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Air pollution from fertilizer nitrogen

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Abstract

An essential component of food production is nitrogen (N). Crops waste about half of the nitrogen fertilizer input, which is then released into the atmosphere as gas emissions or polluting of aquatic groups. It is necessary to reach manufacture stages that promote world food security in the absence of compromising quality. safety of the environment. It is estimated that by 2050, N pollution levels will have risen 150% from 2010 levels, with the The agricultural sector is responsible for 60% of this growth. In this review fertilizer Nitrogen should take into account while discussing air pollution caused by gases that contain nitrogen, which might result in issues like the greenhouse effect.

Nopoint pollution, the involvement of farmer management techniques, the relationship between N fertilizer use, N use efficiency, and regulatory methods to mitigate diffuse pollution brought on by N fertilization. Numerous studies indicate that one of the primary obstacles to achieving habit changes. This study aims to draw attention to the seriousness Considering the necessity for a communication campaign to educate farmers about the current worldwide non-point pollution problem about the implications of their fertilizer management practices and the link between their operations and N pollution

Keywords: Air Pollution; Nitrogen; Greenhouse; Fertilizer; Environment

1. Introduction

The elements that support life are Carbon, hydrogen, oxygen, phosphorus, and nitrogen (N) The creation of amino acids, the building blocks of proteins, depends on nitrogen, among other elements. This component is what makes up roughly 78% of the air in the atmosphere, which is predominantly in the form of molecules (N2) and is essentially inert and unreactive (1). The atmosphere's nitrogen gas is not suited for living things to absorb. The ability of plants to absorb nitrogen (N) into the food chain determines how much protein humans consume, and for plants and subsequently animals to do so, specific transformations must occur. The N cycle and its various versions were defined by Robertson and Groffman

The fixation process converts ammonia (NH3) from ambient dinitrogen gas, which is subsequently fixed in the soil. Numerous microbial activities that transform N2 into soil-remaining organic compounds. are essential to the N fixation process.Because a limited range of ambient water stress and aeration conditions are necessary for biological fixing,in natural settings.

Soil has very little fixed nitrogen. Heterotrophic microbes converted soil-derived organic nitrogen into inorganic compounds (NH4 + and NO3) that plants may easily absorb through the processes of mineralization and nitrification (2). The reactive forms of these ions include nitrogen that can be used for biosynthesis, which starts the production of proteins and amino acids. Because natural N cycle fixation rates are low.

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Of all the soil elements required for plant growth, in terrestrial ecosystems, nitrogen is the most limiting component. due to mineralization and nitrification. The introduction of artificial nitrogen fertilizers caused the Green Revolution to emerge starting in 1913, which contributed to the century-long exponential growth in the global population.

Between 1961 and 2016, the amount of the amount of nitrogen fertilizer used to crops rose from 10 Tg N ha1 to 77 Tg N ha1.Through leaching, runoff, or volatilization, over half of the nitrogen fertilizer that is applied is lost to the environment (3). and is not utilized by crops.

These losses result in environmental issues like greenhouse gas emissions, water body pollution, reduction in biodiversity and acidity of the soil. The degree of nitrogen contamination in the atmosphere is anticipated to be between 102% and 156% greater by 2050 than it was in 2010, with 60% of this growth coming from the agriculture sector.Several earlier reviews have addressed the idea The N utilization efficiency (NUE), or the plant's biological capacity to take up nitrogen. This research examines the NUE as an anthropomorphic behavior and its detrimental effects of excessive use of nitrogen in farming. Enhancing the spread of sound agriculture management techniques is the goal of this a comprehensive evaluation of the literature on diffuse N pollution, optimum management methods, and enhanced farmer behavior is presented in this work (4). The 1980s saw the introduction of the current dispersed pollution management policies. In 1980, we began our search by examining the body of scholarly and gray literature that examines the variables influencing farmers' management strategies in connection to their ability to mitigate diffuse pollution brought on by their farming operations Human health is directly impacted by air pollution. Five million individuals lost their lives to air pollution-related illnesses in 2017; the United States and China rank among the top 10 nations in terms of death rates. Global agricultural activities. are in charge of 60–80% of the world's N2O emissions from human activities and about 15% of annual greenhouse gas emissions. N2O concentrations in the atmosphere have increased due to the growing use of nitrogen fertilizers in agricultural production around the world, and it continues to be a 298-fold more potent greenhouse gasmore than carbon (5). carbon dioxide.Current N2O concentrations are beginning to surpass the levels predicted by the International Panel on Climate Change (IPCC) in most emission scenarios, and they are incompatible with the climate goals of the Paris Agreement. At first, nitrous oxide was considered to be one of the primary greenhouse gases causing global warming. was carried out by (9). who thoroughly measured its worldwide sources and sinks. Their research indicates that, after carbon dioxide and methane, nitrous oxide ranks as the third most significant greenhouse gas. Between 2007 and 2016, 70% of N2O emissions came from agricultural activities, making them the primary source of N2O pollution. Many studies on sustainability 2021, 13, 5625 Three out of fifteen studies show a linear relationship between the usage of N fertilizer in agriculture, including organic modifications) and global N2O emissions.Nonetheless, an exponential association between them has been revealed in a number of recent research on corn cropping systems [45,46]. The average amount of N2O released by N fertilizers worldwide right now is around 0.9% of the N. Agricultural N2O emissions to the atmosphere in 2018 totaled 7.718 Gg.

When climate change adaptation calls for adjustments to energy and water use, an understanding of how the climate interacts with the N cycle will be crucial (6). Even though the US has achieved significant strides in reducing NOX emissions from the energy, industrial, and transportation sectors, if energy use is raised for climate change adaptation, these gains could be slowed or reversed. higher occurrences of diseases linked to NO3. On the one hand, crops may be able to adapt to climate variability through enhancements to the management of agricultural nutrients (e.g., balanced and scheduled nutrient additions) however, increased climate variability will also make nutrient management more challenging. These are just a few instances Several climate-N interactions that climate change adaptation would affect or have an impact on that are examined in this paper in terms of radiative forcing, nitrous oxide (N2O) is the most significant anthropogenic greenhouse gas, and air Pollution influenced by N cycle mechanisms. Therefore, controlling The N cycle will not only lower gas emissions N2O, which contains nitrogen (7)

2. Fertilizer types

Agricultural fertilisers supplement the vegetative development of cropsby providing those nutrients that are scarcest in the soil, thusencouraging plants to grow and reproduce adequately. Its action is based on the supply of three essential chemical elements: nitrogen, phosphorus and potassium. Other micronutrients such as zinc,iron, manganese, copper, etc. are added, which, in turn, improve yieldsand promote the health of the plants being grown. Depending on the source of the nutrients that form the basis of the fertilizer's composition, a distinction is created (8).

2.1. Fertilizers that are organic

Manure has long been utilized as a carbonaceous material source to aid in the growth of crops. The leftovers from domestic animals and plants are used to make it. This happens as a result of their gradual incorporation into the soil, where soil microbes break them down and convert them into mineral nutrients that plants can consume. By adding organic matter, soil fertility loss can be avoided. In turn, organic matter adds to the soil's permeability and porosity, two physical characteristics necessary for sufficient water retention. In organic farming, this kind of fertilizer is most frequently utilized (9).

2.2. Inorganic otherwise synthetic fertilizers

As a result of their foundation in industrial chemical reactions that break down inorganic components like rocks, gasses, and salts, these are also known as chemical fertilizers. Because they facilitate the faster availability of nutrients to plants, they are the most often utilized fertilizers in agriculture. Because they are readily absorbed by plants and affect yield growth, they enhance crops. The harmful Because of technological developments in the fertilizer industry, their efficient usage, which does not produce surpluses that harm the environment, the impacts that this kind of chemical fertilizer has on public health and safety, as well as on wildlife and flora of the natural environment, are being lessened (10).

2.3. Biofertilizers

Fertilizers that employ living microorganisms to nurture plants are referred to by this moniker. They increase the efficiency of crops' nutrient intake and promote biological activities in them. They are frequently utilized in organic farming as they don't produce hazardous waste that ends up in the land or contaminates the air or water (11).

2.4. Mineral-organic fertilizers

These are made chemically by combining organic nutrients from vegetable or animal carbonaceous components with their mineral origin. They help to improve the qualities of the soil and assist plant nutrition (12).

3. Nitrogen from Fertilizer

The primary sources of nitrogen (N) for US agricultural soils are fertilizers, manure, and legume dinitrogen (N2) fixation. Over the previous 20 years, the rate at which N is increased at a comparable rate from cropping systems at harvest leading to a somewhat higher percentage of input recovery in 2007 compared to 1987. Granular urea, fluid urea-ammonium nitrate (UAN), and anhydrous ammonia are the three main types of fertilizer used in the United States. As time goes on, the use of urea-based fertilizers rises while that of anhydrous ammonia falls. According to (12) Between 2010 and 2016, North America's fertilizer N use is predicted to rise by 2.3% yearly, while one group has predicted that it will according to various oxidative states, nitrogen can exist in terrestrial ecosystems in nine distinct forms Many of these forms are lost from agricultural systems, with the majority occurring less than a year after entering the system.While rivers acquire Nitric oxide (NO), N2O, N2, NH3, or nitrogen dioxide (NO2) are examples of air emissions that result from leaching of. Dissolved organic nitrogen (DON) and NO3- Reactive nitrogen that has been loss in one form can "cascade" over a range of media and systems, contributing to various forms of environmental contamination, and can transform into other forms of nitrogen before returning to its original atmospheric form, N2. The various possible environmental sources and fates of nitrogen in the agricultural N cycle must be considered in any effort to reduce N pollution. in order to avoid unintended consequences, try to take a comprehensive approach The prospect of continuing to cultivate huge areas of maize, supported both today by objectives to produce biofuel and in the future by growing food need, is one of the main causes maintaining the demand in the United States for N fertilizer. In the meantime, more people are using new technologies like precision farming and more effective fertilizers that are either made with urease or nitrification inhibitors or have regulated release. is being encouraged by rising fertilizer prices and pressure on producers to perform better environmentally.

4. Effects of Too Much N in Agriculture

Because weather and soil conditions are unpredictable, farmers in underdeveloped nations often overfertilize. The "fertilize for good years" concept informs management strategies that maximize expected returns under. When the maximum yield is attained the LRP function, which is a linear and plateau response function that rises linearly until then stops, has frequently been used to represent how crops react to fertilizer addition. The conventional agronomic model is thought to be this one for reaction to fertilizer, particularly N, where water and Liebig's law of minimum function remarkably well.This excess results from the crops' low NUE and the reactive forms of nitrogen's rapid mobility in the gas or soluble phase., there is a considerable chance that the applied N will be lost to the environment Since its source is difficult to identify, the primary feature of Pollution from agricultural sources distributed .Ammonia and N oxides can travel through the atmosphere due to their high volatility.Nitrogen nitrate is readily absorbed by aquatic environments from the soil profile. habitats due to its high solubility (13).

5. Pollution of the Air

They oxidize when exposed to the Air, creating what are known as nitrogen oxides (NOx), which are essentially nitrogen nitrogen dioxide and carbon monoxide. Along with other gases that are present in significant amounts in the air, like with methane, they play a significant role in the greenhouse effect that causes climate change by degrading the ozone layer.

Public health is greatly impacted by nitrogen molecules in the air. It generally harms the respiratory system, leading to a number of ailments, but it also has an impact on the immune and circulatory systems and has been connected to diseases that arise in organs like the liver and spleen. In order to provide an alarm in the event that any of these gases surpass predetermined thresholds, early detection is necessary. This will help management make effective decisions and prevent health damage from being further exacerbated by the use of synthetic fertilizers and the subsequent addition of emitting air pollutants, including nitrogen oxides. Controlling the environmental impact of the fertilizer sector is also necessary (14).

6. N sources for the cropping system

Through the reduction of N_2 to forms that the plants can use for protein synthesis, rhizobial symbionts help legumes obtain their nitrogen from the atmosphere. A portion Soil organic matter (SOM) is converted by microbes to NH_4^+ and NO_3^- , the soil provides the nitrogen. however certain legumes, like soybeans and alfalfa, may meet all of their nitrogen requirements through N_2 fixation. A portion of the fixed N_2 emerges as root exudates from the roots and into the soi, while the majority is absorbed into plant tissue. During crop harvest, some of the nitrogen ingested by plants is eliminated. The rest turns into plant waste and breaks down into SOM, which is then prepared for mineralization and future seasons' crop uptake or ecological loss. All of the N_2 fixed is converted to SOM when legumes are planted as fallow or winter cover crops after the main crop harvest because the cover crop is destroyed before the next cash crop is planted. The largest source of nitrogen provided to US agricultural systems is synthetic fertilizer. For minor in perennial biofuel crops like switchgrass and grains like wheat, fertilizer N addition rates typically range from 100 to 200 kg N ha^{-1} y^{-1}. For some horticultural crops, high-yielding corn, and grass fodder crops, the rates are higher. Although crop N consumption is frequently poor, theoretically, only as much N has to be provided as is withdrawn during crop harvest. For instance, the annual harvest of grain crops typically removes only roughly 50% of the supplied N fertilizer. To prevent excessive loss, best practices recommend administering N as close to the crop's N requirements as feasible. For maize, for instance, this often refers to the starter N at planting and the remaining N after the first growth of the crop. Fertilizer can be added to irrigation water for maize that is irrigated at any time during the growing season (15). However, decisions to apply N fertilizer well in advance of crop N requirements are frequently influenced by weather uncertainty, equipment and personnel availability, and other factors. For instance, over one-third of US maize fields was fertilized in the fall prior to spring planting in 2005, which resulted in significant potential for nitrogen loss. Slow-release formulations and nitrogen fertilizer additions are made to prevent additional nitrogen from getting into the soil's soluble N pool until crop needs are at their highest. Nitrification inhibitors are among the additives that reduce the conversion of NH_4^+ to NO_3^-. Compared to NO_3^-, NH_4^+ is a cation that is less vulnerable to leaching loss. The majority of crops use NO_3^-, but it is also the type of nitrogen that is most easily lost to the environment by leaching and denitrification to N_2O, NOx [NO + N_2 and NO_2]. Slow-release formulations usually have a shell of another chemical covering the N fertilizer particle. dissolves gradually or polymer that responds to the moisture and temperature of the soil. Slow-release formulations and additives are not commonly employeddue to their varied efficacy and increased cost. In US farming methods, nitrogen comes from soil organic matter. Because nitrogen in fresh crop residues replenishes mineralized nitrogen as it breaks down into SOM, SOM levels are stable in most long-cropped soils, despite the fact that SOM mineralization provides about half of the nitrogen requirements of fertilized crops each year. SOM is consequently usually not a significant supply of nitrogen in the environment, except for freshly repurposed land or high SOM soils such drained Histosols, which can rapidly lose carbon and nitrogen when turned into agricultural land. However, there is proof that SOM is currently being lost from soils that were previously believed to be in equilibrium, possibly as a result of air Pollution (16).

7. Nitrogen interactions with air

Complex interactions exist between air and agricultural N. Some of the interactions are immediate, such how farmers adjust their farming systems to greater temperatures and rainfall patterns due to Indirect connections include the potential for air policy to change how natural gas and oil, which are utilized as feedstocks for the production of NH_3, are used, are consumed. This could have an impact on fertilizer pricing, fertilizer consumption, and ultimately, Nr escape. But in addition to being impacted by air Pollution, agriculture also fuels it by releasing greenhouse gases into the sky.

In the sections that follow, we examine the impact of agricultural N cycles and the effects of climate change on N cycling air Pollution.

7.1. Air quality impact of the interaction of nitrogen and climate change

As was already stated, the weather and Nr are significant factors in the development of ambient air pollution. To make educated guesses about how climate change—that is, shifting weather patterns—will probably affect ambient air pollution (3).

7.2. Nitrogen-associated ambient air pollution

Health and the dangers of N-related air pollution to human health are becoming more and more clear. Table 7.1 summarizes the information relating to NOx, O3, and PM2.5 (fine size fraction), all of which are currently regulated by the EPA. Pollutants are believed to act through a number of pathways, including direct pulmonary irritation, however the specific mechanisms are not fully understood and are outside the purview of this overview (5). immune system suppression, autonomic nervous system disturbance, and oxidative stress pathways through systemic inflammation. Due to the smaller particles' capacity to enter the respiratory system more deeply, PM2.5 has been the subject of a large portion of research on PM. Even though there is increasing interest in the Only a small number of research have looked at the coarse PM size fraction's effects on health. Furthermore, little is known about the health impacts associated with the NO3-component of PM2.5 and SOAs in particular. There is little to no evidence that other N-related chemicals in ambient air, like gaseous NH3 and N2O, have any negative health consequences at the usual ambient quantities found today. contexts, there is evidence that gaseo However, in greater concentrations, like those present in enclosed livestock feeding operations and other industrial us NH3 can have negative health impacts (11). Additionally, the depletion of O3 in the stratosphere caused by N2O has an indirect effect on human health by increasing the amount of UV light that can reach the Earth's surface.

7.3. Guidelines for the Sustainable Administration of N

It has been extensively demonstrated that all of these tactics and methods are effective in raising crop NUE and, thus, lowering diffuse N pollution brought on by the agriculture industry. Farmers have a number of obstacles when it comes to altering their management methods, hence these BMPs have not been extensively adopted. Agronomic and economic aspects of the farm, government policy, and the psychological traits of the farmer all have an impact on the process by which farmers adopt and apply BMPs

Improving fertilizer management requires an understanding of farmers' decision-making process. The general pessimism One of the psychological factors that significantly hinders the adoption of these new technologies is farmers' perceptions of climate change and the connection between climate change and N fertilizers. methods. The risk of environmental contamination from N fertilizer, as well as the deadly effects that are already evident now and have been previously examined, must be educated and made known (14). In a similar vein, empowering farmers as a crucial component of the climate change response will reduce adverse outcomes.

Until public policies are in line with the incentives that drive farmers to alter their management methods, they will not be completely effective in lowering N pollution. enhancing optimistic sentiments that highlight the benefits of putting these BMPs into practice should be a priority (17)

8. Innovations in Technology

The common technological approach to improving NUE is referred to. as the "4Rs": using the appropriate amount, at the appropriate rate, at the appropriate moment, and at the appropriate location Other successful strategies include adaptive management and on-farm research, which gathers farmers locally to gather information on their fields and optimize their N fertilizer management, in addition to the 4R idea that is advocated in the USA. Research and innovation in the areas of plant breeding, agronomic practices, and irrigation support this strategic approach. Additionally, new technology advancements are required. like slow-release and controlled-release fertilizers. It seeks to reduce the loss of applied N fertilizer and raise the NUE (18). by releasing N when needed by the crop. Furthermore, some writers advocate for the use of urease and nitrification inhibitors, which are currently often used in agriculture. Another expanding trend that many governments are promoting is drip irrigation and precision irrigation Fertigation, or the application of fertilizer using irrigation water, is facilitated by the application of water-saving technologies demonstrate that encouraging innovation is a useful strategy for lowering agricultural emissions. Production subsidies, like those are not environmentally friendly in China, but innovation subsidies let farmers make more money while reducing overall pollution emissions (19).

9. Conclusion

A global issue that is challenging to address is diffuse contamination, which is brought on by N fertilization in agriculture. We have looked at the relationships between farmer management, law, no-point pollution, NUE, and N fertilizer use. techniques by conducting a thorough analysis of published literature. The findings indicate that the use of N fertilizer is on the rise globally. The EU and the USA, the two most economically developed nations, are the only ones beginning to slow the rate at which agricultural N consumption is increasing relative to crop yields Apart from this degree of fertilization, research indicates Because we still use an extremely low NUE (around 40% globally), meaning that about 60% of N is utilized as a possible contaminant in the environment. Diffuse contamination from agricultural N fertilizer and volatilization, leaching, and runoff are directly related, according to a number of studies. Raising the NUE is the key to lowering this pollution. There is also a wealth of literature that focuses on explaining, creating, and proving the efficacy of methods and practices that enhance NUE and lessen its adverse consequences on a local and global scale. Certain countries have included some of these traditions in their laws. (mostly within the EU). Farmers, however, have not usually embraced these rules and are hesitant to implement them. Studies that have already been done in this field link managerial change, willingness, and awareness. According to certain studies, farmers' protective mindset is fueled by ignorance about the scope and severity of the issue brought on via fertilization with nitrogen The complexity and seriousness of dispersed pollution today point to a greater comprehension of the variables influencing farmers' management strategies. This will result in more efficient policies that can be created and used to apply BMPs generally, which will ultimately lower diffuse N pollution by improving the NUE.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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