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REVIEW ARTICLE

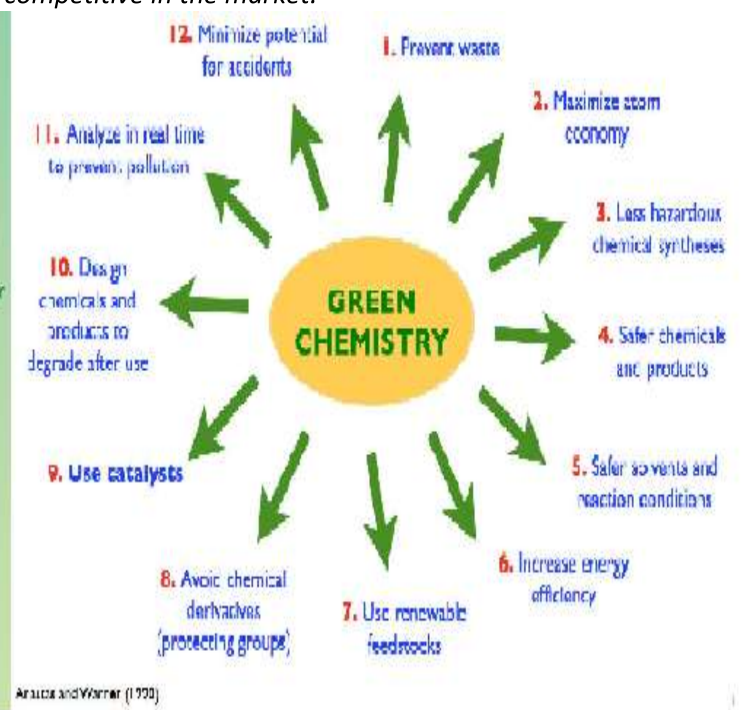
GREEN CHEMISTRY AS ZERO WASTE ALLIANCE

***Satyanand Tyagi[1], Dhrubo Jyoti Sen[2], Anil Kumar Gupta[3], Dron P. Modi[4], Parimal M. Prajapati[5], Pramod Singh Khatri[6], M. Priyanka[7], Naveen[8], Suraj B[9]**

[1]President & Founder, Tyagi Pharmacy Association (TPA) & Scientific Writer (Pharmacy), New Delhi, India.
[2]Department of Pharmaceutical Chemistry, Shri Sarvajanik Pharmacy College, Gujarat Technological University, Arvind Baug, Mehsana, Gujarat, India.
[3]Jyoti Vidyapeeth women's University, Jaipur, discipline of Pharmaceutical Science, Jaipur, Rajasthan, India.
[4]Department of Pharmaceutics, Arihant School of Pharmacy and Bio-Research Institute, Gandhinagar, Gujarat, India.
[5].K. Patel College of Pharmaceutical Education & Research, Samarth Campus, Gujarat Technological University, Himatnagar, Gujarat, India.
[6]Department of Pediatrics, AIIMS Hospital, New Delhi, India.
[7]Samskruti College of Pharmacy, Ghatekesar , Hyderabad, Andhra Pradesh, India.
[8]Sri Sri College of Ayurvedic Science and Research Hospital, 21st Km, Kanakapura Road, Udayapura, Bangalore, Karnataka, India.
[9]Vardhaman Mahavir Medical College (VMMC) & Safdarjung Hospital, Safdarjang Enclave, Safdarjung, New Delhi, India.

ABSTRACT:

Green chemistry consists of chemicals and chemical processes designed to reduce or eliminate negative environmental impacts. The use and production of these chemicals may involve reduced waste products, non-toxic components and improved efficiency. Green chemistry is a highly effective approach in pollution prevention because it applies innovative scientific solutions to real-world environmental situations. Chemical products and processes should be designed to the highest level of this hierarchy and be cost-competitive in the market.



Green Chemistry: Source Reduction/Prevention of Chemical Hazards, Design chemical products to be less hazardous to human health and the environment, Use feedstocks and reagents that are less hazardous to human health and the environment, Design syntheses and other processes to be less energy and materials intensive (high atom economy, low E-factor), Use feedstocks derived from annually renewable resources or from abundant waste, Design chemical products for increased, more facile reuse or recycling, Reuse or Recycle Chemicals, Treat Chemicals to Render Them Less Hazardous, Dispose of Chemicals Properly.

**chemicals that are less hazardous to human health and the environment are: Less toxic to organisms and ecosystems, Not persistent or bio-accumulative in organisms or the environment, Inherently safer with respect to handling and use.*

KEY WORDS: Recycling Process, Chemical waste, Municipal Waste, Waste Management, Industrial Waste, Green Waste, Brown Waste

**Corresponding author: Satyanand Tyagi | Email: sntyagi9@yahoo.com*

INTRODUCTION:

Chemical waste is a waste that is made from harmful chemicals mostly produced by large factories. Chemical waste may fall under regulations such as COSHH in the United Kingdom, or the Clean Water Act and Resource Conservation and Recovery Act in the United States. In the U.S., the Environmental Protection Agency (EPA) and the Occupational Safety and Health Administration (OSHA), as well as state and local regulations also regulate chemical use and disposal. Chemical waste may or may not be classed as hazardous waste.

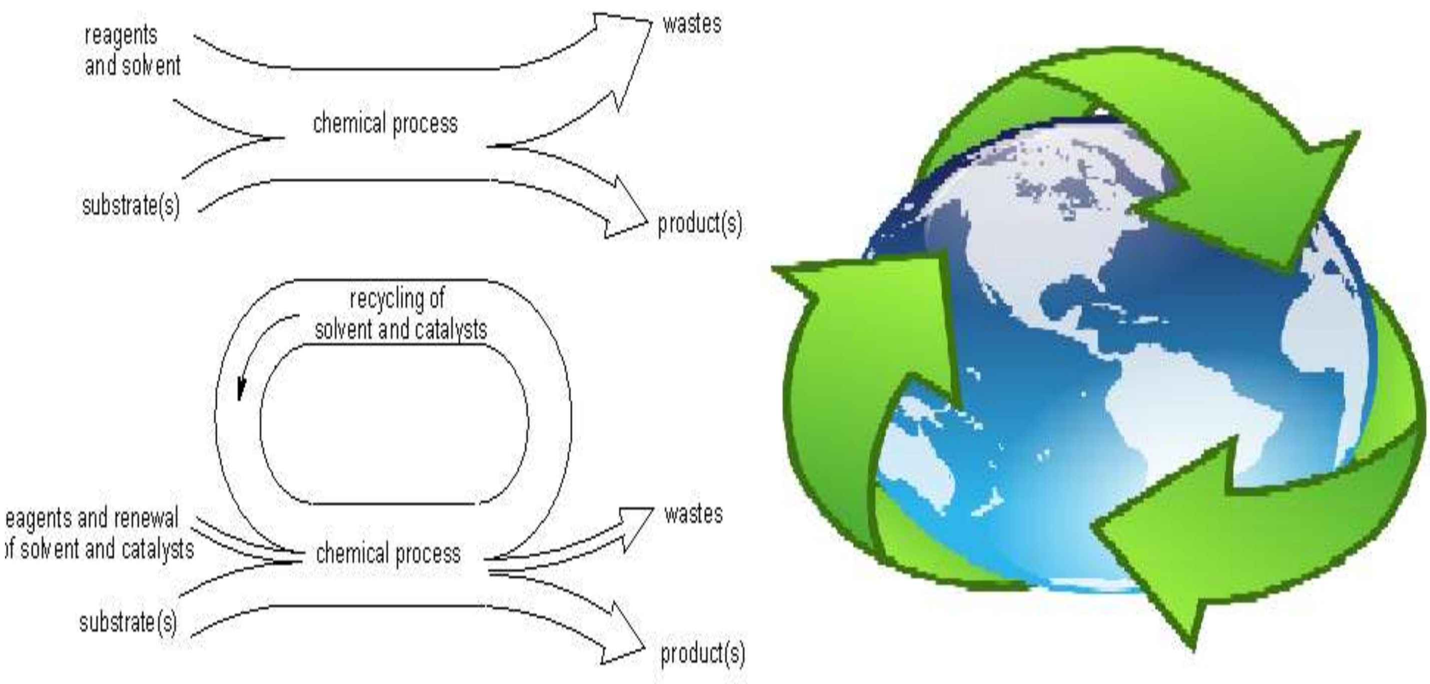


Figure: 1

Chemical waste includes the chemical by-products of large manufacturing facilities and laboratories, as well as the smaller-scale solvents and other chemicals disposed of by households. It may fall under the classification of hazardous waste, depending on the nature of the chemicals — for example, chemicals such as ethanol and glycerol don't require special disposal procedures. Health and safety legislation varies internationally and dictates the manner in which this waste must be handled and disposed of. In the United States, it is regulated by the Resource Conservation and Recovery Act as well as the Clean Water Act; while the Control of Substances Hazardous to Health Regulations (COSHH) regulates chemical waste in the UK. If chemical waste is not handled or disposed of properly, both the environment and nearby individuals are put at risk by its potentially corrosive, toxic, flammable or explosive nature. Proper handling of this waste first requires the separation of chemicals that may react with one another, such as salts from acids, hypochlorites and hydroxides from ammonia, and oxidizing substances from combustible substances. After it is properly separated, it should be safely stored in tightly-sealed drums, bottles, tins or jars that will not be corroded or otherwise affected by the contents.[1-3]

LABORATORY:

In the laboratory, chemical wastes are usually segregated on-site into appropriate waste carboys, and disposed by a specialist contractor in order to meet safety, health, and legislative requirements. Waste organic solvents are separated into chlorinated and non-chlorinated solvent waste. Chlorinated solvent waste is usually incinerated at high temperature to minimize the formation of dioxins. Non-chlorinated solvent waste can be burned for energy recovery. Innocuous aqueous waste (such as solutions of sodium chloride) may be poured down the sink; aqueous waste containing toxic compounds are collected separately. Waste elemental mercury, spent acids and bases may be collected separately for recycling. Broken glass wares are usually collected in plastic-lined cardboard boxes for landfilling. Due to contamination, they are usually not suitable for recycling. Similarly, used hypodermic needles are collected as sharps and are incinerated as medical waste.[4-6]

Municipal solid waste (**MSW**), commonly known as **trash** or **garbage** (US), **refuse** or **rubbish** (UK) is a waste type consisting of everyday items that are discarded by the public.

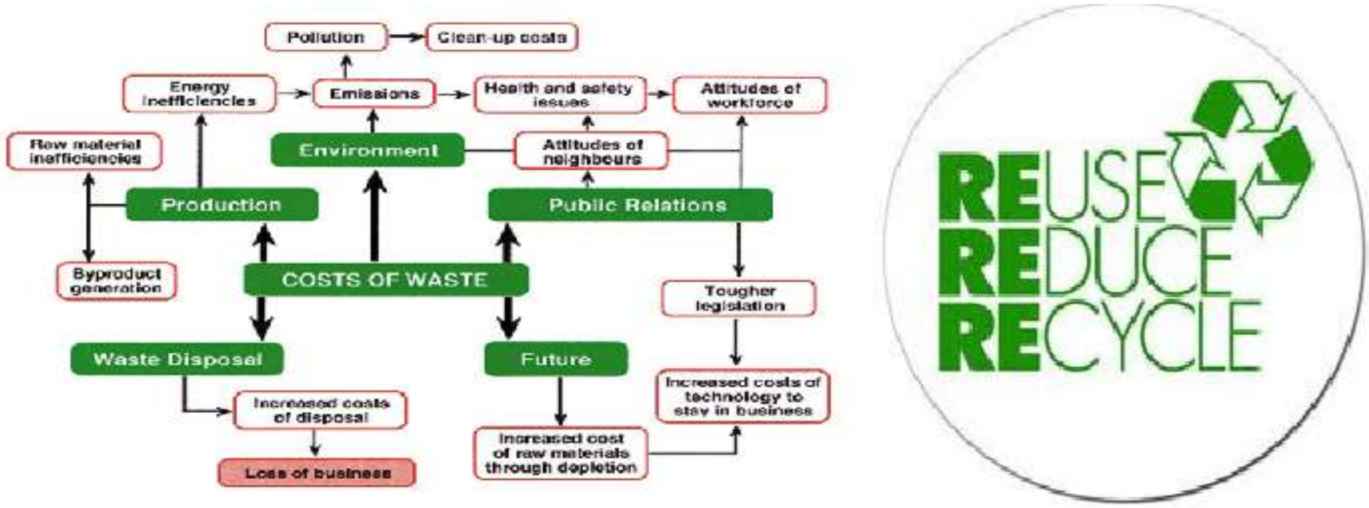


Figure-2: Reuse to Reduce by Recycle in Green Chemistry

COMPOSITION:

The composition of municipal waste varies greatly from country to country and changes significantly with time.

In countries which have a developed recycling culture, the waste stream consists mainly of intractable wastes such as plastic film, and un-recyclable packaging. At the start of the 20th century, the majority of domestic waste (53%) in the UK consisted of coal ash from open fires. In developed countries without significant recycling it predominantly includes food wastes, yard wastes, containers and product packaging, and other miscellaneous wastes from residential, commercial, institutional, and industrial sources. Most definitions of municipal solid waste do not include industrial wastes, agricultural wastes, medical waste, radioactive waste or sewage sludge. Waste collection is performed by the municipality within a given area. The term *residual waste* relates to waste left from household sources containing materials that have not been separated out or sent for reprocessing.[7] Waste can be classified in several ways but the following list represents a typical classification:

- Biodegradable waste: food and kitchen waste, green waste, paper (can also be recycled).
- Recyclable material: paper, glass, bottles, cans, metals, certain plastics, fabrics, clothes, batteries etc.
- Inert waste: construction and demolition waste, dirt, rocks, debris.
- Electrical and electronic waste (WEEE) - electrical appliances, TVs, computers, screens, etc.
- Composite wastes: waste clothing, Tetra Packs, waste plastics such as toys.
- Hazardous waste including most paints, chemicals, light bulbs, fluorescent tubes, spray cans, fertilizer and containers.
- Toxic waste including pesticide, herbicides, fungicides
- Medical waste. **Functional elements of solid waste**

The municipal solid waste industry has four components: recycling, composting, landfilling, and waste-to-energy via incineration. The primary steps are generation, collection, sorting and separation, transfer, and disposal. Activities in which materials are identified as no longer being of value and are either thrown out or gathered together for disposal.

Figure 3: Waste Disposal to Reduce Environmental Pollution

COLLECTION:

The functional element of collection includes not only the gathering of solid waste and recyclable materials, but also the transport of these materials, after collection, to the location where the collection vehicle is emptied. This location may be a material processing facility, a transfer station or a landfill disposal site.

WASTE HANDLING AND SEPARATION, STORAGE AND PROCESSING AT THE SOURCE:

Waste handling and separation involves activities associated with waste management until the waste is placed in storage containers for collection. Handling also encompasses the movement of loaded containers to the point of collection. Separating different types of waste components is an important step in the handling and storage of solid waste at the source.[9]

SEPARATION AND PROCESSING AND TRANSFORMATION OF SOLID WASTES:

The types of means and facilities that are now used for the recovery of waste materials that have been separated at the source include curbside collection, drop off and buy back centers. The separation and processing of wastes that have been separated at the source and the separation of commingled wastes usually occur at a materials recovery facility, transfer stations, combustion facilities and disposal sites.

TRANSFER AND TRANSPORT:

This element involves two main steps. First, the waste is transferred from a smaller collection vehicle to larger transport equipment. The waste is then transported, usually over long distances, to a processing or disposal site.

Figure 4: Waste Management

DISPOSAL:

Today, the disposal of wastes by land filling or land spreading is the ultimate fate of all solid wastes, whether they are residential wastes collected and transported directly to a landfill site, residual materials from materials recovery facilities (MRFs), residue from the combustion of solid waste, compost, or other substances from various solid waste processing facilities. A modern sanitary landfill is not a dump; it is an engineered facility used for disposing of solid wastes on land without creating nuisances or hazards to public health or safety, such as the breeding of insects and the contamination of ground water.[10]

ENERGY GENERATION:

Municipal solid waste can be used to generate energy. Several technologies have been developed that make the processing of MSW for energy generation cleaner and more economical than ever before, including landfill gas capture, combustion, pyrolysis, gasification, and plasma arc gasification. While older waste incineration plants emitted high levels of pollutants, recent regulatory changes and new technologies have significantly reduced this concern. United States Environmental Protection Agency (EPA) regulations in 1995 and 2000 under the Clean Air Act have succeeded in reducing emissions of dioxins from waste-to-energy facilities by more than 99 percent below 1990 levels, while mercury emissions have been by over 90 percent. The EPA noted these improvements in 2003, citing waste-to-energy as a power source "with less environmental impact than almost any other source of electricity."[11]

Waste management is the collection, transport, processing or disposal, managing and monitoring of waste materials. The term usually relates to materials produced by human activity, and the process is generally undertaken to reduce their effect on health, the environment or aesthetics. Waste management is a distinct practice from resource recovery which focuses on delaying the rate of consumption of natural resources. All wastes materials, whether they are solid, liquid, gaseous or radioactive fall within the remit of waste management. Waste management practices can differ for developed and developing nations, for urban and rural areas, and for residential and industrial producers. Management of non-hazardous waste residential and institutional waste in metropolitan areas is usually the responsibility of local government authorities, while management for non-hazardous commercial and industrial waste is usually the responsibility of the generator subject to local, national or international controls.[12-14]

Figure 5: Radioactive Waste Disposal

Radioactive wastes are wastes that contain radioactive material. Radioactive wastes are usually by-products of nuclear power generation and other applications of nuclear fission or nuclear technology, such as research and medicine. Radioactive waste is hazardous to most forms of life and the environment, and is regulated by government agencies in order to protect human health and the environment. Radioactivity diminishes over time, so waste is typically isolated and stored for a period of time until it no longer poses a hazard. The period of time waste must be stored depends on the type of waste. Low-level waste with low levels of radioactivity per mass or volume (such as some common medical or industrial radioactive wastes) may need to be stored for only hours or days while high-level wastes (such as spent nuclear fuel or by-products of nuclear reprocessing) the time frames in question range from 10,000 to millions of years. Current major approaches to managing radioactive waste have been segregation and storage for short-lived wastes, near-surface disposal for low and some intermediate level wastes, and deep burial or transmutation for the high-level wastes.[15]

A summary of the amounts of radioactive wastes and management approaches for most developed countries are presented and reviewed periodically as part of the International Atomic Energy Agency (IAEA) Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management.[1]

Green waste is biodegradable waste that can be composed of garden or park waste, such as grass or flower cuttings and hedge trimmings, as well as domestic and commercial food waste. The differentiation *green* identifies it as high in nitrogen, as opposed to *brown* waste, which is primarily carbonaceous.[16]

Green waste is often collected in municipal curbside collection schemes or through private waste management contractor businesses and subject to independent audit. Biogas captured from biodegradable green waste can be use as biofuel. Green waste can be used as non-food crop to produce cellulosic ethanol.

Figure 6: Industrial Waste

Brown Waste is any biodegradable waste that is predominantly carbon based. The term includes such items as dry leaves, twigs, hay, paper, sawdust, corn cobs, cardboard, pine needles or cones, etc. Carbon is necessary to composting, which uses a combination of green waste and brown waste to promote the microbial processes involved in the decomposition process. The composting of brown waste sustainably returns the carbon to the carbon cycle.[17]

Industrial waste is the waste produced by industrial activity, such as that of factories, mills and mines. It has existed since the outset of the industrial revolution. Penalties and fees are created as enforcement actions and to ensure that violating conditions are corrected in a timely manner to ensure consistent treatment of industrial dischargers; to eliminate economic advantages for violations; and to ensure that states recover expenses attributable to violations.[18]

CONCLUSION:

Green chemistry focuses on the reduction, recycling, and/or elimination of the use of toxic and hazardous chemicals in production processes by finding creative, alternative routes for making the desired products that minimize the impact on the environment. Green chemistry is a more eco-friendly green alternative to conventional chemistry practices. The green chemistry movement is part of a larger movement ultimately leading to a green economy- namely sustainable development, sustainable business and sustainable living practices. Green chemistry can contribute to achieving sustainability in three key areas. First, renewable energy technologies will be the central pillar of a sustainable high-technology civilization. Second, the reagents used by the chemical industry. Third, polluting technologies must be replaced by benign alternatives. The aim of the article is to acquaint the academicians, researchers, scientists and engineers with values and positive impact of green Chemistry in innovation, application and Technology. While Green chemistry offers principles for the development of 'greener' reagents and alternatives and more benign routes to synthetic methodologies, it does not have the capacity to bring about a radical change. A agreement has to be arrived at between the policy makers and the chemical practitioners in order to give Green chemistry the power it rightly deserve. And a policy needs to be frame to guide the practitioners so that overall efficiency as well as environmental cleanliness is achieved. It is reiterate that the espouse for Green chemistry must involve not only the academia or academic intelligentsia but also the science and technology agencies and the S&T administrators, since it is only a synchronized movement of these apparently segregated entities that can bring about a reform movement in chemistry and chemical technology. The role of the academia is to bring about a mass understanding about the pertinence of Green chemistry. This body must also take upon itself to device appropriate educational material for different levels of curricular instructions. The research and development and the science and technology agencies that are responsible for the funding of scientific activities in the country must encourage and give preference to the development of greener science and technology. In order to ensure global environmental protection while keeping scientific and economic development on the forefront, the policy makers should understand the role of 'green' science and technology and make pollution prevention, rather than pollution control, their slogan. Though it is true that many industries and research organizations are yet to implement the principles of Green chemistry, nevertheless some of them have begun to realize that the 'think green' culture is more than just a fashion. In fact, the winds of changes have already started blowing and the more successful chemistry researchers and chemical technologists will like to appreciate and apply the values of Green chemistry in innovation, application and teaching.

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