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Greenhouse Gass Emission form Agriculture and their Effective Mitigation Techniques: A Review

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ABSTRACT

Agriculture plays a dual role in the context of climate change, as it both contributes to and is impacted by climate change. Efforts have been made to decrease greenhouse gas emissions from agricultural practices, but it is crucial to ensure that these measures do not negatively affect farm production and profitability. The primary greenhouse gases (GHG), namely carbon dioxide (CO_2), nitrous oxide (N_2O), and methane (CH_4), have had a harmful impact on climate change, resulting in various catastrophic consequences. This analysis focuses on the factors that contribute to greenhouse gas emissions, including both inorganic factors such as nitrogen, phosphorus, and potassium fertilizers, as well as organic factors like animal manure, composted manure, bio-solids, and crop species. Developing additional successful methods involves integrating various mitigation techniques such as conservation tillage, water management, cropping systems, and nutrient management. The successful implementation of these techniques will pave the way for reducing greenhouse gas emissions from agricultural fields.

Keywords: Agriculture, GHG Emission, Mitigation, Nutreint Management

INTRODUCTION

The Earth has a natural temperature control system. Certain atmospheric gases are essential to this system and are called greenhouse gases. On average, about one-third of the solar radiation reaching earth is reflected back into space. Some of remain radiation is absorbed by the atmosphere, most is absorbed by the land and oceans. The earth's surface heat up and therefore emits infrared radiation. Greenhouse gases trap infrared radiation, thereby heating the atmosphere. Greenhouse gases include water vapor, carbon dioxide, ozone, methane and nitrous oxide together create natural effects. However, human activities lead to an increase in greenhouse gas concentrations in the atmosphere (Islam *et al.*, 2018).

The potential for global warming of CH_4 and N_2O is 21 and 310 times larger, respectively, despite their smaller emissions than CO_2 (Thangarajan *et al.*, 2013). The global increase in greenhouse gas emissions, specifically carbon dioxide, methane, and nitrous oxide, is primarily attributed to anthropogenic activities. These activities contribute to the alteration of the Earth's climate by absorbing and reemitting energy from the lower atmosphere. This phenomenon has been extensively discussed in a recent study by Shakoor *et al*., (2021). Based on the USAP report from 2015 to 2020, the gases responsible for the greenhouse effect, such as CO_2, CH_4, N_2O, and others, have been analyzed. Byproducts of the combustion of fossil fuels, such as nitrogen dioxide, atmospheric ammonia, polycyclic aromatic hydrocarbons, and the primary climate-altering gas carbon dioxide, pose a serious threat to human health and contribute to global warming (Perera *et al.*, 2019). The report also provides information of GHG percentage emissions from these gases and their sources in different sectors worldwide, as shown in Table 1 and Figure 1.

Table 1. Greenhouse gasses, USEPA Report, 2021		
GHG name	Formula	%
Carbon dioxide	CO_2	50
Methane	CH_4	19
Chlorofluorocarbons	CFC	15
Nitrous oxide	N_2O	5
Other	(O_3, H_2O, NOx, CO)	11

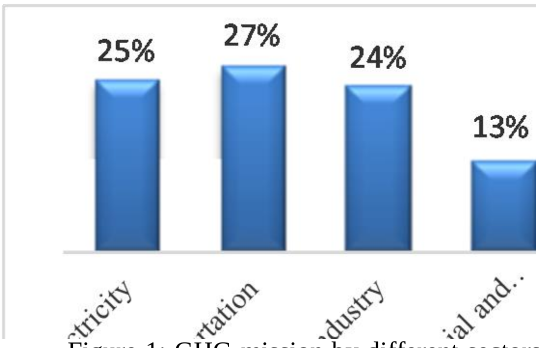

Figure 1: GHG mission by different sectors in (USEPA, 2021)

MATERIALS AND METHODS

The information utilized for this review was obtained from Research Gate, Google Scholar, and officials, technical reports that the authors were informed about. The review was structured into two main sections: causes and mitigation, with additional sub-topics. Although numerous articles different sub-topics were assigned specific identifications, only a limited number of individuals were selected based on their consequence and credibility. A total of approximately 100 articles were examined, but only (23) articles were ultimately included in this review. The review also incorporates secondary data, which was accessed through the author.

RESULTS AND DISCUSSION

The results and discussion were categorized into two main sections: the causes and mitigation of greenhouse gases from agriculture:

A. GHG emission form Agriculture

1. CO_2 Emission

One of the main causes of the heightened greenhouse effect is carbon dioxide, which is released during the burning of biomass and fossil fuels for energy. As many developing countries become increasingly industrialized and urbanized, thus the world's atmospheric concentration of man-made GHGs such as carbon dioxide (CO_2) were increased (Yoro and Daramola., 2020). Figure 3 indicated that carbon dioxide emissions by sectors were globally.

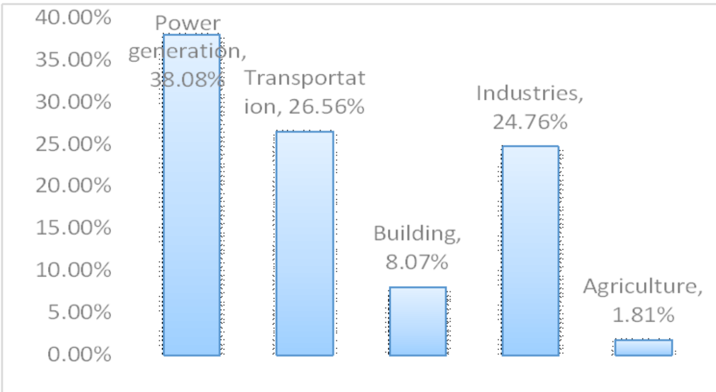

Figure 3. Globally carbon dioxide emission by sectors (Kelvin and Michael., 2020).

2. CH_4 Emission

The concentration of methane in the atmosphere has risen due to various factors such as agriculture (specifically rice and livestock farming), coal mining, human activities, oil and gas production and distribution, biomass combustion, and municipal landfills (Flores et al., 2019). If immediate action is not taken in these sectors, methane emissions are projected to continue increasing even beyond 2030. The energy sector, which encompasses coal mining, natural gas systems, oil systems, and fixed and mobile combustion systems, is the primary contributor to methane emissions in the atmosphere. In 2009, approximately 303 tons of methane was emitted from these sources (Turner et al., 2019). Agriculture, energy, and waste management are the three main categories of human-caused emissions. Methane emissions from energy and waste sectors are found to be lower than those from the agricultural sector (Perera et al., 2019).

3. N_2O Emission

In addition to carbon dioxide and methane, nitrous oxide is another problematic GHG that has a high potential for causing the greenhouse effect. The release of N_2O from biogas production processes significantly contributes to the overall global warming impact (Paolini et al., 2019). Agriculture plays a significant role in N_2O emissions through the use of nitrogen-based fertilizers, soil tillage, manure, biomass combustion, and industrial processes like fertilizer production. Fertilizers derived from nitrogen enrichment of soils are the primary human contributors to nitrous oxide emissions (Sekoai et al., 2018).

B. Mitigation of GHG emission for Agriculture

1. Biological mitigation of methane

An effective biological mitigation option for CH_4 is to focus on selecting and cultivating rice cultivars that prioritize the transportation of a maximum portion of their photosynthates to panicle growth and grain development, rather than using them for the development of vegetative parts such as the root, leaf sheath, and culm. This approach ensures that the energy produced through photosynthesis is directed towards the production of grains, which can help reduce methane emissions. While mitigation and abatement strategies are proposed, the historical patterns in methane emissions from various sectors are examined through their sources (Yusuf et al., 2012).

2. Role of crop cultivars and GM crops

Kovak *et al.,* (2022) reported that there are three methods through which a genetically modified (GM) crop can decrease GHG emissions. 1) It can enhance productivity and increase the amount of residue carbon that can be stored. 2) Herbicide-resistant crops allow for greater utilization of no-till farming, which aids in the preservation of carbon sequestration. 3) Due to the implementation of no-till farming, the usage of fossil fuels by tractors and other equipment is reduced as fewer passes are required across the field.

3. Fertilizer management

Nutrient management and fertilizers have a significant impact on minimizing soil disruption and enhancing residue management. The long-standing concern in agricultural fields has been the excessive, improper, and unbalanced use of fertilizers and nitrogen. By improving the efficiency and effectiveness of nitrogen utilization in crops, it is possible to reduce N_2O emissions and decrease the chances of high residual NO_3 in the soil profile, as emphasized by (Kwon *et al.,* 2021). Additionally, adopting less intensive farming techniques can further decrease emissions by minimizing the use of pesticides and other inputs, as well as reducing the overall cost associated with GHG production.

4. Crop diversifications

Growing appropriate upland crops in tropical rice ecosystems can effectively decrease the cumulative CH_4 emissions by reducing the duration of submergence in the annual cropping cycle. According to a study by (Datta *et al.,* 2011), the highest CH_4 flux was observed in rice-rice rotation, whereas the most suitable cropping system in terms of greenhouse gas emission was found to be rice-potato-sesame. Therefore, diversifying crops in lowland rice ecosystems could be a viable approach to mitigate overall CH_4 emissions.

5. Crop rotation

Legume crops rotation is a significant method for decreasing GHG emissions by reducing the dependence on nitrogen (N) inputs. However, it is important to note that legume-derived N can also contribute to the production of nitrous oxide. According to a long-term research done in Illinois, a corn-soybean rotation can increase yields while lowering greenhouse gas emissions when compared to continuous corn or continuous soybean production (Behnke *et al.,* 2018).

6. Change of crop establishment technique

Direct seeding rice and transplanting rice according to a study conducted by Li *et al.*, (2019), it was found that even after considering the differences in weather conditions and water management practices between the transplanted rice and directed sowing rice systems, the daily CH_4 emissions in the direct system continued to show a significant rise in comparison to the transplanted system.

7. Water management

A single drainage event during the middle of the season can reduce the emission rate by approximately 50%. Furthermore, various studies have shown that alternative irrigation methods for rice cultivation also contribute to the reduction of methane emission. One of the most promising strategies for reducing methane emission is alternative water management, specifically the promotion of mid-season aeration through short-term drainage (Islam *et al.*, 2018).

8. Management of organic inputs

Hoa *et al.*, (2002) reported that the states composting has the potential to greatly reduce GHG emissions. The study found that for the passive aeration treatment, carbon loss in the form of CO_2 and CH_4 was measured at 73.80 and 6.30 kg C/ Mg manure, respectively. On the other hand, the active treatment resulted in carbon loss of 168.0 and 8.10 kg C /Mg manure for CO_2 and CH_4, respectively.

CONCLUSION

Agriculture plays a dual role in the context of climate change, as it contributes to it while also being impacted. Efforts have been made to reduce GHG from agricultural practices, it is important to ensure that these measures do not negatively affect farm production and profitability. The integration of diverse mitigation methods, including conservation tillage, water management, cropping systems and crop rotation, fertilizers and manure management are crucial for the development of further effective approaches.

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