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Harnessing Green Technology for Ecological Sustainability and Healthy Citizenry

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Abstract: Environmental technology, also known as 'green' or 'clean' technology or green chemistry, refers to the application of environmental sciences in the development of new technologies which aim to conserve, monitor or reduce the harm humans regularly cause the environment while consuming its resources. It is the technology or the chemistry which designs and develops chemical products and processes that reduce or eliminate the use and generation of hazardous waste substances. As a matter of fact, the risk to humanity, associated with a toxic substance or a pollutant, is a function of hazard and exposure. Since we have not been able to control the "exposure" effectively, the green technology aims to control the "hazard" itself, by preventing its occurrence. Thus, instead of limiting "risk" by controlling our "exposure" to hazardous chemicals, green technology attempts to reduce or eliminate the "hazard", thereby negating the necessity to control "exposure". The bottom line is, if we do not use or produce hazardous waste substances, the risk is zero and we do not have to worry about the treatment of hazardous substances or of limiting our exposure to them. The use of microbial fuel cells as alternative sources of non-conventional energy are all green technologies, which possesses a good potential for future use, as a clean fuel. Green technology has, therefore, gained a strong foothold in the area of research and development (R & D) in industry and academia. The paper, seeks to highlight major areas for development of environmental technology for ecological balance and a healthy citizenry across the globe.
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1. Introduction

The excessive growth of human population, increasing from about 1 billion in year 1800 to about 6.6 billion in 2007 and 7.7 billion at the start of the year 2019 (United Nations Population Division of the Department of Economic and Social Affairs, 2017), has resulted in enormous urbanization and expansion of agricultural, industrial and commercial activities on our fragile planet-Earth.

The large scale use of fossil fuels (coal, oil and gas) in industries as well as in automobiles have accelerated and resulted in wide spread pollution of our environment, at local, regional, as well as global levels. Not only our physical environment consisting of air, water and land, have been polluted, but even the biological bodies such as plants and animals, providing food to humans, have been contaminated (Rodda and Ubertini, 2014; Anderson *et al.,* 2016). This is mainly connected to the changing lifestyles of modern man, involving excessive consumption of resources. The over-utilization of our natural resources, particularly the non-renewable resources, like metals, minerals and fossil fuels is an unsustainable practice and is likely to deprive our future generations from the availability of such resources, which take millions of years in their regeneration (Solomon, 2016; 2015; 2018).

All such unsustainable human actions are finally likely to cause great damage and harmful effects on humans and may possibly lead to the extinction of man from this planet Earth (Bakpo and Solomon, 2018; McGowan *et al.,* 1991). Sustainable lifestyles and sustainable developments of the countries and of the entire world in this context, assumes a great significance and has become the prime necessity of today. Sustainable development, therefore, could be defined as 'the development that meets the needs of the present without compromising the ability of the future generations to meet their own needs'. This could be achieved if nations apply the principles of environmental technology. The paper, therefore, seeks to highlight the major areas for development of environmental technology for ecological balance and a healthy citizenry across the globe.

1.1 What is so Green in Technology?

Technology is science or knowledge put into practical use to solve problems or invent useful tools. It is the tools and machines that help to solve problems or do new things; the techniques, skills and methods for solving a problem (such as construction technology or medical technology). Green technology, also known as sustainable technology, is one that has a "green" purpose.

Green or clean products are environmentally friendly inventions that often involve energy efficiency, recycling, safety and health concerns, renewable resources and locally sourced organic products formulated for enhanced bioremediation of crude oil-impacted soil (Solomon *et al.,* 2018; Solomon *et al.,* 2019). Environmental technology, green technology, clean technology or green chemistry is an encompassing term. It deals with using science and technology in order to protect the environment.

Green technology could also be seen as the application of one or more of environmental science, green chemistry, environmental monitoring and electronic devices to monitor, model and conserve the natural environment and resources, and to curb the negative impacts of human involvement. The main purpose of green technology is to slow down global warming and reduce the green house effect. The main idea is the creation of new technologies which do not damage the natural resources. This should result into less harm to people, species and the general health of our planet. They are also known as eco-friendly technology and can help preserve the environment through energy efficiency and reduction of harmful waste. Examples of green technology in production include, for example, processes to recycle water or waste in the manufacturing process and the installation of energy-efficient fixtures such as LED light bulbs and flushless toilets (Ogugbue *et al.,* 2015). Speeding their implementation can benefit our environment and truly protect the planet. Explore the goals of green technology, introducing sustainable living, develop renewable energy and reduce waste.

1.2 Ways to Go Green with Technology

Adoption of ecologically-friendly technology which often involves some of the following: Recycled, recyclable and/or biodegradable content, going solar, have virtual meetings, recycling your e-waste, using those smart settings, upgrading older machines and devices and going paperless (or reduce your paper files). The following are basic principles of green technology:

1.2.1 Use Renewable Feed stocks

Whenever possible, chemical transformations should be designed to utilize raw materials and feed stocks that are renewable. Examples of renewable feed stocks include agricultural products or the wastes of other processes. Examples of major depleting feed stocks include raw materials that are mined or generated from fossil fuels (such as petroleum, natural gas or coal) (Solomon, 2015; 2016).

1.2.2 Prevent Waste

The ability of chemists to redesign chemical transformations to minimize the generation of hazardous waste is an important first step in pollution prevention. By preventing waste generation, we minimize hazards associated with waste storage, transportation and treatment.

1.2.3 Design Less-Hazardous Chemical Synthesis

Wherever practicable, synthetic methodologies should be designed to use and generate substances that possess little or no toxicity to human health and the environment. The goal is to use less hazardous reagents whenever possible and design processes that do not produce hazardous by-products. Often a range of reagent choices exist for a particular transformation. This principle focuses on choosing reagents that pose the least risk and generate only benign by-products.

1.2.4 Design Safer Chemicals and Products

Chemical products should be designed to affect their desired function, while minimizing their toxicity. Toxicity and ecotoxicity are properties of the product. New products can be designed that are inherently safer, while highly effective for the target applications. In academic laboratories, this principle should influence the design of synthetic targets and new products.

1.2.5 Maximize Atom Economy

Atom Economy is a concept that evaluates the efficiency of a chemical transformation. Similar to a yield calculation, atom economy is a ratio of the total mass of atoms in the desired product to the total mass of atoms in the reactants. One way to minimize waste is to design chemical transformations that maximize the incorporation of all materials used in the process into the final product, resulting in few, if any and wasted atoms.

Choosing transformations that incorporate most of the starting materials into the product is more efficient and minimizes waste. Obviously, this principle aims at designing or developing reactions and processes as to maximize the incorporation of all materials used in the process into the final product.

1.2.6 Use Safer Solvents/Reaction Conditions

The use of auxiliary substances (e.g., solvents and separation agents) should be made unnecessary wherever possible and innocuous when used. Solvent use leads to considerable waste. Reduction of solvent volume or complete elimination of the solvent is often possible. In cases where the solvent is needed, less hazardous replacements should be employed. Purification steps also generate large sums of solvent and other waste (chromatography supports, e.g.). Avoid purifications when possible and minimize the use of auxiliary substances when they are needed.

1.2.7 Increases Energy Efficiency

Energy requirements of chemical processes should be recognized for their environmental and economic impacts and should be minimized. If possible, synthetic and purification methods should be designed for ambient temperature and pressure, so that energy costs associated with extremes in temperature and pressure are minimized.

1.2.8 Avoid Chemical Derivatives

Unnecessary derivatization (use of blocking groups, protection/deprotection, and temporary modification of physical/chemical processes) should be minimized or avoided if possible, because such steps require additional reagents and can generate waste. Synthetic transformations that are more selective will eliminate or reduce the need for protecting groups. In addition, alternative synthetic sequences may eliminate the need to transform functional groups in the presence of other sensitive functionality.

1.2.9 Use Catalysts

Catalytic reagents (as selective as possible) are superior to stoichiometric reagents. Catalysts can serve several roles during a transformation. They can enhance the selectivity of a reaction, reduce the temperature of a transformation, enhance the extent of conversion to products and reduce reagent-based waste (since they are not consumed during the reaction). By reducing the temperature, one can save energy and potentially avoid unwanted side reaction during manufacturing.

1.2.10 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. Efforts related to this principle focus on using molecular-level design to develop products that will degrade into hazardless substances when they are released into the environment.

1.2.11 Analyze in Real-Time to Prevent Pollution

It is always important to monitor the progress of a reaction to know when the reaction is complete or to detect the emergence of any unwanted by-products. Whenever possible, analytical methodologies should be developed and used to allow for real-time, in-process monitoring and control to minimize the formation of hazardous substances.

1.2.12 Minimize the Potential for Accidents

One way to minimize the potential for chemical accidents is to choose reagents and solvents that minimize the potential for explosions, fires, and accidental releases. Risks associated with these types of accidents can sometimes be reduced by altering the form (solid, liquid or gas) or composition of the reagents.

1.2.13 Application of Microbial Fuel Cell for Electricity Generation

There is an emergent interest to use clean energy sources that are sustainable for wastewater treatment in order to effectively generate power using microbial fuel cell (MFC) other than fossil fuel. The MFC is a bio-electrochemical system which utilize microbial communities to degrade organic materials found within wastewater and convert stored chemical energy to electrical energy in a single step in which microbes are used to catalyze the conversion of organic material into electricity (Ogugbue *et al.,* 2014).

A microbial fuel cell (MFC) has a great potential to offer solution to this problem by generating direct electricity during oxidation of organic matter. Microbial fuel cells can use a wide range of materials (Solomon and Bakpo, 2018).

2. Areas for Development of Green Technology

The primary aim of green technology is to prevent, minimize, or completely eliminate the generation of wastes and emissions of pollutants in the manufacturing processes themselves so as to avoid pollution of our physical environment consisting of air, water and land (Oforibika *et al.,* 2018). Green technology or clean technology as it may be referred to, will, thus, prevent the need of installing pollution control devices, as the basic generation of pollutants itself, will reduce or completely stop.

In order to achieve this goal, the green technology needs to find areas where improvements can be made including the use of plant-based organic biostimulants in the bioremediation of hydrocarbon-contaminated soil environment (Solomon *et al.,* 2018 a, b, c, d). Fungi are also of economic importance in the petroleum, agro-allied, agriculture and pharmaceutical Industries where they helps in the conversion of complex organic substances and materials to simpler and eco-friendly ones (Solomon, *et al.,* 2019).

These areas serve as the tools for green technology. Any improvement made in these areas will help in fulfilling the basic objective of making the manufacturing processes green and clean. The tools of green technology or areas that have been identified for development of clean technology include the following:

2.1 Alternative Feed Stocks (Starting Materials)

Most of the character of the synthetic pathway or the reaction type is determined by the initial selection of the starting materials to be used in the synthetic process. Once such a selection is made, many options then fall into place as a necessary consequence of that decision. The selection of feed stock has a major effect not only on the efficiency of the synthetic pathway, but also on the environment and health effects of the manufacturing process.

The selection of the feed stock for the manufacture of a product determines what hazard will be faced when workers are handling this substance, suppliers are manufacturing it, and transporters are transporting it up to the place of manufacturing. Several types of feedstock chemicals may be available for manufacturing a particular product. We have to make a choice, which is largely governed by economic considerations and available technology (Ogugbue *et al.,* 2017). However, from environment point of view, we must select as green a starting feedstock as possible.

The selected feedstock material should be such as not to put pressure on our nonrenewable resources; should not consume large amount of energy in its production; and should be easily biodegradable. Such alternative green chemicals should replace the conventional polluting raw materials. The invention of finding use of such green raw materials to replace the old conventional non-environment friendly raw materials will lead to the development of a greener, clearner or environmental technology.

For example, at present, almost 98 % of all organic chemicals are being synthesized from petroleum feed stocks. These feedstocks are made from crude oil after being refined in refineries, which consume enormous amount of energy. The energy consumption in petroleum refining is still increasing due to the present availability of the low quality petroleum. Moreover, the petroleum is converted into useful organic chemicals (or feedstocks) by oxidation for addition of oxygen. This process of addition of oxygen has historically been one of the most environmental polluting steps in all chemical synthesis. Based on such considerations, it is important to reduce our use of petroleum based products by using environment friendly feedstocks.

Even otherwise, petroleum is a non-renewable resource, and hence, its continuous large scale use is absolutely non-sustainable. In general, feedstocks of biological origin can be excellent alternatives. Many of such feedstocks are already highly oxygenated and, hence, their use in place of petroleum feedstocks, eliminates the need of polluting oxygenation step. However, the synthesizations can be accomplished with such raw materials in significantly less hazardous manner, as compared to the ones with petroleum product.

Research and development (R & D) of green technology is finding out more and more use of such renewable and biodegradable feed stock products (Oforibika *et al.,* 2018). For example, the agricultural products like corn, potatoes soya and molasses are being transformed into feed stock products for synthesization of various types of polymers and plastics (including textiles and nylons).

Manufacture of such biopolymers is certainly much less polluting and the discarded wastes are biodegradable and compostable, making them environment friendly substances. The exploration of biological sources of alternative feedstocks need not be limited to the agricultural products. Even agricultural wastes or biomass (Solomon, 2015; 2016; Erenee *et al.,* 2017; Solomon *et al*., 2018) and non-food related bio-products, which are often made of variety of lignocellulosic materials, may provide important alternative feedstocks. Together with carbohydrates and proteins, fatty oils are important renewable resources compared with the fossil and mineral raw materials. In addition to the feedstocks of biological origin, other classes of feedstocks, such as U.V. light or sun light, are also emerging. U.V. light is a safe alternative to toxic metal catalysts in many synthetic transformations. For example, heavy metals are often used in petroleum oxidation processes. These metals are quite toxic and may be carcinogenic, or harmful to the neurological systems.

2.2 Alternative Benign Reagents

A reagent is a chemical which reacts with the chosen raw material (chemical substance) to effect a chemical reaction for the synthesization of a given product. These chemicals, for green chemistry, must be as less hazardous as possible, and should be catalytic whenever feasible. The development of use of new benign (mild) innocuous (harmless) reagents, as compared to the conventional polluting or hazardous reagents is one of the prospective fields of green technology.

The selection of a reagent must, therefore, include an evaluation to identify the hazards associated with that particular reagent. This evaluation should include an analysis of not only of the reagent itself, but also of the synthetic transformation associated with the use of that reagent. Such evaluation may include product selectivity, reaction efficiency and separation needs. Additionally, an investigation should be made to determine if more alternative reagents are available, that either are themselves more environmentally benign (less harmful), or are able to carry out the necessary synthetic transformation in a more environment friendly manner.

Such evaluation may also consider as to whether it is possible to use alternative pathways by using less hazardous alternative reagents to synthesize the final target compound. In order to make the final decision, the alternative reagents must be identified, and any hazardous properties that the alternatives possess must be compared with the hazardous properties associated with the reagent originally selected. Example of an innocuous reagent is dimethyl carbonate, which is produced from monotoxic intermediates. An additional important consideration with the selection of a particular reagent is whether it is responsible for the generation of more, or less waste, in comparison to that produced by the other reagents.

Here also, not only the quantity of the generated waste is to be considered, but the hazardous nature of the waste has also to be taken into account. Obviously, the oxidation reactions involving oxygen and hydrogen peroxide will be a preferred choice, as they produce water as a by-product. Green or clean oxidation reactions, however, use nontoxic solvents and mild reaction conditions. Efforts are, hence, being made to develop systems, which are able to selectively activate oxygen and hydrogen peroxide for oxidative transformations.

The use of heterogeneous metal catalysts, in place of homogeneous ones, has been able to activate oxidation reactions using benign oxidants like molecular oxygen and hydrogen peroxide. The choice of a reagent is also governed by its selectivity. A reagent has more selectivity, if more of the starting material is going to be converted into the desired product. High selectivity and high conversion must be achieved in a synthetic transformation to generate little or no waste.

If at all, a catalyst reagent becomes necessary, then it should be required in actually "catalytic amount", i.e. the catalytic reagent is not consumed but only accelerates the transformation. Thus, if a reagent can be utilized to accelerate a reaction and yet not consumed in the process, then it will require less material to continuously effect transformation.

2.3 Clean Synthetic Transformation Reactions

The synthetic transformation reactions used in manufacturing of various chemical products may have different degrees of impact on human health and environment, depending upon the amount and type of generated wastes, and also upon the use of certain chemicals which may be harmful. The concept of atom economy becomes important in this context, since a reaction having higher atom economy will certainly be more clean and preferable, as it will generate lesser waste. A particular reaction is said to be green only when all the atoms of almost all the reactants get incorporated in the end product, without producing any toxic or hazardous byproducts.

For any synthetic transformation, it is important to evaluate the hazardous properties of all the substances necessarily being generated from the transformation, just as it is important to evaluate the hazardous properties of all the starting materials and reagents that are added in the synthetic transformation. Devising green synthetic transformation reactions may also sometimes help in the elimination of the use or production of some hazardous intermediate chemical (s) besides reducing polluting wastes.

2.4 Alternative Solvents or Reaction Conditions

The use of solvents is very often encountered almost everywhere in chemical, or chemical related industries (like Dry Cleaning). Several organic volatile chemicals (VOCs) are currently being used as solvents, and are called to volatile organic solvents. Most of these solvents are highly toxic and harmful to human health. Moreover, these solvents are usually required in much larger quantities than the solutes they carry, and are wasted through evaporation and leakage. So much so that five out of ten chemicals released into the environment are solvents (methanol, toluene, xylene, methyl and ethyl ketones), which account for 27 % (by mass) of the total Toxics Release Inventory (TRI) Chemicals. In addition, VOC solvents contain chlorine, usually called chlorinated *or* halogenated solvents, such as carbon tetrachloride, methyl chloroform (trichloroethylene) and pechloroethylene are found to be highly carcinogenic and mutagenic, and hence are highly damaging to life.

Some other solvents have been found to be having neurotoxicological effects on human health. Most of the VOC solvents are also used in the manufacture of chlorofluoro carbons (CFCs), and cause tumours in animals. The VOC solvents have also been found to be responsible for causing ozone depletions, which have serious adverse global impacts on environment and human health.

Several solvents have been found to pose global warming potential and are believed to be contributing to overall green house gas emissions in the environment. Realizing the extremely hazardous and environmentally harmful potential of the conventional solvents, the green chemistry research is paying a great attention to find alternative environment friendly solvents. Some of the main areas of research on alternative solvents include the following:

i. supercritical fluids,
ii. aqueous applications,
iii. polymerized immobilized solvents,
iv. ionic liquids,
v. solvent less systems and
vi. reduced hazard organic solvents.

As a result of the large scale research carried out on the subject, supercritical and liquid CO_2 have been evolved as the viable alternative benign solvents, for many chemical reactions and polymerizations. It has, thus, become a widespread, growing reality, both in academia and in the industry that CO_2 is a non-toxic, non-inflammable, and inexpensive solvent. While $C0_2$

is a gas at ambient temperatures, it can be easily converted into liquid and also in supercritical states, by compression and heat. Both the liquid and supercritical carbon dioxide have a tuneable density that increases with the increasing pressure or decreasing temperature. Many small molecules are soluble in liquid $C0_2$ and/or in supercritical $C0_2$, including high vapour-pressure solvents, such as methanol, acetone and tetrahydrofuran. Many vinyl monomers and azoperoxy- initiators are also soluble in such forms of $C0_2$. Water and ionic compounds are however insoluble as are most polymers.

2.5 Production of Safer Chemicals/Substances

The chemicals and chemical substances must be designed and produced, as not to have any characteristics that are harmful to the human health and the environment in general. The design of safer chemicals is a process that utilizes an analysis of the chemical structure of the produced chemical, to identify what part of the produced molecule is providing in it the characteristics that are desired from the product point of view and what part of the molecule is responsible for the toxicity or environmental hazard.

By knowing this information, it may be possible to make suitable alterations in the produced chemical, as to maintain the efficacy of its functions while minimizing the hazard. The aim of designing safer chemicals can be achieved through several different strategies, the choice of which is largely dependent on the amount of information that exists on the particular substance. In cases, where mechanism of action is known, there exists the greatest potential to design a chemical that is safer from the perspective of toxicity or other hazard to human health and the environment (Solomon *et al.,* 2016; Solomon *et al.,* 2017).

2.6 Minimization of Energy Consumption

The modern improved design of chemical transformations can reduce the energy requirements of the conventional methods/reactions. While making such an analysis, all the energy input in terms of mechanical, thermal and other forms of energy should be accounted for, along with their environmental impacts. Since excessive consumption of energy always causes excessive burden on non-renewable resources and causes pollution of the environment, one of the important aim of green technology is to design new products and new manufacturing methods, as to reduce the overall consumption of energy (Solomon and Bakpo, 2018).

The assessment of energy consumption in this connection, however, should be made for the entire manufacturing process as a whole. The design of new solvents, or new reagents, or new synthesization reactions may also be such as to simultaneously bring about energy saving along with serving other specific purposes in the industry.

2.7 Zero Waste Technology in Chemical Synthesization

Zero waste technology in chemical synthesization is the fundamental principal of green technology, as it is the basic concept of atom economy. One hundred percent (100 %) atom utilization or atom economy eventually means that there will be no waste products as zero waste technology may also be developed when a by-product or waste product of any unit is utilized as a raw material for another unit in integrated manufacturing system (IMS).

3. Environmental Pollution Abatement and Control Laws

In late sixties and early seventeen, the environment received a great deal of attention in developed countries, including the formation of Environmental Protection Agency (EPA) in United States of America (U.S.A.) and the celebration of the first Earth Day, both of which occurred in 1970. In 1972, the United Nations (U.N.) conference on Human Environment and Development (Stockholm Conference) was held, in which 115 member countries of the U.N. participated to discuss the political, social and economic problems of the global environment, to work out corrective measures to save the environment from getting degraded beyond retrieval.

The conference ended with a declaration called the Stockholm Declaration, laying down 26 principles for initiation of adequate policies and measures for preservation of the environment by nations. In order to abate and control the environmental pollution, particularly, the pollution of air, water and land, several laws were since enacted by member countries of the U.N. These laws include 12 major laws which include:

(i) Clean Air Act, 1970: Regulates air emissions.

(ii) National Environmental Policy Act, 1972: Requires in part that EPA will review environmental impact statements of proposed major federal projects (e.g. highways, buildings, airports, parks, and military complexes).

(iii) Clean Water Act, 1972: Establishes the sewage treatment construction grants program and a regulatory and enforcement program for discharges of pollutants into U.S. waters.

(iv) Federal Insecticide, Fungicide and Rodenticide Act, 1972: Governs distribution, sale and use of pesticide products. All pesticides must be registered (licensed) by EPA.

(v)Ocean Dumping Water Act, 1974:

Regulates the intentional disposal of materials into ocean waters.

(vi) Safe Drinking Water Act, 1974: Establishes primary drinking water standards.

(vii) Toxic Substances Control Act, 1976: Requires the testing, regulating, and screening of all chemicals, produced or imported in the U.S.

(viii) Resource Conservation and Recovery Act, 1976: Regulates solid and hazardous waste form "cradle to grave."

(ix) Environmental Research and Development Demonstration Act, 1976: Authorizes all EPA research programs.

(x) Comprehensive Environmental Response, Compensation and Liability Act, 1980: Provides for a federal "superfund" to clean up abandoned hazardous waste sites, accidental spills, and other emergency releases of pollutants in the environment.

(xi) Emergency Planning and Community Right-to-Know Act: Requires that industries report toxic releases and encourages planning by local communities to respond to chemical emergencies.

(xii) Pollution Prevention Act, 1990: Seeks to prevent pollution by encouraging companies to reduce the generation of pollutants through cost-effective changes in production, operation, and raw material use.

Several rules were also framed and notified under the Environment (Protection) Act. These rules include:

i. The Environment (Protection) Rules, 1986.
ii. The Hazardous wastes (Management and Handling) Rules, 1989.
iii. The Manufacture, Storage and Import of Hazardous Chemicals Rules, 1989.
iv. The Rules for the Manufacture, Use, Import, Export and Storage of Hazardous Microorganism/Genetically. Engineered Organisms or Cells, 1989.
v. The Chemical Accidents (Emergency Planning, Preparedness and Response) Rules, 1996.
vi. The Bio-Medical Waste (Management and Handling Rules, 1998.
vii. The Plastics Manufacture, Sale and Usage Rules, 1999.
viii. The Noise Pollution (Regulation and Control) Rules, 2000.
ix. The Ozone Depleting substances (Regulation and Control) Rules, 2000.
x. The Municipal Solid Wastes (Management and Handling Rules, 2000.
xi. The Batteries (Management and Handling) Rules, 2001.

4. Green Technology and the Citizenry

All our developmental activities should keep the well-being of our environment in mind. This can be done only when there is a public pressure on the industry, trade and above all, on the governments in power. The public pressure, on the other hand, will be developed only when the public knows the values and the importance of the environment and of the harmful effects being caused by the 'environmental degradations'. The citizenry will benefit the more from environmental technology when committed actions are taken towards keeping the Earth alive for sustainability.

5. Conclusion and Recommendations

Most of the acts above, deal with pollution after it is formed. These laws are in general, focused on the treatment or abatement of pollution and have been the "command and control" laws. In most of these cases, these laws place limits on pollution parameters for discharge of effluents into the environment, with little regard to whether the available technology could attain these goals and with little regard to the economic costs of implementing these laws.

The implementation of these laws has, therefore, much remained on paper, because the industry always tries to by-pass these laws, due to financial burden caused by the installation of pollution control devices. Yet, however, some improvement has, of course, been affected in our environment due to controls exercised on our exposure to hazardous substances and release of emissions, by the pollution control authorities.

In spite of such controlling laws, the industrial and transportation activities continue to release tremendous amounts of pollutants into our ambient environment. Realizing the virtual failure of pollution abatement laws, a new paradigm has emerged in the last decade, particularly in advanced countries, which focuses on prevention of pollution rather than on typical treatment and remediation of an existing case.

This paradigm is based on inventing new environmental or green technologies that prevent pollution at source. It is therefore, recommended that developing countries should apply clean technologies targeted at preventing pollution at source rather than remediating its negative impacts later. It is this context, in which it has become extremely necessity for all the vigilant societies, to impart at least the basic knowledge of environmental studies to its entire people and more particularly to the coming generation of the student community.

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