

# International Journal of Innovative Research in Science, Engineering and Technology

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## Green Chemistry: the Effects Describing Water Pollution and Supplies

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**ABSTRACT:** Conventional water treatment processes gradually become more inadequate with the identification of more and more contaminants in the water because of fast growth of population and industrial activities. Therefore, to overcome the challenges associated with traditional processes, there is rapid development of novel chemical technologies. But this growth has turned the attention of environmentalists to complementary actions, like monitoring environmental pollution, reduction of pollutants, and so on, to avoid the negative impacts. In this context, green chemistry solutions provide the most effective way to reduce the harmful effects of water treatment processes by taking into account energy, materials, resource economics, use, and generation of dangerous secondary material, and, finally, the life cycle of the products and their practical recycling into new materials. Some emerging water treatment technologies holding great promises in providing green alternatives for better protection of public health and the environment are discussed in this chapter. Advantages and disadvantages of these technologies are also compared to highlight their existing limitations and future research needs. Hence, it can be said that application of these technologies in association with the emergent knowledge and advances in the manufacturing industries will be highly beneficial to the entire mankind.

**KEYWORDS:** green chemistry, water pollution, supplies, public health, beneficial, resource

### I. INTRODUCTION

Green chemistry is the design of chemical products and processes that reduce or eliminate the use or generation of hazardous substances. Green chemistry applies across the life cycle of a chemical product, including its design, manufacture, use, and ultimate disposal.[1,2]

Green chemistry:

- Prevents pollution at the molecular level
- Is a philosophy that applies to all areas of chemistry, not a single discipline of chemistry
- Applies innovative scientific solutions to real-world environmental problems
- Results in source reduction because it prevents the generation of pollution
- Reduces the negative impacts of chemical products and processes on human health and the environment
- Lessens and sometimes eliminates hazard from existing products and processes
- Designs chemical products and processes to reduce their intrinsic hazards

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Green chemistry reduces pollution at its source by minimizing or eliminating the hazards of chemical feedstocks, reagents, solvents, and products.

This is unlike cleaning up pollution (also called remediation), which involves treating waste streams (end-of-the-pipe treatment) or cleanup of environmental spills and other releases. Remediation may include separating hazardous chemicals from other materials, then treating them so they are no longer hazardous or concentrating them for safe disposal. Most remediation activities do not involve green chemistry. Remediation removes hazardous materials from the environment; on the other hand, green chemistry keeps the hazardous materials out of the environment in the first place.[3,4]

If a technology reduces or eliminates the hazardous chemicals used to clean up environmental contaminants, this technology would qualify as a green chemistry technology. One example is replacing a hazardous sorbent [chemical] used to capture mercury from the air for safe disposal with an effective, but nonhazardous sorbent. Using the nonhazardous sorbent means that the hazardous sorbent is never manufactured and so the remediation technology meets the definition of green chemistry.

The increasing occurrence of environmental contamination due to anthropogenic activities is alarming environmental and health authorities. Growing awareness regarding environmental protection, environmental pollution prevention, safer industrial ecology and cleaner production technologies has propelled tremendous efforts towards eliminating pollution problems and protecting public health and the environment. Green chemistry is a key necessity to eliminate or minimize any side effects of remediation activities towards contaminated water, air and soil. Many materials and processes have been developed for green environmental applications.[5,6]

To prevent the intensity of water pollution, effective safety measures should be employed that prevent point-source and nonpoint-source pollution. Green chemistry solutions should be employed, where possible. An effective way to deal with the water pollution problem is to use the minimum harmful ways to exclude contaminants. Chromatography methods and separation chemistry principles offer a variety of motivating methods to attain these goals. Interesting examples of remediation have been provided to assistance correct contamination of groundwater, which affects nearly hundred million people worldwide. A variability of novel methods has been included for prevention and remediation of water pollution that occasion radical reaction and the utilization of advanced advanced nano-based techniques

Water resources are finite and the population that depends on those supplies is increasing inexorably. Virtually all of the global environmental impacts attributable to this population growth have contributed severe impacts on water resources. These include deforestation resulting from the demand for agricultural land, housing, and fuel; loss of biological species in forests and in waters; pollution of fresh and marine waters, further depleting food sources; introduction of persistent organic pollutants into the ecosystem etc. To prevent the concentration of water pollution, efficient safety measures have be employed that prevent point-source and nonpoint-source pollution. [7,8] Green chemistry solutions should be employed, where it is possible. An effective way to deal with the water pollution problem is to use the least harmful ways to prohibit contaminants. Chromatography methods and separation chemistry principles offer a variety of encouraging methods to attain these attainable goals. Proper remediation has been provided to aid correct contamination of groundwater, which affects nearly hundred million people worldwide.

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A variability of novel methods has been included for prevention and remediation of water pollution that occasion radical reaction and the utilization of advanced nano-based techniques.

Heavy metals are well-known environmental pollutants due to their toxicity, persistence in the environment, and bioaccumulative nature. Their natural sources include weathering of metal-bearing rocks and volcanic eruptions, while anthropogenic sources include mining and various industrial and agricultural activities. Mining and industrial processing for extraction of mineral resources and their subsequent applications for industrial, agricultural, and economic development has led to an increase in the mobilization of these elements in the environment and disturbance of their biogeochemical cycles.[9,10] Contamination of aquatic and terrestrial ecosystems with toxic heavy metals is an environmental problem of public health concern. Being persistent pollutants, heavy metals accumulate in the environment and consequently contaminate the food chains. Accumulation of potentially toxic heavy metals in biota causes a potential health threat to their consumers including humans. Here comprehensively reviews the different aspects of heavy metals as hazardous materials with special focus on their environmental persistence, toxicity for living organisms, and bioaccumulative potential. The bioaccumulation of these elements and its implications for human health are discussed with a special coverage on fish, rice, and tobacco. The article will serve as a valuable educational resource for both undergraduate and graduate students and for researchers in environmental sciences. [11] Environmentally relevant most hazardous heavy metals and metalloids include Cr, Ni, Cu, Zn, Cd, Pb, Hg, and As. The trophic transfer of these elements in aquatic and terrestrial food chains/webs has important implications for wildlife and human health. It is very important to assess and monitor the concentrations of potentially toxic heavy metals and metalloids in different environmental segments and in the resident biota. A comprehensive study of the environmental chemistry and ecotoxicology of hazardous heavy metals and metalloids shows that steps should be taken to minimize the impact of these elements on human health and the environment.[12]

## II. DISCUSSION

Several chemical analysis methods are there, that are both used for chemical identification and concentration determination, whether conventionally or instrumentally. The conventional chemical analysis methods evaluated in this chapter include volumetric and gravimetric, while the instrumental ones presented are limited to atomic absorption spectrometry (AAS) and X-ray fluorescence (XRF) for determination of the analyte concentration, and Infrared spectrometry (IR) and X-ray diffraction (XRD) for chemical identification. Additionally, the pollutant removal methods involving conventional and advanced processes occur. The conventional chemical removal methods such as precipitation, coagulation, and adsorption are illustrated. The advanced methods in removing chemical pollutants discussed in this chapter are photocatalytic degradation, photo-oxidation/reduction, Fenton and Photo-Fenton,[13] and ozonation. In the description of the chemical analysis and the chemical pollutant removal methods, the evaluation of the unsuitableness or suitableness toward some of the Green Chemistry principles are also accompanied. In addition, the ways to make the less green methods to be greener are also known.

The aim of green chemistry is to reduce chemical-related impact on human health and virtually eliminate contamination of the environment through dedicated, sustainable prevention programs. Green chemistry searches for alternative, environmentally friendly reaction media and at the same time strives to increase reaction rates and lower reaction temperatures.

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The green chemistry concept applies innovative scientific solutions to solve environmental issues posed in the laboratory. Paul T. Anastas, an organic chemist working in the Office of Pollution Prevention and Toxins at the EPA, and John C. Warner developed the Twelve Principles of Green Chemistry in 1991. These principles can be grouped into "Reducing Risk" and "Minimizing the Environmental Footprint." [14,15]

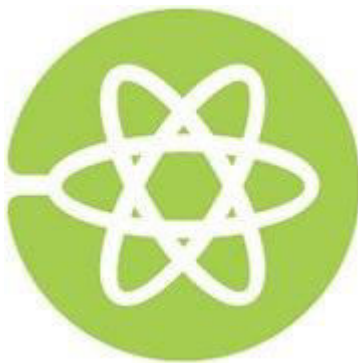
## The Principles & Green Chemistry Examples



### 1. Prevention

It is better to prevent waste than to treat or clean up waste after it has been created.

**Example: Certain ZooMAb<sup>®</sup> Antibodies**



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## 2. Atom Economy

Synthetic methods should be designed to maximize the incorporation of all materials used in the process into the final product.

**Example: Re-engineered Product XPhos**



## 3. Less Hazardous Chemical Syntheses

Wherever practicable, synthetic methods should be designed to use and generate substances that possess little or no toxicity to human health and the environment.

**Example: Certain Solvents & Building Blocks**



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## 4. Designing Safer Chemicals

Chemical products should be designed to affect their desired function while minimizing their toxicity.

**Example: Certain Thermometers & ZooMAb<sup>®</sup> Antibodies**



## 5. Safer Solvents and Auxiliaries

The use of auxiliary substances (e.g., solvents, separation agents, etc.) should be made unnecessary wherever possible and innocuous when used.

**Example: Greener Solvents**



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## **6. Design for Energy Efficiency**

Energy requirements of chemical processes should be recognized for their environmental and economic impacts and should be minimized. If possible, synthetic methods should be conducted at ambient temperature and pressure.

**Example: Certain Antibodies, Enzymes, etc.**



## **7. Use of Renewable Feedstocks**

A raw material or feedstock should be renewable rather than depleting whenever technically and economically practicable.

**Example: Biobased Solvents**



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## 8. Reduce Derivatives

Unnecessary derivatization (use of blocking groups, protection/ deprotection, temporary modification of physical/chemical processes) should be minimized or avoided if possible, because such steps require additional reagents and can generate waste.



## 9. Catalysis

Catalytic reagents (as selective as possible) are superior to stoichiometric reagents.

**Example: Certain Transition Metal Catalysts**



## 10. Design for Degradation

Chemical products should be designed so that at the end of their function they break down into innocuous degradation products and do not persist in the environment.



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**Example: Biodegradable Surfactants**



## **11. Real-time Analysis for Pollution Prevention**

Analytical methodologies need to be further developed to allow for real-time, in-process monitoring and control prior to the formation of hazardous substances.



## **12. Inherently Safer Chemistry for Accident Prevention**

Substances and the form of a substance used in a chemical process should be chosen to minimize the potential for chemical accidents, including releases, explosions, and fires.

**Example: Certain Grignard Reagents in 2-MeTHF**

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## III. RESULTS

Environmental issues such as water pollution, climatic changes, air pollution and renewable energy have become important issues in our daily life. Many people think that chemistry as well as chemical industries are harmful to the environment.[16] However, nowadays many new advances and scientific researches in the field of chemistry are developed to invent more environment friendly applications and objects, while they held keep up with the lifestyle we expect. An example of environment friendly chemistry is ‘**Green chemistry**’

Green chemistry is the utilization of some principles that reduce or eliminate the use of hazardous substances in design, manufacture and application of chemical products.

### Principles of green chemistry:

1. i) **Minimum toxicity** : Way of production should be well designed to minimize the incorporation of all the reactants used in the process to carry out the final product.
2. ii) **Renewable materials**: Auto regenerating
- iii) **No solvents**: For washing, cleaning and binding the materials a huge amount of several solvents are used which are toxic to environment. Thus use of solvents should be reduced.
1. IV) **Catalytic -energy efficient**: Energy requirement should be minimized.
2. v) **Avoid waste**: Raw materials or residue should be renewable instated of depleting into the open place.
3. vi) **Safe ingredients**: Prevention of accidental risk by proper analytical methods.[17]

### Advantages of green chemistry:

1. i) **Environmental benefit**:
2. a) Fewer raw materials and natural resources are used.
3. b) It reduces the emission and product impacts.
4. c) Lower levels of chemicals are released to the environment.
- ii) **Business benefits**:
1. a) It improves the resource efficiency and lowers the material and utility bills.
2. b) It reduces waste treatment and disposal costs.
3. c) Improve health and safety for staff members.

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**Chemists** are now researching new methods that are more environmental friendly and sustainable. Such examples are given below.

## i) **Biofuels:**

It can be obtained from biomass which is coming from Sugar cane, Rapeseed, Corn, Straw, Wood, Animal and Agriculture residues.

### **Example: Bio-diesel:**

**Bio-diesel** is produced from oil or fat through a process called “ **transesterification** “. The yield which is burnt in diesel engine with hydrocarbons and reduces the petroleum fuel consumption as well as toxic gaseous substances.[17]

## ii) **Lighter vehicles preparation, reduced costs and carbon dioxide emission.**

The modern “ Polyesters “ reduce the quantity of foam used in the seats of the car, decreasing its weight sufficiently. It reduces the fuel consumption and carbon dioxide emission into atmosphere.

## iii) **Bio plastics:**

Bio plastics are derived from renewable biomass sources such as corn starch, vegetable oils and fats. It is used for disposable items such as packaging, pots, crockery, bowls, etc.

iv) **New Lighting technologies:** OLEDs (organic light emitting diodes) which produce more light with lower energy consumption.

## v) **Unleaded petrol:**

Octane number (higher the octane number better is the quality of petrol) to petrol can be increased without addition of lead components e.g. TEL (tetra ethyl lead) .

Unleaded petrol is obtained by adding methyl tertiary butyl ether (MTBE) which supplies oxygen of petrol and hence reducing the formation of per-oxy compounds.[18]

## vi) **Nonpetroleum fuels:**

**Power Alcohol:** When ethyl alcohol is used in an internal combustion engines, it is called “ power alcohol “. It is mixed with Gasoline in the ratio of 4:1 to increase its octane number.

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In India ethyl alcohol is manufactured from molasses. It is the dark brown mother liquor residue left after the crystallization of sugar, glucose and fructose. As a result a huge amount of residue is consumed and reduces the pollution.

**Benzol:** It is an important side- product of coal carbonization. It is also derived from the fractional distillation of light oil. It is a mixture of benzene (70%), Toluene (18%) and Xylenes (6%) with other hydrocarbons.[16]

It can be used as a component of motor fuels due to its high anti knocking value and hence it reduced the fuels consumption as well as toxic pollutants.

## IV. CONCLUSIONS

Green chemistry is the discipline of chemistry concerned with the design and optimisation of products and processes to reduce or eliminate the production and the use of harmful substances. Environmental chemistry is not the same as green chemistry. Green chemistry, is also known as sustainable chemistry.[19]

While environmental chemistry concentrates on the impacts of polluting chemicals on the environment, green chemistry focuses on chemistry's environmental impact, such as lowering nonrenewable resource usage and technological approaches to pollution prevention.

The overall goals of green chemistry—more resource-efficient and naturally safer design of molecules, materials, products, and processes—can be pursued in a variety of contexts. The use of supercritical carbon dioxide as a green solvent is one of the major achievements of advances in green chemistry.

### Benefits

- Less dangerous chemicals are released into the air, resulting in less lung damage
- Less dangerous chemical waste is released into the water, resulting in cleaner drinking water
- Chemical workers will be safer since fewer harmful compounds are used, less personal protective equipment will be required, and also it will reduce occurrences of accidents
- New, safer consumer products will be available for purchase; some products will be manufactured with less waste, and some will be substitutes for less safe products
- Elimination of persistent toxic compounds that can infiltrate the food chain

### Principles of Green Chemistry

- **Prevention**

It is preferable to prevent waste rather than treat or clean up garbage that has already occurred.

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- **The Atomic Economy**

Synthetic procedures should be devised to incorporate all components utilised in the process as much as possible into the final result.

- **Chemical Syntheses that aren't as dangerous**

Synthetic processes should be designed to employ and manufacture compounds that are low or non-toxic to human health and the environment whenever possible.[17]

- **Creating Safer Chemicals**

Chemical products can be designed to perform their intended function while being as harmful as possible.

- **Auxiliaries and safer solvents**

Auxiliary compounds should be avoided if possible and used only when necessary.

- **Designing for energy savings**

Chemical processes and energy requirements should be recognised for their financial and environmental consequences and should be minimised. Synthetic techniques should be carried out at room temperature and pressure if possible.

- **Renewable feedstocks**

When technically and economically feasible, raw material or feedstock must be renewable rather than diminishing.

- **Derivatives should be reduced**

Derivatization that isn't required should be reduced or avoided if possible, as it consumes more reagents and produces waste.

- **Catalysis**

Stoichiometric reagents are inferior to catalytic reagents.[19]

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- **Degradation-friendly design**

Chemical products should be intended to degrade into harmless products and not stay in the environment once they have served their purpose.

- **Pollution prevention through real-time analysis**

Analytical procedures must be improved to enable real-time, in-process control and monitoring before forming hazardous compounds.

- **Inherently accident Prevention through safer chemistry**

To reduce the risk of chemical accidents, such as releases, explosions, and fires, substances and the form of a substance utilised in a chemical process should be carefully selected.

## **Tools of Green Chemistry**

Tools for predicting environmental attributes early in the design process, investigating green chemistry alternatives, and designing molecules with minimal environmental implications are as follows:

- The EPA's EPI Suite examines physical and chemical attributes and environmental fate estimation, models
- Green chemistry reactions and reaction conditions can also be designed using the Green Chemistry Expert System (GCES)
- The Program for Supporting the Substitution of Industrial Solvents (PARIS II)
- The software was built to find solvents with similar qualities but less damaging to the environment as replacements for currently used solvents

## **Tools for Evaluating the Environmental Impact of Process Designs**

- Comparison of environmental and non-environmental process criteria simultaneously
- Algorithm for Waste Reduction
- Chemical and other Environmental Impacts Reduction and Assessment Tool
- Tools for estimating pollution discharge from processes into the atmosphere
- For emission factors for significant equipment and fugitive sources, use Air CHIEF CD9
- EPA10's TANKS 4.0 program for storage tanks
- For wastewater treatment, use WATER 8 on Air CHIEF CD11
- CHEMDAT 8 is a treatment proper disposal facility process on the Air CHIEF CD

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## Alternative Tool For Reducing Pollution

Green chemistry is a way of thinking and applying existing knowledge to lessen pollution's negative effects on the environment. Green chemistry can also be viewed as a method of manufacturing that reduces pollution in the environment. Byproducts are produced during every process, and if they are not effectively utilised, they contribute to environmental contamination. If the byproducts aren't used, these operations are inefficient. The processes of waste generation and disposal are both economically problematic. The foundation of green chemistry is the application of knowledge to reduce chemical hazards in development activities.

If all chemical reactants are transformed into usable products in a chemical reaction, no chemical waste is produced. As a result, there will be no pollution in the environment. This is only possible if the reaction conditions are optimised. Green chemistry has a wide range of applications in our daily lives. The following examples will demonstrate its utility:

- **Dry cleaning of clothes**

Tetrachloroethylene was once used as a solvent for dry cleaning. This substance is cancer-causing and pollutes groundwater. This is done nowadays with liquid carbon dioxide and an appropriate detergent. It produced liquid carbon dioxide as a byproduct, resulting in less pollution.

- **Bleaching of paper**

Originally, chlorine gas was used for this process, but currently, hydrogen peroxide is used instead. The bleaching activity of hydrogen peroxide is aided by using a suitable catalyst.

Green chemistry promotes a healthy environment for society, and we should all follow this as responsible citizens. A world free of pollution will improve the surrounding atmosphere and extend the life of the planet's inhabitants.

Green chemistry's ultimate goal is to eliminate the flow of chemicals into the environment. This goal may appear unreachable at this time. Still, advancements in green chemical research and their implementation through consecutive techniques will undoubtedly result in safer specialised chemicals and more adequate procedures for the chemical industry.[20]

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