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The issue of plastic packaging and their impact on the natural environment

ABSTRACT

The subject matter of this article is issues regarding plastic packaging and its impact on the environment. In the article has been characterized plastic packaging and their types emphasizing the harmful influence of such packaging on the environment. The article also includes a review of existing international and national legislation. The study contains the definitions of plastic materials and plastic shopping bags. The present study is based on the analysis of available literature, legal acts and data published by the Central Statistical Office of Poland and PlasticsEurope. Due to the wide scope of the issue, the main focus was put on disposable plastic shopping bags, signaling only a part of the problem related to plastic packaging.

KEYWORDS: *plastic materials, polymeric plastics, plastic shopping bags, plastic waste, international and national environmental regulation*

Introduction

We live in times when plastic materials are an integral part of modern civilization. Polymeric materials, commonly known as plastic, are synthetic or semi-synthetic materials with a wide range of applications such as for the creation of polyethylene bags, eyewear frames, folders and binders, yogurt cups, containers for milk, gumboots, polyurethane sponges, pans with Teflon coating (Borkowski, 2015, p. 280). Synthetic materials are commonplace. They large-

ly replace wood, glass, metal and leather, as wherever one looks, plastic can be found. It is lighter, cheap, universal and can be formed in any way during production (Gervet, 2017, p. 2). The groundbreaking year for plastics was the invention of Bakelite by Leo Baekeland in 1907, as it was and still is possible to use for the creation of products, such as: tool holders, telephones, camera cases, production of billiards, etc. (Geyer, Jambeck, Law, 2017, p. 1). Concurrently, this event became a driving force for the mass production of plastics.

For more than 60 years there has been a huge demand for plastics (Statista, 2018). In 2017, the global production of plastics reached 348 million tons; Europe produced 64.4 million tons (PlasticsEurope, 2018, p. 8), while Poland produced 3448 thousand tons of plastics (Central Statistical Office, 2017, p. 118).

The recorded increase is due to the mass introduction of plastics into various segments of the economy. The largest use of plastics is in the packaging industry and the food industry. The deliberations carried out in this article will focus primarily on:

- 1) providing a professional and legal definition of plastic packaging and its types
- 2) emphasizing the harmful influence of such packaging on the environment
- 3) reviewing solutions to reduce the use of plastic packaging.

The aim of this publication is to analyze the legal regulations concerning plastics in relation to their impact on human life, health and the natural environment. The present study is based on the analysis of available literature, legal acts and data published by the Central Statistical Office of Poland and PlasticsEurope. Due to the wide scope of the issue, the main focus was put on disposable plastic shopping bags, signaling only a part of the problem related to plastic packaging.

Plastic packaging

In the literature, plastics are also referred to as polymeric plastics, which are obtained by combining the basic polymer component with auxiliary compounds, i.e.: carriers, stabilizers, hardeners, dyes, pigments, lubricants, flame

retardants, antioxidants, softeners, fillers. The aforementioned substances do not change the structure of the polymer, but modify the physicochemical properties of the material, providing the products with the necessary functional parameters. As previously mentioned, the main component of plastics is a polymer which is a macromolecular compound consisting of macromolecules made up of repetitive elements called mers. Usually they are a mixture of compounds (homologs) with different chain lengths, and therefore they are compounds that differ in molecular weight (Rabek, 2013, p. 12; Pielichowski, Puszyński, 1998, p. 11; Stachurek, 2012, p. 75). Polymers are categorized as: 1) semi-synthetic, also called artificial polymers (these are of natural origin, i.e. cellulose, rubber, starch, which are not used in their natural form); 2) synthetic (organic or inorganic compounds), which are the basic components of many materials (Żuchowska, 2000, p. 20). Polymers are products of petroleum processing, which are obtainable through chemical processes (polymerization) of low molecular weight compounds (monomers) (Żuchowska, 2000, p. 19). All of these are produced through operations carried out by humans, mainly through the use of petroleum, which is used mainly for the production of plastics (Gourmelon, 2015, p. 1).

The ongoing development of civilization, as well as the advanced food and packaging industry has caused plastics to be included in the packaging meant not only for food (disposable plastic bags, plastic containers), but also for beverages (plastic bottles) (Bondareff, Carey, Lyden-Kluss, 2017, p. 361).

According to EU law, packaging is defined as all products made of any material intended for the storage, protection, transport, delivery and presentation of any goods, from raw materials to processed products, from the producer to the user or consumer. Non-returnable products intended for the same purposes are also considered to be packaging (Article 3(1) of Directive 94/62/EC of the European Parliament and of the Council of December 20, 1994 on packaging and packaging waste (OJ L 365, 31.12.1994, p. 10 as amended). According to the Polish Act of June 13, 2013 on the management of packaging and packaging waste (Journal of Laws from 2019, item 542), a packaging is a product, including a non-returnable product made of any

material, intended for storage, protection, transport, delivery or presentation of products, from raw materials to processed goods (Article 3(1)). As can correctly be observed, the national provision on the concept of packaging is clearly inspired by Directive 94/62/EC of the European Parliament and of the Council of 20 December 1994 on packaging and packaging waste (OJ L 365, 31.12.1994, p. 10, as amended). The packaging can be made of plastic, paper and cardboard, steel and aluminum, wood, cotton or glass. However, for the purpose of this work, plastic packaging has been addressed.

In the aforementioned Directive, the Article 3(1a) includes the term “plastic”, which means a polymer (i.e. a substance consisting of molecules forming a sequence of one or more types of monomer units) to which additives or other substances may be added and which may function as the main structural component of shopping bags. Amongst these, they can be distinguished as e.g. 1) plastic shopping bags – these are plastic bags with or without handles offered to consumers at the places of sale of goods or products; 2) lightweight plastic shopping bags – with a material thickness of less than 50 microns, 3) very light plastic shopping bags – with a material thickness of less than 15 microns; these are required for hygienic reasons or offered as primary packaging for food sold in bulk as this helps to prevent food waste, 4) oxo-degradable plastic shopping bags – made of plastics containing additives that catalyze the disintegration of the plastic into microfragments (Art. 3 (1b), (1c), (1d), (1e) of Directive 94/62/EC).

Shopping bags are not the only plastic packaging, as a whole variety of them can be distinguished. Plastics have the advantage that, depending on their physical and chemical properties, they can be used to produce elastic or rigid packaging. The following plastics are used in the production of packaging: 1) polyethylene (PE) – used for manufacturing bottles for packaging cosmetics, 2) polypropylene (PP) – used for manufacturing cups, bottles and fat-resistant film, 3) polyethylene terephthalate (PET) – used for manufacturing bottles for beverages, i.e. beer, carbonated beverages, mineral water, 4) polystyrene (PS) – used for making meat trays, egg packing boxes, thermal insulation cups, cassettes, CDs as well as polystyrene food packing boxes, 5) polyvinyl chloride (PVC) – used for making con-

tainers for packaging edible oils or cosmetics, 6) polycarbonate (PC) – e.g. reusable bottles, films for packing baked bread confectionery products, 7) ethylene-vinyl alcohol copolymer (EVAL) – is used as an oxygen layer in multilayer packaging. Polyethylene (PE) is classified according to its density into High density polyethylene (PE-HD or HDPE), low density polyethylene (PE-LD or LDPE) and low density linear polyethylene (Rymarz, 2006, p. 17).

Some of these markings appear in the voluntary European system for identifying packaging materials, which was introduced by Directive 94/62/EC of the European Parliament and of the Council of December 20, 1994 on packaging and packaging waste (OJ L 365, 31.12.1994, p. 10, as amended) and established by Commission Decision of January 28, 1997 on the establishment of the system for identifying packaging materials pursuant to European Parliament and Council Directive 94/62/EC on packaging and packaging waste (OJ L 50, 31.12.1997, p. 28). The system is designed to facilitate collection, re-use and recovery, including recycling. Each packaging is made of a certain type of material which has its own symbol and numeric code in the system (Article 8(1) of Directive 94/62/EC). The labeling on the packaging is voluntary, i.e. EU Member States may use it, but are not forced to its implementation. Moreover, in addition to the labels (PET, HDPE, PVC, LDPE, PP, PS), other additional packaging labels may be used. Since January 1, 2105, a national system of identification of domestic materials has also been in force, which was introduced by the Regulation of the Minister of the Environment of September 3, 2014 on the designs of packaging labels (Journal of Laws, item 1298) pursuant to the Act of June 13, 2013 on the management of packaging and packaging waste (Journal of Laws from 2019, item 542). The implemented national system has been copied almost entirely from the European system for identification of packaging materials. Nowadays, the majority of packaging, apart from the labels identifying the packaging material, also contains the labels informing about the content and use of the goods, the packaging itself, including the labels related to environmental protection, transport conditions, logistic requirements, as well as handling labels (Żakowska, 2007, p. 25–29). The packaging market distin-

guishes between (1) single-material packaging, (2) reusable packaging, i.e. packaging that is intended, designed and entered into the market to achieve, within one life cycle, multiple turnovers through refilling or reusing it for the same purpose for which it was originally intended (Article 3(2a) of Directive 94/62/WE), 3) multi-material packaging – which is made up of two or more layers of various materials which cannot be separated manually, forming an integral whole, consisting of an inner container and an outer casing, which is filled, stored, transported and emptied in this form (Article 3(2b) of Directive 94/62/EC).

Multi-material packaging includes:

- 1) bags of laminates, such as those consisting of paper and plastic, of paper and aluminum foil, of paper, of plastic and aluminum foil, of plastic and aluminum foil,
- 2) laminate tubes consisting of plastic material and aluminum foil,
- 3) bag in box containers and paper bags with barrier insert if the different laminate box materials, such as cardboard, plastic and aluminum foil, cardboard and plastic, cannot be separated manually,
- 4) blister pack and skin pack packaging if combined with other materials, e.g. cardboard,
- 5) sachets and bags of laminates containing aluminum foil or metalized foil,
- 6) laminate labels consisting of paper and plastic, etc. (Sosnowski, 2019)

In the literature, it is argued that one should use a tool for assessing the impact of packaging on the environment, called LCA-Life Cycle Assessment, which employs software such as Umberto, EcoPro, SimaPro, Bagi. These programs can be used to assess the impact of a given packaging, including plastic shopping bags, on: 1) environmental damage; 2) consumption of raw materials, water and energy; 3) acidification and eutrophication of surface water; 4) emissions entered into the atmosphere; 5) soil pollution; 6) use of waste; 7) impact on human health, life and nature (Zarębska, 2013, p. 170). Life Cycle Assessment is a useful analytical tool because it allows the whole production system of the aforementioned types of packaging to be examined, thus analyzing the overall scope (global, regional and local im-

part) of environmental problems at the same time, rather than analyzing the individual components of the system or the individual products or processes.

Worldwide, supermarket chains and retailers provide plastic shopping bags. It is a product that makes it easy to carry items from a store to a house, protecting products from dirt and damage. It also takes up very little space, is comfortable, durable and lightweight. They are used primarily for packaging food to prevent it from being wasted (Temsamani, 2014, p. 3). Unfortunately, the production and excessive use of them entails certain nuisances, negative effects and risks to the environment. Progressive Bag Alliance prepared final report about Life Cycle Assessment for Three Types of Grocery Bags – Recyclable Plastic; Compostable, Biodegradable Plastic; and Recycled, Recyclable Paper. According to their report, a standard polyethylene shopping bag has a much lower impact on the environment than a 30% recycled paper bag or a compostable plastic shopping bag made from a blend of EcoFlex (BASF), polylactic acid and calcium carbonate (TEAD, 2007).

The impact of plastic packaging on the environment

The majority of the plastics produced has a negative impact on the environment and constitutes a global problem, with its concentrations reaching 580,000 units per kilometer (Wilcox, Sebille, Hardesty, 2015, p. 11899). Plastic shopping bags have the biggest negative environmental impact when it comes to plastic packaging, as they are mostly used only once and, what is more, approximately only 3% of distributed plastic bags are recycled, with the consequence of that being most of the bags produced end up, in the best case scenario, in a landfill or in bodies of water (Malathy, Santhosh, Nidoni, 2014, p. 73–79).

It is estimated that 8 million tons of plastics reach the oceans each year. Unfortunately, it is not known exactly how much time it takes for plastics to decompose, as this process can take from around a hundred to thousands of years (Barnes, Galgani, Thompson, Barlaz, 2009, p. 1985). On Internet portals, it is possible to find information that a regular disposable plastic shopping bag takes about 400 years to decompose (see Polish news rele-

ases: <https://noweko.pl/czas-rozkladu-tworzyw-sztucznych-wybralismy-te-najczesciej-uzywane/> [accessed 29 May 2019]).

The average Polish citizen generates around 315 kg of waste, while the average European citizen generates around 512 kg (Nowak, 2014, p. 103). Some of it ends up on landfill sites and some is thrown away into forests or rivers. They, in turn, flow into the sea, and with the currents of the sea they enter the oceans, creating a whirlwind of garbage. The commonly known floating island of garbage is the so-called "Great Pacific Garbage Patch". It is a huge floating plastic island between Hawaii and California. According to researchers from The Ocean Cleanup, the floating rubbish spot weighs 79 (45-129) thousand tons and covers an area of 1.6 million kilometers (Lebreton, Slat, Ferrari, Sainte-Rose, Aitken, Marthouse, Hajbane, Cunsolo, Schwarz, Levivier, Noble, Debeljak, Maral, Schoeneich-Argent, Brambini, Reisser, 2018, p. 4666). It is not the only floating waste island. Similar, yet certainly much smaller floating garbage islands can also be found in the Indian Ocean, Atlantic and the Mediterranean Sea.

It should be noted that 70% of the pollution of the oceans and seas is caused by plastics, which may break down into smaller pieces. These tiny particles are called micro-plastics because they have a diameter of less than 5 millimeters. Of the plastics found in the Mediterranean, more than 92% were micro-plastics (Suaria, Avio, Mineo, Lattin, Magaldi, Belmonte, Moore, Regoli, Aliani, 2016, p. 1). It is so small that it is difficult to capture by a effluent treatment system or to remove it from an open body of water (Jambeek, Geyer, Wileox, Siegler, Perryman, Andrady, Narayan, Law, 2015, p. 768).

Plastics floating in oceans and seas pose a real threat to around 86% of sea turtles, 44% of sea birds and 43% of marine mammals (Malathi, Santhosh, 2014, p. 73). The consumption of plastics by birds and marine animals can cause bowel problems, damage of internal organs, clog gills or even affect reproduction (Clapp. Swanston, 2009, p. 318). It is argued in the literature and news that encounters between plastic and fish, birds and other marine animals result, for example, in sea birds having plastic in their stomachs because they mistake plastic for food, sea turtles eating plastic bags because

they mistake plastic for jellyfish, and some plastic fragments piercing penguins' stomachs (Law, 2017, p. 215) Marine animals not only eat plastics, but also become entangled in them, often resulting in suffocation (Lewis, Verghese, Fitzpatrick, 2010, p. 146). Internet sources report that crustaceans living up to 11 kilometers below the surface of the water had plastic in their stomachs (Jamkowski, 2019)

Water pollution is not the only danger for the environment posed by that kind of packaging. Recent years have seen an increase in: 1) energy and water consumption; 2) landscape pollution and environmental deterioration; 3) exploitation of natural resources; 4) greenhouse gas emissions; 5) emissions of gases containing hazardous substances; 6) improper handling of waste; 7) contents of hazardous chemicals in packaging (Żakowska, 2017, p. 16, p. 25).

Legal regulations regarding the use of plastic packaging

The average annual consumption of plastic carrier bags is 198 per capita. The highest number of such bags is used in Bulgaria – 421 per capita and the lowest in Denmark – 4. In Poland, it is estimated that, until the end of 2017, about 300 bags per capita were used annually, which gives an enormous total number of 11,529,897,600 bags. Advertising bags are used on average for 12-20 minutes, i.e. the time it takes to deliver purchases to home (Sosnowski, 2019).

Due to the rising level of bag consumption and significant environmental pollution, the European Union and national authorities have introduced legal regulations limiting their use. The main EU legal act regulating proper management of waste and packaging waste is Directive 94/62/EC of the European Parliament and of the Council of December 20, 1994 on packaging and packaging waste (OJ L 365, 31.12.1994, p. 10, as amended). The primary objective of this act is to reduce the use of lightweight shopping bags so that after use they will not end up somewhere in the natural environment, but instead they will be sent directly to landfill sites. Shopping bags are recyclable pac-

kaging, but unfortunately their level of separate collection and reuse is low. Therefore, the European Union has obliged Member States to permanently reduce the use of lightweight plastic carrier bags on their territories by providing them with a choice between two measures (or applying both of them):

adopting regulations to ensure that, until December 31, 2019, annual consumption rate does not exceed 90 lightweight plastic carrier bags per citizen, and until December 31, 2025 – 40 bags per citizen; or to indicate a similar level in terms of weight. Very light plastic carrier bags may be excluded from the national consumption levels,

adopting regulations to ensure that, until December 31, 2018, light plastic carrier bags are not offered free of charge at the place of sale of goods or products, unless equally effective regulations are entered into force. Very light plastic carrier bags may be excluded from these regulations.

The Republic of Poland adopted the second option by deciding that, until December 21, 2018, shopping bags were added free of charge in each shop to the purchased goods (Zarębska, 2013, p. 168). On the other hand, as of January 1, 2018, the legislator introduced a recycling fee, obliging entrepreneurs managing a retail or wholesale unit which offers light plastic shopping bags intended for packaging products offered in this unit, to charge a recycling fee of PLN 0.20 per item (Article 40a of the Act of June 13, 2013 on management of packaging and packaging waste, Journal of Laws from 2019, item 542 and § 1 section 2 of the Regulation of the Minister of the Environment of December 8, 2017 on the recycling fee rate, Journal of Laws, item 2389). The recycling fee is collected from a plastic bag with a thickness of 15-50 micrometers.

Unfortunately, Poland adopted legal regulations concerning bags very late in comparison to the other countries. The Irish government introduced a 15-cent fee on plastic bags in March 2002, reducing retail sales of plastic bags by almost 90%, thus reducing their number in landfill sites (Convery, McDonnell, Ferreira, 2007, p. 9). The UK introduced a mandatory five-pence (USD 0.06/EUR 0.06) fee for customers for each disposable plastic bag issued by retailers in 2015 (Thomas, Sautkina, Poortinga, Wolstenholme, Whitmarsh, 2019, p. 343). In the US, local authorities have issued regula-

tions on disposable plastic bags, including a ban on their use, fees and taxes, a basic bag design, retailer return schemes and public education. Of the 271 local regulations, only 94% of the authorities banned disposable plastic bags, but 57.6% of these regulations introduced a fee for paper bags. Only 6% of the regulations introduced a fee/tax on all disposable plastic and paper bags in the amount of USD 0.10 per bag (Wagner, 2017, p. 11). In India, the use of plastic bags is punishable by up to even 7 years of imprisonment or a fine in the amount of 100,000 Indian rupees (Gupta, 2011, p. 3).

However, Poland was the first country in the world to introduce the generally available bottle vending machines, accepting three types of packaging, including these made of plastics, aluminum and glass. The machines were produced by EcoTech System as part of a joint action of Coca-Cola, Our Earth Foundation and the city of Warsaw. For each package, the deliverer receives points, which can later be exchanged for free coffee, a ticket to the cinema, or a shopping discount.

It is worth noting that the European Commission has prepared a proposal for a directive of the European Parliament and of the Council on the limitation of the impact of certain plastic products on the natural environment. At the end of March, the European Parliament approved a ban on the sale of disposable plastic products, but the Council of the European Union still has to approve the document in order for it to enter into force. Unfortunately, the draft document does not refer to disposable plastic shopping bags at all. The ban on the sale will only apply to hygiene sticks, balloon sticks, food containers, straws, disposable cups, plastic cutlery and plates (see European Union regulations <https://eur-lex.europa.eu/legal-content/PL/TXT/?uri=COM:2018:0340:FIN> [accessed 25 May 2019]).

Summary

Nowadays, plastics are common materials in our lives, from packaging, through clothing, household appliances, to cars. However, plastics are also becoming widespread in contaminating bodies of water, posing a real threat to the animal world, the entire ecosystem and people.

It should be pointed out that the risks associated with plastic packaging cannot be entirely resolved, but they can and should be reduced, which is why the packaging market should promote packaging that does not have a negative impact on the environment. For example, the use of starch as a renewable raw material in the production of bio-plastic packaging has resulted in lower consumption of non-renewable energy resources (by 50%), and thus lower greenhouse gas emissions (by 60%) in comparison to polystyrene packaging (Emadian, Onay, Demirel, 2017, p. 527). In the scientific literature, as well as in the studies on the negative impact of plastic bags on the environment, opinions remain divided. Even if a ban on plastic shopping bags is introduced, it does not mean that the amount of waste, raw materials and energy consumption will be reduced through the use of bags made of materials alternative to plastic.

An important role is fulfilled by raising the environmental awareness of the society and, above all, of consumers to choose reusable bags over disposable plastic bags. There has been a slow shift from disposable to reusable packaging, which is one of the solutions that industry has developed in the face of growing environmental concerns (Mollenkopf, Closs, Twede, Lee, Burgess, 2005, p. 171). Until recently, bags have been free of charge at retail outlets and usually had a retailer's logo printed on them, serving as a kind of mobile advertising. Therefore, consumers were neither motivated nor willing to carry bags if they could receive them free of charge and as a new product. Nonetheless, the amount of plastic waste must be reduced, along with raising the public awareness to make people more concerned about the place everyone lives in appreciative of what they have, ensuring environmental safety for present and future generations.

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