The Pharma Innovation Journal 2018; 7(6): 712-715

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.03
TPI 2018; 7(6): 712-715

www.thepharmajournal.com
Received: 24-04-2018
Accepted: 29-05-2018

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# Green chemistry for sustainable development and environment protection

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**Abstract**
A latest study by the National Oceanic and Atmospheric Administration (NOAA), the US claims that the source of alarming level air pollution in urban spaces has budged to other Volatile Chemical Products (VCPs), or everyday products such as pesticides, coatings, printing inks, adhesives, cleaning agents and personal care. Such highly sought products contain organic solvents, which are major sources of contaminants called Volatile Organic Compounds (VOCs). These facts of study conducted by NOAA are also echoed in a study published in journal called Science. The study published confirms that pollution from chemical products used indoors is usually more dangerous than outdoor pollution. Also a lot of regulatory laws, newer treaties and agreements across globe indicate for alarming situation of steep environmental deterioration. There the paper presented is an attempt to envisage the role of green chemistry in sustainable development through greener processes and products. In this paper an attempt is made to highlight the need and importance of green chemistry, principles that guide and environmental initiative taken so far. The crux of the study is presented in form of suggestions to promote green chemistry for greener tomorrow.

**Keywords:** Environment, sustainable development and consumerism

## Introduction
The importance of chemistry can be accounted to extreme wonders of science and technology, from farther space to deeper in earth, chemistry has played a pivotal role. Still the relevance of substance is subject to philosophical dichotomy of opinion, one such contrast opinion is chemical culpability; something to afraid of and avoid. This augment a debate on complexity of pros and cons of the field. Throughout the globe, medical and agricultural revolution to sustain health and feed to humans can't be actualized in absence of chemistry. But everything comes with a price tag, present day environment deterioration is being blamed by environmentalists and public.

The industrial revolution of the west in early 20$^{th}$ century creeped in the boundaries across all the continents. Producing at larger scale required high inputs and mass processing resulting in bulk production. Such phenomena in the market ultimately paved way for consumerism. Consumerism is consuming commercial products more and more to satisfy human wants. In hundred years of industrialization, industrial litters as well as redeems have smoked chemicals in the air, streaked chemicals in to water, variegated chemicals in to the soil posing a threat to environment and sustainable development (Johnson, 1999) [8]. For instance, the Dichloro Diphnyl Trichloroethane (DDT) is a pesticides belonging to organochlorides, primarily and widely used by farmers to protect agricultural produces. It is a synthetic chemical compound that doesn't occur in nature, it is colorless and crystalline solid. DDT can't be dissolved in water, but it is easily dissolved in organic solvents, fats, or oils. Since it can liquefy in fats and can build up in the fatty tissues of animals exposed to it. Such kind of tissue amassing is known as bioaccumulation. Environmental Protection Agency (EPA) has labeled DDT as a persistent, bioaccumulative toxin. Due to this bioaccumulation, DDT remains in the food chain. It moves from crayfish, frogs, and fish into the bodies of animals that eat them. The bodies of animals near the top of the food chain, such as predatory birds like eagles, hawks, pelicans, condors and other meat-eating birds, often have the highest DDT levels. It effects deadly on health of all creatures including humans as a cumulative toxin in food intake. DDT also has serious health effects on humans. According to the EPA, DDT can cause liver damage including liver cancer, nervous system damage, birth defects, and other reproductive harm. This is just an example where a boon turned in to bane.

**Evolution of Green Chemistry**

Early work on concept of chemistry was recorded late 20th century. Initially the concept Green Chemistry has evolved by the way of different basic concepts like Environmentally Benign Chemistry, Clean Chemistry, Atom Economy, Benign and Design Chemistry and Sustainable Chemistry. Green chemistry is swiftly becoming a trusted tool to improve profits, social and ecological concern of the organizations (Gaskill, 2000) [6]. Green chemistry can be defined as a particular type of pollution prevention initiative for sustainable development of society taken by chemists. Only green chemistry cannot solve the purpose of ecosystem protection, the approach only explores various methods useful for changing intrinsic nature of products and processes so that inherited risk to environment can be lowered down. Green chemistry encompasses devising as well as reengineering chemical syntheses and chemical products to prevent environmental compromises. Green chemistry is a fresher way of using chemicals in industrial production to minimize the negative effect on natural resources (Anastas and Warner, 2008).

Industries are now looking for greener approaches for chemical processes involved in production of goods. Industrial researchers are joining hands with academicians and freelance research organizations for better substitutes of chemical processes. Big organizations have understood the importance of going green, smalls are on the way of learning. The organic wastes of industries which is potentially harmful to health and the environment are primarily produced in the synthesis stage of manufacturing processes. Many such synthetic unit process, such as halogenation, oxidation, alkylation, nitration and suffocation are common to a large number of organic chemical manufacturing in several different industrial sectors. Adopting cleaner unit processes can significantly reduce the negative impact of organic chemical syntheses. Such integrated efforts being green and environment friendly is adding in to the image of company and products.

**International Environmental Laws**

International Environmental Law (IEL) is concerned with the attempt to control pollution and the depletion of natural resources within a framework of sustainable development. IEL covers topics such as population, biodiversity, climate change, ozone depletion, toxic and hazardous substances, air, land, and sea and transboundary water pollution, conservation of marine resources, desertification, and nuclear damage.

Key Declarations and Treaties at international level

Declarations

Two major declarations on international environmental law are:

1. The Declaration of the United Nations Conference on the Human Environment (the 1972 Stockholm Declaration) (UN Doc. A/CONF/48/14/REV.1 (1972). This declaration represented a first major attempt at considering the global human impact on the environment, and an international attempt to address the challenge of preserving and enhancing the human environment. The Stockholm Declaration espouses mostly broad environmental policy goals and objectives rather than detailed normative positions. The UN website provides introductory information, procedural history and preparatory documents associated with the Declaration, as well as the full text of the Declaration.
2. The Rio Declaration on Environment and Development (UN Doc. A/CONF.151/26 (vol. I)) was a short document produced at the 1992 United Nations Conference on Environment and Development (UNCED), known as the Rio Earth Summit. The Rio Declaration consists of 27 principles intended to guide future sustainable development around the world. Treaties

Customary law and general principles relating to the environment, such as the 'precautionary principle' and sustainable development, are evolving but it is arguable whether any have yet become normative rules. The speed with which awareness of global environmental problems has reached the international political agenda has meant that customary law has tended to take second place to treaty law in the evolution of legal norms, and treaties have been the main method by which the international community has responded to the need to regulate activities which threaten the environment. There are hundreds of bilateral and multilateral environmental treaties creating states' rights and obligations. The UN Environment Program (UNEP) and the UN Commission on Sustainable Development have negotiated many of these treaties.

Treaties generally concern one of the following broad subjects: toxic and hazardous substances, nuclear damage, ocean and marine sources, ozone and protection of the atmosphere, pollution, biodiversity and the protection and conservation of species and wildlife, sustainable development, and trade and the environment.

1. Vienna Convention for the Protection of the Ozone Layer, 1985, and Montreal Protocol on Substances that Deplete the Ozone Layer, 1987
2. Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, 1989
3. Convention on Biological Diversity, 1992, and Cartagena Protocol on Biosafety to the Convention on Biological Diversity, 2000
4. United Nations Framework Convention on Climate Change, 1992 (UNFCCC)
5. Kyoto Protocol to the United Nations Framework Convention on Climate Change, 1997
6. United Nations Convention to Combat Desertification in those Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa, 1994 (UNCCD)
7. Convention on the Law of the Non-Navigational Uses of International Watercourses, 1997

**Environment Laws in India**

The need for protection and conservation of environment and sustainable use of natural resources is reflected in the constitutional framework of India and also in the international commitments of India. The Constitution under Part IVA (Art 51A-Fundamental Duties) casts a duty on every citizen of India to protect and improve the natural environment including forests, lakes, rivers and wildlife, and to have compassion for living creatures. Further, the Constitution of India under Part IV (Art 48A-Directive Principles of State Policies) stipulates that the State shall endeavour to protect and improve the environment and to safeguard the forests and wildlife of the country.

Several environment protection legislations existed even before Independence of India. However, the true thrust for putting in force a well-developed framework came only after

the UN Conference on the Human Environment (Stockholm, 1972). After the Stockholm Conference, the National Council for Environmental Policy and Planning was set up in 1972 within the Department of Science and Technology to establish a regulatory body to look after the environment-related issues. This Council later evolved into a full-fledged Ministry of Environment and Forests (MoEF).

MoEF was established in 1985, which today is the apex administrative body in the country for regulating and ensuring environmental protection and lays down the legal and regulatory framework for the same. Since the 1970s, a number of environment legislations have been put in place. The MoEF and the pollution control boards ("CPCB", ie, Central Pollution Control Board and "SPCBs", ie, State Pollution Control Boards) together form the regulatory and administrative core of the sector.

Some of the important legislations for environment protection are as follows:

1. The National Green Tribunal Act, 2010
2. The Air (Prevention and Control of Pollution) Act, 1981
3. The Water (Prevention and Control of Pollution) Act, 1974
4. The Environment Protection Act, 1986

These important environment legislations have been briefly explained in the succeeding paragraphs.

**1. The National Green Tribunal Act, 2010**

The National Green Tribunal Act, 2010 (No. 19 of 2010) (NGT Act) has been enacted with the objectives to provide for establishment of a National Green Tribunal (NGT) for the effective and expeditious disposal of cases relating to environment protection and conservation of forests and other natural resources including enforcement of any legal right relating to environment and giving relief and compensation for damages to persons and property and for matters connected therewith or incidental thereto.

**2. The Air (Prevention and Control of Pollution) Act, 1981**

The Air (Prevention and Control of Pollution) Act, 1981 (the "Air Act") is an act to provide for the prevention, control and abatement of air pollution and for the establishment of Boards at the Central and State levels with a view to carrying out the aforesaid purposes.

**3. The Water (Prevention and Control of Pollution) Act, 1974**

The Water Prevention and Control of Pollution Act, 1974 (the "Water Act") has been enacted to provide for the prevention and control of water pollution and to maintain or restore wholesomeness of water in the country. It further provides for the establishment of Boards for the prevention and control of water pollution with a view to carry out the aforesaid purposes. The Water Act prohibits the discharge of pollutants into water bodies beyond a given standard, and lays down penalties for non-compliance.

**4. The Environment Protection Act, 1986**

The Environment Protection Act, 1986 (the "Environment Act") provides for the protection and improvement of environment. The Environment Protection Act establishes the framework for studying, planning and implementing long-term requirements of environmental safety and laying down a system of speedy and adequate response to situations threatening the environment. It is an umbrella legislation designed to provide a framework for the coordination of central and state authorities established under the Water Act, 1974 and the Air Act. The term "environment" is understood in a very wide term under s 2(a) of the Environment Act. It includes water, air and land as well as the interrelationship which exists between water, air and land, and human beings, other living creatures, plants, micro-organisms and property.

**Environment Friendly Twelve Principles of Green Chemistry**

A twelve principles guide on green chemistry suggested by Paul Anastas and John Warner outlines an early conception of what would make greener chemical process and products to address the regulatory bindings of several environmental law regime at national and international level.

1. Prevention: It is better to prevent waste than to treat or clean up waste after it has been created.
2. Atom Economy: Synthetic methods should be designed to maximize the incorporation of all materials used in the process into the final product.
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.
4. Designing Safer Chemicals: Chemical products should be designed to affect their desired function while minimizing their toxicity.
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.
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.
7. Use of Renewable Feedstocks: A raw material or feedstock should be renewable rather than depleting whenever technically and economically practicable.
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.
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.
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.

**Conclusion**

By the discussion it is quite evident that human consumption of industrial goods is root cause of ecological disturbance. Firstly, raw material and other inputs in industries dispose

chemical dump in air, water and soil. Then the left outs of final consumer products adds all kind of pollution in environment. Such chemical contamination of Earth is endangering all living and nonliving things. In such a disturbing scenario, green chemistry approach provides a chance to present chemistry in a stimulating and effective eco- friendly manner. Chemist are ought to be more responsible than any other person concerned for conservation of environment. Chemist can understand the damage caused by to the environment by chemical processes in better way. Chemists are expected to realize ethical values, chemical and ecology relations, educational needs and research necessities for sustainable development of society and ecosystem. The challenge in front of chemists is to new fundamentals of chemical research to fulfill needs of consumers in a greener way. This is the only way to wash off the blemish image of chemistry and to inculcate more faith of entrepreneurs in further industrial advances. There is a dire need to replace the brown chemistry in to green, which require sincere efforts of researchers, academia, NGO's, industrialists and government. It is also important that students and scholar interested in chemistry are appropriately introduced with green chemistry fundamentals timely.

Also, there is an exigent need for the Government to diagnose the categories and groups of chemicals that are extensively used in various consumer products which are maliciously polluting the environment. Sufficient awareness needed to be bred on the subject so as to edify the chemists engaged in industrial sector. Efforts must be made to identify inexpensive and less detrimental alternatives. The only manner in which a threat to the humans and environment can be quashed is by defusing the threat before it becomes unmanageable.

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