Review Article

General overview of climate change and global warming: Their effect on microorganisms

Abstract
Global warming is the rise in average global temperatures brought on by the greenhouse effect. Sunlight heats the earth's surface, but certain gases in the atmosphere act like the glass of a greenhouse, trapping the heat as it radiates back into space. Greenhouse gases build up in the atmosphere, causing the Earth to warm. This process leads to climate change, which is also known as rapid climate change. Numerous factors that contribute to global warming have negative effects on people, plants, and animals. Both natural and human-caused factors may contribute to these issues. The modern world faces significant issues due to global warming and climate change. In this regard, microbes have a significant impact on the environment as users or producers of greenhouse gases. Due to its capacity to thrive in a variety of climatic situations and to its particular metabolic characteristics, microbial diversity in diverse ecosystems has a significant impact on climate change by reducing its negative effects. There are a variety of potential roles for mitigation that microorganisms and their biological constituents can play by supplying a forward response. They offer a great deal of potential, particularly when used to treat and lower greenhouse gas emissions through nutrient recycling. This review article gives a general overview of the argument over public policy and the science behind global warming. It takes into account the elements contribute to rising near-surface air temperatures, greenhouse gases potential ecological and societal impacts of temperature increases and the influence of climatic and environmental change on microorganisms.

Keywords: Climate change, Global warming, Microorganisms, greenhouse gases, environment.

Introduction

Climate is the long-term pattern of weather in a particular area,which includes the winds, rainfall, and temperature. A complicated system that includes the ground surface, atmosphere, ice, snow, rivers, seas, and oceans, among other bodies of water and living organisms including bacteria, yeasts, and fungi. The earth's climate is most affected by wind, latitude, topography, and the difference in temperatures between land and sea. Gases surrounding the planet make it possible for organisms, including plants, animals, and microorganisms, to live [1]. These atmospheric gases prevent the planet from overheating. The globe is warming due to increased human activity, such

as the burning of fossil fuels, which traps more heat from the atmosphere in the gases surrounding the earth (global Warming) [2]. Despite playing a key role in controlling climate change, microbes are rarely the focus of research on the topic and are not taken into account when developing new strategies. It is difficult to determine their function in the ecosystem due to their diversity and different responses to environmental change. Microorganisms offer long- and short-term feedback reactions to global warming and climate change that are both positive and negative. As they can reuse and alter the fundamental elements like carbon and nitrogen that make up cells, they serve a crucial role as either producers or consumers of these gases within the environment. In unused areas that were already too cold for them to survive, such as Valley fever, certain disease-causing parasites and coccidioides fungus have been able to spread. These fungi frequently result in incorrect diagnoses and inappropriate treatment, and they can cause fatal infections [3]. New fungal infections could emerge when the gap between natural temperatures and human body temperatures closes. Flooding and other natural disasters are made more likely by climate change, which also raises the risk of fungi growing in people's houses. In this regard, certain fungi can result in serious contamination of the lungs and brain [4,5]. According to the US National Oceanic and Atmospheric Administration, the amount of carbon dioxide (CO_2) in the atmosphere in May 2022 was 50% more than it was in the pre-industrial era. A year when carbon dioxide levels were about 400 parts per million or more, indicating that the cause of this new rise is global warming caused by human activities, the most important of which are transportation, cement production, deforestation and electricity production using fossil fuels. And the administration warned that this warming is beginning to lead to dire consequences, including the proliferation of heat waves, droughts, fires and floods. And the administration indicated that the concentration of carbon dioxide in May 2022 exceeded the threshold of 420 ppm, and in 2020 it was 417 ppm [6]. The aim of this review is to discuss the role of microorganisms in helping to fight climate change and greenhouse gases emission and the proposed strategies to reduce carbon dioxide emission.

Effects of climate and environmental change on microorganisms

In general, the threat of harm, illness, and death from heat waves, wildfires, strong storms, flood rises, distinctions, natural disasters, extreme heat, poor air quality, drought, and disease spread is a result of climate change [7-10]. Decomposition of organic material produced by bacteria, fungi, and algae was accelerated by climate change, increasing the transport of carbon dioxide into the atmosphere and hastening global warming [11,12]. In response to rising global temperatures, microbial degradation of soil carbon is providing positive feedback. In order to accelerate warming, microbial biomass and enzymes are useful instruments since they effectively break down carbon-based organic matter and release harmful substances into the environment [13-15]. Terrestrial microbial community composition and functions are affected by climate change both directly and indirectly. The impact of climate change on microorganisms causes metabolic activity changes that cause mortality, a decrease or increase in biomass, a boost in variety, negative or positive impacts on their physiology, and the production of greenhouse gases. As a result of climate change, there is a temperature rise which alters the composition of the microbial population and speeds up processes like methanogenesis, fermentation, and respiration. Microorganisms, on the other hand, play a significant role because of their capacity to recycle and change the crucial carbon and nitrogen elements that constitute their cells [16-18].

Climate change is caused by microbes, and on the other hand microorganisms are affected by climate change. As a result of human activities like waste disposal and agriculture, soil microorganisms play a substantial role in the generation and consumption of greenhouse gases like carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), and nitric oxide (NO). Although it is unknown how much these impacts will contribute to global warming, as these gas concentrations grow, soil bacteria may have a variety of feedback reactions that speed up or slow down the process [19]. Understanding the role soil microbes play as both causes of and responses to climate change will help us decide whether they can be employed to reduce emissions or if they will accelerate the onset of a climatic change disaster [20]. According to several studies, rising temperatures hasten the pace of microbial decomposition, increasing the amount of CO2 released by soil respiration and creating a positive feedback loop for global warming (Allison et al., 2010). In this case, global warming would result in the significant loss of carbon from terrestrial soils, perhaps turning them into a larger carbon source than store [21,22]. Research suggests that as temperatures continue to rise, this boost in respiration might not last. In a 10-year soil warming experiment, Melillo et al. (2002) report a 28 percent increase in CO2 flux in the first six years of warming compared to control soils, followed by significant decreases in CO2 released in the following years, and no discernible response to warming in the experiment's final year[22].

Participation of microorganisms in global cycles

1. Carbon cycle

Microbial communities play a key role in the global carbon cycle by fixing atmospheric carbon, fostering plant growth, and degrading or transforming organic matter in the environment. Global warming is being slowed down by microorganisms, which has implications for key ecological processes like the cycling of nutrients. The process of decomposing and converting dead organic matter into forms that can be utilized by other organisms depends heavily on microorganisms. The interaction between photosynthesis and respiration, in balance, controls the terrestrial carbon cycle [23]. Through "carbon-fixing" autotrophic organisms like photosynthesizing plants and photo and chemoautotrophic bacteria, which convert atmospheric carbon dioxide into organic material, carbon is transported from the atmosphere to soil. The primary objective of soil microorganisms is to survive through reproduction, which requires the movement of carbon between environmental compartments. Photosynthesis and respiration are in equilibrium, and this equilibrium controls the terrestrial carbon cycle [24,25]. Methane and carbon dioxide are the two main types of carbon in the earth's atmosphere. Microorganisms participate in a more extensive carbon cycle that takes place on a global scale. Microorganisms work to take carbon from non-living sources so that it can be used by living organisms through the process of carbon fixation. The most well-known instance of carbon fixation is photosynthesis, which uses solar energy to create organic compounds. Effective chemoautotrophs in this context are photosynthetic algae [26,27]. Microorganisms can cycle carbon molecules in anaerobic conditions to produce energy through the process of fermentation. It is possible for other microorganisms such as *Thiobacillus ferrooxidans*, sulphur bacteria, and *Clostridium butyricum* to participate in the cycling of carbon. The carbon cycle describes the process in which carbon atoms continually travel from the atmosphere to the Earth and then back into the atmosphere (Figure 1).

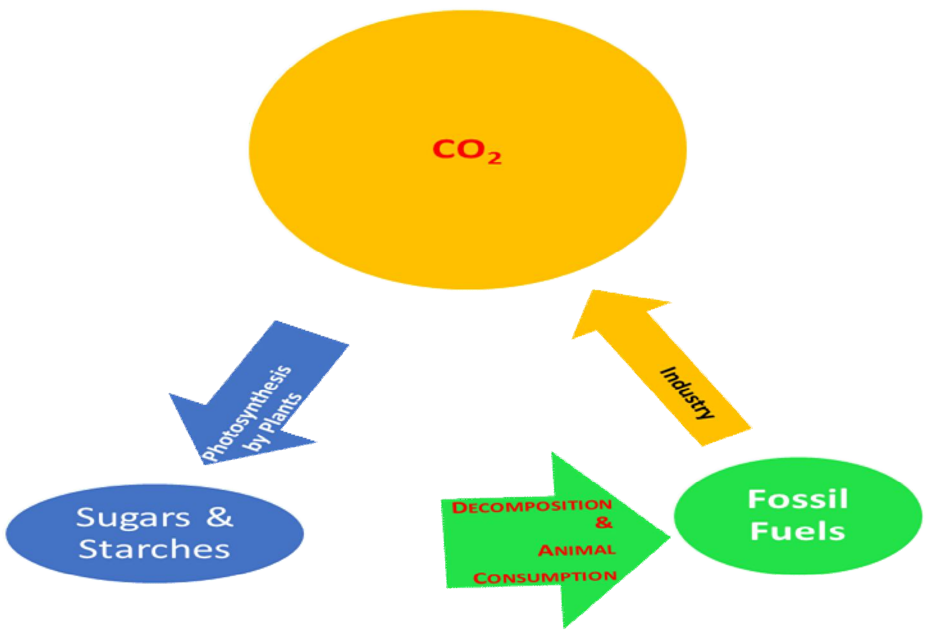

Figure 1: Carbon cycle diagram.

2. Nitrogen cycle.

As the primary element of air, nitrogen accounts for around 78 percent of the gases in the earth's atmosphere. Nitrogen fixation is the process of converting atmospheric nitrogen into chemical forms that can be utilized by living beings. Nitrogen gas (N_2)enters the biosphere through biological fixation. For instance, the bacteria are fairly specific to particular plants. The plant creates a hollow thread leading into the root as a result of the bacterium attaching to one of the plant's root hairs. Through this infection thread, bacteria develop and finally cause the formation of a nodule on the root. For bacteria, the plant provides food and energy; for fungi, nitrogen from the air is supplied in a form that the plant can use through fixation by bacteria and fungi [28,29]. Rhizobium trifolium contains nitrogenase enzymes that fix atmospheric nitrogen into an ammonium ion form that is chemically advantageous to higher species. The plant converts the fixed ammonium ion into nitrogen oxides and amino acids to create proteins and other compounds like alkaloids as part of their symbiotic association [30]. The main function of the nitrogen cycle is the conversion of nitrogen. Microorganisms drive the system almost all of the time in gathering energy or building up nitrogen in a form necessary for their growth and development. The main steps in the nitrogen cycle processes include, nitrogen fixation, nitrification, assimilation, ammonification, and denitrification [31].The flow of nitrogen atoms through Earth's living and non-living processes is referred to as the nitrogen cycle, which is vital for life on Earth (Figure 2).

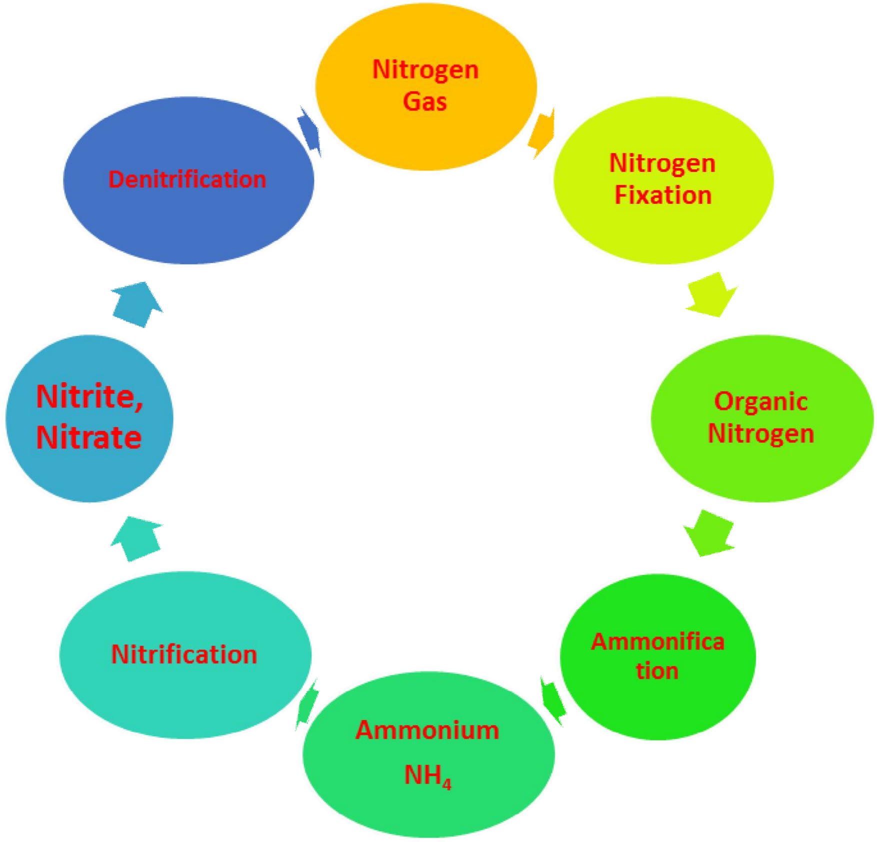

Figure 2: Nitrogen cycle diagram.

3. Methane cycle.

Carbon cycling between carbon dioxide and organic molecules is regarded as having ecological significance. The fixation of carbon dioxide into organic compounds involves both eukaryotes (such as plants and algae) and autotrophic microorganisms (such as cyanobacteria). Additionally, consumers use organic molecules, which emit carbon dioxide. Most of the time, microbial activity causes methane (CH4), a greenhouse gas, to enter the atmosphere. For the Earth's climate to remain stable, methane-consuming microbes are essential. Methane is used by bacteria as an energy source for metabolism. Methane is the only source of energy that methanotrophic bacteria use, and during digestion, they turn it into carbon dioxide [32-34]. These bacteria have a large methane consumption capacity, which helps to lower methane emissions from landfills and enterprises that produce methane [35,36]. High concentrations of CH4 molecules, which are present everywhere, are used by microorganisms [37]. Methanogenic bacteria rapidly convert carbon dioxide to methane in anaerobic environments, such as deep compacted mud. Hydrogen is required for the conversion process, which also produces water and energy for the methanogens. Another kind of methane bacteria known as methane oxidizing bacteria or methanotrophs can change methane to carbon dioxide to carry out the

recycling cycle. This aerobic conversion also results in the production of water and energy. Methanotrophic bacteria convert CH4 to CO2when there is oxygen present. The carbon cycle is finished by the oxidation of CH4 to CO2. Methanotrophs typically inhabit areas where anaerobic and aerobic conditions converge. They have access to the anaerobic methanogenic bacteria's produced methane as well as the oxygen required for the conversion of that methane [38,39].The following methane cycle illustrates the flow of methane from sources into the atmosphere, as well as methanotrophs microorganisms that consume methane (Figure 3).

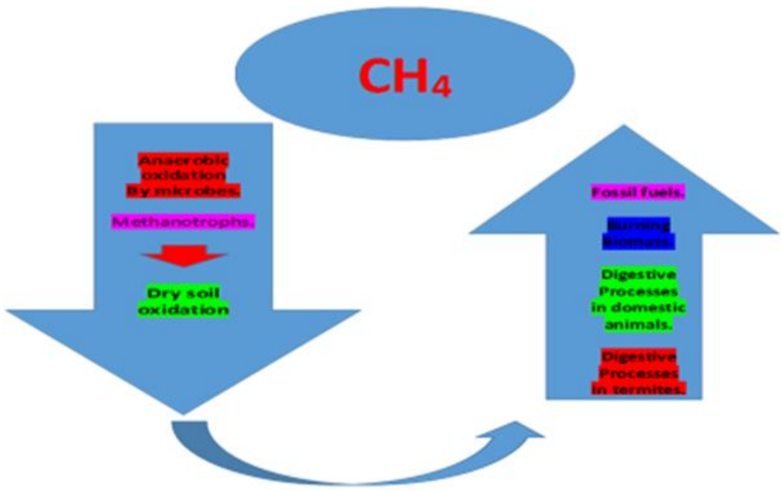

Figure 3: Methane cycle diagram.

Greenhouse gases

The dramatic increase in greenhouse gas emissions in recent years can be attributed to both human activities and natural occurrences like volcanic eruptions. All of these gases have numbers are increasing during the industrial period. The quantities of these gases progressively increase as they accumulate in the atmosphere. A particular class of gases called greenhouse gases traps heat from the environment [40,41]. The principal greenhouse gases that are released or withdrawn from the atmosphere are listed below.

1. Carbon dioxide: This gas is produced by natural processes such as the respiration process, the decay of plants, and the microbial breakdown of organic waste. The use of fossil fuels for transportation, heating, cooling, and other human activities contributes to it as well [42,43].

2. **Methane: Rice farming, the burning of biomass, and the production of fossil fuels are examples of anthropogenicactivities that produce methane. Additional wetlands and oceanic natural processes are sources of methane emissions [16].**

3. **Ozone: This gas is produced and destroyed in the atmosphere by chemical reactions. Halocarbons released by human activities destroy ozone in the stratosphere and cause an ozone hole in the atmospheric layer.**

4. **Nitrous oxide: This gas is released by the burning of fossil fuels and the use of fertilizers. Additionally, it is naturally leaked into the oceans and soils[44].**

5. **Halocarbon gases: These gases contain chlorofuorocarbons, and are extensively utilized in industrial operations such as refrigeration. Because of stringent worldwide rules designed to safeguard the ozone layer, the abundance of these gases is declining[45].**

6. **Water vapor: The most prevalent greenhouse gas in the atmosphere is water vapor. However, the amount of water vapor is only slightly impacted by human activity. Humans may indirectly alter water vapor by modifying the climate or by emitting methane[46].**

7. **Aerosols: Some of these gases are directly discharged into the atmosphere, while others are created from substances that are emitted. These molecules that are emitted (as a result of human activity) and naturally occurring substances are both present in aerosols. Burning biomass and fossil fuels has increased several types of sulfate and organic-compound-containing aerosols [1,42,47,48].**

Strategies for Carbon dioxide reduction

Many strategies were reported to reduce CO2 emission in the atmosphere.

1. **Energy efficiency strategy: This method is implemented through utilizing more energy-efficient electrical equipment, increasing building insulation, and driving more fuel-efficient cars [49].**
2. **Fuel switching strategy: The use of fuels with reduced carbon contents and increased energy generation from renewable sources are both part of this strategy's carbon dioxide reduction efforts [50].**
3. **Energy conservation strategy: This strategy can be implemented by turning off lights and electronics when not in use and consuming less petroleum are two ways to carry out this policy [51].**
4. **Changes in uses of land and land management practices strategy: Since agriculture and forestry are the main sources of greenhouse gas emissions, this can be accomplished by planning and preventing biomass burning and deforestation [52,53].**

5. **Carbon capture and sequestration strategy: To achieve this, CO_2 from coal-fired power plants' stacks can be captured before it hits the atmosphere, transported by pipeline, and then injected deep underground at a carefully chosen depth [54].**

Conclusion

Research, estimates, and scientific reports clearly confirm that climate change has become an existential threat to many countries and societies worldwide. In a way, it is no longer possible to postpone the implementation of climate-related commitments.Especially since all countries participating in many international conferences with regard to climate change agreed unanimously that the priority during the next stage is to transform the nationally determined contributions into an actual reality within the framework of the international principles governing the work of the international climate. Foremost among these is fairness and joint responsibility, with different burdens and varying capacities of countries, and affirming the commitment of governmental and non-governmental parties to transfer their promises and commitments. It is actual implementation on the ground that ensures the process of transition to a low-emission economy is capable of dealing with and adapting to the negative effects of climate change and contributes to enhancing the volume, quality, and mechanisms of climate finance available to developing countries. Some countries are currently increasing their contribution and expansion in renewable energy, developing a comprehensive strategy for green hydrogen, reducing carbon and methane emissions in the oil and gas sector, and relying on clean transportation through metro and train network expansion and localization of the electric car industry. Even while the issues of global warming and the resulting climate change are expected to persist for some time, the fact that the overwhelming majority of the data points to human activity as the principal cause of the current rapid changes means that we are not powerless to lessen their consequences. There are a number of interesting technologies out there to help us better manage our energy resources while maintaining a healthier environment, some of which are already fully established and accessible. These include more energy-efficient vehicles, tighter regulation of currently operating coal-burning power plants, more energy-efficient homes and buildings, wind, solar, and nuclear energy. Innovative new technologies are also possible. There is a lot that can be done right away to lessen the effects of climate change and global warming. The absence of appropriate incentives to apply the new technologies more quickly is what makes it difficult to address the issue, not the lack of technology.

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