

Lecture outline

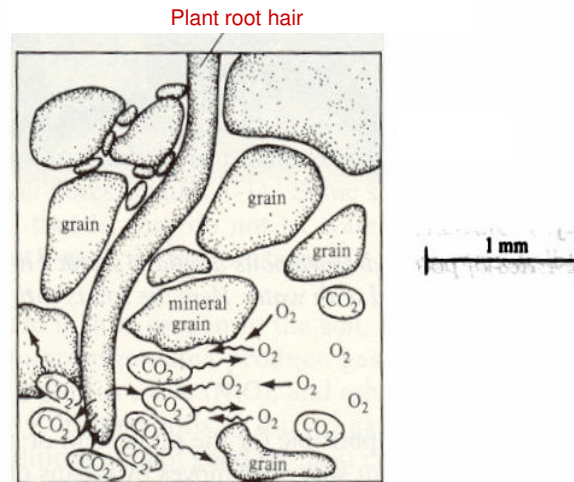
- A. Soil aeration
 - A.1. Nature of soil aeration
 - A.2. Diffusion
- B. Solute transportation processes

3



A1. Nature of soil aeration

CO₂ and O₂ movement in soil



5

Oxygen availability depends on

- Soil macropores
- Soil water content
- O₂ consumption by respiring soil organisms

6

- **Atmospheric air contains:**

0.035% CO₂

21% O₂

78% N₂

- **Soil air contains:**

0.35% CO₂

~20% O₂ near soil surface

~ 5% O₂ in lower horizons of poorly drained soils

78% N₂

7



Water stands in the pit

Poor soil aeration

when >80-90% of the soil pores are filled with water

8

Gas exchange between atmosphere and soil air is due to

- Mass flow (convection) of air
- Diffusion

9

Mass flow (convection) of air results in the entire mass of air streaming from a zone of **higher** pressure to one with *lower* pressure.

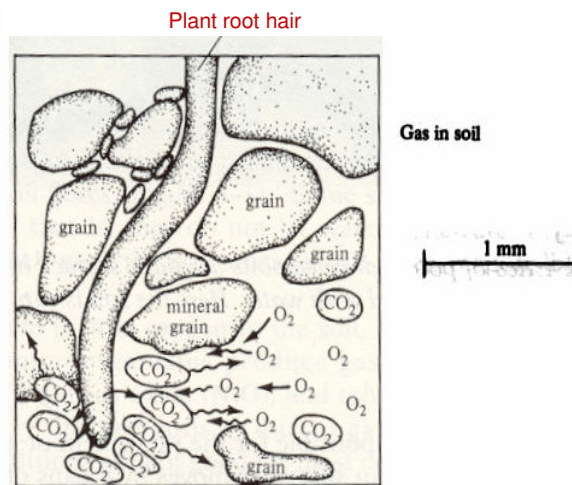
Moving force → gradient of total gas pressure

10

Diffusion – each gas moves in a direction determined by its own partial pressure.

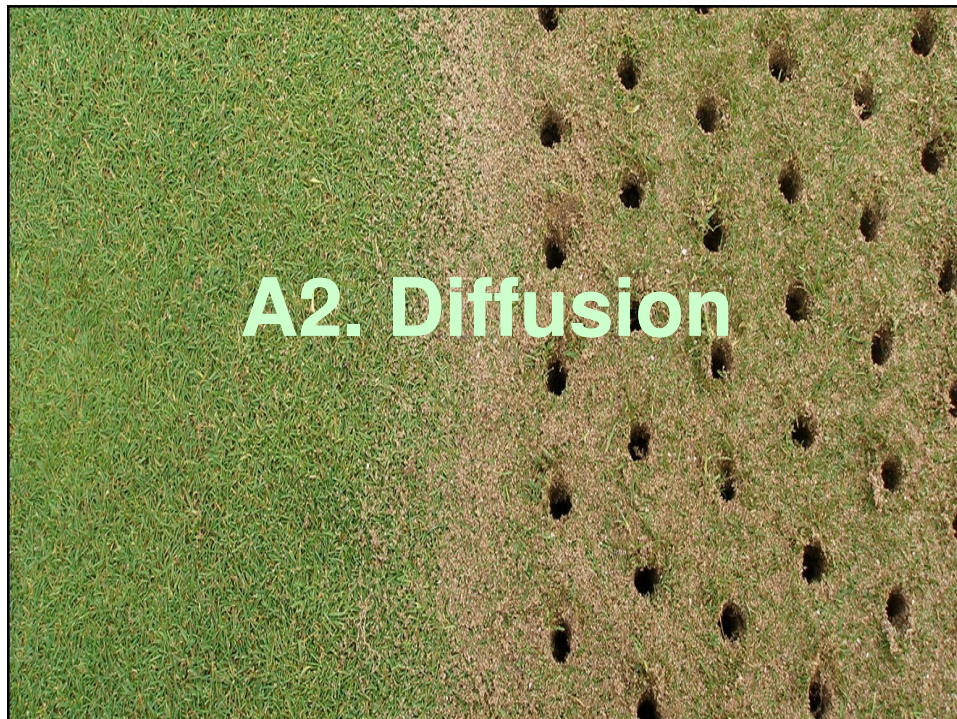
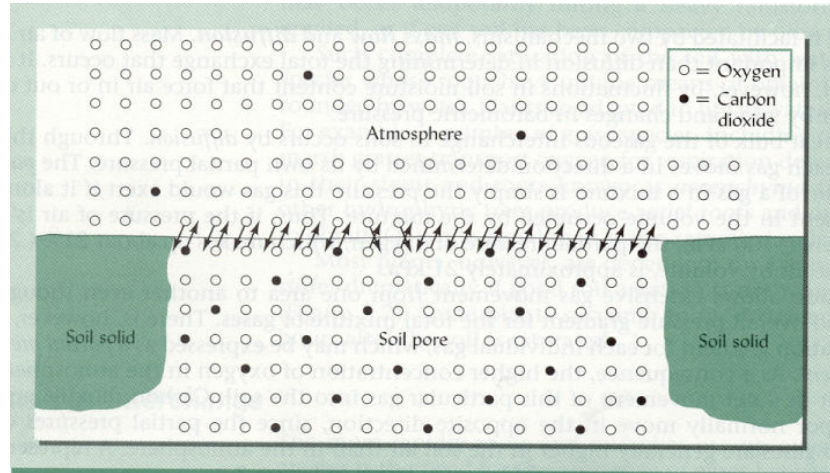
Moving force → gradient of partial pressure of any constituent member of air

11



12

CO₂ and O₂ diffusion between atmosphere and soil air



Fick's Law of Diffusion

$$J = -D \frac{dC}{dx}$$

J = diffusive flux density of a gas [mg/m²s]

D = diffusion coefficient [m²/s]

dC/dx = gas concentration gradient [g/m⁴]

15

- **Oxygen flux** is amount of O₂ which crosses a plane per unit time [g of O₂/s]
- **Oxygen flux density** is the O₂ flux per unit area of the plane per unit time [g of O₂/m² s]
- The axis of O₂ flow is perpendicular to the plane

16

Oxygen diffusion coefficient (D) for diffusion in air is about 10,000 times as large as the coefficient for diffusion in water.

D is strongly affected by soil water content

17



Solutes (substances dissolved in the solvent) in soil solution are translocated by:

- Mass flow
- Diffusion

19

Mass flow - due to solution concentration gradient the entire mass of soil solution moves from **higher** to *Lower* concentration zone

20

Diffusion of solutes means that each type of solutes moves in a direction determined by its own concentration gradient

21

Fick's Law of Diffusion

$$J = -D \frac{dC}{dx}$$

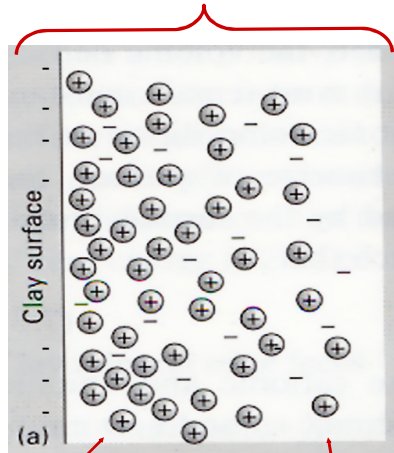
J = diffusive flux density of a solute [mg/m²s]

D = diffusion coefficient [m²/s]

dC/dx = solute concentration gradient [g/m⁴]

22

Diffuse double layer (DDL)



High conc. of cations

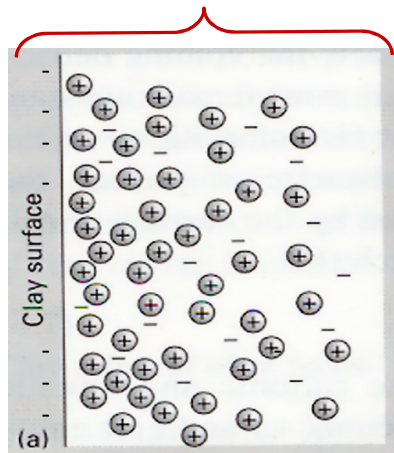
Low conc. of cations

A third type of nutrient (solute) movement occurs near electrically charged surfaces of soil colloids (e.g. clay).

Solute movement is along the electrical potential gradients imposed by charged surfaces (and is caused by Coulombic forces).

23

Diffuse double layer (DDL)



Electrokinetic flux density of cations toward the particle

Diffusive flux density of cations away from the particle

The electrostatic (Coulombic) attraction of cations by the charged clay surface is counteracted by diffusion.

A steady state is reached when the electrokinetic flux density of cations toward the clay particle is balanced by the diffusive flux density of cations away from the particle.

24

Thickness of diffuse double layer (DDL) depends on:

- Concentration of soil solution
- Valence of attracted ions
- Cation size (hydration radius)

25

Particle with a **thick DDL** tends to stay **DISPERSED**

Particle with a **thin DDL** is susceptible to **FLOCCULATION**

26