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Recycling and environmental pollution Of plastic material in Erbil city

Research Project

Submitted to the Department of (Chemistry) in partial fulfillment of the requirements for the degree of **BSc.** in **chemistry**

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Acknowledgments

To begin with, I thank (Allah) for His blessing, which made me able to complete and perform this study with success, the lord of the universe, blessing, and peace be on Muhammad (Allah's peace and prayers be upon him).

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Abstract

With the increase in the population of the city of Erbil and an increase in the number of tourists, as well as immigrants and displaced persons, we notice an increase in consumption, and with this, the percentage of waste increases, especially plastic waste for this reason, we searched for the reason of the increase in waste in the landfill, in addition to that, what are the damages caused by plastic materials if they remain in the environment and what materials are emitted during their decomposition, and we also searched for how to dispose of them and the mechanism of work of recycling labs.

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1. Introduction

Problems related to increased consumption and depletion of resources, as well as increased output of various sorts of trash, are becoming more significant than ever as a result of economic development and population growth. Clearly, limiting the environmental impact is the best way to go. The amount of garbage that is produced if this is not possible, waste must be recycled. The greatest option is to recycle. Strategy to addressing the problem because it decreases the amount of waste that must be disposed of in a landfill. Furthermore, recycling has the potential to cut trash disposal expenses, waste transportation costs, and landfill costs. To extend the life of the dump site According to studies, you can start a new business. A product made from natural resources that benefits the environment and the economy in some way. The viability of the recycling program, however, is contingent on significant public engagement. Recycling waste must be separated. Recycling is described as the process of reusing, repurposing, or re Paper, glass, plastic, metals, and building and demolition materials are among the resources that can be recovered. Numerous research has been conducted on recycling behavior. In Erbil City number of researches investigated quality , reliability and the amount of solid garbage in a household using a new method, waste engine oils may be recycled. A cleaning agent the majority of garbage recycling studies in industrialized countries focused on Models and tools are examples of technological applications. Study's emphasized the importance of the informal sector in waste minimization and recycling. The most diverse is municipal solid waste (MSW), which consists of the remnants of practically all materials utilized by humans: food and other organic wastes, papers, plastics, textiles, leather, metals, glass, and other miscellaneous elements. MSW can be disposed of in four different ways:

1-Recovery of materials, such as paper, metal, plastic, and glass.

2-Recovery of energy, such as by the burning of organic materials.

3-Bioconversion: Under regulated conditions, the inherent organic components of MSW can be oxidized aerobically. As a soil conditioner, the compost product can be employed. Anaerobic digestion or fermentation generates methane or alcohol, as well as compost.

4-Landfilling non-recoverable waste must be disposed of in properly built landfills.(Aziz, Ismail and Omar, 2019)

2. Plastic and environment

The amount of garbage produced by people grows in lockstep with the world's population. Products that can be readily discarded, such as soda cans or water bottles, are ideal for on-the-go lifestyles. Despite this, the accumulation of these products has resulted in an increase in global plastic pollution. Plastic, which is made up of major harmful pollutants, has the ability to pollute the air, water, and land, causing substantial harm to the ecosystem.

Simply, plastic pollution occurs when a large amount of plastic has accumulated in a region, severely impacting the natural environment and causing difficulties for plants, wildlife, and even humans. This frequently entails the annihilation of plant life and the endangering of nearby wildlife. Plastic is an extremely versatile material, however, it is made of poisonous substances that are known to cause illness, and it is not biodegradable because it is designed to last. And the impact is on all levels of the environment as follows.(Okunola A *et al.*, 2019)

2.1 Land pollution

In both the business and the home, plastic products are abundant. Plastic pollution and pollution from plastic products can injure and pollute the terrestrial environment, which can then be carried to the aquatic environment. Despite the fact that around 80% of plastic garbage at sea comes from land-based sources, there is a scarcity of data on the volume of plastic waste on land compared to the vast amount of data available on plastic debris in marine habitat. Plastic additives (e.g. stabilizers, harmful colorant moieties, plasticizers, and heavy metals) can leach and eventually percolate into various aspects of the environment, causing soil and water contamination. Dumping plastics on land or landfilling plastics causes abiotic and biotic degradation of the plastics. Micro plastics have been found in reports. Chlorinated plastics can leach hazardous chemicals into the soil, which can then leak into underground water or the surrounding aquatic system, damaging the ecosystem. During the microbial biodegradation of plastics, methane, a harmful greenhouse gas that contributes greatly to global warming, is emitted.(Okunola A *et al.*, 2019)

2.2 Air pollution and plastic burning

Incineration is a viable option to landfilling plastic trash, but there are growing concerns about the potential for dangerous chemicals to be released into the atmosphere during the process. Plastic waste gases, for example, release halogenated additives and polyvinyl chloride, while combustion of plastics releases furans, dioxins, and polychlorinated biphenyls into the environment. The air pollution created by the poisonous gases emitted into the atmosphere is a disadvantage of burning plastics. Plastics irreversibly damage the combustion heater of flue systems during plastic incineration, and the results of this plastic combustion are harmful to both individuals and the environment. Low molecular weight compounds can evaporate directly into the air, polluting it, and some may generate a combustible mixture, depending on their variations, while others may oxidize in solid form. The production of chark is frequently followed by the burning of plastics, and the level of coking is determined by the incineration

conditions. The discharge of gases during the burning of plastic and plastic composite items is extremely hazardous. (Table 1) depicts the chemicals released during PVC burning, as well as the health implications of these compounds. Soot, ashes, and other powders are created during the burning of plastics, which eventually settle on plants and soil, with the potential to migrate to aquatic environments. Rainfall can cause some of these poisonous substances to sink into the soil, contaminate ground water, or be absorbed by plants growing on the soil, allowing them to enter the food chain. Some of these plastic combustion products can chemically react with water, changing the pH and hence changing the functioning of aquatic ecosystems.

Carbon dioxide and methane are emitted into the atmosphere when landfilled plastic waste decomposes. In 2008, an estimated 20 million tons of CO2 equivalent (eqCO2) was released into the atmosphere from the decomposition of solid waste in landfills. CO2 is also emitted into the atmosphere when plastics and plastic items are burned, and this CO2 has the ability to store radiant heat and prevent it from escaping the earth, resulting in global warming. Air pollution is one of the most serious environmental risks to human health, and it is responsible for more than 6 million fatalities worldwide. When plastics and plastic goods are burned openly, pollutants such as heavy metals, dioxins, PCBs, and furans are released into the air, posing health hazards, particularly respiratory problems. Plastics' influence in air pollution in developing and underdeveloped countries cannot be overstated, and the consequences for future generations could be devastating.(Okunola A *et al.*, 2019)

Table 1: Compounds generated during the incineration of polyvinylchloride and their harmful effects.(Gilpin, Wagel and Solch, 2005)

Compounds generated	**Health effect**
Acetaldehyde	It damages the nervous system, causing lesions.
Acetone	Irritates the eyes, the respiratory tract.
Benzaldehyde	Irritates the eyes, skin, respiratory system, limits brain function.
Benzole	Carcinogenic, adversely effects the bone marrow, the liver, the immune system.
Formaldehyde	Serious eye damage, carcinogenic.
Phosgene	Gas used in the WWI. Corrosive to the eyes, skin and respiratory organs.
Polychlorinated dibenzo-dioxin	Carcinogenic, irritates the skin, eyes and respiratory system. It damages the circulatory, digestive and nervous system, liver, bone marrow.
Polychlorinated dibenzofuran	Irritates the eyes and the respiratory system, causes asthma.
Hydrochloric acid	Corrosive to the eyes, the skin and the respiratory tract.
Salicyl-aldehyde	Irritates the eyes, the skin and the respiratory tract. It can also affect the central nervous system.
Toluene	Irritates the eyes and the respiratory tract, can cause depression.

Xylene	Irritates the eyes. It can also affect the central nervous system, reduces the level of consciousness and impairs learning ability.
Propylene	Damages the central nervous system by lowering of consciousness.
Vinyl chloride	Carcinogenic, irritating to eyes, skin and respiratory system. Effect on the central nervous system, liver, spleen, blood-forming organs.

2.3 Water Pollution

In 2012, it was projected that 165 million tonnes of plastic garbage were present in the world's oceans, while an average of 8 million tonnes of plastic being dumped into the ocean each year, with about 5 trillion plastic fragments floating around. Plastics in the waters often disintegrate within a year, but not fully. Toxic compounds like polystyrene and BPA can be released into the water during the plastic breakdown process, resulting in water contamination. Plastic makes up to 80% of the waste found in the oceans. Plastic garbage floating in the ocean can be quickly colonized by sea animals, and because of its long-term persistence on the ocean surface, it may promote the spread of 'alien' or non-native species. Because of their abundance in benthic and pelagic habitats and their small sizes, micro plastic contaminants are bioavailable to a wide range of marine life. Plastics have been reported to concentrate and sorb pollutants existing in seawater from several other sources within the marine ecosystem. Persistent organic pollutants such as nonylphenol, PCBs, dichlorodiphenyldichloroethylene (DDE), and phenanthrene are examples of such contaminants, which have the ability to accumulate many times more on plastic trash than in the surrounding ocean. More than 260 marine creatures, including turtles, invertebrates, seabirds, fish, and mammals, have consumed or become entangled in or with plastic trash, resulting in decreased movement, feeding, reproductive output, ulcers, lacerations, and death.(Okunola A *et al.*, 2019)

2.4 Effect of Plastic additive on Health

Different additives are used in the manufacture of plastics, and they have been linked to a variety of health problems in people. Table 2 depicts the many types of additives used in plastic production, as well as their impacts and the various types of polymers.(Okunola A *et al.*, 2019)

Table 2: Different additives used in plastic production, their effects and the plastic types.(Halden, 2010)

Toxic Additives	**Uses**	**Public health effect**	**Plastic types**
Bisphenol A	Plasticizers, can liner	Mimics oestrogen, Ovarian disorder	Polyvinyl chloride (PVC), Polycarbonate (PC)
Phthalates	Plasticizers, artificial fragrances	Interference with testosterone, sperm motility	Polystyrene (PS), Polyvinyl chloride (PVC)

Persistent Organic Pollutants (POPs)	Pesticides, flame retardants, etc.	Possible neurological and reproductive damage	All plastics
Dioxins	Formed during low temperature combustion of PVC	Carcinogen, interferes with testosterone	All plastics
Polycyclic aromatic hydrocarbon (PAHs)	Use in making pesticides	Developmental and reproductive toxicity	All plastics
Polychlorinated biphenyls (PCBs)	Dielectrics in electrical equipment	Interferes with thyroid hormone	All plastics
Styrene monomer	Breakdown product	Carcinogen, can form DNA adducts	Polystyrene
Nonylphenol	Anti-static, anti-fog, surfactant (in detergents)	Mimics oestrogen	PVC

3. Plastic degradation

When widely used plastics are released into the environment, they typically do not degrade rapidly. This is rather unsurprising, given that one of the key reasons for many polymers' popularity and extensive use is their outstanding stability and endurance. (Photo degradation, thermooxidative degradation, hydrolytic degradation, and biodegradation by microorganisms) are the four methods by which plastics deteriorate in the environment. In general, natural plastic deterioration starts with photo degradation and progresses to thermooxidative degradation. The activation energy required to commence the incorporation of oxygen atoms into the polymer is provided by ultraviolet radiation from the sun. The plastic becomes brittle and breaks into smaller and smaller bits as a result, until the polymer chains reach a molecular weight low enough for microorganisms to metabolize. The carbon in the polymer chains is either converted to carbon dioxide or incorporated into biomolecules by these bacteria.

However, the entire process is extremely sluggish, and plastic can take up to 50 years to entirely disintegrate. This is hampered by the fact that the photo degradative impact in seawater is greatly reduced due to lower temperature and oxygen availability, and that the rate of hydrolysis of most polymers in the ocean is negligible.(Webb *et al.*, 2013)

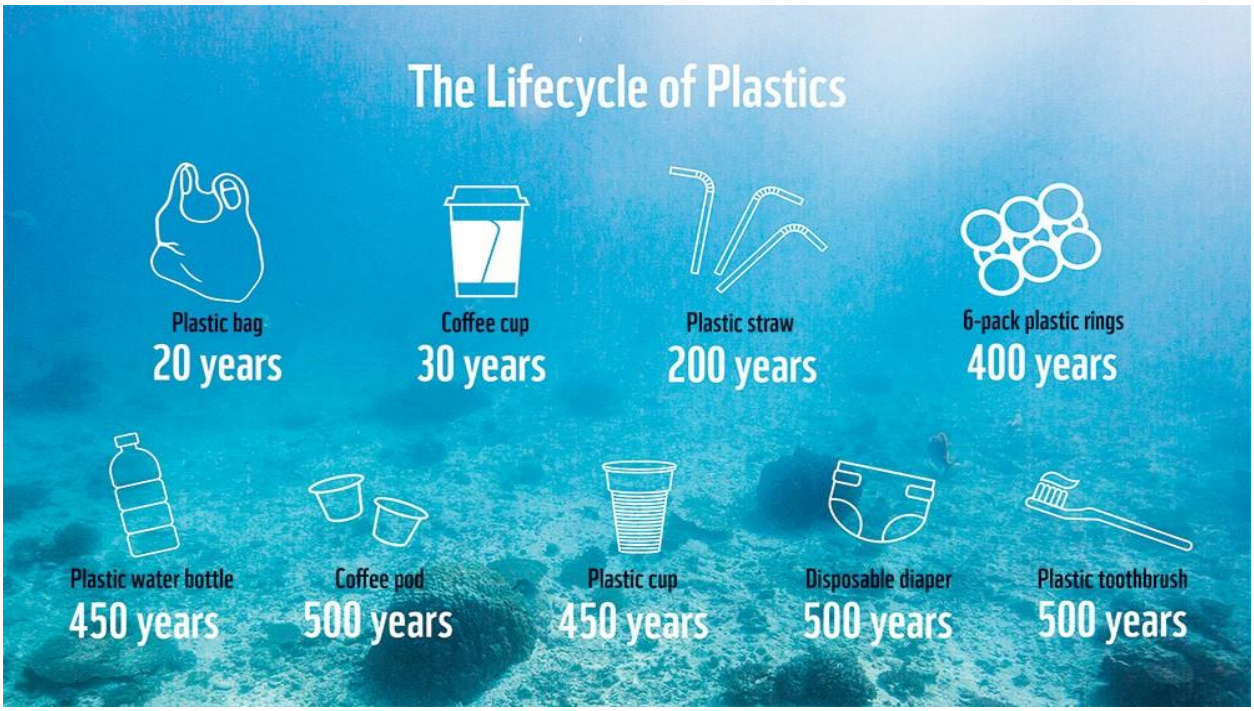

Fig.1. time to degradable of plastic waste.

4. Plastic Recycling

Waste materials are recycled, reclaimed, and reprocessed so that they can be reused in new products. The basic procedures in recycling are the collection of waste materials, their processing or manufacturing into new products, and the purchase of those commodities that can subsequently be recycled. Recyclable materials include iron and steel scrap, aluminium cans, glass bottles, paper, wood, and plastics. Raw materials originating from increasingly scarce natural resources such as petroleum, natural gas, coal, mineral ores, and forests can be replaced by recycled materials. Recycling can help to reduce the amount of solid waste disposed of in landfills, which are getting more expensive. Recycling also reduces pollution of the air, water, and land caused by rubbish disposal.(Al-Salem, Lettieri and Baeyens, 2009)

4.1 Types of Plastic Recycling

4.1.1 Mechanical Recycling

Before recycled materials can be reprocessed into new products, they must first be converted from trash to fresh raw resources. This phase, often known as 'End-of-Waste, begins after the collecting phase. This procedure for SPW can include the steps below, which can appear anywhere from not at all to many times throughout the sequence:

1-Separation and sorting: this is done based on the shape, density, size, colour, or chemical composition of the items.

2-Baling: If the plastic isn't treated where it's sorted, it's often baled in between.

3-Cleaning: removing pollutants (often organic).

4-Grinding is the process of reducing the size of items to flakes.

5-Compounding and pelletizing: converting the flakes into a granulate, which is easier for converters to use than flakes.(Sikorska *et al.*, 2021)

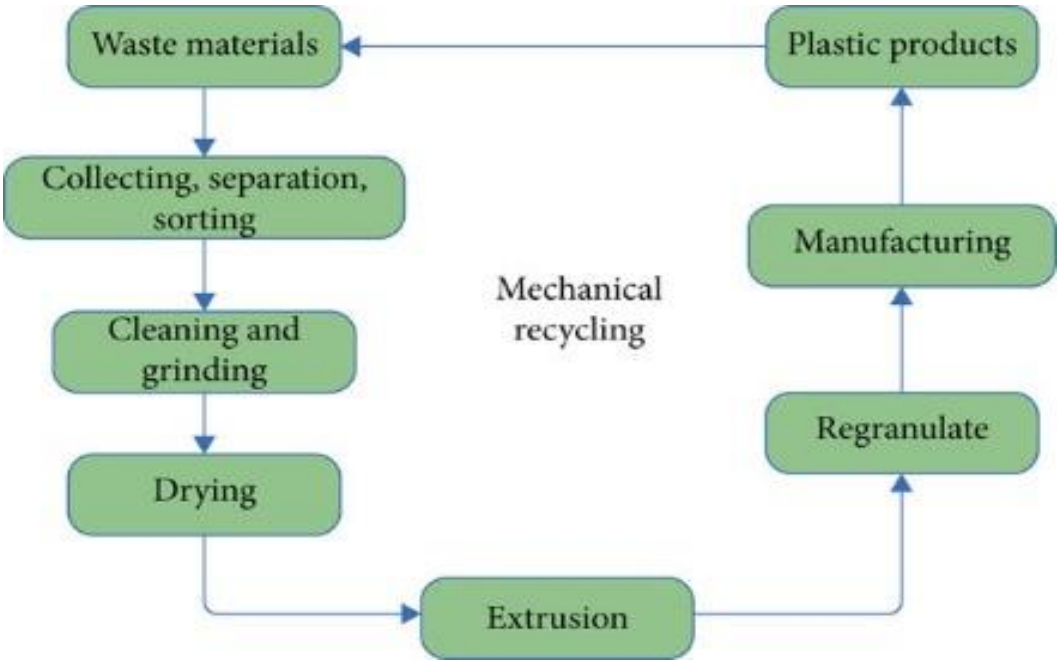

Fig.2.Mechanical recycling.(Sikorska *et al.*, 2021)

4.1.2 Gasification

This figure shows the schematic of gasification of plastic waste designed in Aspen Plus simulator. Plastic wastes considered in this work consist of polyethylene (PE) and polypropylene (PP). In the real practice, the plastic waste can be directly supplied to the gasifier where it is reacted with steam as a gasifying agent. Since the plastic waste is a non-conventional component and thus, it must be decomposed into each element before occurring the reaction.

In the simulation, the gasification consists of two parts: decomposition of plastic waste (DECOMP) and reaction of plastic waste with steam (GASIFIER).plastic waste (PLASTIC) is firstly heated through the heater (HEATER1) before feeding to the decomposition unit (DECOMP). Then, the DE-PLA stream is sent to the gasifier (GASIFIER) simultaneously with steam (STEAM) which water (WATER) is preheated via heater (HEATER2). When the chemical reactions are accomplished in the gasifier, the gas product (PRODUCT) can be provided.(Saebea *et al.*, 2020a)

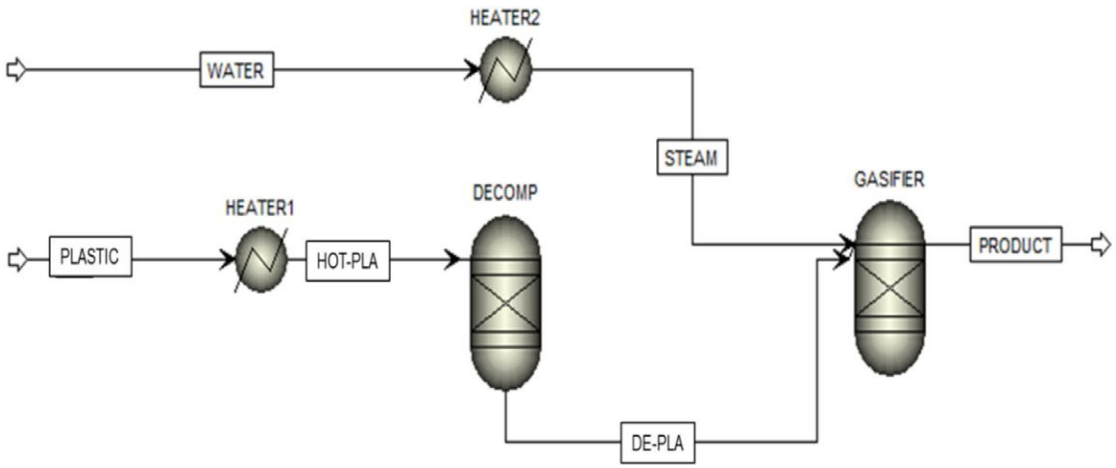

Fig.3. Gasification of plastic waste.(Saebea *et al.*, 2020a)

4.1.3 Pyrolysis

Pyrolysis is the process of a material's heat breakdown in the absence of oxygen, A cylindrical cylinder is filled with plastic. The pyrolytic gases are condensed in a specifically constructed condenser system to generate a hydrocarbon distillate containing straight and branched chain aliphatic, cyclic aliphatic, and aromatic hydrocarbons, and the liquid fuel products are separated by fractional distillation. The plastic is pyrolysis at temperatures ranging from 370°C to 420°C. The key steps in the pyrolysis of plastics are as follows:

1. Evenly heating the plastic to a narrow temperature range without excessive temperature variations.
2. Purging oxygen from pyrolysis chamber.
3. Managing the carbonaceous char by-product before it acts as a thermal insulator and lowers the heat transfer to the plastic.
4. Careful condensation and fractionation of the pyrolysis vapors to produce distillate of good quality and consistency.(Anuar Sharuddin *et al.*, 2016)

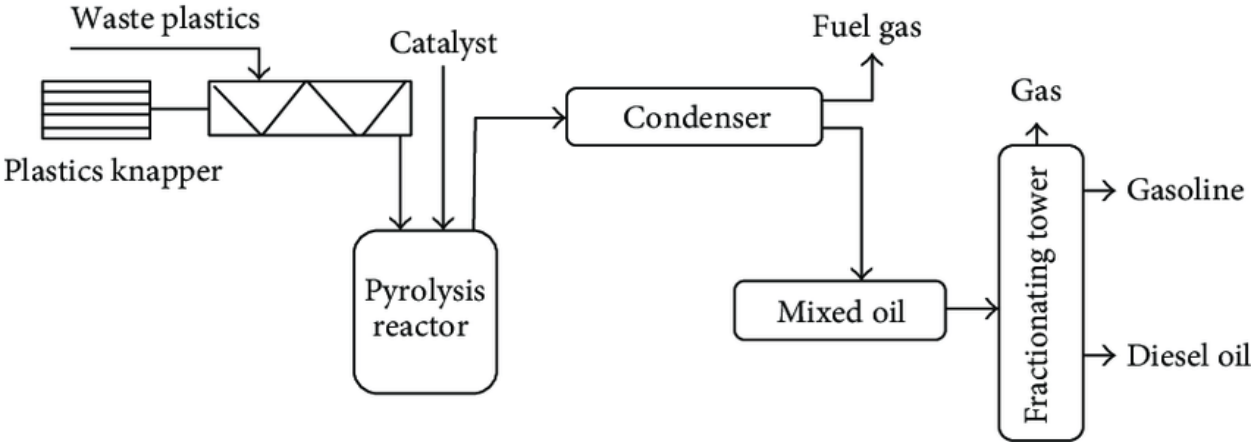

Fig.4.Pyrolysis Process of generating fuel oil from the waste plastics.(Patni *et al.*, 2013)

Advantages of pyrolysis process are:

1. Waste volume is significantly reduced (50– 90%).
2. Solid, liquid, and gaseous fuel can be produced from the waste.
3. Storable/transportable fuel or chemical feed stock can be obtained.
4. Environmental problems are reduced.
5. Desirable process because energy is obtained from renewable sources such as municipal solid waste or sewage sludge.
6. Capital cost is low.(Patni *et al.*, 2013)

5. Solid waste in Erbil landfill

Erbil landfill sited near kani-qrzhala sub-district),now in 2022 it receives more than 2000 ton of solid waste daily as in fig(5) the waste contains different materials these are classified according to different parameters,one of the useful classifications is depending on the nature of the waste materials,organic,inorganic,combustible, non combustible, putrescible and non-putrescible, the percentage of recyclable material from the mass of solid waste is 52.34% according to the data from director of service and Environment protection. the recyclable materials include: plastic,glass,aluminium, iron, and paper, the estimated percentage of plastic in the total solid waste was 6% in 2009 and it increased to 35% 2016 fig(6)and fig(7).(Aziz, Ismail and Omar, 2019)

Figure.5. Recyclable materials from landfill site.

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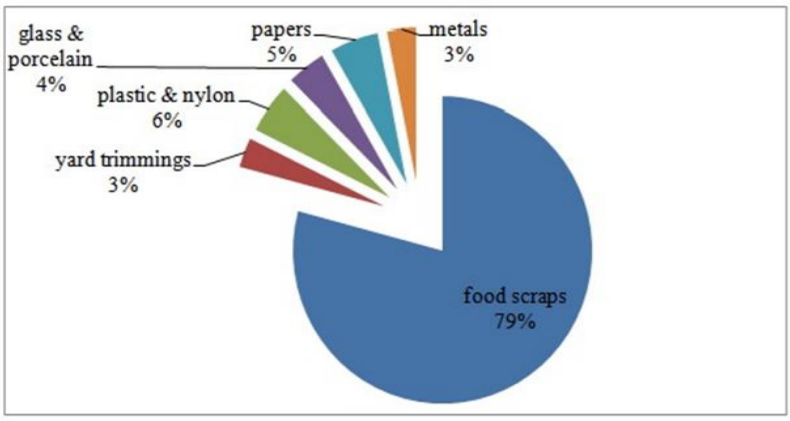

Fig.6. Percentage for different solid waste component of Erbil city in 2009

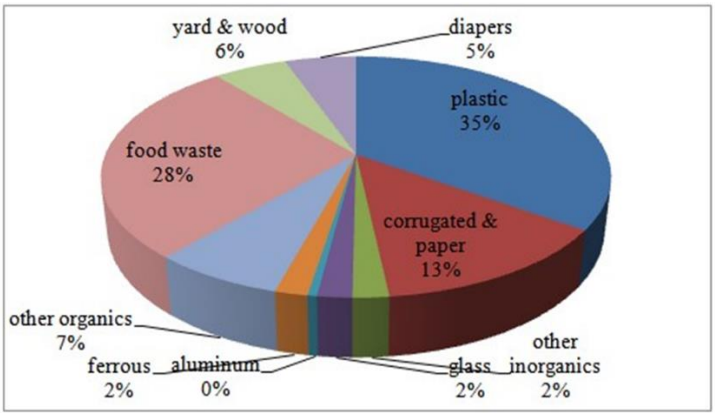

Fig.7. Municipal Solid Waste in Erbil City 2016.

5.1 The plastic waste in Erbil

The sudden increase in population density in recent years and the appearance of covid-19 had an effect on the reduction of recycling and the increase in waste especially the increase in use of disposable products. In Erbil city the total size of daily solid waste in 2009 was 400 ton/day fig(6) the data shows that only 6% of total waste but in 2016 the solid waste reached 1560 tons/day and the fraction of plastic waste increased to 35 % from the total waste in 2021 the average daily collections of waste materials was exceed 2000 tons daily with an increase in percentage of plastic waste to 44% according to the data the percentage of plastic waste in the total recyclable material is more than the other materials like metal, paper, glass, this increase in plastic waste in the last few years is return to some factor such as lifestyle, personal income, type of food consumption, public awareness and the effectiveness recycling factories.

In our study we try to focus on the effects of public awareness of plastic usage for the age group sample (12-27) years from segment of 200 people in Erbil city fig(8).

In our study we try to focus on two factor including the public awareness of Erbil citizens and the effectiveness of recycling factories in our city and finally mention a number of obstacles that face the recycling factories in our city.

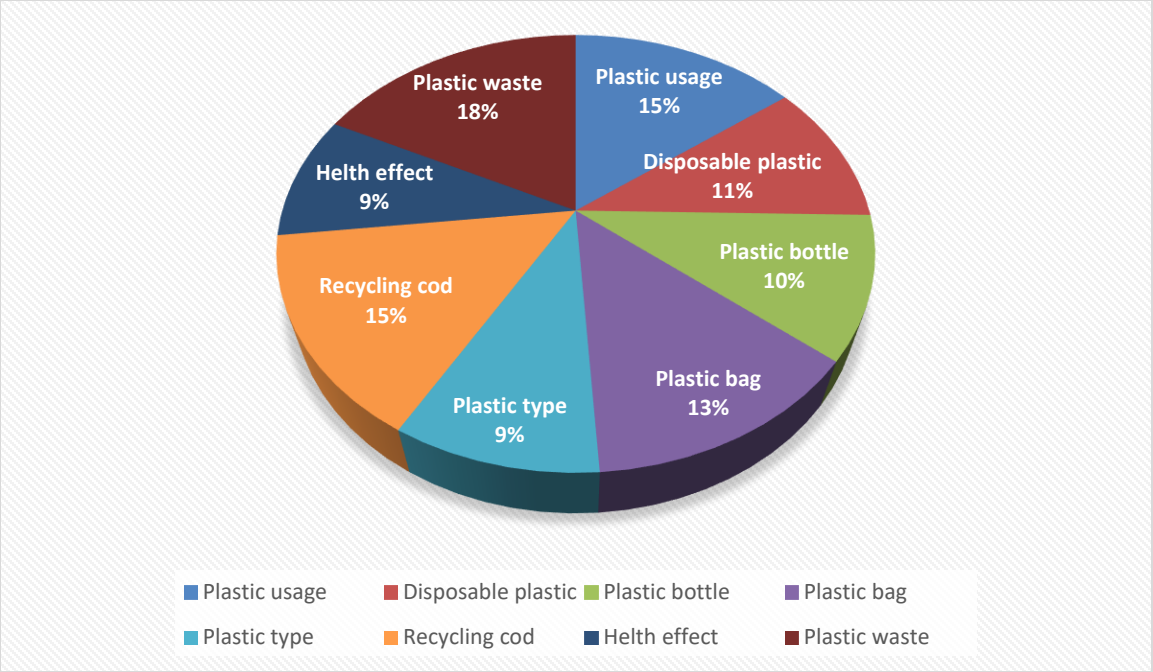

Fig.8. research for awareness of people about plastic in Erbil city.

6. Results and Discussion

A part of our research includes a questionnaire to survey the public awareness of the impact of different types of plastic and their correct use in daily life for groups sample age (12-27)years from a segment of 200 people in Erbil city fig() . The result of our questionnaire shows that the usage of plastic products reaches 49% from the total daily personal used items and only 18% of the total people is interested in the collection and remove the plastic garbage from public places, also the diagram shows that there a lack of knowledge and a personal awareness toward the type of plastic and their health effects in above 33% of total people the data is disappointing because the age category of (12-27 years) include teens and young adults are future generations with a lack of public awareness and knowledge, so this is signal to all those officials responsible in all fields of education environment organization media and government to work on educate and conscious society.

The second part of our research focuses on the recycling factories in Erbil city. As we mention the % of waste plastic is about (35-44) % in Erbil city which there are potentially recyclable with a small amount of non-recyclable plastic. The effective recycling can increase the income level

of recycling factories since it's a good source of raw materials and decrease the generation of waste and landfill usage. In Erbil city a number of recycling factories are listed in table (3) with types of recycled plastic and % of recycling per month for each factories.

Table.3. list of factories in Erbil city

Name of factories	Type of polymer	Type of recycled polymer	% of total production tons /month
Promise	Recycled	PE drinking bottle	400
Abdulrazaq	Recycled\standard	PVC water hose	closed
Adel	Standard	PET food container	900000 bottle
kalipsan	Standard	PE household	_____
Hewa Ali	Recycled\standard	PE oil container	20
BAZ Plastic	Standard	PE tanks	____
Dyara Plastic	Standard	PVC pipes	150
Mazin	recycling	PE bottle PVC basket PVC False ceiling	60

7. Obstacles of recycling:

Most factories in Erbil city face these obstacles:

1. Only a small amount of recyclable material are separated by scavengers on-site
2. Permission given to export plastic waste outside Iraq because it is sold at a higher price than in Iraq. This causes lake waste plastic sources for local recycling factories.
3. Import plastic materials (standard & recycled) from a board.
4. Taxes.
5. The high cost of labor, water and electricity.
6. Lake of foundation given to the recycling factories form governorate, environmental protection organization, and public awareness.

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