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Climate Change: Impact of Carbon Emission to the Atmosphere

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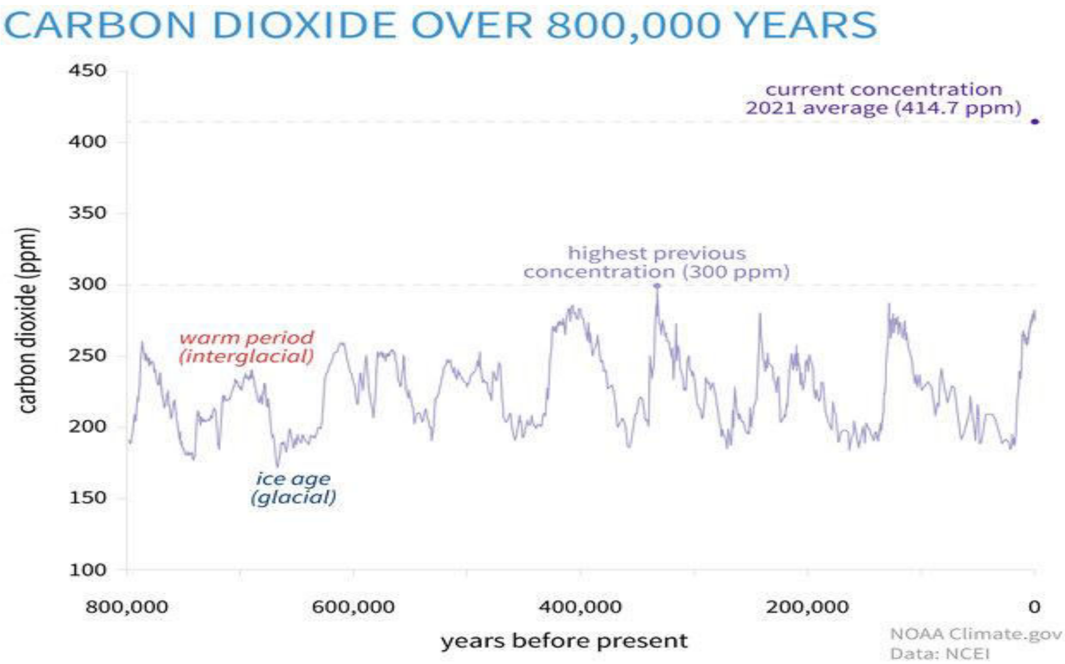
ABSTRACT: Carbon dioxide in the atmosphere warms the planet, causing climate change. Human activities have raised the atmosphere's carbon dioxide content by 50% in less than 200 years. Carbon dioxide (CO_2) is an important heat-trapping gas, or greenhouse gas, that comes from the extraction and burning of fossil fuels (such as coal, oil, and natural gas), from wildfires, and from natural processes like volcanic eruptions. Since the beginning of industrial times (in the 18th century), human activities have raised atmospheric CO_2 by 50% – meaning the amount of CO_2 is now 150% of its value in 1750. This is greater than what naturally happened at the end of the last ice age 20,000 years ago. Carbon dioxide concentrations are rising mostly because of the fossil fuels that people are burning for energy. Fossil fuels like coal and oil contain carbon that plants pulled out of the atmosphere through photosynthesis over many millions of years; we are returning that carbon to the atmosphere in just a few hundred. Since the middle of the 20th century, annual emissions from burning fossil fuels have increased every decade, from an average of 3 billion tons of carbon (11 billion tons of carbon dioxide) a year in the 1960s to 9.5 billion tons of carbon (35 billion tons of carbon dioxide) per year in the 2010s

KEYWORDS: carbon, emissions, climate, change, atmosphere, fossil fuels, energy, wildfires

I.INTRODUCTION

Carbon cycle experts estimate that natural "sinks"—processes that remove carbon from the atmosphere—on land and in the ocean absorbed the equivalent of about half of the carbon dioxide we emitted each year. Because we put more carbon dioxide into the atmosphere than natural processes can remove, the amount of carbon dioxide in the atmosphere increases every year.The more we overshoot what natural processes can remove in a given year, the faster the atmospheric concentration of carbon dioxide rises. In the 1960s, the global growth rate of atmospheric carbon dioxide was roughly 0.8± 0.1 ppm per year. Over the next half century, the annual growth rate tripled, reaching 2.4 ppm per year during the 2010s. The annual rate of increase in atmospheric carbon dioxide over the past 60 years is about 100 times faster than previous natural increases, such as those that occurred at the end of the last ice age 11,000-17,000 years ago. [1,2]Carbon dioxide is Earth's most important greenhouse gas: a gas that absorbs and radiates heat. Unlike oxygen or nitrogen (which make up most of our atmosphere), greenhouse gases absorb heat radiating from the Earth's surface and re-release it in all directions—including back toward Earth's surface. Without carbon dioxide, Earth's natural greenhouse effect would be too weak to keep the average global surface temperature above freezing. By adding more carbon dioxide to the atmosphere, people are supercharging the natural greenhouse effect, causing global temperature to rise. Another reason carbon dioxide is important in the Earth system is that it dissolves into the ocean like the fizz in a can of soda. It reacts with water molecules, producing carbonic acid and lowering the ocean's pH (raising its acidity). Since the start of the Industrial Revolution, the pH of the ocean's surface waters has dropped from 8.21 to 8.10. This drop in pH is called ocean acidification.Natural increases in carbon dioxide concentrations have periodically warmed Earth's temperature during ice age cycles over the past million years or more. The warm episodes (interglacials) began with a small increase in incoming sunlight in the Northern Hemisphere due to variations in Earth's orbit around the Sun and its axis of rotation. That little bit of extra sunlight caused a little bit of warming. As the oceans warmed, they outgassed carbon dioxide—like a can of soda going flat in the heat of a summer day. The extra carbon dioxide in the atmosphere greatly amplified the initial, solar-driven warming.[3,4]

Based on air bubbles trapped in mile-thick ice cores and other paleoclimate evidence, we know that during the ice age cycles of the past million years or so, atmospheric carbon dioxide never exceeded 300 ppm. Before the Industrial Revolution started in the mid-1700s, atmospheric carbon dioxide was 280 ppm or less. Carbon dioxide levels today are higher than at any point in human history. In fact, the last time atmospheric carbon dioxide amounts were this high was more than 3 million years ago, during the Mid-Pliocene Warm Period, when global surface temperature was 4.5–7.2 degrees Fahrenheit (2.5–4 degrees Celsius) warmer than during the pre-industrial era. Sea level was at least 16 feet higher than it was in 1900 and possibly as much as 82 feet higher.If global energy demand continues to grow rapidly and we meet it mostly with fossil fuels, human emissions of carbon dioxide could reach 75 billion tons per year or more by the end of the century. Atmospheric carbon dioxide could be 800 ppm or higher—conditions not seen on Earth for close to 50 million years.[5,6]



II.DISCUSSION

The greenhouse effect is the natural process of how the sun warms the Earth's surface. When greenhouse gases release into the atmosphere — these include carbon dioxide, methane, nitrous oxide, ozone, and water vapor — and trap the sun's heat, they warm the average global temperature, causing it to rise. This is known as global warming.

What should happen is that infrared radiation escapes into space, but instead, it gets trapped in our atmosphere and warms the planet.Carbon emissions are one type of greenhouse gas emission that happens when carbon dioxide enters the air after a human activity or process. They are crucial to this conversation because they are the most significant type of emission in terms of quantity. What causes carbon emissions are humans. Carbon dioxide gets released into the atmosphere after everyday human processes like driving a vehicle, the agricultural industry, and more. The Environmental Protection Agency lists the six main sources of greenhouse gases as transportation, electricity production, industry, commercial and residential, agriculture, and land use and forestry. According to National Geographic, carbon dioxide is considered a pollutant, though we may more readily associate "pollution" with things like smoke or plastic floating in a lake. But pollutants are anything that falls under the umbrella of a mix of particles and gases that have the capacity to reach harmful concentrations, according to National Geographic. Things like soot, smoke, mold, and pollen are considered pollutants, but greenhouse gases like methane and carbon dioxide are, too.[7,8] While increased carbon dioxide levels can "increase water-use efficiency in crops" and also "mitigate yield losses due to climate change," these levels can also create imbalances in nitrogen and carbon, minimizing crops' necessary nutrients like iron, zinc, and protein. Perhaps the most important way that carbon emissions affect the planet is by causing climate change. As the average global temperature warms, our climate inherently changes — it warms. This warming causes extreme weather events like tropical storms, wildfires, severe droughts and heat waves. And while an increase in carbon in the air can, in some ways, positively affect plants and crops, if the climate changes the lands and

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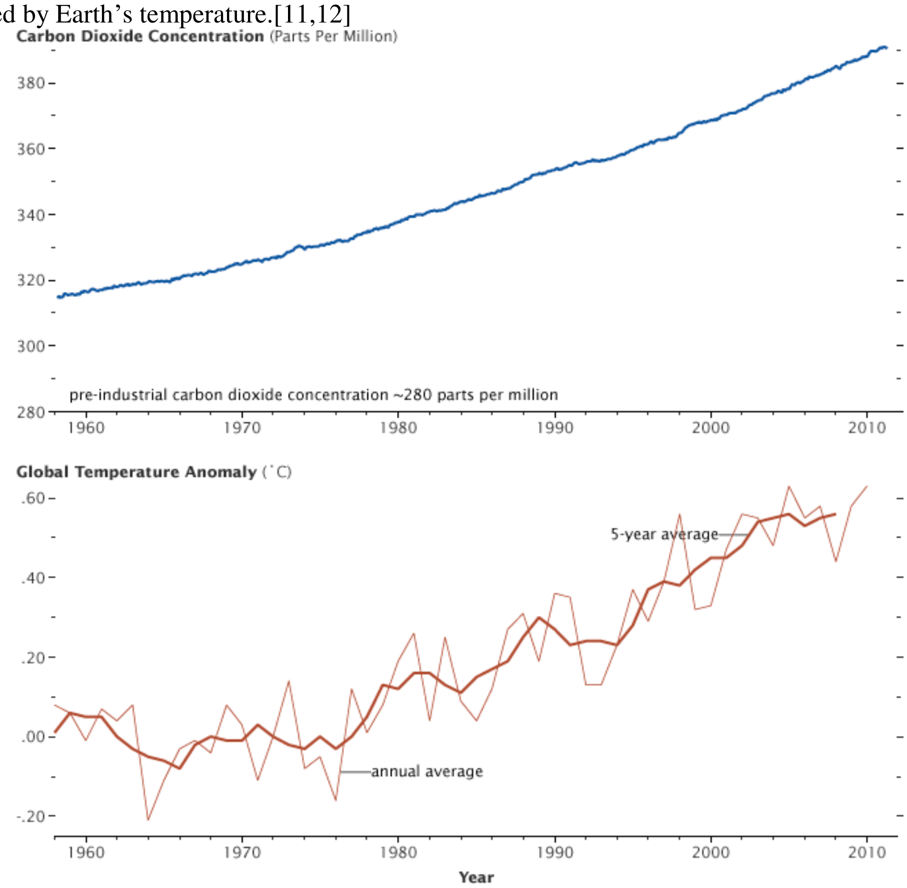
causes drought or other weather events that crops and plants are unable to survive in, it can be detrimental to crop yields. The same problem holds for animals, as well; as climate change alters our environment and natural habitats, different indigenous species take a hit. Some species may disappear altogether, while others might thrive and overtake others. Carbon emissions directly affect humans, too, causing more respiratory disease from an increase of smog and air pollution. Not to mention that if carbon emissions eradicate certain animal species, destroy crop yields and lands, humans will also see the repercussions of those effects as well.

Carbon emissions are dangerous in that they threaten the livelihood of our planet, animals, humans, and ultimately, life as we know it. The amount of carbon emissions trapped in our atmosphere causes global warming, which causes climate change, symptoms of which include melting of the polar ice caps, the rising of sea levels, the disturbance of animals' natural habitats, extreme weather events, and so many more negative side effects that are dangerous to the planet, to human and animal life, and to our future.[9,10]

III.RESULTS

It is significant that so much carbon dioxide stays in the atmosphere because CO_2 is the most important gas for controlling Earth's temperature. Carbon dioxide, methane, and halocarbons are greenhouse gases that absorb a wide range of energy—including infrared energy (heat) emitted by the Earth—and then re-emit it. The re-emitted energy travels out in all directions, but some returns to Earth, where it heats the surface. Without greenhouse gases, Earth would be a frozen -18 degrees Celsius (0 degrees Fahrenheit). With too many greenhouse gases, Earth would be like Venus, where the greenhouse atmosphere keeps temperatures around 400 degrees Celsius (750 Fahrenheit). Because scientists know which wavelengths of energy each greenhouse gas absorbs, and the concentration of the gases in the atmosphere, they can calculate how much each gas contributes to warming the planet. Carbon dioxide causes about 20 percent of Earth's greenhouse effect; water vapor accounts for about 50 percent; and clouds account for 25 percent. The rest is caused by small particles (aerosols) and minor greenhouse gases like methane.Water vapor concentrations in the air are controlled by Earth's temperature.[11,12]



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Warmer temperatures evaporate more water from the oceans, expand air masses, and lead to higher humidity. Cooling causes water vapor to condense and fall out as rain, sleet, or snow.Carbon dioxide, on the other hand, remains a gas at a wider range of atmospheric temperatures than water. Carbon dioxide molecules provide the initial greenhouse heating needed to maintain water vapor concentrations. When carbon dioxide concentrations drop, Earth cools, some water vapor falls out of the atmosphere, and the greenhouse warming caused by water vapor drops. Likewise, when carbon dioxide concentrations rise, air temperatures go up, and more water vapor evaporates into the atmosphere—which then amplifies greenhouse heating.So while carbon dioxide contributes less to the overall greenhouse effect than water vapor, scientists have found that carbon dioxide is the gas that sets the temperature. Carbon dioxide controls the amount of water vapor in the atmosphere and thus the size of the greenhouse effect.Rising carbon dioxide concentrations are already causing the planet to heat up. At the same time that greenhouse gases have been increasing, average global temperatures have risen 0.8 degrees Celsius (1.4 degrees Fahrenheit) since 1880.[13,14]

This rise in temperature isn't all the warming we will see based on current carbon dioxide concentrations. Greenhouse warming doesn't happen right away because the ocean soaks up heat. This means that Earth's temperature will increase at least another 0.6 degrees Celsius (1 degree Fahrenheit) because of carbon dioxide already in the atmosphere. The degree to which temperatures go up beyond that depends in part on how much more carbon humans release into the atmosphere in the future. About 30 percent of the carbon dioxide that people have put into the atmosphere has diffused into the ocean through the direct chemical exchange. Dissolving carbon dioxide in the ocean creates carbonic acid, which increases the acidity of the water. Or rather, a slightly alkaline ocean becomes a little less alkaline. Since 1750, the pH of the ocean's surface has dropped by 0.1, a 30 percent change in acidity.

Ocean acidification affects marine organisms in two ways. First, carbonic acid reacts with carbonate ions in the water to form bicarbonate. However, those same carbonate ions are what shell-building animals like coral need to create calcium carbonate shells. With less carbonate available, the animals need to expend more energy to build their shells. As a result, the shells end up being thinner and more fragile.Second, the more acidic water is, the better it dissolves calcium carbonate. In the long run, this reaction will allow the ocean to soak up excess carbon dioxide because more acidic water will dissolve more rock, release more carbonate ions, and increase the ocean's capacity to absorb carbon dioxide. In the meantime, though, more acidic water will dissolve the carbonate shells of marine organisms, making them pitted and weak.Warmer oceans—a product of the greenhouse effect—could also decrease the abundance of phytoplankton, which grow better in cool, nutrient-rich waters. This could limit the ocean's ability to take carbon from the atmosphere through the fast carbon cycle.On the other hand, carbon dioxide is essential for plant and phytoplankton growth. An increase in carbon dioxide could increase growth by fertilizing those few species of phytoplankton and ocean plants (like sea grasses) that take carbon dioxide directly from the water. However, most species are not helped by the increased availability of carbon dioxide.[15,16]

Plants on land have taken up approximately 25 percent of the carbon dioxide that humans have put into the atmosphere. The amount of carbon that plants take up varies greatly from year to year, but in general, the world's plants have increased the amount of carbon dioxide they absorb since 1960. Only some of this increase occurred as a direct result of fossil fuel emissions.

With more atmospheric carbon dioxide available to convert to plant matter in photosynthesis, plants were able to grow more. This increased growth is referred to as carbon fertilization. Models predict that plants might grow anywhere from 12 to 76 percent more if atmospheric carbon dioxide is doubled, as long as nothing else, like water shortages, limits their growth. However, scientists don't know how much carbon dioxide is increasing plant growth in the real world, because plants need more than carbon dioxide to grow.Plants also need water, sunlight, and nutrients, especially nitrogen. If a plant doesn't have one of these things, it won't grow regardless of how abundant the other necessities are. There is a limit to how much carbon plants can take out of the atmosphere, and that limit varies from region to region. So far, it appears that carbon dioxide fertilization increases plant growth until the plant reaches a limit in the amount of water or nitrogen available.Some of the changes in carbon absorption are the result of land use decisions. Agriculture has become much more intensive, so we can grow more food on less land. In high and mid-latitudes, abandoned farmland is reverting to forest, and these forests store much more carbon, both in wood and soil, than crops would. In many places, we prevent plant carbon from entering the atmosphere by extinguishing wildfires. This allows woody material (which stores carbon) to build up. All of these land use decisions are helping plants absorb human-released carbon in the Northern Hemisphere. In the tropics, however, forests are being removed, often through fire, and this releases carbon dioxide. As of 2008, deforestation accounted for about 12 percent of all human carbon dioxide emissions.[17]

The biggest changes in the land carbon cycle are likely to come because of climate change. Carbon dioxide increases temperatures, extending the growing season and increasing humidity. Both factors have led to some additional plant growth. However, warmer temperatures also stress plants. With a longer, warmer growing season, plants need more water to survive. Scientists are already seeing evidence that plants in the Northern Hemisphere slow their growth in the summer because of warm temperatures and water shortages.

Dry, water-stressed plants are also more susceptible to fire and insects when growing seasons become longer. In the far north, where an increase in temperature has the greatest impact, the forests have already started to burn more, releasing carbon from the plants and the soil into the atmosphere. Tropical forests may also be extremely susceptible to drying. With less water, tropical trees slow their growth and take up less carbon, or die and release their stored carbon to the atmosphere.The warming caused by rising greenhouse gases may also “bake” the soil, accelerating the rate at which carbon seeps out in some places. This is of particular concern in the far north, where frozen soil—permafrost—is thawing. Permafrost contains rich deposits of carbon from plant matter that has accumulated for thousands of years because the cold slows decay. When the soil warms, the organic matter decays and carbon—in the form of methane and carbon dioxide—seeps into the atmosphere.Current research estimates that permafrost in the Northern Hemisphere holds 1,672 billion tons (Petagrams) of organic carbon. If just 10 percent of this permafrost were to thaw, it could release enough extra carbon dioxide to the atmosphere to raise temperatures an additional 0.7 degrees Celsius (1.3 degrees Fahrenheit) by the future[18,19]

IV.CONCLUSIONS

Black carbon, or soot, is part of fine particulate air pollution ($PM_{2.5}$) and contributes to climate change.Black carbon is formed by the incomplete combustion of fossil fuels, wood and other fuels. Complete combustion would turn all carbon in the fuel into carbon dioxide (CO_2), but combustion is never complete and CO_2, carbon monoxide, volatile organic compounds, and organic carbon and black carbon particles are all formed in the process. The complex mixture of particulate matter resulting from incomplete combustion is often referred to as soot.

Black carbon is a short-lived climate pollutant with a lifetime of only days to weeks after release in the atmosphere. During this short period of time, black carbon can have significant direct and indirect impacts on the climate, the cryosphere (snow and ice), agriculture and human health.Several studies have demonstrated that measures to prevent black carbon emissions can reduce near-term warming of the climate, increase crop yields and prevent premature deaths. Black carbon is an important contributor to warming because it is very effective at absorbing light and heating its surroundings. Per unit of mass, black carbon has a warming impact on climate that is 460-1,500 times stronger than CO_2.When suspended in the atmosphere, black carbon contributes to warming by converting incoming solar radiation to heat. It also influences cloud formation and impacts regional circulation and rainfall patterns.When deposited on ice and snow, black carbon and co-emitted particles reduce surface albedo (the ability to reflect sunlight) and heat the surface. The Arctic and glaciated regions such as the Himalayas are particularly vulnerable to melting as a result. Black carbon and its co-pollutants are key components of fine particulate matter (PM2.5) air pollution, the leading environmental cause of poor health and premature deaths.[20]

At 2.5 micrometres or smaller in diameter, these particles are, many times smaller than a grain of table salt, which allows them to penetrate into the deepest regions of the lungs and facilitate the transport of toxic compounds into the bloodstream.PM2.5 has been linked to a number of health impacts including premature death in adults with heart and lung disease, strokes, heart attacks, chronic respiratory disease such as bronchitis, aggravated asthma and other cardio-respiratory symptoms. It is also responsible for premature deaths of children from acute lower respiratory infections such as pneumonia.Each year, an estimated 7 million premature deaths are attributed to household and ambient (outdoor) PM2.5 air pollution.Black carbon can affect the health of ecosystems in several ways: by depositing on plant leaves and increasing their temperature, dimming sunlight that reaches the earth, and modifying rainfall patterns. Black carbon’s short atmospheric lifetime, combined with its strong warming potential, means that targeted strategies to reduce emissions can provide climate and health benefits within a relatively short period of time.[21]

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