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Course: Microbial Ecology

Assignment title: roles of microbes in various ecosystem

Question

As a microbial ecologist discuss the variety of diverse analytical techniques you will employ to understand the critical role of microbes in specific ecosystems and in maintaining life on earth.

Answer

Roles of microbes in land

Bacteria: Bacteria are organisms that have only one cell and are, therefore, microscopic. There are anywhere from 100 million to one billion bacteria in just a teaspoon of moist, fertile soil. They are decomposers, eating dead plant material and organic waste. By doing this, the bacteria release nutrients that other organisms could not access. The bacteria do this by changing the nutrients from inaccessible to usable forms. The process is essential in the nitrogen cycle.

Actinomycetes: Actinomycetes are soil microorganisms like both bacteria and fungi, and have characteristics linking them to both groups. They are often believed to be the missing evolutionary link between bacteria and fungi, but they have many more characteristics in common with bacteria than they do fungi. Actinomycetes give soil its characteristic smell. They have also been the source of several significant therapeutic medicines.

Fungi: Fungi are unusual organisms, in that they are not plants or animals. They group themselves into fibrous strings called hyphae. The hyphae then form groups called mycelium which are less than 0.8mm wide but can get as long as several metres. They are helpful, but could also be harmful, to soil organisms. Fungi are helpful because they have the ability to break down nutrients that other organisms cannot. They then release them into the soil, and other organisms get to use them. Fungi can attach themselves to plant roots. Most plants grow much better when this happens. This is a beneficial relationship called mycorrhizal. The fungi help the plant by giving it needed nutrients and the fungi get carbohydrates from the plant, the same food that plants give to humans. On the other hand, fungi can get food by being parasites and attaching themselves to plants or other organisms for selfish reasons.

Some of the functions performed in soil by fungi are:

Decomposers – saprophytic fungi – convert dead organic material into fungal biomass, carbon dioxide (CO2), and small molecules, such as organic acids.

Mutualists – the mycorrhizal fungi – colonise plant roots. In exchange for carbon from the plant, mycorrhizal fungi help to make phosphorus soluble and bring soil nutrients (phosphorus, nitrogen, micronutrients and, perhaps, water) to the plant. One major group of mycorrhizae, the ectomycorrhizae, grow on the surface layers of the roots and are commonly associated with trees. The second major group of mycorrhizae are the endomycorrhizae that grow within the root cells and which are commonly associated with grasses, row crops, vegetables and shrubs.

Parasites: The third group of fungi, pathogens or parasites, causes reduced production or death when they colonise roots and other organisms.

Algae: Algae are present in most of the soils where moisture and sunlight are available. Their number in the soil usually ranges from 100 to 10,000 per gram of soil. They are capable of photosynthesis, whereby they and obtain carbon dioxide from atmosphere and energy from sunlight and synthesise their own food.

The major roles and functions of algae in soil are:

Playing an important role in the maintenance of soil fertility, especially in tropical soils.

Adding organic matter to soil when they die and thus increasing the amount of organic carbon in soil.

Acting as a cementing agent by binding soil particles and thereby reducing and preventing soil erosion.

Helping to increase the water retention capacity of soil for longer time periods.

Liberating large quantities of oxygen in the soil environment through the process of photosynthesis and, thus, facilitating submerged aeration.

Helping to check the loss of nitrates through leaching and drainage, especially in

un-cropped soils.

Helping in the weathering of rocks and the building up of soil structure.

Protozoa: These are colourless, single-celled animal-like organisms. They are larger than bacteria, varying from a few microns to a few millimetres. Their population in arable soil ranges from 10,000 to 100,000 per gram of soil and they are abundant in surface soil. They can withstand adverse soil conditions, as they are characterised by a protected, dormant stage in their life cycle.

The major functions, roles and features of protozoa are:

Most protozoans derive their nutrition from feeding or ingesting soil bacteria and, thus, they play an important role in maintaining microbial/bacterial equilibrium in the soil.

Some protozoa have been recently used as biological control agents against organisms that cause harmful diseases in plants.

Several soil protozoa cause diseases in human beings that are carried through water and other vectors. Amoebic dysentery is an example.

Viruses: Soil viruses are of great importance, as they may influence the ecology of soil biological communities through both an ability to transfer genes from host to host and as a potential cause of microbial mortality. Consequently, viruses are major players in global cycles, influencing the turnover and concentration of nutrients and gases.

Despite this importance, the subject of soil virology is understudied. To explore the role of the viruses in plant health and soil quality, studies are being conducted into virus diversity and abundance in different geographic areas (ecosystems). It has been found that viruses are highly abundant in all the areas studied so far, even in circumstances where bacterial populations differ significantly in the same environments.

Soils probably harbour many novel viral species that, together, may represent a large reservoir of genetic diversity. Some researchers believe that investigating this largely unexplored diversity of soil viruses has the potential to transform our understanding of the role of viruses in global ecosystem processes and the evolution of microbial life itself.

Nematodes: Not microorganisms (strictly speaking), nematode worms are typically 50 microns in diameter and one millimetre in length. Species responsible for plant diseases have received much attention, but far less is known about much of the nematode community, which play beneficial roles in soil. An incredible variety of nematodes have been found to function at several levels of the soil food web. Some feed on the plants and algae (the first level), others are grazers that feed on bacteria and fungi (second level), and some feed on other nematodes (higher levels).

Free-living nematodes can be divided into four broad groups based on their diet. Bacterial-feeders consume bacteria. Fungal-feeders feed by puncturing the cell walls of fungi and sucking out the internal contents. Predatory nematodes eat all types of nematodes and protozoa. They eat smaller organisms whole or attach themselves to the cuticle of larger nematodes, scraping away until the prey’s internal body parts can be extracted.

Like protozoa, nematodes are important in mineralising, or releasing, nutrients in plant-available forms. When nematodes eat bacteria or fungi, ammonium is released because bacteria and fungi contain much more nitrogen than the nematodes require.

Nematodes may also be useful indicators of soil quality because of their tremendous diversity and their participation in many functions at different levels of the soil food web.

Role and Functions

Collectively, soil microorganisms play an essential role in decomposing organic matter, cycling nutrients and fertilising the soil. Without the cycling of elements, the continuation of life on Earth would be impossible, since essential nutrients would rapidly be taken up by organisms and locked in a form that cannot be used by others. The reactions involved in elemental cycling are often chemical in nature, but biochemical reactions, those facilitated by organisms, also play an important part in the cycling of elements. Soil microbes are of prime importance in this process.

Soil microbes are also important for the development of healthy soil structure. Soil microbes produce lots of gummy substances (polysaccharides and mucilage, for example) that help to cement soil aggregates. This cement makes aggregates less likely to crumble when exposed to water. Fungal filaments also stabilise soil structure because these threadlike structures branch out throughout the soil, literally surrounding particles and aggregates like a hairnet. The fungi can be thought of as the “threads” of the soil fabric. It must be stressed that microbes generally exert little influence on changing the actual physical structure of the soil; that is performed by larger organisms.

Soil microorganisms are both components and producers of soil organic carbon, a substance that locks carbon into the soil for long periods. Abundant soil organic carbon improves soil fertility and water-retaining capacity. There is a growing body of research that supports the hypothesis that soil microorganisms, and fungi in particular, can be harnessed to draw carbon out of the atmosphere and sequester it in the soil. Soil microorganisms may provide a significant means of reducing atmospheric greenhouse gasses and help to limit the impact of greenhouse gas-induced climate change.

Roles of microbes in water (bacteria)

Legionella

The genus Legionella is a pathogenic group of Gram-negative bacteria that includes the species L. pneumophila, causing legionellosis(all illnesses caused by Legionella) including a pneumonia-type illness called Legionnaires' disease and a mild flu-like illness called Pontiac fever.

Cyanobacteria also known as Cyanophyta, are a phylum consisting of free-living photosynthetic bacteria and the endosymbiotic plastids, a sister group to Gloeomargarita, that are present in some eukaryotes. They commonly obtain their energy through oxygenic photosynthesis.The oxygen gas in the atmosphere of earth is produced by cyanobacteria of this phylum, either as free-living bacteria or as the endosymbiotic plastids. The name cyanobacteria comes from the color of the bacteria Cyanobacteria, which are prokaryotes, are also called "blue-green algae",though some modern botanists restrict the term algae to eukaryotes.Cyanobacteria appear to have originated in freshwater or a terrestrial environment.

Acinetobacter is a genus of Gram-negative bacteria belonging to the wider class of Gammaproteobacteria. Acinetobacter species are oxidase-negative, exhibit twitching motility,[2] and occur in pairs under magnification.

Flavobacterium is a genus of gram-negative, nonmotile and motile, rod-shaped bacteria that consists of 130 recognized species. Flavobacteria are found in soil and fresh water in a variety of environments. Several species are known to cause disease in freshwater fish

Aeromonas veronii is a Gram-negative, rod-shaped bacterium found in fresh water and in association with animals.It can be a pathogen of humans and a beneficial symbiont of leeches. In humans A. veronii can cause diseases ranging from wound infections and diarrhea to sepsis in immunocompromised patients. Humans treated with medicinal leeches after vascular surgery can be at risk for infection from A. veronii and are commonly placed on prophylactic antibiotics.Most commonly ciprofloxacin is used but there have been reports of resistant strains leading to infection.In leeches, this bacterium is thought to function in the digestion of blood, provision of nutrients, or preventing other bacteria from growing.

Aeromonas caviae is a Gram-negative bacterium of the genus Aeromonas isolated from epizootic guinea pigs

Micrococcus is a genus of bacteria in the Micrococcaceae family. Micrococcus occurs in a wide range of environments, including water, dust, and soil. Micrococci have Gram-positive spherical cells ranging from about 0.5 to 3 micrometers in diameter and typically appear in tetrads. They are catalase positive, oxidase positive, indole negative and citrate negative. Micrococcus has a substantial cell wall, which may comprise as much as 50% of the cell mass. The genome of Micrococcus is rich in guanine and cytosine (GC), typically exhibiting 65 to 75% GC-content. Micrococci often carry plasmids (ranging from 1 to 100 MDa in size) that provide the organism with useful traits.

 Ralstonia pickettii is a Gram-negative, rod-shaped, soil bacterium

Cronobacter sakazakii, which before 2007 was named Enterobacter sakazakii,is an opportunistic Gram-negative, rod-shaped, pathogenic bacterium that can live in very dry places. The majority of Cronobacter sakazakii cases are adults but low-birth-weight preterm neonatal and older infants are highest at risk. The disease is associated with a rare cause of invasive infection infants with historically high case fatality rates (40–80%).

Arcobacter is a genus of Gram-negative, spiral-shaped bacteria in the class Epsilonproteobacteria. It shows an unusually wide range of habitats, and some species can be human and animal pathogens.Species of the genus Arcobacter are found in both animal and environmental sources, making it unique among the epsilonproteobacteria.This genus currently consists of five species: A. butzleri, A. cryaerophilus, A. skirrowii, A. nitrofigilis, and A. sulfidicus, although several other potential novel species have recently been described from varying environments.Three of these five known species are pathogenic. Members of this genus were first isolated in 1977 from aborted bovine fetuses. They are aerotolerant, Campylobacter-like organisms, previously classified as Campylobacter.The genus Arcobacter, in fact, was created as recently as 1992.Although they are similar to this other genus, Arcobacter species can grow at lower temperatures than Campylobacter, as well as in the air, which Campylobacter cannot

Anabaena is a genus of filamentous cyanobacteria that exist as plankton. They are known for nitrogen-fixing abilities, and they form symbiotic relationships with certain plants, such as the mosquito fern. They are one of four genera of cyanobacteria that produce neurotoxins, which are harmful to local wildlife, as well as farm animals and pets. Production of these neurotoxins is assumed to be an input into its symbiotic relationships, protecting the plant from grazing pressure.

Roles of microbes in air

Bacterial

One such bacterial microorganism that can resist environmental stresses is Bacillus anthracis. It is a gram positive rod shaped bacteria that utilizes spore formation to resist environmental stresses. The spore is a dehydrated cell with extremely thick cell walls which can remain inactive for many years. This spore makes Bacillus anthracis a highly resilient bacteria, allowing it can survive extreme temperatures, chemical contamination, and low nutrient environments (Gatchalian 2010). This bacteria is associated with Anthrax, which is a severe respiratory disease that infects humans.

Fungal

Another such microorganism that can resist environmental stresses is Aspergillus fumigatus, which is a major airborne fungal pathogen (McCormick 2010). This pathogen is capable of causing many human diseases when conidia are inhaled into the lungs. While A. fumigatus lacks virulence traits, it is very adaptable to changing environmental conditions and therefore is still capable of mass infection. (McCormick 2010).

Viral

An example of a viral airborne pathogen is the Avian Influenza Virus, which is a single stranded RNA visur that can infect a broad range of animal species as well as humans and cause the Avian Influenza.