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WASTE PREVENTION STRATEGIES IN GREEN CHEMISTRY

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Abstract

Green chemistry is a revolutionary way of carrying out processes and developing products so that the use of hazardous materials will be minimized or altogether avoided to have a least negative impact on the environment. In a bid to provide a qualitative synthesis of the concepts in green chemistry, this paper seeks to establish ways and means by which it is possible to ensure that industrial processes produce minimal water pollution. Extinction of waste principle, principles in the design of safer chemicals and products, principles based on the use of renewable feed stocks and principles involving efficient use of energy. Thus, by applying these principles, industries are in a position to reduce their environmental impact, improve sustainability, and meet stricter regulatory requirements to the environment. The paper examines different real-life uses of green chemistry to control water pollution in areas like the textile, pharmaceutical, and agriculture industries. Moreover, the aspect of policy and regulation regarding the implementation of green chemistry practices is also discussed. The study emphasizes that the application of green chemistry provides not only environmental impacts, but economic impact regarding cost effect demonstrated in waste reduction and compliance cost. Thus, this study calls for more research efforts and integration of scientists, engineers, and policy makers in the improvement of green chemistry to make industrial practice sustainable.

Keywords:*Waste Prevention, Green Chemistry, Human Health, Pesticides, Fertilizers*

Introduction

The growth in the levels of environmental degradation puts pressure to the industries towards more sustainable processes. This pointed at water pollution as a major risk factor in the ecosystems exercise and the overall health of the population and economy. Routine conventional industrial procedures include the application of dangerous substances and may result in most of their waste products seeping into water sources. Thus, as understanding of the problem deepens across the world there is a need for industries to reorganize themselves to reduce their impact. Green chemistry, a concept that surfaces in the 1990s, presents an ideal solution for the above problem.

According to the definition given above to green chemistry, it is evident that green chemistry entails the designing of chemical products and processes that allows for minimal or no use and formation of hazardous materials at all. The concepts of green chemistry coined by Paul Anastas and John Warner spell out the guidelines for the environmentally friendly industrial process. These principles deal with the elimination of waste, use of renewable starting materials, better energy usage and better characteristics of the substances. Thus, following these recommendations, industries can develop the processes that are non-harmful to the environment and financially sustainable.

Prevention of waste is among the twelve principles of green chemistry. The conventional modes of manufacturing are known to create vast volumes of poisonous waste which need to be treated and discharged, thereby threatening the supply of water through seepage. Industries can thus design their processes in a manner that they produce little waste, and therefore, incur low waste management charges. For instance, the application of catalytic reactions which entail use of less reactants and generate minimal byproducts is one of the strategies in waste management.

Green chemistry also includes safer chemicals design as one of the decade’s goals. The regular employed chemicals in industrial operations are often acute, steady, and biomagnetical; hence, they have unfavourable effects on the environment over the long haul. Green chemistry seeks the creation of new materials and processes that are safer to the human beings and the surrounding ecosystem. It entails making a choice as to which materials should be utilized in the construction process, since they break down to mere nontoxic products. For instance in textile industries whereby conventional dyes can be replaced with bio degradeable dyes would reduce considerably the quantity of hazardous effluents that finds its way into water bodies.

Another aspect of Green Chemistry that is encompassed by renewable feedstocks is well known. Most production processes involve using materials that are exhaustible, and events that have negative impacts on the environment. Thus, they can come up with more environment-friendly products by using renewable resources like plant material. Apart from this, this transformation helps in the saving of resources from the natural face of the earth, in addition to cutting down the total emission of greenhouse gases emanating from the extraction and processing of raw materials.

Energy efficiency is another PHS of green chemistry which imposes a limit on the amount of energy that may be used in a chemical synthesis. Most Industries have relied on several techniques that are very energy intensive meaning that they release a lot of greenhouse gases and hence contribution to climate change adversely. Energy efficiency is practiced by green chemistry principles where there is preferred use of processes that work under standard conditions. For instance, in the synthesis of pharmaceuticals the very process of microwave-assisted synthesis can consume less energy than conventional heating methods.

Other elements include the following: An overview of policy and regulation frameworks particularly as it applies to green chemistry. Companies and the industries acting within them are heavily influenced by governments and various regulatory authorities that push for change through incentives, rules, and standards. Government policies such as research grants on green chemistry, project funding for sustainable chemistry, and increase in global environmental protection benchmark can encourage the practice of green chemistry.

Waste Management: Ensuring Environmental and Human Health

Waste management is also referred to as waste disposal whereby it can be defined as a course of action that is followed in the disposal of waste starting from when the waste is produced to the time it is disposed. This entails in the tasks of collection, transportation, treating and disposal of wastes as well as managing and supervising the process to ensure environmental standards are met. Waste management concerns several types of wastes such as industrial waste, biological waste, household waste, and the special wastes like the biomedical and the radioactive wastes which must be disposed differently. Moreover, it entails a sound legal and regulatory mechanism that governs the administration of waste and recycling. This way waste handling is done in such a manner that minimizes the impacts on the health of beings, depending on the type of waste. As shown in the tips stated above, it is evident that wastage could be reduced to a minimal and the ecosystem as well as the people’s health protected.

Collection and Transportation of Waste

One of them includes the collection of waste, which is the initial stage of waste management. This includes the collection of waste from households, businesses, and other organizations/institutions. Collection systems are pivotal prongs because they enable the scheduled and consistent removal of wastes. Various wastes should be collected in various processes; for example, biomedical and radioactive wastes have had to be collected separately and in special protected containers to avoid the spread of the disease or affected individuals coming into contact with radioactive materials. Afterwards, waste needs to be taken to treatment plants or dumpsites depending on its category. The handling of waste requires certain protocols to prevent any mishaps of spilling that will affect the living standards of society and the environment.

Treatment of Waste

Remediation is one of the stages that should be considered when dealing with waste. If the waste is hazardous, then special equipment and steps are required for treatment. The management of all these wastes can be done through processes like; burning or incineration, mounding or composting and recycling. Incineration encompasses burning of waste at very high temperatures in a bid to minimize its extent and transform it to energy. Composting is known as the biological degradation of organic matter with the aim of obtaining compost for agricultural purposes. Recycling is defined as taking waste products and subjecting them back through the process to create new products and copy originals hence saving resources and pollution. Sewage treatment involves physical removal of pollutants including filtration, sedimentation, and chemical treatment for the liquid waste before they are let out or recycled. Some of the control measures include scrubbing where unwanted gaseous effluent are either separated from other emission before being let out into the atmosphere.

Disposal of Waste

Waste disposal is the last process of waste management that involves the transfer of waste from the storage area to a disposal site. This involves burying of waste in dumps, burning, or through any other ways of disposal. A landfill therefore is an engineered facility that aims at disposing off waste while at the same time ensuring that wastes do not spread their effects all over the Land. Contemporary landfills have liners, leachate collecting systems, and gas removal structures to reduce the effect on the environment. Incineration previously mentioned, leads to volume reduction of waste and can produce energy; however, pollutants need to be well managed when burning waste. The following are other methods of waste disposal; hazardous liquid wastes are injected into deep wells and radioactive wastes of special types are encapsulated.

Regulatory Framework

The legal and regulatory systems of waste management is significant in approach to the management and disposal of wastes in a safer and ecological manner. Laws laid down specific ways how waste should be collected, transported, processed and disposed and more often they prescribed the waste generators to acquire permit and act accordingly. To check on aspects like the dumping of hazardous material and the like, regulating authorities conduct and enforce on checks on the firms. Also, regulations are put into place to ensure that there is a reduction in waste, alongside the development of better recycling standards by the setting of standards and installation of incentives for the reduction of waste generation and enhancement of recycling.

Impact on Human Health

From these works it becomes very clear that proper disposal of wastes is very vital in the protection of human health. Management of waste can also lead to polluting the air we breathe, water, and the surface we tread on which finally leads to health complications. For instance, where industrial wastes are dumped, population is at risk of getting respiratory diseases, skin rashes, and other illnesses due to exposure to hazardous chemical wastes. Collecting biomedical waste and not disposing of it correctly is a major way that infectious diseases are spread. Hazardous waste is radio-active waste which has long periods of emitting radiation and this can cause lots of harms to the health of people. Hence, by adhering to these techniques of waste disposal, people can avoid the occurrence of the above health hazards since every patient deserves a safe environment.

Special Types of Waste

A number of wastes have uniquely different characteristics that call for more demanding management measures citing the dangers affiliated with the casualties they can cause like biomedical and radioactive wastes. Health care waste comprises items within the biomedical wastage categories as those that are used in the health facilities, and these could contain infectious agents. This waste should be therefore characterized, collected, transported and disposed in a manner that relieves the infections. As we know radioactive waste emanates from nuclear power plants, medical treatment, and various research activities; thus, it requires appropriate management. They seek to have storage facilities that will confine radiation to prevent it from spreading within the environment.

Waste Management and Sustainability

Appropriate waste disposal that has little impact to the natural environment is very crucial in the conservation of natural resources. Here are generally outlined methods: recycling, composting, and utilizing renewable resources can help to cut the quantity of waste conveyed to landfills and lessen the usage of nonrenewablemateria. Besides, sustainable waste management assists in preventing climate change by offering ways of managing waste without emitting the gases, and the use of green energy.

WASTE DISPOSAL AND MANAGEMENT

Most of the waste materials originate from man and his undertakings like the discarding of material processed or used in extracting raw materials in organizations. Looking at the waste disposal and management system, there is a sharp difference between the developing and the developed nations. The stewardship practices also differ by the country, by area, whether rural or urban, and sort, whether the industrial or the residential.

Therefore, the general objective of waste management is the minimization of the impact of wastes on the environment, the wellbeing of living creatures, and appearance. Among the components of waste management, municipal solid waste management (MSW) is considered to be a crucial one. The Major part of MSW includes industrial waste, commercial waste and residential waste. However, the waste found in households is not the only type of the said solid waste in the world. Similarly any waste result from agricultural activities, medical, mining or any industrial activities are also considered to be solid waste.

Disposal of these wastes in the environment attracts pollution and degradation of the environment. Hence, there is a need to manage wastes and their disposal in a proper manner so that various living organism are not affected or the environment is not harmed. Spreading principles of efficient waste management can reduce considerably the detrimental effect of waste on the surrounding environment and improve the quality of life.

CONSEQUENCES OF IMPROPER WASTE DISPOSAL

Littering has many dangers and implications that a proper disposal of waste should address. If waste does not go to the garbage bin, it goes to the sewer. Some of this waste may be eaten by the cattle, but items such as metal hulks, glass, and polythene bags may jam up the sewerage system hence creating ‘headache and discomfort’.

The consumption of polythene bags by cattle is lethal to the animals. This underscores the necessity for people to adhere to the standard measures of waste management by actualising the act of taking domestic wastes and dumping them in waste bins for collection. Lack of proper waste disposal results in prevalence of diseases and in some extreme measure, epidemics because of waterborne diseases from contaminated water sources.

It is extremely risky for people who are in direct contact with waste for every now and then, especially rag pickers and waste disposal personnel. These individuals come in contact waste often using their bare hands and faces without any protective measures such as gloves and masks this exposes them to various diseases and illnesses. Proper waste disposal measures remain critical in conserving the environment and ensuring the health of the people since poor waste disposal is characterized by several negative impacts.

GREEN CHEMISTRY: A SUSTAINABLE APPROACH TO DEVELOPMENT

India was able to attain self-sufficiency in food production by the end of the twentieth century through the use of pesticides, fertilizers, improved techniques of farming, provision of irrigation and use of high-quality seeds. However, regular and intensive use of fertilisers and exploitation of soil degrades the soil, water and air substantially. Solving these environmental problems is possible only with unique approaches that do not negatively affect development but encourage it. It is at this point that Green Chemistry comes in handy. Green Chemistry is an approach's concept that breaks the traditional way of performing chemical processes. It centres on the concept that with advanced scientific information and process knowledge one can minimize or even eradicate the adverse effects that come with chemical manufacture. Green Chemistry is the creation of methods and techniques that will reduce the quantities and toxicity of products that are being formed at every stage while improving the efficiency. Stemming from basic concepts of chemistry and chemical engineering, Green Chemistry desires to accommodate modifications to the conventional manufacturing processes to be environmentally amicable. Industrial processes that have been employed for a long time are enemies to the environment since they pollute the environment and produce health-compromising wastes. Through incorporation of Green chemistry principle, industries will be in a position to minimize on formation of hazardous waste and in the case they exist, there will not be any harm posed to the environment.

Green Chemistry is guided by twelve fundamental principles, which provide a framework for designing safer chemicals and processes: The 12 principles of green chemistry include; prevention, atom economy, less hazardous chemical syntheses, designing safer chemicals, safer solvents and auxiliaries, energy efficiency, renewable feedstocks, minimizing the use of derivatives, catalysis, design for degradation, real-time analysis to prevent pollution and using inherently safer chemistry for accident prevention. These principles combined are primarily focused on reducing the effects of chemical processes and products on the natural environment. For instance the principle of prevention postulates that it is much cheaper to keep waste from happening than it is to scrub it up after it has happened. This can be attained in the following ways including coming up with methods that produce little or no waste hence relief pressure on waste management system. Atom economy in Green chemistry also attracts the formation of synthetic methods that guarantee utilization of all the materials and reagents in attaining the final product. This reduces the formation of being products and chemicals and improves the standards of chemical processes.

Safer chemicals design is the early step of developing chemical substances that can achieve the adequate purpose along with having lower likelihood of producing toxic impact. This can be done through reducing the toxicity of the reactants and other reagents used in the synthesis and employing the right conditions of the reaction that gives rise to safer products. One of the permissible principles implemented in chemical processes is the principle of safer solvents and auxiliaries as they should not be toxic and flammable and have a negative impact on the environment. This decreases the chances of employees coming across hazardous compounds and decreases the effects of chemical manufacturing on the environment. This concept entails a technical approach of saving energy in chemical processes through design. This can be done through conducting the reactions at room temperature and pressure, use of energy intense reactors, and efficient reaction control. The raw material utilisation for an item should be derived from renewable sources rather than consume non-renewable resources this is opted for by the renewable feedstocks match. This ensures the wise use of the natural resources hence cutting on the damages caused to the environment by chemicals.

The principle of minimization of the number of steps means avoiding or limiting blocking groups, protections/deprotections, and temporary changes in the physical and chemical characteristics. These steps also need more reagents and produce waste, which has threatened the environment in many regions across the globe. The principle of catalysis gives an impetus to the utilization of catalytic reagents, as compared to stoichiometric reagents, they are selective and work with higher efficiency. It must be noted that catalysts can accelerate the chemical processes and decrease the reagent consumption as well as lessen the amounts of by-products formed. Design for environment, one of the principles is design for degradation where the chemical products have to be designed in a way that the can be disassembled into non-harmful components when they are obsolete. This reduces the chances of accumulation of undesirable chemicals in the environment as well as their effects on the social structures. The concept of real time analysis for pollution control better focuses on the establishment of methodological frameworks that make it possible to detect pollution during the process and take corrective measures. This helps prevent occurrences of probably hazardous environments that may be incidences of certain calamities. The concept of confining inherently safer chemistry for accident prevention revolves with choosing the type of chemical that will not lead to an accident like a release, an explosion and or fire.

Thus, Green Chemistry is of paramount significance because it applies existing information to reduce chemical risks and foster developmental processes. Green Chemistry promotes the wise choice of materials and procedures to reduce the impact made on people's health and the environment. For instance, substitution of highly dangerous organic solvents such as toluene, benzene, and carbon tetrachloride reduce pollution of the environment. Chemical reactions are usually expected to work with definite reactants, mediums, and the certain conditions of pressure, temperature, and catalyst inclusive. Green Chemistry also supports the use of relatively less toxic media to avoid the synthesis of hazardous products. This approach is also advantageous in that it is beneficial to the environment while at the same time improving the chemical processes' output and productivity. For instance, employing water as the medium of reactions is preferred because of low volatility of water, its high specific heat, no flammability, relative cheap and non-carcinogenic disposition.

Greener Chemistry practices can be applied in rudimentary functions of people's day to day lives. In the dry cleaning of clothes, which is a petty demand for/environmental cleaning, earlier the chemical tetrachloroethylene (Cl2C=CCl2) was used as a solvent, though it has toxic and carcinogenic effects and has the tendency to pollute the ground water. Currently, liquid carbon dioxide CO2 has become the most preferred solvent than tetrachloroethylene for dry cleaning. Carbon dioxide in liquid state is significantly less dangerous to the ground water than the solidified CO2 and hence has a lower probability of polluting the water sources. Further, with the modern improvement, the use of hydrogen peroxide H2O2 has replaced the bleach and gives better results with lesser water consumption for washing clothes. Historically, chlorine was commonly used in the process of bleaching paper and is actually well known to seriously harm the environment. These days, hydrogen peroxide H2O2 with proper catalyst comes into used in place of chlorine and offers the same result of bleaching but has relatively much less harm on the environment as compared to chlorine. One more example of Green Chemistry practice is the displacement of the chlorine utilization in processes of paper bleaching and its substitution with hydrogen peroxide. In the pharmaceutical industry, the conventional manufacturing procedures are usually cumbersome and require many stages and the process entails production of a lot of waste and usage of toxic reagents. Green Chemistry can be defined as the scientific discipline that seeks to improve these processes to become cleaner. For instance, biocatalysis which involves the use of natural catalyst like protein enzymes are known to improve the selectivity and conversion hence requiring minimal hazardous chemical reagents and producing minimal waste.

Several case studies will demonstrate successful implementations of Green Chemistry principles. A good examples is the Warner-Lieberman Clean Production Act of the United States espousing the utilization of chemical processes that minimize or eliminate the use of dangerous substances. This legislative work has strengthen the integration of Green Chemistry in the different sectors, the benefits of which have been thorough in the returns in terms of reduction of environmental pollution and draw in of income. Another example is the EPA's Presidential Green Chemistry Challenge Awards providing incentives to advance the concept of green chemistry and to spread the use of chemical technologies that adhere to the principles of Green Chemistry. Accepted projects have also provided preeminent environmental impact by saving on hazardous wastes, resources, and energy. These awards focus upon the application of Green Chemistry advancements and their implications for large practice.

The precautions applied under Green Chemistry are highly useful for the environment and also cost-effective. Since the methods decrease the residual risk of hazardous waste production and increase process effectiveness, industries can cut expenses to become more competitive. Moreover, Green Chemistry enables corporations to meet and exceed customers and governments' expectations of environmental standards, thus avoiding legal consequences of violations. Moreover, Green Chemistry stimulates progress and creates new market niches for green goods and services.

Conclusion

Green chemistry therefore emerged as the right strategy in combating water pollution, especially in India, by using safer chemicals, less hazardous processes and with environmentally benign chemistries. Green chemistry principles such as use of catalysts, new solvent feathers, biodegradable reagents, and real-time characterization can help industries reduce their negative influences towards the environment with the same efficiency and profitability. The applicability of catalytic processes has been well demonstrated in the context of India's pharmaceutical and agrochemical industries in terms of optimization of environmental impacts, particularly with the reduction in toxic by products as well as the improvement in the quality of the water used in the processes. Efforts to replace and reduce solvents in industries such as pharmaceutical and textile showed a possibility of removing dangerous solvents and using environment friendly ones like supercritical CO2 thus reducing water pollution. The use of biodegradable chemicals in making of detergents, agriculture, and even in the pharmacy makes sure that these chemicals do not pollute the water since they decompose to harmless chemicals.

Presumably, the greatest source of influence on applying real-time monitoring and in-process controls is the mitigation of pollutants release into the environment. Through the process of monitoring and controlling chemical processes, industries can be able to achieve better results with regard to emission of chemicals and be output oriented. People and organizations, research institutions, nongovernmental organizations, government institutions, industries, and stakeholders in general should be educated on green chemistry with supporting research, development, and legislation from governmental institutions. The Indian government has, through policies and regulatory instruments influenced the industries to embrace green chemistry technologies by giving them incentives and funds for green activities.

Therefore, it is seen that the incorporation of green chemistry principles is necessary for water pollution control and water resource sustainability in India. With coordination with the government sectors, industries and universities and creating awareness among the publics, India can expand the use of green chemistry in order to reduce the deterioration of environment along with the health of the publics. Accepting the main principles of green chemistry, it will be possible not only to protect water resources but also to develop efficient industries, which are the basis for the further preservation of the environment in general.

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