Review Article

Microbial contributions to Global climate changes in soil environments: impact on Carbon cycle: a short review

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Abstract

Microorganisms play important role in recycling the elements, like carbon, nitrogen in nature. There is considerable interest in understanding the biological mechanism that regulates carbon exchanges between the land, water and atmosphere, and how these exchanges respond to climate change. An understanding of soil microbial ecology to assess terrestrial carbon cycle climate play important role for balanced ecosystem. The complexity of the soil microbial community and the many ways that it can be affected by climate and other global changes hampers the metabolic activity of organisms in different ways. This paper relates to understand the potential negative and positive contributions of soil microbes to land atmosphere carbon exchange and global warming requires explicit consideration of both direct and indirect impacts of climate change on microorganisms. Global climate changes definitely influence the factors like temperature, moisture, C:N ratio of the soil environment and in turn the types and density of heterotropic microorganisms. Moreover, this requires consideration of complex interactions and feedbacks that occur between microbes, plants and their physical environment in the context of climate change, and the influence of other global changes which have the capacity to amplify climate- driven effects on soil microbes.

Overall, we emphasize the urgent need for greater understanding of how soil microbial ecology contribute to land-atmosphere carbon exchange in the context of climate change, and identify some challenges for the future. In particular, we highlight the need for a multifactor experimental approach to understand how soil microbes and their activities respond to climate change and consequences for carbon cycle feedbacks.

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Microbes are involved in many processes, such as the carbon and nitrogen cycles, and are responsible for both the production and consumption of greenhouse gases such as carbon dioxide and methane. Microbes have various positive and negative feedback responses to temperature.[1] The reason is that microbes live in very diverse communities that interact with other organisms and the environment in complex ways, which makes it difficult to make predictions about the effects of microbes on climate change, but scientists are trying to include microbial activity in climate change models. Also, it is certain that human activities have helped to increase the production of green house gases by microbes.[2]

Carbon-based molecules are crucial for life on earth, because it is the main component of biological compounds. Carbon is also a major component of many minerals. Carbon also exists in various forms in the atmosphere. Carbon dioxide (CO_2) is partly responsible for the greenhouse effect and is the most important human contributed greenhouse gas.

In the past two centuries, human activities have seriously altered the global carbon cycle. Although carbon dioxide levels have changed naturally over the past several thousand years, human emissions of carbon dioxide into the atmosphere is more than natural fluctuations.[3] Changes in the amount of atmospheric CO_2 are considerably altering weather patterns and indirectly influencing oceanic chemistry. Records from ice cores have shown that, although global temperatures can change without changes in atmospheric CO_2 levels, CO_2 levels cannot change significantly without affecting global temperatures. Current carbon dioxide levels in the atmosphere exceed measurements from the last 420,000 years and levels are rising faster than ever recorded, making it of critical importance to better understand how the carbon cycle works and what are its effects on the global climate.

The Earth is a 'closed system' which means that it produces everything it needs to ensure the survival and growth of its residents. In nature there are chemical cycles such as the carbon cycle to control and balance these gases that surround the earth. The carbon cycle is a complex series of processes through which all of the carbon atoms in existence rotate. This means that the carbon atoms in our body today have been used in many other molecules since time began e.g. as the carbon found in carbon dioxide in the air. Microbes play an important role as either generators or users of these gases in the environment as they are able to recycle and transform the essential elements such as carbon and nitrogen that make up cells.

Bacteria and archaea are involved in the 'cycles' of all the essential elements. In the carbon cycle methanogens convert carbon dioxide to methane in a process called methanogenesis. In the nitrogen cycle nitrogen-fixing bacteria such as *Rhizobium* fix nitrogen, i.e., they convert nitrogen in the atmosphere into biological nitrogen that can be used by plants to build plant proteins. Other microbes are also involved in these cycles. For example, photosynthetic algae and cyanobacteria form a major component of marine plankton. They play a key role in the carbon cycle as they carry out photosynthesis and form the basis of food chains in the oceans. Fungi and soil bacteria, the decomposers, play a major role in the carbon cycle as they break down organic matter and release carbon dioxide back into the atmosphere.[4]

Animal, especially ruminants contribute to green house gases. Ruminants have a special four chambered stomach. The largest compartment is called the rumen. This pouch is full with billions of bacteria, protozoa, moulds and yeasts. These microbes digest the cellulose found in the grass, hay and grain that the animal consumes, breaking it down into simpler substances that the animal is able to absorb.[5] Animals can't break down cellulose directly as they don't produce the necessary digestive enzymes. The methanogens, a group of archaea that live in the rumen, specialize in breaking down the animal's food into methane. The ruminant then belches this gas out at both ends of its digestive system. Methane is a very powerful greenhouse gas because it traps about 20 times as much heat as the same volume of carbon dioxide.[6] As a result it warms the planet up to 20 times more than carbon dioxide. Around 20% of global methane production is from farm animals.

Soil is home to a vast array of life ranging from moles to microbes which makes it a very active substance. As the climate heats up, the activity of microbes responsible for the breakdown of carbon-based materials in the soil will speed up. If this happens then even more carbon dioxide will be released into the environment. This is because increased microbial activity results in an increase in respiration, which produces more carbon dioxide as a waste product.[7]

The soil respiration and carbon dioxide release can double with every 5-10^{0}C increase in temperature. A vicious cycle is set up as more carbon dioxide is released it causes global warming, which in turn speeds up the activity of the soil microbes again.[4,8] Soil microorganisms are vital to many of the ecological processes that sustain life such as nutrient cycling, decay of plant matter, consumption and production of trace gases, and transformation of metals. Although climate change studies often focus on life at the macroscopic scale, microbial processes can significantly shape the effects that global climate change has on terrestrial ecosystems.[9] According to the International Panel on Climate Change (IPCC) report,[10] warming of the climate system is occurring at unprecedented rates and an increase in anthropogenic greenhouse gas concentrations is responsible for most of this warming. Soil microorganisms contribute significantly to the production and consumption of greenhouse gases, including carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and nitric oxide (NO), and human activities such as waste disposal and agriculture have stimulated the production of greenhouse gases by microbes. As concentrations of these gases continue to rise, soil microbes may have various feedback responses that accelerate or slow down global warming.

Thus, understanding the role of soil microbes as both contributors and reactive components of climate change can help us to determine whether they can be used to curb emissions or if they will push us even faster towards climatic disaster.

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Competing Interests

None declared.

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