01.02.2016: Statement of Open-Bio partners to the UNEP (2015) report on "Biodegradable Plastics and Marine Litter. Misconceptions, concerns and impacts on marine environments."

Executive summary

While the Open-Bio consortium generally appreciates the UNEP report for its contributions to explaining and clarifying many aspects concerning the relation between different plastic materials and marine plastic litter, several aspects are criticized as well.

- Both the summary and the conclusion simplify matters too much, thus inviting confusion by the public and policy makers.
- Some of the final conclusions concerning the possible role of biodegradable plastics are not solution-oriented and remain rather pessimistic, whereas the main text offers several well-elaborated segments of the general topic, where solutions via market regulation, legislation, directed scientific research and industrial development could be achieved in relatively short time or may be readily adopted through political action.
- The statements on rate of biodegradation and impact made by the report are not differentiated enough. More research is clearly needed.
- In terms of communication and labelling, even more concise wording is needed and a strict distinction should be made between B2B communication and B2C communication in order to avoid litter.

The Open-Bio statement furthermore offers some corrections to technical mistakes of the UNEP report and preliminary results from the project's research.

The Open-Bio group concludes that biodegradable plastics are not a solution to littering. Littering must be opposed by means of prevention, waste management (that includes separate collection and organic recycling of biodegradable plastics), public awareness, etc. On the other hand, plastics that are shown to be truly biodegradable in the marine environment could be profitably used in those applications where dispersion in the sea is certain or highly probable (e.g. fishing gear, fish farming gear, beach gear, paint, etc.).

General considerations

Generally, the report is appreciated because in its main text it clarifies and explains many aspects concerning the relation between different plastic materials and marine plastic litter, which is well accepted as a global problem. The report also shows the complexity of the topic, addresses weak points, highlights the lack of sound scientific evidence for some aspects and possible sources of conflict between different interest groups/stakeholders. Unfortunately, both in the summary and in the conclusions of the report, some statements lose explanatory power due to shortening, and some reflect the interpretations of the author that could be challenged. Some of the statements might thus lead to misinterpretation by the public, industry, policy makers and journalists. And there is the risk that the conclusions could be used out of context and summarised by mass media in a one-liner such as "biodegradable plastics are of no use at all". This, however, is not the case as there are many applications where biodegradability in a specific environment is a desired functionality. Furthermore, we will continuously need to emphasise that biodegradable plastic shall not be confused with bio-based plastic. This statement of Open-Bio addresses *biodegradable* marine litter. Because for biodegradability, it makes no difference whether a product is fossil- or biomass-based. In terms of sustainability and long-term strategy, it is certainly important to include bio-based products, however that is not the focus within this text.

In the UNEP report it is stated that in general, biodegradable polymers will not play a significant role in reducing marine litter. It further states that for well-justified purposes, e.g. key components of fishing traps, biodegradable alternatives tend to be significantly more expensive and may require financial inducement. It concludes “on the balance of current scientific evidence, the adoption of plastic products labelled as ‘biodegradable’ will not bring about a significant decrease either in the quantity of plastic entering the ocean or the risk of physical and chemical impacts on the marine environment.”

It is certain that **littering needs to be avoided and reduced possibly to zero by all means** (prevention, cutting waste streams, raising public awareness, etc.). But even if that ideal situation of no litter entering the marine environment would become reality, for certain applications it is inevitable that whole items, parts and/or microplastics will enter the oceans, via rivers or e.g. by loss of fishing gear[1] or wear of tourist beach equipment. Wouldn’t it be better if this litter was biodegradable? This is stated with always seeing that biodegradable litter is still litter, and should also be avoided at all means! However, it will at least not remain there forever, compared to non-biodegradable plastic litter.

One main point of critique to the UNEP report is that some of the final conclusions concerning the possible role of biodegradable plastics are not solution-oriented and remain rather pessimistic, whereas the main text offers several well-elaborated segments of the general topic, where solutions via market regulation, legislation, directed scientific research and industrial development could be achieved in relatively short time or may be readily adopted through political action. Examples are polymers used in fisheries, and other applications in or close to the marine environment where plastic loss into the environment is intrinsic to its use or known to be very likely (lobster traps, floats, nets, ropes, polystyrene fish boxes, etc.). The report mentions that biodegradable polymers for marine applications are **much more expensive to produce and financial incentives may be required** to encourage uptake. That is indeed an issue, however it is not only related to marine applications as such.

Rate of biodegradation and its risk assessment

Another point of critique concerns the frequently mentioned **rate of (bio)degradation** in the report. It is not differentiated between the inherent biodegradation rate of an industrial biodegradable material and the degradation rate of the item that finally ends up in the environment. A biodegradable plastic net for shellfish farming will be few micro-meters thick and will have different rate of degradation than a solid block of plastic several centimetres thick. This is also true for natural polymers such as wood for example. A toothpick will degrade within a relatively short time compared to the trunk of a jungle tree giant weighing several tons that is washed into the ocean.
The UNEP report states that biodegradable plastics do **degrade under marine conditions but much slower than claimed by the manufacturers for industrial composting, and also when tested in gastrointestinal fluids of a turtles, and will therefore still harm** the marine environment. Most biodegradable plastics are not water-soluble. This means that the biodegradable plastic products will not immediately “disappear” when they reach the sea but persist in this environment for a given time (a residence time). A biodegradable plastic fishing gear placed in the environment is a physical object basically equivalent to its non-biodegradable counterpart, if biodegradation has not occurred. It is therefore not a surprise that short term experiments fail to determine differences between biodegradable and non-biodegradable plastic

items. They both represent an "hazard" by a "risk assessment" viewpoint. "Risk" is the chance of harmful effects to ecological systems resulting from exposure to an environmental stressor. A plastic product reaching the sea is an “environmental stressor” because, for instance, sea turtles and other marine creatures can mistake it as food and ingest it. This mistake causes blockages within their digestive system and eventual death.
By means of a risk assessment it is possible to characterize the magnitude of risks to ecological receptors (e.g. mammals, birds, fish, corals, microorganisms or even whole ecosystems) from the stressors, that may be present in the environment. Risk depends on how much of a stressor is present in the environment and how much contact (exposure) an ecological receptor has with the stressor. Biodegradation of the plastic net for shellfish farming, i.e. the conversion into CO_2 and biomass, stops exposure. By this viewpoint, biodegradability is a factor that reduces the risk, by reducing the residence time of the stressor in the environment. Needless to say, the risk is eliminated if exposure is brought to zero by reducing to zero littering (no littering, no stressor introduced into the environment, no risk) and by increasing to infinite the biodegradation rate (the product “disappear” when reaching the sea, reducing to zero exposure).
Plastic items littered to the sea do have impact on several levels, some of which are well documented and some still lack scientific knowledge (GESAMP 2015, Bergmann et al. 2015). However, biodegradable plastic items have the advantage that the duration of impact will be shorter. But biodegradable plastic litter still remains litter and has to be avoided.

Impacts

In **terms of impact to the marine environment,** little research has been completed comparing non-biodegradable and biodegradable plastics. There are scientific studies on the impacts of non-biodegradable litter and parts of the knowledge can be transferred to biodegradable litter, but not all of it. More research on the impact of biodegradable polymers is clearly needed. Before full biodegradation has occurred – meaning that the transformation to carbon dioxide/methane, water and biomass has been completed – the litter can, and will most probably harm or at least alter the environment. There are two publications, which investigated the impact of both litter types (Green et al. 2015a and 2015b). They show that also biodegradable litter has an impact on both organism and ecosystem level in an intertidal zone of Ireland. The studies do not report if and how fast the organisms and ecosystem recover after the litter is biodegraded, which is important to know to evaluate the overall impact of biodegradable litter, again also in comparison to persisting conventional plastic litter. However, these studies indicate an aspect where biodegradable plastic could have a more pronounced impact than conventional plastic. Biodegradable plastic adds a source of organic matter available to microorganisms, whereas conventional plastic is inert in this respect. Here as well more field and lab studies are clearly needed. Therefore we think that the statement of the UNEP report is important, however a bit premature.

The global perspective

In the discussion we miss **the global view and also more options for developing countries**. Many have currently no (or insufficient) waste management infrastructures in place. But the plastic consumption in many of these countries (esp. China, Indonesia, India, etc.) are expected to rise tremendously in the coming years. Waste management most likely will not develop at the same speed. But taking all available treatment technologies into account, biological treatment of organic wastes is certainly the cheapest (besides dumping which we want to avoid), and it could be established quite fast and on different scales. It also makes sense in small decentralised units. For this reason, compostable packaging materials, esp. for food, catering items (cups, etc.) could make perfect sense as a tool to reduce mismanaged waste. Of course this line of argumentation only works if at least a composting infrastructure is developed at the same time as compostable packaging is introduced into the market. However, in the case of mismanagement and the waste ends up in the ocean, it would not remain there forever when it is biodegradable under marine conditions.

Recycling

The report addresses **recyclability** and explains the problem of separation of different materials. Regarding marine litter this issue is misleading because litter in the sea is not foreseen to enter the recycling cycle. Generally, this topic is important, however, it needs to be tackled in waste stream discussions where biodegradable plastics do enter the recycling stream. For example, when biodegradable plastics are implemented in the (bio-based circular) economy where biodegradability is a valuable property. In this respect, the UNEP report incorrectly suggests that biodegradable plastics pose a threat to existing recycling programs. **Biodegradable plastics do not hinder plastic recycling** by being 'biodegradable' or 'compostable' (investigated by Open-Bio consortium, Task 6.4), but because recycling requires pure waste streams. Any contamination of a waste stream of a particular plastic (e.g. PE) with another type of polymer (whether it is biodegradable or not) requires good separation practices. PLA or PHB do not differ in this sense from PVC, PET, PEF or paper/PE laminates and can be just as easily separated. Only so called 'oxo-degradable' plastics pose a threat to plastic recycling by compromising the quality of the final product.

Labelling

The labelling of 'oxo-degradable' plastics as 'biodegradable' or 'compostable' is not correct (see EN 13432:2000) because these materials simply fragment and do not biodegrade, no matter where their life cycle will end.

Avoiding litter also includes that at consumer level, products should not be **labelled 'biodegradable'**. The UNEP report names studies that show that labelling a product as 'biodegradable' offers a "technical solution" and removes responsibility from the individual (Klöckner 2013, Keep Los Angeles Beautiful, 2009). Obviously, it requires great caution when plastics claim biodegradability in marine conditions in order to avoid any excuse for littering. Belgium and the US State of California already prohibit the labelling of consumer products to avoid unintended justification for littering. The main conclusion of the UNEP article should be that it is best to avoid labelling a product as 'biodegradable'.
Open-Bio confirms that a label or certification should be not misleading and should not lead to wrong behaviours. The information should preferably only be used at the industrial level to describe material properties to business partners, but not on a consumer level unless necessary. Therefore, such a label should be limited to only some very specific applications for which communication can mostly be held on a B2B level, and the communication on a B2C level is to be avoided unless needed to specific applications. Examples where such a strategy could make sense are mulch films for agricultural applications, clips and ties applied in greenhouses (horticulture) and fishing gear in the marine business sector. Since the term 'biodegradable' often leads to confusion, it should be clearly defined in which environment the material is biodegradable. For example: "Compostable in municipal and industrial composting facilities" / "Compostable under home composting conditions" / "Biodegradable in soil" / "Biodegradable in waste water treatment plant" / "Biodegradable in marine environment". In this way, confusion is prevented which is an important aspect in all communication pathways.

Based on the current state of knowledge we recommend also not to label a product for the general public unless necessary for the specific application, but to enforce by political means that those products which will certainly or probably end up in the marine environment need to be biodegradable in the specific marine environment of application. The Open-Bio team is currently working on an update of the standard methodology taking into account the current standards for marine biodegradation (see Open-Bio D5.5).

First results from Open-Bio and further research

First results from Open-Bio do confirm the statement of the report that degradation is slower under marine conditions than under composting conditions and that it depends on the material type and specific environmental conditions. The work within Open-Bio shows that the tested polymers do biodegrade under optimal laboratory conditions. Linking the lab data with the data we obtain from field and mesocosm experiments will allow us to validate the lab test. Further ecotoxicological tests should be added to the tests, which will provide more insight on the impact of biodegradation. The goal is to develop a test scheme and specifications (time of biodegradation, temperature range, etc.) for the biodegradation under marine conditions to be finalised by a standardisation organisation. That will provide policy makers and the industry with a **good instrument to implement biodegradable polymers where they can be part of a concept to mitigate unavoidable marine litter**.

Polymers that are proven to be biodegradable in the marine environment can thus be part of the solution in case plastic is not to be replaced by other materials, in concert with all possible measures like prevention, waste management, public awareness, etc. Summarising the mentioned points, we think that the public, mass-media, industry and policy makers have a great potential and possibilities to support the protection of the environment here.

Some technical mistakes which are present in the report

- In the report it is mentioned that ISO, ASTM or EN standards define criteria for compostable or biodegradable plastics.

This is not completely correct. In standards like ISO 17088, ISO 18606, EN 13432, ASTM D6400, etc. it is mentioned that plastics or packaging are biodegradable under industrial composting conditions (not in all environments). Labelling as ‘biodegradable’ is not mentioned in these standards for industrial compostable materials.
Example 1: Definition of ISO 17088: This specification is intended to establish the requirements for the labelling of plastic products and materials, including packaging made from plastics, as “compostable” or “compostable in municipal and industrial composting facilities” or “biodegradable during composting” (for the purposes of this International Standard, these three expressions are considered to be equivalent).
Example 2: Definition of ASTM D6400: The purpose of this specification is to establish requirements for identifying items made from plastics or polymers so that they do not interfere with their satisfactorily composting in commercial and municipal aerobic composting facilities. Products meeting the requirements outlined below be labelled as “compostable in municipal or industrial aerobic facilities” in accordance with the guidelines issued by the Federal Trade Commission as long as proper qualifications as to the availability of such facilities are included on the label.

- Definition of compostable in the report = capable of being biodegraded at elevated temperature *in soil* under …

This is not correct. It should read: capable of being biodegraded at elevated temperature *in composting conditions*.

▪ Overview of materials that are biodegradable.
This overview seems to be incomplete. For example, it is mentioned that PLA is biodegradable in terrestrial environment. This is normally not the case. Also PHB is present in the list. It is known that this material is a good example for materials biodegradable in the marine environment, but this is not mentioned.

▪ In the article it is mentioned that EN 13432 requires no more than 30% of the residue to be retained by a 2 mm mesh sieve after 3 months composting.
This is not correct. EN 13432 requires that not more than 10% of the original dry weight of test material shall fail to pass through a > 2 mm fraction sieve. (EN 13432:2000, A.3 at page 11).

Comments to the section 4.2 "degradation processes" (based on the Open-Bio D5.5 review)

GENERAL COMMENT: Indirect measurements are indeed difficult to interpret and do not prove biodegradation, but can give an indication at best. Furthermore, if biodegradation is measured directly in a lab test (O_2 consumption/CO_2 production), the interpretation of how biodegradation will occur in the field is still difficult. That is due to the fact that in the lab, the microbes usually are offered only one carbon source, namely the polymer to be tested for biodegradability. In the field, however, there are multiple carbon sources available and usually the more easily bioavailable carbon will be digested by the microbes. To better understand the biodegradation in the environment, more combined research at field, mesocosm and lab level is recommended. Open-Bio makes use of this 3-level approach to tackle exactly this difficulty.

UNEP report: Bacteria capable of degrading PCL have been isolated from deep seawater off the coast of Japan (Sekiguchi et al. 2011).
COMMENT: This study nicely combined field and lab tests. For the lab tests unfortunately direct measurements of biodegradation are missing and so the data can be taken as an INDICATION of biodegradation only!

UNEP report: The time-dependence and extent of biodegradation was expected to be influenced by competition from other colonizing bacteria as well as temperature and oxygen levels. The addition of PLA to PUR was shown to increase the rate of degradation in seawater (Moravek et al. 2009). However, the reaction was very temperature dependent and the results have limited applicability to natural conditions.
COMMENT: This study nicely shows the dependence of the rate of degradation on some environmental conditions. In addition, this is a good example of a blend where only one compound (PLA) might be biodegraded and the rest of the item will subsequently just fragment without biodegrading. And again because direct measures of biodegradation are missing, the transfer to the potential of biodegradation of the tested polymers is not possible.

UNEP report: Biodegradation of plastics that are considered recalcitrant, such as PE, can take place in the marine environment at an extremely slow rate. There is limited evidence suggesting that microbial degradation of the surface of PE particles happens in the marine environment (Zettler et al. 2013).
COMMENT: We are not aware of direct measurements yet proving the biodegradation of PE in marine conditions. Numbers available in the literature, for example that a plastic bag will be gone

within 400 years, are based on assumptions and projections. This is in line with the statement in the UNEP report page 7 "As with all such assessment studies, it is very important to consider the scope, assumptions, limitations, motivations, data quality and uncertainties before drawing conclusions about the study's validity and wider applicability." However, is biodegradation of PE one day really proven, the rate will be extremely slow, means beyond the scope of several generations of human beings.

Literature

Bergmann M, Gutow L, Klages M. 2015. Marine Anthropogenic Litter. SpectrumOpen. DOI 10.1007/978-3-319-16510-3.

Bilkovic DM, Havens KJ, Stanhope DM, Angstadt KT. 2012. Use of Fully Biodegradable Panels to Reduce Derelict Pot Threats to Marine Fauna. Conservation Biology 26, 957–966.

GESAMP. 2015. "Sources, fate and effects of microplastics in the marine environment: a global assessment" (Kershaw, P. J., ed.). (IMO/FAO/UNESCOIOC/UNIDO/WMO/IAEA/UN/UNEP/UNDP Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection). Rep. Stud. GESAMP No. 90, 96 p.

Good TP, June JA, Etnier MA, Broadhurst G. 2010. Derelict fishing nets in Puget Sound and the Northwest Straits: Patterns and threats to marine fauna. Marine Pollution Bulletin 60, 39–50.

Green DS, Boots B, Blockley DJ, Rocha C, Thompson R. 2015b. Impacts of discarded plastic bags on marine assemblages and ecosystem functioning. Environmental Science & Technology, 49, 5380−5389.

Green DS, Boots B, Sigwart J, Jiang S, Rocha C. 2015a. Effects of conventional and biodegradable microplastics on a marine ecosystem engineer *Arenicola marina* and sediment nutrient cycling. Environmental Pollution, 208, 426-434.

Keep Los Angeles Beautiful. 2009. "Littering and the iGeneration: City-wide intercept study of youth litter behaviour in Los Angeles." Session paper at XIII Environmental Psychology Conference Granada, June 23-26, 2015 http://www.congresopsicamb2015.com (Accessed 10 Aug 2015)

Kim S, Park S, Lee K. 2014a. Fishing Performance of an Octopus minor Net Pot Made of Biodegradable Twines. Turkish Journal of Fisheries and Aquatic Sciences 14(1), 21-30.

Kim SG, Lee WIL, Yuseok M. 2014b. The estimation of derelict fishing gear in the coastal waters of South Korea: Trap and gill-net fisheries. Marine Policy 46(0), 119-122.

Klöckner CA. 2013. A comprehensive model of the psychology of environmental behaviour—A meta-analysis. Global Environmental Change, 23(5), 1028-1038.

NOAA Marine Debris Program. 2015 Report on the impacts of "ghost fishing" via derelict fishing gear. Silver Spring, MD. 25 pp

Uhrin A, Matthews T, Lewis C. 2014. Lobster Trap Debris in the Florida Keys National Marine Sanctuary: Distribution, Abundance, Density, and Patterns of Accumulation. Marine and Coastal Fisheries, 6(1), 20–32.

UNEP 2015. Biodegradable Plastics & Marine Litter. Misconceptions, Concerns and Impacts on Marine Environments. Nairobi.

---

[1] **Examples of items where, intrinsic to their use, eventual loss cannot be excluded:**
For example lost fishing gear, beach gear, paint, etc.:

- UNEP p 27: an estimated 175,000 lobster traps are lost in the Gulf of Maine per year
- Kim et al. 2014b: an estimated 11,436 t of traps and 38,535 t of gill-nets are abandoned annually in South Korea
- Uhrin et al. 2014: estimated, over 85,000 lobster and crab ghost traps in the Florida Keys National Marine Sanctuary
- Good et al. 2010: The plastic monofilament does not degrade and, once discarded or lost, these nets can potentially continue to ghost fish for extended periods of time; some have been recovered actively ghost fishing after 20 years
- NOAA p12: Prevention: Reducing ghost fishing efficiency of gear (improve biodegradable aspects for release or disabling of lost gear over time).