Mikroorganisme Dalam Lingkungan Darat

Nur Hidayat

Materi Kuliah Mikrobiologi Lingkungan

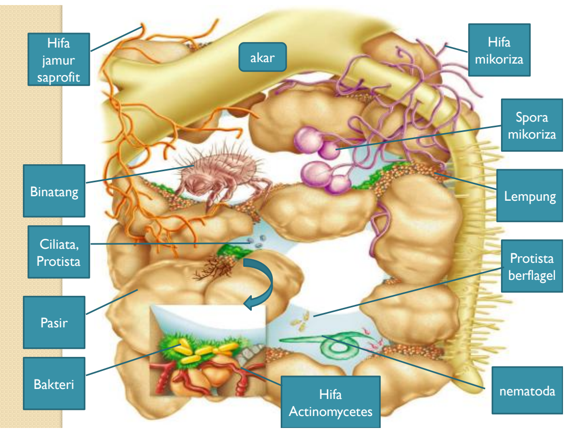
Pendahuluan

- Mikrobiologi tanah penting karena berbagai alasan.
- Mikroorganisme di daratan berkontribusi pada siklus biogeokimia dan fungsi2 penting lainnya dalam bidang pertanian dan menjaga kualitas
- Ekologi mikrobia pada tanah bersifat dinamik dan terus berkembang.
- In the past, culture-based investigations limited scientists' understanding to an estimated 1% of the soil microbes in any given community. As we shall see, the ability to study these complex communities without relying on the direct isolation and growth of individual species has had a profound impact on the appreciation of the soil as a complex and vital environment.

Tanah sbg Lingkungan untuk Mikroorganisme

- A soil scientist would describe soil as weathered rock combined with organic matter and nutrients. An agronomist would point out that soil supports plant life.
- Microbial activities in these environments can lead to the formation of minerals such as dolomite; microbial activity also occurs in deep continental oil reservoirs, in stones, and even in rocky outcrops.
- These microbes are dependent on energy sources from photosynthetic protists and nutrients in rainfall and dust.

- Most soils are dominated by inorganic geological materials, which are modified by the biotic community, including microorganisms and plants, to form soils.



Soils, Plants and Nutrients

- Soils can be divided into two general categories: A mineral soil contains less than 20% organic carbon whereas an organic soil possesses at least this amount.
- Soil organic matter (SOM) helps to retain nutrients, maintain soil structure, and hold water for plant use.
- SOM is subject to gains and losses, depending on changes in environmental conditions and agricultural management practices

Soils, Plants and Nutrients

- Microbial degradation of plant material results in the evolution of CO2 and the incorporation of the plant carbon into additional microbial biomass
- However, a small fraction of the decomposed plant material remains in the soil as SOM.
- it is convenient to divide the SOM into humic and nonhumic fractions

SOM Fraction	Definition	Physical Appearance
Humic substances	High-molecular-weight organic material produced by secondary synthesis reactions	Dark brown to black
Nonhumic substances	Unaltered remains of plants, animals, and microbes, from which macromolecules have not yet been extracted	Light brown
Humic acid	Organic matter extracted from soils by various reagents (often dilute alkali treatment) that is then precipitated by acidification	Dark brown to black
Fulvic acid	Soluble organic matter that remains after humic acid extraction	Yellow
Humin	SOM that cannot be extracted from soil with dilute alkali	

The degradation of plant material and the development of SOM

- First, easily degraded compounds such as soluble carbohydrates and proteins are broken down
- About half the carbon is respired as CO2 and the remainder is rapidly incorporated into new biomass

The degradation of plant material and the development of SOM

- During the second stage, complex carbohydrates, such as the plant structural polysaccharide **cellulose, are degraded.**
- Fungi and members of the bacterial genera *Streptomyces, Pseudomonas, and Bacillus* produce extracellular cellulase enzymes that break down cellulose into two to three glucose units called cellobiose and cellotriose, respectively
- These smaller compounds are readily degraded and assimilated as glucose monomers

The degradation of plant material and the development of SOM

- Finally, very resistant material, in particular lignin, is attacked.
- **Lignin is an important** structural component of woody plants. While its exact structure differs among species, the common building block is the phenylpropene unit. This consists of a hydroxylated six-carbon aromatic benzene ring and a three-carbon linear side chain
- Basidiomycete fungi and actinomycetes (e.g., *Streptomyces spp.) are* capable of extracellular lignin degradation. These microbes produce extracellular phenoloxidase enzymes needed for aerobic lignin degradation.

Microorganisms in the Soil Environment

- Most soil procaryotes are located on the surfaces of soil particles and require water and nutrients that must be located in their immediate vicinity. Procaryotes are found most frequently on surfaces within smaller soil pores (2 to 6 m in diameter)
- Terrestrial filamentous fungi, in comparison, bridge open areas between soil particles or aggregates, and are exposed to high levels of oxygen. These fungi will tend to darken and form oxygen-impermeable structures called sclerotia and hyphal cords

Microorganisms in the Soil Environment

- The microbial populations in soils can be very high. In a surface soil the bacterial population can approach 10^9 to 10^10 cells per gram dry weight of soil as measured microscopically
- Fungi can be present at up to several hundred meters of hyphae per gram of soil

Microorganisms in the Soil Environment

- The coryneforms, the nocardioforms, and the true filamentous bacteria (the streptomycetes) **are an important part of** the soil microbial community. These gram-positive bacteria play a major role in the degradation of hydrocarbons, older plant materials, and soil humus.
- The filamentous actinomycetes, primarily of the genus *Streptomyces, produce an odor-causing compound* called **geosmin, which gives soils their characteristic earthy odor**

Microbe-plant interactions

- Microbe-plant interactions can be broadly divided into two classes: microbes that live on the surface of plants are called **epiphytes;** those that colonize internal plant tissues are called **endophytes.**
- The environment of the aerial portion of a plant, called the **phyllosphere,** was once thought to be too hostile to support a stable microbial community

Phyllosphere Microorganisms

- the phyllosphere is home to a diverse assortment of microbes including bacteria, filamentous fungi, yeasts, and photosynthetic and heterotrophic protists
- Numerically, it appears that the γ -proteobacteria *Pseudomonas syringae and Erwinia, and Pantoea spp. are most important. Another abundant bacterial* genus, *Sphingomonas, produces pigments that function like suncreen* so it can survive the high levels of UV irradiation occurring on these plant surfaces.

Rhizosphere and Rhizoplane Microorganisms

- Plant roots receive between 30 to 60% of the net photosynthesized carbon. Of this, an estimated 40 to 90% enters the soil as a wide variety of materials including alcohols, ethylene, sugars, amino and organic acids, vitamins, nucleotides, polysaccharides, and enzymes
- These materials create a unique environment for soil microorganisms called the **rhizosphere.**
- The plant root surface, termed the **rhizoplane, also provides a unique environment** for microorganisms, as these gaseous, soluble, and particulate materials move from the plant to the soil.

Rhizosphere and Rhizoplane Microorganisms

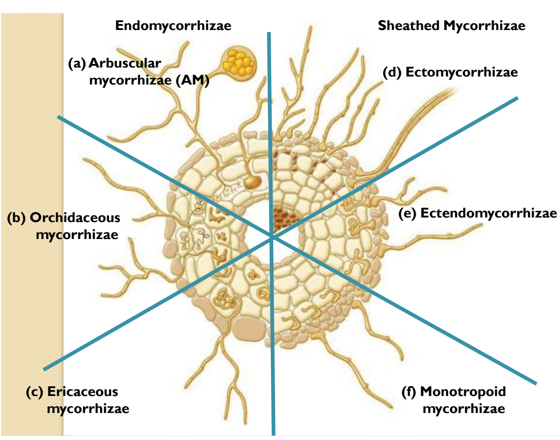
- A wide range of microbes in the rhizosphere can promote plant growth. Plant growth-promoting rhizobacteria include the genera *Pseudomonas and Achromobacter*
- Acritical process that occurs on the surface of the plant, and particularly in the root zone, is **associative nitrogen fixation.** This process is carried out by representatives of the genera *Azotobacter, Azospirillum, and Acetobacter. These bacteria contribute to nitrogen* accumulation by tropical grasses.
- Recently methanogenic archaea have been identified in the rhizosphere of rice.

Mycorrhizae

- Mycorrhizae (derived from the Greek "fungus root") are mutualistic relationships that develop between most plants and a limited number of fungal species.
- In this case, fungi colonize the roots of about 80% of all higher plants as well as ferns and mosses.
- Unlike most fungi, mycorrhizal fungi are not saprophytic—that is, they do not obtain organic carbon from the degradation of organic material.
- Instead, they use photosynthetically derived carbohydrate provided by their host. In return, they provide a number of services for their plant hosts, including enhanced nutrient uptake.

Mycorrhizae

- Mycorrhizae can be broadly classified as **endomycorrhizae—** those with fungi that enter the root cells, or as **ectomycorrhizae—** those that remain extracellular, forming a sheath of interconnecting filaments (hyphae) around the roots.
- The ectomycorrhizae (ECM) are formed by both ascomycete and basidiomycete fungi.



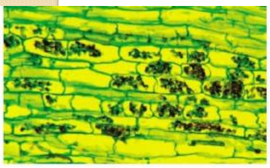


Figure 29.10 Endomycorrhizae. Endomycorrhizae, or arbuscular mycorrhizae, form characteristic structures within roots. These can be observed with a microscope after the roots are stained. The arbuscules of *Gigaspora margarita* can be seen inside the root cortex cells of cotton.

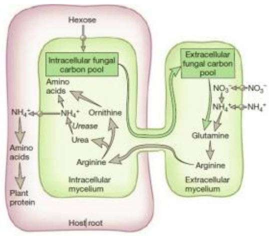


Figure 29.11 Nitrogen Exchange between Arbuscular Mycorrhizal Fungi and Host Plant. Nitrate and ammonium are taken up by the fungal mycelium that is outside the host plant cell (extracellular mycelium) and converted to arginine. This amino acid is transferred to the mycelium within the host plant cell and broken down so that only the ammonium enters the plant.