RAMA UNIVERSITY, KANPUR, UTTARPRADESH

Faculty of Agricultural Sciences & Allied Industries

Dr. Ajay Singh
Assistant Professor (Agronomy)

Course: Principles of Organic farming

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Soil fertility, nutrient recycling

In organic farming systems, soil fertility means more than just providing plants with macro- and micronutrients. Effective fertility management considers plants, soil organic matter (SOM), and soil biology. Ideally, organic farming systems are designed to enhance soil fertility to achieve multiple goals. Important goals include: the protection and, if possible, improvement of soil physical condition so that the soil supports healthy plants and soil-dwelling organisms and has the ability to resist and recover from stresses like flooding or aggressive tillage; the maintenance of soil buffering capacity to minimize environmental degradation caused by soil loss or soils' failure to filter nutrients or degrade harmful compounds; and increased water and nutrient use efficiency by increasing biological fixation and retention of needed nutrients while reducing their loss from the system to the extent possible. Organic farming systems are designed with the aim of maintaining nutrients in organic reservoirs or in bio-available mineral forms instead of just supplying nutrients through
frequent fertilizer additions. This is achieved by cycling nutrients through organic reservoirs. Soil fertility is improved by organic matter management and not through input substitution.

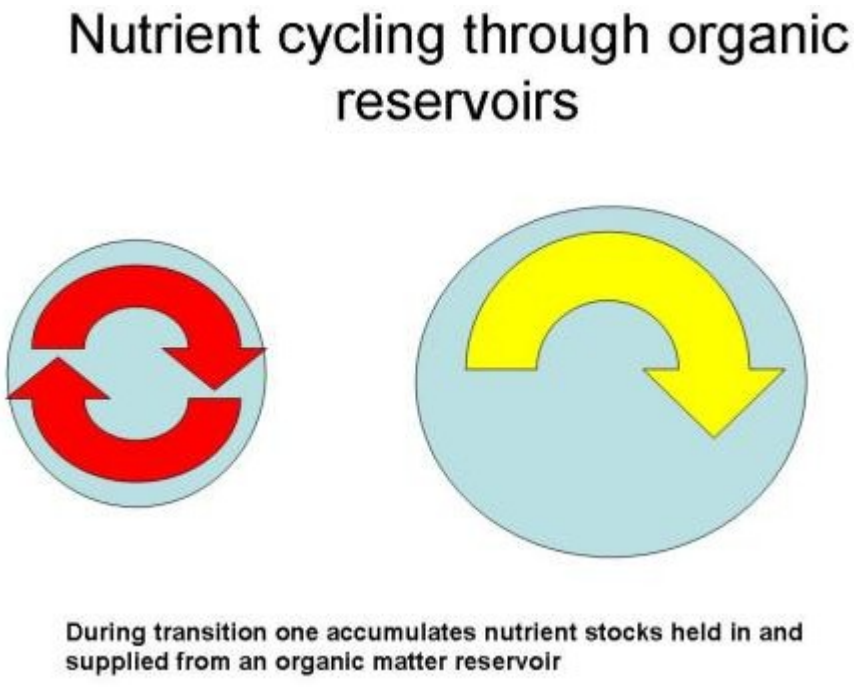

Figure 1. *This cartoon depicts idealized changes that occur where fast mineral nutrient cycling (depicted by red arrows) in depleted organic reservoirs (depicted by blue sphere) is altered by improved management to result in slower cycling rates (yellow arrow) within an enlarged reservoir. Figure credit: Michelle Wander, University of Illinois.*

The intention of organic systems is to manage the full range of soil organic and inorganic nutrient reservoirs and prevent unwanted loss by retaining them in forms that can be accessed by crops through biological leveraging. One objective during transition is to enhance symbiotic associations between plants and their microbial partners, organic reserves, and the physical environment. For more on the role that microbes play inN cycling see Soil Microbial Nitrogen Cycling for Organic Farms.

This holistic view is the basis for the soil fertility management practices used in organic agriculture.

There are four soil fertility management practices typically used in organic cropping systems that determinethe cycling and availability of nutrients in the soil:

1. use of organic residues as soil amendments or sparingly soluble minerals;
2. use biological N-fixation as the major N source;
3. use of a rotation that includes active plant growth (cover crops, intercrops etc.) as much as possible and thatminimizes bare fallow.
4. Plant species are diversified in space and time to fulfill a variety of functions (minimize weeds and pests,support below-ground processes, erosion control, N fixation, build SOM etc.).

Organic fertility is not a matter of input substitution:-

Organic farming systems cannot rely on use of soluble, inorganic nutrient sources. Conventional fertilizer management guidelines hinge upon assessments of plant-available N and P combined with empirical fertilizeraddition studies that are able to provide estimates of the amount of fertilizer required to achieve yield goals.
Although many organic producers do use soil testing to assess soil nutrient levels, they report that while these tests often indicate that plant-available N or P may be limiting, their yields do not reflect these soil test results.There are several reasons to expect that organic production systems require their own suite of management tools. First, organic soil amendments vary in quantity and quality.

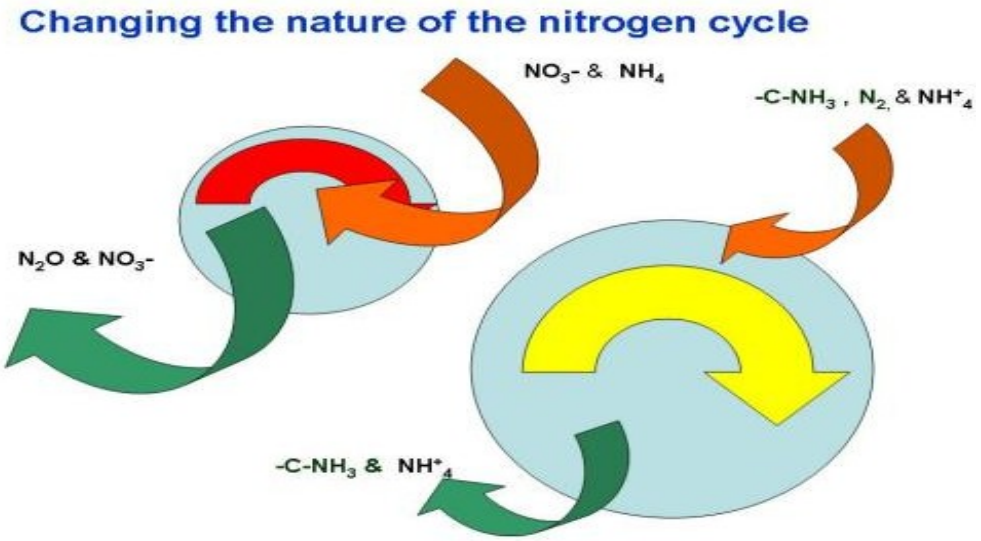

***Figure 2**. The figures above depict changes in N cycling in systems where N is supplied in inorganic fertilizersto systems that rely on organic sources. The size of the blue sphere represents the active or labile fraction of soil organic matter and the thickness and coloration of the arrows reflect the size and cycling rates of nutrient reserves. Red arrows identify pools that cycle more rapidly than yellow.*

Nutrient recycling:-

Nutrients are the substances that are required by organisms for growth and development. A nutrient is defined as any substance that provides nourishment to the body and is essential for normal growth and development, reproduction, and survival of the organism.

All the organisms obtain nutrients from the environment surrounding them. The total amount of nutrients on our planet has been constant since its birth. These nutrients are continuously used by the organisms and are added back to the environment in some modified form. The modified form is again converted back to its original form by some other organisms. This cyclic flow of nutrients from the environment to organisms and back into the environment is called nutrient recycling. Nutrient recycling ensures that they are never depleted but are reused again and again.

In this article, we will discuss how nutrient recycling takes place in the biosphere. We will discuss nutrientrecycling in terms of various nutrient cycles.

Nutrient Cycles:-

The recycling of various nutrients takes place in the form of nutrient cycles. A nutrient cycle is a cyclic movement of nutrients from its major reservoir through different organisms back into the same reservoir. These cycles indicate the flow of nutrients in an ecosystem.

Components:-

Each nutrient cycle comprises of three components;

1. **Reservoirs**: These are the major storage sites of a nutrient. Different organisms consume a nutrient fromthese reservoirs.
2. **Sources**: These are the ways by which a nutrient is regenerated and added to its reservoirs.
3. **Sinks**: They are the major consumption sites of a nutrient.

Types of Organisms

The organisms involved in any nutrient cycle are divided into three major categories;

1. Producers
2. Consumers
3. Decomposers

All these organisms play a designated role in different nutrient cycles.

Producers

These are the organisms that can prepare their food using raw material and light energy. All the photosynthetic organisms are included in this group. They are called autotrophs. They are the most abundant organisms present in an ecosystem. This group includes plants, algae, and other autotrophs.

Consumers

These are the organisms that cannot prepare their food and depend on producers. They obtain their food by consuming the producers. They are also called heterotrophs.

Consumers can also be further classified as follows;

- **Primary consumers**: They obtain food by eating producers. They are herbivores like goats, cows,grasshoppers, etc.
- **Secondary consumers**: They obtain food by eating producers or primary consumers. These includehumans, bears, hen, etc. They are known as omnivores.
- **Tertiary consumers**: Such animals obtain food by eating other consumers. They are called carnivores andinclude lion, tiger, cat, etc.

Decomposers

These organisms obtain food from the dead and decaying matter of producers or consumers. These includefungi and some types of bacteria

All these organisms play their designated roles in each nutrient cycle. The absence of any of the organismscan disturb the cycle.

Major Nutrients

Some of the major nutrients that are continuously being recycled in every ecosystem are as follows.

- Oxygen
- Carbon
- Nitrogen
- Sulphur
- Phosphorus
- Water

We will discuss the recycling of each of these nutrients in the remaining article.

Oxygen Cycle

Oxygen is the most important nutrient present in the environment. It is continuously being used andrecycled by organisms in various ecosystems.

The different components of this cycle are discussed below.

Reservoirs

Oxygen is abundantly present in the earth's crust as well as the atmosphere. The major reservoirs of oxygenare as follows;

- **Earth crust**: Oxygen is the major element that makes the surface and the crust of the earth. It is present inthe form of silicate and oxide minerals.
- **Atmosphere**: Atmosphere is the major reservoir of oxygen in gaseous form. Oxygen makes around 21% ofthe total gases present in the atmosphere.
- **Biosphere**: It contains around 22% oxygen by volume. Oxygen is present in the biosphere in the form oforganic molecules.
- **Hydrosphere**: Around 33% oxygen is present in hydrosphere as a component of water molecules.

- **Lithosphere**: The lithosphere contains around 46% oxygen in the form of oxides. The most abundant oxideis silica oxide.

Sources

Oxygen gets added to the reservoirs in two ways; biological production and abiotic production.

Biological production is by far the most important source of atmospheric oxygen. Oxygen is produced during the process of photosynthesis and gets added to the atmosphere. This process is carried out by all thephotosynthetic organisms including plants, algae, and some bacteria.

Abiotic production occurs when water molecules present in the atmosphere are broken down by ultravioletrays into hydrogen ions and molecular oxygen.

Sinks

Oxygen is removed from the atmosphere by two means; biological consumption and non-biologicalconsumption.

The major sink of atmospheric oxygen is biological consumption by organisms during respiration. Animals, plants, and other organisms use oxygen during cellular respiration to break down the food molecules and release carbon dioxide.

The non-biological consumption includes the conversion of oxygen to ozone by chlorofluorocarbons in thepresence of ultraviolet light.

Role of organisms

The role of different organisms in the oxygen cycle is as follows;

Producers
They are the major sources of atmospheric oxygen. They add oxygen to the environment during the processof photosynthesis.

Consumers
Consumers are the major sinks of atmospheric oxygen. They consume oxygen in the process of cellularrespiration.

Decomposers
Decomposers are involved in the decay process. They feed on the dead organisms and add the oxygen fromdead tissues back into the soil.

Carbon Cycle

Carbon is a major constituent of living systems. It is the most abundant element found in living organisms.It is also present inside the earth in the form of minerals.

The major components of the carbon cycle are mentioned below.

Reservoirs
The major reservoirs of carbon are as follows:

- **Atmosphere**: Carbon is present in the atmosphere in the form of two gases; carbon dioxide and methane.
- **Biosphere**: Carbon is a major component of land and water biosphere. It is present in all living organisms inan abundant amount as a major constituent of organic compounds.
- **Geosphere**: Carbon is present in the earth's lithosphere. It has been stored in the earth since it was formed.

Sources
The sources of carbon are of two types; biological and non-biological.

Cellular respiration by living organisms is the major source of carbon being added to the atmosphere. Carbon dioxide is released by animals, plants, and other organisms during the process of cellular respiration.

The non-biological source is the burning of fossil fuels in automobiles as well as in the industry. Theburning process utilizes oxygen and the carbon in fuels is released in the form of carbon dioxide.

Sinks
The major sinks of carbon include the following;

- It is used by plants in the process of photosynthesis
- It is used by animals for carbon fixations
- It is used by decomposers during the decomposition process
- It gets converted into fossil fuels

Role of Organisms

The role of different organisms in the carbon cycle is discussed below.

Producers

Producers use carbon dioxide present in the atmosphere during photosynthesis.

Consumers

They add carbon back to the atmosphere during cellular respiration as carbon dioxide. They also use carbon in carbon fixation.

Decomposers

They use carbon during the decay process and play a role in adding carbon to the lithosphere. They are also responsible for converting the carbon in the dead organisms into fossil fuels.

Nitrogen Cycle

The nitrogen cycle is one of the classical examples of nutrient recycling in the environment. It involves theconversion of nitrogen into several compounds and the recycling of these compounds in different ecosystems. In this section, we will only briefly discuss the nitrogen cycle. The details of this cycle will be covered in a separate article.

The cycle is divided into the following components.

Reservoirs

The major reservoir of nitrogen is our atmosphere. Nitrogen makes more than 70% of the total gases presentin the atmosphere.

Sources

Nitrogen gets added back to the atmosphere by denitrifying bacteria. Denitrification is the major source ofatmospheric nitrogen.

Sinks

Nitrogen is consumed by plants in their growth. It is present in the majority of fertilizers that are responsible for the rapid growth of plants. It is required to make amino acids by plants.

Role of Organisms

The role of different organisms in the nitrogen cycle is as follows.

Producers
Plants are the major sinks of nitrogen. They use nitrogen for their growth.

Consumers
Animals obtain nitrogen by eating plants. They convert this nitrogen to urea and other ammoniumcompounds and add it back to the soil.

Decomposers
Decomposers like fungi also use nitrogen for their growth. Bacteria convert various forms of nitrogen present in the soil into nitrogen gas and add it back to the atmosphere.

Water Cycle

Water is the medium of life. All the chemical processes in living organisms take place in the presence of water. It also makes more than 70% of the bodies of living organisms. The normal water cycle is essential for the maintenance of life on our planet.

The various components of the water cycle are discussed below.

Reservoirs
The main reservoirs of water are as follows:

- **Atmosphere**: Water is present in the atmosphere in the form of water vapors.
- **Biosphere**: Water is present in the biosphere as a component of living systems. Water makes more than70% of the total mass of any organism present on the earth.
- **Hydrosphere**: Water is present in rivers, oceans, glaciers, seas on earth.

Sources
Water is not added but recycled in the environment by various processes.

- Water present in the hydrosphere is added to the atmosphere by the process of evaporation. Clouds areformed in this process.
- As the rain falls, water is added from the atmosphere back into the hydrosphere.
- Water present in the biosphere is added to the atmosphere during perspiration in animals and transpiration inplants.

Sinks
Water is used in several biological and non-biological processes.

- It is used by plants in the process of photosynthesis to make food. It is also used in other processes withinthe plant cells.
- Water is used by animal cells in various metabolic reactions.
- It is also used in many domestic and industrial processes.

Role of Organisms
Almost all organisms play a two-way role in the water cycle. They use water in some processes and release water back to the environment in others. A brief detail is as follows.

Producers

They use water in photosynthesis and water back to the atmosphere during transpiration.

Consumers

They use water during cellular respiration and other metabolic processes. Water is added back to theatmosphere during perspiration.

Decomposers

Water is used in some reactions of the decomposing process and is released in others.

Summary

Nutrient recycling is the process by which nutrients continue to circulate in the environment, again andagain. It occurs via various nutrient cycles.

Each nutrient cycle is divided into three components:

- Reservoirs
- Sources
- Sinks

The organisms participating in the nutrient cycle are divided into three categories:

- Producers
- Consumers
- Decomposers

The oxygen cycle is the cyclic movement of oxygen in the environment.

- Major reservoirs are atmosphere, biosphere, lithosphere.
- Important sources are photosynthesis and photolysis.
- It is being consumed in cellular respiration and decay process.

The carbon cycle involves the recycling of carbon in the environment.

- Its reservoirs are atmosphere, biosphere, and geosphere.
- Sources of carbon in the atmosphere are cellular respiration and the burning of fuels.
- It is used in photosynthesis and carbon fixation.

The nitrogen cycle is a complex cycle during nitrogen is recycled via complex nitrogen compounds.

- The atmosphere is the major reservoir of nitrogen.
- Denitrifying bacteria add nitrogen back to the atmosphere.
- It is used by organisms for growth and development.

The water cycle involves the recycling of water molecules in the environment.

- Atmosphere, biosphere, hydrosphere are all reservoirs of water.

- Water is not produced but recycled by living organisms.
- It is used in some reactions and produced in others.