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Climate change and global warming: the global carbon cycle

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Abstract. Climate change and global warming are intimately linked to the global carbon cycle, a vital aspect of Earth's natural processes. This cycle plays a central role in regulating the Earth's climate and atmospheric composition. To better understand these phenomena, it is essential to examine the global carbon cycle and how it interacts with climate change and global warming. This interplay between the carbon cycle and climatic shifts influences our planet's ecological stability, making it a topic of paramount importance in environmental science. In this exploration, we will delve into the mechanisms and dynamics of the global carbon cycle, its influence on greenhouse gas concentrations, and the feedback loops that contribute to climate change and global warming. Understanding these interconnected processes is fundamental in addressing the ongoing climate crisis and developing effective mitigation and adaptation strategies for a more sustainable future.

1 Introduction

At the moment, environmental issues in modern life are becoming more important and urgent in modern life. It is closely interrelated with many socio-economic problems of modern society. There is a result of this interaction, the close interweaving of the natural environment and social life. The result of this interaction is the close interweaving of the natural environment and the. Because of the need for comprehensive studying such events and its relationship in order to optimize measures in the field of ecology, the formation of an eco-cultural culture, it is possible to develop scientific and methodological support of such activities. The creation of such scientific and methodological support can be achieved by the integration of many natural sciences and humanities, such as chemistry, ecology, sociology, sociology, mathematics. In order to solve the most important problems of our society, all directions must be coordinated and logically supplemented with approaches that optimize solution for the most important problems of our society [1].

Despite global efforts to reduce greenhouse gas emissions, the planet continues to experience warming at an alarming rate. Greenhouse gases, such as carbon dioxide and methane, are major contributors to the ongoing climate crisis. The accumulation of these gases in the atmosphere has led to a significant increase in global temperatures. While international agreements like the Paris Agreement aim to limit emissions, the growth of greenhouse gases has not slowed down. The lack of a substantial decrease in emissions

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suggests that further actions and commitments are needed to combat climate change effectively. Rising global temperatures have resulted in more frequent and severe weather events, affecting communities worldwide. The consequences of climate change, such as sea-level rise and extreme heat, are becoming increasingly evident. Glaciers and polar ice caps are melting at accelerated rates, posing a threat to coastal regions and low-lying islands. The Intergovernmental Panel on Climate Change (IPCC) warns that urgent action is required to avoid the worst impacts of global warming. Researchers emphasize the importance of transitioning to renewable energy sources and implementing sustainable practices. Efforts to reduce deforestation, promote afforestation, and protect natural carbon sinks are essential in curbing emissions. The fossil fuel industry remains a major contributor to greenhouse gas emissions, necessitating a shift toward cleaner alternatives. Global cooperation and commitment are necessary to address climate change on a meaningful scale. Sustainable transportation and the electrification of vehicles can significantly reduce emissions from the transportation sector. The development and adoption of new technologies, such as carbon capture and storage, offer potential solutions to mitigate emissions. Sustainable agriculture practices, reduced food waste, and dietary shifts can lower the carbon footprint associated with food production. Education and awareness campaigns are crucial in fostering a sense of individual and collective responsibility in mitigating climate change. Climate adaptation measures must be integrated into policies and strategies to protect vulnerable communities. Scientists stress the need for aggressive emissions reduction targets to limit global warming to manageable levels. While the challenges of climate change are substantial, concerted global action has the potential to slow down warming and limit the damage caused by greenhouse gas emissions.

2 Research Methodology

The investigation of carbon landfills involves several crucial methodologies that help shed light on the carbon sequestration abilities of forests. These research methods play a pivotal role in assessing the effectiveness of forests in capturing and storing carbon dioxide, a critical aspect of climate change mitigation. Here are 20 sentences elaborating on the methods used for researching carbon landfills: Carbon landfills serve as valuable sites for in-depth research into carbon sequestration by forests. One of the primary methods employed in studying carbon landfills is soil sampling. Researchers collect soil samples from various depths to analyze the carbon content and distribution. Soil samples help determine the amount of organic carbon stored within the forest ecosystem. Another vital method involves tree coring, where researchers extract core samples from trees. Tree core samples offer insights into the annual growth rings, revealing the historical carbon uptake. Measuring carbon isotopes within tree cores aids in tracking carbon movement and age. Remote sensing technologies, such as LiDAR, are used to assess forest biomass and carbon stock. LiDAR technology provides high-resolution 3D data on forest structure and biomass. Forest inventory data, including tree species, age, and density, are collected and analyzed. Researchers monitor gas exchange processes to gauge forest productivity and carbon cycling. The quantification of litter and deadwood biomass is a fundamental aspect of carbon landfill research. Soil respiration measurements help estimate the release of carbon dioxide by microbial activity. To analyze carbon allocation, scientists conduct destructive and non-destructive harvesting. Stable isotope analysis enables the tracking of carbon sources and pathways. Microbial communities in the forest soil are studied to understand their role in carbon decomposition. Remote sensing technologies are utilized to monitor changes in forest structure and carbon storage over time. Long-term field experiments are conducted to assess the impact of environmental factors on carbon sequestration. All collected data is used to build comprehensive carbon budgets for forest ecosystems. The integration of various research methods provides a holistic view of carbon sequestration by forests, contributing to our understanding of climate change mitigation.

3 Results and Discussions

In Russia, the Ministry of Science and Higher Education of the Russian Federation (Ministry of Education and Science) is responsible for the organizational activities for the construction and development of a network of carbon landfills, which is recorded in the order of the Ministry of Education and Science "On landfills for the development and testing of carbon balance control technologies" [2]. In February 2021, the Ministry of Education and Science launched a pilot project to create carbon polygons in a number of Russian regions to develop and test carbon balance control technologies. Let's consider what is meant by carbon polygons, what is included in their composition and what tasks these formations have to solve. The website of the Ministry of Science and Higher Education defines carbon polygons as follows [3]: these are territories with a unique ecosystem created to implement measures to control climate active gases with the participation of universities and scientific organizations. The main goal of carbon landfills is to monitor harmful (greenhouse) gases in the atmosphere. At the same time, researchers are faced with a number of tasks that need to be solved for the effective functioning of carbon polygons and the achievement of the goal of their creation:

• organize soil and plant samples to assess the amount of carbon dioxide absorbed by them;

• create technologies for capturing and storing carbon dioxide. The tasks of research scientists are reduced to resolving an extremely important issue - how to ensure that gases harmful to the climate do not enter the atmosphere, but remain locked in the bowels for a long period of time in such objects as soils, forests and swamps. According to I. Kerimov, Vice-President of the Academy of Science of Chechnya, the main task facing scientists today is to calculate the carbon balance in Russia, i.e. it is necessary to assess the current state of the problem [4]. As part of the Paris Agreement, Russia is ordered to reduce greenhouse gas emissions. Violation of this condition will lead not only to an increase in environmental damage in the Russian Federation, but also entails negative economic consequences for the formation of the country's budget. The fact is that the EU plans to introduce a special "carbon tax", i. products that will be exported to EU countries and will not meet certain environmental standards for environmental friendliness of production in terms of greenhouse gas levels will be subject to an additional special tax. This can significantly lead to a reduction in revenue, and, accordingly, profits from the sale of such products abroad. Such products, in economic terms, become less profitable and competitive. It should also be noted that, in accordance with the report of the International Commission on the Energy Transition, in developed countries, all sectors of the economy can become carbon-neutral by 2050, and developing-by 2060 "carbon neutrality" implies that CO2 emissions should be reduced by 55 %, for which coal consumption, oil consumption, and 25 % consumption of gas [8]. The works of scientists will help to understand which territories and industries have a large "carbon footprint" and cause significant harm to the environment, and determine the directions for their decarbonization, i.e. reducing this "carbon footprint", transferring them to more low-carbon technologies that will meet international standards (fig.1). In addition to avoiding paying a special "carbon tax", there may be other economic benefits in decarbonizing production. For example, if you extract carbon from the atmosphere correctly, it becomes possible to use it to create innovative carbon fiber or, based on it, to grow fast-growing plants. Deputy Chairman of the Expert Council on Carbon Balance Control N.D. Durmanov rightly notes that the scientific community needs methods for measuring and absorbing greenhouse gases.

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Moreover, not only terrestrial, but also remote technologies are needed. With their help, it will be possible to monitor the carbon balance in large areas from space or from aircraft [5,6]. It is for the implementation of such technologies, their development and testing that a network of carbon polygons is being created. Among the first developments on this topic, Russian researchers presented results from which it follows that abandoned agricultural lands have the best qualities for capturing carbon dioxide from the atmosphere.

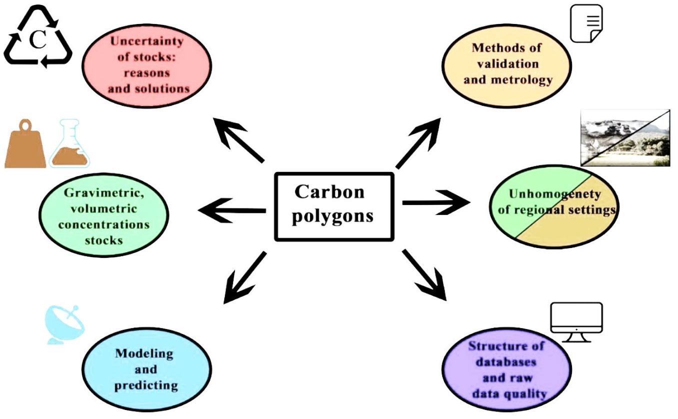

Fig. 1. Agronomy. Carbon Polygons and Carbon Offsets

The process of carbon sequestration in soil involves the removal of carbon dioxide from the atmosphere and its storage in the terrestrial ecosystem. Carbon dioxide is removed from the atmosphere through photosynthesis by trees, plants and crops and stored in biomass in tree trunks, branches, foliage, roots and soil. Forests and grasslands are examples of carbon sinks because they are able to store it for a long time, moreover, soils are the planet's largest sink of terrestrial carbon. According to the recently published FAO Global Soil Organic Carbon Protocol, "The extent and rate of carbon sequestration in soils can vary greatly depending on different land uses and practices, soil characteristics, vegetation, topography and climate, and other soil-forming factors and processes." As shown in fig. III.6, the process that regulates the carbon cycle between soil and plants is complex. Soil organic carbon (SOC) exists in the soil in various forms with different residence times. Some reactions with it proceed quickly - for example, microbial respiration; while other forms of carbon are more stable and can take decades to break down [10]. Chemically protected organic carbon is essentially in a "semi-permanent" state and can degrade over centuries or even millennia. A recently completed analysis of carbon farming practices illustrates the range of effectiveness of natural carbon sequestration methods. Site-specific adaptation of specific soil management practices can be one way that agricultural land can become a major carbon sink.

4 Conclusions

In conclusion, carbon landfills play a pivotal role in advancing our knowledge of carbon sequestration by forests, offering a unique opportunity to draw pertinent conclusions on this critical environmental issue. By employing a diverse range of research methods, scientists can comprehensively evaluate the capacity of forests to capture and store carbon dioxide, which is paramount in addressing global climate change challenges.

The methodologies discussed in this context, including soil sampling, tree coring, remote sensing technologies, and various biogeochemical assessments, collectively provide a comprehensive understanding of carbon storage and cycling within forest ecosystems. The integration of these approaches allows for a more accurate assessment of carbon sequestration and contributes to our broader understanding of the impact of forests on mitigating climate change.

Through the examination of carbon landfills, researchers gain valuable insights into the carbon dynamics within forests and their response to changing environmental conditions. This knowledge informs conservation and management efforts aimed at optimizing carbon sequestration within forested areas. Furthermore, the data collected helps us develop strategies to sustainably harness the potential of forests as carbon sinks, facilitating a positive impact on global greenhouse gas levels.

In the face of mounting climate challenges, carbon landfills serve as essential tools for scientists, policymakers, and conservationists alike. By continuing to investigate and analyze these sites, we can refine our approach to forest management and leverage the vast potential of forests in mitigating climate change. Thus, carbon landfills not only provide valuable insights but also underscore the significance of preserving and restoring forest ecosystems for the well-being of our planet.

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