

1 **Bioplastics and waste management**

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

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

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

- 25 • increase the interception of plastic waste by waste management systems in
26 order to avoid its uncontrolled dispersion on land (littering) and consequent
27 transport to the oceans;
- 28 • substitute the traditional “petro-based” polymers with biodegradable ones,
29 based on renewable feedstocks (Luckachan and Pillai, 2011), which are less
30 persistent in the environment (Emadian et al., 2017).

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

38 The EU Directive 2015/720, which entered into force on May 26th, 2015, focused on a
39 very specific and, as already mentioned, important issue concerning the reduction of
40 plastic pollution: the use of lightweight plastic carrier bags. The Directive aims at limiting
41 the annual number of lightweight plastic carrier bags consumed in the EU to a maximum
42 of 90 units per person by the end of 2019 (50% reduction compared to 2010) and to 40
43 units per person by the end of 2025 (80% reduction compared to 2010). Moreover, the
44 Directive addresses the issue of biodegradable and compostable plastic carrier bags,

45 with special emphasis on their true biodegradability and on the need of proper labelling
46 in order to deliver the correct information to customers.

47 The EN 13432 norm states that a material, specifically when it is used in lightweight
48 plastic carrier bags, must meet certain requirements in order to be declared
49 compostable, the most relevant of which are the following:

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

58 Some EU countries, namely France and Italy, have been very active on this issue, by
59 imposing bans on the use of non-biodegradable, disposable plastic carrier bags. In
60 France, the law on energy transition and green growth brought an end to the use of
61 plastic carrier bags starting in January 2016, while in Italy such a ban entered into force
62 in 2011. Starting in January 2018, the Italian Government completely banned the use of
63 lightweight, non-biodegradable plastic carrier bags in supermarkets and grocery stores
64 for the purchase of several goods (especially loose fruit and vegetables), requiring the
65 stores to replace them with bags that are compostable. Moreover, starting from 2011,
66 food waste placed for collection before biological treatment must be contained in bags
67 that are compostable. Types of compostable bags include those manufactured from bio-

68 plastic (i.e. from biodegradable plastic resins) or from paper fibre, the latter still being a
69 very minor fraction. As a rough estimate, no less than 100 plastic compostable bags per
70 person per year (average weight about 10 g each) will actually enter the Italian food
71 waste management system. Nevertheless, a recent survey conducted by the Italian
72 Composting Network (CIC) has shown that nearly half of the bags delivered to
73 composting and anaerobic digestion plants for the treatment of food waste are still
74 manufactured from conventional, petroleum-based plastics. The fact that the physical
75 appearance of petro-based and biodegradable plastic bags is very similar to the public
76 eye does not help in clearly distinguishing them; this paves the way to possible
77 fraudulent behaviours by the economic operators, who might be tempted to adjust their
78 blend when manufacturing plastic carrier bags, without guaranteeing their true
79 biodegradability.

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

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

89 First, whether biodegradable plastic material already present on the market as
90 packaging material, including bags, should be delivered to the waste management

91 system together with organic waste, is yet to be scientifically assessed under a variety
92 of typical operating conditions. This type of assessment becomes all the more critical
93 when rigid biodegradable plastic items (such as dishware) and other items (such as wine
94 bottles corks) are considered, which are becoming more and more popular because of
95 their “green” image.

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

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

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

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

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