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Greenhouse Effect: Greenhouse Gases and Their Impact on Global Warming

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

The Greenhouse effect is a leading factor in keeping the Earth warm because it keeps some of the planet's heat that would otherwise escape from the atmosphere out to space. The study report on the Greenhouse gases and their impact on Global warming. Without the greenhouse effect the Earth's average global temperature would be much colder and life on Earth as we know it would be impossible.

Greenhouse gases include water vapor, CO_2, methane, nitrous oxide (N_2O) and other gases. Carbon dioxide (CO_2) and other greenhouse gases turn like a blanket, gripping Infra-Red radiation

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and preventing it from escaping into outer space. The clear effect of the greenhouse gases is the stable heating of Earth's atmosphere and surface, thus, global warming.

The ability of certain gases, greenhouse gases, to be transparent to inbound visible light from the sun, yet opaque to the energy radiated from the earth is one of the best still events in the atmospheric sciences. The existence of greenhouse effect is what makes the earth a comfortable place for life.

The study also reveals the importance of greenhouse gases to the warming of the planet earth.

Keywords: Greenhouse gases; global warming; greenhouse effect; global temperature; atmosphere.

1. INTRODUCTION

The factor that Earth has an average surface temperature pleasurably between the boiling point and freezing point of water, therefore suitable for our kind of life, cannot be clarified by merely proposing that planet Earth orbits at just the precise space from the sun to absorb just the right amount of solar radiation. The moderate temperatures are also the outcome of having just the precise kind of atmosphere. The atmosphere in planet Venus would produce hellish, Venus-like conditions on planet Earth; the Mars troposphere would leave earth shivering in a Martian-type deep freeze [1].

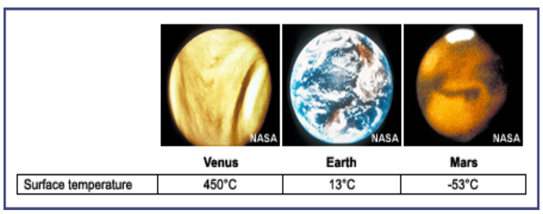

Fig. 1. Showing the temperature of some planets: Mars, Earth, and Venus [2]

Additionally, parts of the earth's atmosphere act as shielding blanket of just the right thickness, receiving appropriate solar energy to keep the global average temperature in an amusing range. The Martian blanket is too thin, and the Venusian blanket is way too thick. The 'blanket' as stated here, is termed as a collection of atmospheric gases called greenhouse gases based on the knowledge that the gases also capture heat similar to the glass walls of a greenhouse.

These gases, mostly water vapor, carbon dioxide, methane, and nitrous oxide, all perform as effective global insulators [3].

The conversation of inbound and outward-bound radiation that warms the Earth is often referred to as the greenhouse effect because a greenhouse works in much the same way.

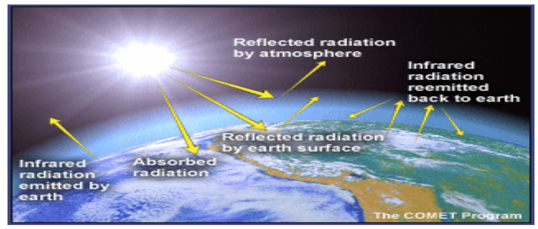

Fig. 2. Showing radiation absorption and emission by greenhouse gases [2]

Inbound Ultra Violet (UV) radiation easily passes through the glass walls of a greenhouse and is absorbed by the plants and hard surfaces inside. Weaker Infrared (IR) radiation, however, has difficulty passing through the glass walls and is trapped inside, that is, warming the greenhouse. This outcome lets tropical plants flourish inside a greenhouse, even during a cold winter.

The greenhouse influence upsurges the temperature of the Earth by trapping heat in our atmosphere. This retains the temperature of the Earth higher than it would be if direct heating by the Sun was the only source of warming [1].

When sunlight reaches the surface of the Earth, some of it is absorbed which warms the ground and some jumps back to space as heat. Most Greenhouse gases that are in the atmosphere fascinate and then transmit some of this heat back towards the Earth [4].

The greenhouse effect is a foremost factor in keeping the Earth heartfelt because it keeps some of the planet's heat that would otherwise escape from the atmosphere out to space. In fact, without the greenhouse effect the Earth's average global temperature would be much colder and life on Earth as we recognize it would not be possible [3]. The difference between the Earth's actual average temperature 14°C (57.2°F) and the expected effective temperature just with the Sun's radiation -19°C (-2.2°F) gives us the strength of the greenhouse effect, which is 33°C [4].

The greenhouse effect is a natural process that is millions of years old. It plays a critical role in a variable the overall temperature of the Earth. The greenhouse effect was first discovered by Joseph Fourier in 1827, experimentally verified by John Tyndall in 1861, and quantified by Svante Arrhenius in 1896 [5]. [6] has published a paper on (A Synopsis on the Effects of Anthropogenic Greenhouse Gases Emissions from Power Generation and Energy Consumption). It gives information about Despite the looming difficult energy context in the majority of countries in the world, global change in environmental dignity resulting from power generation and energy consumption scenario is rapidly becoming a globally disturbing phenomenon. The present study focused on the greenhouse effect: the greenhouse gases and their impacts on global warming.

2. LITERATURE REVIEW

[7] has published a paper on Modeling carbon cycles and estimation of greenhouse gas emissions from organic and conventional farming systems. It gives information on carbon (C) and nitrogen (N) fluxes in the system soil-plant–animal–environment. The model couples the balancing of C, N and energy fluxes with the target to estimate the climate-relevant CO_2, CH_4 and N2O sources and sinks of farming systems [8].

2.1 Foundations of Greenhouse Effect

The greenhouse effect is mostly caused by the interaction of the sun's energy with greenhouse gases such as carbon dioxide, methane, nitrous oxide and fluorinated gases in the Earth's atmosphere. The ability of these gases to capture heat is what causes the greenhouse effect [9].

Greenhouse gases consist of three or more atoms. This molecular structure makes it possible for these gases to trap heat in the atmosphere and then transfer it to the surface which further warms the Earth [10]. This uninterrupted cycle of trapping heat clues to an overall increase in global temperatures. The procedure, which is very similar to the way a greenhouse works, is the main reason why the gases that can produce this outcome are collectively called as greenhouse gases [11].

The prime forcing gases of the greenhouse effect are: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and fluorinated gases.

2.2 Reaction Gas (Water vapor) of the Greenhouse Effect

Carbon dioxide is to some extent one of the greenhouse gases. It involves one carbon atom with an oxygen atom bonded to each side. As soon as its atoms are bonded tightly together, the carbon dioxide molecule can absorb infrared radiation and the molecule starts to vibrate. Eventually, the vibrating molecule will emit the radiation again, and it will likely be absorbed by yet another greenhouse gas molecule. This absorption-emission-absorption cycle serves to keep the heat near the surface, effectively insulating the surface from the cold of space [12].

Carbon dioxide, water vapor (H_2O), methane (CH_4), nitrous oxide (N_2O), and some limited other gases are greenhouse gases. They all are molecules made up of more than two constituents atoms, bound loosely enough together to be able to vibrate with the absorption of heat. The foremost mechanisms of the atmosphere (N_2 and O_2) are two-atom molecules too closely bound together to vibrate and consequently, they do not absorb heat and subsidize to the greenhouse effect [13].

Carbon dioxide, methane, nitrous oxide and the fluorinated gases are all well-mixed gases in the atmosphere that do not react to changes in temperature and air pressure, so the levels of these gases are not affected by condensation effect [5]. Water vapor also is a highly active component of the climate system that retorts briskly to fluctuations in conditions by either dwindling into rain or snow or evaporating to return to the atmosphere. Consequently, the imprint of the greenhouse effect is principally circulated through water vapor, and it turns as a fast reaction effect [5].

Carbon dioxide and the other non-condensing greenhouse gases are the vital gases within the Earth's atmosphere that tolerate the greenhouse effect and rheostat its strength. Water vapor is a fast-acting feedback but its atmospheric concentration is controlled by the radiative forcing supplied by the non-condensing greenhouse gases [5].

In fact, the greenhouse effect would collapse were it not for the presence of carbon dioxide and the other non-condensing greenhouse gases. Together the feedback by the condensing and the forcing by the non-condensing gases within the atmosphere both play an important role in the greenhouse effect [5,14].

2.3 Reduction of Greenhouse Gases

The primary objective of WWTPs is to meet effluent standards. In order to protect the receiving water body. However, reduction of GHG emissions from WWTPs requires a broadening in scope. The estimated quantity of N_2O from WWTPs by the United States Environmental Protection Agency [15]. Accounts for approximately 3% of N_2O from all national sources which rank as the sixth largest contributor to GHG emissions [16]. The right quantification of GHG is a necessity to better understand how to effectively reduce GHG emissions from WWTPs, as well as to improve the accuracy in the GHG emission reporting processes [17].

There is keen interest in climate change issues due to a fast increasing rate of GHG emissions. This has emphasized the need to innovate and establish right approaches to better design, control and optimize WWTPs on the plant-wide scale [18,19].

In recent years, one of the cheap modern and promising solutions to decreasing GHG emission into the Earth's atmosphere is the employment bioremediation technique. Other mitigation plans to avert the negative outcomes of greenhouse effect may include activities such increase in tree planting, reduction in burning fossil fuels, exploitation of affordable, clean and renewable of energy, carbon dioxide capture and sequestration etc.

Bioremediation technique employs microbial metabolism to remove pollutants. A bioremediation technique and strategy (phytoremediation enhanced by endophytic microorganisms) can be used to remove hazardous waste including greenhouse gases from the biosphere [17].

Phytoremediation is the most effective bioremediation technique employed to remove greenhouse gases. In phytoremediation, living green plants in situ are used. Living green plants have the ability to decrease or remove contaminants from soil, air, water, and sediments. Recently, selected or engineered endophytic microorganisms have been used to improve the phytoremediation processes. Many studies have demonstrated the efficacy of endophytic microorganisms in accelerating these processes by interacting closely with their host plants [19,20].

Another technique for reducing the negative effects of the greenhouse effect is to use methanotrophic endophytes inhabiting Sphagnum Spp. which can act as a natural methane filter. It can reduce CH_4 and CO_2 emission from peatlands by up to 50% [21,22]. Studies have demonstrated potential ability of the plant–methanotrophic bacteria systems in the reduction of methane emission up to 77%, depending on the season and the host plant [23].

2.4 Some Current Existing Challenges to Reducing Greenhouse Gases (GHG)

Currently, there are difficulty challenges in controlling GHG emissions for different WWTPs. Measurement uncertainties and lack of transposable data still hinder a correct and required GHG emission quantification process [24,25,26].

One recommendation to fill this gap includes the use of mathematical models which offer useful tools for assessing GHG and evaluating different mitigation alternatives before putting them into practice. GHG modelling can enhance the correct quantification of GHG emissions for different WWTP configurations and evaluate the effects of various operating conditions. In recent years, a large portfolio of mathematical modelling studies has been developed to include GHG emissions during design, operation, and optimization of WWTPs [27,28,29,30,31,32].

[33] admonished the scientific community to examine the key elements of GHG modelling using a plant-wide approach. Several advantages and potentials of this approach include: i) an approach which takes into account the role of each plant treatment unit process and the interactions among them and ii) operation or control of each particular unit, not only at local level but as a component of a system, and avoids the risk of a sub-optimization (an example is a reduction of effluent quality at higher operational costs; [34].

2.5 The Solar Radiation

The sun radiates gigantic quantities of energy into space, crosswise a wide spectrum of wavelengths.

Utmost of the radiant energy from the sun is concentrated in the visible and near-visible portions of the spectrum. The narrow band of visible light, between 400 and 700 nm, signifies

43% of the total radiant energy emitted. Wavelengths shorter than the visible account for 7 to 8% of the total, but are extremely important because of their high energy per photon. The shorter the wavelength of light, the more energy it contains. Accordingly, ultraviolet light is very energetic (accomplished by breaking apart stable biological molecules and instigating sunburn and skin cancers). The residual 49 - 50% of the radiant energy is spread over the wavelengths longer than those of visible light. These lie in the near infrared range from 700 to 1000 nm; the thermal infrared, between 5 and 20 microns; and the far infrared regions. Various components of earth's atmosphere absorb ultraviolet and infrared solar radiation before it penetrates to the surface, but the atmosphere is quite transparent to visible light [35].

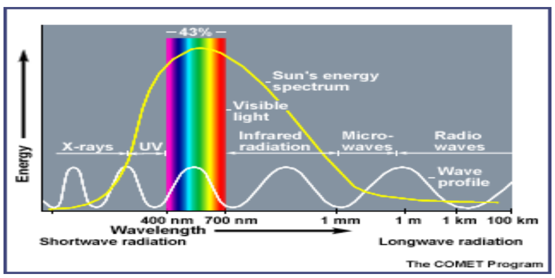

Fig. 3. Showing the wave profile of various radiations (COMET program) [2]

Absorbed by land, oceans, and vegetation at the surface, the visible light is transformed into heat and re-radiates in the form of invisible infrared radiation. During the day, earth heats up, but at night, all the accumulated energy would radiate back into space and the planet's surface temperature would fall far below zero very rapidly. The reason this doesn't happen is that earth's atmosphere contains molecules that absorb the heat and re-radiate the heat in all directions. This reduces the heat radiated out to space called greenhouse gases because they serve to hold heat in like the glass walls of a greenhouse, these molecules are responsible for the fact that the earth enjoys temperatures suitable for our active and complex biosphere [14,36].

2.6 Sources of Greenhouse Gas Emissions

In recent times, one of the major sources of greenhouse gas (GHG) emission is from water resource recovery facilities (wastewater treatment plants (WWTPs). Wastewater treatment plants (WWTPs) are recognized as one of the larger minor sources of GHG emissions [37]. The WWTPs emit gases such as nitrous oxide (N_2O), carbon dioxide (CO_2), and methane (CH_4). Increasing emission of GHG from this source poss harm to our climate, [38,39,40].

Biological mechanisms such as emissions of CO_2 due to microbial respiration, emission of N_2O by nitrification and denitrification, and emission of CH_4 from anaerobic digestion processes are direct emissions from WWTPs. Sources that not regulated directly within the WWTP are indirect internal emission sources; consumption of thermal energy and indirect external emission sources; third-party biosolids hauling, chemical productions and their transportation to the plant, etc. [16].

The increasing rate of GHG emissions is due to the changes in the economic output, extended energy consumption, increasing emission from landfills, livestock, rice farming, septic processes, and fertilizers as well as other factors. Increase industrialisation, use of fertilizers, burning of fossil fuels and other human and natural activities result in a rise above normal average atmospheric temperature; thus posing threat to our environment.

Research identifies methane and carbon dioxide as the main greenhouse gases [41]. Therefore, the reduction of methane concentration in the atmosphere, both from natural and anthropogenic sources, is indispensable to tackle the negative outcomes of global warming.

2.7 Greenhouse Effect

Atmospheric scientists first used the word 'greenhouse effect' in the later 1800s. At that time, it was used to designate the naturally happening functions of trace gases in the atmosphere and did not have any negative implications. It was not up until the mid-1950s that the term greenhouse effect was attached to concern over climate alteration. And in contemporary decades, we often hear about the greenhouse effect in somewhat negative terms. The negative concerns are related to the possible impacts of an improved greenhouse effect. It is important to remember that without the greenhouse effect, lifecycle on earth as we know it would not be possible.

While the earth's temperature is reliant on upon the greenhouse-like action of the atmosphere, the extent of heating and cooling are toughly influenced by several factors just as greenhouses are pretentious by various factors.

In the atmospheric greenhouse effect, the type of surface that sunlight first happenstances are the most important factor. Forests, grasslands, ocean surfaces, ice caps, deserts, and cities all absorb, reflect, and radiate radiation differently. Sunlight falling on a white glacier surface strongly reflects back into space, resulting in minimal heating of the surface and lower atmosphere. Sunlight falling on a dark desert soil is strongly absorbed, on the other hand, and contributes to significant heating of the surface and lower atmosphere. Cloud cover also affects greenhouse warming by both reducing the amount of solar radiation reaching the earth's surface and by reducing the amount of radiation energy emitted into space [31].

Scientists outline the percentage of solar energy reflected back by a surface. Understanding local, regional, and global effects are life-threatening to foretelling global climate change.

2.8 Greenhouse Gases and Global Warming

Greenhouse gases (GHGs) such as carbon dioxide, methane, nitrous oxide, and halogenated compounds emissions are caused by human activities and some do occur naturally. The GHGs absorb infrared radiation and trap heat in the atmosphere, thereby enhancing the natural greenhouse effect defined as global warming. This natural occurrence warms the atmosphere and make life on earth possible, without which the low temperature will make life impossible to live on earth [17].

"Gas molecules that captivate thermal infrared radiation, and are in a substantial amount, can force the climate system. These type of gas molecules are called greenhouse gases," Michael Daley, an associate professor of Environmental Science at Lasell College told Live Science. Carbon dioxide (CO_2) and other greenhouse gases turn like a blanket, gripping Infrared (IR) radiation and preventing it from evading into outer space. The net effect is the steady heating of Earth's atmosphere and surface, and this process is called global warming.

These greenhouse gases include water vapor, CO_2, methane, nitrous oxide (N_2O) and other gases. Since the dawn of the Industrial Revolution in the early 1800s, the scorching of fossil fuels like coal, oil, and gasoline have greatly increased the concentration of greenhouse gases in the atmosphere, specifically CO_2, National Oceanic and Atmospheric Administration (NOAA). "Deforestation is the second largest anthropogenic basis of carbon dioxide to the atmosphere ranging between 6% and 17%," said Daley. [42,43].

Some human activities like the production and consumption of fossil fuels, use of various chemicals agriculture, burning bush, waste from incineration processes and other industrial activities have increased the concentration of greenhouse gases (GHG), particularly CO_2, CH_4, and N_2O in the atmosphere making them harmful [44].

This increase in atmospheric GHG concentration has led to climate change and global warming effect, which is motivating international efforts such as the Kyoto Protocol, signing of Paris Agreement on climate change and other initiatives to control negative outcomes of the greenhouse effect. The contribution of a greenhouse gas to global warming is commonly expressed by its global warming potential (GWP) which enables the comparison of global warming impact of the gas and that of a reference gas, typically carbon dioxide [45].

Atmospheric CO_2 intensities have increased by more than 40% since the beginning of the Industrial Revolution, from about 280 parts per million (ppm) in the 1800s to 400 ppm today. The last time Earth's atmospheric levels of CO_2 reached 400 ppm was during the Pliocene Epoch, between 5 million and 3 million years ago, according to the University of California, San Diego's Scripps Institutions of Oceanography [46].

The greenhouse effect, collective with growing levels of greenhouse gases and the resultant global warming, is expected to have profound consequences, according to the near-universal consensus of scientists [10,43].

If global warming undergoes unimpeded, it will cause noteworthy climate change, a rise in sea levels, increasing ocean acidification, life-threatening weather events and other severe natural and societal impacts, according to NASA, the Environmental Protection Agency(EPA) and other scientific and governmental bodies [10,46,47].

2.9 Can the Greenhouse Effect be Overturned?

Several scientists approve that the impairment of the Earth's atmosphere and climate is long-gone the point of no reoccurrence or that the destruction is near the point of no return [47]. "I agree that we have passed the point of avoiding climate change," Josef Werne, an associate professor at the department of geology & planetary science at the University of Pittsburgh. In Werne's opinion, there are three options from this point forward:

1. Do nothing and live with the moments.
2. Acclimatize to the changing climate (which includes things like rising sea level and related flooding).
3. Alleviate the impact of climate change by belligerently enacting policies that actually reduce the concentration of CO_2 in the atmosphere [47,48].

Keith Peterman, a professor of chemistry at York College of Pennsylvania, and Gregory Foy, an associate professor of chemistry at York College of Pennsylvania believes that the damage isn't to that point yet and that international agreements and action can save the planet's atmosphere [49].

3. CONCLUSIONS

The capacity of certain suggestion gases to be relatively transparent to inbound visible light from the sun, yet opaque to the energy radiated from the earth is one of the best silent procedures in the atmospheric sciences. This occurrence, the greenhouse effect, is what makes the earth a comfortable place for life’s activities. I recommend future work to be done on greenhouse gases.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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