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PLASTIC WASTE: CURRENT ENVIRONMENTAL POLLUTION, HEALTH HAZARD AND BIODEGRADATION STRATEGIES AND ITS MANAGEMENT

Abstract

Plastic changed everyday life; production and usage of plastic exceeded every day reaches 390 million tons by 2021. In this review paper, we are concerned about the growing demand for plastic everyday all over the world. It is evident that plastic become a solution in every field because plastic is a low-cost and durable product. Plastic brings many benefits socially and future for technologies and medical advances. But plastic has become a very serious problem because plastic causes pollution in the environment. The disposal of plastic and accumulation waste in landfill is a matter of concern. We all know that plastic is non-degradable product plastic can be land filled for years and cause serious problems which are related to humans, wildlife, the ecosystem, and others. Plastic pollution in the marine environment is a serious threat because marine animals get affected by neoplastic and microplastics. Plastic sustainability we are destroying our future with these activities. Around 4% of the total world, oil is used in biofuel to make plastic and around 4% is used in energy in the process. More than half of the product is used in packaging which is discarded same time in the landfill and plastic stays in the landfill for years. There are many solutions to overcome this problem including material reduction, end-of-life recyclability designing, recycling capacity, short-loved applications of plastics, limited disposal of plastic, policies for reducing littering, and application for green chemistry. These actions can be most effective with the help of the public, industries, scientists, and policymakers. Because it's time to take

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action because there is some urgency, the quantity of plastic production is growing very fast and the problems with the growing demand for plastic are also increasing. For the degradation of plastic there are many ways but biological degradation is environmental-friendly, low cost, easy and sustainable process. There are many microbes which have ability to degrade plastic so we need to understand the interaction between plastic and microbes so we can overcome from the plastic pollution. In this review article we discussed the overall scenario of plastic uses, plastic misuses, plastic pollution and management of plastic pollution.

Keywords: Polymer, Endocrine disruption, phthalates, Biodegradation, fungi.

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I. INTRODUCTION

Plastics are basically made from polymers that have a wide range of materials such as synthetic and semisynthetic. Plastics have excellent ability because they can be molded and pressed into various shapes. Plastic has other various properties as plastics are lightweight, durable, flexible, and cost-effective products, and the whole world plastic has been used for any purpose. Basically, plastics are manmade products and it is typically made through human industrial systems. Plastic is made from fossil fuel-based chemicals like natural gas and petroleum. Although, through recent methods, plastics are also made from renewal materials, such as corn or cotton derivatives. ("Life Cycle of a Plastic Product". Americanchemistry.com. Archived from the original on 2010-03-17. Retrieved 2011-07-01)

Plastic was estimated made from 1950 to 2017 at least 9.2 billion tonnes. Half of the 9.2 billion tons has been produced in 2004. And in the recent year 2020, it has produced at least 400 million tons. If it will continue like this it is estimated that the global production of plastic will be over 1,100 million tons by 2050. (Environment, U. N. (2021-10-21). "Drowning in Plastics – Marine Litter and Plastic Waste Vital Graphics". UNEP - UN Environment Programme. Retrieved 2022-03-21).

Bakelite was the first world's fully plastic and it was invented by Leo Baekeland in New York in 1907. *(American Chemical Society National Historic Chemical Landmarks. "Bakelite: The World's First Synthetic Plastic". Retrieved 23 February 2015.)* Baekeland invents the term "plastics". (Jump up to *Edgar D, Edgar R (2009). Fantastic Recycled Plastic: 30 Clever Creations to Spark Your Imagination. Sterling Publishing Company, Inc. ISBN 978-1-60059-342-0 – via Google Books).*

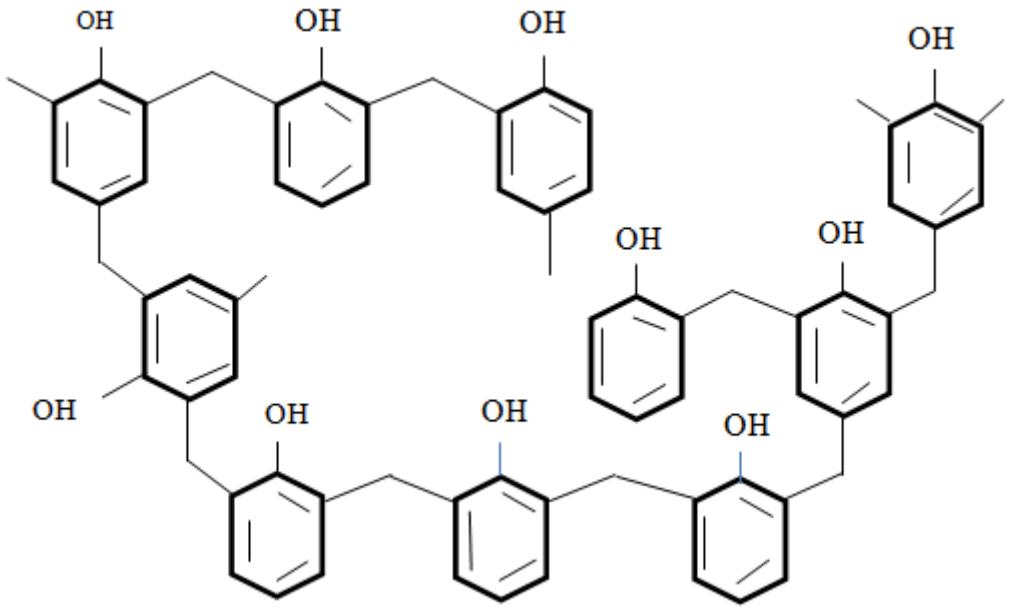

Figure 1: Chemical structure of Bakelite

In todays time hundreds of different types of products such as polyethylene and many more. Polyethylene is widely used in packaging and in construction and pipe production

PolyVinyl chloride (PVC) has been used because of its strength and durability. There was many chemist and scientist who contributed to the material science of plastic such as Noble laureate Hermann Staudinger has been called "the father of polymer chemistry" and Herman Mark is known as "the father of polymer physics". (Jump up to *Teegarden DM (2004). Polymer Chemistry: Introduction to an Indispensable Science. NSTA Press. ISBN 978-0-87355-221-9 – via Google Books).*

Plastic is basically driven from the Greek word "plastikos" which means plastic is capable of being shaped; it can be molded in any shape. Plastos means "molded". Plasticity refers specifically to materials used in the manufacturing of plastics. Plasticity allows molding and compression into different shapes: films, fibers, plates, tubes, bottles, boxes, etc. the substances which are non-reversible change in form of solids are defined as plasticity. ("Plastic"Online Etymology Dictionary.Retrieved 2021-07-29).

Approximately, 1600 BC ago Mesoamericans' ancient first processed natural rubber was used as balls, figurines, and bands humans have benefited and it was made from polymer. From that time man has depended on plastics and rubber because the use of plastic was increasing day by day first polymer was used as horn, waxes, natural rubber, and resins, and when the thermoplastics began as modern plastic in the nineteenth century these types of plastic have vanished from the market. (Hosler et al. 1999)

In 1839 vulcanized rubber was invented by a German scientist Eduard Simon discovered polystyrene (PS). From the nineteenth century developmental work was continued on natural and synthetic polymers and synthetic producing celluloid for billiard balls and polyvinyl chloride (PVC) is used in myriad applications and viscose for clothing. In 50 years of development of the plastic structure of plastics contains organic polymers. Most polymers are formed from carbon atoms chains it can be with oxygen, nitrogen, or sulfur atoms or they can be without these attachments. These chains include frequent units formed from monomers. And each polymer chain comprises thousands of repeating units. The main path of the chain is the backbone which links together a large number of repeat units. The properties of plastic on the basis of molecular groups are called a side chain attached from the backbone. Monomers are linked together to form the polymer chain. The side chain structure affects the properties of polymers. (Ebbing D, Gammon SD (2016). The chemical structure of the polymer's backbone and side chains are classified as plastics. Groups like acrylics, polyesters, silicones, polyurethanes, and halogenated plastics are included for plastic classification. Condensation, polyaddition, and cross-linking are the basic chemical process which is used in plastics synthesis.("Classification of Plastics". Joanne and Steffanie's Plastics Web Site.Archived from the original on 2007-12-15.Retrieved 2011-07-01"Classification of Plastics". Joanne and Steffanie's Plastics Web Site.Archived from the original on 2007-12-15. Retrieved 2011-07-01) Plastic can be classified through physical properties like hardness, density, tensile strength, thermal resistance, and glass transition temperature. And an additional classification of the plastic can is determined by the resistance and various substances reactions and processes such as oxidation and ionizing radiation. On the basis of manufacturing of plastic products design including thermoplastics, thermosets, conductive polymer, biodegradable plastics, engineering plastics, and estomers. (*Kent R. "Periodic Table of Polymers". Plastics Consultancy Network.Archived from the original on 2008-07-03).*

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Thermosetting and thermoplastic polymers are two chemical processes through which plastic can be classified whether it is reversible or not.

In thermoplastics, there is no chemical change in their composition when heated so they can be heated and molded frequently. Thermoplastics include polyethylene (PE), polystyrene (PS), and polyvinyl chloride (PVC). (*"Composition and Types of Plastic". Infoplease.Archived from the original on 2012-10-15. Retrieved 2009-09-29*) On the other hand, thermosets or thermosetting polymers take shapes only once if the thermostat gets solidified it will stay solid. Because in thermostats some irreversible chemical reaction takes part in the process if thermostat polymer is reheated it will decompose and then melt. (Gilleo K (2004). Most of the plastics are amorphous and which means amorphous plastics do not have a high molecular structure. Amorphous plastic includes thermostats, polystyrene, and methyl methacrylate (PMMA). And crystalline plastics have spaced atoms like high-density polyethylene (HDPE), polybutylene terephthalate (PBT), and polyether ether ketone (PEEK). Although in some cases plastics can be amorphous and crystalline both at the same time. And semi-crystalline plastics include polyethylene, polypropylene, polyvinyl chloride, polyamides (nylons), polyesters, and polyurethane. (Kutz M (2002).

One of the types of polymers is conducive which are more precisely intrinsically conducting polymers (ICPs) (*Inzelt, György (2008).* and these are organic polymers and ICPs are electricity conductors. These compounds may have metallic conductive polymers or semiconductors. Conductive polymers have advantages because they have dispersion processability. Conductive polymers are not thermoformable. But they are organic materials (*Naarmann, Herbert 2000)* Conductive polymers have high electrical conductivity. And the electrical properties can also be adjusted by using some methods like organic synthesis and advanced dispersion techniques. (*Nalwa, H.S., ed. (2000).*

Biodegradable plastics are those plastics that degrade by natural factors like sunlight, ultraviolet radiation, water, bacteria, enzymes, and wind abrasion. Plastics get attacked by insects such as wax worms and mealworms these types of degradation are called as biodegradation. Biodegradation is of two types Aerobic and Anaerobic degradation. In Aerobic degradation plastic degrade by exposure. In aerobic degradation, plastics degrade in landfill or composting systems. Biodegradable additives are also produced by some companies to enhance the biodegradation. (*Brandl H, Püchner P (1992).*

Bioplastics are those which are made from the renewal plant's materials like cellulose and starch. (Biochemical Opportunities in the UK, NNFCC 08-008 — NNFCC".Archived from the original on 2011-07-20. Retrieved 2011-03-24).Rising levels of greenhouse gases and fossil fuel reserves are the main reason for burning fuels and the development of bioplastics is growing. The worldwide production of bioplastic is estimated at 327000 tons every year. And polyethylene and polypropylene were estimated produced 150 million tons in 2015 (Galie F (November 2016)

In plastic industries, the production of plastic compounding and conversion with the sale of plastic products are included. Russia and the Middle East are the two biggest producers of petrochemical raw materials; plastic industries contain many companies and companies divided into several sectors.

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Between 1950 and 2017 plastic production was estimated at 9.2 billion tons, and half of this was produced in 2004. The plastic industry was established in the 1950s and plastic production has increased worldwide tremendously. And the outcome of this production seen in 2021 the production of plastic reached 400 million tons (Geyer et al 2017 In 1950 use of plastic occurred in packaging, building, and construction and in many sectors. And the demands for plastic globally are still high and by 2050 the production of plastic will reach 1100 million tons estimated. (*Environment, U. N. (2021-10-21). "Drowning in Plastics – Marine Litter and Plastic Waste Vital Graphics". UNEP - UN Environment Programme. Retrieved 2022-03-21*)

Polymerization is the method by which plastics are produced in chemical plants from their starting material's monomers. Monomers are petrochemicals in nature. These facilities are similar to oil refineries and large with sprawling pipework running throughout. These plants affect the economies of scale at a large level. In spite of Plastic production not taking over the company's accounting of worldwide production. And half of the production takes place in East Asia and only is the single largest producer in the world. ("Top 100 Producers: The Minderoo Foundation". *www.minderoo.org. Retrieved 14 October 2021)*

Notably, Europe and North America have been influenced by global plastics production. Although Asia become a remarkable producer, China considers 31% of total plastic production in 2020. Plastic production differences consider the user demand in every region. It is based on the price of fuels and feedstocks and investments in the petrochemical industry. For example, US$200 has been invested in United States plastic and chemical plants since 2010 and encouraged by cost-effective raw materials. In European Union (EU) a heavy contribution has been made in the industry of plastics and plastic industry employing more than 1.6 million people and the turnover is shocking at 360 billion euros annually. But in China, at least more than US$366 billion was generated through plastic manufacturing companies. (*Environment, U. N. (2021-10-21). "Drowning in Plastics – Marine Litter and Plastic Waste Vital Graphics". UNEP - UN Environment Programme. Retrieved 2022-03-21).Thermoplastic is the most used plastic type which is followed by globally. Because thermoplastics can be melted and recast and this includes polyethylene (PE), polyethylene terephthalate (PET), polypropylene (PP), polyvinyl chloride (PVC), polystyrene (PS) and synthetic fibers, and thermoplastic represent 86% of all the types of plastics.*

1. Uses of Plastic in different sectors

Modern plastics are organic chemicals and the manufacturer offers a huge range of physical properties. At that time plastic-made products were considered low-quality products. But nowadays plastic has a wide range you may have wearing plastic the polyester you are wearing is made from plastic and a watch is made with plastic components. Plastic has the ability to mold in any shape and can be laminated plastic can be customized physically and chemically. Plastic is suitable for every application. Plastic doesn't get rusty but plastic can degrade in UV, sunlight affects plastic and PVC is soluble in acetone. (https://www.thoughtco.com/uses-of-plastics-820359)

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2. Plastic products in home

In-home, plastic is in television as sound systems and in cell phones in fact in vacuum cleaners plastic in furniture is a firm of foam. Floors are sometimes also made from plastic unless the floor is covered by real wood; probably clothes are also made from natural/synthetic fibers. In fact in kitchens, there are products that are made from plastic like chairs, stool seats, countertops, and plastic linings (PTFE) in nonstick cooking pans and plastic plumbing in the water systems. In the refrigerator, the food wrapped in PVC cling film yogurt is packed in plastic tubs, cheese in plastic wrap, and water and milk in blow-molded containers. Plastic bottles are also available in the market which can prevent gas from escaping pressure in soda bottles. (https://www.thoughtco.com/uses-of-plastics-820359)

3. Plastic use in Transport

The use of plastic in transport is getting extensive in every automobiles there are plastic products in trains, planes, and even ships from wood and string in planes and canvas. The plastic used extensively in:

- *Seating*
- *Paneling*
- *Instrument enclosure*
- *Surface covering*

Plastics have the ability to combine with any other materials and can be structural in all kinds of transport, even skateboards, rollerblades, and bicycles. (https:// www. thoughtco. com/uses-of-plastics-820359)

4. Uses of plastic in construction industry

In the construction industry plastic have used in various companies. Most of the parts like hinges, screws, and other biggest parts are made from plastics and used in different sectors like wall covering, electric wire, waterproofing, decoration, and flooring. FRP (fiber-reinforced polymers) can be part of different types of plastic and can be in a different forms. FRP is made of carbon, aramid, basalt, and glass. These fibers are easy to weave and can be stitched because their FRP has better tensile strength and stiffness. FRP is blended with other fillers and additives so it can improve mechanical properties. These are the different criteria construction professionals are preferred plastic these are as follows.

5. Durability

As compared to other materials plastics are way better because they are more durable and stronger. Plastics are resistant to corrosion and plastics have the ability to increase their lastingness and versatility.

6. Cost-Effectiveness

Cost-effectiveness is one of the most versatile properties and every construction industry need a product that is cost-effective and durable and plastics are one of them. Plastic

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is economically better as compared to other metals like wood and other parallel materials. These are the reason why builders and construction professionals preferred plastics.

7. Recycling

Plastics have the property to recycle and plastic can be recycled over and over again because plastic is a non-degradable product so it can take different shapes, again and again, the chemical properties remain the same.

8. Energy Saving

Plastic can be molded at low heat, and consume less heat. Plastic can be prevented sound pollution also because plastic has insulating properties.

9. Safety

Plastics are safe to use because they are light weight easy to carry, and easy to lift from one place to another. On the other hand, metals are heavier compared to plastic so it is dangerous to move them it can cause injuries.

10. Easy to installed

Plastic can be installed easily because they are light in weight.

11. Flooring

Polyethylene and PVC are used for manufacturing on the floor because these materials are rough and tough plastics that don't break easily. Furthermore, it is not sound polluting and is cleaned easily.

12. Roofing

In roofing two plastic materials are used to make sure that damage doesn't take place. The roof is divided into two parts: the upper part and the lower part upper part consists of thermoplastic olefin and vinyl and the lower part consists of polyurethane. These materials of plastics absorb less heat, and the interior of the house stayed cooler.

13. Insulation

At the point of pollution, polyurethane spray is used for insulation in the construction of green and low-energy buildings. Rigid polyurethane foam has the ability of high thermal resistance for temperature consistency. Polyurethane is very light in weight, resistant to many chemicals, and flame-blocking. Polyurethane is closed-cell in nature, work as an insulator air barrier, and energy savings.

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14. Pipes

In construction, pipes are commonly made from polyethylene, PVC, acrylonitrile butadiene styrene (ABS), and CPVC. These plastic products are lightweight, flexible, and easy to use and carry, water and chemical resistant. They are made for the harsh environment also.

15. Windows

Windows made from polycarbonate are more burglar-proof as compared to other glass windows. Plastic materials which are used for manufacturing window frames are fiberglass and vinyl is cost-effective and strongly vinyl is resist to impact also.

16. Doors

In the manufacturing of doors, the constructor used polyurethane foam and FRP coating for stronger doors.(https://www.plastivision.org/blog/what-are-the-uses-of-plastic-materials-in-the-construction-industry/)

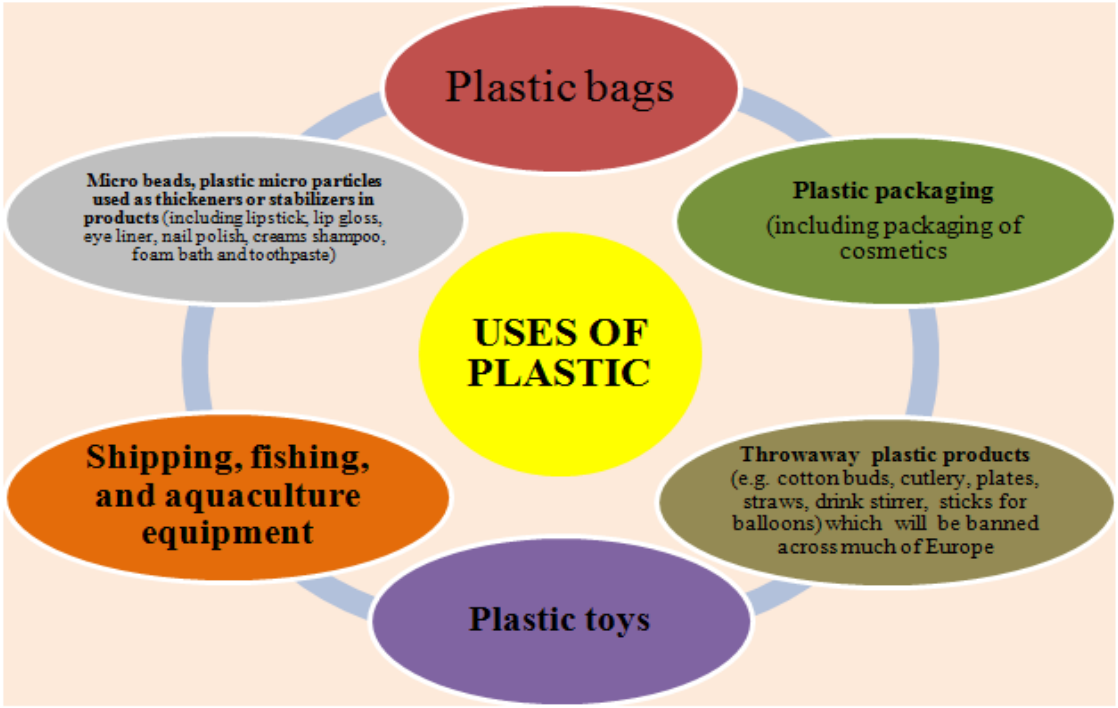

Figure 2: Uses of plastic (W.L. Filho, A.L. Salvia, A. Bonoli *et al.*)

17. 5 types of plastics and their uses

Plastic materials are widely used in modern life like microchips in computer shopping bags. Plastic is widely used everywhere because have a group of materials it is not just one material. Plastics are of many types like polyethylene, PVC, acrylic etc. plastic has incredible and versatile properties.

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One of the types is Polyether Ether Ketone (PEEK) which is used in a wide range of applications. Plastic with these characteristics is still being developed and they are useful but they are not used because of their higher cost. But apart from these types of plastic many other types of plastic are available that don't have this problem. It may be possible that they are not that impressive but at a point these types of plastics were revolutionary. Plastics are the 5 most common types which are used in daily life. Plastic is used on daily bases today's life seems like very impossible without plastics. For now, plastic can't be replaced by any other materials.

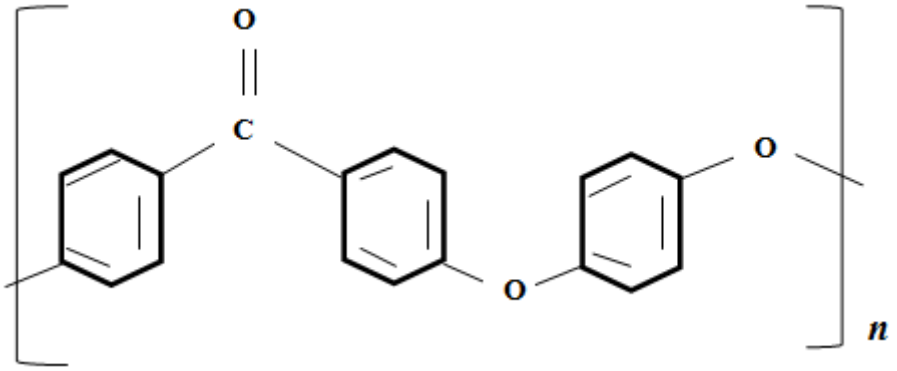

Figure 3: Chemical Structure of PEEK

18. Polyethylene Terephthalate (PET)

PET is one of the most used plastic on daily basis and today's life totally depends on plastic. Because PET is completely flexible and the molecular structure of PET is rigid. PET is chemical and weather resistant and it is resistant to water and gas also. PET's common uses are soft drinks, water, cooking, packaging trays, frozen ready-meal trays, first aid blankets, and polar fleece.

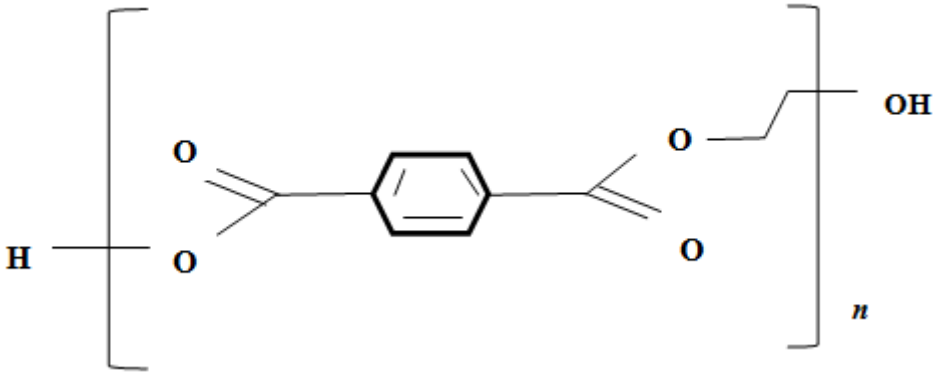

Figure 4: Chemical Structure of PET

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19. High density polyethylene (HDPE)

High-density polyethylene is solid in nature so it can tolerate high pressure and strong chemicals HDPE is strong on the basis of density. HDPE is versatile plastic and it can be recycled many times and used regularly it is a convertible HDPE that can be used in different things. The common use of HDPE in containers for packaging, storage of packed food and drink, pipes, insulation, bottle caps, vehicle fuel tank, helmets, etc.

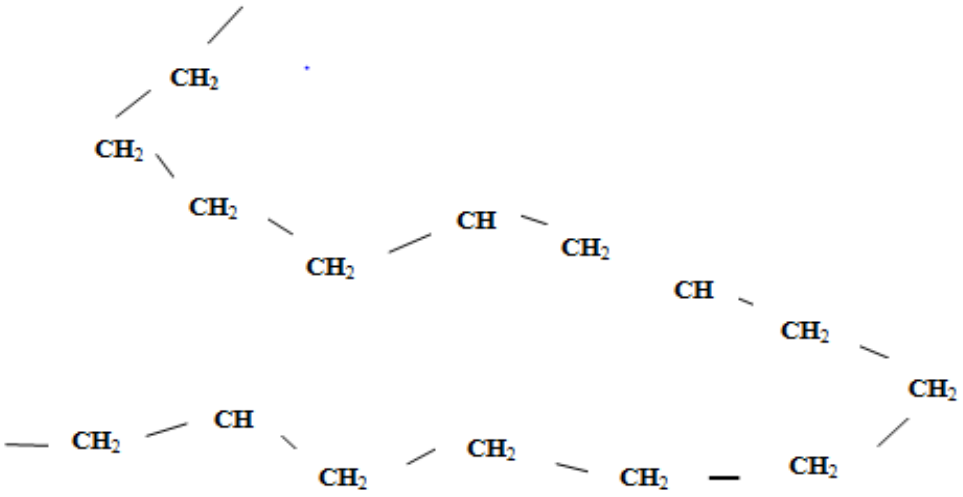

Figure 5: Chemical Structure of HDPE

20. Polyvinyl Chloride (PVC)

PVC (polyvinyl chloride) is a cost-effective material and it is resistant to chemical and biological damage. PVC is easy to handle and the advantage of PVC is that it can be molded into any shape. PVC is a versatile material because it can be used in different sectors like lightweight sheets like Foamex: it is superior quality and versatile PVC sheet and it is fabrication friendly Foamex can be cut into pieces easily blended and drill and get the print on it for beautification. The use of PVC is in signage, furniture, clothing, medical containers, tubing, water and sewage pipes, flooring, cladding, cables, and water bottles.

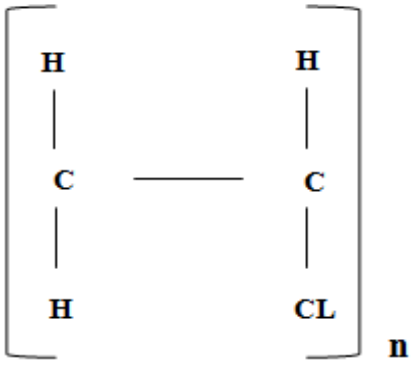

Figure 6: Chemical structure of PVC

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21. Low density polyethylene (LDPE)

Low-density polyethylene is a non-reactive material this is the biggest reason LDPE is widely used and common plastic. It can tolerate 100℃ but it is not as strong as HDPE. The main uses of LDPE in trays, containers, machine parts, lids, drink cartons, computer hardware, dustbin bags and you have laundry bags.

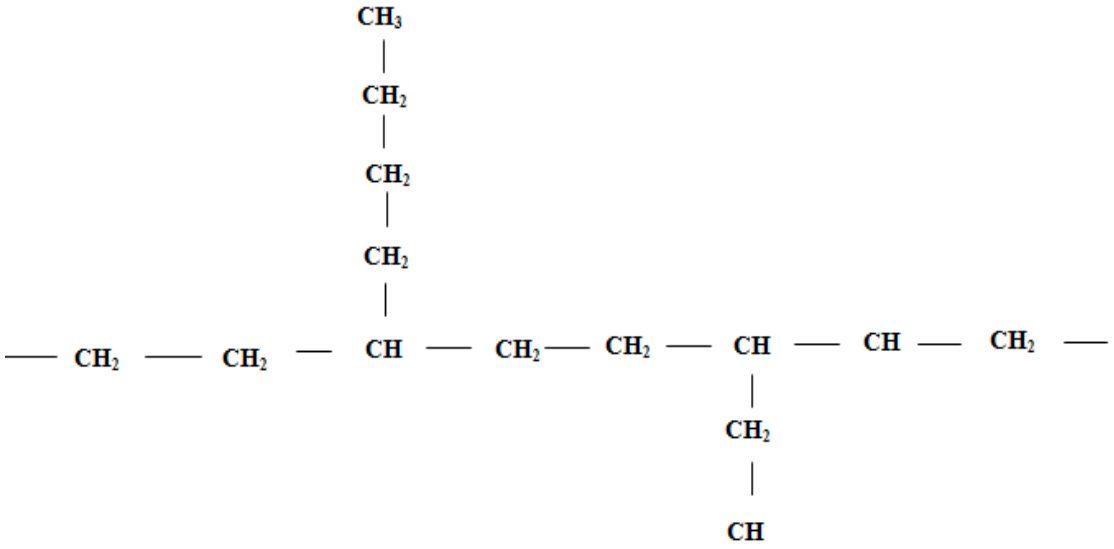

Figure 7: Chemical Structure of LDPE

22. Polypropylene (PP)

Polypropylene is a very hard material but after melting it is good and very effective in injection molding. It has a high tolerance to temperature. Compared to other plastic it is considered safe for food material packaging. The common use of PP is in Clothing, Surgery tools and supplies, Bottle cap, Straws, Crisp bags, Kettles, and lunch boxes.

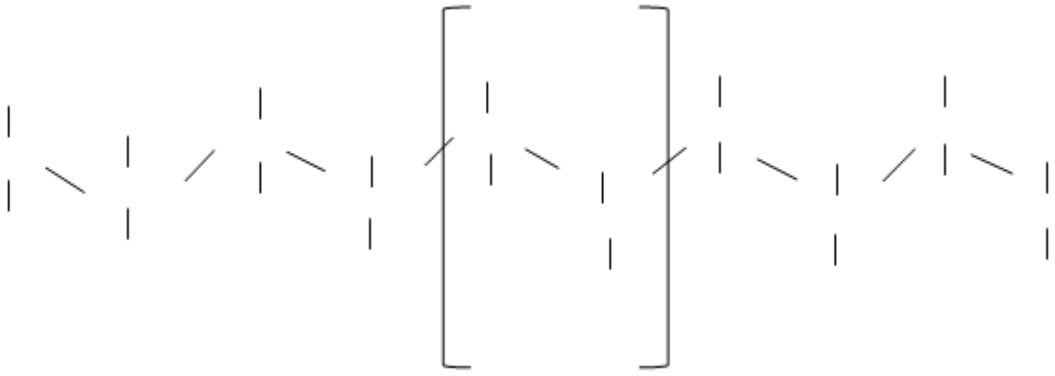

Figure 8: Chemical Structure of PP

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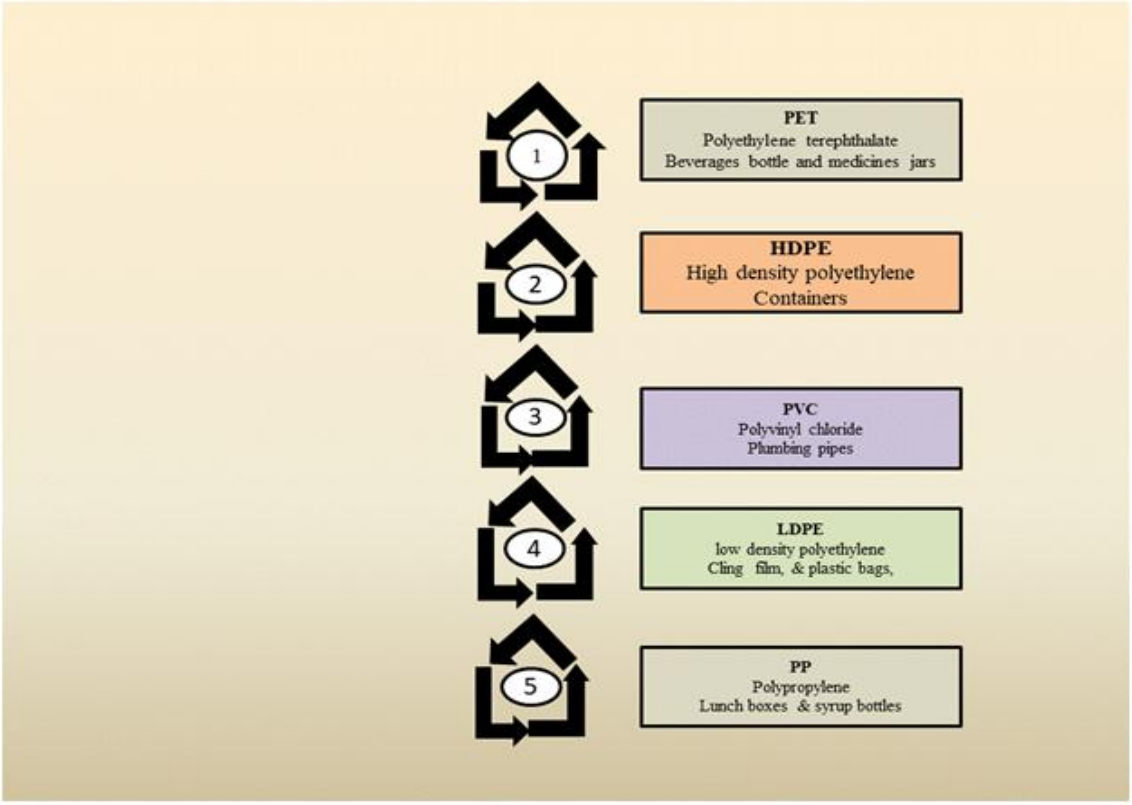

Figure 9: https://www.cutplasticsheeting.co.uk/the-5-most-common-plastics-their-everyday-uses/

23. Effect of Plastic on Environment

In 1990, it became abundantly clear that the industrialization of the world is happening at an unsustainable speed. Among the major sustainability issue of public concern is the high rate of consumption of energy and materials, the short life of the manufactured product, and the lack of space for the safe disposal of high volumes of solid, liquid, and gaseous water generated by human activities. Global warming, the cumulative effect of their problems, has emerged today as the most serious sustainability issue of the 21st century. Solid wastes are all wastes arising from human and animal activities that are normally solid that are discarded as useless or unwanted. These wastes are increasing day by day due to the increase in population, urbanization, and industrialization. These wastes are generated at a much higher rate in developed societies as compared to developing ones.

Plastic pollutes marine life as well as landfills because hazardous substances are accumulating in the sea which causes ecological effects. Plastic refuses a threat to wildlife, and some species are negatively impacted by the environment. The plastic objects connected with some species and ingest by some organisms. (Derraik, J.G.B.2002)

When immature animals involve and ingest plastic waste it becomes dangerous and causes serious injury when the animal grows. (Pemberton, D *et al* 1992), At least prevent animals from feeding plastic, particularly mammals (Gregory, M.R. 2009).

Plastic debris impacted a big number of animal species negatively. Like: marine birds, sea turtles, cetaceans, fur seals, and sharks. Most of the time birds mistake plastic for food and ingest it. And after ingesting this plastic marine birds and animals lead to serious problems such as decreased feeding stimuli, gastrointestinal blockage, and decreased secretion of enzymes and steroid hormones also get affected and which leads to reproductive problems. (Azzarello, M.Y.;. 1987, Blight, L.K.; Burger, A.E.. 1997, Barreiros, J.P.; Barcelos, J. 2001, Baird, R.W.; Hooker, S.K. 2000,)

A particle of plastic leads to high levels of organic pollutants in the ocean. Many toxic pollutants are continuously found in oceans such as polychlorinated biphenyls (PCBs), nonylphenol (NP), and organic pesticides like diphenyl ethers (PBDEs) and bisphenol A (BPA). (Mato, Y .*et al* 2001. Rios, L.M *et al* 2007,.)

(Hirai, H. *et al*. 2011, Because of these compounds risks of ingestion of plastic by animals and marine birds are getting increasing day by day. And many of these plastics are the reason of increasing in biomagnification and it has a direct threat to human health. (Hirai, H *et al* 2011,) And it leads to many serious health problems including the development of impairment, cancer, endocrine disruption, arthritis, breast cancer, and diabetes. (Schecter, A. *et al* 2010,.Trudel *et al* 2011, Chung, S.Y *et al* 2011, Zhou, Q *et al*. 2011,)

Plastic debris leads to migrating the invasive species of fauna to the new environments and it is increasing. (Masó, M *et al* 1916, Censky, *et al*. 1998., Barnes *et al*.1997, Walker, *et al*. 1997,) Colonization and dispersal of marine species are now common like barnacles, bryozoans, polychaetes, dinoflagellates, algae, and molluscs. These species are found upholder to the plastic materials in the environment. Terrestrial animals ride to new marine areas because of plastic debris. And ants also have been reported that they ride to several kilometers away from the Brazillian mainland to San Sebastian Island. (Censky,*et al*.. 1998, Barnes, D.K.A.; Milner, P.. 2005,).

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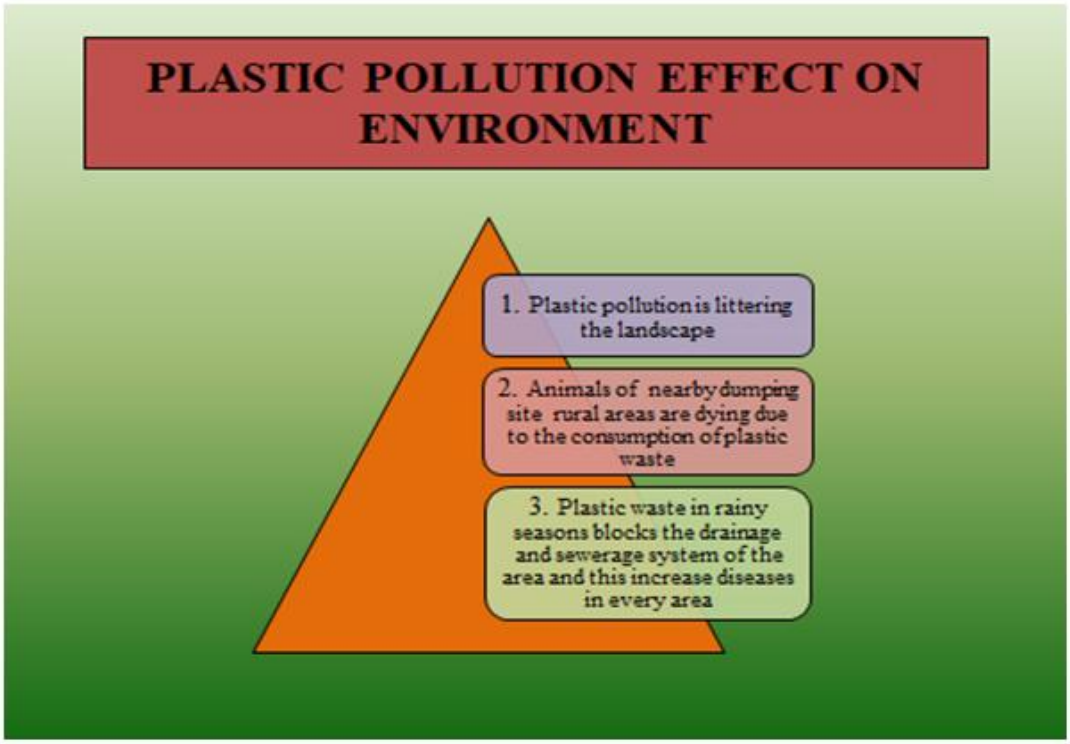

Figure 10: (Obebe S.B., Adamu A.A, 2020)

24. Plastic Pollution in Marine Environment

There are many efforts to quantify the level of plastic pollution in the marine environment, but the majority of this only focus on the accumulated debris on beaches because the plastic typically floats on the surface (). The bulk of plastic waste is delivered to beaches, numerically composed of plastic items. Three-quarters of all plastic waste accumulate ashore. High level of plastic in the environment has high availability of plastic product to stay in the environment for a long time. Frost, A *et al* 1997, Martinez-Ribes, *et al* 2007, Morishige, *et al* 2007, Santos, I.R *et al*. 2008, Ivar do Sul, J.A.; Costa, M.F. 2007,)

Plastic was used to build trawl nets for exceeding the zooplankton level for a sampling of a neutronic layer of open ocean waters in the north pacific. (Moore, C.J. *et al* 2001). As per the number of plastic particles, zooplankton is approximately one out of five but the total weight of plastic as compared to the zooplankton is almost six times greater. Other studies reported similar plastic pollution abundance. During the journey of the Atlantic Ocean, floating debris with naturally occurring debris was characterized as the southern ocean, all the way north to the high Arctic. Plastic is the most abundant type of plastic in every sample of waste from the ocean at every 100 latitudinal belts plastic was recovered. (Barnes, D.K.A.; Milner, P. 2005,Ryan, *et al* 2009,).

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25. The Sources of Plastic and Pathways to the Ocean

There are many sources of plastic pollution and the pathways of these products through which they enter the ocean are countless. Plastic pollution enters in the ocean mostly through the land and rests through the maritime (e.g. fishing vessels, and cruise ships). And many sources like households, wastewater, and industries. (e.g. agriculture, plastic manufacturing). Mismanaged waste reached through wind-blown from landfills, overflowing garbage bins, natural disasters, accidental spills, and sewage overflows. And the dominant pathways of plastic to reach the ocean are rivers. (Lebreton, L.C.*et al* 2017.). Through storms, runoff plastic reaches watersheds, wastewater effluent, and industrial and agricultural runoff and they can reach to ocean possibly. There are many emission models that have been created to examine the plastic waste in the ocean. (Jambeck et al., 2015; Borrelle et al., 2020; Lau et al., 2020). It was used to project population growth and plastic waste per capita mismanaged waste that enters the environment from each and every country per year. At least in 2010 4-12 million tons of plastic reach to ocean. This model became a measuring parameter (Borrelle et al., 2020; Lau et al., 2020). The researchers estimate the plastic emission at a smaller geographic scale which means nationally because of illegal dumping and material flow analysis (Bai et al., 2018). Rivers are the pathways for plastic to reach the ocean, in many Research Rivers are modeled for major emissions of plastic. (Lebreton et al., 2017; Schmidt et al., 2017)

In many studies, the term microplastics were also used but in some studies, it is neglected because of the size of microplastics. The calculated mass of the plastic waste is big and microplastics are relatively small in fraction weight but the microplastic make up a large fraction of the ocean.(vanSebille et al., 2015). When it comes to the degradation of plastic microplastic it will be on second. And in the counting plastic waste microplastics double in counting. Many pathways of microplastics are uncountable till now. These include microfibers from textiles industries and “dust” from tires, microbeads in personal care products, plastics from agriculture waste, and plastics pellets from industries. And the pathway of microplastics is storm water, agriculture waste, industrial runoff, and wastewater (Grbić et al., 2020). There are many reports which claim that the microplastics from marine paint, cosmetics, road paint, building paints, textiles, pre-production pellets, and the making tire at least 8-12% enters the ocean annually (Eunomia, 2016; Boucher and Friot, 2017).

In a report tires, pellets and textiles are responsible for 50% of the emissions (Eunomia, 2016). But the majority comes from textiles and tires (Boucher and Friot, 2017). Recent research says microfibers released through the washing of textiles at least 0.17 million tons of microfibers and reach the ocean per year (Gavigan et al., 2020). These studies consider a threat because microplastics contribute a lot to plastic pollution and some research work needs to be done on the microplastics emissions to the global ocean (Lee et al., 2020).

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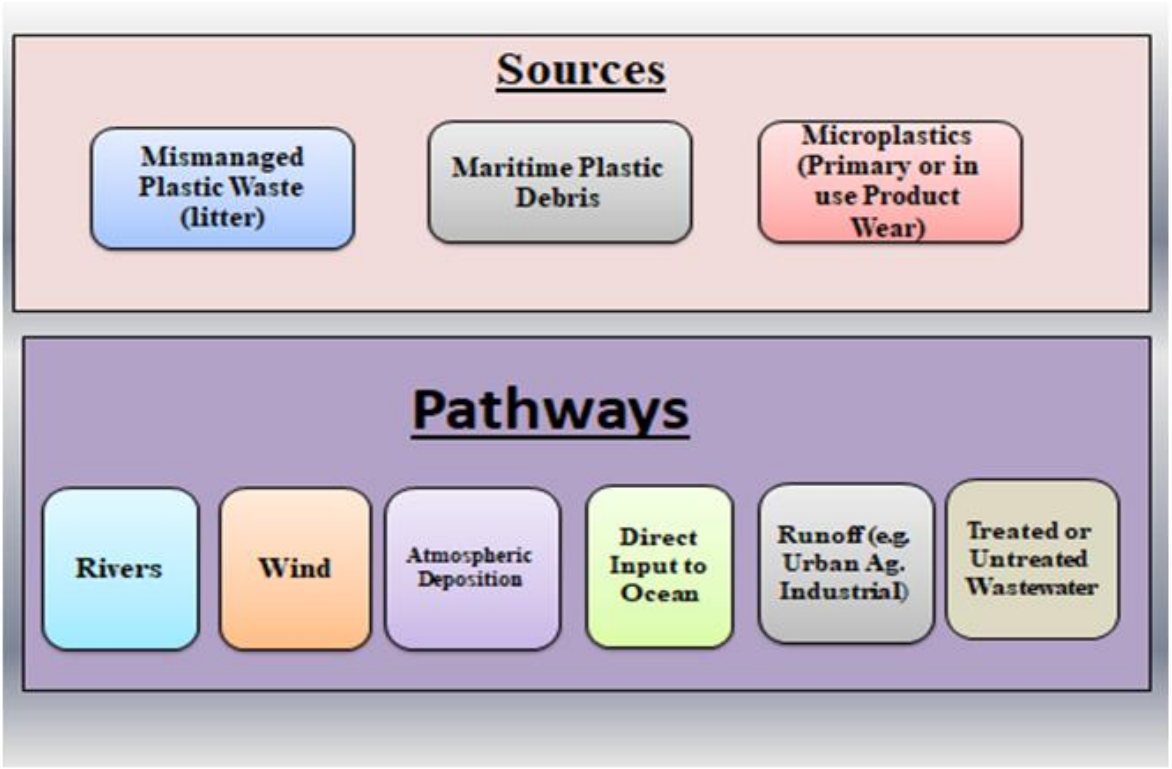

Figure 11: The Sources of Plastic and Pathways to the Ocean (Chelsea M. Rochman 2020,).

26. Plastic Pollution on Landfills

In the meantime, scientists are exploring a lot like mineral products and natural resources for the environment for the production of consumer goods and infrastructure construction, and these activities dispose of the waste in landfills and this is called urbanization (Krook, J., 2010..Krook, J., Svensson, N., Eklund, M., 2012.). The occupation of urban lands is to bury the recyclable materials underground without making use of it. A great amount of plastic waste comes from urban life and production like: agriculture, commodities, the construction industry, the manufacturing industry, and packaging, and these plastics are made from nonrenewal fossil resources.(Zhang, G., Zhu, J., Okuwaki, A., 2007., Al-Salem, S.M., Lettieri, P., Baeyens, J., 2009). The concept of "land mining" is a step toward sustainable material management, in this concept two ideas are followed together which are "urban solid waste management" and "material cycle"Krook, J., 2010. Land mining is a process in which the stored waste scooped out from a landfill recycles the waste material, recovers the high-calorie waste, and makes the airspace on land. In recent years landfills mining cover a lot of attention. (Jain, P. 2012, Johansson *et al*, 2013.) In landfill mining the waste comprises: 20-30% combustible materials (plastic wastes), 50-60% soil-type material, 10% inorganic substances (including concrete, stones, and glass), metals in very small quantity. Cossu, R. *et al* 2008, Kaartinen, *et al* 2013, Quaghebeur *et al* 2013.). From landfills mining every type of waste can be recycled into energy construction waste can easily be recycled and soil-type material can be used in green gardens as fertilizers. But the question is still about plastic waste that how to recover plastic waste is still discussing. (Bosmans,A.*et al* 2013)

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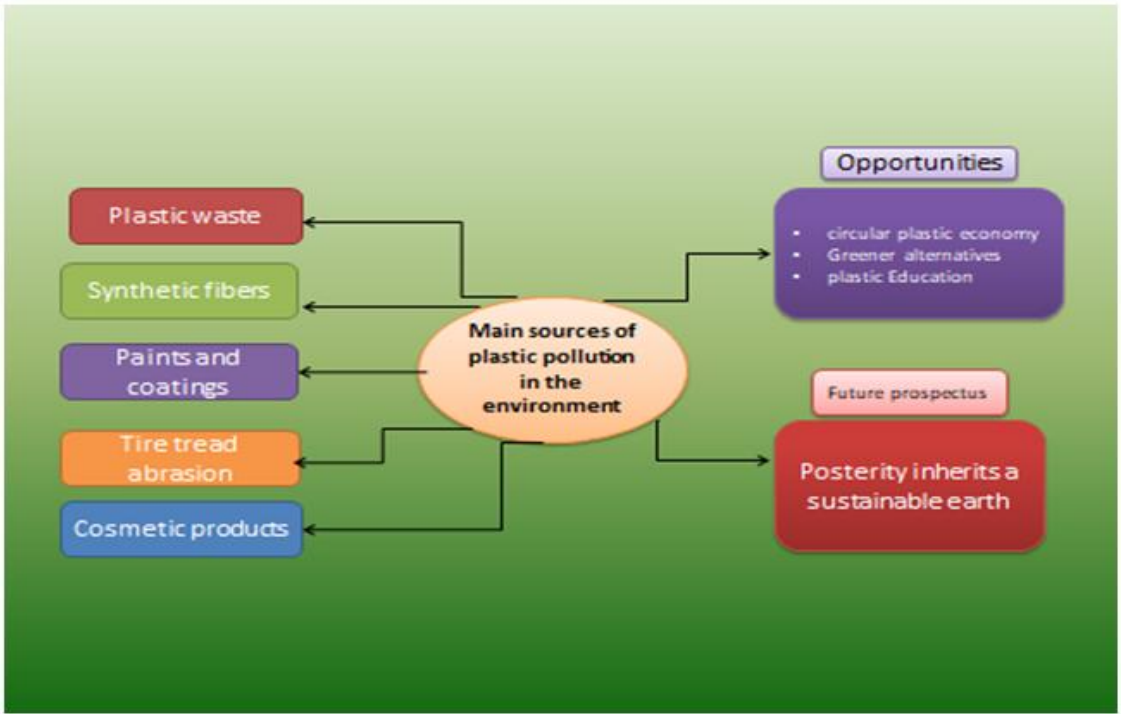

Figure 12: (AustineOfondu 2021)

27. Plastic pollution and climate change

- **Extraction and Production**: Plastics originate from fossil fuels and many people do not know about this. The plastic industry uses 6% of oil consumption at the global level and it will exceed 20% by 2050. In plastic production, the energy-intensive process required to distill oil extraction and due to this process the emission of greenhouse gases generate and it causes air pollution and change in climate

- **Consumption:** people think that the plastic they through it will be recycled and get back to them the same product of plastic but no only 9% of the total plastic can be recycled and the rest of the plastic stays in the environment for years. South Asia is also a plastic waste generator they discard at least 26 million tons of plastic so we Indians are also contributing more pollution to the environment. Not only this South Asia is discarded the waste in open nearly 75%.

- **End of Life:** A non-recycled product like plastic is discarded mismanaged manner so it generates GHG (Greenhouse gases) emissions and these gases are exposed to the air and water both. In South Asia 18 million tons of plastic originated which is mismanaged, therefore the plastic delivers to the Oceans. And the consequences of plastic in water they produce methane and ethylene in reaction to the sunlight. Polyethylene is single-handedly responsible for emitting methane and ethylene because it is a highly used plastic product globally.

- **Recycling and Closing the Loop:** Recycling can reduce the impact of plastic pollution. Recycling is reducing the climate and saving the environment. But only 5%

of the total plastics are recycled which is generated in South Asia. The circular economy principles AIR (Avoid, Intercept, Redesign) applied to aluminum, cement, steel, and plastic this combination could reduce the emission from industries by 40%.

- **Ocean litter:** On average a garbage truck full of plastic is dumped into the in every minute. Plastic in marine creating pollution inside the ocean because the plastic breakdown into microplastic and therefore climate change occurs. Because of the emission of GHG and climate change, the organism of the ocean gets affected. The Plankton has tucked away at least 30-50% because of the ingestion of microplastic and create of CO2 emissions from manmade activities. Because planktons have the ability to reduce the CO2 emission from the atmosphere they are saviors of the environment but plastic pollution hits them hard.

- **Open burning:** Burning in open is a very old practice to treat waste in South Asia and in the World. In India and Nepal, the amount of waste burned is 8.4% of the total waste burned in the world. The fire of waste burned in the open leads to many problems which are very serious air pollutants. In air pollutants black carbon is responsible for visible smog in many cities like New Delhi. Black Carbon has more potential than carbon dioxide for global warming.(Nina tsydenova, PawanPatil - 6 reason to blame plastic pollution for climate change November 9,2021)

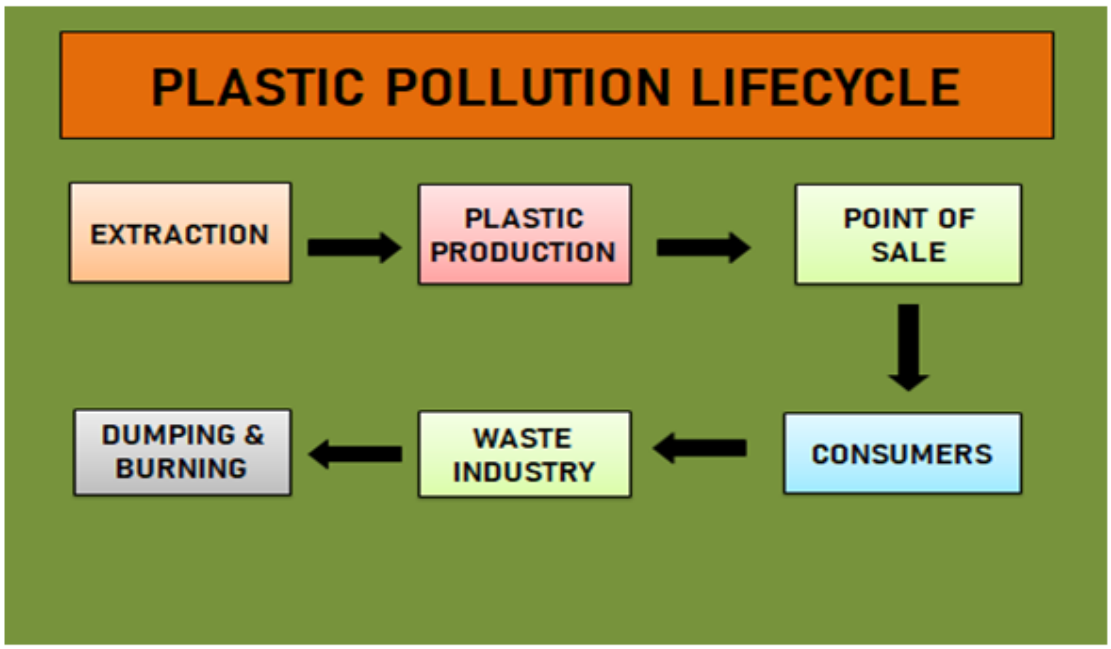

Figure 13: Ninatsydenova, PawanPatil - 6 reasons to blame plastic pollution for climate change November 9 2021

28. How to control plastic pollution

[15]. Changing of physical and chemical properties is called as degradation. Degradation takes part through different process like: chemical, physiochemical (photo-

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degradation, thermal degradation and mechanical degradation) and biological process (Smith R, 2005). The degradation of polymer which takes part in natural environment it can be chemical or biological degradation and it is called as primary degradation. The process of photo-degradation is a decomposition process of material through light. And this process is considered as primary degradation. The photo-degradation is a primary source which can damage polymeric substrate at environmental conditions. Some synthetic polymers are initially degraded by ultra violet (UV) and visible lights (Ranby B, 2005)

Biodegradation process is based on the different factors such as polymer characteristics microorganism type, pretreatment nature. When the biodegradation takes part some polymer characteristics such as crystallinity, tactility, molecular weight, mobility, substituents and types of functional group and plasticizers added to the polymer play an important role (Artham T, *et al.* 2008). The initial degradation of different types of polymer can result some biological and physical forces (Swift G, 1997) Biodegradation have several steps and these steps have specific terminology. Biodeteriroration is one of the steps of biodegradation and it includes combined action of microbial communities (Francois *et al,* 2014) Deterioration modifies the mechanical, physical and chemical properties of material. Depolymerization is a second step of biodegradation it is generally breakdown of polymeric molecules in to oligomers, dimers, or monomers by different catalytic agents which secreted by organisms (Lucas *et al,* 2008). Assimilation is a next step which integrates the transportation of molecules in to cytoplasm in the microbial metabolism to the production of new biomass, energy, storage of vesicles and growth of primary and secondary metabolites. Mineralization is a last step and it is related to the excretion of every type of salt it could be simple or different salt and complex they can reach to extracellular environment (Francois *et al,* 2014)

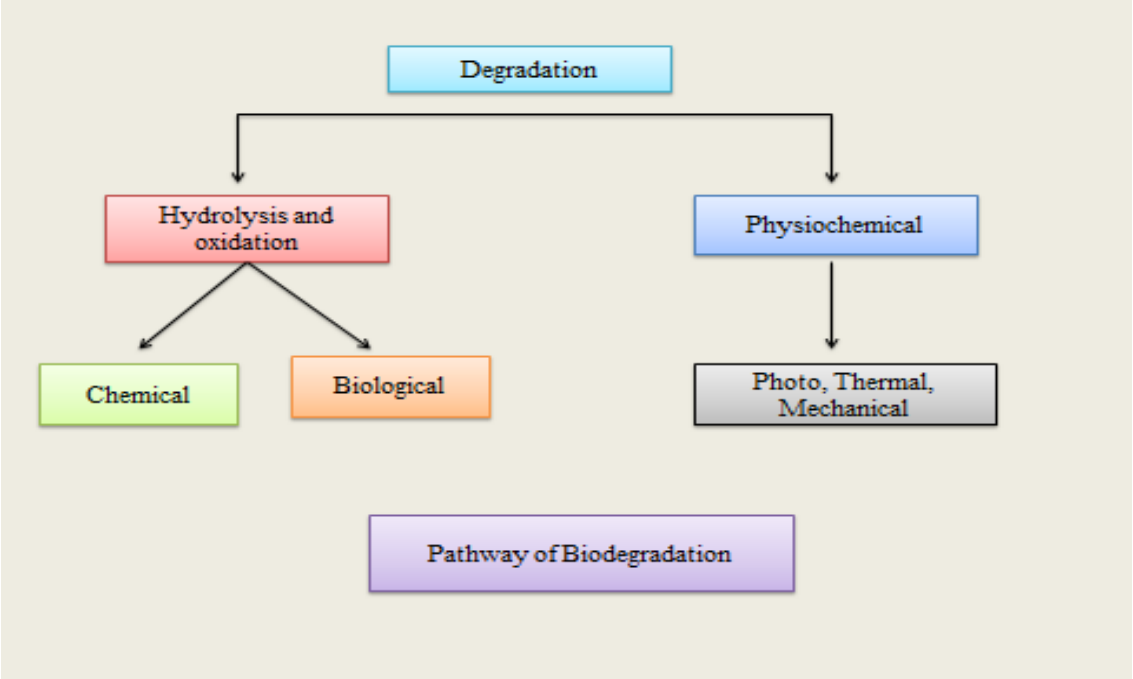

Figure 14: Pathway of degradation

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29. Biodegradation of Plastic

The utilization of polythene is growing every day and the degradation of polythene is testing us. About 500 billion polythene bags are being used annually around the world. In the present study, an effort has been come together all the accessible studies of polythene degradation under the following goals.1) Polythene pollution level. 2) Join up the low cost methods. 3) Collaborate the polythene degrading microbes. 4) Methods of polythene degradation. 5) Polythene degradation methods. 6) Evaluate the efficient polythene degrading microbes. 7) Enlist the products of degradation process. 8) Assessment of toxicity level of degraded polythene. 9) Examine the future aspects of polythene degradation. (Sangale et al., 2012**).** Plastics when burn causes pollution by releasing CO_2 and dioxins. General procedures to dispose plastics are not sufficient to degrade. Hence it is necessary to keep an eye on biodegradation of plastics by the help of microbes because the degradation of plastics can take thousand years **(Kale *et al*., 2015)**. Mangrove soil contains microbes which have capability to degrde polythene and plastics. Some gram positive and gram negative bacteria and several fungal species of *Aspergillus* **(Kathiresan, 2003)**. Low density polythene degradation is a very large challenge due to increase in white pollution. This investigation has concentrated the microbial biodegradation. Different microbes were isolated from the municipal landfill sites. 0.2g LDPE powder with growth medium was used for screening of soil bacteria for potential biodegradation. The screened bacteria were exposed to biodegradation analysis in presence of LDPE sheets in growth media. All the four strains gave degradation rate as 5%, 17%, 09% and 06% based on weight loss in four days. The maximum degradation was recorded through SEM and FTIR and Thermogravimetry. It has proved the efficacy of strains. The strains were identified by DNA isolation followed by PCR and 16S rRNA sequencing. Pseudomonas citronellios was identified by genotypic identification. **(Dafalla *et al. 2010*).** From the Golf of Mannar dumpsites sample were collected and 15 bacteria isolated from the sample and Arthrobacter sp. and Pseudomonas were selected for further degrading studies. Afterv30 days of incubation period degradation rate was nearly 12% for Arthrobacter sp. and 15% for Pseudomonas sp. FTIR spectrum confirmed the some keto, ester and vinyl bond were changed and its indicate the changing in functional groups**. (V. Balasubhramanian, 2010).** Plastic causes a major problem in the environment in production and disposal both the conditions are causing pollution. Biodegradation of plastic through microbes could solve the problem. This research investigate that microbes have ability to degrade the plastics. So the eight fungal strains were isolated named as FSM-1, FSM-3, FSM-4, FSM-5, FSM-6, FSM-8, FSM-9, and FSM-10. Six were Asprgillus sp. And two were Fusarium sp. The microscopic analysis showed the ability to grow on hydrophobic surface of LDPE film. **(kumar and Das, 2013)**. Polythene leads long term pollution so in this article two strains of bacteria were isolated from municipal sites. And reportedly these strains Bacillus amylolique (BSM-1) and Bacillus amyloliquefaciens (BSM-2) were responsible for degradation of polythene. This degradation was recorded by the weight loss of polythene, color changing of medium, Scanning electron microscopy (SEM) and Fourier transform infrared spectroscopy (FTIR). Surface degradation was analyzed by SEM and chemical changing was recorded by FTIR and CO_2 estimation and pH change were also analyzed by BSM-1 and BSM-2 strains. **(Das and Kumar 2015)** Biodegradation of LDE and HDPE were recorded in this article. The bacterial strains were isolated from Appikonda, Bheemli, Sagarnagar of Bay of Bengal, and Vishakhapatnam. Agar over layer method and BATH assay were used to evaluate the degrading ability of bacterial strains. And the characteristics of morphology and biochemical were further evaluated by

measuring the weight loss and confirmed by SEM and FTIR**. (Ambika et al. 2014).** In recent era the plastic bags are have become a big problem in markets polythene bags are widely use. And the degradation of the polythene bags is a very big question. The market bags are verified by specific bodies. The FTIR spectroscopy is a technique which is very fast, inexpensive and easy to use instrument to analyze the classification of polythene bags. (**Alfie at el. 2021).** From the polluted sites of Chennai some fungal strains were isolated and identified by the plating and staining technique. Isolated fungal strains were *Aspergillus niger, A. japonicas, A. terreus, A.flavus and Mucor sp.* These strains degrade the LDPE polythene in 4 weeks duration in terms of weight loss under laboratory. A. niger degrade the polythene up to 8% while A. japonicus degrade the polythene up to 12%. Further analysis of SEM revealed the fragility of fungus on the surface of polythene**. (N. Raman, 2012**). Aspergillus has the great intensity to degrade the polythene in many researches it revealed. Aspergillus niger, A. flavus and A. oryzae degrade the polythene in 55 days period biodegradation was analyzed by weight loss, SEM and FTIR. In 55 days 26.15% weight loss was obtained. **(G. DSouza et al, 2021).** Now a day's plastic is used in every field and the wastage of plastic is a big problem around the globe. In this research the rizophere soil was used for the isolation of fungus. 12 different eco- geographical locations sample were collected and 109 fungal strains were isolated. From the different techniques after 60 days of incubation it is recorded the fungal isolates Aspergillus terreus and Aspergillus sydowii had the efficiency to degrade the polythene. Polythene degradation was further recorded by FTIR and SEM**. (Sangale K. et al, 2019).**

II. CONCLUSION

Plastic has become entangled and essential part of today's lives. The amount of plastic which is consumed by the public is already growing. And plastic has many qualities like low density, strength, user-friendly, long life, lightweight, and more importantly low cost, these are the reason behind the phenomenal growth of the production of plastic. Plastic has many beneficial properties it includes: extremely versatile and plastic has the ability to mold in any shape, resistance to water, and resistance to chemicals. Plastic has the unique ability to combine with materials like Aluminum and Foil paper. But on the other hand, the disadvantages of plastic are more as compared to the advantages. Because the production of plastic uses harmful chemicals which cause serious problems in the environment, human health, wildlife animals, and ecosystems. The risk to the environment and human health is uncertain for example in the manufacturing of PVC phthalates are used and PVC is used in the manufacturing of toys. But the problem occurs when the toys are sucked. Most type of plastic is single used and non-degradable. If these types of plastic are landfilled once they do not break down easily and stay in landfill for years. The landfilling of plastic is a matter of concern because dumping in an uncontrolled manner is growing day by day. Toxic chemicals percolate from plastic and transfer to everybody's blood tissue. The result of plastic disposal is related to many problems like tumors, birth defects, compromised immunity and disturbance of the endocrine systems, and other disorders. Climate change is one of the biggest disadvantages of plastic disposal in landfill because through the climate everything got disturbed. So these disadvantages are more important than the advantages of plastic because the loss is bigger than the benefits.The use and disposal of plastic are not sustainable. In our opinion, some actions which include public and individual responsibility, appropriate usage and disposal, industries should adopt green chemistry, reduction of material, design reusable products, end-of-life recyclability for government and policymaker by setting the

targets, scientists should do relevant research technologies development. And rest of the plastic pollution which is already present in the environment we can degrade through the biological degradation.in this review paper we analyzed that some microbes have ability to degrade the plastics.

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