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Bioplastics and waste management

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ABSTRACT

Pollution of the marine environment due to plastic materials is one of the most severe environmental problems humanity has to face in the 21st century. The strategy devised until now to address this issue is mainly based on two pillars: (1) increasing the interception of discarded plastic wastes by waste management systems; and (2) substituting the traditional "petro-based" polymers with biodegradable ones. Many issues on the overall sustainability of the second option by the waste management system must still be clarified.

Pollution of the marine environment due to plastic materials is one of the most severe environmental problems humanity has to face in the 21st century. It is now clear that, in addition to other deleterious effects like causing the death of endangered species, such as sea mammals and turtles, microplastics originating from plastic debris can easily enter the human food chain. It is also well known that the vast majority of plastics found in the oceans (70–80%) actually originates on land.

Plastic waste prevention should stand as a top priority. In fact, in many countries worldwide policies have been implemented to reduce plastic use and, as a consequence, plastic waste. Most of these policies have been directed at reducing the use of plastic carrier bags charging retailers or customers who choose to use them. The first experience in this field was conducted in Denmark (1994) but now many countries over the five major continents are adopting this approach. More recently, several countries (e.g. UK and France) are implementing policies to ban the use of other disposable plastic items, such as straws, plastic cutlery, and stirrers.

However, since the above-mentioned policies have proven to be insufficient to solve the problem linked to plastic pollution, additional measures have been devised to address this issue, centred on two main pillars:

- Increase the interception of plastic waste by waste management systems in order to avoid its uncontrolled dispersion on land (littering) and consequent transport to the oceans.
- Substitute the traditional "petro-based" polymers with biodegradable ones, based on renewable feedstocks (Luckachan and Pillai, 2011), which are less persistent in the environment (Emadian et al., 2017).

While the first option has been extensively studied and the various opportunities linked to the reuse of plastic waste, recycling, energy recovery and final waste disposal in landfills (acting as carbon sinks) have been explored, the second option is more recent and its impact on the global plastic market is still limited. In 2017 the amount of biodegradable plastics produced at the global level was about 880 Gg (European bioplastics, 2018), corresponding to less than 0.3% of the total amount of plastics produced in the same year (320,000 Gg).

The EU Directive 2015/720, which entered into force on May 26th, 2015, focused on a very specific and, as already mentioned, important issue concerning the reduction of plastic pollution: the use of lightweight plastic carrier bags. The Directive aims at limiting the annual number of lightweight plastic carrier bags consumed in the EU to a maximum of 90 units per person by the end of 2019 (50% reduction compared to 2010) and to 40 units per person by the end of 2025 (80% reduction compared to 2010). Moreover, the Directive addresses the issue of biodegradable and compostable plastic carrier bags, with special emphasis on their true biodegradability and on the need of proper labelling in order to deliver the correct information to customers.

The EN 13432 norm states that a material, specifically when it is used in lightweight plastic carrier bags, must meet certain

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requirements in order to be declared compostable, the most relevant of which are the following:

- the material must be degraded by at least 90% in weight in 6 months in an environment rich in carbon dioxide;
- at least 90% of the mass of the selected material must be reduced to fragments of less than 2 mm if in contact with organic materials for a period of 3 months;
- the presence of the material must not cause negative effects on the composting process, and
- the amount of heavy metals present in the composted material must not exceed specified standards.

Some EU countries, namely France and Italy, have been very active on this issue, by imposing bans on the use of non-biodegradable, disposable plastic carrier bags. In France, the law on energy transition and green growth brought an end to the use of plastic carrier bags starting in January 2016, while in Italy such a ban entered into force in 2011. Starting in January 2018, the Italian Government completely banned the use of lightweight, non-biodegradable plastic carrier bags in supermarkets and grocery stores for the purchase of several goods (especially loose fruit and vegetables), requiring the stores to replace them with bags that are compostable. Moreover, starting from 2011, food waste placed for collection before biological treatment must be contained in bags that are compostable. Types of compostable bags include those manufactured from bio-plastic (i.e. from biodegradable plastic resins) or from paper fibre, the latter still being a very minor fraction. As a rough estimate, no less than 100 plastic compostable bags per person per year (average weight about 10 g each) will actually enter the Italian food waste management system. Nevertheless, a recent survey conducted by the Italian Composting Network (CIC) has shown that nearly half of the bags delivered to composting and anaerobic digestion plants for the treatment of food waste are still manufactured from conventional, petroleum-based plastics. The fact that the physical appearance of petro-based and biodegradable plastic bags is very similar to the public eye does not help in clearly distinguishing them; this paves the way to possible fraudulent behaviours by the economic operators, who might be tempted to adjust their blend when manufacturing plastic carrier bags, without guaranteeing their true biodegradability.

An additional point is that such a widespread distribution of bio-degradable plastic bags makes them become part of several different waste management streams, not only food waste but also source-separated plastics, mixed residual waste as well as programs collecting mixed recyclables.

As of this writing, the scientific literature does not provide comprehensive answers to a number of significant issues related to the choice of bioplastics as the most suitable solution to replace conventional materials in the packaging sector, especially when it comes to their role in waste management and to their end-of-life. Such open issues are briefly listed below.

First, whether biodegradable plastic material already present on the market as packaging material, including bags, should be delivered to the waste management system together with organic waste, is yet to be scientifically assessed under a variety of typical operating conditions. This type of assessment becomes all the more critical when rigid biodegradable plastic items (such as dishware) and other items (such as wine bottles corks) are considered, which are becoming more and more popular because of their "green" image.

Second, the food waste treatment facilities (composting and anaerobic digestion plants) already in operation have to be evaluated for their efficiency in effectively managing bioplastics, which have been declared as compostable and are present in the organic waste. Or, at the least, the necessary technological improvements to process mixtures containing bioplastics and other organic materials should be identified and evaluated.

Third, the quality of compost/digestate affected by the presence of bioplastic items must be evaluated on the basis of the existing legislation as well as in relation to the farmers' expectations.

Fourth and last, the fate of bioplastics eventually delivered to other types of processing plants also needs to be addressed. This is the case of their delivery to plastic sorting and recycling facilities together with traditional plastics, as well as their delivery to incineration plants, to plants for mechanical-biological treatment or landfills.

Given all the open issues just described, a joint effort by the waste management and packaging industries should be promoted to effectively address the issue of production, use and management of bioplastics from the perspective of a life cycle analysis. At the same time, awareness should be raised among citizens with respect to the correct recognition of bioplastic items and to their discard to the appropriate solid waste management alternative.

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