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Overview on the Key Figures with Impact on the Circular Economy Through the Life Cycle of Plastics

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Abstract: *Intended to draw a frame of the impact of plastics usage and the role of the circular economy, this paper relied on specific literature, data from different studies, case studies, reports and databases existing on the research area. Being produced at low costs and used in a wide range of fields, plastics has been confirmed as one of the most impactful inventions for human. Recently, during the pandemic years, plastics has gotten multiple usages, such as keeping a hygienic sanitary environment facing the critical situations, with a highly increased role in the fight against the SARS-COVID-19 crisis. It is also well known that plastics presents risks arising from its production flow, linked to a huge degree of massive pollution with high impact on the environment. Plastic waste exposed to the environment generated problems and it is of huge concern for all forms of life. As plastics products are present all around the world, there is an increasing statement to one-use plastics in the environment. Thus, it is urge to take actions for managing this situation as appropriate, to protect the environment and reduce the consumption of plastics, which can be achieved by developing and sustain the circular economy, as a new research field to explore. Through this paper we intended to emphasize the importance that, both theoretical contribution and practical measures, have on the production, the use and recycling of plastics and on the circular economy.*

Keywords*: plastic waste, plastics, circular economy*

1. Introduction

Nowadays speaking about plastics leads to the pollution approach as one of the environmental problems that affects not only Europe, but the whole world with an increased level in plastic waste daily produced [1]. This was observed since the plastic pollution meant the most important environmental issue, especially in the Asian and African regions where it is due, basically, to the inefficient garbage selection system. As a result of four main reasons which contribute to the plastic packaging pollution, the findings of some authors [2] have suggested that regulators, alongside with delivery platforms and consumers, should all work together to avoid pollution as much as possible and fight for a sustainable consumption. The Theory of Planned Behaviour (TPB) applied in empirical studies [3] for evaluating the determinants of plastic waste sorting intentions among Nigerian students, offered suggestions to policy makers on the importance of introducing practices and implementing waste management measures in the Nigerian university. Remaining on the African side, we found an investigation form of a case study, with data derived from an educational project focused on plastics as a vehicle for environmental education, stated that an increased consumption of plastics, is generating an exponential rise in plastic waste [4].

Facing similar situations, with growing incidence of plastic pollution in the European area, "the European Commission has proposed several rules to target the single-use plastic products most often found on Europe's beaches and seas. These applies to plastic cotton buds, cutlery, plates etc., which have to be made exclusively from more sustainable materials instead of plastics". These new rules have been applied to the consumption reduction and the obligations for producers to help covering the costs of waste management, labelling requirements, awareness-raising measures on the negative impact of littering of single-use plastics [5].

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More specifically, setting up "strategies for a sound management of Plastic Packaging Waste (PPW) is becoming increasingly crucial at many levels of the value chain in Europe" [6]. Other studies established "the current global status quo in the plastics industry and assess the sustainability of some bio-based biodegradable plastics, while extend producer responsibility (EPR) and deposit refund schemes (DPRs) are important add-ons to consider in plastic waste management, as they have been found to be effective in Australia, France, Germany and Ecuador" [7]. In this sense, there are authors stated that "the continuous generation of plastic wastes is one of the most serious environmental problems that we are facing and so, information campaigns have been used to encourage people to reduce plastic consumption" [8]. By reconsidering this situation that we all admit today, one answer is to review the necessity of developing strategies that could lead to a circular economy, as a viable solution on the pollution struggle. Actually, "plastic waste management is at a dismal level, especially in developing countries and so, there is need to develop clear mechanisms to address plastic issues for better monitoring, innovations, technology transfer and collaboration between organizations and citizen science to take collective action" [9]. On the other side, "the increasing consumption of plastics and plastic products results in correspondingly substantial volumes of waste, but with the ongoing environmental actions, the application of circular economy on the waste stream is becoming inevitable" [10].

There are other approaches indicated that the problems of plastic pollution and the mismanagement of plastic waste relied also on the educational and training aspects [11]. Because one of the main concerns is the use of plastics, upon on which researchers are deeply worried, the Covid-19 pandemic could reverse the global move, away from single-use plastic, by rebounding a specific demand. Meanwhile, there are studies which have shown that these products are not necessarily safer than reusable alternatives with respect to viral spread. Moreover, "Covid-19 pandemic has impact plastic recycling process by intensifying the price between recycled and new plastic materials" [12]. During the pandemic, personal protective equipment (PPE, such as masks and gloves) involved individual choices during lockdowns, which together with pollution, are also increasing plastic demand [13]. Beside all these, "the Covid-19 pandemic has severely distracted plastic reduction policies and induced significant changes in plastic waste management, with potential for negative impacts in the environment and human health" [14]. Because of these implications and impact on a large range of uses, the plastic pollution is the core of an important range of literature, approached in various methods and frames. As other authors mentioned, "the plastics play an important role in various areas such as food, chemical, construction, automotive, agriculture, electronic and fashion, due to their properties: easier processability, durability or corrosion resistance" [15]. Taking note that agriculture is considered a sector that produce plastic waste, it is necessary to look for solutions that contribute to reducing the quantities of packaging using and reusing them [16]. Although, the types of waste resulting from agriculture and forestry are: vegetable waste and waste from preparation; waste from manure; waste from forest holdings etc. [17], "every option has potentially positive and negative environmental. Incineration requires transport to plants and generates greenhouse gases, but it can be used to generate energy. Recycling is also not suitable in all cases, such as for plastics containing more than one type of monomer" [18]. Meanwhile, these involve a whole chain of major implications in using plastics (single-use face mask production, packages and home-delivered meals), which bring stress on regular waste management practices. All these actions have been led to measures on the circular economy, by including adapted practices and new policies against plastic pollution. The impact on the human health has been also analysed in many studies and thus, we can cite the following statements. "Plastics have become a severe transnational peril to natural systems and to human health, with studies predicting a double increase in the number of plastics remains by 2030" [19]. As a reaction to the need for deeper changes in the manner we produce and then, consume, the concept of a circular economy, has recently gained support. This offers an alternative to the model of production and consumption; however, it should be understood that for a simple phrase, "circular economy" covers a large variety and challenges [20].

The European Union is one of the most active entities where measures and research on the plastic pollution are on the top of the political agenda. "The European plastics industry supports the European Commission's strategy for plastics in a circular economy and there is no doubt that plastics have redesigned our life style and will still continue to shape the future" [21]. Plastic pollution is one of the most significant global environmental issues. A large number of governments and social activists have set up policies and actively promoted awareness [22]. By approaching the plastic life cycle, we mentioned several responses to address plastic pollution on the end-of-life stage. Meanwhile, the complexity of the plastic crisis "asks that we consider effects and opportunities at the life cycle to the frame significant responses that will limit all impacts of plastic" [21]. Considering all these approaches, plastic pollution become a rough issue of global concern which needs an immediate and international response involving all relevant actors [23]. It is also true that accepting that the use of plastic is a worldwide problem, means that international cooperation is required for implementing actions and to have an efficient decision making. We mention below some of the actions taken for this purpose: Basel convention with plastic waste amendments, CIEL (Centre for International Environmental Law) - Progress on plastics, "Global partnership on marine litter", "Global governance Centre - Governing plastic: The Global political economy and regulation of plastic production and pollution" [24]. There are also some other approaches. While the results on plastics issues vary based on the system boundaries of the model, in their article it was shown through an LCA (Life cycle analyse) matrix that the technologies can be used in the near future, as potential tool of recycling a wide range of polymers to improve the environmental performance [25]. Other research on Life cycle assessment has been also developed "as a tool that can help to quantify the impacts of different processes to facilitate comparison and decision making, revealing how the decision to include or exclude factors such as transport can have a significant impact on the outcomes." [26]. Another approach has been noticed in the report of the EEA [23], where plastics and their usage affecting the environment and climate, looked to be on their place in a European circular economy by taking into consideration the packaging sector based on plastics and meanwhile underlined the new transport solution for logistic sector.

Considering potential alternatives of reducing the impact of plastics on the environment, there are authors stated that "The circular economy represents an organized effort within society in order to find solutions to the current environmental problems that are generated by the development of the society" [27]. As for the impact of the plastic pollution, the literature mentioned that "the lifespan or degradation of plastics is very long" [28], going until over 140 years in case of the PVC and PTFE plastic types. While, the results of their study have shown a different side of the pollution, namely that "the presence of microplastics in the form of fibers and spheres in the municipal wastewater, is the consequence of household activities" [28].

The recent coronavirus pandemic (COVID-19) has impacted the production and the consumption of the plastics, because of their global demand for protective equipment (masks, bottles, gloves etc.), but there are some other issues that need to be mentioned. The World Health Organization (WHO) and the International Labour Organization have called for measures to be put in place to protect workers' health while teleworking. In another report, mentioning similar approach it was stated that the health benefits and risks of teleworking and "the changes needed to accommodate the shift towards different forms of remote work arrangements brought on by the COVID-19 pandemic and the digital transformation of work" [29-31]. Although the plastics issues are very important worldwide and ask for urgent measures at the global level, we found that the availability of the related database is quite limited. Thus, some figures on plastics pointed out around 359 million tonnes produced worldwide, out of which 40% are used for packaging, mainly for immediate discard. "Most plastics materials end up in the environment, in the form of microplastics also found across the globe" [32]. As we all accept that "plastic pollution has become a global concern, because of the increasing volume of plastic litter and micro-plastics... societies have become highly dependent on single-use or disposable plastic, which have huge environmental consequences" [24]. Even there is a consent on its necessity, turning to a circular economy, involve many challenges into the production, consumption and waste management system and

that will massively affect the environment. These include financing mechanisms, consumer behaviour, government intervention (such as tax policy and technological, social and business innovation). For now, implementing a circular economy "requires fundamental changes throughout the value chain, from product design and technology to new business models, new ways of preserving natural resources, by extending product lifetimes and turning waste into a resource" [33].

Meantime, the concept of circularity is tightly linked to the efficiency of the use of natural resources throughout the life cycle of products, as well as the transformation of waste into new resources for other industries. In this respect, the "Framework Directive 2008/98 / EC on waste, establishes the so-called "waste hierarchy", as well as the criteria for defining by-products, important aspects in promoting circularity and in revaluation in the internal market of new products resulting from waste processing" [34].

2. Materials and methods

There are many methods for dealing with the plastic waste and thus, it become tough to decide which one is the most suitable in terms of environmental impact. The methodology used in this paper referred on the structural changes analysis, based on literature review, case studies, on the data and information published in the dedicated sources with the main purpose to provide a perspective over the plastics sector. To approach the environmental and climate impacts linked to the plastics area, will constantly lead to the circular economy viewed as a viable solution to deal in a sustainable way, with the associated effects of the plastics. "The biodegradability of the bio-based plastics is limited to applications that do not require high tensile strength and flexural strength and based on the review, bio-based plastic nets made from polyamino acids, polysaccharide derivatives (DS), polyhydroxybutyrate (PHB), polycaprolactone (PCL), polyhydroxylalkanoate (PHA), and polylactic acid (PLA) are shown to be highly biodegradable compared to conventional plastics such as high-density polyethylene (HDPE), polyethylene (PE), and polyvinyl chloride" [35, 36].

In this study, several data sources regarding the evolution and interaction of the plastics issues were explored to emphasize the dynamics of this sector in the last years. The chosen topic proved to be of major interest both at European and international level, has been approached based on reports, studies and the scientific literature review, dedicated data bases and the legal frame. Thus, it has been set out an analyse focused on the main indicators and their dynamics in terms of production, use and life cycle of plastics, with a focus on European area. From this standpoint of view, the European Union is considered one the most active in the circular economy field, where already in 2015, it has been adopted the First Circular Economy Action Plan (CEAP) with specific actions (from production - consumption - waste management and the market for secondary raw materials) for the EU's transition to a circular economy, enhance the competitiveness, promote sustainable economic growth, create new jobs and with less stress on natural and freshwater resources. In the EU, there is a strong legal frame related to the circular economy, out of which we mention the Directive on single-use plastics, the Directive on plastics bags, Delegated Regulation on plastic waste shipments, the Directive (EU) 2019/904 of the Europe-an Parliament and of the Council of 5 June 2019 on the reduction of the impact of certain plastic products on the environment PE/11/2019/REV/1, the Directive (EU) 2015/720 of the European Parliament and of the Council of 29 April 2015 amending Directive 94/62/EC as regards reducing the consumption of lightweight plastic carrier bags and from 1 January 2021, new EU rules applied to shipments of plastic waste.

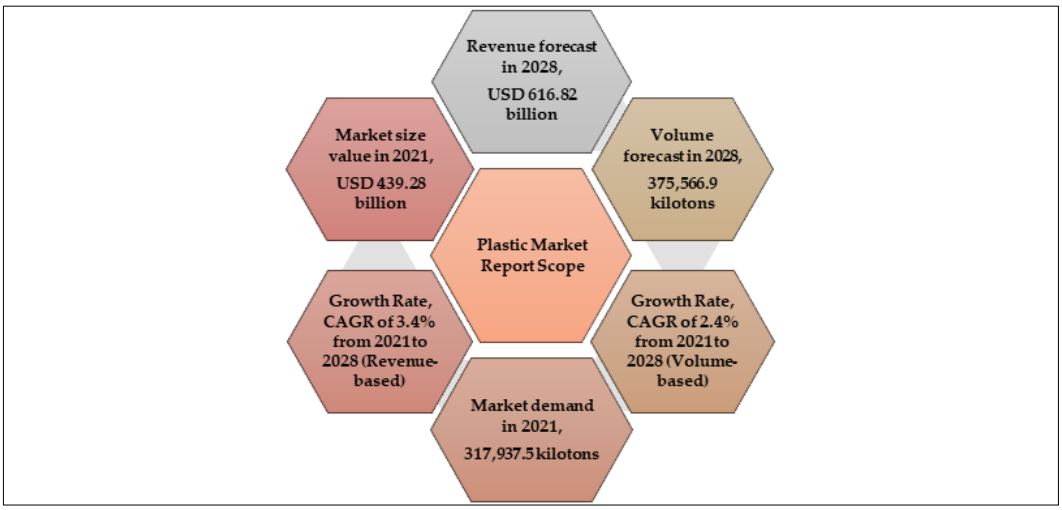
3. Results and discussions

It is highly accepted that plastics still have a role in the modern life due to the contribution they have made in the development of many areas, but their extensive use, the human behavior, together with the inadequate management on recycling, have led to the situation in which we are facing many problems related to environmental protection. On the other side, there are papers where it was stated that "It is too early to draw robust conclusions on the environmental impact that bans and levies have had. In 50% of

cases, information about their impact is missing, partly because some countries have adopted them only recently and partly because monitoring is deficient" [37].

3.1. Global aspects

At global level, Asia Pacific (including China) is the main market. In 2020 the intensive use of plastic across food and beverage industries of plastic led to the growth of packaging materials market (the highest revenue share of +36.0%). As for the key players on the global market operating all around the world, there are big players including BASF SE, SABIC, Dow Inc., DuPont de Nemours, and some other prominent corporations. According with the estimations of Fortune Business Insights (Plastic Market Size) the global plastic market reached in 2021 the value of $439.28 billion, with $4.57 billion more than in the pandemic year of 2020. They also estimated, a forecast for CAGR* (Compound Annual Growth Rate - the mean annual growth rate over a specific period of time) of 5.0% for 2021-2028 periods and that the sector will worth more than $616 billion in 2028 [38, 39] (Figure 1).



** CAGR (Compound Annual Growth Rate) is the mean annual growth rate over a specific period of time.*

Figure 1. The main characteristics of plastic market

The same source as above also indicated the dominance of Asia-Pacific regions on the global market with a turnover of $220.57 billion, which means over 50% of the market. Actually in 2020, Asia Pacific holds 45% from Polyurethane market, 53% from Polypropylene market and 32% from Fluoropolymer market (Figure 2).

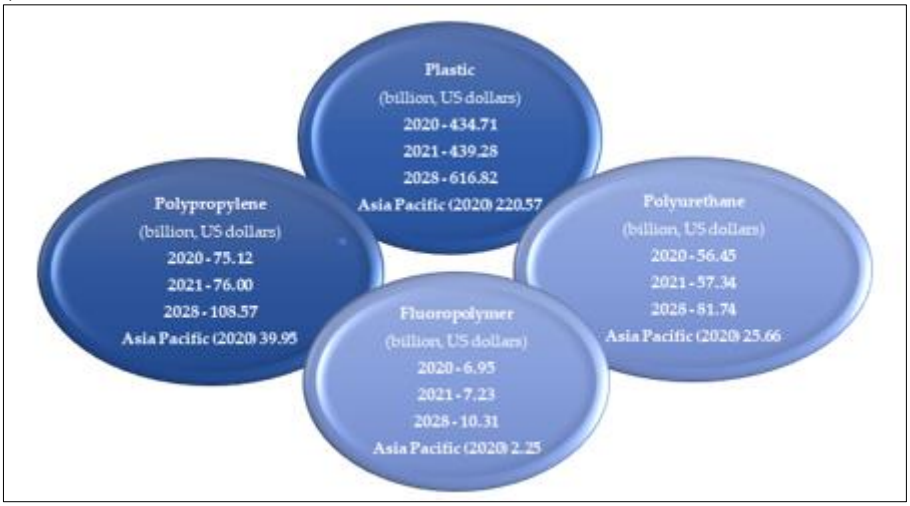


Figure 2. Plastic market size 2020-2028 (estimations for 2021 and 2028)
Source: own representation based on [38, 39]

The current trend is expected to maintain the same direction. China is anticipated to remain the leading country; the US will have the largest share in North America and the plastic market will continuously grow in the next years in Europe (especially polymers market due to the rising demand from the automotive sector). In Middle East and in East Africa is expected to grow the demand for textile and packaging industries and also in Latin America due to the rising urbanization.

3.2. European plastic market

Within the plastic waste collection data, there are some discrepancies imposed by the different life span of post-consumer and so, data does not fit information on demand or consumption. According with Plastics Europe, the European plastics industry includes plastics raw materials producers, plastics converters, plastics recyclers and plastics machinery manufacturers, engaged in circularity [40, 41]. Some key figures of the European plastics industry are presented in the figure below (Figure 3).

Figure 3. European plastic market size 2018-2020

Source: Own representation based on the data from Plastics Europe in 2019, 2020 and 2021 [40, 41]

Within the figure above, it was presented the evolution of some data during the period 2018-2020. The three categories, number of jobs (million people), companies (number) and the turnover (billion euros) have slightly decreased in Europe, validating the hypothesis that the plastic sector is on a down-trend [41, 21], mainly due to the impact of the COVID-19, but it seems that it will recovered quite fast. Shaping the picture around the plastic industry, in the figure below (Figure 4) there were presented the main features of the European plastic industry. We can thus notice a trade balance of 15.8 billion euros, 8th place on the contribution to the European industrial value added and an average number of 29 employees per company activating in the plastic industry.

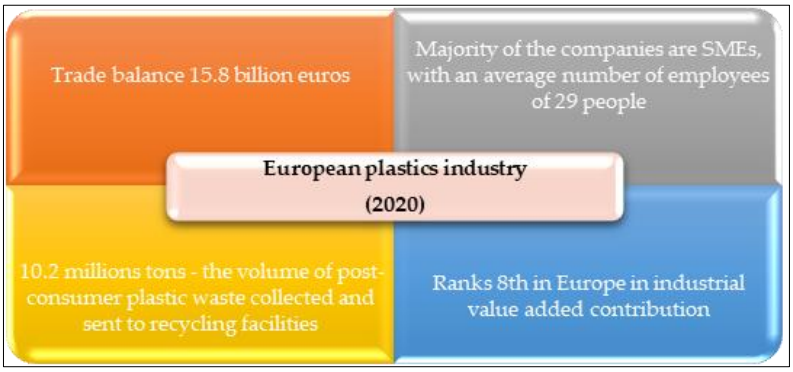


Figure 4. Main figures of European plastic industry in 2020

Source: Own representation based on the data from Plastics Europe from 2021

The plastic production over the 2002 – 2020 period at the European and global level is presented in the figure below (Figure 5). As data has indicated, the Europe had a higher proportion in the global

production level, during the first year of the analyzed period, while during the last five years, the European share in the world plastic production has constantly decreased until 15% in 2020.

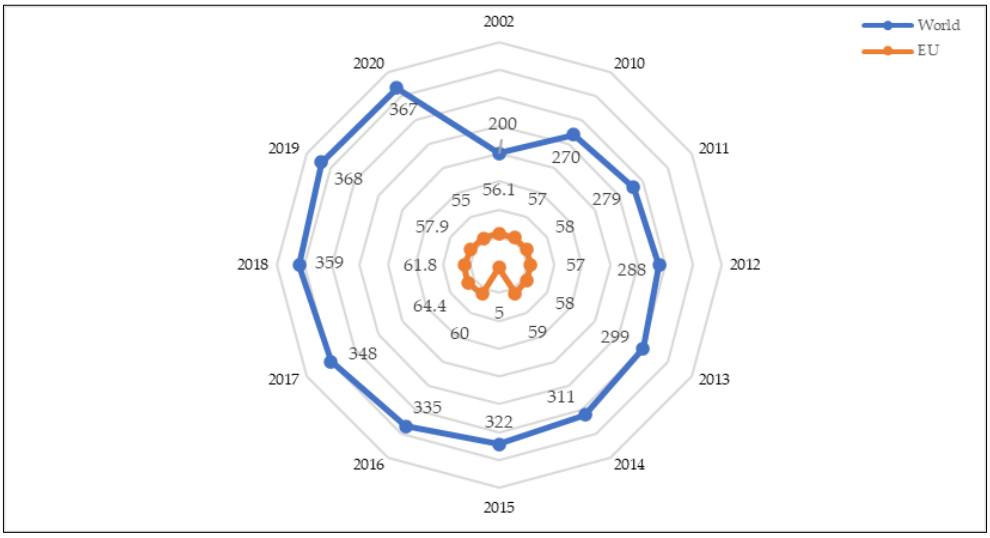


Figure 5. Production of plastics in the period 2002-2020* (Mt) (*the figures do not include the production of recycled plastics; 2020 - is preliminary data)
Source: Own representation based on the data from plastics Europe Market Research Group (PEMRG) and Conversio Market& Strategy GmbH. Estimated data. Data are rounded estimations based on extrapolations of 2019 waste data for 2020 [42].

Analyzing the plastics production side among the six international zones, we noticed from the figure below that Europe is on the third place in 2018 and in 2020 year, with 55 Mt [43] on the ranking of the global plastic production (which accounted for 368 Mt in 2019 and 367 Mt in 2020), behind China and NAFTA' countries (Figure 6). These all three latest regions summed up more that 65% of the global production. The last place in the ranking considered here below, there are Commonwealth of the Independent States (CIS) with 3% of the production.

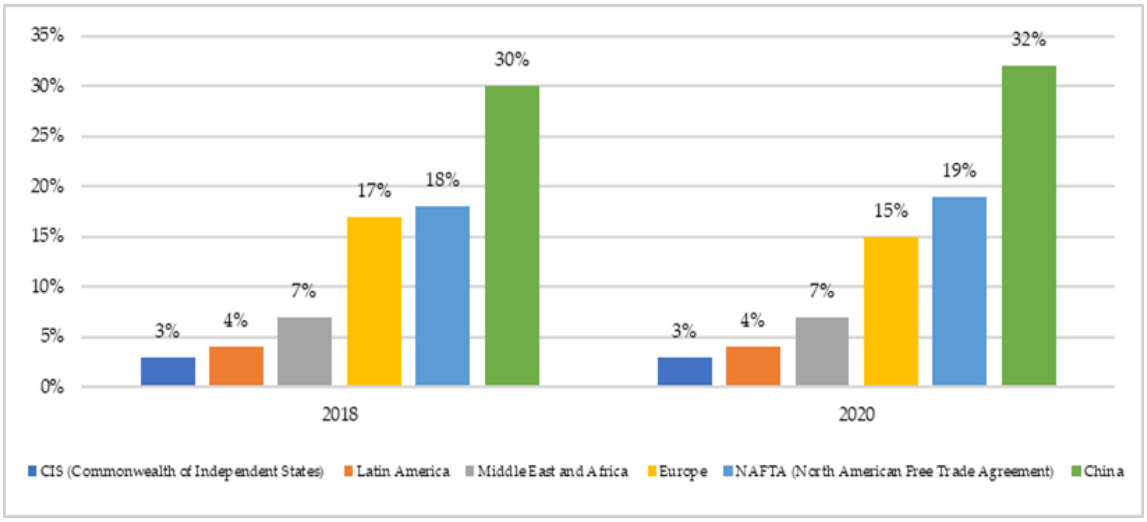


Figure 6. Distribution of the Global plastic production; Not included PET-, PA- and Poly-acryl-Fibers; Source: own representation based on the data from Plastics Europe Market, Research Group and Conversion Market & Strategy GmbH [42]

European total demand on plastics was 51.2 Mt in 2018, decreasing two years later with 4.1%, until 49.1 Mt (2020), out of which more than 37% represents the demand of Italy and Germany. The European demand on plastic materials among the first six countries has been presented in the figure below (Figure

7) and indicated no significative differences between the two years (2018 and 2020).

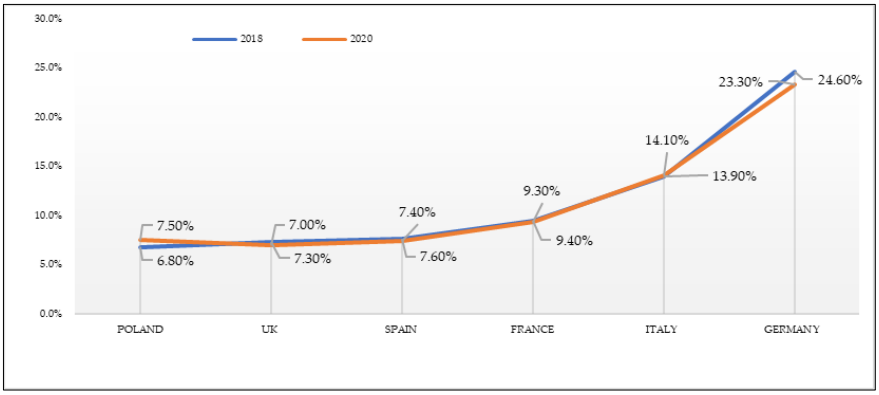


Figure 7. European demand on plastics materials (2018, 2020) - Not included PET-, PA- and Poly-acryl-Fi (*Demand estimation do not include recycled plastics)
Source: own representation based on the data from Plastics Europe Market, Research Group and Conversion Market & Strategy GmbH, 2020-estimated data [42]

Breaking down by usages fields in 2018 and 2020 (Figure 8), the European plastic demand indicates the following ranking: packaging (around 40%) and building construction (20%) these two first sectors represent the largest end-use markets. The other segments are – automotive (around 9%), electrical and electronic (6.2%), house-hold, leisure & sports (around 4%), agriculture (less than 3.5%) and others sectors (a bit more than 16.5%). As it was presented in the figure below, the date is very similar between the two years considered, which means that during the considered period, no major impact has registered for these sectors.

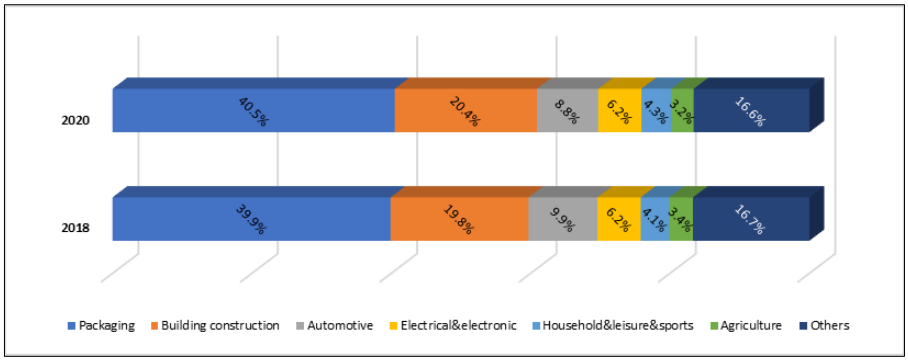


Figure 8. Ranking of the European plastic demand by segment, 2018-2020
Source: own representation based on the data from Plastics Europe Market, Research Group and Conversion Market & Strategy GmbH [42]

3.3. European bioplastic market

In a market where the packaging industry is the leading segment, we may notice the increasing importance of recyclable plastics for this industry and for all global markets. Actually, to reduce the environmental pressure caused by the use of these plastic products, many governments and companies tried to introduce greener alternatives (biodegradable polymers) or recyclable plastics. There are many countries (including in Asia Pacific region) which have committed to remove single use polymers and to shift towards non-plastic products. The EU adopted the European strategy for plastics in January 2018. It is "part of the EU's circular economy action plan and builds up on existing measures to reduce plastic waste. The plastics strategy is a strategic element of Europe's transition towards a circular economy. It will contribute to reaching the 2030 Sustainable Development Goals, the Paris Climate Agreement objectives and the EU's industrial policy objectives" [44]. Among other initiatives, the European Commission adopted in March 2020, the new circular economy action plan (CEAP). It is one of the

main sections of the European Green Deal, Europe's new agenda for sustainable growth. The proposal is for a transition to a "circular economy that will reduce stress on natural resources and will create sustainable growth and more jobs" [45]. In these conditions the demand for biodegradable polymers will increase in the next years if all the countries will respect the assumed policies. For example, there is a request to switch 50% of online deliveries and 20% of online food delivery towards biodegradable products until 2025 which will increase the demand of China for biodegradable plastic products with 700 thou tonnes when the current production is around 290 thou tonnes [46].

Among the most used plastics, the polylactic acid is a wide-spread biodegradable plastic which can reduce the fossil fuels consumption and the use of natural resources. In 2019, almost 60% of biodegradable plastics used in flexible packaging (around 250 thou tonnes) were produces from this material. Even if it has multiple applications (consumer goods, textile, fresh fruits, compostable bags etc.) is expensive compared with other plastics. The polylactic acid market size from Europe reached in 2020 around $226 million, but globally exceeds $698 million and it is expected to increase four times until 2028. Germany is the most consuming country of polylactic acid in Europe. There are expected changes all over the world as the population incline towards organic food, natural ingredients etc. [47] estimating that Europe will dominate the polylactic acid market due to the policies which promote the use of these products next to bioplastics. Actually, Europe is the leading region in the consumption of bioplastic products and is a major producer [46]. In numbers, this means a world market of $7.6 billion in 2021, from which Europe holds $3.4 billion and $US hold 1.8 billion [48]. However, the market is expected to grow with 10% annually and to reach over $15 billion in 2028 (Figure 9).

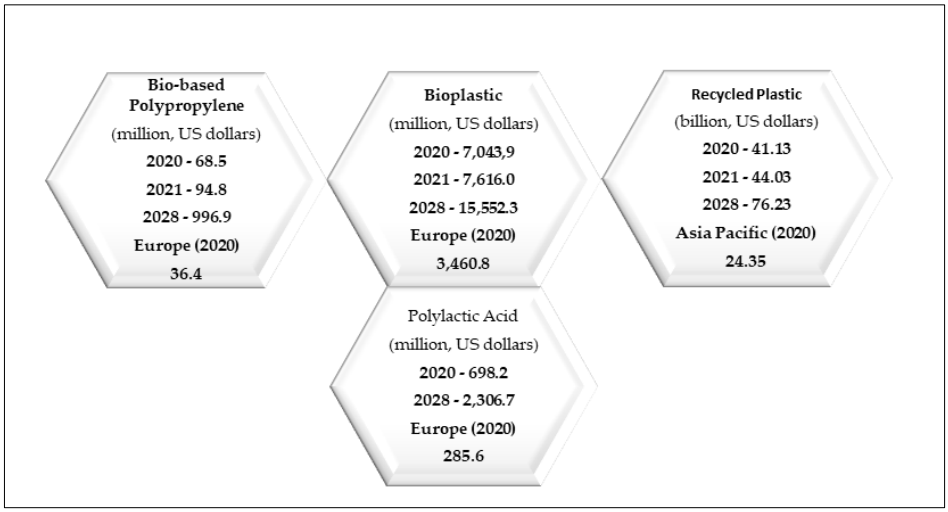


Figure 9. Bioplastic market size 2020 (estimations for 2021 and 2028)
Source: own representation based on the data from Fortune Business Insights [46]

Another type of biodegradable material is bio-based polypropylene (polymer derived from plants like vegetable oils, corn or sugar cane) [49]. This bioplastic market is expected to have a high growth in the next years due to its usage possibilities (in packaging, tubing, wiring etc.), from $68.5 million in 2020 to $94.8 million in 2021 and $997 million in 2028. The main usages are in packaging industry, consumer goods and constructions, sectors which will lead the growth all over the world. In 2020, Europe had a share of over 50% from the market, due to the automotive industries and it is expected to play a main role in the next decade. Regarding the recycled plastic market, we noticed a volume of $44 billion in 2021 which is expected to almost double in the next decade [50]. Asia Pacific region reached over half of the world market (around $24 billion in 2020) due to the predominance of bottled water industry from China and India. For Europe this market reached in 2021 an amount of 11.4 million tonnes and it is expected to increase with 37.7% until 2027 [51]. The food packaging sector will support the growth of recycled plastic market and even if PET and HDPE are the main recycled plastics, the non-food sector remains, due to the demand for wraps and films.

3.4. European plastic waste

Waste governance is becoming more regional; and particularly, waste management is organized on a regional basis in developed countries, where citizens generate significantly more waste than other residents, while people in the developing world are generally creating less waste, because of using biogenic products [9]. For instance, in the European Union the volume of plastic packaging waste generated per inhabitant increased in the last decade by 24% and reached in 2019 a value of 34.4 kg/person (around 19% from the total packaging waste of 177.4 kg/persons). That means around 15.4 million tonnes of plastic waste [52]. However, only 41% of this amount was recycled [53] which means that in Europe only 65% of waste is recycled (around 114 kg per capita) and from this amount, only 12,4% represent plastics [54]. Even if the increase has been over 50%, over half of the recycling activities are concentrated in only ten countries, on the first places being Lithuania with a recycling rate of 69.6% and Czechia with 61%. On the last places are Poland (31.5%) and Hungary (33%). The European recycling companies collect mainly industrial waste and only 16% was plastic from municipal solid waste [55]. As we mentioned, the majority of EU countries are trying to comply with recycling targets (Figure 10).

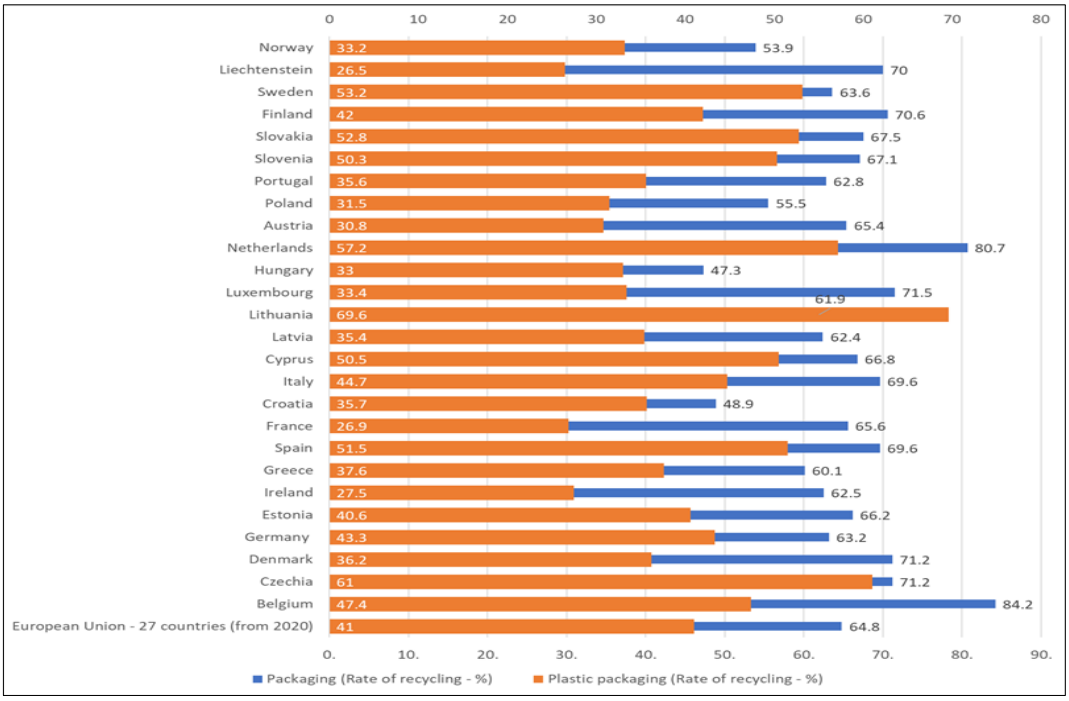


Figure 10. Recycling rates of packaging waste for monitoring compliance with policy targets and the share of plastic waste

Source: own representation based on Eurostat, ENV_WASPACR, last update: 27/10/2021

Almost all of the above presented European Member States have a rate of recycling in packaging sector over 50-60%. However, the plastic waste recycling rate is very low, even under 30% in countries such as Austria, Liechtenstein or France. Of course, we will have to follow up these analyses because the ban on single-use plastics has just taken effect since 2021. Looking to the statistics from the last years to see how some of the member states implement the policy in the field and comparing evolution between the years 2018 and 2019, the plastics recycling rate and the evolution of consumption of lightweight plastic carrier bags (under 50 microns), it was observed that the majority of the plastic recycling rates were decreasing and in the meantime the consumption of plastic bags increased with 35% in Finland and 12% in Belgium (Figure 11).

If the comparison is considered separately, it can be observed that Germany and Croatia have had a full positive approach towards plastic recycling, followed by Czechia, Italy and Lithuania. However, the EU will continue to tackle plastic pollution and to support the transition to a circular plastics economy.

According with European Commission, annually in EU there are almost 26 million tonnes of plastic waste which are disposed especially by energy recovery and recycling [56].

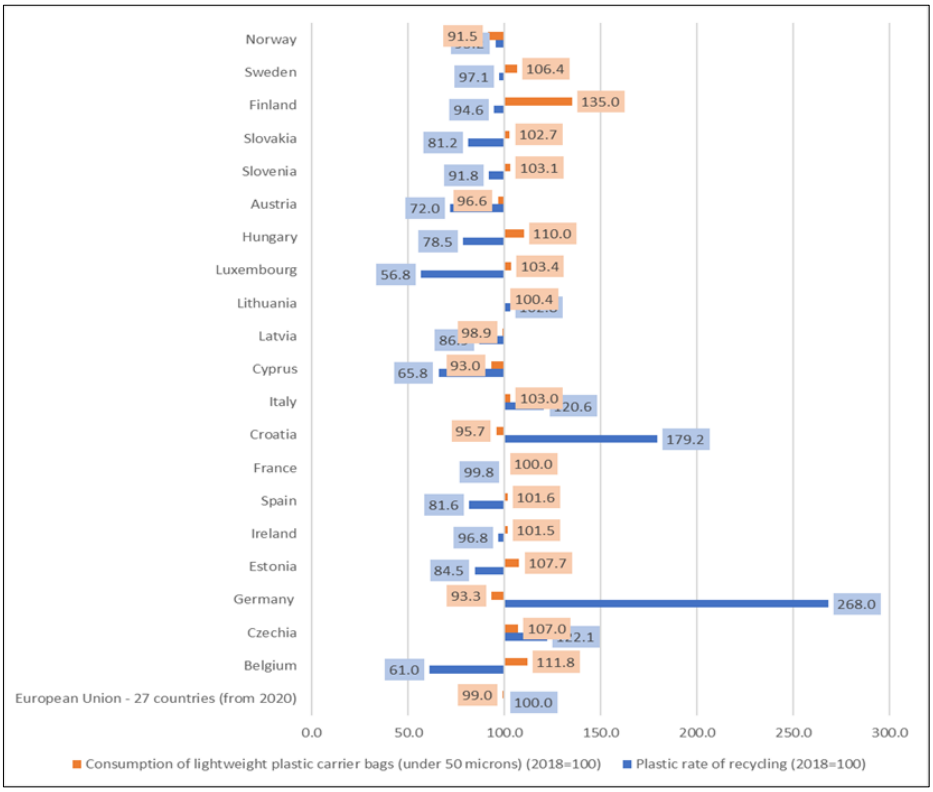


Figure 11. The dynamics of the plastics recycling rates and of the consumption of lightweight plastic carrier bags (under 50 microns) (2018=100; %)
Source: own representation based on Eurostat, ENV_WASPACR, last update: 27/10/2021

Going further, there is another concern, the plastic post-consumer waste treatment in the recycling facilities; this indicator was higher with 8.51% in 2020, compared to 2018 (although in 2020, 34% of the European plastic waste was sent to the recycling facilities), the treatment in the landfill (23% of the total European plastic waste, in 2020) having decreased with 4.17% (7.2 Mt in 2018 and 6.9 Mt in 2020), while within the energy recovery operations (42% of the total European plastic waste, in 2020), the level between the two analyzed years, remained the same. Still, these changes between the two years considered are not relevant (Figure 12).

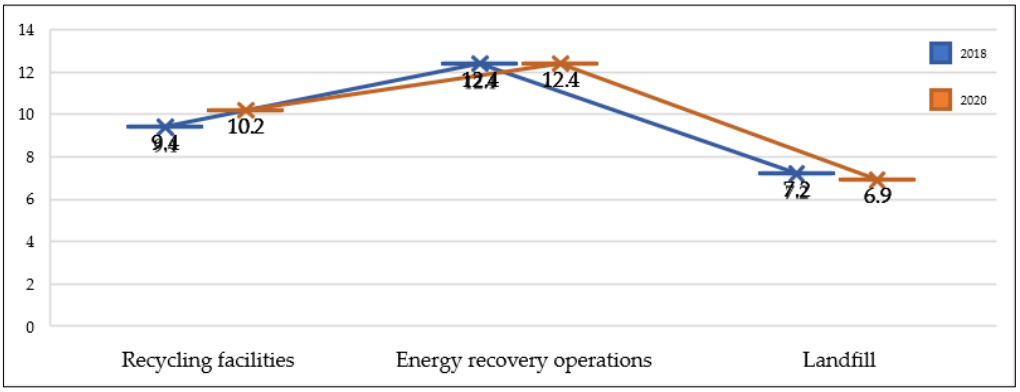


Figure 12. Plastic post-consumer waste treatment in 2020* (preliminary data), Mt
Source: own representation based on the data from Plastics Europe Market, Research Group and Conversion Market & Strategy GmbH [42]. Data are rounded estimations based on extrapolations of 2019 waste data for 2020

Still, having a look at the data in the sector, it remains the question that, at the current rate of recycling, the European targets can be reached. "Increasing the EU's average plastic packaging recycling rate in the next ten years, coupled with the need to improve the uptake of recycled content in new products, is an important challenge based on the entering into force of the new Basel convention in 2021" [57]. This will put pressure on the export of plastic packaging waste, will do it more difficult and with an increasing pressure on the EU's recycling capacities.

4. Conclusions

One of the most important stages of the global research on the plastics, was the Covid-19 pandemic and this was an important moment for balancing between the benefits and non-benefits on the use of plastics. It is well known that the current period we are facing is one that has never been met before. The pandemic situation has imposed conditions that later can leave important marks on our lives and on the environment. As it was stated in this paper, the use of plastics is a sensitive approach around the world. It affects the humans, the animals and the environment, but in the meantime, it cannot be replaced for the moment. We can only reduce production and rationalize consumption. The need to use plastic products during this pandemic has somehow put between brackets the decisions to reduce consumption. Correlated with the key features presented above in the paper, these have confirmed once again, the necessity for a circular economy massively supported, because of the benefits that come from the lower pressure on the environment and induced by the waste production, from the innovation and from the higher level of responsibility of the civil society. Among the measures that could be applied in order to get better impact for the environment protection, there were mentioned stimulative schemes for consumers and producers and thus, expecting to take an appropriate decision regarding the use of plastics. The findings of this paper have led to the conclusion that in recent years, the plastics industry has been constantly growing, with an accelerated trend that causes concerns for the unexpected effects that may occur. Moreover, the Covid-19 pandemic situation has had a huge impact on the politics and measures already into force before 2020 SARS-CoV-2 crisis. With a volume exceeded 11 million tonnes last year, the European recycled plastics market is expected to increase with more than 35% until 2027. Recently, plasticulture in the European space has become an important commitment with the implementation of National Collection Schemes (NCS) for the management of agriplastics waste, which assured higher collection rate, as well as a growing value of the plastic waste collected. This engagement was made in order to increase the circular economy impact and to avoid having a negative consequence on the environment.

References

1.CELAURO, C., TERESI, R., GRAZIANO, F., LA MANTIA, F.P., PROTOPAPA, A., Preliminary Evaluation of Plasmix Compound from Plastics Packaging Waste for Reuse in Bituminous Pavements, *Sustainability*, 13(4):2258, 2021. DOI:10.3390/su13042258.
2.GUO, M., WU, L., PENG, J., CHIU, C.-H., Research on Environmental Issue and Sustainable Consumption of Online Takeout Food-Practice and Enlightenment Based on China's Meituan, *Sustainability*, 13, 2021, 6722. https://doi.org/10.3390/su13126722.
3.AIKOWE, L.D., MAZANCOVÁ, J., Plastic Waste Sorting Intentions among University Students, *Sustainability*, 13, 2021, 7526. https://doi.org/10.3390/su13147526.
4.PAREJO, J.-L., CORTON-HERAS, M.-O., NIETO-BLANCO, A., SEGOVIA-BARBERAN, C., Plastics as an Educational Resource for Sustainable Development: A Case Study in Ghana, *Sustainability*, 13, 2021, 6727. https://doi.org/10.3390/su13126727.
5.***European Commission - Single-use plastics. Available online: https://ec.europa.eu/environment/topics/plastics/single-use-plastics_en (accessed on 18 January 2022)
6.PICUNO, C., VAN EYGEN, E., BROUWER, M.T., KUCHTA, K., THODEN VAN VELZEN, E.U., Factors Shaping the Recycling Systems for Plastic Packaging Waste-A Comparison between Austria, Germany and The Netherlands, *Sustainability*, 13, 2021, 6772. https://doi.org/10.3390/su13126772.

7.MAZHANDU, Z.S., MUZENDA, E., MAMVURA, T.A., BELAID, M., NHUBU, T., Integrated and Consolidated Review of Plastic Waste Management and Bio-Based Biodegradable Plastics: Challenges and Opportunities, *Sustainability*, 12, 2020, 8360. https://doi.org/10.3390/su12208360.
8.RAPADA, M.Z., YU, D.E., YU, K.D., Do Social Media Posts Influence Consumption Behavior towards Plastic Pollution? *Sustainability*, 13(22):12334, 2021. 10.3390/su132212334.
9.KUMAR, R., VERMA, A., SHOME, A., SINHA, R., SINHA, S., JHA P.K., KUMAR, R., KUMAR, P., DAS, S., SHAR-MA, P., VARA PRASAD, P.V., Impacts of plastic pollution on ecosystem services, sustainable development goals, and need to focus on circular economy and policy interventions, *Sustainability*, 13(17):9963, 2021. https://doi.org/10.3390/su13179963.
10.ALASSALI, A., PICUNO, C., CHONG, Z.K., GUO, J., MALETZ, R., KUCHTA, K., Towards Higher Quality of Recycled Plastics: Limitations from the Material's Perspective. *Sustainability*, 13, 2021, 13266. https://doi.org/10.3390/su132313266.
11.STOJIC, S., SALHOFER, S., Capacity Development for Plastic Waste Management-A Critical Evaluation of Training Materials, *Sustainability*, 14, 2022, 2118. https://doi.org/10.3390/su14042118
12.***Reuters Investigates - The plastic pandemic, 2020. Available online: https://www.reuters.com/investigates/special-report/health-coronavirus-plastic-recycling/ (accessed on 15 September 2021).
13.TANVEER, M. A., Accumulation of plastic waste during Covid-19, *Science*, 369:6509, 2020, 1314-1315. Doi: 10.1126/science.abd 9925.
14.SILVA, A.L.P., PRATA, J.C., WALKER, T.R., CAMPOS, D., DUARTE, A.C., SOARES, A.M.V.M., BARCELÒ, D., ROCHA-SANTOS, T., Rethinking and optimising plastic waste management under Covid-19 pandemic: Policy solutions based on redesign and reduction of single-use plastics and personal protective equipment, *Science of the Total Environment*, 742:140565, 2020. https://doi.org/10.1016/j.scitotenv.2020.140565.
15.CONSTANTINESCU, M., BUCURA, F., IONETE, R.E., NICULESCU, V.C., IONETE, E.I., ZAHARIOIU, A., OANCEA, S., MIRICIOIU, M.GHE., Comparative Study on Plastic Materials as a New Source of Energy, *Mater. Plast.*, **56**(1), 2019, 41-46. DOI:10.37358/MP.19.1.5119.
16.MARCUȚĂ, A., TINDECHE, C., TUDOR, V., CARBARĂU (SMEDESCU), C., SMEDESCU, D., MARCUȚĂ, L., Application of the principles of the circular economy in conventional agriculture. Case study - pesticide waste recycling. *Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development"*, Vol. 21 Issue 2, 2021, 375-382.
17.BONCIU, E., PĂUNESCU, R.A., ROȘCULETE, E., PĂUNESCU, G., Waste management in agriculture. Scientific Papers. *Series "Management, Economic Engineering in Agriculture and rural development"*, Vol. 21 Issue 3, 2021, 219-228.
18.ALHAZMI, H., ALMANSOUR, F.H., ALDHAFEERI, Z., Plastic Waste Management: A Review of Existing Life Cycle Assessment Studies. *Sustainability*, 13, 2021, 5340. https://doi.org/10.3390/su13105340
19.SILVA, A.L.P., PRATA, J.C., WALKER, T.R., DUARTE, A.C., OUYANG, W., BARCELÒ, D., ROCHA-SANTOS, T., Increased plastic pollution due to Covid-19 pandemic: challenges and recommendations, *Chem Eng J.*, 405:126683, 2021. DOI: 10.1016/j.cej.2020.126683
20.HART, J., POMPONI, F., A Circular Economy: Where Will It Take Us? *Circ. Econ. Sust.*, 1:127–141, 2021. https://doi.org/10.1007/s43615-021-00013-4
21.***Plastics Europe, enabling a sustainable future - Plastics - the Facts 2019. Available online: https://plasticseurope.org/wp-content/uploads/2021/10/2019-Plastics-the-facts.pdf (accessed on 08 January 2022)
22.TEH, P.L., PIAO, S., ALMANSOUR, M., ONG, H.F., AHAD, A., Analysis of Popular Social Media Topics Regarding Plastic Pollution, *Sustainability*, 14, 2022, 1709. https://doi.org/10.3390/su14031709.

23.***European Environment Agency - Plastics, the circular economy and Europe′s environment - A priority for action, 2021. Available online: https://www.eea.europa.eu/publications/plastics-the-circular-economy-and (accessed on 18 January 2022)
24.***Geneva Environment Network - Facing the plastic pollution crisis, 2021. Available online: https://www.genevaenvironmentnetwork.org/resources/updates/plastics-and-the-environment/ (accessed on 10 February 2022)
25.SCHWARZ, A.E., LIGTHART, T.N., GODOI, D., BIZARRO et al., Plastic recycling in a circular economy, determining environmental performance through an LCA matrix model approach, *Waste Management*, 121:331–342, 2021. https://doi.org/10.1016/j.wasman.2020.12.020
26.ALHAZMI, H., ALMANSOUR, F.H., ALDHAFEERI, Z., Plastic waste management: a review of existing life cycle assessment studies, *Sustainability*, 13(10):5340, 2021. https://doi.org/10.3390/su13105340
27.TIUC, A.E., NEMEȘ, O., VERMEȘAN, H., TĂMAȘ-GAVREA, D.R., VASILE, O., New Sound Absorbing Materials Obtained from Waste Rigid Polyurethane Foam, *Mater. Plast.*, **56**(4), 2019, DOI:10.37358/MP.19.4.5301
28.BĂTRINESCU, GHE., IONESCU, I.A., SCUTARIU, R.E., CHIRICUȚĂ, B., SURUPĂCEANU, I.C., Characterisation of Microplastics from the Effluent of a Municipal Wastewater Treatment Plant and from its Natural Receptor, *Mater. Plast.*, **58**(4), 2021, 47-54 https://doi.org/10.37358/Mat.Plast.1964
29.***ILO - Technical brief on healthy and safe telework Report. Available online: https://www.ilo.org/wcmsp5/groups/public/---ed_dialogue/---lab_admin/documents/publication/wcms_836250.pdf (ac-cessed on 10 February 2022)
30.***World Health Organization - Healthy and safe telework: Technical brief. Available online: https://www.who.int/publications/i/item/9789240040977 (accessed on 10 February 2022)
31.***World Health Organization - Crucial changes needed to protect workers' health while teleworking. Available online: https://www.who.int/news/item/02-02-2022-crucial-changes-needed-to-protect-workers-health-while-teleworking (ac-cessed on 10 February 2022)
32.***Think Tank European Parliament - The environmental impacts of plastics and micro-plastics use, waste and pollution: EU and national measures, 2020. Available online: https://www.europarl.europa.eu/thinktank/en/document/IPOL_STU(2020)658279 (accessed on 05 September 2021)
33.***European Environment Agency - Circular Economy in Europe developing the knowledge base, 2016 Available online: https://www.eea.europa.eu/publications/circular-economy-in-europe (accessed on 15 September 2020)
34.TÂRȚIU, V.E., ȘTEFĂNESCU, M., PETRACHE A.M., GURĂU C.R., Tranziția către o economie circulară. De la managementul deșeurilor la economie verde în România, 2018. Available online: http://ier.gov.ro/wp-content/uploads/2019/03/Final_Studiul-3_Spos-2018_Economiecircular%C4%83-1.pdf (accessed on 02 April 2020)
35.MARAVEAS, C., The sustainability of plastic nets in agriculture, *Sustainability*, 12(9): 3625, 2020. https://doi.org/10.3390/su12093625
36.***Plastic Oceans. Available online: https://plasticoceans.org/7-types-of-plastic (accessed on 5 December 2021)
37.TUDOR, V.C., MARIN, A., VASCA, D.Z., MICU, M.M., SMEDESCU, D.I., The influence of the plastic bags on the Environment. *Mater. Plast.*, **55**(4), 2018, 595-599, DOI:10.37358/MP.18.4.5081
38.***Grand View Research - Plastic Market Size, Share & Trends Analysis Report by Product (PE, PP, PU, PVC, PET, Polystyrene, ABS, PBT, PPO, Epoxy Polymers, LCP, PC, Polyamide), By Application, By End-use, By Region, And Segment Forecasts, 2021-2028. Available online: https://www.grandviewresearch.com/industry-analysis/global-plastics-market (accessed on 10 December 2021)

39.***Fortune Business Insights - Plastic Market Size, Share & COVID-19 Impact Analysis, By Type (Polyethylene, Polypropylene, Polyethylene Terephthalate, Polyvinyl Chloride, Acrylonitrile Butadiene Styrene, Polyamide, Polycarbonate, Polyurethane, Polystyrene, and Others), By End-Use (Packaging, Automotive & Transportation, Infrastructure & Construction, Consumer Goods/Lifestyle, Healthcare & Pharmaceutical, Electrical & Electronics, Textile), and Regional Forecast, 2021-2028. Available online: https://www.fortunebusinessinsights.com/plastics-market-102176 (accessed on 08 February 2022)
40.***Plastics Europe, enabling a sustainable future - Plastics - the Facts 2020. Available online: https://plasticseurope.org/knowledge-hub/plastics-the-facts-2020/ (accessed on 08 January 2022)
41.***Plastics Europe, enabling a sustainable future - Plastics - the Facts 2021. Available online: https://plasticseurope.org/wp-content/uploads/2021/12/Plastics-the-Facts-2021-web-final.pdf (accessed on 08 January 2022)
42.***Plastics Europe Market Research Group (PEMRG) / Conversio Market & Strategy GmbH. Estimated data, 2021
43.***STATISTA - Global plastics industry - statistics & facts. Available online: https://www.statista.com/topics/5266 /plastics-industry/#dossierKeyfigures (accessed on 07 December 2021)
44.***European Commission - Plastics strategy. Available online: https://ec.europa.eu/environment/strategy/plastics-strategy_en (accessed on 05 December 2021)
45.***European Commission - Circular economy action plan. Available online: https://ec.europa.eu/environment/strategy/circular-economy-action-plan_en (accessed on 05 December 2021)
46.***Fortune Business Insights - Bioplastics Market Size, Share & COVID-19 Impact Analysis, By Type (Biodegradable and Non-Biodegradables), Application (Rigid Packaging, Flexible Packaging, Textiles, Automotive & Transportation, Agri-culture & Horticulture, Consumer Goods, and Others), and Regional Forecast, 2021-2028. Available online: https://www.fortunebusinessinsights.com/industry-reports/bioplastics-market-101940 (accessed on 08 February 2022)
47.***Fortune Business Insights - Polylactic Acid Market Size, Share & COVID-19 Impact Analysis, By Application (Packaging, Textiles, Consumer Goods, Agriculture & Horticulture, and Others), and Regional Forecast, 2021-2028. Available online: https://www.fortunebusinessinsights.com/polylactic-acid-pla-market-103429 (accessed on 09 February 2022)
48.***Fortune Business Insights - North America and Europe Bioplastics Market Size, Share & COVID-19 Impact Analysis, By Type (Biodegradable and Non-Biodegradable {Bio-Polyethylene, Bio-Polypropylene, and Other Non-Biodegradables}), Application (Rigid Packaging {Bottles & Jars, Trays, and Others}, Flexible Packaging {Pouches, Shopping / Waste Bags, and Others}, and Others), and Regional Forecast, 2021-2028. Available online: https://www.fortunebusinessinsights.com/north-america-and-europe-bioplastics-market-105290 (accessed on 09 February 2022)
49.***Fortune Business Insights - Bio-Based Polypropylene Market Size, Share & COVID-19 Impact Analysis, By Application (Building & Construction, Automotive, Consumer Goods, Packaging, and Others) and Regional Forecast, 2021-2028. Available online: https://www.fortunebusinessinsights.com/bio-based-polypropylene-market-102758 (accessed on 08 February 2022)
50.***Fortune Business Insights - Recycled Plastic Market Size, Share & COVID-19 Impact Analysis, by Type (Polyethylene Terephthalate, High-density Polyethylene, Polypropylene, Low-density Polyethylene, and Others), by Application (Non-Food Packaging, Food Packaging, Construction, Automotive, and Others), and Regional Forecast, 2021-2028. Available online: https://www.fortunebusinessinsights.com/recycled-plastic-market-102568 (accessed on 08 February 2022)
51.***IMARC - Europe Recycled Plastics Market: Industry Trends, Share, Size, Growth, Opportunity and Forecast 2022-2027. Available online: https://www.imarcgroup.com/europe-recycled-plastics-market (accessed on 02 February 2022)

52.***Eurostat - Packaging waste statistics. Available online: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Packaging_waste_statistics (accessed on 12 December 2021)
53.***Eurostat - EU recycled 41% of plastic packaging waste in 2019. Available online: https://ec.europa.eu/eurostat/web/products-eurostat-news/-/ddn-20211027-2?mc_cid=22a3c2ae13 (accessed on 12 December 2021)
54.***Eurostat - Packaging waste by waste management operations. Available online: https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=env_waspac&lang=en (accessed on 12 December 2021)
55.***Sources of plastic waste collected by recycling companies* in the European Union in 2020. Available online: https://www.statista.com/statistics/1232586/sources-of-plastic-waste-for-recycling-companies-eu/ (accessed on 14 January 2022)
56.***Plastics. Available online: https://ec.europa.eu/environment/topics/plastics_en (accessed on 15 January 2022)
57.***European Court of Auditors - EU action to tackle the issue of plastic waste. Review EN NO04. 2020, Available online:
https://www.eca.europa.eu/Lists/ECADocuments/RW20_04/RW_Plastic_waste_EN.pdf (accessed on 15 January 2022)

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