Modern Food Packaging Technologies: Regulatory Aspects and Global Trends

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Week – 11
Lecture – 55

Welcome to the NPTEL online certification course on Modern Food Packaging Technologies: Regulatory Aspects and Global Trends. Dear friends in the last lecture we have covered the recent trends in packaging materials that is the edible packaging materials. In this lecture, we will be covering the recycling and disposal of plastic waste and environmental concern and the topics which we will be covering is introduction, global plastic waste, prime causes of plastic waste, benefits of reducing plastic waste, technologies and approaches for removal of plastic. The introduction Plastic waste or plastic pollution is the accumulation of plastic objects for example, plastic bottles and much more in the earth's environment that adversely affects wildlife, wildlife habitat and humans. It also refers to the significant amount of plastic that is not recycled and ends up in landfill or in the developing world thrown into the unregulated damp sites. In the UK for example, over 5 million tons of plastic is consumed every year and yet only one quarter of it is recycled.

The three quarters that is not recycled enters our environment polluting our oceans and causing damage to our ecosystem. In less developed countries, the majority of plastic waste eventually ends up in the ocean meaning that marine animals are especially at risk. So much of what we consume is made of plastic such as plastic bottles and food containers because it is inexpensive yet durable. However, plastic is slow to degrade taking over 400 years or more due to its chemical structure which presents a huge challenge.

Reducing plastic consumption and raising awareness about plastic recycling is crucial if we are not to overcome the problem of plastic waste and pollution on our planet. The global plastic waste, plastic waste is one of the most serious environmental issues of our time. According to the organization for economic cooperation and development, global plastic outlook the world generated 353 million tons of plastic waste in 2019, a number which has more than doubled since 2000. Out of this only 9 percent was recycled while almost 50 percent was landfilled, 19 percent was incinerated and 22 percent was discarded in uncontrolled sites or in the environment. In 2023 a staggering 43 percent of plastic that is produced and used is mismanaged as waste thus likely to end up in the earth's air, water and soil.

This means 6,86,42,999 tons of additional plastic waste will end up in nature this year. In terms of global governance the Basel Convention is the key international instrument to regulate trans boundary movements of hazardous waste and their disposal the secretariat

is based in Geneva. The global plastic waste, recent statistics indicate that plastic waste is approximately 30 percent of all waste produced worldwide. The world generates 242 million tons of plastic waste, 12 percent of all municipal solid waste, the majority of waste come from three regions that is the North America about 35 million tons from the Europe, 45 million tons from East Asia and the Pacific 57 million tons. And estimated 81 percent of global ocean plastic waste was emitted from Asia in 2019.

Countries with a smaller geographical area, longer coastline, high rainfall and poor waste management systems are more likely to wash plastics into the sea. Of the global plastic waste estimated about 55 percent was discarded, 25 percent was incinerated and 20 percent was recycled. Similarly, China produces the largest amount of plastic waste by a significant margin followed by Indonesia, the Philippines, Vietnam and Sri Lanka which all makes the top 5. The household plastics waste, there are different types of plastic waste like household plastic waste, industrial plastic waste, agricultural plastic waste, electrical plastic waste, medical plastic waste etcetera. These are the sources of different types of plastic wastes.

Prime causes of plastic waste, plastic is cheap, readily available and its use is widespread. Since, plastic is an affordable and durable material, it can be found in everything from packaging materials to plastic bottles, straws to plastic bags and much more. Until businesses start to utilize more environmentally friendly alternative materials such as paper, the cycle of producing and disposing of plastic will continue. The world's population is growing and so is urbanization. The more of us there are in the world, the greater the demand for cheap materials and in turn the more plastic we use to access.

To illustrate this in the first decade of this century, more plastic has been produced than ever due to rapid urbanization and in turn demand. We have a disposable mentality when it comes to plastic. Plastic items typically have a very short life span - think carrier bags, water bottles, straws and food containers and because they are so cheap to make, we do not value them enough to hang on to individual items. Not only that, but the disposal of plastic is often mismanaged.

So again, it ends up in landfills. The plastic takes over 400 years to decompose. The chemical bonds that makes up plastic are strong and made to last. The decomposition rate of plastic can vary depending upon the type. However, this typically ranges from 50 to 600 years.

In other words, according to the US EPA that is Environmental Protection Agency, almost every bit of plastic ever made and sent to landfill are dumped in the environmental still exist, a sobering thought for all of us. New plastic items are manufactured every day and the cycle repeats. The marine shipping and fishing industries. The shipping and fishing industries are also responsible for contributing towards plastic waste and pollution particularly in our oceans. Plastic waste is often washed to source from ships and nets used for fishing which are usually made up of plastics.

Not only does this plastic pollute the water, but marine animals can become trapped in nets and are swallow the toxic particles. Overall, the shipping and fishing industries have a lot to answer for when they comes to plastic pollution. Benefits of reducing plastic waste. The preventing pollution by lessening the amount of new raw materials used. It saves energy, reduces greenhouse gases emissions which contribute towards climate changes, reduces the amount of waste that needs to be recycled or developing countries sent to landfills or incinerators.

Saves money since reusable items work out cheaper than the constantly purchasing more plastics. Technologies and approaches for removal of plastics. Since the last decade, efforts have been made to eliminate plastic pollution either by reducing it at their source or by removing it after generation. Various technologies such as adsorption, photocatalytic degradation, coagulation and microbial decomposition have been introduced and investigated to reduce plastic loads. Along with this approaches such as landfill, incineration and 3R that is the reduce, reuse and recycle have also been copped up.

The plastic waste in water that degrade quality of drinking water. They impact oceans and aquatic animals. The plastic waste in terrestrial area can reduce soil fertility. It adds heavy metals. Plastic waste in air they will release such air pollutants that affects human health and gases can lead to climate change like for example, carbon dioxide and methane.

The removal of plastic waste the techniques can be adsorption, coagulation, photocatalytic degradation, microbial decomposition and the approaches could be landfill, incineration, reduction, reuse and recycle. For ocean adsorption, adsorption among the oldest techniques has been successfully explored for removal of organic and inorganic pollutants from water and waste water. This is the surface phenomena where pollutants from the water or gaseous phases are transferred to the surface of solid materials called absorbents. The removal of micro plastics can be easily adsorbed and separated from waste water through various micro meso and micro porous nano materials. These techniques are limited to plastic size more than 5 micrometer.

The photocatalysts, photocatalysts is an exciting approach for handling plastic waste especially micro and nano plastic. This technique is a light mediated redox process in which appropriate light energy excites nano structured semiconductors that lead to the creation of excitant pairs which react with surroundings waste water or moisture to produce highly reactive species like super oxides and hydroxyl radicals that can effectively oxidize organic species including polymers. Various photocatalysts such as zinc oxide and titanium oxide have been used to study the degradation of polyvinyl chloride, polyethylene terephthalate, polystyrene and polyethylene. Coagulation, coagulation is the chemical method for the removal of solid particles from water by introducing small and highly charged molecules into the water to manipulate the electrostatic charges of the suspended particles in the water. Microorganisms, now a days researchers and scientists have shifted their efforts to develop strains that could potentially help eliminate plastic waste.

Various microorganisms such as bacteria and fungus have been reported to potentially degrade plastic waste especially micro plastics. In microbial degradation plastics decompose and end up as biomass methane, carbon dioxide, water and other inorganic compounds. For land use the most preferred should be from the top to bottom and the prevent the first should be it should be prevented, then its use should be reduced, then it should be reused, then it should be recycled, then it should be recover and lastly it should be disposed. Land filling that is the dispose, the plastics constitute a significant portion of municipal solid waste and most of them have been imperiled to land fills without further treatment. Due to legislative pressures, lack of maintenance and infrastructure, emission of greenhouse gases and poor biodegradability of commonly used polymers etcetera causing the disposal of the waste in land fills has become a serious threat to environment.

In light of this hazardous waste management, environmental protection agency has improved federal and state regulations for land filling by normalizing the use of land filling beds, ground water testing and post care after landfilling. Energy recovery by incineration, the energy recovery from plastic waste undergoes a process named incineration by which energy is recaptured by non degradable plastic wastes. This is because the octane number of some plastic materials is analogous with respect to some crude oil derivatives and it is predicted that almost 50 percent of total plastic waste will be cured by incineration by 2050. However, the main incineration products are water and carbon dioxide which makes it conceivable to be used as a substitute for conventional fossil fuels. Incineration equipment includes a program control system, detection system, and a chemical system, cyclone separator, combustion chamber, air supply bumps, cooling systems etcetera.

This is the flow chart which shows the production of energy from the waste. Here the that waste solid waste is dumped from here it is transported to the burning chamber where the flue gases are generated and which is able to run the turbine for production of electricity. And the fly ashes which are heavier and they can be disposed for the land filling. However, the lighter ashes are separated by a cyclone separator and again it is thrown away for the land filling and the water and flue gases can be desorched to the environment. The recycling, the mechanical recycling is the process of converting the used thermoplastics to form a new or a similar type of product.

This is a type of primary and secondary recycling process which starts with sorting out the thermoplastic to be used in the recycling process. In addition in biological recycling organic carbon materials are also converted into biomass which possesses energy potential and saves environment. The chemical recycling process can also handle mixed and contaminated polymers as they reform the degraded polymer structure according to the applications and properties entitled for final products. This is the mechanical recycling of the plastics. Here the raw materials are collected and then these plastics are separated and then cyclone separated are separates the dirt etcetera.

And then it is scrap is ground to powder then cleaning will take place then passed through the hot air oven then development of composition for newer and then newer material is developed then it is passed through the extrusion and then injection molding to get the new product. Whereas, the in organic recycling the organic bio plastic granules are collected in a bio waste bin then it is separated and collected in the bio waste then the it is sent to the industries for bio waste treatment and industrial compost plant. Then it is sent to for the compost which is produce that will use as a plant fertilizer and then it is used sent to the bio refinery for further producing of the bio plastic granules. Reuse, reuse is another approach that may reduce the demand for the new plastic products. However, many people prefer the recycling or refuse approach over reuse, but the reuse approach saves money and conserves energy and resources.

Reuse is an efficient approach for the reduction of plastic waste load, but recycling is considered more effective methodology to restrict the utilization of virgin materials in the manufacturing of plastic products. Further recycling could saves 40 to 100 mega joules per kg depending upon the polymer and reduce the depletion of fossil fuels. Reduce reduction is always considered the best way to manage any waste. The key factor is reducing the purchasing amount or restricting only to buying what we need. This approach is not only limited to saving resources and energy, but also reduces the number of pollutant emissions and subsequently improves the environment. Thank you very much.