Chapter 5: Organisms and their Residues

I. Kingdoms of Organisms

All the kingdoms are represented in the soil: bacteria, protests, fungi, animals and plants. Natural soil is not inert mineral matter.

A. Monera – One-celled organisms, the simplest organisms in structure though highly efficient, the oldest organisms on Earth; no organelles, including nucleus – they are Prokaryotes. There are photoautotrophic bacteria, the cyanobacteria that use photosynthesis– stromatolites are the fossils of ancient cyanobacteria; the heterotrophic bacteria, some of which are parasites, some saprophytes and some are chemoautotrophs and get their energy and carbon by oxidizing organic compounds.

Bacteria are either aerobic, able to live in an oxygen rich environment and completely oxidize glucose in cellular respiration or anaerobic; use electron acceptors other than oxygen such as nitrates or sulfates; do not require free oxygen and might even die in oxygen environment. Clostridium botulinum and tetanii.

Monera are very important in the process of nitrogen fixation.
Symbiotic N_2 fixers are associated with a host plant; both host and bacteria benefit; fixes nitrogen from atmosphere. Non-symbiotic exist as free bacteria without a host but they fix N_2 also.
Nitrosomas convert ammonium compounds to nitrites; Nitrobacter then convert nitrites to nitrates. These nitrifying organisms achieve maximum growth under the following conditions:
Abundant proteins to release ammonium (enzymes)
Adequate aeration
Moist but not overly wet soil.
Non-acidic soil
Temperatures between 68 and104 F

Symbiotic include those associated with legumes and other plant groups. Rhizobium is the genus of most of these bacteria. They are specific for a particular plant. The nitrogenase enzyme reduces dinitrogen to ammonia, NH_3. This is transformed into organic compounds such as amino acids that organisms use to make proteins, including enzymes.

Some legumes form nodules on the roots. An innoculum of a powdered form of bacteria are added to crop seed to ensure that there is a supply of organisms.

Legumes such as Sesbania (rattlebox) and alfafa are two of the greatest fixers of nitrogen. Sesbania may fix 482 lbs/acre!
Clovers, lespedezas, beans, soybean, kudzu all contribute; non-legumes include red alder, buckthorn, and lichens.

B. Protista: Algae, slime molds and protozoans are also present in soil. Algae are microscopic organisms that perform photosynthesis. One gram of soil may contain up to a million algal cells. Green algae are most abundant in temperate climate and are restricted to upper layer where they receive sunlight. Diatoms or yellow green algae also occur in soil; diatomaceous earth is a commonly used pesticide. They are not important decomposers like bacteria and fungi, but they produce lots of organic compounds, polysaccharides, oils that help to form soil aggregates and that increases water infiltration and overall structure. Protozoans are unicellular organisms that have no cell wall. They ingest bacteria, fungi, nematode larvae, eggs and even smaller protozoans. There are the amoeboids, flagellar, and ciliate organisms. They are numerous in soil and help control other microbes but in humans can cause serious disease such as malaria. Protozoan digestion of bacteria and algae help to speed of recycling of nutrients. They don't cause plant diseases but in humans sleeping sickness, amoebic dysentery, malaria and giardia a close relative of the protozoa do cause humans distress.

C. Fungi: What would soil be without fungi? We now think that a tree root pathogenic mushroom fungi called Armillaria is the largest organism on Earth, larger than a sequoia or a blue whale! Michigan forest for 1500 yrs has harbored a 37 acre fungus that is estimated to weight 220,000 lbs; but now, it is thought that the Malheur National Forest in eastern Oregon holds the largest example, an area nearly 60 X that of the Michigan fungus. It is thought to have been sprouting mushrooms for 2400 yrs. The oldest living tree of course is the bristlecone, thought to be 4800 yrs old.

Fungi include molds, mushrooms and mycorrhizae. They live on dead or living plant or animal tissue. Hyphae are slender filaments that make up the mycelium, the white threadlike structures visible when you look under decaying logs or scrape off the topsoil. A few fungi are direct sources of food for humans. The button mushroom, an Agaricus. The most important role of fungi in the soil is decomposer.

Fungi attack cellulose, lignins, gums and other compounds and can grow in acidic conditions. The first sign of decomposition is the appearance of mycelia, a mass of hyphae. Molds on bread and cheese exhibit this. They compete for nutrients, especially nitrogen, phosphorus and sulfur. Fungi secrete organic substances that aid in soil aggregation. When fungi decompose organic matter, carbon dioxide is released back into the environment. Carbon can be sequestered in the soil by land management practices such as afforestation and adoption of minimum tillage, which makes less residue for fungi to decompose. That way, perhaps, global warming might be decreased.

Deleterious fungi: Some are predators or parasites on living cells. They can attack protozoans and digest them. Nematodes can be snared in the mycelia and devoured.

Plant diseases such as mildews, root rot, smut, rust, wilt canker, and several blights are attributed to fungi. Chestnut blight and Dutch elm disease has affected our populations of these trees for a long time. Potato blight in Ireland in the mid 1800's led to mass migrations of people into the US.

Mycorrhizae means fungus root. They are mutalistic in their relationship with plants of the forest, including trees. Some form a sheath or mantle around the plant roots. The fungi can gain organic substances from the root and fungi help the roots to take on minerals and water. Hyphae can reach into deeper areas of the soil and extract phosphorus, zinc, copper and molybdenum. They protect a plant from drought, high temperatures, infection from disease fungi and extreme soil acidity. Ectomycorrhize sheath the host root but penetrate only spaces between the cells of the root cortex. Endomycorrhizal fungi penetrate into the host cells. VAM (vesicular arbuscular mycorrhizae) VAM are helpful in phosphate absorption and are the most common form on plants, but are less obvious than others.

If soil is sterilized, it is often necessary to re-inoculate the soil with the appropriate fungus. The greatest growth responses occur in weathered tropical soils low in basic cations, are acidic and low in phosphorus and may have toxic levels of aluminum. The fungi help protect the plants from their hostile environment. Page 136 : fungi-root symbiotic association benefits include.

D. Plants: Because they produce carbon (glucose based) foods using carbon dioxide and sunlight energy, they play the most important role in the cycle of life. 16,000 species of bryophytes and 250,000 species of vascular plants.
   Root hairs facilitate water and mineral uptake and increase surface area. Older roots develop protective coverings of mucilage. Root hairs are single cells near the surface. Mature trees can have as many as 5 million active root tips.
   The area in the soil near the roots is called the rhizosphere. This portion may be one to two pH units more acidic than bulk soil and provide lots of different chemicals. Quantities of exuded material vary from 2 percent of o.m. flowing into the root system from plant tops to values of 7 percent exuded from plant roots in sand cultures.
   Roots exude and secrete various substances, 18 amino acids, 10 sugars, 10 organic acids, various proteins, and growth substances, microbe attractants and repellents.
   Dead nettle exudes a substance that will deter nematodes. Products around the root result in an environment that is teeming with microbes, each helping to decompose, fix nitrogen or other activities.

E. Animalia
   Large animals range in size from badgers and ground hogs to mites (arachnids barely visible to the eye, such as chiggers). Earthworms contribute substantially to the soil biomass. But most of the biomass comes from bacteria and fungi. Large burrowing animals aerate soil and alter its fertility and structure, but they can also be damaging to a crop of yard for they often eat vegetation.

   Earthworms can reach populations of ½ million per acre up to 1 million/acre. 625 miles of burrows can be produced in 2.5 acres of land each week.

Earthworms may live up to 8 years. They do not have to come up for air but rather to mate and migrate. They prefer moist, warm well aerated soil between pH 5 and 8.4, plenty of palatable organic matter, low salt concentrations but high calcium, in a fairly deep soil of medium or fine texture, undisturbed by tillage. No till and conservation tillage practices may help to increase earthworm populations in agricultural soil.

Arthropods such as mites, millipedes, centipedes and insects such as ants, termites, springtails, beetles and flies feed on decaying vegetation and help aerate the soil; however, some of these can be pests on plants.
Gastropods, slugs and snails, feed on decaying vegetation but will eat and damage living plants.

Nematodes are microscopic un-segmented, threadlike worms. Omnivorous nematodes live on decaying organic matter and are the most common of the soil nematodes; predaceous prey on soil bacteria fungi, algae and other nematodes. Parasitic infest plant roots, causing knots that are visible. Almost all field and vegetable crops and trees are infected. Sugar beets, soybean and corn are susceptible. They can be helpful in controlling white grub on golf courses, etc. They can be controlled by chemical fumigants. Hardwood bark mixed with soil is a natural low cost technique for control of plant parasitic nematodes.

F. Viruses are not living organisms, yet they cause much damage to crops worldwide. In Latin, it means poison venom and secretion of poison. They are nucleic acids often surrounded by a protein coat.
Prions are various nucleic acids without a protective coat
Viroids have no protective coat around RNA
Virus has a protective protein coat around its RNA or DNA; sometimes even a lipid containing envelope surrounds the nucleic acid.

Diseases caused by viruses: carnation latent virus, beet yellows virus, citrus tristeza virus, mosaic viruses of cucumber, rice dwarf virus, tomato spotted wilt lettuce necrotic yellow, tobacco mosaic, and cacao mosaic. Carrier species include nematodes, fungi and insects.

Enzymes act as catalysts and decompose viruses. Few viruses can over winter in soil but are usually hosted by nematodes or fungi; otherwise, common plant viruses may survive only about 1 to 4 weeks. Insect control is often the most effective and reasonably priced method to kill out the vectors that are transferring these.

Prions may elicit no host response and be extremely deadly. How long they persist in the soil are transmitted in food chain are not completely answered questions.

Conditions for Microbial Activity:

Some ecosystems (biomes) are inhospitable for certain of these organisms.
Microbes are in competition with each other for carbon compounds and other nutrients.
Temperature, moisture,, soil acidity, soil nutrient levels, energy source and competition by other microbes are factors. Microbes are most numerous in soils with moisture near field capacity, with near neutral pH, with high nutrient content, and at temperatures near 86 degrees F.

Dryness kills many microbes but others develop a thick coat and enter a dormant stage. A few anaerobes grow best at saturated conditions. Most cannot tolerate constant flooding.
Optimal soil pH is 7. Bacteria are usually less tolerant of acidic conditions than are fungi and few will grow if it drops below 5. Sulfur oxidizing Thiobacillus produces sulfuric acid and tolerates soil pH down to 0.6. Forest and organic soils with a pH as low as 3 has been reported for other fungi.
Local microenvironments near roots can produce locales of lower pH than that of soil as a whole.

Generally speaking, biological activity doubles between 50 degrees F to 68 degrees F with a 10 degree rise in temperatures; however, there is a point at which the enzymes (proteins) will be denatured and growth will be inhibited. At freezing, most plants and microbes are nearly dormant. Majority of soil bacteria and actinomycetes, however, have optimum activity temps.
Psychrophiles: grow best at temps below 41 F; optimal 59 to 68 degrees F.
Mesophiles: show little growth below zero ddgeres or above 104 degrees F. For most organims, 77 to 99 F is optimal).

Protozoans eat microbes such as bacteria; one amoeboe may devour several thousand bacteria per one cell division (once or twice a day). Some produce antibodies, substances that retard or kill other nearby organisms and acquire more nutrients by eliminating the competition. Bacteriophages are viruses that attack bacteria and may cause their breakdown. Optimum growth conditions include an absence of enemies.

G.Beneficial Organisms:

Maintaining optimal field conditions for them.

1. Inoculate the soil with desired organisms (Rhizobia) .
2. Lime the soil, for most crops like values up to and above6.
3. Sterilize soil if necessary
4. Minimize soil fumigaton or sterilization.
5. Maintain high organic matter levels.
6. Avoid contgamination. Don’t mix contaminated soil to clean field. Burn infected plants.
7. Avoid causing stress conditions, such as drought salt aaumulation, waterlogging or excessivefertier.