

Chemical Farming, Emerging Issues of Chemical Farming

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Abstract:- Chemical farming, an essential element of modern agriculture, has considerably increased global food production while also posing a number of difficult challenges, most notably those related to environmental sustainability, human health, and water resource integrity. This research project will conduct a thorough examination of these multifaceted issues, investigating the negative environmental consequences of chemical farming practices, determining the associated health risks to human populations, and examining the widespread contamination of water sources. This paper aims to shed light on the complicated connection between chemical farming and its emergent consequences by making use of doctrinal data, academic discussion, and policy insights, as well as exploring viable strategies and alternative approaches to mitigate these negative effects and advance the adoption of sustainable agricultural paradigms.

Keywords:- Chemical Farming, Environmental Impact, Human Health Concerns, Water Pollution, Sustainable Agriculture, Alternative Practices.

I. INTRODUCTION

Chemical farming, characterised by the intensive use of synthetic fertilizers, pesticides, and herbicides, has played a pivotal role in revolutionizing agricultural practices worldwide, fueling unprecedented increases in food production. However, this conventional approach to farming is not without its drawbacks, as it has led to the emergence of pressing issues that threaten environmental sustainability, human health, and water quality.

In recent years, concerns have grown regarding the adverse environmental impacts of chemical farming. The indiscriminate use of synthetic inputs has been linked to soil degradation, loss of biodiversity, and contamination of air and water resources. These environmental consequences not only compromise the long-term productivity of agricultural land but also pose significant risks to ecosystems and wildlife.

Moreover, the health risks associated with exposure to chemical residues from farming activities have garnered increasing attention. Farmworkers, nearby communities, and consumers are potentially exposed to harmful pesticides and herbicides, leading to acute and chronic health effects ranging from respiratory ailments to neurological disorders. The cumulative impact of chemical exposure on human health underscores the need for greater scrutiny and regulation of chemical farming practices.

Furthermore, the pollution of water sources due to agricultural runoff containing chemical residues presents a significant challenge. Contaminants from chemical fertilizers and pesticides can leach into groundwater, surface water, and aquatic ecosystems, jeopardizing water quality and posing risks to human health, wildlife, and ecosystem integrity.

As these emerging issues continue to escalate, there is a growing imperative to reevaluate current agricultural practices and explore alternative approaches that prioritize sustainability, resilience, and environmental stewardship. By addressing the root causes of these challenges and embracing innovative solutions, we can strive towards a more sustainable and equitable agricultural system that meets the needs of both present and future generations. This paper seeks to explore these emerging issues in depth, analyzing their causes, impacts, and potential solutions to inform policy, practice, and future research endeavors.

II. STATEMENT OF PROBLEM

A. Research Problems

- How do chemical fertilizers affect the environment?
- What are the risks to human health posed by chemical fertilizers?
- How can the negative impacts of chemical fertilizers be mitigated?

B. Hypothesis

The increased use of chemical fertilizers in agriculture is hypothesized to cause environmental degradation, human health risks, and water pollution. Exposure to nitrogen-based compounds from fertilizers may lead to carcinogenic effects and methemoglobinemia. Additionally, widespread fertilizer application is expected to contaminate water sources, causing eutrophication and harmful algal blooms (HAB). However, implementing sustainable agricultural practices and alternative fertilization methods may mitigate these adverse effects on the environment, human health, and biodiversity.

C. Objectives

- Assess the environmental impact of chemical fertilizers, focusing on their contribution to soil degradation, nutrient depletion, and disruption of ecosystems.
- Identify and evaluate the risks to human health associated with chemical fertilizers, including potential carcinogenic effects and other health hazards resulting from exposure to nitrogen-based compounds.

- Investigate strategies and approaches for mitigating the negative impacts of chemical fertilizers on the environment, human health, and biodiversity, with an emphasis on sustainable agricultural practices and alternative fertilization methods.

III. RELEVANCE AND SIGNIFICANCE OF THIS STUDY

A. Relevance

This research will focus on evaluating the environmental impact and human health risks of chemical fertilizers in agriculture. It will investigate their effects on soil quality, biodiversity, and human health, particularly concerning exposure to nitrogen-based compounds. Additionally, the study will explore mitigation strategies to reduce adverse effects. Relevant literature from environmental science, public health, and agronomy will be considered for a comprehensive analysis.

B. Significance

This study is crucial for raising awareness about the environmental and health risks posed by chemical fertilizers in agriculture. By identifying these risks and exploring mitigation strategies, the research contributes to promoting sustainable farming practices, protecting public health, informing policy development, and advancing agricultural sustainability.

C. Sources of Data

This research draws on a combination of doctrinal and secondary sources, primarily focusing on online resources. Doctrinal sources include international environmental conventions. Secondary sources comprise web articles, reports, and statistics obtained from online platforms, databases, and reputable institutions' websites. These sources provide a comprehensive understanding of the environmental impact and human health risks associated with chemical fertilizers in agriculture.

IV. LITERATURE REVIEW

In an effort to maximise productivity and quality, agricultural methods have grown more intensive as a result of the rising demand for food. Agricultural productivity depends on proper plant nutrition, and crop yield is directly impacted by soil nutrient levels. Producers prioritise fertilisation combined with pest control, irrigation, and other agricultural practices to overcome nutritional deficits in permanent agricultural land. This research, however, emphasises the detrimental impacts chemical fertiliser has on the ecosystem and public health. Chemical fertilisation techniques are linked to problems like air pollution, water eutrophication, carcinogenic effects, methemoglobinemia. With a focus on

¹ Thorat J, More A. The effect of chemical fertilizers on environment and human health (February 2023) <https://www.ijisrt.org/papers/IJSDR2202016.pdf> (accessed on 08 February 2024)

²Chandhini, Randeep kumar, Ravendar kumar, om prakash, Impact of chemical fertilizers on our environment (February

nutrient management techniques and sustainable fertilisation methods, this review seeks to identify the environmental and health concerns brought on by overfertilization and offers solutions. Using organic inputs like precision agriculture, genetic engineering, organic fertilizers instead of chemical-intensive agriculture is one of these techniques. The agriculture industry hopes to lessen its dependency on synthetic chemicals and lessen their negative effects on the environment and human health by encouraging the use of these alternative inputs.¹

Prudent and sustainable methods are required to reduce the risks associated with overuse of fertilisers. For improved crop productivity and environmental preservation, it is imperative to use a variety of nutrient sources in an integrated manner. To maximise output while lowering the danger of pollution, enhanced nutrient-efficient fertilizers must be used in conjunction with sustainable resource management.²

V. DISCUSSIONS AND FINDINGS

A. How do Chemical Fertilizers Affect the Environment?

Synthetic (chemical) fertilizers containing nitrogen and phosphorus have been pivotal in modern agriculture, significantly enhancing farming practices from the mid-20th century to the present day. These chemical inputs have played a crucial role in increasing food production, particularly for staple crops like corn, wheat, and rice. The widespread use of synthetic fertilizers has fueled the explosive growth of cereal cultivation in recent decades. China, with its rapidly growing population, has emerged as the world's leading producer of nitrogen fertilizers, highlighting the substantial reliance of modern agriculture on these chemical inputs. While synthetic fertilizers have undoubtedly played a crucial role in doubling food production rates, they have also triggered a staggering surge, potentially up to 600 percent, in reactive nitrogen levels across the environment. This excessive influx of nitrogen and phosphorus has transformed once-beneficial nutrients into pollutants. Approximately half of the nitrogen present in synthetic fertilizers escapes from agricultural fields, infiltrating soil, air, water bodies, and even rainfall. Following the conversion of fertilizer nitrogen into nitrates by soil bacteria, rainstorms or irrigation systems transport these contaminants into groundwater and river networks.

The accumulation of nitrogen and phosphorus poses a significant threat to both terrestrial and aquatic ecosystems, leading to eutrophication – a process characterized by an overabundance of nutrients. This phenomenon is implicated in the proliferation of toxic algae blooms in lakes across China, the United States, and elsewhere. As excessive organic matter decomposes in aquatic environments, it precipitates oxygen depletion, giving rise to "dead zones" where life cannot thrive.

2019)
https://www.researchgate.net/publication/331132826_The_Impact_of_Chemical_Fertilizers_on_our_Environment_and_Ecosystem (Accessed on: 11 February 2024)

The accumulation of nitrogen in both terrestrial and aquatic environments poses a grave threat to biodiversity, native plant species, and natural habitats. Moreover, the application of fertilizers in soil contributes to the generation and emission of nitrous oxide, a potent greenhouse gas. With the global population continuing its rapid ascent, the conundrum intensifies between sustained agricultural expansion and the ecological well-being of the land upon which humanity relies.³

Pesticide spraying can significantly reduce or offset the economic costs from plant diseases, insect pests, and weeds on agricultural production and fertilizer application can provide a variety of nutrients required for the growth of crops and for an increased yield in production. However, many countries have reported alarming residues of agricultural chemicals in soil, water, air, agricultural products, and even in human blood and adipose tissue⁴

However, the overuse of chemical fertilizer has occurred in many developing countries such as China and India, has caused and still is causing a range of environmental problems, including, the degradation of soil and water quality, and the loss of biodiversity and ecosystem services

In China, the excessive use of fertilizers leads to the release of nitrogen, phosphorus, and other elements into the environment, resulting in water pollution from runoff, leaching, and absorption. Since the 1980s, major river basins in China have experienced significant increases in nitrogen and phosphorus levels, primarily attributed to fertilizer runoff. Consequently, groundwater in agricultural regions often surpasses WHO drinking water standards due to nitrate contamination.

Additionally, banned pesticides such as HCH and DDT persist in water bodies, posing health risks to the population. Although China's substantial utilization of fertilizers and pesticides has contributed to increased grain yields, it has concurrently exacerbated water pollution issues. This situation is further exacerbated by China's position as the world's largest consumer of fertilizers and pesticides, with excessive application driving surface water eutrophication and groundwater nitrate pollution. Both fertilizers and pesticides also pose risks as persistent organic pollutants and environmental endocrine disruptors, thereby threatening drinking water safety, particularly in rural areas. Despite efforts to address these challenges, the persistence of cyanotoxins and nitrates in water bodies remains a concern, as highlighted by numerous epidemiological surveys.⁵

In India, the use of chemical fertilizers has emerged as a significant concern, with the country ranking second globally in consumption, following China (IFA, 2017). Chemical fertilizers, primarily consisting of nitrogen, phosphorus, and potassium (collectively known as NPK), are extensively utilized in agricultural practices. The Fertilizer Association of India reports a substantial increase in fertilizer production and NPK consumption over the years, with figures rising from 201.6 and 65.6 tonnes in 1951-52 to 41,427.8 and 25,949.9 tonnes, respectively, in 2016-17. This surge represents a staggering increase of 395 and 205 times from the levels recorded in 1951-52. However, alongside this growth, concerns have arisen regarding the negative impacts of fertilizer production and use on human and animal health, as well as the environment. The by-products of fertilizer industries, as well as the direct use of fertilizers, have been linked to various adverse effects on health and the environment, highlighting the need for sustainable agricultural practices and environmental management strategies.

The excessive use of fertilizers contributes to soil fertility degradation. Toxic substances accumulate in vegetables, adversely affecting both humans and animals. Nitrogen fertilizers can lower soil pH, while potassium fertilizers disrupt nutrient balance. Elevated nitrogen levels may contain carcinogenic compounds like nitrosamines, leading to harmful accumulation of NO₃ and NO₂ in vegetables such as spinach and lettuce. These findings underscore the importance of balanced fertilizer use and its implications for human and environmental health.

Nitrate pollution in groundwater is a major issue in agriculturally rich areas. Andhra Pradesh, Gujarat, Haryana, Punjab, and Maharashtra there are several types of metals present above the permissible levels in the contaminated water due to the production and use of chemical fertilizers, such as aluminium, lead, chromium, zinc, copper, cobalt, cadmium, and the continuous consumption of these waters may cause various types of dangerous diseases such as cancer, arthritic syndromes, diabetes, kidney disease, improper mental and physical growth, hypertension, haemoglobin deficiency, hair loss, skin diseases. There are several types of metals present above the permissible levels in the contaminated water due to the production and use of chemical fertilizers, such as aluminium, lead, chromium, zinc, copper, cobalt, cadmium, and the continuous consumption of these waters may cause various types of dangerous diseases such as cancer, arthritic syndromes, diabetes, kidney disease, improper mental and physical

³ National Geographic Society, Published (October 19, 2023), Environmental Impacts of Agricultural Modifications:<https://education.nationalgeographic.org/resource/environmental-impacts-agricultural-modifications/> (Accessed on: 10th February 10, 2024)

⁴ Alvarez A, Saez JM, Costa JSD, and others. Actinobacteria: current research and perspectives for bioremediation of pesticides and heavy metals. *Chemosphere* 2017;166: 41–62

⁵ HANG Xiao-nan, GUO Qiu-ping, SHEN Xiao-xue, YU Sheng-wen, QIU Guo-yu, 2015, Water quality, agriculture and food safety in China: Current situation, trends, interdependencies, and management, *Journal of Integrative Agriculture*, Pg 2371-2373

growth, hypertension, haemoglobin deficiency, hair loss, skin diseases.⁶

The presence of urea in fertilizers can lead to various health issues such as skin diseases and environmental impacts such as soil acidification, which adversely affect seed germination. Ammonium and nitrogen oxides in fertilizers are associated with respiratory illnesses, asthma, methemoglobinemia, infant diseases, and premature death. These compounds also contribute to environmental problems like ozone depletion, global warming, and acid rain. Chemical phosphorus in fertilizers can cause health problems like hyperphosphatemia, renal failure, heart disease, arthritic syndromes, atherosclerosis, and osteoporosis. Additionally, it increases the concentration of cadmium in soil and contributes to eutrophication in lakes and ponds. Potassium chloride in fertilizers is linked to gastric diseases, stomach pains, dizziness, and bloody diarrhea in humans, while environmentally it disrupts the nutrient balance in soil. These findings underscore the importance of considering both human health and environmental impacts when using fertilizers.⁷

➤ *Situations in Which Chemical Fertilizers have a Detrimental Effect:*

• *A Case Study on Hooghly District, West Bengal, India*

This case shows that between 1989 and 2007, the nitrogen, phosphorus, and potassium (N-P-K) ratio in chemical fertilizers in the studied area did not follow the ideal ratio of 4.0:2.0:1.0. Rather, throughout this time, fertilizers high in potassium, phosphate, and nitrogen were consistently overused. This investigation emphasises how crucial it is to attain a balanced supply of nutrients by taking into account variables like the right time, particular soil and climate conditions, and cultivation techniques for every crop. However, this investigation concentrates on examining the total volume of chemical fertilizers used in the agricultural sector as a whole due to the scarcity of data related to soil and crops.

• *Effect:*

The data from West Bengal's Hooghly district shows that using chemical fertilizers more frequently hasn't increased agricultural yield or productivity. Variations in agricultural yield have been noted; these may be related to the improper formulation and application of N-P-K (nitrogen-phosphorus-potassium) fertilizers in excess of what the soil

can absorb. Degradation of the environment and deterioration of soil fertility have been caused by improper usage of chemical fertilizers. These problems have been made worse by the district's increased reliance on chemical fertilizers as a result of increased crop diversification.⁸

B. What are the Risks to Human Health Posed by Chemical Fertilizers?

This study also looks into how pesticide exposure affects farmers' health. When farmers handle pesticides directly without wearing protective gear, they can suffer from a range of acute symptoms, such as irritation of the eyes, blurred vision, skin problems, respiratory problems, and sore throats and noses. There is a relationship between the length of pesticide exposure and the severity of these symptoms. In order to reduce health hazards, the study highlights how crucial it is to enforce rules and increase awareness about chemical fertilizers. Both have the potential to directly or indirectly taint crops, exposing people when they eat them.

Overuse of fertilisers can contaminate groundwater with nitrates, which can harm livestock and people by altering haemoglobin levels in the blood. Organophosphate pesticides can cause acute health concerns such as nausea, vomiting, headaches, dizziness, and skin and eye problems, although they are less permanent in the environment than organochlorine pesticides.⁹

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⁶ Acharya Balkrishna, Jitendra Kumar Pandey, Pankaj Kumar Tripathi, Ritika Joshi and Vedpriya Arya, (d 10 August, 2021) Biological Forum – An International Journal, Chemical Fertilizers and Pesticides in Indian Agriculture, pg 409 – 410

⁷ Pahalvi, H.N., Rafiya, L., Rashid, S., Nisar, B., Kamili, A.N. (2021). Chemical Fertilizers and Their Impact on Soil Health. In: Dar, G.H., Bhat, R.A., Mehmood, M.A., Hakeem, K.R. (eds) Microbiota and Biofertilizers, Vol 2. Springer pg 1-20

⁸ Suman Patra, Pulak Mishra, S. C. Mahapatra, S.K. Mithun(2016) Modelling impacts of chemical fertilizer on agricultural production.

⁹ Yang Y, Li Z and Jin M (2022) How do chemical fertilizer reduction policies work? —Empirical evidence from rural china. Front. Environ. Sci. 10:955278. doi: 10.3389/fenvs.2022.955278

¹⁰ Erica davis, (2021), harmful effects of chemical fertilizers on human health: (<https://www.drugwatcher.org/bad-health-effects-of-fertilizers/>),

(Assessed on: ,February 10, 2024)

A waste product of protein breakdown, urea is created in the liver. Normally, the body eliminates it through urine. However, there may be health problems if blood urea levels become too high. A high level of urea in the blood may indicate dehydration or renal failure. Additionally, it may result in symptoms including confusion, nausea, vomiting, and exhaustion. When high urea levels are significant, they can cause illnesses like uremia, which can damage several organ systems and be fatal if left untreated. All things considered, even while urea is a natural byproduct of metabolism, high amounts can be harmful to human health, especially if renal function is impaired.¹¹¹²

- **Phosphorous:** A standard characteristic of mineral and bone disorders associated with chronic kidney disease (CKD) is increased phosphorus retention. Abnormal metabolism of calcium, phosphorus, parathyroid hormone (PTH), and/or vitamin D are associated with this disorder. Bone turnover, mineralization, volume, growth, or strength are disrupted, and vascular or soft-tissue calcification occurs as a result. If untreated, chronic kidney disease (CKD) is a mineral and bone problem that affects several organ systems and can have significant consequences.¹³
- **Nitrogen:** when used excessively, these fertilisers can degrade soil fertility and the relative composition of plant species, upsetting the delicate balance in our ecosystems and contaminating our waterways. In addition, the U.S. Environmental Protection Agency states that acid rain, contaminated drinking water, oxygen deprivation, and "dead zones" in bodies of water can seriously impact aquatic animals.

Recent studies have highlighted the risks associated with nitrate, a crucial part of nitrogen fertilisers, which is present in drinking water. An increasing amount of research suggests that exposure to nitrates in drinking water may be linked to a number of negative health impacts, such as headaches, nausea, cramping in the abdomen, and heart disease. Some research even suggests that eating nitrate may raise the risk of cancer, especially gastric cancer.¹⁴

- **Carcinogenic Effects:** Studies have connected pesticides particularly ones that contain arsenic to a higher risk of cancer. Because they are exposed on a daily basis, agricultural workers should be especially concerned, most people are not exposed enough to see a difference.

Herbicides are another possible cause for worry. The pesticides 2,4-D or glyphosate may be present in these items. There is no evidence to support the recent International Agency for Research on Cancer's finding that some herbicides raise the risk of cancer.

Nitrates from fertilisers are frequently present and can end up in drinking water. People who utilise well water and live in agricultural areas are more likely to experience this. On a connection to cancer, however, research is conflicting.¹⁵

- **Methemoglobin:** When methemoglobin replaces more than 1% of the hemoglobin in red blood cells, the condition is known as methemoglobinemia. Our blood contains hemoglobin, which transports oxygen from the lungs to the rest of our body. Because methemoglobin does not transport oxygen well, it can cause cyanosis, or a grayish-blue coloration of the skin, when it replaces hemoglobin.

The blood absorbs nitrate from water nearly entirely. Part of that nitrate is transformed into nitrite by our bodies. Methemoglobin is produced when blood and nitrite combine. The blood's ability to carry oxygen where it is needed is negatively correlated with the amount of methemoglobin in it. In addition to these alterations in blood chemistry, methemoglobinemia can cause weakness, nausea, an increased resting heart rate, and, in extreme circumstances, even death.¹⁶

C. How can the Negative Impacts of Chemical Fertilizers be Mitigated?

To mitigate the negative impacts of chemical fertilizers, providing viable alternatives or reducing the cost of non-harmful fertilizers is essential. In line with this, the Government of India decided to launch the PM-PRANAM scheme on June 28, 2023. The main objective of this initiative is to reduce the usage of chemical fertilizers and promote sustainable agricultural practices. Approved by the Cabinet Committee on Economic Affairs (CCEA), the PM-PRANAM scheme focuses on Restoration, Awareness Generation, Nourishment, and Amelioration of Mother Earth, aiming to foster a healthy environment.

This program incentivizes states that actively contribute to balanced chemical fertilizer usage, thereby addressing excessive fertilizer and pesticide use in agriculture, which adversely affects soil fertility and environmental health. The scheme emphasizes adopting soil test-based balanced

¹¹ StatPearls. Urea Cycle Disorders (<https://www.statpearls.com/ArticleLibrary/viewarticle/30804>), (Accessed 10 Feb. 2024)

¹² Cleveland clinic (<https://my.clevelandclinic.org/health/diseases/23470-urea-cycle-disorder>), (Accessed 10 Feb. 24) (Accessed on 08 feb 2024)

¹³ National institute of health (May 4, 2023), (<https://ods.od.nih.gov/factsheets/Phosphorus-HealthProfessional/>) Accessed on: 10 Feb. 24)

¹⁴ Yoram kapulnik (2023) <https://www.triplepundit.com/story/2023/alternatives-nitrogen-fertilizers/781191> (Accessed on 10 Feb. 24)

¹⁵ Kellie bramlet (2016)(<https://www.mdanderson.org/publications/focused-on-health/lawncare-cancer-risk.h26Z1590624.html>), (accessed on 10 February 2024)

¹⁶ National library of medicine , (2014), (<https://www.mdanderson.org/publications/focused-on-health/lawncare-cancer-risk.h26Z1590624.html>), (accessed on 10 February 2024)

fertilizer use, integrating bio/organic fertilizers, and embracing sustainable farming practices such as organic farming, resource conservation, and crop rotation. Subsidy savings calculations will be based on data from the Integrated Fertilizer Management System (iFMS), taking into account the increased adoption of organic fertilizers and the expansion of organic farming. The Department of Expenditure will oversee grant disbursement, with the majority allocated to states for capital expenditure and Information, Education, and Communication (IEC) activities promoting soil health and alternative fertilizers. Funding for the scheme will be sourced from existing fertilizer subsidy schemes, thereby contributing to environmental preservation and economic efficiency. Incentives provided through the PM-PRANAM scheme will support infrastructure development, health, and education, ensuring a sustainable future for agriculture and future generations.^{17,18}

Some other ways to overcome the challenge of chemical fertilizers include, numerous cost-effective and environmentally friendly solutions can be employed, but some mentioned here. First, encouraging the use of organic farming practices can drastically reduce dependency on chemical fertilisers. This includes using natural fertilisers like compost, manure, and crop leftovers, which not only supply nutrients to crops but also improve soil health and fertility over time. Furthermore, using integrated nutrient management techniques like crop rotation and intercropping can improve nutrient utilisation and reduce the requirement for external inputs.

Encourage the government to invest in research and development of new technologies and practices, such as precision agriculture and nutrient management software, to improve fertiliser efficiency and reduce over application. Furthermore, providing incentives and subsidies to farmers who switch to organic and sustainable farming methods can encourage widespread adoption and help the move away from chemical fertilisers.

Education and outreach programmes targeted at raising awareness about the environmental and health consequences of chemical fertilisers can also help promote sustainable agriculture. Farmers may make more informed decisions that prioritise long-term soil health and environmental sustainability if they are educated about alternate fertilisation processes and their benefits.

Overall, a comprehensive approach that includes regulatory assistance, technological innovation, financial incentives, and education is required to effectively reduce the usage of chemical fertilisers while ensuring farmers' economic viability and encouraging responsibility for the environment.

¹⁷Department of fertilizers IND, (2023) <https://www.fert.nic.in/sites/default/files/2023-12/PM-PRANAM.doc>, (Accessed on 11 February. 2024)

VI. CONCLUSION

In conclusion, chemical farming has undeniably played a crucial role in increasing global food production, but it has also brought forth significant challenges related to environmental sustainability, human health, and water resource integrity. The indiscriminate use of synthetic fertilizers, pesticides, and herbicides has led to soil degradation, loss of biodiversity, and contamination of air and water resources, posing risks to ecosystems and human health alike. However, through a comprehensive examination of these issues and exploration of alternative approaches, there is potential to mitigate these negative impacts and transition towards more sustainable agricultural practices. By prioritizing environmental stewardship, resilience, and innovation, we can address the root causes of these challenges and work towards a future where agriculture meets the needs of both people and the planet. It is imperative that policymakers, researchers, and stakeholders collaborate to implement effective strategies that promote sustainable agriculture and safeguard the well-being of current and future generations.

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¹⁸ Govt of IND ministry of chemicals & fertilizers (17 march 2023) <https://sansad.in/getFile/loksabhaquestions/annex/1711/AU2765.pdf?source=pqals> (Accessed on 11 Feb. 24)

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