Abstract

This study investigates the relationship between atmospheric carbon dioxide (CO_2) levels and temperature changes in Bogotá, Colombia, aiming to understand their impact on urban architecture and public health. With the objective to understand increasing droughts and water shortages, the research examines how rising CO_2 emissions contribute to temperature changes and deteriorating air quality. Using NASA data, CO_2 levels from 1990 to 2024 and temperature trends from 2002 to 2023 were analyzed. The findings reveal a clear correlation: as CO_2 emissions rise, surface air temperatures increase, leading to more extreme climate conditions. Poor urban planning and transportation reliance on fossil fuels causing pollution, affecting air quality. This decline in air quality has been linked to respiratory diseases such as asthma, bronchitis, and cardiovascular issues, moreover in densely populated areas. Additionally, urban design plays a crucial role, with inefficient infrastructure amplifying the effects of climate change. The study concludes that immediate action is needed, favoring eco-efficient buildings, sustainable mobility solutions, and improved land planning to reduce CO_2 emissions, temperature increases, and protect public health.

Exploring the relationship between atmospheric carbon dioxide and temperature in Bogota, Colombia.

Hanna Isaza-Student

Maria Camila Gomez-Student

Matthew Reis-Teacher

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Research Question and Hypothesis

We decided to conduct this investigation because Bogota is experiencing severe droughts. This has led to the rationing of water in the city. For example, every eight days the city cuts off the water for 24 hours. This has a major influence on our daily habits and routines. During the cutoff, we are unable to bathe, cook, brush our teeth or flush toilets. Restaurants are seriously affected. As you can imagine, biosecurity protocols are also jeopardized because of decreased hygienic practices due to lack of water. Because of these reasons, we wanted to investigate the relationship between atmospheric conditions and climate change. Based on the current events described above, we proposed the following questions.

- What is the relationship between carbon dioxide emissions and changes in temperature in Bogotá, Colombia?
- How are the CO_2 levels and temperature connected to the architecture?
- How does the air quality affect the health of Colombians?

In Colombia, the increased CO_2 production has a direct relationship with the rise of the temperature causing multiple affections towards Colombians. Through the years the increase in population and climate change has been an ongoing issue because people's most common way of transportation is through cars, and since there's a 1.14% constant increase in population more and more cars start to circulate causing more CO_2 emissions in Colombia.

Materials and Methods

1. Using mynasadata.org, we filtered and downloaded CO_2 atmospheric levels from 1990 to 2024 in Bogota, Colombia
2. Using mynasadata.org, we filtered and downloaded temperature levels from 2002 to 2023 in Bogota, Colombia.
3. We transformed the data to visual graphs.

Data Summary

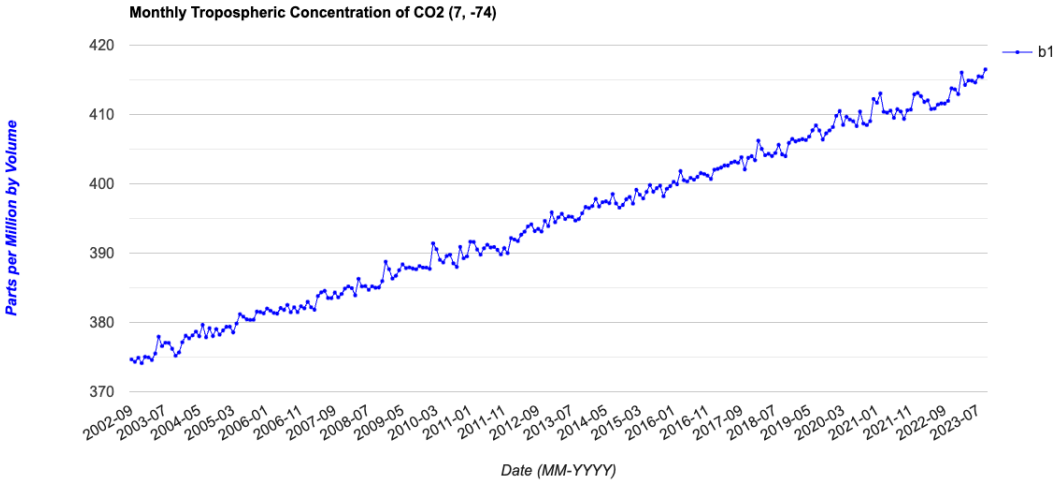

Figure 1. Change in tropospheric carbon dioxide levels from 2002 to 2023.

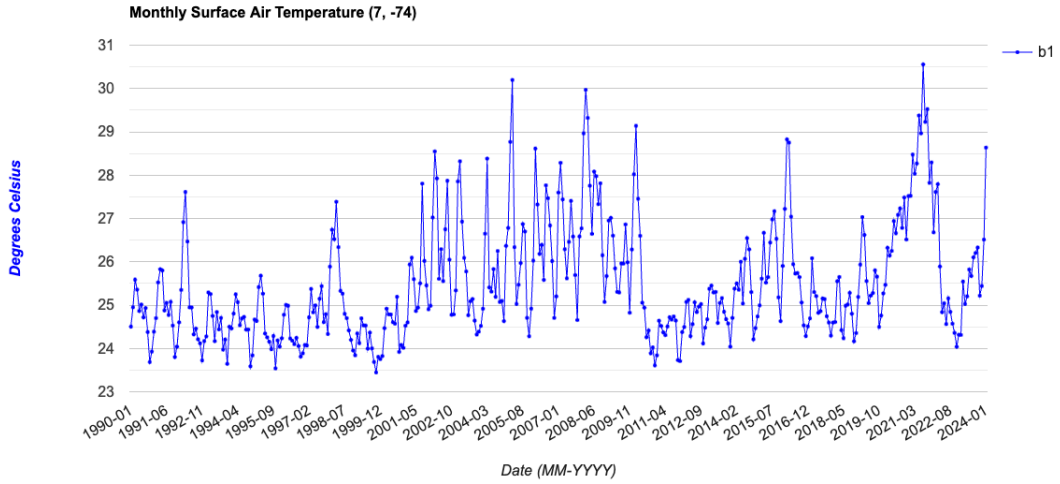

Figure 2. Change in surface air temperature from 1990 to 2024 in Bogota, Colombia

Analysis and Results

Figure 1 shows the change in carbon dioxide (CO_2) levels from 2002 to 2023. The CO_2 level in 2002 was 375 ppm. The CO_2 concentration gradually increased to 415 ppm in 2023. The CO_2 levels changed by 40 ppm during those 21 years.

Figure 2 shows changes in surface air temperature (SAT) in Bogota, Colombia from 1990 to 2024. From 1990 to 1991 the SAT mildly fluctuated between 24.5ºC and 23.5ºC. The SAT spiked in 1992 to 27.5oC. From 1993 to 1998 the SAT fluctuated between 23.5ºC and 25.5ºC. Again the SAT spiked in 1998 to 27.5ºC. From 1999 to 2010, the SAT fluctuated greatly between 25ºC and 30.5ºC. The SAT dropped to 23.5oC in 2011 and then gradually increased yearly to 28.5ºC in 2016. Once again the SAT dropped to 24.5ºC in 2017 and gradually increased yearly to the greatest recorded SAT of 30.5ºC in 2021. The SAT dropped to 24ºC the following year and then dramatically increased to 28.5ºC in 2024.

Conclusions

Question1: What is the relationship between carbon dioxide emissions and changes in temperature in Bogotá, Colombia?

There is a relationship between tropospheric CO_2 and SAT. As we can see from the graphs, as CO_2 increased, SAT also increased and fluctuated more drastically. For the graphs we used My Nasa Data (Data, 2024) and we used data from macro trends, to identify how much the actual CO_2 levels have risen, and according to the graph we can see that levels were stable until 1995, which is when the levels started increasing linearly. By using climate transparency.org we found that through the years the CO_2 levels have increased around 16% and this affects the air quality in Colombia heavily because even with large ecosystems the footprint is extremely high. Aside from these tools we used a study from Guangdong Experimental High School that demonstrates that there was effectively a correlation between CO_2 and the rising temperature levels, and we used information from ourworldindata.org to calculate how much the CO_2 levels have risen per capita over the years.

From the year 1990 to 2024 there has been a significant increase in the average CO_2 and temperature, this is demonstrated by various sources and the data that we collected from MyNasaData evidenced the fact that CO2 levels have been increasing, this is something that makes sense if we consider the actual amount of people and the evident increase in population “Colombia's population has grown from 32,440,069 in 1990 to an estimated 52,695,952 in 2024” (UN), demonstrating that evidently the population in Colombia is growing significantly, this causes more pollution and CO_2 production because the most common way of transportation is using cars or motorcycles, these vehicles produce greenhouse gases and oxidized residues that pollute the atmosphere.

Question 2: How are the CO_2 levels and temperature connected to the architecture?

The urbanization in Bogota has multiple issues that do not contribute to diminish the overall CO_2 that is produced in the city, this is because multiple laws urge citizens to own more than one car causing

traffic and therefore more pollution in the climate and as stated before the rising CO_2 levels to generate higher temperatures and causing the water levels to decrease and consequently causing more issues for the daily lives of the people who live in Bogota since the multiple cutoffs affect the restaurants, the shops and even people's homes. By implementing sustainable mobility we would significantly reduce the amount of CO_2 being produced. This is because if the people that usually use cars switched to these methods and the city was already implementing ecological transportation infrastructure, then the CO_2 levels would diminish and the overall repercussions would be less severe. Another way that the city itself could also reduce emissions is by implementing eco efficient buildings. These types of buildings promote proper air flow and also utilize ecological sources of energy which would also benefit the environment. The most important method yet to be implemented is urban planning. Urban planning would promote normal car circulation and the amount of cars needed for mobility would decrease, causing the CO_2 levels to drop as well. Overall we can see that if these changes are implemented the future of Bogota will look brighter not only lowering the CO_2 but also enhancing public health and promoting sustainable development in the country.

Question 3: How does the air quality affect the health of Colombians?

In Colombia, air quality may vary depending on the place. For instance, rural air quality is not the same as urban air quality. Air pollution in Colombia is a major public health concern, causing respiratory diseases such as asthma, bronchitis, and chronic obstructive pulmonary disease (COPD), as well as increasing the risk of strokes and heart attacks. The air quality varies depending on the location, it is not the same air quality in an urban area than in a rural area. This is seen to be affected by various factors, in urban places, it is common gas emissions from vehicles, industrial activity (e.g., factories), and construction sites. Rural areas are affected mainly by household air pollution (use of solid fuels such as: charcoal and wood), as well as trapped gases in houses due to lack of access to clean energy sources, which leads to various respiratory system diseases (including lung infections, chronic respiratory diseases, and cancer). Finalizing the idea, a good air quality is crucial for a healthy life, however, taking into

account all the gases emitted by the daily life of human beings, it is almost impossible to reach this level of air quality without much air pollution.

Discussion

It is known that Earth's temperature is constantly changing, however, this occurs due to many factors, including: solar radiation, greenhouse gases, and human activity. The real question is, how does it affect Earth's temperature and why does it keep getting hotter? The answer to this is well known: greenhouse gases. Moving on to each factor, solar radiation is a factor humans cannot control since it comes from outer space, directly from the sun. Solar radiation is mainly responsible for the sun's activity, which depending on Earth's tilt, will cause more or less heat. According to the British Geological Survey (2021), Earth's climate has experienced various temperature changes due to changes in its orbit, affecting the amount of solar radiation and heating received.

The fact that most of Colombia's GDP comes from agriculture and other types of land use these factors contribute to the rise of CO_2 levels, and since products such as meat or products that come from agriculture have such a high demand the production should be equally balanced to comply with the necessities of production, another cause for the increased CO_2 production is the fossil fuels produced and the burning of harsh materials that generate greenhouse gases such as coal, oil, and natural gas for power generation are extremely important factors that contribute to the development and growth of CO_2 levels, moreover one of the biggest contributing causes is the deforestation, this is because when trees are cut down the production of oxygen is affected, because the function of trees in the environment is to absorb CO_2 and provide "clean" air, so when deforestation takes place the damage caused by these different factors is even harder to "reverse" or manage.

Over the past decades, Colombia has gone through significant temperature changes influenced by global and local factors. Human activity involves all sorts of factories, enterprises and more manhand buildings created. This factor causes tons of gases, due to all the smoke and gas released by factories, trucks, and more. This factor not only affects Earth's temperature, but it also affects life on Earth, since it is responsible for air pollution, leading to respiratory system problems, deaths of many living organisms, and a worse quality of life by cutting down many trees to turn the space into a more profitable

organization. According to The British Geological Survey (2021) as well, changes in land, such as deforestation, can affect atmospheric temperature by altering surface reflectivity and carbon storage.

Finally, there is the greenhouse gases. The reason why this is the most damaging variable, is because greenhouse gasses are responsible for melting glaciers, rising temperatures, and the deaths of many living organisms. NASA (2024) has evidence of how human activities, particularly burning fossil fuels have led to an increase in greenhouse gases (e.g., CO_2), as well as it emphasizes how the scientific community agrees with the human-induced impact of greenhouse gas emissions in warming Earth.

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