GREENHOUSE GAS ANALYSIS AT THE CARBON TEST SITE OF THE CHECHEN REPUBLIC: MONITORING METHODS AND RESULTS

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Abstract

The article presents the analysis of greenhouse gases at the carbon test site of the Chechen Republic, which serves as an important platform for research in the field of climate change and ecosystem management. The main focus is on the methods for monitoring carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O) levels used to assess the carbon balance in various ecosystems of the test site, such as mountain, forest and steppe. The work considers both traditional methods, such as gas analyzers and meteorological stations, and modern technologies, including drones and remote sensors. The evaluation of the obtained data allowed us to identify the key sources of greenhouse gas emissions and determine their impact on the local and global climate. The results showed significant variations in greenhouse gas levels depending on the season, ecosystem type and land management practices. The article also discusses practical recommendations for optimizing monitoring methods for more accurate and effective accounting of carbon flows, as well as the significance of the obtained data for the development of climate change mitigation strategies in the Chechen Republic. The results of the study can serve as a basis for further research in the field of carbon cycle and sustainable management of ecosystems in the context of climate change.

Keywords: carbon polygons, local ecosystems, carbon flows, biodiversity, carbon management, monitoring, research, greenhouse gases

I. Introduction

There are two types of greenhouse effect: natural and enhanced. The natural greenhouse effect is caused by naturally occurring greenhouse gases and is critical to life on Earth. Without this effect, the average surface temperature of the planet would be about 33°C cooler. The enhanced greenhouse effect is due to the additional radiative forcing caused by increased greenhouse gas (GHG) concentrations caused by human activity.

The main greenhouse gases whose concentrations are increasing in the atmosphere are carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), hydrochlorofluorocarbons (HCFCs), and hydrofluorocarbons (HFCs). Due to the long lifetime of these main greenhouse gases, they accumulate in the atmosphere.

Emissions from human activities are causing an enhanced greenhouse effect and climate change. The planet is currently warming faster than at any time in recorded history.

Changes in the chemical composition of the atmosphere lead to changes in weather conditions and disruption of the natural balance, which creates enormous risks for humans and all living beings on Earth.

Atmospheric levels of three major greenhouse gases – carbon dioxide, methane and nitrous oxide – have reached new records, according to the World Meteorological Organization (WMO) Greenhouse Gas Report 2021.

In 2021, atmospheric carbon dioxide levels were 149% of pre-industrial levels, mostly due to emissions from burning fossil fuels and cement production. About half of the CO2 emitted by human activity remains in the atmosphere, while the other half is absorbed by land and oceans, which act as "sinks" — systems that can absorb greenhouse gases. The balance between sources and sinks changes annually due to natural variability.

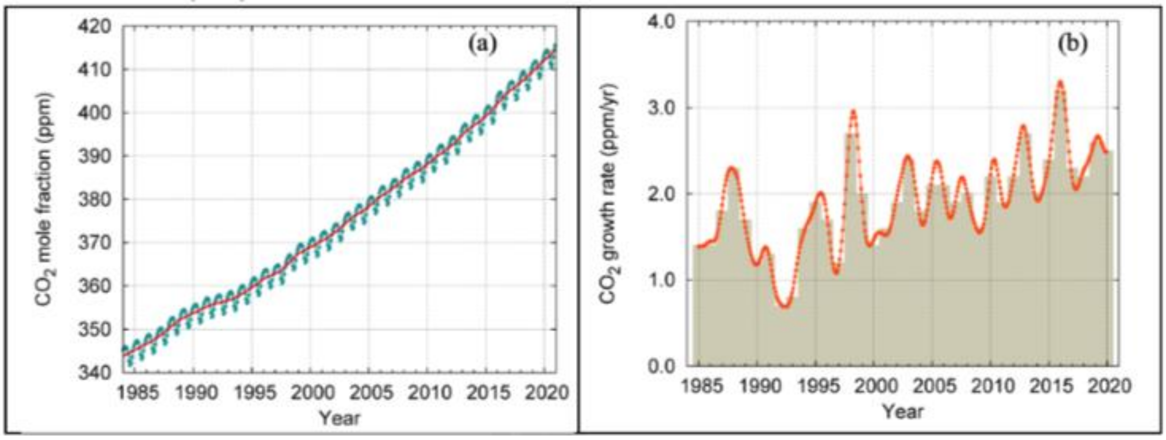

Figure 1: *Globally averaged atmospheric CO2 mole fraction (left) and growth rate (right), 1984-2020.*

As future greenhouse gas emissions increase, land ecosystems and oceans become less effective at absorbing CO2 and acting as a buffer against rising temperatures, which could lead to additional warming of the Earth's atmosphere.

Methane (CH4) accounts for about 16% of the warming effect of long-lived greenhouse gases and remains in the atmosphere for about a decade. 40% of methane in the atmosphere comes from natural sources such as wetlands, while human activities such as rice farming and biomass burning account for the remaining 60%.

Nitrous oxide (N2O) is a potent greenhouse gas and ozone-depleting substance. It is responsible for about 7% of warming caused by long-lived greenhouse gases. Human-related sources, such as fertilizer use and biomass burning, account for about 40% of its presence in the atmosphere.

II. Methods

Concentrations of carbon dioxide (CO2), the most important greenhouse gas, reached 413.2 parts per million in 2020, 149% of pre-industrial levels. Methane (CH4) is 262% and nitrous oxide (N2O) is 123% of the levels that existed in 1750, when human activity began to upset the Earth's natural balance. The economic downturn caused by COVID-19 has not had a noticeable impact on atmospheric greenhouse gas levels and growth rates, although there has been a temporary decline in new emissions.

With continued emissions, global temperatures will continue to rise. Given the long lifetime of CO2, the temperature levels already recorded will persist for several decades even if emissions are rapidly reduced to zero. This, along with rising temperatures, will lead to more frequent extreme weather events, including intense heat and rain, melting ice, rising sea levels, and ocean acidification, with far-reaching socioeconomic consequences.

About half of the CO2 emitted by human activity remains in the atmosphere, while the other half is absorbed by oceans and land ecosystems. The report raises the possibility that the ability of land and ocean ecosystems to act as "sinks" may decline in the future, reducing their ability to absorb carbon dioxide and offset more severe temperature increases.

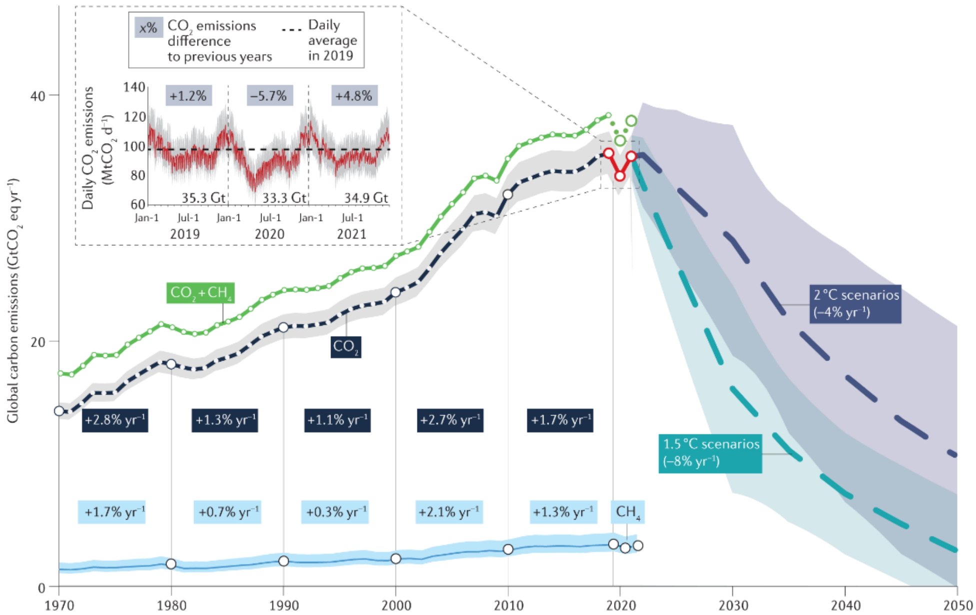

Figure 2: *Global CO_2 and CH_4 emission trends*

Global CO $_2$ emissions have exhibited a rapid increase (Fig. 2). However, embedded within this long-term trend are interannual fluctuations arising from global energy, finance and health crises. For example, during 2020, global lockdowns owing to the COVID-19 pandemic temporarily reduced CO_2 emissions [1 , 2] . The Carbon Monitor program [1,3] — which provides near-real-time daily global CO $_2$ emissions from power generation (29 countries), industry (73 countries), road transportation (406 cities), aviation and maritime transportation, and commercial and residential sectors (206 countries) - offers an opportunity to track the evolution of these CO $_2$ emissions, and in doing so, assess remaining carbon budgets and progress in reaching the Paris Agreement. Here, we document the status of CO $_2$ and fossil CH $_4$ emissions for 2021, revealing a rebound from COVID-related 2020 reductions and a corresponding decrease in the remaining CO $_2$ budget.

According to the report, from 1990 to 2020, radiation exposure— warming effect on our climate — long-lived greenhouse gases increased by 47%, with CO2 accounting for about 80% of that increase. The data is based on monitoring by the WMO's Global Atmosphere Monitoring network. The Greenhouse Gas Bulletin provides a clear scientific message for climate negotiators at COP26. "At the current rate of increase in greenhouse gas concentrations, we will see temperature increases by the end of this century that significantly exceed the Paris Agreement goals of limiting the temperature increase to 1.5 to 2 degrees Celsius above pre-industrial levels," said WMO Secretary-General Professor Petteri . Taalas : "We are on the wrong path."

"The amount of CO2 in the atmosphere passed the 400 parts per million mark in 2015. And just five years later it exceeded 413 ppm. This is not just a chemical formula and numbers on a graph. It has serious negative consequences for our daily lives and well-being, for the state of our planet and the future of our children and grandchildren," added Professor Taalas .

"Carbon dioxide stays in the atmosphere for centuries, and in the oceans even longer. The last time the Earth experienced similar concentrations of CO2 was 3-5 million years ago, when the temperature was 2-3°C higher and sea levels were 10-20 meters higher than now. However, there were not 7.8 billion people on the planet then ," said Professor Taalas .

"Many countries are now setting carbon neutrality targets, and we hope that COP26 will see a sharp increase in commitments. We need to translate our commitments into actions that impact the gases that cause climate change. We need to rethink our industrial, energy and transport systems, as well as our way of life."

III. Results

Carbon landfills play an important role in combating climate change and sustainable management of natural resources. significance Can highlight in several key aspects :

1. **Carbon Balance Monitoring**: Carbon polygons serve as sites for scientific research into the carbon cycle. They monitor greenhouse gas concentrations to assess the level of carbon uptake by ecosystems and the impact of human activity on climate.
2. **Technology development and testing**: Carbon polygons develop and test new technologies and methods to reduce greenhouse gas emissions and increase carbon sequestration. This includes agroforestry practices, rotational grazing, and other sustainable agricultural approaches.
3. **Biodiversity conservation**: Carbon landfills help preserve natural ecosystems and biodiversity. They create conditions for the restoration of degraded lands and support the sustainability of ecosystems, which is important for combating climate change.
4. **Education and Outreach**: These sites also serve an educational function, providing opportunities to study ecology, climate and sustainable development. They serve as a place for learning and sharing experiences among scientists, students and local communities.
5. **Stimulating sustainable development**: Carbon landfills contribute to the development of local sustainable development strategies that can be adapted to specific regional conditions. This includes the creation of jobs in environmental protection and sustainable farming.
6. **Global collaboration**: Carbon polygons facilitate international collaboration on climate change research. They can serve as platforms for sharing knowledge and best practices between countries and research institutions.

Carbon landfills are thus an important tool in the fight against climate change, providing both scientific data and practical solutions to improve the carbon balance and conserve natural resources.

Carbon polygons play a key role in understanding and managing greenhouse gases and combating climate change. They are unique research sites where the carbon balance and concentrations of greenhouse gases such as carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O) are monitored. This data helps to assess the impact of human activity on climate and identify sources and sinks of carbon.

Carbon landfills also develop and test new technologies and methods to reduce greenhouse gas emissions and increase carbon sequestration. This can include sustainable agricultural practices such as rotational grazing and agroforestry , which help conserve biodiversity and restore degraded land.

Simplified scheme showing greenhouse gases (GHG) and their effects on plants. GHG (H_2O vapor, clouds, CO_2, CH_4 , N_2O, and NO) have both natural and anthropogenic origin, contributing to greenhouse effect. Short-term effects of GHG increase is mainly CO_2 rise, that activates photosynthesis (PS) and inhibits stomatal opening (SO). Long-term effects of GHG increase are extreme climate changes such as floods, droughts, heat. All of them induce the generation of reactive oxygen species (ROS) and oxidative stress in plants. Nitric oxide (NO) could alleviate oxidative stress by scavenging ROS and/or regulating the antioxidant system (AS). GHG and volatile organic compounds (VOC) react in the presence of sunlight (E#) to give tropospheric O 3 . Although tropospheric O 3 is prejudicial for life, stratospheric O 3 is beneficial, because filters harmful UV-B radiation. The size of arrows are representative of the GHG concentration.

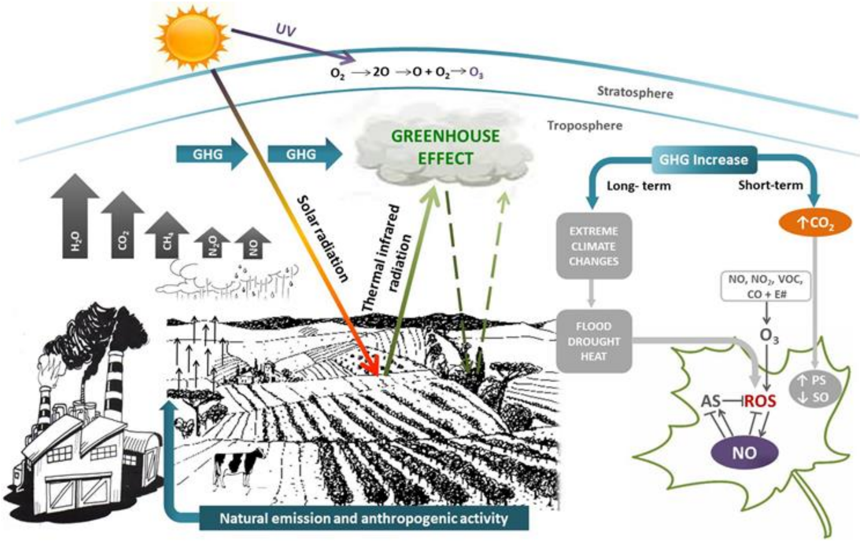

Figure 3: *Greenhouse gases*

The educational function of carbon polygons is also important: they provide an opportunity for learning and exchange of experience among scientists, students and local communities. This contributes to the development of local sustainable development strategies that are adapted to the specific conditions of the region and creates jobs in the field of environmental protection.

In addition, carbon polygons stimulate global cooperation in climate change research by serving as platforms for the exchange of knowledge and best practices between countries and scientific institutions. Carbon polygons are therefore an important tool not only for greenhouse gas research and monitoring, but also for developing practical solutions aimed at improving the carbon balance and preserving natural resources.

IV. Discussion

WayCarbon carbon testing ground in the Chechen Republic is a unique scientific platform designed for research in the field of climate change and ecosystem management. It was created to monitor and analyze greenhouse gas levels, as well as to develop and implement technologies aimed at reducing carbon emissions and increasing carbon absorption.

Main characteristics of the WayCarbon carbon polygon :

1. Scientific Research: WayCarbon conducts detailed studies of the carbon cycle, including monitoring atmospheric concentrations of carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O). Scientists use a variety of monitoring methods, including weather stations, drones, and sensors, to collect data on carbon emissions and uptake.

2. Ecosystem diversity: The site is located in a variety of landscape types, including steppes and subalpine meadows, allowing for research in a variety of ecosystems and the assessment of their carbon sequestration capacity. Each of these zones has its own characteristics and the research conducted in them.

3. Sustainable Agriculture: The carbon site is home to a regenerative livestock project that includes rotational grazing. This helps maintain biodiversity, restore ecosystems, and increase carbon sequestration, as healthy pastures are better able to absorb CO2.

4. Educational function: WayCarbon also serves as a platform for education and awareness-raising among local communities and students. Participation in research and educational programs helps to shape the next generation of specialists in the field of ecology and sustainable development.

5. Global collaboration: The site actively collaborates with international scientific organizations and universities, facilitating the exchange of knowledge and best practices in the field of climate change research.

6. Socio-economic aspects: The WayCarbon carbon landfill creates new jobs and contributes to the development of the local economy through sustainable management of natural resources and the implementation of environmentally friendly technologies.

WayCarbon carbon polygon in the Chechen Republic is an important tool for combating climate change, providing essential data for monitoring greenhouse gases and developing practical solutions. Its unique scientific base and focus on sustainable development help preserve ecosystems and shape a future focused on environmental protection and social well-being.

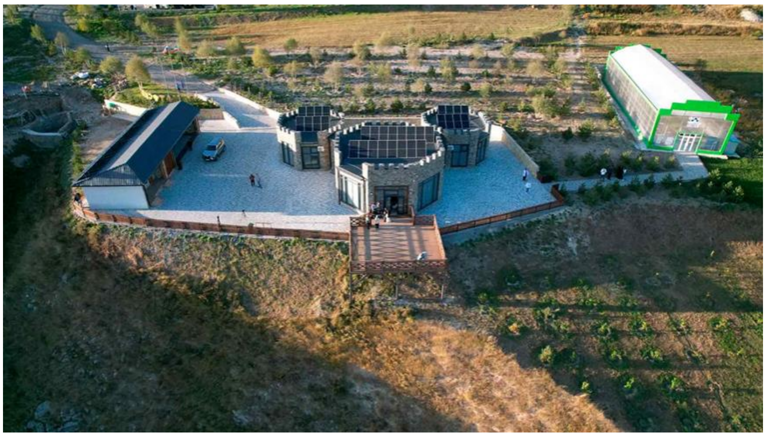

Figure 3: *Carbon Polygon of Kadyrov Chechen State University*

Another way to achieve carbon neutrality is to create conditions for the absorption of carbon dioxide (CO2), which helps offset carbon emissions. This can be done, for example, by planting grasses and trees with high carbon sequestration potential.

What is carbon sequestration? It is the process of absorbing carbon, in this case CO2. The site actively monitors emissions, i.e. the amount of carbon dioxide released from the soil, and the rate at which it is absorbed by plants. The goal is to achieve carbon neutrality, which means zero emissions versus carbon sequestration.

Paulownia, a tree known for its high carbon sequestration potential, was chosen as one of the recommended plant species. In addition, poplar trees provided by the Voronezh Forestry University are also planted at the landfill. Both of these trees are characterized by fast growth, which makes them suitable for carbon absorption projects.

There are plans to introduce other native crops that will also contribute to carbon sequestration. According to forecasts, the carbon farm area will reach 30 hectares by the end of the year. This will significantly increase the volume of carbon dioxide absorption and will contribute to achieving carbon neutrality at the landfill.

At the carbon polygon in the mountains, you will be shown greenhouses where paulownia and poplar trees are grown. These plants have a high potential for absorbing carbon dioxide, which makes them important for projects to improve the carbon balance in the region.

In the laboratory of the engineering center, you will be able to see young seedlings in test tubes. Paulownia, known as one of the most effective trees in terms of carbon sequestration, undergoes a special adaptation process to successfully take root in mountain conditions. First, the seedlings are placed in laboratory test tubes, where they develop in a controlled environment. Then they are transplanted into pots, where they continue to grow and prepare for more difficult conditions. Only then do the young trees go to the greenhouses of the carbon polygon, where they receive the necessary care and attention.

Figure 4: *Planting Paulownia*

The experts at the site will provide detailed information on all stages of growing trees with high sequestration potential. In addition, scientists conduct research and study the sequestration potential of other plants, such as mulberry, willow, linden and ash. This research helps to understand which plant species are most effective in absorbing carbon dioxide in different climates and which of them can successfully grow in mountainous areas. Thus, the carbon polygon not only contributes to the fight against climate change, but also develops scientific knowledge about the vegetation that can help in this process.

The WayCarbon carbon polygon and the A.A. Kadyrov Chechen State University play an important role in achieving carbon neutrality in the Chechen Republic. Thanks to the work carried out, the university territory has already achieved carbon neutrality, which is a significant achievement for the region. At present, it is planned to formalize the status of the first climate-neutral Russian university in the Institute of Global Climate and Ecology. The absence of large-scale production in the republic is an important factor contributing to the implementation of environmental initiatives, since it helps to avoid significant greenhouse gas emissions.

The university's expert council of professors believes that the region is likely to be carbon neutral, but evidence needs to be provided to confirm this. The initiative is actively building evidence bases to assess the university's impact on the environment. Factors such as emissions from transport, energy consumption, and the implementation of climate projects aimed at absorbing CO2 are taken into account.

WayCarbon carbon landfill is planted with plants with high carbon sequestration potential, such as paulownia and poplar. These trees grow quickly and significantly contribute to the absorption of CO2. By the end of the year, the carbon farm is planned to be expanded to 30 hectares, which will help increase the volume of carbon absorption and bring the university closer to carbon neutrality. If the results of the projects confirm a zero or negative carbon impact, CSU will be able to officially secure its status as a carbon neutral university. This will be a significant contribution to efforts to combat climate change both at the regional and national level.

Acknowledgments

The work was carried out within the framework of the state assignment of the Ministry of Science and Higher Education of the Russian Federation (topic No. 075-03-2021-074/4).

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