



# Review of "The Role of Bacteria in Climate Change: Emissions and Carbon Cycling"

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## Abstract

The accumulation of greenhouse gases has been slowly increasing over time due to various anthropogenic natural processes. These determinants include burning of excess coal, oil, and coal, biodegradation, and biomass burning. Currently, climate change and global warming are formidable challenges that nations between people meet. This phenomenon negatively affects many natural processes. It also affected the structure, efficiency, and metabolism of microbial assemblages. It identifies strategies for effectively addressing climate change. For example, microorganisms and other organisms have great potential for mitigation through adaptive responses. They play various roles in preventing and reducing greenhouse gases, especially through nutrient recycling processes. They act constructively as producers or consumers of this gas. This project serves to address environmental hazards from natural and man-made sources. In summary, biogeochemical cycles and climate change should not be interpreted as separate events.

**Keywords:** Bacteria, Climate Change, Emissions, Carbon Cycling, Mitigation

## 1-Introduction

Important challenges of the 21st century include climate change, energy supply, health and disease management, and the promotion of sustainable environmental practices. These issues represent urgent issues in contemporary discourse. Current global climate change action is at the forefront of scientific research [1], while carbon and nitrogen, which are cellular structures [2,3]. Using biological methods to manage greenhouse gas emissions is critical when it comes to nutrient recycling. Biodiversity contributes significantly to mitigating climate change and its negative impacts, due to its remarkable versatility and adaptability to a wide range of environmental conditions . . . . This review aims to elucidate the role of microorganisms in concerted efforts to combat climate change and reduce greenhouse gas emissions and furthermore, seeks to investigate how these roles can be developed in future mitigation strategies. This study attempts to clarify the critical role of ecosystems in climate change mitigation and highlights the critical importance of microorganisms in this ongoing struggle. Microbial organisms respond to climate change and global warming by exhibiting immediate and long-term response mechanisms that can facilitate or inhibit development [6,7]. Microorganisms act as key agents of environmental sustainability due to their ability to recycle and transform essential cellular elements including carbon and nitrogen [8,9]. In nutrient recycling, ecological strategies aimed at reducing greenhouse gas emissions are proving to be more beneficial. Microbial communities in many ecosystems play an important role in mitigating and managing the negative impacts associated with climate change, due to their remarkable metabolism and ability to thrive for environmental reasons.

## 2-Climate change

Ecology seeks to understand the mechanisms by which ecosystems arise and sustain themselves in time and space, climate strongly influences community interactions and organizational patterns, and their functional characteristics. Projected global warming, distinct from other putative environmental determinants, have dramatic effects on changes in soil microbial diversity by increasing surface temperature and simultaneously reducing water activity on the inner surface [13,14]. This statement is true



for all environmental factors altered by climate change, including changes in precipitation patterns, drought conditions, and wind variability. In the broad climate characteristics of a region—e.g. temperature, precipitation, and wind patterns—collectively known as the climate. Oceans, other Water resources and ecosystems exist [15, 16]. Many factors such as latitude, axial tilt of the earth, wind belt movement, ocean and land temperature changes, and geophysical factors greatly influence planet this so the weather. .. of microbial life, plants and animals They dilute nutrients. This gas acts like a heat blanket. Without this protective layer, ground temperatures would drop by 20–30°C, making it extremely uninhabitable [17].

### **2-1 Changes in climate and their effects on microbes**

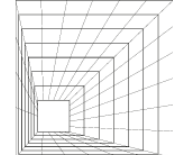
Climate change has direct and indirect effects on the structural and functional dynamics of soil microbial ecosystems. The following list illustrates the many impacts of climate change on microorganisms: mortality and environmental degradation; significant direct and indirect effects on metabolism; extinction or modification by reduction or increase in biodiversity, species, and structure; and physiological effects, as well as greenhouse gas emissions, which can have positive or negative consequences. Structural changes of the cellular community take place in response to increased temperature, simultaneously accelerating processes such as methanogenesis, fermentation and respiration. Risk of injury, illness and death from heat waves, wildfires, extreme weather events, sea level rise, natural disasters, extreme heat, oxygen depletion, drought, disease new spread and occurrence are serious consequences. Climate change affects both ecosystems and ecosystems. Climate change has direct and indirect effects on the structural and functional dynamics of soil microbial ecosystems. An overview of the effects of climate change on microorganisms is presented. These branches include mortality and environmental disturbance, direct and indirect severe metabolic effects, biodiversity reduction (or stimulation), species and systemic processes leading to extinction or change occurs, and the physiological effects of greenhouse gas emissions. with simultaneous rates of methanogenesis, fermentation, and respiration. Important ecological and abiotic impacts of climate change are subsequent risks of damage, disease and death from heat waves, wildfires, extreme weather events, floods, natural disasters, warming a severe weather, decreased ventilation, drought, and the spread of other diseases.

### **3- Microbial populations and the carbon cycle**

Bacteria play an important role in the carbon cycle by influencing the stability and longevity of carbon compounds, as well as by determining whether carbon is released into the atmosphere as a greenhouse gas [22]. Important for natural resource degradation importance based on microbial activity, such as if the nitrogen cycle. Bacteria play an important role in breaking down decomposed organic matter and converting it into products that can be used by other organisms [23]. Thus, microbial enzyme systems are considered an important "engine" of Earth's biogeochemical cycles thrive. The balance of respiration and photosynthesis is a key mechanism for the terrestrial carbon cycle. Autotrophs—such as photosynthetic plants and microorganisms that produce photographs and chemicals—play an important role in "carbon fixation," converting atmospheric carbon dioxide into organic matter and facilitating the transfer of carbon from the atmosphere to the soil. In reactions, bacteria use carbon as a metabolite, from the atmosphere. It absorbs significant amounts of carbon dioxide. A variety of bacteria and fungi are involved in the carbon cycle in aquatic environments. Anaerobic carbon metabolism can also occur in low-oxygen environments, such as aerobic-anaerobic metabolism in lakes, ponds, and other deep water bodies, where algae are transported by aerobic processes the involvement of the. Moreover, under anaerobic conditions, microorganisms can recycle carbon molecules through fermentation for energy [24, 25].

### **3- Bacteria that consume carbon: A new finding**

Advances in biotechnology and genetic engineering have greatly facilitated the manipulation of native biological processes in microorganisms. A recent study by an Israeli research group developed an *E. coli* strain capable of efficiently utilizing carbon, showing how obligate heterotrophs are converted to full form during experimental. This mutant bacterium uses a Kelvin cycle non-native uses to convert CO<sub>2</sub> to biomass carbon ]. With respect to biomass production and the utilization and



storage of atmospheric CO<sub>2</sub>, the abundance of heterotrophs on Earth is generally high. A deeper understanding of their metabolic properties enabled researchers to develop metabolically altered autotrophic *E. coli* strains [27]. *E. coli* in its natural state produces an enzyme called formate hydrogenlyase (FHL), which oxidizes formaldehyde to carbon dioxide, and directly links this process to the reduction of protons to molecular hydrogen. Researchers have found that FHL acts as a hydrogen-dependent CO<sub>2</sub> reductase can, if Formate causes FHL to accumulate outside the cell by a reversible reaction, a Compressed CO<sub>2</sub> and H<sub>2</sub>. The reduction energy derived from formate (HCOO<sup>-</sup>) can be used for carbon fixation through the Calvin cycle to conserve energy. [28].

The transition to a new diet was accomplished in approximately 200 days by means such as introducing mutations in genes encoding enzymes to alter the mechanisms of action through chemostat-directed growth cell culture played a role. This research undoubtedly provides a practical alternative to atmospheric CO<sub>2</sub> reduction and forms the basis for new projects aimed at address global climate change challenges [30].

#### **4- Microbes in the soil and oceans' contribution to lowering GHG emissions**

Microorganisms in soil play an important role in maintaining the environmental balance necessary for the functions of life. According to [31], soil microbes play an important role in organic matter decomposition, nitrogen cycle, trace gas generation, and metal-elemental biotransformation. Through these processes, soil microbes contribute significantly to the aerobic process are hot in birth and consumption. Understanding how soil microorganisms respond to and are affected by global climate change is essential for implementation to reduce greenhouse gas emissions. Soil microbes can effectively harness the emissions generated by human activity to counteract the effects of climate change. Various microorganisms such as decomposers, nitrogen-fixing bacteria, chemolithoautotrophs, and photosynthetic cyanobacteria play important roles [32].

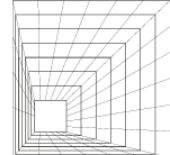
Decomposers are especially important in controlling global environmental temperatures. The decomposition is highly influenced by atmospheric temperature; with higher or optimal temperatures, the bacterial activity increases, promoting the decomposition and causing more CO<sub>2</sub> migration into the atmosphere [33, 34]. There is emerging evidence that simultaneous GHG mitigation may be more effective than CO<sub>2</sub>-mitigation alone. As early as 1901, Beijerinck noted that atmospheric nitrogen is converted into nitrogenous compounds such as ammonia (NH<sub>3</sub>) in the soil by nitrogen-fixing bacteria. These viruses exist independently and in association with plants, especially in maize [35, 36].

Nitrogen-deficient cells convert nitrogen oxide, a potent greenhouse gas, into harmless nitrogen gas. In addition, many bacteria are able to reduce N<sub>2</sub>O emissions into the environment. Cyanobacteria as photosynthetic bacteria contribute to the reduction of greenhouse gas emissions, especially from the marine environment, where *Prochlorococcus* and *Synechococcus* species are commonly encountered [37, 38, 39].

#### **Conclusion**

Bacteria play important roles in biodegradation, greenhouse gas release, and contribute to global climate change through nutrient cycling. But they can reduce emissions of various gases and slow climate change by converting this gas into useful biomass for themselves and other organisms. Microorganisms are important in the environment monitoring environmental improvements through gas production and consumption. Ecosystems regulate the movement of carbon and nitrogen between the soil and the atmosphere. Microbial ecology is useful for analyzing the terrestrial carbon cycle, which is critical for maintaining ecosystem balance and regulating the atmosphere. Methylophs can use greenhouse gases as resources to meet their carbon and energy needs. Greenhouse gases are released from the atmosphere due to processes such as respiration, decomposition and combustion. Nature is adept at balancing nitrogen and carbon within the biogeochemical nutrient cycle.

Further research and collaborative projects are needed to explore the relationship between microbes, climate change, and human well-being to address complex issues. Microbial pathogens can directly impact human health through infection and infection changing networks, changing microbial

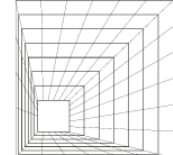


biogeography, and terrestrial, marine, and urban microbes Given the scope of this issue, microbes can be used in a variety of ways to address global climate change role through production reduction and consumption, there is a need for more innovative solutions with special focus on microorganisms.

## References

1. Singh BK, Bardgett RD, Smith P, Dave SR (2010) Microorganisms and climate change: terrestrial feedbacks and mitigation options. *Nat Rev Microbiol* 8: 779-790. Link: <https://goo.gl/9ufLPN>
2. Joshi PA, Shekhawat DB (2014) Microbial contributions to Global climate changes in soil environments: impact on Carbon cycle: a short review. *Annals of Applied Bio-Sciences* 1: R7-9. Link: <https://goo.gl/2ThBRc>
3. Pradnya A. Joshi, Dhiraj B. Shekhawat (2014) Microbial contributions to Global climate changes in soil environments: impact on Carbon cycle: a short review. *Annals of Applied Bio-Sciences* 1: R7-9.
4. Venkataramanan M, Smitha (2011) Causes and effects of global warming. *Indian Journal of Science and Technology* 4: 226-229. Link: <https://goo.gl/nqd3GR>
5. Olufemi Adedeji, Okocha Reuben, Olufemi Olatoye (2014) Global Climate Change. *Journal of Geoscience and Environment Protection* 2: 114-122. Link: <https://goo.gl/GycSER>
6. Davidson EA, Janssens IA (2006) Temperature sensitivity of soil carbon decomposition and feedbacks to climate change. *Nature* 440: 165-173. Link: <https://goo.gl/uCLiRj>
7. Sanford RA, Wagner DD, Cu QW, Chee-Sanford J, Thomas SH, et al. (2012) Unexpected non-denitrifier nitrous oxide reductase gene diversity and abundance in soils. *Proceed Natl Acad Sc* 109: 19709-19714. Link: <https://goo.gl/JpXQ1n>
8. Charu Gupta, Dhan Prakash, Sneh Gupta (2014). Role of microbes in combating global warming, *International Journal of Pharmaceutical Sciences Letters* 4: 359-363. Link: <https://goo.gl/Rf8fex>
9. Lal R (2005) Forest soils and carbon sequestration. *Forest Eco Manage* 220: 242-58. Link: <https://goo.gl/XZd5om>
10. Hasin AAL, Gurman SJ, Murphy LM, Perry A, Simth TJ, et al. (2010) Remediation of chromium (VI) by a methanoxidizing bacterium. *Environ Sci Technol* 44: 400-405. <https://goo.gl/DiKzFR>
11. Swati Tyagi, Ramesh Singh and Shaily Javeria (2014) Effect of Climate Change on Plant-Microbe Interaction: An Overview. *European Journal of Molecular Biotechnology* 5: 149-156. Link : <https://goo.gl/tvo1AC>
12. Weiman, S (2015) Microbes help to drive global carbon cycling and climate change. *Microbe Mag* 10: 233-238.
13. Castro HF, Classen AT, Austin EE, Norby RJ, Schadt CW (2010) Soil microbial community responses to multiple experimental climate change drivers. *Appl Env Microbiol* 76: 999-1007. Link: <https://goo.gl/UQ1d9N>
14. Fierer N, Schimel JP. (2003) A Proposed mechanism for the pulse in carbon dioxide production commonly observed following the rapid rewetting of a dry soil. *Soil Sci Soc Am J* 67: 798-805. Link: <https://goo.gl/8PQDoJ>
15. Bardgett RD, Freeman C, Ostle, NJ (2008) Microbial contributions to climate change through carbon cycle feedbacks. *ISMEJ* 2: 805-814. Link: <https://goo.gl/KGPJEK>
16. Allison SD, Wallenstein MD, Bradford MA (2010) Soil carbon response to warming dependent on microbial physiology. *Nature Geosci* 3: 336-340. Link: <https://goo.gl/bdT73m>
17. Friedlingstein P, Cox P, Betts R, Bopp L, Bloh WV, et al. (2006) Climate-carbon cycle feedback analysis: Results from the C4MIP model intercomparison. *J Clim* 19: 3337-3353. Link: <https://goo.gl/YyadFk>





18. Steinweg JM, Plante AF, Conant RT, Paul E A, Tanaka DL (2008) Patterns of substrate utilization during long-term incubations at different temperatures. *Soil Biol Biochem* 40: 2722-2728. Link: <https://goo.gl/mA5Crg>
19. Bradford MA, Davies CA, Frey SD, Maddox TR, Melillo JM, et al. (2008) Thermal adaptation of soil microbial respiration to elevated temperature. *Ecol Lett* 11: 1316-1327. Link: <https://goo.gl/JdDfzJ>
20. Zimmer C (2010) the microbe factor and its role in our climate future. Link: <https://goo.gl/c8wjdu>
21. Zhou J, Xue K, Xie J, Deng Y, Liyou Wu, et al (2011) Microbial mediation of carbon-cycle feedbacks to climate warming. *NATURE CLIMATE CHANGE*. 1-5. Link: <https://goo.gl/Nk6QHu>
22. Prosser JI (2007) Microorganisms cycling soil nutrients and their diversity. In: *Modern Soil Microbiology*, ed. by Van Elsas JD, Jansson JK and Trevors JT. CRC Press, New York, NY 237-261.
23. Gougoulas C, Clark JM, Shaw LJ (2014). The role of soil microbes in the global carbon cycle: tracking the below-ground microbial processing of plant derived carbon for manipulating carbon dynamics in agricultural systems. *J Sci Food Agric* 94: 2362-2371. Link: <https://goo.gl/f72aKe>
24. Falkowski PG, Fenchel T, Delong EF (2008) the microbial engines that drive Earth's biogeochemical cycles. *Science* 320: 1034 -1039. Link: <https://goo.gl/FDdWWL>
25. Crowther TW, Thomas SM, Maynard DS, Baldrian P, Covey K, et al (2015) biotic interactions mediate soil microbial feedbacks to climate change. *Proc Nat Acad Sci* 112: 7033-7038. Link: <https://goo.gl/6WFa9f>
26. Semrau JD, DiSpirito AA, Yoon S (2010) Methanotrophs and copper. *FEMS Microbiol Rev* 34: 496-531. Link: <https://goo.gl/M1C4vy>
27. Nikiema J, Bibeau L, Lavoie J, Brzezinski R, Vigneux J et al. ( 2005) Biofiltration of methane: An experimental study. *Chemical Engineering Journal* 113: 111-117. Link: <https://goo.gl/XoXKfJ>
28. Bousquet P, Ciais P, Miller JB, Dlugokencky EJ, Hauglustaine DA et al. (2006) Contribution of anthropogenic and natural sources to atmospheric methane variability. *Nature* 443: 439-443. Link: <https://goo.gl/ZtjVvs>
29. Shindell D, Kuylenstierna JC, Vignati E, Dingenen VR, Amann M et al (2012) Simultaneously mitigating near-term climate change and improving human health and food security. *Science* 335:183-189. Link: <https://goo.gl/PsSrAf>
30. Zimmerman L, Labonte B (2015) Climate change and the microbial methane banquet. *ClimateAlert*, 27. Link: <https://goo.gl/ZEd7qm>
31. Parul Rajput, Rupali Saxena, Gourav Mishra, SR Mohanty and Archana Tiwari (2013) Biogeochemical Aspect of Atmospheric Methane and Impact of Nanoparticles on Methanotrophs. *J Environ Anal Toxicol* 3: 2-10. Link: <https://goo.gl/yrk1nZ>
32. Anne Bernhard (2010) the Nitrogen Cycle: Processes, Players, and Human Impact. *Nature Education Knowledge* 2: 1-9.
33. Vitousek, P. M., Menge, D. N. L., Reed, S. C., and Cleveland, C. C (2013) Biological nitrogen fixation: rates, patterns and ecological controls in terrestrial ecosystems, *P. T. Roy. Soc. B*, 368, 20130119, doi:10.1098/rstb.2013.0119.
34. Jama Bashir, Ndufa, J. K., Buresh, R. J., Shepherd, K. D (2013) Vertical Distribution of Roots and Soil Nitrate: Tree Species and Phosphorus Effects. *Soil Science Society of America Journal* 62: 280-286.
35. Orr CH, James A, Leifert C, Cooper JM, Cummings SP, et al. (2011) Diversity and activity of free-living nitrogen-fixing bacteria and total bacteria in organic and conventionally managed soils. *Appl Environ Microbiol* 77: 911-919. Link: <https://goo.gl/6ETxwf>



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36. Ward BB (2011) Measurement and distribution of nitrification rates in the oceans. *Methods Enzymol* 486: 307-323. Link : <https://goo.gl/eG39KX>
  37. Kim SW, Miyahara M, Fushinobu S, Wakagi T, Shoun H (2010) Nitrous oxide emission from nitrifying activated sludge dependent on denitrification by ammonia-oxidizing bacteria. *Bioresour Technol* 101: 3958-3963. Link: <https://goo.gl/tL6NNNo>
  38. Wunderlin P, Mohn J, Joss A, Emmenegger L, Siegrist H (2012) Mechanisms of N<sub>2</sub>O production in biological wastewater treatment under nitrifying and denitrifying conditions. *Water Res* 46: 1027-1037. Link: <https://goo.gl/rhZrVj>
  39. Singh RK, Kundu S (2014) Review on Changing Natural Nitrogen Cycle: Special Reference to Kingdom of Saudi Arabia. *International Journal of Engineering Science Invention Research & Development* 1: 73-80. Link: <https://goo.gl/4xaEHt>