CHAPTER 7

# Chemical Wastes and Environmental Pollution

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## Chemical Wastes and Environmental Pollution

### What is Environment?

The environment is the sum of all the actions that surround all living beings and affect their lives positively or negatively, or the physical, biological, chemical and social factors that can have an indirect or direct effect on human activities and living beings immediately or over time (Nebel et al., 1993).

That is, the environment;

- Human's mutual relations with other people,
- People's influencing each other in the process of these relations,
- Human being's mutual relations and interaction with all living beings other than himself, namely plant and animal species,
- It describes the reciprocal relations of human beings with all the non-living things that are outside the world of living things but in the environment where living things live, namely air, water, soil, underground riches and climate (Johnson et. al., 1997)

In short, the environment is the environment in which biotic and abiotic entities interact in harmony with each other (Erten, 2004).

## Environmental Problems and Environmental Pollution

The intensive mixing of foreign substances in the air, water and soil, which adversely affects the living and non-living elements of the environment, causes structural damages on them and impairs their qualities, is called "environmental pollution".

The rapidly increasing world population, unplanned industrialization and unhealthy urbanization, nuclear tests, regional wars, the use of pesticides, artificial fertilizers and chemicals such as detergents cause environmental problems.

In general, environmental problems damaging the natural structure of the environment. This destruction is faster in cities and slower in rural areas. The most important factor in the occurrence of environmental problems is chemical wastes. Chemical waste is the waste that occurs in health facilities or industrial establishments and consists of harmful chemicals, which is harmful to humans, animals and organisms in the environment.

## Types of Chemical Waste

### Carcinogenic Toxic Waste

Exposure to toxic waste carcinogens in some way causes cancer to be seen more. While individuals are exposed to such toxic substances in waterways and groundwater sources, some toxins, such as mercury, remain in the environment, accumulating intact. Humans and animals often consume such toxins when eating fish. Toxic wastes containing organic carcinogens can be destroyed by incineration at high temperatures, but this process is very costly. If the waste contains heavy metals or radioisotopes, it should be stored as non-degradable material. Children born near toxic waste sites such as factories, landfills, and places of industrial accidents are often physically deformed or have various developmental disabilities. Such children are often born without eyes or teeth, or have extra fingers, missing brains, skin lesions, and many other serious physical illnesses (He et al., 2019).

### Radioactive Substances

Radioactive materials play a vital role in our lives. Most of the electricity used in the world is produced from nuclear reactors. In addition, radioisotopes are used in many medical applications. However, since even minor exposure to nuclear radiation is harmful to health, it is necessary to know how to safely dispose of the waste of these materials. A person may feel nauseous and vomit after exposed to radioactive materials and continued exposure can lead to fever and chronic fatigue, and a person may develop radiological illness as a result of prolonged exposure to radioactivity, which is referred to as acute anemia. Caused by inability to produce red blood cells. The body is weakened by ionizing radiation and cannot produce red blood cells.(UNSCEAR, 1996).

### Liquid Chemical Waste

Liquid wastes that are mixed with the liquids formed as a result of washing the laboratory equipment and the impurities such as detergent residue and dissolved substances. These wastes pose a danger to the environment and cause diseases. They carry the oxides of gases dissolved in them into the drainage pipes. It can occur as a result of domestic and industrial processes, as well as a result of agricultural production. It may result from irrigation and harvesting processes, especially depending on the type of fertilizer used to

improve crop quality or pesticides used for pest control (Arbanah et al., 2012).

### Industrial Waste Residues

Liquid wastes, especially heavy-duty liquids such as oils and greases, not only threaten the ecological life, but also pollute the river environment and the seas where the streams flow, causing unpleasant images on the beaches and negatively affecting the movement of tourism and recreational activities (Hogland et al, 1996; Gunkel et al., 2007).

### Hazardous Wastes

It is a waste that can harm people and the environment with various effects when interacting with flammable, toxic or other substances. Nowadays, there are many household products that are considered hazardous waste, such as sink cleaners, paints, air freshener, nail polishes, and adhesives. It can be in liquid, solid and gaseous state mainly containing toxic chemical compounds, Hazardous wastes including, but not limited to, mercury, dioxins, and pesticides, various acids that interact with oxygen, rainwater and groundwater (Hogland et al, 1996).

### Liquid-Gas Wastes

These wastes can be toxic organic substances, inorganic and non-toxic substances, gaseous wastes formed as a result of various human activities. Waste water, factory water, mining activities, fertilizers and pesticides, and liquids filtered from products considered in this group. For example, gaseous wastes include carbon monoxide, carbon dioxide, nitrogen oxides, sulfur oxides, methane and its compounds (Manisalidis et al., 2020).

## Effects of Chemical Wastes on the Environment

The effects of chemical wastes on the environment are air pollution, soil pollution, water pollution, thermal pollution, radioactive pollution, and it will be broadly express as environmental pollution in the later sections. In this section, it will be briefly stated and more pollutants and their effects will be emphasized.

### Air Pollutants and Their Effects

Air Pollution is the presence of foreign substances in the air in the form of solid, liquid and gas in the atmosphere in an amount, density and duration that will harm human health, living life and ecological balance. The air layer is polluted with the wastes generated during the production and consumption activities that occur as a result of various activities of people, and the living life on earth is adversely affected. For example, acid rain occurs as a result of mixing harmful gases with wet or semi-wet materials such as rain, clouds or snow (Moores, 2009).

*Sulfur Dioxide (SO2)*

SO2 is a colorless reactive gas with a pungent odor. It is formed as a result of combustion of sulfur-containing fuels such as coal, fuel-oil, metal smelting processes or other industrial processes. Its main sources are thermal power plants and industrial boilers. In general, the highest SO2 concentrations are found near major industrial sources (Chen et. al. 2007).

*Particulate Matter (PM10)*

The term particulate matter (PM) refers to solid particles and liquid droplets found in the air. It mixes directly with the atmosphere as a result of human activities and natural sources. They form PM by reacting with other pollutants in the atmosphere and are released into the atmosphere (Manisalidis, 2020). The sizes of solid and liquid particles span a wide range. Particles subject to health are particles with an aerodynamic diameter of less than 10 µm. Particles in this size range can accumulate in the respiratory tract (Kloog et. al., 2013).

Particles smaller than 2.5 µm are called "fine particles". Fine particle sources include all combustion processes and some industrial processes. Particles in the 2.5-10 µm range are called "coarse" particles. The sources of coarse particles are the dust removed from the roads as a result of crushing and grinding processes (Maji et al., 2017; Wilson et al., 1997).

*Carbon monoxide (CO)*

Carbon monoxide is an odorless and colorless gas. It is formed as a result of incomplete combustion of carbon in the structure of fuels. There are couple of sources, such as wild fires or combustion of fuels in industrial processes. The CO concentration reaches its highest value during the cold seasons. Because low temperatures cause incomplete combustion and cause pollutants to collapse at ground level (Chen et. al. 2007).

*Nitrogen Dioxide (NO2)*

NO2 is reddish brown in color. When nitrogen monoxide (NO) combines with oxygen in the atmosphere, NO2 is formed as a highly reactive gas. Once formed, it reacts with other pollutants such as NO2, VOCs. These reactions result in the formation of ground-level ozone. The main sources are motor vehicles and thermal power plants (Hesterberg et. at., 2009; Chen et. al. 2007).

*Ozone (O3)*

Ozone is an odorless, colorless gas consisting of 3 oxygen atoms. Ozone occurs both at

ground level and in the upper atmosphere. Ozone can be beneficial or harmful depending on its location (Bezirtzoglou et al., 2009).

Useful Ozone: Ozone naturally occurs in the upper layer of the atmosphere 15-40 km above the earth's surface, and as a protective layer, it protects the atmosphere from the harmful ultraviolet rays of the sun. This beneficial ozone is slowly destroyed by chemicals containing fluorine gas by humans (Bezirtzoglou et al., 2009).

Harmful Ozone: Near the earth's surface; Pollutants released into the atmosphere from motor vehicles, thermal power plants, industrial boilers, refineries, chemical factories react chemically in the presence of sunlight to form Ozone. Ground-level Ozone is a harmful to human health. Ozone pollution occurs in sunny weather and high temperature, especially in summer (Villányi et al., 2010).

## Water Pollutants and Their Effects

The situation that is observed in the form of a negative change in the chemical, physical, bacteriological, radioactive and ecological properties of the water source and which creates directly or indirectly obstructive deterioration in biological resources, human health, fisheries, water quality and the use of water for other purposes is called "water pollution"(Güler et al., 1994; Egemen, 1999).

### *Acid Rain*

Industrial activities, fossil fuels used for heating in houses, exhaust gases from motor vehicles and thermal power plants that produce energy based on fossil fuels pollute the air and emit sulfur dioxide, nitrogen oxide, particulate matter and hydrocarbons as a result of these activities (WHO, 2000). These pollutants, which can hang in the air for 2 to 7 days, undergo various chemical and physical reactions in the atmosphere, react with water vapor and other components in the atmosphere, forming pollutants such as sulfuric acid (HSO), sulfuric acid (H2SO4) and nitric acid (HNO3) (Hesterberg et al. 2009). During the natural cycle of water, it falls to the earth by taking the gases, dust, radioactive fallout and microbes found in the polluted air layers as rain, snow or hail, which is called Acid Rain (Zuhara et al. 2018).

Although this problem is experienced intensely in developed countries today, it threatens the whole world. Because these pollutants, which are released in the atmosphere, are carried by the winds and affect other regions. Acid rain affects the chemical structure and biological conditions of the soil. It washes the elements such as calcium and magnesium in the soil structure and carries them to the ground water, causing the soil to weaken and agricultural productivity to decrease. The substances that contribute most to the acidification of the soil are the sulfur compounds that pass into the soil as a result of

accumulation in the atmosphere (Kjellstrom et al., 2006). 2 Nitrogen compounds, on the other hand, play a role in the acidification of the soil when the amount is more than the plants can absorb (Hesterberg et al., 2009). Statistics show that about 80% of diseases, especially in developing countries, are related to water contamination. In fact, it is known that about five million babies die every year due to insufficient hygienic water resources (Farhat et al., 2013).

One of the most important direct effects of acid precipitation is seen on lakes and their aquatic ecosystems. Acidic chemicals can reach lakes in many ways; rain, snow, fog, haze in the form of precipitation as wet particles into lakes. Apart from direct precipitation, precipitation falling on the land discharges its water into lakes through wastewater channels or runoff. Another way, with the rapid melting of snow in spring due to sudden temperature change, chemical pollutants in the snow are released and reach lakes by mixing with rivers. These pollutants reaching the lake suddenly cause a drastic change in the pH of the lake, which is called spring acid shock. Aquatic ecosystems cannot find time to prepare themselves for this sudden change, and since the spring season is a very sensitive period for the reproduction of fish and insects, the sudden pH change causes serious changes in the offspring (Yeager, 1999). One of the indirect but also very important effects of acidification on the environment is acid moisture, which is formed as a result of industrial activities. They can react with toxic substances such as mercury, cadmium or aluminum that have landed in the soil or lake beds, and these substances, which are considered insoluble under normal conditions, reach humans through drinking water and cause toxic effects as a result of the reaction with acidic moisture (Goyer et al., 1990; Bellinger, 2008).

### *Bacteria, Viruses and Other Disease-Causing Creatures*

Organisms that cause hygienic pollution of waters usually originate from the feces and urine of diseased or carrier animals and humans. The contagious effect occurs either by direct contact with these wastes or by the waters where the wastes are mixed. This type of water is not drinkable and unusable (Güler et al., 1994).

### *Contamination from Organic Substances*

It occurs when dead animals, plant residues and agricultural residues mix with surface waters. It affects the water quality by causing changes in the oxygen level of the water. It also provides a suitable breeding and development environment for microorganisms (Bülbül et al. 1997; Abbasi et al. 2011).

### *Industrial Residues*

They consist of substances with toxic effects such as phenol, arsenic, cyanide, chromium,

cadmium, mercury from various industries (Gunkel et al., 2007).

### *Oils and Similar Substances*

This type of pollution occurs when oil transported by tankers and pipelines mixes with surface waters as a result of accidents and leaks. It is important in terms of the negative effects of mixing with surface waters (Fried et al., 1979).

### *Synthetic Detergents*

The phosphates they contain cause eutrophication, pollution and poisoning in surface waters (Goel et al, 2012).

### *Radioactive Wastes*

The reaction products of the facilities where nuclear energy is used are radioactive. During long-term storage of nuclear wastes underground or under the sea, their toxic properties may appear when they leak from the containers and mix with the waters. It may originate from hospital research organizations. Nuclear weapons tests contaminate rainwater and create radioactive contamination of surface and groundwater (Bonavigo et al. 2009).

### *Artificial Organic Chemicals*

They are produced by the pharmaceutical, petrochemical, and chemical industries. These substances are more difficult to degrade than the natural organic substances they replace. Over time, it accumulates in the body and creates a toxic and carcinogenic effect (Díaz-Cruz et al., 2008).

### *Inorganic Salts*

Dissolved salts are found in waters and discharge points as sodium, potassium, calcium, magnesium, iron, sulfate, nitrate, bichromate, and phosphates. It makes the waters unsuitable for drinking, irrigation and many industrial uses (Zhang 2017).

### *Eutrophication (Phosphate Contamination)*

Eutrophication is an excessive increase in plant existence in any large aquatic ecosystem, such as a lake, as a result of a large increase in nutrients for various reasons, especially those coming from land (Harper, 1992). This can reduce the amount of dissolved oxygen in the water, which can lead to the death of the aquatic ecosystem in the long run. Phosphorus, nitrogen and other nutrients gradually increase in older aquatic ecosystems. The increase in organic material that can be converted into nutrients in a system increases the productivity level of the system (Gilbert et al., 2005). The aquatic ecosystem contains

soil living residues that are dragged from the surrounding land. Algae and microscopic organisms collected on the water surface prevent the absorption of oxygen, which is vital for underwater life, by blocking the sun's rays. Eutrophication, particularly from phosphate, is also known as phosphate contamination (Burkholder, 2007).

The so-called cultural eutrophication occurs when the aging process of water is accelerated by humans dumping excessive nutrient-containing substances such as sewage, cleaning materials, and fertilizers into an aquatic ecosystem (Gilbert et al., 2005). Among the factors that accelerate eutrophication are the dry climate, excessive evaporation, and the use of lake water for irrigation with a canal. Eutrophication may disrupt wetland ecosystems and cause the decline or extinction of birds, fish and other living things. In the advanced stages of eutrophication, since oxygen will be depleted, the related system first turns into a swamp and then a meadow. Thus, the system moves from the aquatic ecosystem to the terrestrial ecosystem (Khan et al., 2005).

## Soil Pollutants and Their Effects

Soil pollution, with a general definition, is the deterioration of the physical, chemical, biological and geological structure of the soil as a result of human activities. Soil pollution occurs as a result of the application of wrong agricultural techniques, the use of wrong and excessive fertilizers and agricultural pesticides, the accumulation of waste and residues, toxic and dangerous substances in the soil (Pettry et al., 1973; Alloway, 1996).

Pesticides, which contain many chemicals, have an important role in water and soil pollution. As they pass to higher organisms in the food chain, they become increasingly concentrated at each stage and cause significant damage to the carnivores, which gradually form the last link of the chain (Rodríguez-Eugenio et al., 2018). That is, harmful chemicals are present in very small quantities in simple organisms, which intensify as these organisms are eaten by more complex organisms; when it reaches carnivores that eat herbivores, it has reached harmful levels. Negative effects of pesticides have been observed especially in birds of prey such as hawks and eagles or birds that feed on fish such as pelicans and cormorants (Mirsal, 2008). Today many insect species are immune to these substances; In addition, the resistance of the next generations to toxic drugs increases through heredity. On the other hand, the continued use of these chemicals has led to the emergence of previously nonexistent pest communities in some regions. This is mainly because pesticides destroy the carnivorous insects that keep the herbivorous insect population in check (Mishra et al., 2015).

### *Sediments*

Sediment accumulating as a result of erosion is another factor that leads to soil degradation

and turbidity of waters. Sediment production is a growing problem resulting from the misuse of forest and agricultural lands. Mining and construction activities also play a role in this area (Provoost et al., 2008).

### *Mineral Wastes*

Although mineral wastes constitute a significant part of the total solid wastes on the earth, they are relatively less harmful as a pollutant. The main reason for this is that they are not concentrated at certain points, such as wastes from residential areas and industry, but spread over wider areas (Razo et al., 2004).

The main source of mineral solid wastes is mining activities and related industries. Pollution caused by open coal mining not only affects rivers and drainage basins, but also leads to barren soil.

### *Animal Wastes*

Animal excrement and waste from slaughterhouses are the most important sources of soil pollution. Farm animals such as cattle, pigs, sheep and chickens produce 1,000 times more feces than the total human population. While nutrients in the past were returned to the soil through pasture or farm animals, today's innovations cause these wastes to concentrate in certain areas (Rodríguez-Liébana et al., 2014).

### *Industrial Wastes*

Water and air pollution that occurs during industrial activities tend to mix with the soil by chemical means. In addition, it is a common practice to spread various industrial residues around the factories or in a more open place. In some branches of industry, such as the sugar industry, pulp is formed, which is thrown onto the soil (Mirsal, 2008). Some occupations such as copper mining and marble mining also have significant pollutants. Air pollution caused by industrial activities, thermal power plants, exhaust or heating-based polluting gases affects the ecological structure of the soil.

Low quality and highly polluting lignite is used in thermal power plants in Turkey. Since Turkey is a lignite-rich country, it is the backbone of energy production for the country. However, as a result of the use of this coal, high amounts of sulfur 15 oxides (SOX), nitrogen oxides (NOX), carbon monoxide (CO), ozone, hydrocarbons, particulate matter (PM) and ash are formed. SOX and NOX gases are the main responsible gases in the formation of acid rain (Zuhara et al., 2018).

Acid rain caused by toxic gases released into the air pollutes the soil. Acid rain affects the chemical structure and biological conditions of the soil and is harmful to the plants growing on these soils. Sulfuric acid reaching the soil increases the acidity of the soil

solution, that is, the density of active hydrogen ions (Kjellstrom et al., 2006; Zuhara et al., 2018). The increased amount of hydrogen ions replaces plant nutrients such as Ca, K, Mg and Na, which are held by clay minerals and humus colloids, which are colloidal complexes of the soil, and causes these elements to be washed from the soil to mix with the ground water. In addition, heavy metals and elements carried by particulate matter in polluting gases and radioactive wastes mixed with the air reach the soil and cause radiation pollution in the soil (Qin et al., 1994).

Industrial establishments that use soil as raw material cause soil loss. The brick and tile industry uses the most fertile soils of 40-50 cm on the land surface as raw materials. The land structure of the remaining part deteriorates and loses its ability to be suitable for agriculture.

### *Domestic Waste*

Soil quality is noticeably deteriorated in areas where urbanization is intense. Poor use of the land, pollution of construction techniques, inadequacies of infrastructure, polluted water and sewage mixing into the soil and garbage accumulation significantly affect soil pollution (Pettry et al., 1973). Another factor that causes soil pollution around the city is air pollution. Both the toxic gases coming out of the chimneys during the heating of the city and the exhaust gases of the vehicles condense and fuse with the soil and kill the living things in the soil. One of the most important causes of soil pollution around the city is the accumulation of urban residues in the soil by the septic tank method. The pollution concentrated in this way infiltrates the deeper layers of the soil and also pollutes the groundwater (Azimov et al., 2019).

### *Pesticides*

In general, all pesticides contaminate the soil when they are used. Pesticides are reduced to less toxic or non-toxic components such as carbon dioxide, methane and water as they make their way into the groundwater (Edwards, 2013). As the half-life of the pesticide shortens, its degradation accelerates and it loses a significant portion of it before reaching groundwater. When the opposite happens, a significant portion of the pesticide is likely to reach groundwater and contaminate the source where it reaches. On the other hand, pesticides with cationic properties are strongly absorbed in the soil and the movements of these chemicals in the soil are reduced. Therefore, the risk of cationic pesticides to contaminate groundwater is lower than neutral or anion pesticides (Khan, 2016).

The techniques used in agricultural control have a special importance in terms of human and environmental health. In general, it is known that product loss occurs when plant diseases and pests are not dealt with in a timely and correct manner. Chemical control is among the most used methods to prevent this loss. Intense pesticides are used especially

in the Mediterranean and Aegean Regions where polyculture agriculture is carried out (Rodríguez-Liébana et al., 2014).

### *Excessive Fertilization*

The effect of fertilization on the soil is soil reaction, deterioration of the structure, destruction of living things in the soil and enrichment of toxic substances in the soil. The negative effects of fertilization on surface waters and drinking water are mostly due to the unbalanced use of nitrogenous and partly phosphorus fertilizers. Nitrate, which mixes with waters with fertilization or can accumulate in the plant, is the main environmental pollutant. Drinking water should not contain nitrates higher than 20 mg/kg. This limit value can be exceeded in places close to water sources and in loose soils with high infiltration capacity. For this reason, many European countries restrict nitrogen fertilization in areas close to groundwater (Boawn et al., 1971).

Fertilization can have positive and negative effects on the air. Fertilization increases the amount of oxygen in the atmosphere thanks to the oxygen released by photosynthesis. In this way, the amount of oxygen produced in one hectare of grain production increases to 12 tons per year. Oxygen production in this way in agricultural areas is higher than in forests or uncultivated lands. However, despite the air-healing effect of fertilization, the use of increased nitrogen fertilizer may adversely affect the air due to ammonia and nitrogen oxide outputs. The increasing use of nitrogen fertilizers, nitrous oxide gas, which passes into the atmosphere in increasing amounts, encourages the decomposition of the ozone layer (Bezirtzoglou et al., 2009).

As a result of excessive nitrogen fertilization, a significant accumulation of nitrate and nitrite is observed in plant tissues. The accumulation of these nitrogen forms in the plant can cause significant health problems in humans and animals fed with these plants. Contamination of soils with phosphorus fertilizers is greater than with nitrogen fertilizers. Compared to nitrate, phosphates have low mobility in the soil profile. Therefore, phosphate enrichment in groundwater in deep layers is not as high as nitrate.

### *Cadmium*

Batteries pollute the soil with various heavy metals and chemicals they contain. The most dangerous of these pollutants is Cd metal. There is a great danger in the contamination of soils by heavy metals such as Cd. Because the contamination and accumulation of these elements on the soil is irreversible. Cd in the structure of waste batteries and phosphorus fertilizers accumulates in the soil. Batteries can be kept away from the soil by special disposal methods, but this is not the case for fertilizers (Qin et al., 1994; Satarug et al., 2003).

Various alternatives are sought to reduce Cd entry into agricultural areas with phosphorus fertilizers. One of them is the use of raw phosphate rocks of volcanic origin with less Cd content in fertilizer production. The other one is to reduce Cd content of sedimentary sourced raw phosphate material and phosphoric acid used in fertilizer production (Provoost et al 2008). Phosphate deposits of volcanic origin with low Cd content are only found in Russia and South Africa. This situation causes the countries with raw materials to form a monopoly and cause the prices to rise excessively. During the production of phosphorus fertilizers, 70-80% of the Cd in the raw phosphate rock passes into the fertilizer (Orlov., 1992).

### *Remaining Materials from Water Treatment*

Sewage sludge is a dry intermediate product obtained as a result of the applications of wastewater. The treatment and disposal of solid materials, which are defined as "sludge sludge" and where pollutants carried with water are collected intensively, are as important as wastewater treatment. It has been observed that it causes soil pollution, especially when used as fertilizer or to store them in agricultural lands (Gülümser et al., 2001).

### *Petroleum*

During the use of petroleum products, ecological resources, which are very difficult to recover, are rapidly polluted. Oil pollution is the contamination of the environment through spills, explosions and accidents during the refining, storage and transportation stages after drilling (ASCE 1996). First of all, oil fills the pores in the soil, preventing the air inlet and outlet necessary for plant roots and soil creatures living in layers close to the surface. In addition, the clay and humus in the soil act as a filter to temporarily or permanently hold the substances included in the soil. Oil and its products completely cover the clay and humus surfaces, eliminating this natural filtration feature of the soil. Depending on these changes, losses occur in the physical properties of the soil. Petroleum, which contains high molecular weight components in its structure, has very low solubility in water (Wong et al., 1989). This situation also prevents the entry of water into the soil and the movement of water in the soil. For this reason, the transport of nutrients necessary for the continuation of life in the soil is interrupted. Thus, in addition to the loss of physical quality, various damages occur in the chemical properties of the soil (Ceyhan et al., 2012).

## Economy Friendly, Environmentally Enemy: Polymers

Polymers are high molecular weight compounds formed by the regular bonding of many molecules by chemical bonds. Polymers remain in nature for a long time and pose serious dangers in environmental pollution. It is possible to say that the world plastic consumption is gradually increasing.

The use of many plastic packaging materials for packaging many foods, such as pickles and canned goods, can be of serious concern. In particular, containers made of recycled materials carry impurities left over from their first use. In addition, it is possible for poor quality plastics to deteriorate and turn into monomers and other harmful substances. For this reason, plastics are not preferred much, especially in the food sector. Since disposable plastic materials are cheap, throwing them into the environment can cause serious pollution (Kayan & Küçük, 2020)

For this reason, it is possible to minimize the damage to the environment by considering the recycling of these materials. The two most important types of plastics whose recovery is focused on are Polyethylene Terephthalate (PET) and Polyvinyl Chloride (PVC). Due to the risk of mixing toxic gases and hydrochloric acid in the environment, the additives in PVC are separated from PET and other plastics in order to prevent these damages.

### *Polyesters*

Polyester is an artificial fiber synthesized from petrochemical products such as ethylene glycol and dimethyl terephthalate through a process called polymerization.

This fabric is not environmentally friendly. The manufacture of the fabric involves the use of large amounts of water, chemicals and fossil fuels. Raw materials and by-products are toxic, pollute water and air. Many garments are made from a mix of polyester and other materials. In this case, recycling them makes it difficult if not impossible. It doesn't matter if the garments are polyester or recycled polyester, both contribute to microplastic pollution (Arslan, 2018).

### *Polyamides*

Polyamides are polymers that contain amide groups in repeating units in the main polymer chain. (Taşdemir, 2019)

In the production process of polyamide fabric, serious damages are given to ecosystems. The water used to cool the polyamides often introduces pollutants into the surrounding ecosystems where the production plant is located. During the production of adipic acid, which is used to produce most polyamides, nitrous oxide is released into the environment. However, nitrous oxide is 300 times more harmful to the environment than carbon dioxide gas and 15 times more harmful than methane, and is a very powerful greenhouse gas. It causes depletion of stratospheric ozone. Also, nylon and other synthetic polyamides are not biodegradable (Taşdemir, 2019).

According to the World Bank, the textile industry is responsible for 17-20% of the world's wastewater. A large amount of water is used to produce polyamide. The wastewater generated in this process carries the pollutants to the water resources (Vijaraghavan,

1999). However, only 20% of the world's wastewater undergoes proper treatment, as reported by the United Nations (Handa, 1991). At the same time, workers exposed to the nylon manufacturing process experience irritation of their skin, nose, eyes, and throat from by-products, dust, and fumes (Kant, 2012).

### *Polyethylene*

Among the total thermoplastics, the most consumed commercial polymer with a rate of 34% is polyethylene, which is synthesized by the polymerization of ethylene gas.

Especially due to environmental laws and other sanctions enacted in recent years, this method is not applied much. On the other hand, toxic gases generated by the burning of wastes threaten human health. In addition to the waste of resources, the burning of plastic waste in the recycling method requires expensive investments to remove and control harmful gases such as furan, dioxin and heavy metal vapors entrained by flue gas during combustion (Hakkarainen et al., 2004).

### *Polyurethane*

It is a polymer that is synthesized in the laboratory environment and then used in many parts to make people's lives easier, and diversified with its hard or soft properties. Polyurethane has a smooth foam structure, 90-95% of the cells in its structure are closed. This allows polyurethanes to have excellent heat retention, that is, to be the best insulator known in the world. When polyurethane is thrown into the environment, it preserves its structure in nature for up to 1000 years because it is made of polymer (Kairyte et al. 2018).

### *PVC*

Polyvinyl chloride is one of the amorphous plastics. Hard PVC is mostly used in areas such as pipes, window profiles, and wall coverings. They are resistant to weather conditions, have high strength, hardness and self-ignition properties. Soft or flexible PVC types are mostly used in cable industry, flooring, toys and gloves production (Taşdemir, 2019).

Normal PVC contains 53-55% chlorine. It is possible to operate polyvinyl chloride up to 60ºC. It dissolves by chlorinated hydrocarbons when heated. The production of PVC powder involves the transport of hazardous explosives such as vinyl chloride monomer (VCM) and leads to the generation of toxic wastes, especially ethylene dichloride (EDC) tars (Taşdemir, 2019). In particular, tar wastes contain large amounts of dioxins and emit dioxins over an even larger area when incinerated or discharged (Persico et al., 2009). Previously, this waste was incinerated on oceanic incinerators until a worldwide ban was imposed in 1991. The ban was due to their toxic emissions and threatening the underwater ecosystem. These wastes are currently incinerated in land incinerators or

dumped into deep pits. Numerous additives are added to PVC to create a wide variety of products. Some of these additives are plasticizers for softening and pliability, heavy metals as stabilizers or colorants, and fungicides used to prevent fungi from ingesting other additives. Thus, PVC production includes a separate industry that produces a very large secondary poison (Bidoki et al., 2010).

In addition to being harmful to the environment, PVC consumer products also pose dangers to consumers. Plasticizers do not bind to plastic and spread by breaking over time. For example, plasticizers in PVC flooring will start to float in the room. The most used plasticizers (phthalate DEHP) are suspected to be carcinogenic. Phthalate softeners are global pollutants and 90% are used only in making soft PVC (Persico et al., 2009).

The disposal of PVC creates more environmental problems. In case of combustion (in an open area or incineration plant), PVC will emit an acidic gas along with dioxins due to its chlorinated content. In case of landfill, it will eventually leave a contribution that will threaten groundwater resources (Kayan et al., 2020). Incineration of PVC-containing waste in open landfills will lead to the release of even more dioxin sources. Recycling PVC is neither technically nor financially viable. Currently, less than one percent of PVC is materially recycled. Post-consumer products or PVC waste cannot be converted to the required PVC quality to make products of the same quality. Much of this collected waste is downcycled or used to make downstream products such as garden benches and sound barriers along highways. Many recycled PVC products have to be reconstituted with toxic heavy metal compounds or other stabilizers. This further increases the sequence of toxic compounds in the secondary product.

### *Teflon*

Teflon is the trade name for polytetrafluoroethylene (PTFE) polymer. It has very inert properties due to its molecular structure consisting of a long and straight carbon chain saturated with fluorine atoms and strong bonds between atoms.

Chemical substances, after absorption and distribution in the body, can be stored in the body, eliminated from the body or interact with the body. The areas where they are most stored in the body are adipose tissue, bones, hair and nails. The stored chemicals continue to increase in the body as the exposure continues, and their accumulation exceeds the excretion amounts over time. Most studies have shown that inhalation of gases from Teflon causes lung toxicity and death in mammals and birds (Dong et al., 2019).

Since Teflon does not interact with any substance, Teflon particles entering our body do not interact with the atoms that make up our body. Therefore, Teflon has no effect on our body. However, it has been found that the substance called PerFloric Octanoic Acid (PFOA), which is used in the bonding process of Teflon to the metal pan surface,

increases the risks of some tumors in animal experiments.

Like other polymers, the biggest problem in Teflon in nature is that they do not decompose like organic substances. When plastic materials used in very large quantities are thrown into the environment after use, they do not rot, do not rust, do not dissolve, do not biodegrade and remain in nature for many years without decomposition (Dong et al., 2019). It causes pollution of water and soil. It harms aquatic creatures and even causes their death.

### *PMMA*

Polymethylmethacrylate is a starting material used for the production of polymers and is a type of acid. It is used in a wide area from the automotive to the cosmetics industry, from the medical industry to the lighting industry. PMMA is a polymer and acrylic based material.

Acrylic acid is a very harmful type of acid. Causes damage to the skin and respiratory tract. It can cause irreversible health problems in contact with skin, inhalation and eye contact. Since PMMA is a polymer, it may not disappear for a long time when thrown into the nature. This causes soil pollution, which in turn affects the food chain (Van Grimbergen et al., 2018).

## Disposal Methods of Chemical Wastes

The fact that chemical wastes are so harmful to human health and the environment has made it necessary to take some measures for the disposal of these wastes. Disposal of liquid wastes by discharge into sewer pipes deteriorates the quality of groundwater, causes food spoilage and creates unpleasant odors, as well as can cause the formation of gases harmful to human health, such as hydrogen sulfide, carbon dioxide and methane. Liquid wastes often contain microorganisms that cause disease in living things. It can also occur in new chemicals that may affect human health and physiological functions. These effects appear sometime after exposure to these substances (Amour, 2016). For this reason, various disposal methods have been developed according to the characteristics of the wastes. For example, some of the liquid wastes are disposed of in landfills immediately after being treated, while others are incinerated to prevent pollution. They can also be turned into new products that can be reused.

Chemical wastes can be disposed of as follows:

### Incineration

It is the process of converting organic materials in solid waste into ash, gas and heat by burning. The burning heat is used to generate electrical energy. The advantage of

incineration is that it does not pollute the groundwater and the furnaces do not occupy a lot of land. The disadvantages are that incinerators pollute the air, leave behind about 10% of the waste that cannot be incinerated but still need to be disposed of, and is very costly (Ott et al., 2020).

### Landfill

It is one of the ways of disposal of solid wastes by throwing them into landfills or pits prepared for this purpose. The gases that emerge as a result of the decomposition of wastes such as methane and carbon dioxide by microorganisms are released into the atmosphere. When these pits are full, they are covered with a layer of soil and mud to prevent rainwater from reaching (Barnes et al., 2012). These areas can then be used as picnic areas or resting areas.

### Recycling

It is the reuse of waste to produce new materials. One of the advantages of this method is that it reduces the need for new resources. The energy required to recycle materials is less than to manufacture a product using new materials, and above all, recycling reduces the amount of waste that must be disposed of by incineration or landfilling. The most important recyclable materials include metals, glass, paper and plastic.

### Conversion to Organic Fertilizers

This method is based on leaving the domestic waste in the open for the decomposition of aerobic bacteria, insects, worms and fungi. It is necessary to allow oxygen to penetrate the waste so that bacteria do not perform anaerobic decomposition by inverting the waste from time to time. This process produces methane and other gases that cause an unpleasant odor (Mrozik 2003). When the decomposition process ends, the waste turns into a biological fertilizer, sometimes called black gold, which can be mixed with soil or placed around plants.

### Converting Solid Organic Waste to Biogas Technology

It is the process to produce biogas consisting of methane and carbon dioxide while decomposing wastes containing organic matter under the influence of anaerobic bacteria (Mrozik et al., 2003).

### Water Treatment

It is the whole of filtration, precipitation and chemical cleaning processes to treat wastewater. Bioremediation is done by passing sewage water through beds of aerobic bacteria that decompose organic material. Undissociated materials are pumped into

settling tanks, where they precipitate as clay sediment, the liquids are separated from the sediment and treated with chlorine to kill pathogenic organisms (Petterson, 1985). Thus, waste water can be reused for both physical and chemical cleaning structures. It can be reused for irrigation of crops, algal blooms and aquatic plants.

### Waste Disposal Methods for Radioactive Materials

From 1946 to the 1990s, the United States destroyed hundreds of thousands of barrels of radioactive waste at about 50 locations in the ocean. Of these, only 50,000 barrels were literally thrown from the ship into the ocean, 50 kilometers off the coast of San Francisco, near the Farallon Islands. When the barrels did not sink, artillery fire was opened from the ships and holes were made in the barrels in order to sink them. This has led to the leakage of radioactive waste such as plutonium, strontium and uranium. Other countries, including Russia, China, Japan, New Zealand and many other European countries, were also disposing of their waste in similar ways during this time (Medalia, 2008).

The main purpose of the disposal process is to neutralize radioactive materials and prevent them from moving to neighboring areas. In order to prevent waste from mixing with air and water, solid masses of 20 kg are formed by melting with glass bottles and metal cans, and placed in metal containers and buried on the ocean floor. Thus, it is not affected by erosion and does not leak harmful radiation (Friedman, 2011). This process, in which radioactive material wastes are mixed with glass and a solid material is obtained, is called nuclear waste glazing. In addition, it can also be disposed of by solidifying the radioactive materials at a very high pressure and placing them in concrete and metal cylinders and burying them in predetermined pits on the surface (Medalia, 2008).. Post-uranium waste is one of the most dangerous types of radioactive waste and consists of highly concentrated radioactive materials from which nuclear weapons are made. It is disposed of in leaded containers under strict control. The containers are buried about 100 meters underground and are located in certain lands. It takes about ten thousand years for such packages to become low-level waste. Nuclear wastes cannot be disposed of like other wastes because they harm living things.

## Toxic Waste Legislation and Regulations

The first regulation on waste in Turkey was made in 1983. The provisions regarding the protection of the environment and the disposal of toxic wastes have been determined in the Environmental Law No. 2872. In addition, the disposal of toxic wastes to other waste areas is defined as “illegal waste disposal”. Several current draft laws have been prepared to regulate the illegal dumping of toxic waste (MoEaU, 1983).

**Activity:** What Happened to the Materials?

**Purpose:** To observe the changes in the soil for a certain time period of the substances that cause soil pollution.

**Duration:** 3 Months

**Making the Activity:**

1. Identify a zone in a garden or soil area and mark it.
2. Scrape the area you marked.
3. Place fruit peel (remains), plastic bottles, cans and bags on the excavated area and cover it with soil.
4. Wait three months to observe what happens to the items you buried.
5. Make predictions about what might happen to the items after burial.
6. At the end of three months, dig up the buried materials and write down your observations.
7. Compare your observations with your previous estimates and draw conclusions about what could be causing soil pollution.

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