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Climate Change: Causes, Effects, and Solutions

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Abstract

Climate change has become a widespread topic in recent years. This a problem that resulted from the emission of greenhouse gases that affect our environment. Therefore, it raises questions on whether the problem is caused by human activities or it's just a part of nature's cycle. This paper discusses and compares the factors that contribute to climate change by humans and nature, some effects of climate change, and some solutions that have been developed to prevent or slow climate change from progressing.

Climate Change

According to NASA, the Earth average temperature has increased about 1 degree Fahrenheit during the 20th century (Global Climate Change: Effects). That might sound like it isn't a great change, but its effects on our environment have proven otherwise. The impacts of this small change in the temperature are many, from longer drought seasons and heat waves to more aggressive hurricanes (Global Climate Change: Effects). Furthermore, the increase in the earth's average temperature created a variety of problems that left a lasting scar on our environment (Global Climate Change: Effects).

Causes

Greenhouse Gases

Greenhouse gases are thought to be the main contributor to climate change (The Greenhouse Effect). They are very efficient in trapping heat into the atmosphere; therefore, it results in the greenhouse effect.

The solar energy is absorbed by the earth's surface and then reflected back to the atmosphere as heat. Then as the heat goes out to space, greenhouse gases absorb a part of the heat. After that, they radiate the heat back to the earth's surface, to another greenhouse gas molecule, or to space (The Greenhouse Effect). Daniela Burghila et al. stated in "Climate Change Effects- Where to Next?", the biggest concern scientists have is about the emission of CO_2 since it is about 75% of the total global emission of greenhouse gases (406).

Methane and CO_2

According to L.A. Berbisi et al. in "Methane leakage from evolving petroleum systems: Masses, rates and inferences for climate feedback," the present-day warming trend has been attributed to an annual increase in the atmospheric methane concentration andCO_2 (225). The Berbisi et al. study also investigated the potential of methane contribution to the atmosphere during the evolution of petroleum system in two different geological settings: The western Canada sedimentary basin and the Central Graben area of the North Sea. Numerical simulation and different types of mass balance (conversion of mass to the analysis of physical systems) as well as theoretical approaches were applied. In western Canada sedimentary basin case, maximum thermogenic methane leakage rates in the order of 10^{-2} -10^{-3} and maximum biogenic

methane generation rates of 10^{-2} Tg/yr were estimated. In the Central Graben case there was an estimate of maximum thermogenic methane leakage in order of 10^{-3} Tg/yr. Applying the results to a global scale shows that thermal gas generation in hydrocarbon, single process kitchen area would not influence climate (227). On the other hand, only the sudden release of surface methane accumulations, formed over geological time scales, petroleum systems can influence climate (219).

The following chemical equations demonstrate the production of each (Global Climate Change: Human Influences-- The Chemistry):

Combustion of fossil fuels:

$6\ O_2 + C_6H_{12}O_6$ --------> $6\ H_2O + 6\ CO_2$ + energy

Production of methane during microbial metabolic process:

CH_3COOH --------> $CO_2 + CH_4$

Nature Contributions

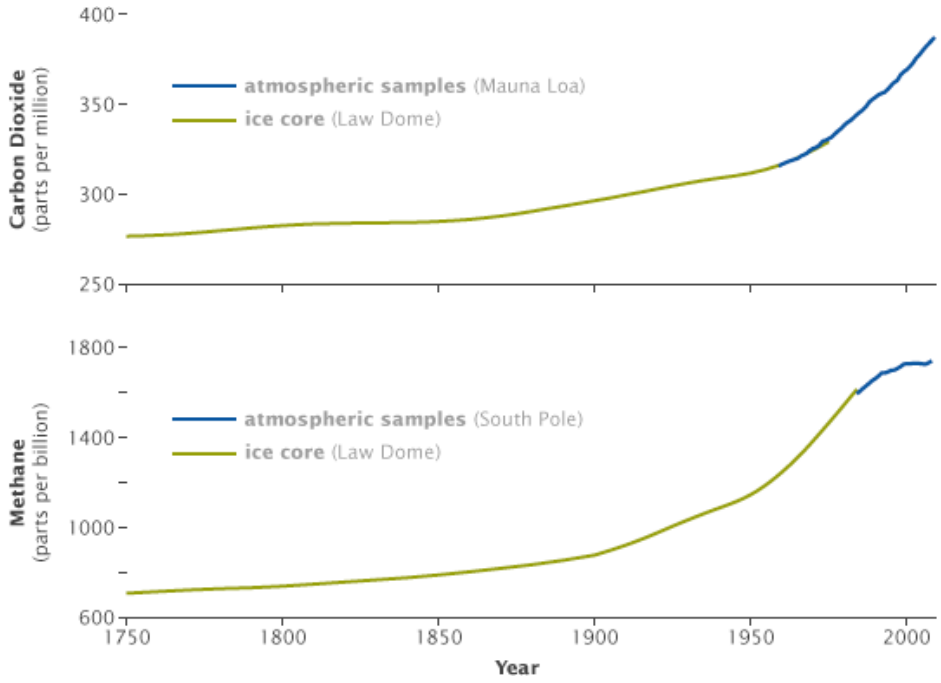
According to Holli Riebeek, the author of "Global Warming," nature also contribute to climate change by emitting CO_2 from volcanos. Don Wuebbles, a coordinating lead author and contributor to a number of the reports of the International Intergovernmental Panel on Climate Change (IPCC), which was awarded the Nobel Peace Prize in 2007, and a Professor of Atmospheric Sciences at the University of Illinois at Urbana-Champaign, stated, "Volcanos used to release CO_2 many millions years ago. Back where dinosaurs existed, we had levels of CO_2 that is approximately similar to what we have now because of the CO_2 emitted by volcanos.

But, volcanos release a small amount of CO_2 and they can't explain the increase of CO_2 that we had in the last century" (Phone interview).

Volcanos do contribute to climate change by emitting CO_2. However, the amount of CO_2 they emit is relatively small if we compare it to the amount of CO_2 that is being released by human activities. According to NASA, on average, volcanoes emit between 130 and 230 million tons of CO_2 per year. However, by burning fossil fuels, people release in excess of 100 times more, about 26 billion tons of CO_2, into the atmosphere every year (as of 2005) (rIEBEEK).

Human Contributions

Scientists believe humans' activities contribute to climate change because we depend on fossil fuels for our energy needs (Riebeek). Wuebbles said, "A large amount of climate change happens widely because we are burning fossil fuels and that increases gases such as CO_2, methane, and some other gases in the atmosphere" (phone interview). According to the Australian Greenhouse Office, the world depends on fossil fuels such as oil, coal, and natural gas for 80% of its energy needs. Therefore, that makes it very hard to switch from fossil fuels to any other forms of energy because we depend on fossil fuels to a large degree. The emission of greenhouse gases has increased dramatically from the industrial revolution, mostly from the burning of fossil fuels for energy, agriculture, industrial process, and transportation (Ecological Impacts of Climate Change). The graph on the next page shows how much CO_2 and methane increased in the last 250 years.



Source: ("Climate Change" graph done by Robert Simmon.)

The graph was done by taking a sample of ice and another sample was taken from the atmosphere. For the ice sample, drilling a hole through the ice sheets and looking at the air molecules inside the sample determined the concentration of CO_2 and methane (Chasing Ice). The graph illustrates that carbon dioxide levels have increased nearly 38 percent from 1750-2009 and methane levels have increased 148 percent (Riebeek).

Effects of Climate Change

Climate change has affected many aspects of our planet. One aspect that has been greatly affected by climate change is the weather. In Romania, for instance, extreme weather events have multiplied since 2002. Burghila et al. stated in "Climate Change Effects- Where to Next?", that the country's 2007 drought was the severest in 60 years (408). By increasing the concentration of the greenhouse gases, we are increasing the amount of heat that is in our atmosphere (NASA). Hurricanes have also become more aggressive largely because of warmer

temperatures that mainly resulted from the emission of greenhouse gases. Warmer temperatures result in warmer water in the oceans. As the result of warmer oceans, hurricanes and tornados become more intense. Wuebbles stated, “Warmer atmosphere result in more energy in the atmosphere. When hurricanes start, they usually pick up energy from the oceans and as the result of warmer water in the oceans because of greenhouse effect, hurricanes have more energy. Therefore, hurricanes become more intense. Now if the water was colder that gives less energy to hurricanes and make it less intense” (phone interview). Also, warmer temperature means the atmosphere holds more water vapor and that makes rainfalls more extreme and intense (Riebeek).

Climate change also resulted in playing a major role in shrinking of ice sheets (Riebeek). The melting of ice results in the rise of sea levels and that endangers many islands to disappear completely (Riebeek). According to NASA, up to 10 percent of the world’s population lives in areas where there about 30 feet above sea level (NASA). Furthermore, Greenland and West Antarctic ice sheets are melting about 125 billion tons of ice per year (Riebeek). Wuebbles said, “As the earth warming its leading to melting more ice and glaciers. We could see as much as 6 feet sea level rise in this century” (Phone interview).

According to Weiwei Mo, Haiying Wang, Jennifer M. Jacobs in “Understanding the influence of climate change on the embodied” the energy of water supply is commonly perceived that climate change has a negative impact on water quantity and quality as well as drinking water treatment. However, some issues such as, geographical locations, local water resources, and water technologies that could potentially influence the effect of climate change on drinking water supply are still unsettled (221).

Weiwei, Haiying, and Jacobs also stated that their study was performed on a selected water supply system located in northeast US. Multivariate regression analyses were implemented to test the statistical correlation, among monthly life cycle energy consumptions, three indicators of water quality (UV_{254}, PH and water temperature) and five climate indicators (monthly mean temperature, monthly mean maximum/minimum temperature, total precipitation, and total snow fall) (221).

The study also concluded that most of the variations in chemical and energy uses were attributed to water quality and climate variations except for the use of soda ash. The study also found that future climate change might slightly reduce energy and chemical uses under both the highest emission and the lowest emission levels generated by the intergovernmental panel on climate change (IPCC). Another major finding of this study that the effects of climate change on the volumetric life cycle energy use in the water supply (reduction by 3-6%) could outweigh the increase in demand for water due to a warmer climate in the case of study system by the end of the century (225,227,229).

Findings of this study reveal the importance of considering factors, such as geographical locations, local environment, water treatment technologies, and water resource management, on appreciating and identifying the potential impact of climate change on the quantity and the quality of drinking water (229).

Solutions

There have been many debates and discussions on how to combat climate change among nations. However, many factors influence on whether the solutions are efficient economically or it cost too much to maintain. The following solutions are considered among the efficient solutions to reduce the progress of climate change:

1. Wind power

According to the EPA, wind power is the fastest-growing energy resources in the world since 1990. Since wind turbines use the wind, a renewable source of energy, to generate electricity it has little to no impact on the environment (EPA). Furthermore, wind turbines don't need water to operate (EPA). According to the U.S. Department of Energy, the usage of wind turbines cut water consumption in the power sector by 36.5 billion gallons in 2013 alone. Also, the usage of wind turbines in 2013 reduced CO_2 emission approximately by 115 million metric tons, which equals the emission of 20 million cars during the year (Wind Energy Benefits).

However, there are some challenges that face wind power. One main challenge is that birds and bats have been killed from flying into the spinning blades. However, to help solve the problem of birds and bats getting killed by the spinning blades, one solution is to avoid building wind turbines in areas where there is a high concentration of migrants. Another solution is to make the wind turbines blades rotate only above certain wind speed. Researchers have found that when wind speed is over 15 mph, 99% of bat activity has stopped in some areas (How to Make Wind Power More Wildlife Friendly 19).

2. Green Buildings

Existed buildings emit CO_2 because of their dependence on fossil fuels for energy from air-conditioning to electricity (Energy–Efficient Buildings). Furthermore, the buildings that we live and work account for 30% of all greenhouse gases emissions in the United States (Energy–Efficient Buildings). Using light bulbs that use less energy and more efficient heating and cooling systems helps in reducing the amount of CO_2 that is being emitted from the buildings (Energy–Efficient Buildings). Therefore, that reduces our dependency on fossil fuel for electricity resulting in a reduction of greenhouse gases emission (Energy–Efficient Buildings).

For instance, the Empire State Building in New York went through renovations to improve energy efficiency. The renovations have reduced energy usage by 38% and save 4.4 million dollars on heating and electricity bills each year (Energy–Efficient Buildings).

3. Methane Leaks

As it has been mentioned above, that Methane is a greenhouse gas that contributes to the progress of climate change. Natural gas and petroleum systems are also considered, among the main sources of methane emission. Upgrading the equipment used in transferring, storing, and producing oil and gas can limit methane leaks (Overview of Greenhouse Gases).

Solutions undergoing research

According to Li, Bo Zou, Changwen in "Nitrogen-doped Porous Carbon Nanofiber Webs for Efficient CO_2 Capture and Conversion" there have been two ways developed to try to solve the excess amount of CO_2 that is being released from using fossil fuels. Both solutions are aimed to capture CO_2 from the air and turn it into a usable material. The first solution is called

chemical absorption (79). Using amine-ammonia aqueous solution to capture as much CO_2 as possible. The process is done by an absorber and a stripper. First, the gas containing CO_2 flows through a tube or a pipe and it contacts a CO_2 absorbent that is flowing in the opposite direction. After absorption, the absorbent that is filled with CO_2 flows into a stripper for thermal regeneration. According to Yu, Cheng-Hsiu, Chih-Hung Huang, and Chung-Sung Tan in "A Review of CO_2 Capture by Absorption and Adsorption" the pure CO_2 that has been released are compressed for transportation and storage (746). However, the process's high cost of regeneration, toxicity, the corrosion of equipment, and its low capacity to capture CO_2 are major setbacks for the process unless improved (79).

Li, Bo Zou, Changwen in "Nitrogen-doped Porous Carbon Nanofiber Webs for Efficient CO_2 Capture and Conversion" also stated, the second solution is called adsorption. Several solid adsorbents have been developed to better capture CO_2 such as zeolites, mesoporous silica, microporous organic polymers, metal-organic frameworks (MOFS), and porous carbons. However, carbon based materials are the most efficient because of low cost, wide availability, thermal and chemical stability, large specific surface area and pore volume, easy-to-design pore structure, surface functionalization and low energy consumption for regeneration. However, it has low capacity to capture CO_2.These solid adsorbents can better capture CO_2 by either temperature, pressure, or the combination of both (80).

Conclusion

Climate change is a problem that is facing our planet and it has progressed a lot after the industrial revolution. The emission of greenhouse gases has accelerated the progress of climate change and made our weather more intense. However, the world's dependence on

fossil fuel for energy, transportation, and manufacturing have created a major obstacle for us to switch to renewable energy. I would like to conclude with what Dr. Wuebbles mentioned regarding the solutions that have been developed to prevent climate change from progressing, he said, “We need to transfer our energy to renewable energy. Also, one of the things we must do is to adapt to the changes that occurred and will occur. We need to prevent any future changes from happening, but adaptation is a major thing we need to do” (Phone interview). Scientists, environmentalists, communities, as well as policy makers need to diligently and cooperatively to live up to these challenges and combat climate change.

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