GREEN CHEMISTRY: DESIGN OF ENVIRONMENTALLY FRIENDLY PROCESSES

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The growing process of Industrialization was accompanied by plenty of changes in the global economy and social structure. However, since the 1940s, environmental issues started to arise associated with the development of industrial activities. Despite environmental issues and concerns, industries have changed their way of conventional production methods and product development traditions by adopting sustainable processes. Over the past few years, chemists have been trained to develop new chemical reactions that are less hazardous to human health and the environment. Green chemistry is an approach to chemistry that looks into maximumproductivity and minimum toxicity on human health and the environment.

In 1993, the Toxic Release Inventory of the U.S. Environmental Protection Agency reported that 30 billion pounds of toxic chemicals were released to air, land, and water (Figure 1). While this information covers the release of hazardous compounds from a variety of industrial sectors which include only 1% of chemicals available today. Out of the industrial sectors, chemical manufacturing industries are reasonably the largest releaser of chemicals to the environment, delivering more than 4 times as many pounds to the environment as the next highest sector (Figure 2).

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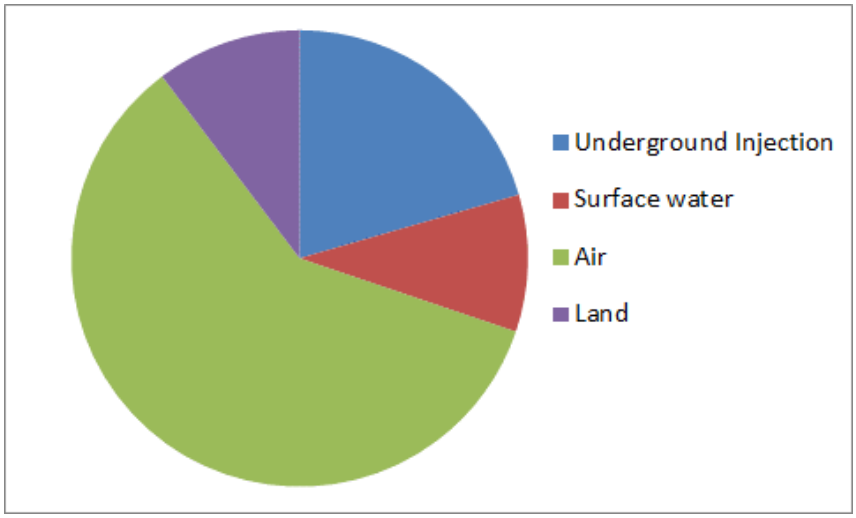

Figure 1. Distribution of Chemical Releases to the Environment

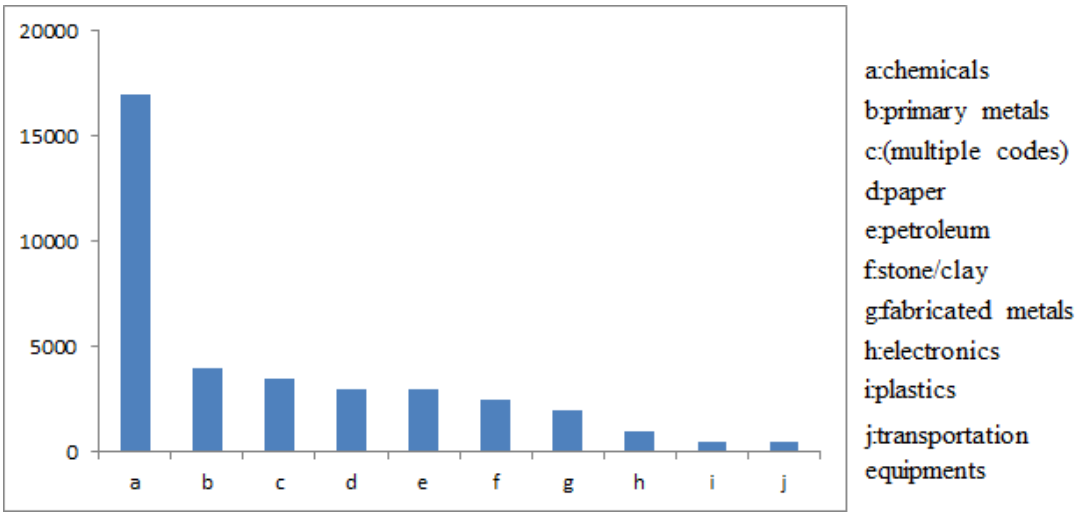

Figure 2. Chemical Releases by Industry Sector (in millions of pounds)

During the 1990s, Paul Anastas proposed the 12 principles of Green Chemistry, still being used today, that depend on the minimization or non-utilization of poisonous solvents in chemical reactions, as well as the non-generation of wastes from these cycles.

1. Waste prevention:-Priorities the minimization of waste at every step
2. Atom economy:-Design the reaction with maximum incorporation of all atoms used in the process into the final product.
3. Less hazardous chemical synthesis:-Design synthetic methods to be as safe as possible (less toxic reactants and products)
4. Designing safer chemicals:-Minimize toxicity by using safer chemicals
5. Safer solvents and auxiliaries:-Choose the safest solvents and auxiliaries available for any given step and use a minimum amount.

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6. Design for energy efficiency:- Design the synthetic methods at ambient temperature and pressure
7. Use of Renewable feedstocks:- Whenever technically and economically practicable, use raw materials which are made from renewable sources.
8. Reduce derivatives:- Unnecessary derivatization should be avoided if possible
9. Catalysis:- Use catalytic reagents instead of stoichiometric reagents
10. Design for degradation:- Chemical products should be designed in such a way that degrades and discard easily.
11. Real-time analysis for pollution prevention:-Real-time monitoring of chemical reactions and control before the formation of hazardous substances.
12. Inherently safer chemistry for accident prevention:-Adopt chemical methods that minimize the risk of accidents.

While no reaction can be perfectly 'green', the adverse consequence of the chemical industry can be diminished by implementing these principles of green chemistry wherever possible. These principles help to design environmentally favorable processes from the planning of the product to its synthesis, processing, analysis, its degradation after use.

In 2017, Toxics Release Inventory displays significant reductions in releases of toxic chemicals into the air due to the impact of industrial Green Chemistry practices and the use of preferred waste management systems such as recycling, energy recovery, and treatment.

In conclusion, Green Chemistry is an approach used in the synthesis, processing, and use of chemicals that reduce hazards to human health and the environment. Recently, many innovative chemical reactions have been developed that are efficient, and more environmentally benign. Finally, the success of Green Chemistry ultimately depends on the practicing chemists who will use the same.

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