

Contribution of Green Chemistry Method in Business Economy

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ABSTRACT

Green chemistry emphasizes the development of chemical products and manufacturing methods that minimize environmental damage without compromising quality or effectiveness. In the modern global marketplace, companies are increasingly expected to adopt sustainable practices as a result of stricter environmental laws, higher raw material costs, and growing public concern for the environment. This paper explores the impact of green chemistry on the business economy, focusing on its role in reducing operational costs, promoting long-term sustainability, strengthening brand image, and driving technological advancement. It also highlights the difficulties businesses may encounter when implementing green chemistry principles.

Keywords: Green Chemistry, Chemistry in business, chemical industry, Business innovation, sustainable development, economic growth.

1. Introduction

Environmental issues have become increasingly serious and require strong attention from governments and industries. Rapid industrial growth, driven by expanding lifestyles and rising consumption, has led to a significant increase in waste generation. Not only has the quantity of waste grown, but changes in consumption patterns have also altered the composition of waste materials, making them more difficult to decompose naturally. As a result, environmental pollution has intensified, posing serious risks to ecosystems and human health. In this context, the adoption of green chemistry is essential to minimize or prevent environmental damage. When green chemistry principles are not applied, harmful chemical substances continue to be released into the environment, negatively affecting both nature and human well-being. This environmental degradation increases financial burdens on governments and businesses, as additional resources are required to manage pollution and restore damaged environments. Furthermore, declining environmental quality can slow economic growth and trigger long-term social conflicts involving communities, industries, and policymakers. Green chemistry focuses on reducing or eliminating the harmful effects of chemical substances on the environment and human health, and it is widely recognized as an effective approach to pollution prevention because it can be directly implemented by scientists and industries in current production processes.

2. Methodology

This research article surveys the concept of green chemistry and its impact on economic activities. The study is based on a literature review approach, which involves assembly of information from existing origins such as reference books, peer-reviewed articles, newspapers, magazines, and other scholarly publications. The materials analyzed in this review were obtained from various scholarly publications which talk about green chemistry and its connection with economic development.

3. Concept of Green Chemistry

Green chemistry refers to the design and application of chemical products and processes that reduce or eliminate the use and production of hazardous substances. Its core principles include preventing waste, utilizing renewable resources, improving energy efficiency, and creating products that can safely degrade in the environment. By applying these principles, industries are able to lower their environmental impact while continuing to maintain high levels of productivity and product quality.

4. There are 12 principles of green chemistry

1. Waste Prevention

Avoiding the creation of waste is more effective than managing or treating waste after it has already been produced.

2. Efficient Use of Materials (Atom Economy)

Chemical reactions should be planned so that most, or ideally all, of the materials involved are incorporated into the final product, reducing unnecessary by-products.

3. Safer Chemical Synthesis

Whenever feasible, chemical manufacturing methods should use and produce substances that pose minimal risk to human health and the environment.

4. Development of Low-Toxicity Products

Chemical products should be designed to perform their intended purpose while reducing harmful effects on living organisms and ecosystems.

5. Safer Use of Solvents and Additives

Supporting substances such as solvents or separation agents should be avoided where possible, and when required, they should be safe and environmentally friendly.

6. Energy-Efficient Process Design

Chemical processes should aim to reduce energy consumption, as energy use affects both environmental sustainability and economic costs. Preference should be given to processes that operate under normal temperature and pressure conditions.

7. Use of Renewable Raw Materials

Whenever it is technically and economically possible, renewable resources should be selected over non-renewable ones for chemical production.

8. Minimization of Chemical Modifications

Unnecessary chemical alterations, such as temporary protective steps, should be reduced or eliminated because they increase material use and generate additional waste.

9. Preference for Catalytic Methods

Using catalysts, which can be reused and act selectively, is more efficient and environmentally beneficial than using large quantities of reactive chemicals.

10. Design for Environmental Breakdown

Chemical products should be created so that, after use, they decompose into harmless substances and do not accumulate in the environment.

11. Continuous Monitoring for Pollution Control

Improved analytical techniques should be applied to monitor chemical processes in real time, allowing potential hazards to be detected and prevented before they occur.

12. Safer Chemical Processes to Prevent Accidents

The choice of chemicals and processing conditions should reduce the risk of accidents such as leaks, explosions, or unintended releases.

Failure to adopt green chemistry practices can lead to serious environmental pollution and degradation. Such environmental damage results in various economic losses, which can be categorized as follows:

1. Emergency Response Costs

When environmental pollution or damage occurs, immediate measures must be taken to control and prevent the situation from worsening. These response actions may be carried out by companies responsible for the activity, government authorities, or both. Emergency efforts often involve containment, cleanup, and mitigation activities, all of which require significant financial resources.

2. Environmental Restoration Costs

Polluted or damaged environments must be rehabilitated to restore their condition and functionality as much as possible. Environmental restoration applies to public resources managed by governments as well as to areas affecting communities, individuals, and organizations. Although some ecosystems cannot be fully returned to their original state, the parties responsible for causing pollution or environmental damage are obligated to undertake restoration efforts. The goal of restoration is to recover environmental functions that existed before the damage occurred. However, different ecosystems—such as forests, rivers, oceans, and wetlands—require specialized methods and technologies for recovery. As a result, restoring environmental conditions involves substantial financial investment.

3. Loss of Ecosystem Services

Environmental pollution and degradation disrupt natural ecosystems and reduce the benefits they provide. Damage to ecosystems affects their ability to support biodiversity, regulate environmental processes, and sustain economic activities. For example, an oil spill in marine waters can contaminate ecosystems such as coral reefs, mangrove forests, and seagrass beds. This damage reduces fish populations and lowers the productivity of fisheries, resulting in long-term economic losses. The total impact of ecosystem damage must be assessed in economic terms to accurately measure environmental losses.

5. Chemistry and Sustainable Business Development

5.1 Importance of Green Chemistry for Businesses

Companies that implement green chemistry approaches often gain significant economic advantages. By reducing waste generation and minimizing the use of hazardous substances, businesses can lower disposal and treatment expenses while more easily meeting environmental regulations. In addition, adopting environmentally friendly practices enhances a company's public image and builds customer trust. As consumers become more aware of environmental issues, they increasingly favor products that are produced responsibly, allowing businesses that apply green chemistry to stand out in the market. As a result, many sectors—including pharmaceuticals, agriculture, packaging, and textiles—are incorporating green chemistry principles into their manufacturing processes.

5.2 Energy and Power Industries

Chemistry plays a key role in the growth of energy and power sectors by enabling fuel refinement, efficient energy storage, and the development of renewable technologies. Progress in chemical science has led to better-performing batteries, more efficient solar cells, and cleaner alternative fuels. As a result, companies can lower their environmental footprint while also reducing long-term operational expenses.

8. Green Chemistry and Environmental Responsibility

Green chemistry focuses on designing products and processes that minimize harm to people and the environment. Companies that apply these principles are able to reduce waste and emissions, meet

environmental standards, and strengthen their reputation with the public. Adopting sustainable chemical methods has become a crucial factor in achieving long-term business growth and stability.

9. Chemistry in Trade and Economic Expansion

Products derived from the chemical industry—such as medicines, fertilizers, plastics, and industrial materials—form a significant part of global trade. Companies operating in this sector support national economies by generating export revenue, creating employment opportunities, and driving industrial growth. A well-developed chemical industry strengthens a nation's competitiveness in the international marketplace.

10. Challenges in Chemistry-Related Businesses

Although chemistry-based industries offer many benefits, they also face several obstacles. These include environmental pollution, workplace safety risks, and the high cost of research and development. Addressing these challenges requires strict adherence to safety standards, responsible waste management, and investment in environmentally sustainable technologies. Government support through policies, education, and research funding is essential. In many developing regions, progress is further limited by high startup costs, insufficient technology, and a shortage of skilled professionals.

11. Future Outlook

The role of green chemistry within a circular economy is expected to grow steadily. Increased environmental awareness, tougher environmental laws, and ongoing technological innovation are pushing industries toward more sustainable approaches. Strong cooperation among governments, industries, and educational institutions will be vital in expanding green chemistry practices and promoting efficient use of resources.

12. Conclusion

The findings indicate that adopting green chemistry offers clear economic advantages, including lower costs related to environmental damage, disaster response, and waste management. In contrast, failing to implement green chemistry can lead to higher recovery expenses and long-term financial losses due to environmental harm. Therefore, green chemistry is not only environmentally beneficial but also economically practical.

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