A

Term Paper

On

**ROLES OF MICROBES IN NUTRIENT CYCLING AND FOOD CHAIN**

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# ABSTRACT

# Microorganisms abound in the ecosystem and are critical to recycling nutrients and in food chains which are essential for the majority of the ecosystem’s functions and services.

Flows of nutrients from living to non-living components of the Earth are called biogeochemical cycles. Ecosystems hinge on biogeochemical cycles. The nitrogen cycle, the phosphorous cycle, the sulfur cycle, and the carbon cycle all involve assimilation of these nutrients into living things. These elements are transferred among living things through food webs and food chains, until organisms ultimately die and release them back into the ecosystem.

This report presents details on the roles of microorganisms in nutrient cycling and food chains. system services

# CHAPTER ONE

# INTRODUCTION

## 1.1 NUTRIENT CYCLING

Nutrient cycling is one of the most important processes that occur in an ecosystem. The nutrient cycle describes the use, movement, and recycling of nutrients in the environment. Valuable elements such as [carbon](https://www.thoughtco.com/what-is-the-carbon-cycle-607606), oxygen, hydrogen, [phosphorus](https://www.thoughtco.com/phosphorus-facts-606574), and nitrogen are essential to life and must be recycled in order for organisms to exist. Nutrient cycles are inclusive of both [living](https://www.thoughtco.com/biology-meaning-373266) and nonliving components and involve biological, geological, and chemical processes. For this reason, these nutrient circuits are known as biogeochemical cycles.

Biogeochemical cycles can be categorized into two main types: global cycles and local cycles. Elements such as carbon, nitrogen, oxygen, and hydrogen are recycled through abiotic environments including the [atmosphere](https://www.thoughtco.com/definition-of-atmosphere-604801), water, and soil. Since the atmosphere is the main abiotic environment from which these elements are harvested, their cycles are of a global nature. These elements may travel over large distances before they are taken up by biological organisms. The soil is the main abiotic environment for the recycling of elements such as phosphorus, calcium, and potassium. As such, their movement is typically over a local region.

## 1.2 FOOD CHAINS

A food chain is a linear sequence of organisms through which nutrients and energy pass: primary producers, primary consumers, and higher-level consumers are used to describe ecosystem structure and dynamics. There is a single path through the chain. Each organism in a food chain occupies what is called a trophic level. Depending on their role as producers or consumers, species or groups of species can be assigned to various trophic levels.

All life forms in an ecosystem can be broadly grouped into one of two categories (called trophic levels): Autotrophs, which produce organic matter (food) from inorganic substances; and Heterotrophs, which must feed on other organisms in order to obtain organic matter. In general, trophic levels are used to describe the way in which a particular organism within an ecosystem gets its food. Using this description, we can restate and reorganize the categories above to define the three basic ways organisms acquire their food:

Producers (autotrophs) do not usually eat other organisms but pull nutrients from the soil or the ocean and manufacture their own food using photosynthesis. It is the energy from the sun that usually powers the base of the food chain.

Consumers (heterotrophs) cannot manufacture their own food and need to consume other organisms.

Decomposers break down dead plant and animal material and wastes and release them into the ecosystem as energy and nutrients for recycling.

Microorganisms play a vital role in every ecological community by serving both as producers and as decomposers

# CHAPTER TWO

# ROLES OF MICROBES IN NUTRIENT CYCLING

## 2.1 ROLES OF MICROBES IN NITROGEN CYCLE

Nitrogen is a necessary component of biological molecules. Some of these molecules include [amino acids](https://www.thoughtco.com/amino-acid-373556) and [nucleic acids](https://www.thoughtco.com/nucleic-acids-373552). Although nitrogen (N2) is abundant in the atmosphere, most living organisms can not use nitrogen in this form to synthesize organic compounds. Atmospheric nitrogen must first be fixed, or converted to ammonia (NH3) by certain bacteria

The nitrogen cycle is the process by which nitrogen is converted from organic to inorganic forms; many steps are performed by microbes.

Fixation: In order for organisms to use atmospheric nitrogen (N2), it must be “fixed” or converted into ammonia (NH3). This can happen occasionally through a lightning strike, but the bulk of nitrogen fixation is done by free living or symbiotic bacteria such as *Azotobacter*, *Beijerinckia*, and *Clostridium*) . These bacteria have the nitrogenase enzyme that combines gaseous nitrogen with hydrogen to produce ammonia. It is then further converted by the bacteria to make their own organic compounds. Some nitrogen fixing bacteria live in the root nodules of legumes where they produce ammonia in exchange for sugars.

Nitrificaton: Nitrification is the conversion of ammonia (NH3) to nitrate (NO3–). It is usually performed by soil living bacteria, such asN*itrobacter*. This is important because plants can assimilate nitrate into their tissues, and they rely on bacteria to convert it from ammonia to a usable form.

Ammonification /Mineralization: In ammonification, bacteria or fungi convert the organic nitrogen from dead organisms back into ammonium (NH4+). Nitrification can also work on ammonium. It can either be cycled back into a plant usable form through nitrification or returned to the atmosphere through denitrification.

De-Nitrification: Nitrogen in its nitrate form (NO3–) is converted back into atmospheric nitrogen gas (N2) by bacterial species such as *Pseudomonas* and *Clostridium,* usually in anaerobic conditions. These bacteria use nitrate as an electron acceptor instead of oxygen during respiration.



Figure 1: Nitrogen cycle

Source: https://courses.lumenlearning.com/trident-boundless-microbiology/chapter/nutrient-cycles/

## 2.2 ROLES OF MICROBES IN CARBON CYCLE

Carbon is essential to all life as it is the main constituent of living organisms. It serves as the backbone component for all [organic polymers](https://www.thoughtco.com/biological-polymers-373562), including [carbohydrates](https://www.thoughtco.com/carbohydrates-373558), [proteins](https://www.thoughtco.com/proteins-373564), and [lipids](https://www.thoughtco.com/lipids-373560). Carbon compounds, such as carbon dioxide (CO2) and methane (CH4), circulate in the atmosphere and influence global climates. Carbon is circulated between living and nonliving components of the ecosystem primarily through the processes of photosynthesis and respiration. Plants and other photosynthetic organisms obtain CO2 from their environment and use it to build biological materials. Plants, animals, and decomposers ([bacteria](https://www.thoughtco.com/bacterial-reproduction-373273) and [fungi](https://www.thoughtco.com/interesting-facts-about-fungi-373407)) return CO2 to the atmosphere through respiration. The movement of carbon through biotic components of the environment is known as the fast carbon cycle. It takes considerably less time for carbon to move through the biotic elements of the cycle than it takes for it to move through the abiotic elements. It can take as long as 200 million years for carbon to move through abiotic elements such as rocks, soil, and oceans. Thus, this circulation of carbon is known as the slow carbon cycle.

Steps of the Carbon Cycle

* CO2 is removed from the atmosphere by photosynthetic organisms (plants, cyanobacteria, etc.) and used to generate organic molecules and build biological mass.
* Animals consume the photosynthetic organisms and acquire the carbon stored within the producers.
* CO2 is returned to the atmosphere via respiration in all living organisms.
* Decomposers break down dead and decaying organic matter and release CO2.
* Some CO2 is returned to the atmosphere via the burning of organic matter (forest fires).
* CO2 trapped in rock or fossil fuels can be returned to the atmosphere via erosion, volcanic eruptions, or fossil fuel combustion.



Figure 2: carbon cycle

Source: https://courses.lumenlearning.com/trident-boundless-microbiology/chapter/nutrient-cycles/

## 2.3 ROLES OF MICROBES IN SULPHUR CYCLE

Many bacteria can reduce sulfur in small amounts, but some bacteria can reduce sulfur in large amounts, in essence, breathing sulfur. The sulfur cycle describes the movement of sulfur through the atmosphere, mineral forms, and through living things. Although sulfur is primarily found in sedimentary rocks or sea water, it is particularly important to living things because it is a component of many proteins.

Sulfur is released from geologic sources through the weathering of rocks. Once sulfur is exposed to the air, it combines with oxygen, and becomes sulfate SO4. Plants and microbes assimilate sulfate and convert it into organic forms. As animals consume plants, the sulfur is moved through the food chain and released when organisms die and decompose.

Some bacteria – for example *Proteus, Campylobacter, Pseudomonas and Salmonella* – have the ability to reduce sulfur, but can also use oxygen and other terminal electron acceptors. Others, such as *Desulfuromonas,* use only sulfur. These bacteria get their energy by reducing elemental sulfur to hydrogen sulfide. They may combine this reaction with the oxidation of acetate, succinate, or other organic compounds.

The most well-known sulfur reducing bacteria are those in the domain Archea, which are some of the oldest forms of life on Earth. They are often extremophiles, living in hot springs and thermal vents where other organisms cannot live. Lots of bacteria reduce small amounts of sulfates to synthesize sulfur-containing cell components; this is known as assimilatory sulfate reduction. By contrast, the sulfate-reducing bacteria considered here reduce sulfate in large amounts to obtain energy and expel the resulting sulfide as waste. This process is known as dissimilatory sulfate reduction. In a sense, they breathe sulfate.

Sulfur metabolic pathways for bacteria have important medical implications. For example, *Mycobacterium tuberculosis* (the bacteria causing tuberculosis) *and Mycobacterium leprae* (which causes leoprosy) both utilize sulfur, so the sulfur pathway is a target of drug development to control these bacteria.



Figure 3: Sulphur cycle

Source : wikipedia

# CHAPTER THREE

# ROLES OF MICROBES IN FOOD CHAINS

## 3.1 ROLES OF MICROBES AS PRODUCERS

Autotrophs or primary producers are organisms that acquire their energy from sunlight and materials from nonliving sources. Algae, higher plants, and some bacteria and protists are important autotrophs in running waters. A primary producer converts an [abiotic](https://en.wikipedia.org/wiki/Abiotic) source of energy (e.g. light) into energy stored in [organic compounds](https://en.wikipedia.org/wiki/Organic_compounds), which can be used by other organisms (e.g. [heterotrophs](https://en.wikipedia.org/wiki/Heterotrophs)). The primary producers can convert the energy in the light ([phototroph](https://en.wikipedia.org/wiki/Phototroph%22%20%5Co%20%22Phototroph) and [photoautotroph](https://en.wikipedia.org/wiki/Photoautotroph)) or the energy in inorganic chemical compounds ([chemolithotrophs](https://en.wikipedia.org/wiki/Chemolithotrophs%22%20%5Co%20%22Chemolithotrophs)) to build [organic molecules](https://en.wikipedia.org/wiki/Organic_molecules), which is usually accumulated in the form of [biomass](https://en.wikipedia.org/wiki/Biomass) and will be used as carbon and energy source by other organisms (e.g. [heterotrophs](https://en.wikipedia.org/wiki/Heterotrophs) and [mixotrophs](https://en.wikipedia.org/wiki/Mixotrophs%22%20%5Co%20%22Mixotrophs)). The photoautotrophs are the main primary producers, converting the energy of the light into chemical energy through [photosynthesis](https://en.wikipedia.org/wiki/Photosynthesis), ultimately building organic molecules from [carbon dioxide](https://en.wikipedia.org/wiki/Carbon_dioxide), an [inorganic](https://en.wikipedia.org/wiki/Inorganic) [carbon source](https://en.wikipedia.org/wiki/Carbon_source).[[1]](https://en.wikipedia.org/wiki/Primary_producer#cite_note-:0-1) Examples of chemolithotrophs are some [archaea](https://en.wikipedia.org/wiki/Archaea%22%20%5Co%20%22Archaea) and [bacteria](https://en.wikipedia.org/wiki/Bacteria) (unicellular organisms) that produce [biomass](https://en.wikipedia.org/wiki/Biomass) from the [oxidation](https://en.wikipedia.org/wiki/Oxidation) of inorganic chemical compounds, these organisms are called [chemoautotrophs](https://en.wikipedia.org/wiki/Chemoautotroph), and are frequently found in [hydrothermal vents](https://en.wikipedia.org/wiki/Hydrothermal_vent) in the deep ocean. Primary producers are at the lowest [trophic level](https://en.wikipedia.org/wiki/Trophic_level), and are the reasons why Earth is sustainable for life to this day. There are many different types of primary producers out in the Earth's ecosystem at different states. Fungi and other organisms that gain their biomass from oxidizing organic materials are called [decomposers](https://en.wikipedia.org/wiki/Decomposer) and are not primary producers. However, [lichens](https://en.wikipedia.org/wiki/Lichen) located in tundra climates are an exceptional example of a primary producer that, by mutualistic symbiosis, combine photosynthesis by [algae](https://en.wikipedia.org/wiki/Algae) (or additionally nitrogen fixation by cyanobacteria) with the protection of a decomposer [fungus](https://en.wikipedia.org/wiki/Fungus). Also, plant-like primary producers (trees, algae) use the sun as a form of energy and put it into the air for other organisms.There are of course H2O primary producers, including a form of bacteria, and [phytoplankton](https://en.wikipedia.org/wiki/Phytoplankton). As there are many examples of primary producers, two dominant types are coral and one of the many types of brown algae, kelp.

## 3.2 ROLES OF MICROBES AS CONSUMERS

Protozoa and nematodes consume other microbes. After the protozoa and nematodes consume the bacteria or other microbes (which are high in nitrogen), they release nitrogen in the form of ammonium (see the graph on net mineralization). Ammonium (NH4+) and nitrates (NO3-) are easily converted back and forth in the soil. Plants absorb ammonium and soil nitrates for food with the help of the fungi mycorrhizal network.

## 3.3 ROLES OF MICROBES AS DECOMPOSERS

Decomposition releases the mineral nutrients (e.g., N, P, K ) bound up in dead organic matter in an inorganic form that is available for primary producers to use. Without this recycling of inorganic nutrients, primary productivity in th ecosystem would stop.

On land, most of the decomposition (also called "mineralization") of dead organic matter occurs at the soil surface, and the rate of decomposition is a function of moisture and temperature (too little or too much of either reduces the rate of decomposition). Fungi are important in terrestrial systems, but not in aquatic. They are present even before the leaves and twigs enter the soil and so decomposition starts in the living or senescent plant material. Fungi are the most important decomposers of structural plant compounds (cellulose and lignin – but note that lignin is not broken down when oxygen is absent). The fungi invade the organic matter in soils first and are then followed by bacteria.

In water, the decomposition of organic matter is mostly toxic in streams and in the ocean and anoxic in the bottoms of lakes or in swamps.

Stages of Decomposition

When an organism dies and decomposers do the work of decomposition, the organism’s remains go through five stages of decomposition: fresh, bloat, active decay, advanced decay, and dry/remains. There are two main processes that occur in a decomposing organism: autolysis and putrefaction. Autolysis is when cellular enzymes in the dead organism’s own body break down cells and tissues, while putrefaction is when microbes grow and reproduce throughout the body after death. Here is a brief summary of the five stages.

Fresh

Putrefaction also begins to occur.

Bloat

Due to putrefaction, a buildup of gases occurs and the organism’s remains appear bloated in what is known as the bloat stage. Some gases and fluids are purged out.

Active Decay

The remains lose mass, and liquefaction and disintegration of tissues begins to occur. Bacteria produce chemicals such as ammonia, hydrogen sulfide, and methane, which cause strong odors.

Advanced Decay

The organism has lost a lot of mass, so there is not much left to be decomposed. If the organism is on or in soil, the surrounding soil will show an increase in nitrogen, an important nutrient for plants.

Dry/Remains

In this stage, only dry [skin](https://biologydictionary.net/skin/), [cartilage](https://biologydictionary.net/cartilage/), and bones are left. Plant growth may occur around the remains because of the increased nutrient levels in the soil. Eventually, only the bones of the organism will remain.

# CONCLUSION

Microorganisms are essential for the majority of soil ecosystem functions and services. They play a central and essential role in the biogeochemical cycling of soil nutrients. This ensures the turnover and supply of nutrients that are essential for plant and crop growth, through the inter-conversion of different forms of nitrogen, sulphur and interlinked with the carbon cycle. Thus all microbiological activity in soil contributes to cycling of nutrients and other ecosystem functions and all soil functions contribute to ecosystem services.

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