

Review

Environmental and Economic Perspectives of Nano Urea Production: A Review

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Abstract

Agricultural scientists have come up with an innovation known as nano urea, which is a form of nanotechnology that can be used as a replacement for traditional urea. The plant can easily absorb particles because it has a desired particle size and increased surface area. In result it improves its ability to take up nutrients, which promotes efficient nutrient use and reduces environmental pollution as well as sustenance of crops. Nano urea production is very important in terms of environmental as well as economical aspects. Research shows that nano urea enhances rapid nutrient assimilation into developing plant parts promoting higher dry matter build up and chlorophyll synthesis thus improving crop yield and plant wellbeing. Furthermore, nano urea is effective in minimizing pollution and increasing the quality traits of crop plants under stress conditions. Economically, using nano urea proves as a cost-effective measure with significant saving opportunities and profit margins. Nano urea production facilities can be developed with the potential of creating economic prospects and augmentation of agricultural practices. Nano urea Production is an eco-friendly energy saving process whereby the carbon footprint and power requirements are significantly lower than in typical urea manufacturing. This method, unlike the traditional ones, is more efficient in terms of energy consumption, produces less waste and environmentally safe. Still, there is cause for concern regarding the possible environmental impacts of nano-based urea synthesis and more research work may be required in order to establish the full scope of its long-term effects and ways to achieve optimum results based on this technology. In general, nano urea is an innovative approach that promises minimize impacts on the environment as well as enhancing yields.

Keywords: Nano urea, agriculture, environmental impact, economic perspectives, sustainable agriculture, nanotechnology

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Introduction

Nano urea, an innovation based on nano technology, a new breakthrough in the agricultural sector. The size of particles desired has increased surface area enabling easy transportation of nutrients to plants. Nano urea enhances nutrient use efficiency while also reducing pollutions in the environment through achievement of sustainable food production. First, when making any considerations pertaining to nano urea production, environmental and economic factors play a pivotal role. Studies have revealed that nano urea enhances rapid availability of nutrients to maturing tissues and thereby dry matter formation and synthesis of chlorophyll, which in turn results in improved agricultural yields and quality of plants (Gupta, R. et.al.2020)[1]. Also, nano urea has shown that it could limit air contamination and augment the morphogenic attributes of plants, particularly in difficult situations. The environmental relevance of the nano urea is confirmed by these results, making it a green replacement for the traditional urea.

Cost effectiveness becomes the primary concern when approached from the economic point of view. A number of studies have made comparisons between the production costs of conventional and nano urea. Another thing is that developing such nano urea manufacturing factories like the one formed by India Farmers Fertilizer Co-operative Limited can create employment opportunities and facilitate agriculture expansion. Nano urea promises saving energy while at the same time it being environmentally friendly. Contrary to old urea factories, Nano urea manufacturing units produce lesser pollutants and a toxic substance thereby looks a more eco-friendly approach. This element is of primary importance when related for the concept of sustainable agriculture and the global drive for cleaner industrial processes.

Production Process

1. Energy and Resource Efficiency of Nano Urea Production: Nano urea production is an energy-efficient and environmentally friendly process, which involves the conversion of bulk urea into nano-sized particles. This process results in reduced carbon footprints and lower energy requirements compared to conventional urea production methods. The production process of nano urea is nearly zero-discharge and does not require additional control measures, making it a clean and eco-friendly alternative to traditional urea manufacturing.

2. Comparison with Conventional Urea Production Methods: Conventional urea production is a highly energy-intensive process, involving the production of solid urea particles, which can lead to significant emissions and pollution. In contrast, nano urea production requires less energy and results in fewer emissions, making it a more sustainable option for agricultural input. Additionally, nano urea production generates fewer aerosols and does not contribute to air pollution, as opposed to conventional urea production methods. Nano urea formulations exhibit variations in terms of particle size, coating materials, and nutrient encapsulation techniques. These formulations aim to optimize nutrient release, control solubility, and prolong the availability of nitrogen for plant uptake. Encapsulation of urea nanoparticles in polymercoatings or matrices is one prominent approach, enabling gradual nutrient release in response to environmental factors [2].

3. Technological Pathways and Their Environmental Impact: Nano urea production can be achieved through various technological pathways, each with its own environmental and cost implications. These pathways involve different scenarios for methane gas, electricity, and water sources, which can influence the overall impact of nano urea production on the environment. By assessing the environmental impact of these pathways, researchers can identify the most sustainable and cost-effective methods for nano urea production. Nano urea production offers several advantages over conventional urea production methods, including improved energy and resource efficiency, reduced emissions, and lower environmental impact. The development and adoption of sustainable technological pathways for nano urea production can further enhance its environmental benefits and contribute to a more sustainable agricultural future.

Environmental Impact of Nano Urea Production

Nano urea is a promising innovation in the field of sustainable agriculture, with potential benefits such as increased crop yields, reduced environmental pollution, and cost savings for farmers. One of the key environmental benefits of nano urea is the reduction of excess application of nitrogen, which can lead to decreased risk of nitrogen pollution in waterways and ecosystems [3] The smaller particle size of nano urea allows for more efficient uptake by plants, reducing the amount of fertilizer needed and minimizing the risk of fertilizer runoff into water.

However, a study calculated the GHG emissions due to treatments (N100PK and N75PK+ nano-urea) and found that comparatively higher GHG emission was recorded in N100PK treatments over N75PK + nano-urea [4]. Therefore, it is important to consider the sustainability aspects of nano urea production, such as energy and resource efficiency, to minimize its environmental impact. In terms of economic perspectives, nano urea application can be cost-effective and can lead to lower fertilizer application rates. However, there is a need for subsidies and pricing strategies to make it more accessible to farmers. The market potential and future prospects of nano urea are also promising, with potential for innovation and collaboration between researchers, farmers, and industry stakeholders. Nano urea has the potential to revolutionize sustainable agriculture, but it is important to consider its environmental and economic impact. Further research is needed to fully understand the long-term effects of nano biotechnology on the environment and to optimize the technology to meet the needs of different crops, soil types, and agricultural practices.

Economic Perspectives on Nano Urea Application

Nano urea, a technological advancement in agriculture, has garnered attention due to its potential to revolutionize fertilizer efficiency. Examining its cost-effectiveness involves a multifaceted analysis considering economic, environmental, and agricultural dimensions. The cost-effectiveness of nano urea application is evident in its ability to enhance nutrient absorption by crops, leading to increased yields. Traditional urea often faces challenges such as nutrient leaching and volatilization, contributing to environmental concerns and reduced efficacy. Nano urea addresses these issues by providing a controlled release of nutrients, minimizing wastage, and optimizing plant uptake.

From an economic standpoint, the initial investment in nano urea might be higher than conventional urea, but the long-term benefits in terms of increased crop productivity and reduced environmental impact make it a potentially cost-effective solution. Farmers adopting nano urea could experience higher returns on low investment through improved crop yields and reduced dependency on frequent reapplication.

1. Subsidies and Pricing Strategies: Governments play a crucial role in the adoption of innovative agricultural technologies. Subsidies can be instrumental in making nano urea more accessible to farmers, easing the financial burden of transition. Policymakers must consider creating targeted subsidy programs that promote the adoption of nano urea, especially among small and marginalized farmers. Pricing strategies also come into play. Striking a balance between affordability for farmers and sustaining the economic viability of nano urea manufacturers is essential. Transparent pricing mechanisms that consider production costs, research and development investments, and market dynamics will contribute to a sustainable ecosystem.

2. Market Potential and Future Prospects: The market potential for nano urea is vast, with global agriculture facing the challenge of feeding a growing population while minimizing environmental impact. As sustainability becomes a focal point, nano urea's ability to enhance nutrient use efficiency aligns with the evolving demands of modern agriculture.[5]

Future prospects of nano urea hinge on continuous research and development, addressing any concerns related to its environmental impact and scalability. Collaborative efforts between governments, research institutions, and private sector stakeholders are vital for creating an enabling environment for the widespread adoption of nano urea.

Conclusion

Nano urea, as an innovative approach of green technology, has several advantages towards its users including environmentalists and farmers. It releases nitrogen slowly thus maximizes absorption of nutrients from plants, reduces nutrient flow through surface and streams as well as lowering greenhouse gases as compared to conventional urea usage. This technology can raise yield, minimize application rates of urea nano crystals and also prevent contamination of environmental water bodies and ecosystems. Its environmentally friendly and efficient energy production process that has fewer carbon footprints, thus cheaper for the farmers. Nevertheless, the success of its adoption may be challenged by issues such as awareness, affordability, compatibility, and regulatory approvals. Besides some lingering worries regarding possible environmental impacts by nano-materials that have not been appropriately taken care of can slow down acceptance as well. Long term consequences of nano-biotechnology and the possible toxicity of nano-material on plants and environment are still not clear and this is an area where future work needs to be carried out. Thus overall, nano urea is an innovative approach that shows promise in minimizing negative environmental consequences while enhancing crop yields.

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