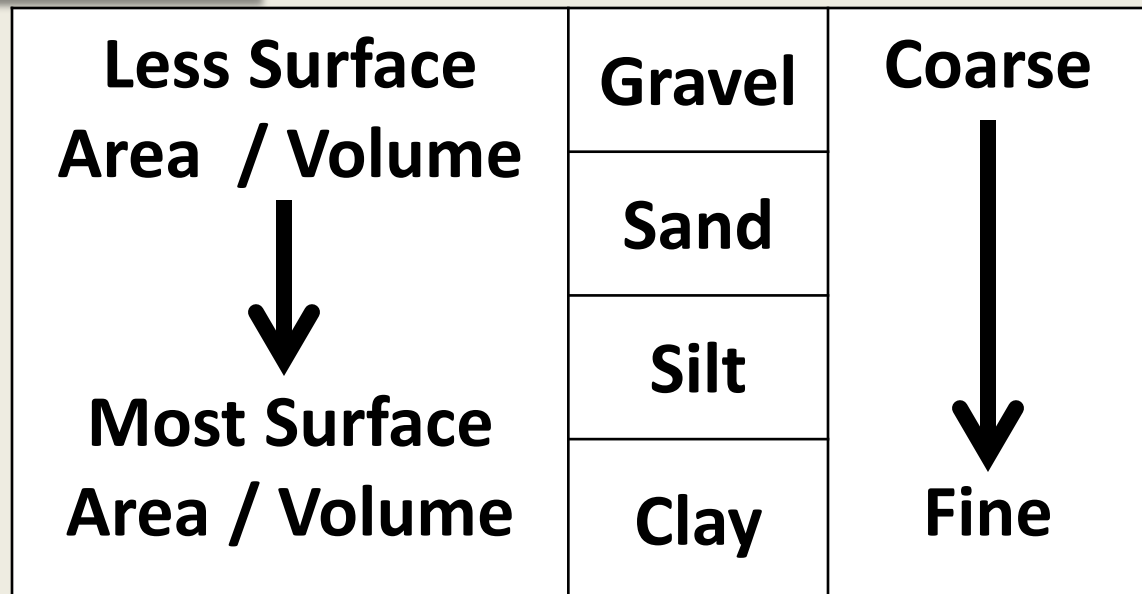
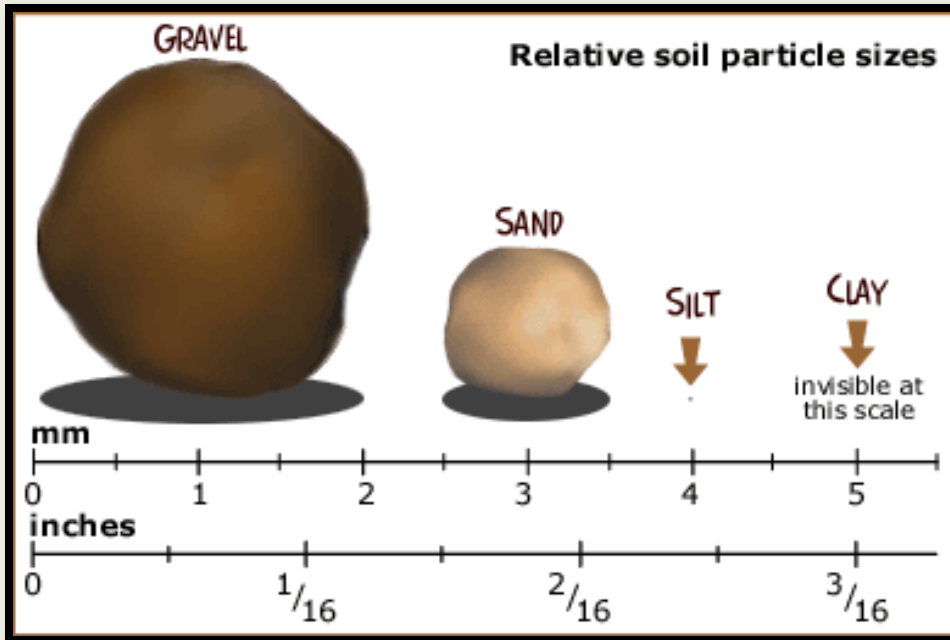


**Surface Area
increases as
volume increases**



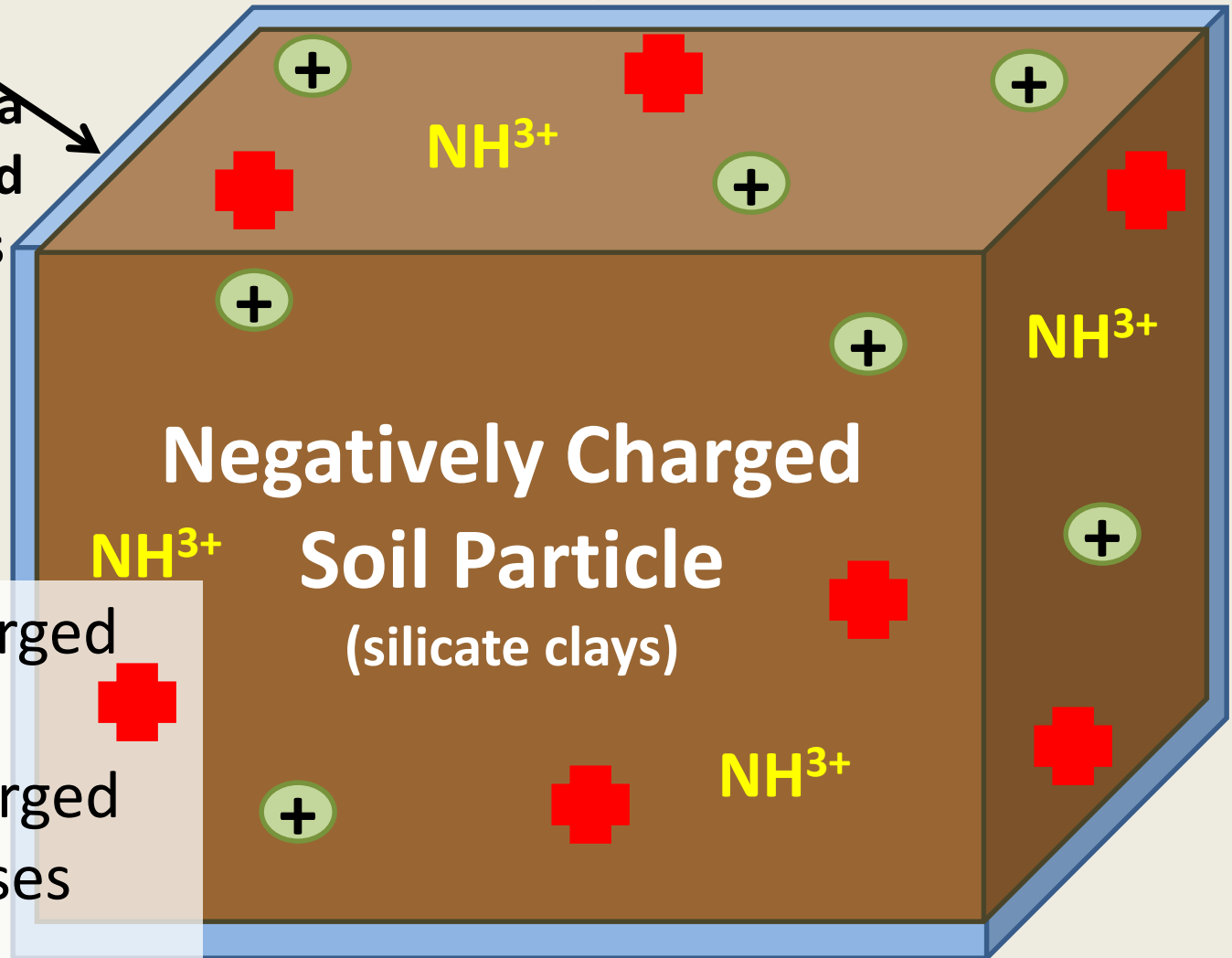
Total surface area (height × width × number of sides × number of boxes)	1X1X6X1= 6	5X5X6X1= 150
Total volume (height × width × length × number of boxes)	1X1X1X1= 1	5X5X5X1= 125
Surface-to-volume ratio (surface area / volume)	6/1= 6	150/125= 1.2

Soil Texture and Surface Area



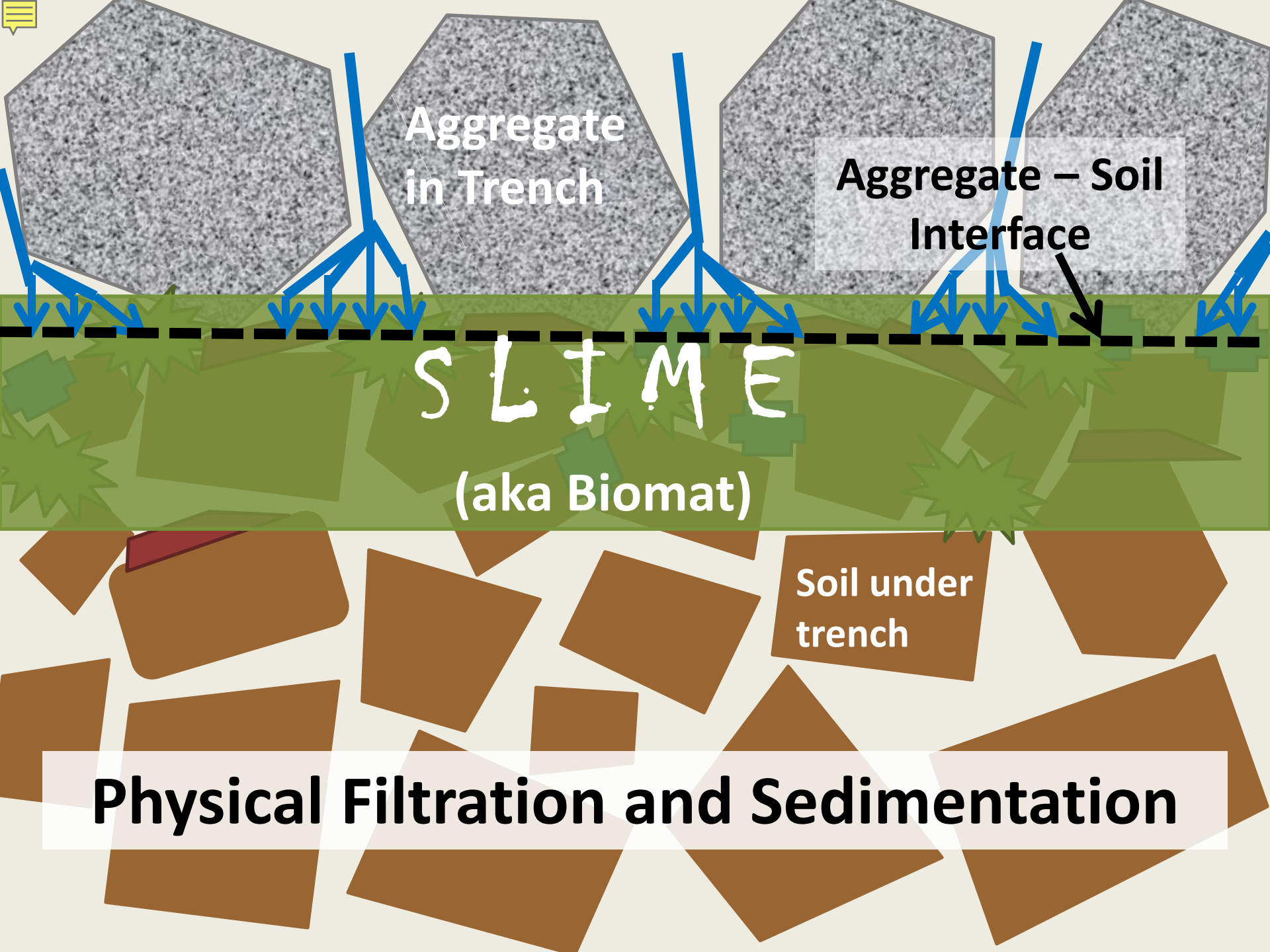
Chemical Properties of Soil

Slightly positively charged water molecules form a thin layer around the soil particles in unsaturated conditions



Positively charged cations and positively charged bacteria, viruses and organic compounds adhere to the soil particles

ADHESION



Aggregate
in Trench

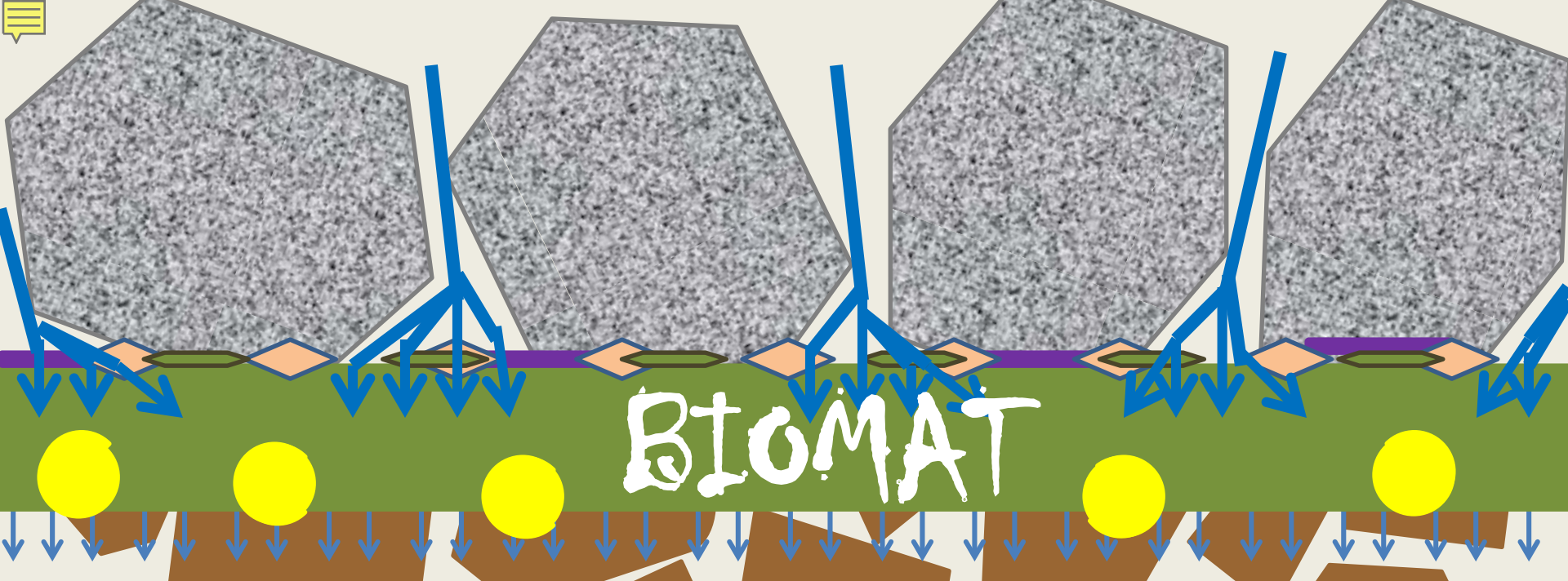
Aggregate – Soil
Interface

SLIME

(aka Biomat)

Soil under
trench

Physical Filtration and Sedimentation



How does slime help you?

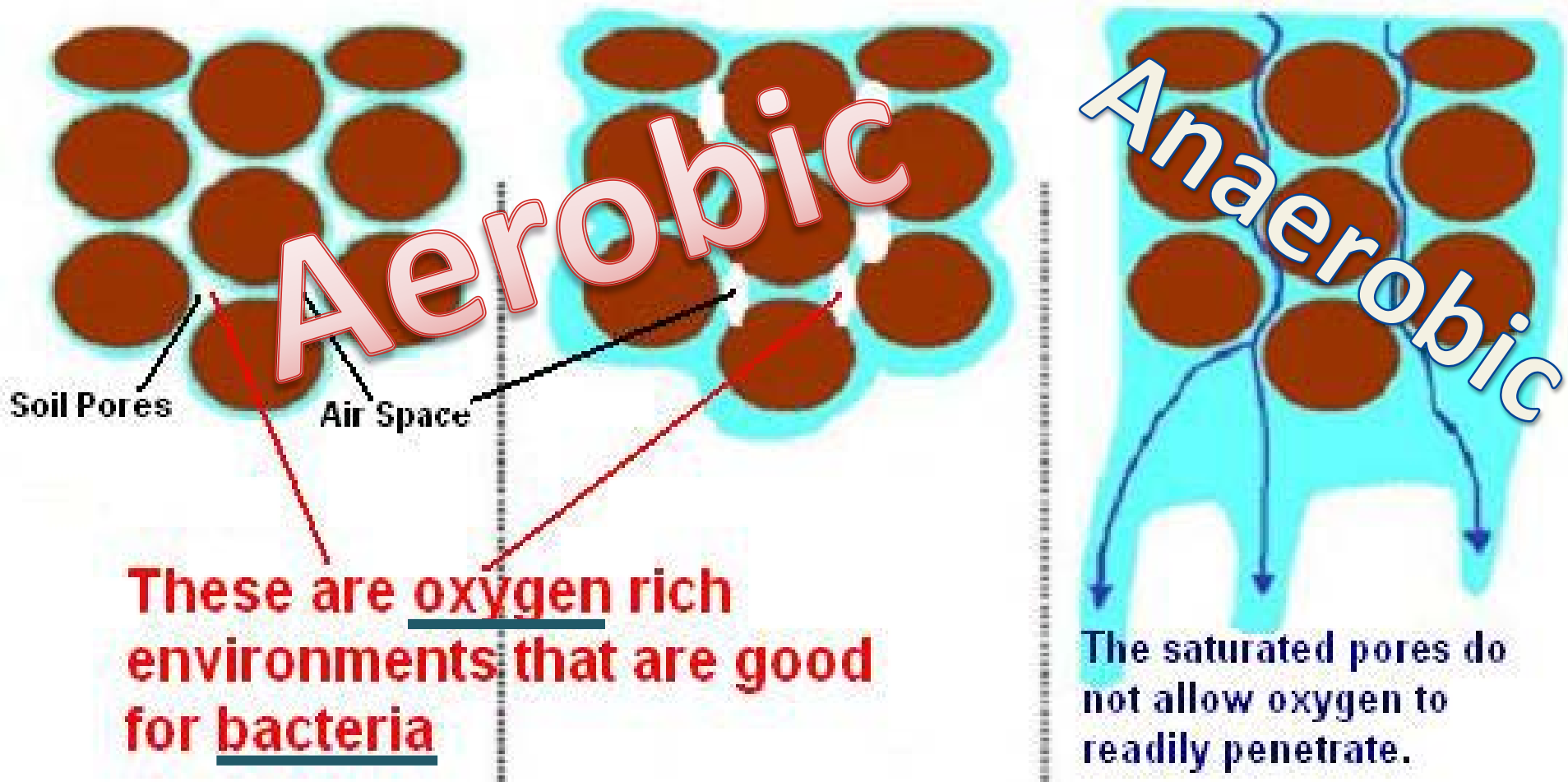
1. Slows down the movement of water
2. Physically filters large particles and chemicals which reduces BOD and TSS
3. Harbors beneficial microorganisms

Why do we want to slow down water movement?

Little or No Flow

Unsaturated Flow

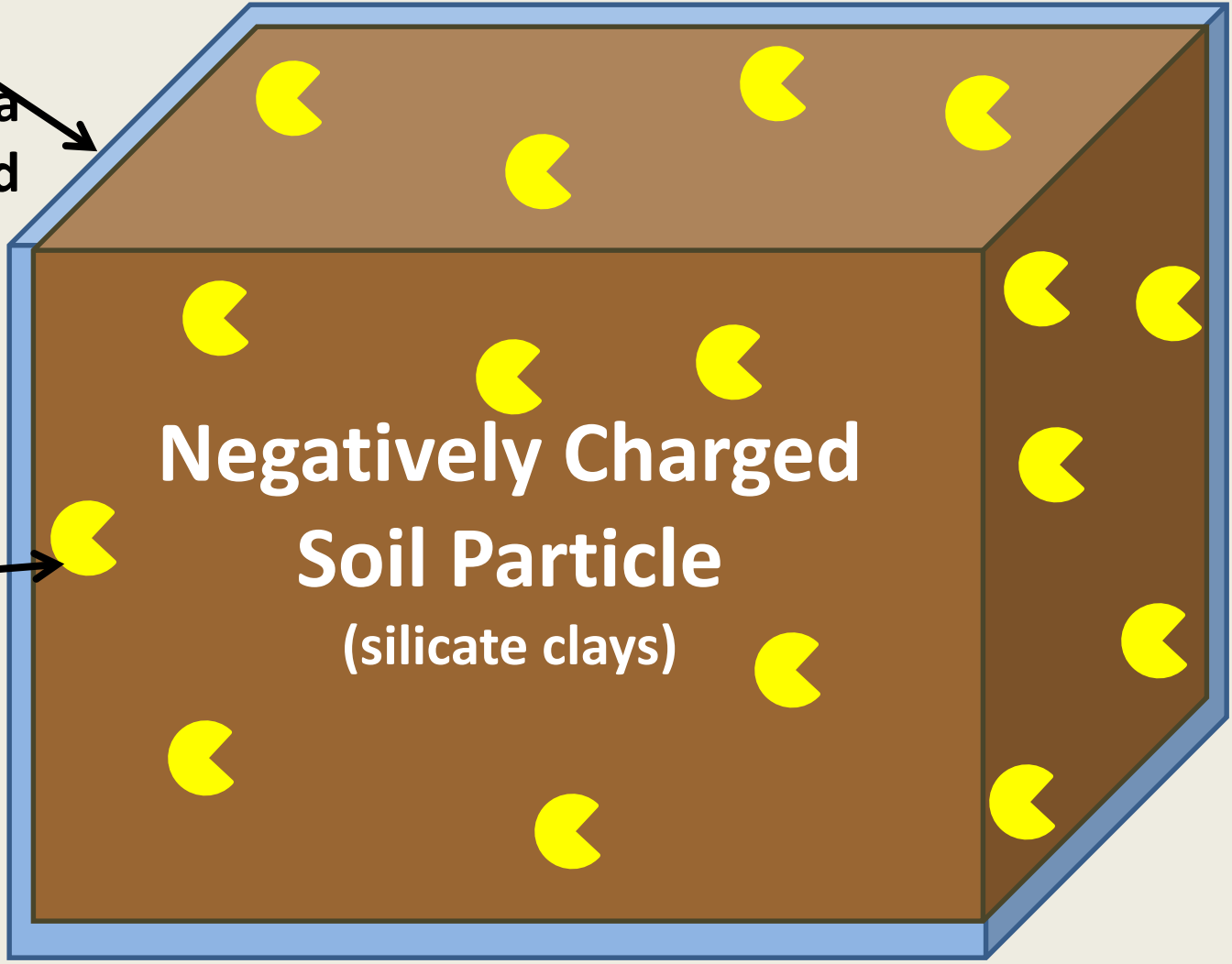
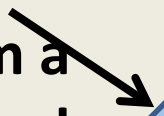
Saturated Flow
Hydraulically Overloaded





Chemical Properties of Soil

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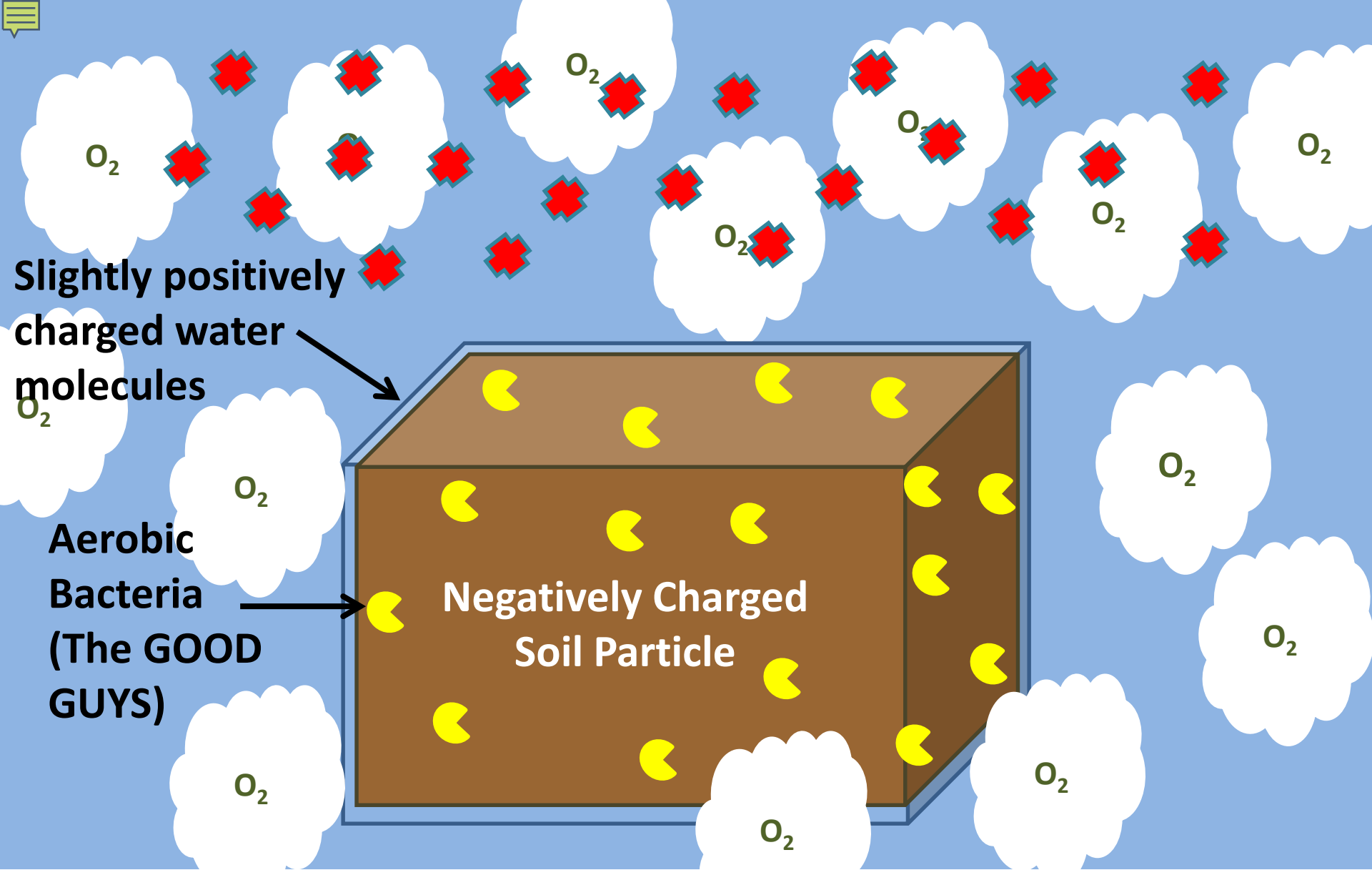
Negatively Charged Soil Particle
(silicate clays)

Aerobic bacteria
(The GOOD GUYS)



Aerobic bacteria need oxygen

ADHESION



ADHESION



Soil Microbes

- Aerobic
 - They need oxygen
- Naturally present in the soil

Effluent Pathogens

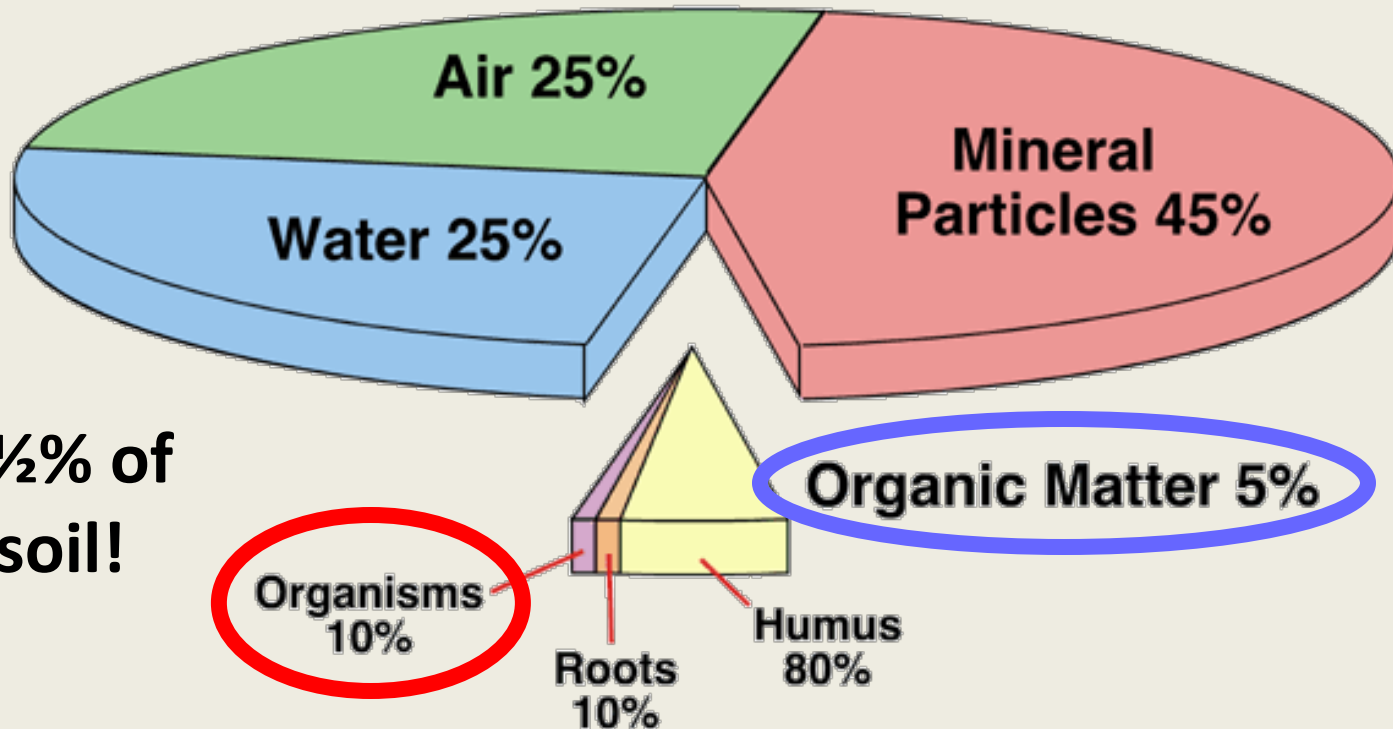
- Primarily anaerobic
 - They thrive in environments void of oxygen
- Abundant in effluent
- Can live in aerobic environments

Promoting aerobic bacteria in the SAF

- Provide aerobic environment
 - Provide unsaturated conditions
 - Allow air movement
- Provide food source
- Provide a large surface area on which these bacteria live

What is Soil?

- 50% Pore Space
 - Air
 - Water
- 50% Solids
 - Minerals
 - Organic Matter



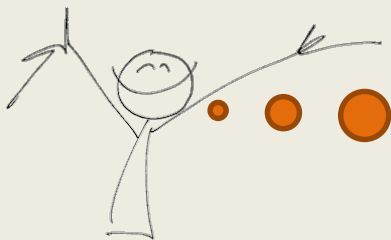
Only 1/2% of
the soil!

The soil is alive!

1 Teaspoon of Soil



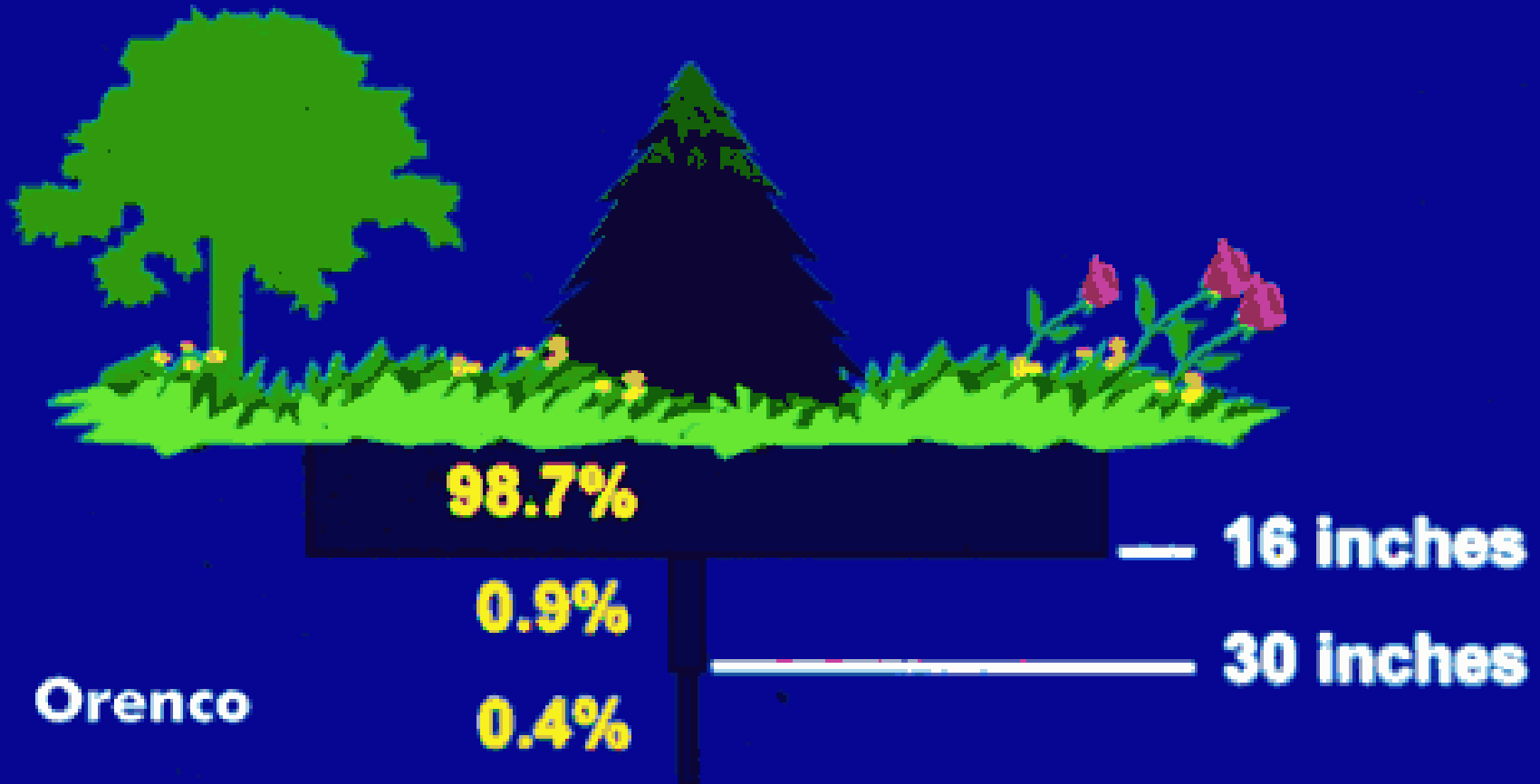
1 million to 1 billion microscopic organisms



Now that's
a party!

Where do soil microbes live?

SOIL BIOTA POPULATION vs SOIL DEPTH



Soil surface


Infiltrating wastewater

Suspended solids removal 1 foot

Ammonia removal 1.5 to 2 feet
Organic matter removal 1.5 to 2 feet
Bacteria removal 1.5 to 2 feet

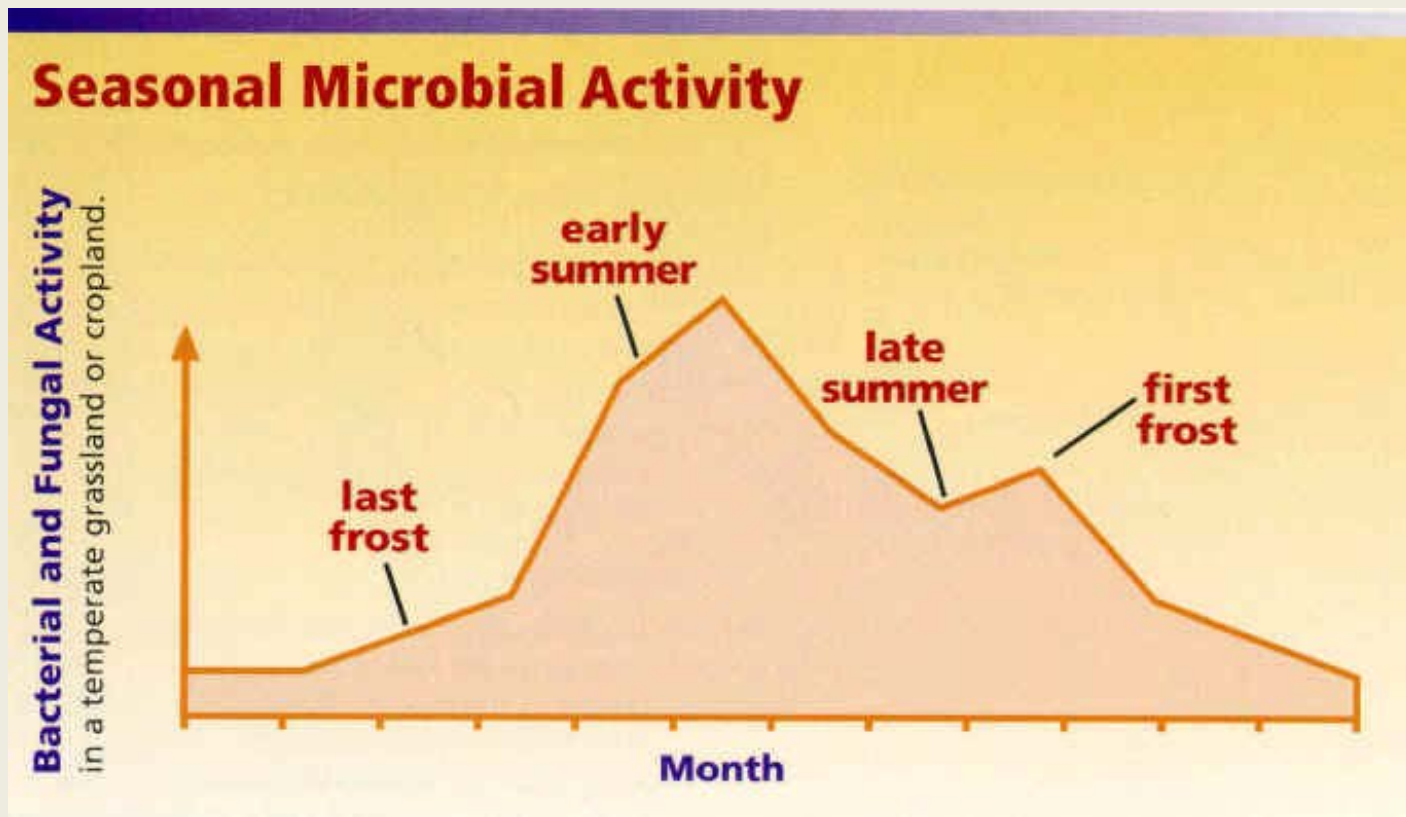
Virus removal 0.5 to 2 feet following organic matter removal

Limiting condition

<p>Very Large</p>  <p>Very Small</p>	Suspended Solids
	Helminths
	Protozoa
	Bacteria
	Viruses

Environmental Factors

- Temperature – Low temps reduce biological efficiency and treatment performance.



Environmental Factors

- Temperature – Low temps reduce biological efficiency and treatment performance.
- Oxygen Levels – Low levels reduce the aerobic bacteria living the in the soil
 - Saturated conditions
 - Deep soil absorption field
 - Lack of oxygen supply due to compaction of soil cover
- Soil moisture – Ground water or hydraulic load
 - Less oxygen in soil
 - Promotes water movement through large voids, not by capillary action

What kind of soil is best?

- Sand **Good for moving water**
 - Large particles / relatively small surface area
 - Fast water movement / short detention time
 - Air pockets with large voids

**VERY COARSE SAND CAN LEAD TO
INADEQUATE TREATMENT**

- Clayey soil **Good for treating pathogens**
 - Small particles / relatively large surface area
 - Slow water movement / long detention time
 - Small air pockets with small voids

**TIGHT CLAYS CAN LEAD TO VERY SLOW WATER
MOVEMENT CAUSING PONDING AND ANAEROBIC
CONDITIONS**

Summary

- **Soil structure and texture**
 - Filters wastewater
 - Provides surface area for biochemical reactions and adhesion
- **Filtration of wastewater causes biomat formation**
 - Additional filtration
 - Harbors beneficial microorganisms
- **Aerobic bacteria**
 - need oxygen
 - remove or inactivate pathogens in wastewater
- **Unsaturated flow**
 - Detention time
 - Aerobic conditions

Soil: a secret garden of beautiful microorganisms