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Applications of Green Chemistry in Various Industrial Processes for a Sustainable Future

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Abstract: Green Chemistry is an increasingly prominent branch of chemical industry. It attempts to quantify the environmental impacts and operational hazards of chemical processes using standarized matrics. Green Chemistry initially promoted safer chemicals and protection of environment but at the same time introduced to the principles of energy efficiency, atom economy in chemical processes with reduction of waste. The present paper deals with the green technologies and processes, which are emerging in four main industrial processes: 1. development of biofuels 2. sustainability in agriculture 3.biodegradable eco-friendly packaging materials 4. waste management. Recently, biofuels have attracted considerable attention as a promising alternative to fossil fuels. Biofuels are made from biomass through the processes such as chemical, biochemical or hybrid conversion. Biofuels donot create additional emissions apart from those produced during the production and transportation stages. Hence, biofuels avoid the environmental drawbacks associated with fossil fuels. Based on feedstocks and method of production, biofuels are classified as first, second, third and four generation. The paper emphasizes the development of biofuels from first to fourth generation. The various ways by which green chemistry play an important role for agriculture sustainability such as use of biopesticides, biofertilizers, conversion of agriculture waste into energy and electricity are explained. In the packaging industry the eco- friendly and biodegradable polymeric materials, their synthesis and applications are described in the paper. Waste management is a global challenge because of significant fraction of greenhouse gases emission, generated by improper waste disposal and this requires sustainable treatment and consumption of the waste. The treatment of hospital waste, non-biodegradable recyclable waste, biodegradable waste, non-biodegradable non-recyclable waste and toxic waste by using green chemistry technologies are discussed in the paper.
Key words: Green chemistry, sustainability, biofuels, biodegradable packaging, waste management.

Introduction :- The word sustainability refers to the ability to provide a healthy and satisfying life for all people on mother earth, now and for generation to come, while inhancing the health of ecosystem and the ability of other species to survive in their natural environment. In 1987 a United Nation report defined sustainable development as "development that meets the needs of present without compromising the ability of future generation to meet their own needs". This report is often recognized as the genesis of the modern sustainability movement. As the challenges of living in harmony with the earth becomes increasingly difficult, more than ever, society needs education and high quality cutting-edge research to meet this challenge [1]. In 25 September 2015 United Nation with their member countries agreed a collective global mission to transfer the planet to achieve a sustainable future. This mission it spelled out in 17 Sustainable development goals (SDGs) with the target yera of 2030. These new SDGs embrace a global vision of development for all, based on the core principle of sustainability and with responsibility shared by all countries [2].

Chemistry and sustainable development: The chemical sciences provide understanding of physical and chemical properties of atoms and molecules and practical method for creating new molecular structures with useful applications. Chemistry is a platform of central science, underpinning fundamental aspects of range of established and emerging sciences including biochemistry, nanoscience, molecular and synthetic biology, physics and soft condensed matter physics as well as many major practical advances seen in such field as agriculture, biotechnology, energy, ecology, the environment, genetics, Information technology, materials and medicine, and the dramatic rises in over all human health and well-being during past two centuries. Chemistry has played a dual role in the unfolding picture of global development. On the positive side the knowledge and products contributes by chemistry providing source of energy, a host of material including polymers, plastic, semiconductors and solid state display devices; agents for crop protection and plant growth; pharmaceutical and much else, has been a major factor in the advances in human wealth, health and well being over the past two centuries and justify chemistry claim to be quality of life science par excellence. It promises to go on being the source of innovative new products and processes, including smart material for better life style, catalytic process is for light harvesting towards hydrogen production and carbon dioxide fixation, new vaccines and drugs for some incurable disease. On the other hand, chemistry must also accepted responsibility as one of the source of many of the processes and products that have inadvertently contributed to the range of emerging global problems. The extent to which the activities of human beings are having a major effect on the physical characteristics of the planet is reflected in the adoption of the term “Anthropocene Age” to describe the current period. Changes to earth environment (air, land and sea) occasioned by human activity have accelerated in the past 200 years resulting in global warming, damage to protective ozone layer and depletion of natural resources. Increasing energy consumption, industrial activity, population growth and urbanization add pressure to the planetary system and it is clear that major change are now needed if multiple crisis (relating to food, water, climate and energy) are to be avoided and humanity is to move to a path of sustainability[3].

Introduction of Green Chemistry: In the recent years, Green Chemistry has gained a strong foothold in the areas of research and development in both industry and academia, especially in the developed industrial countries. Green chemistry has to cover a broad section of chemical and technological aspects in order to offer its alternative vision for sustainable development[4]. Green Chemistry had to include fundamental ways to reduce or to eliminate environmental pollution through dedicated sustainable prevention programs. Green chemistry must focus on alternative environment friendly chemicals in synthetic routes but also to increase reaction rates and lower reaction temperature to save energy. Green Chemistry looks very carefully on reaction efficiency, use of less toxic solvents, minimizing the hazards of feedstocks and products and reduction of waste. Poul T. Anastas and John C. Warner developed the 12 principles of Green Chemistry in 1991[5] as given below:

1. Prevention
2. To maximize synthetic methods, atom economy
3. Less hazardous Chemical synthesis
4. Designing safer chemicals
5. Safer solvent and auxiliary substances
6. Design for energy efficiency
7. Use of renewable raw materials and feedstocks
8. Reduce intermediate derivatives
9. Catalysis, catalytic reagents
10. Design products which degradate easily
11. Real time analysis for pollution prevention
12. Inherently safer chemistry for accident prevention

These principles are obviously very difficult to apply immediately for many chemical processes. After 21 years of Green Chemistry initiative and industrial applications, it is amazing to see many creative innovations at various scientific and industrial processes. The cooperation of chemist, engineers, material scientists, bioscientists and technologists has achieved interesting results. The interdisciplinary approach has expanded the field of green chemistry and produced some excellent non-toxic materials and feedstock savings in chemical industries. The present paper deals with the applications of the green chemistry in four industrial processes: development of biofuels, different agriculture activities, packaging industry and waste management, to obtain the sustainable development goals.

1. Developing Biofuels : An ecofriendly sources of energy

In the twentieth century, change in the global climate was identified as one of the most serious issue that the world faces. The main reason for this problem is high consumptions of fossil fuel which represent about 80% of the global energy usage. The combustion of fossil fuel results in the emission of greenhouse gases especially CO_2. There are several techniques that are used to capture CO_2 such as adsorbing by chemicals like amines, carbonates, ammonia or by pre-combustion techniques such as chemical looping combustion processes. Hoever, these techniques are insufficient to suppress the rapid increase in the environmental CO_2 concentration resulting from fossil fuel combustion. Also, the high demands of fossil fuel lead to another problem which is a severe depletion of this important source of energy. Although, there are several ways to create clean energy from the wind, the sun and water, the use of biomass is very important because unlike the other energy sources it provides liquid fuel for transportation. The United States is at the forefront of the bio fuel market with a target of substituting 20% of the transportation fossil fuel with biofuel by 2022[6]. Depending upon the feedstock, biofuels are categorized into four types first, second, third and fourth generations.

1.1 First generation biofuels are obtained from edible biomass such as sugarcane, corn, wheat grains, oil seeds, vegetable oils and renders animal fats. They are also known as conventional biofuels such as ethanol prepared by fermentation of sugarcane or sugar beds. Most commonly known first generation biofuels are biogas, biodiesel and bio alcohol. The future success of first generation biofuel is limited as it negatively impact greenhouse gas emissions, biodiversity, land use and water use due to increase use of fertilizers to grow crops for biofuels, which has led to increased amounts of nitrogen and phosphorus entering ground and surface water[7]. These biofuels are likely to be banned in European Union to secure the food supply as the compromise to edible food stocks.

1.2 Second generation biofuels are derived from cellulosic biomass sources including crop residues, perennial grasses and trees. They may be grown on marginal cropland where crop production is not profitable. By focusing on areas that are highly erodible or have marginal soil quality, this avoid competition with fertile ground that may be best used to grow food crops. Although this crops required little initial input, they do require additional treatment to break down cellulose for creating an end product such as liquid fuel[8]. In addition transporting high quantities of biomass can be a logistical and financial challenge for production, all such things make reasons for limiting the second generation biofuels.

1.3 Third generations biofuel: Recently researchers have focused their interest on the algal biomass as an alternative feed stock for the production of biofuels. Moreover algal biomass has no competition with agriculture food and feed production. The photosynthetic microorganisms like microalgae require mainly light, carbon dioxide and some nutrients (nitrogen, phosphorus and potassium) for its growth and to produce large amount of lipids and carbohydrates, which can be further processed into different biofuels and other valuable co-products[9]. There are several advantages of algal biomass for biofuel production such as (a) ability to grow throughout the year (b) higher tolerance of high CO_2 content (c) the consumptions rate of water is very less in algal cultivation (d) no requirement of herbicides and pesticides (e) growth potential of algal species is very high and (f) ability to grow under harsh condition like saline brackish water, coastal sea water where other cultivation is not possible.

1.4 Fourth generation biofuels: While microbial biofuel production is a well established practice in a small scale system, its industrial scale production is not economically viable. This is mainly due to the low lipid content and growth rate of microbial strain. Genetic engineers offer a wide range of options to enhance the lack of industrial competent strains by several approaches such as transcription and targeted expression of key proteins involved in microalgal lipogenesis. Production of biofuels from genetically engineered algae have been discussed by scientist in FGB terms. The FGB- photo logical solar fuel and electro fuels are expected to bring fundamental break through in the field of biofuel. Technology for production of such solar fuel is an emerging field and based on direct conversion of solar energy into fuel using raw material that are inexhaustible, cheap and widely available[10].

Sustainable utilization of biomass waste to produce energy can also solve the problem of pollution by burning and spoiling the agri-waste problem of rural employment and utilization of waste land. It is helpful to enhance the social and economic status of the farmer and people of the rural areas.

2. Green Chemistry and sustainable agriculture

Now a days, Green Chemistry plays an important role in the field of agriculture. In the last few years, for sustainable production of agriculture, use of renewable biomass resources increases to generate bio-based food products with low inputs, zero waste, sustainable social values and minimizing environmental impact[11]. The main goal sustainable agriculture as:-

- To satisfy human food and fibre needs.
- To enhance environmental quality and natural resources base upon which the agriculture economy depends.
- To make the most efficient use of non renewable resources and on farm resources and integrate where appropriate, natural biological cycles and controls.
- Sustain the economic viability of farm operations.
- To enhance the quality of life for farmers and society as a whole.

Green chemists are trying to keep farmers how to tackle with contamination, removing pollutant, unwanted chemicals and manages use of recycled water. Researchers are focused to use bio-based materials or use feed-stock or raw materials which are renewable e.g. agriculture waste products as well as they are emphasizing the work on developing biopesticides, biofertilizers and biocatalyst for transforming the agriculture materials into high value products and also enhancing their production and protection.

2.1. Biological control and use of non-toxic pesticides:- Synthetic pesticides and chemical fertilizers which are being used for the agriculture, are resulting in residues of chemicals in soil, water and air, there by causing a hazardous contamination. By promoting different methods of eco-friendly agriculture like organic farming, biopesticides global goal of sustainable agriculture can be achieved for improving the quality and quantity of food produced globally .

Biopesticides are competitive subclass of pesticides that are naturally occurring organisms and compounds that suppress the growth and proliferation of pests population by diverse mechanisms of action, excluding those that interfere with pests nervous system. They are categorized in to three groups.

2.1.1 Microbial biopesticides: They are originated from micro organisms. They are target specific. Basillus thuringiensis (Bt) control 90% of the microbial bio-pesticide market. However, Beauveria bassiana, Baculovirus, Nosema and chlorella have also demonstrated significant roles.

2.1.2 Biochemical biopesticide: They are herbal substances and also known as plant pesticides.They control pest by mechanism that are non toxic to target pest, environment and human. Biochemical pesticides include substance that interfere with growth or mating, such as plant growth regolators or substances that repel or attract pests such as pheronomes e.g. essential oils.

2.1.3 Plant Incarporated Protectants (PIPs): These are genetically modified materials, pooduced by scientists by inserting genes into plants or other micro organism so it produces its own biopesticides. PlPS are transgenic plants that render the plant unsuitable for pest attack. Insecticidal molecules employed in PIP technology are Bt Cry protein, toxic complex (Tc) protein from Xenorhabdus and photorhabdus, X-amylase inhibitors, protease from Baculovirus, double stranded ribonucleic acid ds RNA and Mir 1-CP from Maize[12].

Bio-pesticides exert their inhibitory effects through multiple mode of actions such as growth regulators, gut disruptors metabolism poison, neuromuscular toxins and non specific multi site inhibitors. The advantages of bio-pesticides over synthetic pesticides are eco-friendliness, specificity (thus have little or no negative impact on non target organisms and humans), biodegradability and little or no problem of post harvest contamination, stability against abiotic stress and compatibility in integrated pest management (IPM)

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2.2 Eco-friendly fertilizers: Fertilizers are the nutrient filled sources which nourish the plants with essential nutrients and soil, acts as a medium between the crops and fertilizers. Using the fertilizers in agriculture can be very useful for a food production, but on the other hand it may be very dangerous for environment. The biggest issue facing the use of chemical fertilizer is ground water contamination. Nitrogen fertilizers break down into nitrates and travel easily through the soil, because it is water soluble and can remain in ground water for decades the addition of more nitrogen over the years has an accumulative effect. It is found to altered immune, endocrine and nervous system function in mice as well as influence on children's and foetus developing neurological, endocrine and immune system. They also contributes to acid rain, ground water contamination and ozone depletion due to release of nitrous oxide by denitrification process.

2.2.1 Organic fertilizers:- They are manufactured using organic substance which are biodegradable i,e. organic fertilizers are naturally occurring fertilizers and nutrients, enhancers of the soil. These organic substances are further decomposed and broken into smaller and soluble particles by numerous micro organism. After being turned into soluble and simpler compounds, these fertilizers are taken in by the roots. Manure, slurry, worm casting, peat seaweed, sewage are naturally occurring green manure. Compost, blood meal, bone meal and seaweed extracts etc. are manufactured organic fertilizers. Organic fertilizers work over time to create a healthy growing environment they improve the structure of soil and increase its ability to hold water and nutrients.

2.2.2. Chemically synthesized Controlled Release Fertilizers

Controlled released fertilizers have become increasingly popular and have gathered a great deal of attention to growers and agronomists around the world. Applying lower amount fertilizer is one solution to deal with new regulations, limiting the amount of least nitrogen. Scientific proof has shown that growers can achieve the goal of production and higher quality with coated fertilizers. These fertilizers achieve results which are as good as standard fertilizers while using less fertilizers . In recent use there have different types of slow or controlled released fertilizers some of them are as follow:-

- Sulfur coated compound fertilizers.
- Sulfur Coated Urea
- Resin coated fertilizers
- Urea formaldehyde
- Tower melt spraying granulation compound fertilizers.
- Urea melt spraying granulation compound fertilizers.
- Chemically modified biomass coating urea for controlled released.
- Bulk blend fertilizers.
- Glass fertilizers.

These controlled released fertilizer can produce the same yield with the rate 10-40% less than conventional fertilizer. Sometimes, only single application is required which can reduce labour cost by 75%

Glass fertilizers do not contain toxic substances since it does not have an acidic sulphate or chloricradical, glass fertilizers does not cause acidity to the soil, toxic gas or hydro sulpharic that can destroy plant roots[13]. The glass fertilizers is not water soluble, it lies with in soil and continues providing necessary nutrients for plants. The glass fertilizers not only helps increase the fertility of soil, suitable for many kinds of plant but also help to prevent lack of magnesium and other nutrients in the soil that support the plants growth. The experiments have shown a 25-50% increase in the crop production with the use of these micro nutrient glass fertilizers and the benefits can be seen for over 20 years of each addition.

2.3.Conversion of agriculture waste as energy source:- India is an agriculture based country, most of the population lives in rural area and adopt agriculture as main occupation. As a result, lots of agriculture waste are generated and remained unutilized. Globally 140 billion metric ton biomass it generated from agriculture, this include sugarcane bagasse, rice straw, grasses sawdust, corn stalk, coconut shell, coffee husk, etc. depending on regional characteristics. In developing country like India the direct burning of agriculture is a common practice which lead to serious environmental impact e.g. emission of carbon dioxide, nitrogen oxide and other harmful gases. India needs to burn approx. 92 million turns of agriculture biomass every year leading to considerable impact on air quality and health. The improper utilization of agriculture waste contributes to global change, water and soil contamination and local air pollution. Beside this waste is of high significance with respect to material and energy recovery[14]. Since energy crisis of 1970's many countries are interested to develop biomass as fuel source. Up until recently the interest in biomass has lessened due to technological breakthrough that make fossil energy inexpensive. However, the higher greenhouse emission, deadly air pollution, stable fossil base energy prices and strong growth of global transportation fuel demand have booster extensive research efforts in developing bioenergy. Bioenergy is energy derived from any fuel that originated from biomass. Biomass is a renewable sources and consider as an alternative feed stock to provide sustainable energy. Biogas, bio-char, bio-diesel, bio-ethanol are example of bioenergy. The share of energy from renewable source in European countries is growing every year. Over the last 15 year the share of energy of renewable sources has more than double and has amount it to 22.1% in 2020 (10.2% in 2005). Sustainable utilization of biomass waste to produce energy can solve the problem of pollution by burning the spoiling of agro waste, problem of rural employment and utilization of waste land. It is helpful to enhance the social and economic status of the farmer and people of the rural areas[15].

By these ways Green chemistry seeks the goal towards farm profitability, community prosperity and improving soil quality by reducing the dependence use of nonrenewable resource like synethetic fertilizers and pesticides minimizing the adverse effect on water quality, wild life and safety. We can say that the green chemistry generates the new green inputs for sustainable agriculture production and protection.

3. Green chemistry and sustainable packaging

Plastic is a necessary component of packaging industry. In recent years, the use of plastic in fpackaging industry has raised severe environmental issue. According to India's ministry of environment, the nation presently produces about 70 million tons of municipal solid waste, out of it nearly 20% of get recycled and remaining 80% ends up in landfills and ocean, where it harms humans, marine life and ecosystem. To cope with the issue business today have embraced sustainable packaging. Sustainability can be achieved in packaging industries by the green chemistry.

The approach of green chemistry, to eliminate the use of potentially harmful substances in the design, manufacture and use of chemical products, is applying to develop the plastic alternatives for packaging. The industry is exploring the use of biodegradable materials in place of traditional plastic. Biodegradable plastic is a plastic that degrade because of the action of naturally occurring microorganism such as bacteria, fungi and algae. They are produced by renewable sources and have similar properties to conventional plastic. Bio based polymers or plastic can be classified into three main groups depending upon their origin and method of preparation[16].

3.1. Polymer extracted/isolated directly from biomass or natural materials

3.1.1. Chitin and chitosan: Chitin is a linear copolymer of N-acetylglucosamine and N-glucosamine. The monomers are randomly arranged through the polymer depending on the processing method. It is abundantly available and considered as amino cellulose. Chitin is mainly present in shells of insects, crabs, shrimps, etc. Another source for chitin is from fungi cultivation where protein content ranges from 10 to 15%. The solubility of chitin is very low, so it is usually blended for packaging application.Partial N-deacetylation of chitin forms chitosan that is insoluble in water and soluble in very few acidic solutions and has a compact crystalline structure and strong hydrogen bonding . Chitosan is degraded by chitosanase or lysozymes. Both are applied to produce various biodegradable films for packaging, and the largest they use as an edible coating to prolong the shelf-life of fresh fruits and vegetables[17]. Chitin and chitosan have good antimicrobial properties to a variety of fungi, yeasts, and bacteria found in food.

3.1.2. Starch and cellulose: Starch is composed of amylopectin and amylose. It is abundantly available and extracted from wheat, rice, potatoes, and corn. As the source changes, the content of amylose and amylopectin changes. The elongation and strength increase as the amylose content increases. Starch is mostly used as thermoplastic starch (TPS). Cellulose is a linear polymer formed from repeating units of cellobiose. It is crystalline and insoluble in organic solvents. Due to its insolubility and low fluency, it is transformed in different forms for their application. This transformation is achieved by various degrees of substitution. As the substitution degree increases the mechanical properties and degradation rate decreases.

3.1.3. Collagen and gelatin: Collagen is a connective tissue protein composed of various polypeptides, which includes hydroxyproline, proline, glycine, and lysine. The glycine content is responsible for the flexibility of collagen. They are incorporated into cellulose and PVA films.. A higher molecular weight polypeptide formed by chemical degradation of collagen is gelatine. It has excellent film forming abilities and consist of 19 amino acids. Degradation of gelatine is caused by the enzyme protease.

3.1.4. Wheat gluten and soy protein: Wheat gluten is of low cost and a readily available by-product of the fabrication of starch. Their degradation speed is highest as compared to other polymers with no harmful by-products. It is an excellent film-forming agent but is brittle without a plasticizer. Soy protein concentrate does not have water-soluble carbohydrates. It has a protein concentration of 70%.. Soy protein film incorporated with glycerol, gellan gum, or K-carrageenan is for the production of biodegradable soybean-based packaging containers (trays)[18].

3.2. Polymers produced by classical chemical synthesis from bio-monomers

3.2.1. Polylactic acid (PLA): PLA is a type of aliphatic polyester obtained by ring opening polymerization of lactide monomer. The lactic acid monomers are usually obtained from the fermentation of renewable materials like corn, sugar, and other feedstocks, etc. It is recyclable, compostable, and degrades within a short life span having a high molecular weight and has high transparency. By changing the monomeric ratio, the properties of PLA can be changed from crystalline to amorphous. PLA is currently used for food packaging of short-shelf products.

3.2.2. Polycaprolactone (PCL): PCL is a semi-crystalline, completely biodegradable, easy to process, and cheap fossil-based polymer. It is soluble in many organic and inorganic solvents and has a glass transition temperature (Tg) of −60 °C which increases its application as a compatibilizer in formulations of polyurethane

3.2.3. Polybutylene succinate (PBS): Polybutylene succinates belong to the polyalkenedicarboxylate family and are obtained by polycondensation of glycols such as 1,4- butanediol and ethylene glycol with aliphatic dicarboxylic acids, like adipic and succinic acid. It is a white crystalline polymer, with good processibility having a Tg of −45 to −10 °C and a melting point of 90-120 °C with 330% elongation at break. PBS has mechanical properties approximately like Polyethylene (PE) and polypropylene (PP)

3.2.4. Polyglycolide (PGA): Polyglycolide or polyglycolic acid prepared by glycolic acid polycondensation. It is one of the simplest aliphatic polyesters with a glass transition temperature (Tg) of 35-40 °C and melting point (Tm) of approximately 220-250 °C. It is insoluble in water due to high crystallinity of 40-55% and soluble in most fluorinated solvents which can be used to form high molecular weight polymer films. The polymer is completely reabsorbed by the organism within 5-6 months

3.2.5. Polybutylene adipate-*co*-terephthalate (PBAT): PBAT is a linear aromatic co-polyester obtained from the condensation of 1,4-butanediol with a mixture of terephthalic acid and adipic acid. At a terephthalic acid concentration of more than 35% mol, it exhibits excellent properties. As the content increases above 55% the biodegradation rate of PBAT decreases. PBAT is flexible and soft like PCL so it is used in the production of films, filaments, bottles, and molded products. PBAT can be blended with cellulose, starch, and other biodegradable polymers.

3.2.6. Polyvinyl-alcohol (PVA): PVA is a semicrystalline polymer comprising mainly amorphous phases with only a small amount of crystallinity and consists of 1, 3-diol units or 1, 2-diol units, depending on the hydrolysis degree of poly (vinyl-acetate). The properties of PVA generally depend on its molecular weight and degree of hydrolysis with the molecular weight of PVA generally ranging between 20,000-400,000 and based on the length of vinyl acetate used to produce PVA ,the degree of hydrolysis is typically in the range of 80-99%[19] .

3.3. Polymers obtained from natural or genetically modified organisms

3.3.1. Polyhydroxylalkanoates(PHAs): PHA represents natural polyesters produced by bacterial fermentation of sugar, glucose, or vegetable oil feedstock. It is one of the most recent and widely used biodegradable polymers for food packaging applications. PHAs are completely biodegradable. Biodegradation occurs through the esterase activity of linkage breaking of the monomer from the chain ends. The most common PHA is the PHB (polyhydroxybutyrate), formed by the polymerization of 3-hydroxybutyrate. PHB is known for its excellent UV-resistivity and high optical properties with T_m of 180 °C and T_g of 55 °C. PHB has a crystallinity of more than 50%.

Biodegradable polymers help in reducing the environmental impact of plastic production and processing. As biodegradable polymers are made from renewable feedstocks, agricultural waste; there is a great opportunity for research work in harnessing this economic opportunity. Biodegradable polymers at present only replace about 1% of the plastics. Several factors like policy and legislative changes, as well as world demand for food and energy resources, influences the development of biodegradable packaging. The use of bio-based polymers is increasing for the packaging of food and other applications at a great speed.

4.Green Chemistry and waste management:

Waste management is global challenge because of significant fraction of green house emissions generated by improper waste disposal, and a priority to be addressed to ensure sustainable treatment and consumption of the waste. The usage and reproduction of the chemicals produces reduced waste products, non-toxic components and improved quality. Green chemistry is a highly effective motivation in pollution prevention because it applies innovative scientific approaches in real-world environmental situations. Green chemistry approaches the use of feedstocks derived from annually renewable resources or from abundant waste, design of chemical products for increased, more facile reuse or recycling, reuse or recycle of chemicals, treatment of chemicals to make them less hazardous, disposal of chemicals properly including radioactive wastes. Hazardous material management chemists work on teams responsible for detecting and identifying chemical pollutant in the air water and soil[20]. They make significant contribution toward:

-Reducing pollution and remediating problems caused by hazardous waste.
-Evaluating and coordinating the storage and handling of hazardous waste.
-Clean up contaminated soil or water.
-Other activities that impact the environmt.

Garbage can be segregated into five types, they must be treated separately. these are

-Hospital waste
-non biodegradable waste that can be recycled
-non biodegradable waste that cannot be recycled
-toxic chemical waste
-biodegradable waste.

The approximate composition of city garbage its 50% organic matter 25% plastic and 25% other matter. The garbage that could not be clear is stay in the city and year after year the heap increases and hence the cities are becoming more and more unhygienic it is very necessary to treat the different type of garbage day by day[21].

4.1 Treatment of hospital waste: Every hospital must install an incinerator in its premises and all biomedical waste which are not incinerable must be disposed of in an environmentally sound manner. Controlled air incinerators are the best incinerator to get ride of all type of hospital waste. In these incinerators the heat and air for combustion is regulated in such a way as to first volatize in conditions of inadequate air and then totally destroy the waste by adequate heat and excess air.

4.2 Non-biodegradable but recyclable waste: The predominant non-biodegradable waste is plastic. The raw material for the manufacture of plastic items constitutes resins. These resins consist of thousands of particles which melt into syrupy liquid then heated and can we shaped into almost any form. Although various types of plastic may look same, they are quite distinct groups of material of different molecular structure. The plastic garbage collected from the cities, villages, factories are brought to plastic recycled unit and make the product of different use. The other recyclable but non-biodegradable garbage are non ferrous metal. Lead is one of the toxic waste all over the world. Lead storage batteries are used to provide power for electrical system of automobiles electronic instruments, computers, etc. The waste cells are sent to the places where disposal and processing cost are lower from the lead scrap. Lead plates are generated by heating with coal. These new lead plates so produced are used to make new storage cells. Phasing out is the best solution to eliminate the risk of lead pollution in environment. The alternative medium of KOH with Ni-Cd electrodes or Ag-Zn electrodes, Ni/Nickel Hydroxide as anode and finally divided iron as cathode called Ni-Fe cell have been introduced. Silver- zinc cell and Ni-Fe cell are being used in aeroplane all over the world. The most promising use of waste paper is the conversion of material to energy, it has a high calorific value approximately half that of coal and does not cause air pollution[22]. The waste paper can also be used to make paper board.

4.3 Biodegradable garbage: In nature all that matter is gradually acted upon by the force of nature such as sun, wind, rain and microbes, which serve to break down complex material into simple molecules. If such materials is left to decay on roadside, it begin to decompose and stink, and invite many diseases. Instead the process of decomposition can be used to convert organic waste which we generate everyday to produce compost, which can help us keep our surrounding clean and green. Now a days, such type of organic waste become a great source of energy. Development of biogas technology in India begin almost 75 years ago. It was in 1937 that a sewage treatment plant employing anaerobic digestion process was set up in Bombay. This generated the interest of scientists and researchers in the field of anaerobic digestion of cattle dung for the production of combustible gas called- biogas. Biogas plant, if installed adjacent to electric generator plant can be used as fuel for the production of electricity. Compressed biogas can be used a fuel for running city bus services with a non polluting exhaust. Such a management of organic garbage will give particular matter free, cheap fuel and organic fertilizer[23]. With the time entire organic matter may be managed to be converted to energy and pollution of garbage can be sustainably tackled.

4.4 Toxic waste and non-biodegradable non-recyclable waste: Toxic waste, chemical waste material capable of causing death or injury to life. Waste is considered toxic if it is poisonous, radioactive, explosive, carcinogenic (causing cancer), mutagenic (causing damage to chromosomes), teratogenic (causing birth defects), or bioaccumulative (that is, increasing in concentration at the higher ends of food chains). Poisoning occurs when toxic waste is ingested, inhaled, or absorbed by the skin.

The most-effective method of reducing the effects of toxic waste on human health and the environment would be to eliminate its production. Toxins can be reduced through the substitution of nonpolluting alternatives, such as oxygen for chlorine in the bleaching of wood, or through "green chemistry," a movement that seeks to build chemical products and processes that reduce or eliminate the need for toxic substances. Efficient production processes and proper maintenance of machinery also reduce toxins. Some wastes, such as expensive heavy metals, can be recycled, which can cut both the amount of toxins needed in the production process and the producer's costs[24]. Toxic wastes can be disposed of by depositing them in specially built landfills or by incineration, depending on their chemical type. With land disposal, waste is buried in landfills that should be "permanently" sealed to contain the waste. Landfills may be lined with clay or plastic, or waste may be encapsulated in concrete. Incineration may be at low temperatures, primarily for urban refuse, or at high temperatures, which are best for many industrial wastes such as tar, paint, pesticides, and solvents since they prevent the formation of dioxins. Toxic wastes may be disposed of by using bioremediation processes, in which living organisms are added to the waste to degrade organically or transform contaminants or to reduce them to environmentally safe levels. Some microorganisms use oil as a source of food, producing compounds that can emulsify oil in water and facilitate the removal of the oil. Successfully applied following the Exxon Valdez oil spill of 1989 and the Gulf of Mexico oil spill of 2010, bioremediation treats contamination in place, thus avoiding removal and disposal costs while reducing environmental stress associated with conventional cleanup efforts. A similar process, called phytoremediation, uses plants to draw in toxic substances, such as heavy metals from soil.

Conclusion: As we can see from all the above technological advances, green chemistry principles have advanced considerably in the last decads. Research on various industrial applications has been very successful and with considerable advantages for energy consumption, less toxic products and minimum waste. Green Chemistry, through design and better synthetic routes focused on cleaner production techniques, energy saving techniques and less toxic consumer products. From fuels, pesticides, fertilizers elastomers, plastic, medicines, analytical reagents and other commercial products, the major industrial persons now concentrating in the production of safer, healthier and more benign products for the environment. At the same time industry takes part in the goals of sustainability and prevention of environmental damage, not only because technological advances provide alternative methodologies but because it makes economic sense and averts the future lack of resources for feedstocks and energy.

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