Open Letter to the JRC

How can the environmental effects of bio-based polymers be compared with those of petrochemical polymers on equal footing?

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In principle, there are published standards for life cycle assessments (LCA) that provide guidance on how to compare different polymers fairly with regard to their environmental impacts. However, the rules still leave sufficient room for manoeuvre to specify the methods by which such comparisons are to be carried out in LCA[1]. The fact that there is still a need for more far-reaching, coordinated rules is shown by the ongoing activities on the "Product Environmental Footprint" and in particular by the activities of the Joint Research Center (JRC) on bio-based polymers. The overall objective of these activities is to elaborate on a consistent and appropriate LCA-based method for the purpose of a "Comparative Life-Cycle Assessment of alternative feedstock for plastics production", including a number of case studies (JRC 2018). The final report is expected by end of the year or early 2020. Michael Carus, main author of this text, was invited to the stakeholder workshop "Comparative Life-Cycle Assessment of alternative feedstock for plastics production" (29 & 30 November 2018 in Brussels). During the workshop there were many discussions, most of which concerned methodological-technical aspects. These were taken up by the JRC experts and will be considered for the further development. Experts from European Bioplastics have also made further submissions in this regard. In this document, we want to focus on the rather fundamental problems that make a fair comparison hardly possible, and which can often be solved only with difficulty and incompletely, both methodically and technically. Nevertheless, after having discussed these fundamental problems, we make a proposal on how the problems could be dealt with in the most targeted way possible. We hope that our suggestions can still find their way into the final JRC paper.

Economy of scale

Let us start with the simple things. New bio-based polymers are usually produced in much smaller plants than petrochemical polymers. Their process chains and system integrations are far from being at the elaborated

1 "Although there are published standards for LCAs (ISO 14040/44, and the International Reference Life Cycle Data System (ILCD) handbook), these do not give fixed rules for calculating GHG reductions: much is left to users to select what they consider the most appropriate method in particular cases. The results often depend strongly on these choices. This is why the LCA guidelines do not offer a consistent or unambiguous way of determining carbon intensities by economic operators or by national authorities." https://ec.europa.eu/clima/sites/clima/files/transport/fuel/docs/novel_transport_fuels_default_values_en.pdf

level of petrochemistry. The high integration of energy and raw material flows in petrochemical plants ("verbund sites") is missing in the first commercial plants for bio-based polymers. This has a significant impact on the results of a life cycle assessment because bio-based polymers and petrochemical polymers are compared on a different basis. How to handle this?

Impact of crude oil versus biomass – sustainable feedstock for biomass, but nothing for crude oil?

For any biomass, excessively detailed research is carried out to identify dark sides and negative impacts, both direct and indirect – new criteria are discussed and implemented (often with the support of representatives of the petrochemical industry), such as direct and indirect land use changes or impact on biodiversity. All this costly work can be accepted to properly analyse a technology of the future. However, in a fair comparison with today's petrochemistry, the technologies must be evaluated on equal terms.

When it comes to crude oil and its process chains up to the end product, there are larger gaps in transparency and in analysing all of the effects. What is the entire land and water footprint of the crude oil production and the petrochemical industry? What is their impact on terrestrial and marine biodiversity? Are incidents and accidents entirely included in the calculations? In countries such as Nigeria, large parts of the country are severely damaged by oil use and pipeline leaks. In Canada, whole oil sand areas are being dug up and devastated, shale-gas production in North America may have contributed more than half of increased fossil fuels emissions globally in the past decade. Transport accidents cause serious and lasting damage to marine life.

In many cases, the ambivalence of the evaluation shows:

- For crude oil, the above-mentioned uncertainties and efforts are considered too high to justify an analysis of the impacts. For biomass, no uncertainties and no efforts are too large to cover.

- Just as biomass from different origin has different ecological footprints, so has oil. There are detailed sustainability certifications for biomass, but for petroleum there are no certifications to differentiate the impact of the oil industry and to prefer specific origins.

- It is good that attempts are being made to anchor the criterion of biodiversity conservation in LCAs. But biodiversity must not be just a parameter for biomass! The extraction of crude oil has massive impacts on terrestrial and marine biodiversity. And since global warming has extreme consequences for biodiversity: Is the CO_2-reducing effect of using biomass sufficiently recognized?

- Even in classic LCA categories such as greenhouse gas emissions, fossil energy demand etc. it is not always transparent how default values for crude oil are derived. For calculations in the crude oil extraction and the petrochemical industry, approaches and values provided by the oil industry and PlasticsEurope are usually taken. If you want to look deeper, to also assess accidents, land use, influence on biodiversity, as JRC does comprehensively for biomass, there is no entire information and the excuse is: too much work.

- The default values from PlasticsEurope used for comparison of petrochemical polymers with bio-based polymers, are frequently subject of criticism. They are collected at great expense but, according to the criticism, there is a trend to include more modern installations than older ones (simply because operators do not provide data for them), so that the results are not real average values. Also, the data covers only the environmental footprint of European manufacturing sides – the majority of polymers used in European industry is produced outside Europe. Additional data sources including country specific data should therefore also be taken into account.

Looking at all these issues, it becomes apparent that bio-based technologies are subject to highly critical evaluation. And, by all means, this is how it should be. But it begs the question why the petrochemical industry, which uses non-renewable resources and which has been and still is involved in many environmental disasters, is not scrutinized with the same level of detail and transparency, which is crucial for a comparison on equal footing.

Renewable Carbon

In order to stop further increase of CO_2 in the atmosphere, which leads to global warming, no further fossil carbon may be extracted from the geosphere and used in the chemical and plastic industry. Instead, we need to shift to renewable carbon for those sectors that cannot be decarbonised (as for example the chemical industry). Biomass is a renewable and abundant resource and the main source of renewable carbon. The use of renewable carbon must be seen as an advantage in itself, as global warming has extreme consequences for land use and biodiversity and for life on Earth in general. The use of renewable carbon instead of fossil carbon is a value in itself that should be recognised.

But the importance of renewable carbon is not sufficiently valued in the LCA methodology, although of course it can be quantified. Potential future chemicals completely made from renewable carbon will show significantly lower GHG emissions than those from today's petrochemicals. But this fact is not reflected in life cycle assessment – it misses the forest for the trees.

Storage

In addition, storage of biogenic carbon is generally not taken into account in life cycle assessment, although new dynamic models exist to integrate storage into an LCA. For cradle-to-grave assessments, various methods can be used or are already used in practice. In LCA methodology, there are so far no credits for temporary carbon storage, all emissions happen at the same point in time. Due to LCA experts from JRC, storage and delayed emissions should only be reported as „additional environmental information". The forestry industry, in particular, is demanding that storage should be recognised. The carbon uptake and storage in the tree is carried over into the product, while in the forest the next tree collects carbon. Since JRC is making great efforts to integrate microplastics and biodiversity into an extended LCA approach, similar endeavours for the topic of storage would also be desirable.

Footprint of bio-based polymers in comparison to biofuels

Based on available information, the scientifically strict LCA methodology for bio-based polymers that is currently being developed by JRC will differ considerably from the methodology for biofuels (according to Renewable Energy Directive I and II). The rules for biofuels are quite favourable: for example, a "cut-off" approach is applied to waste streams, i.e. the waste biomass used as a resource enters the LCA free of environmental burden. Even biomass flows that have monetary value, and are therefore not a waste according to the waste directive, are calculated load-free.

But, according to the proposed new scientifically strict rules for bio-based polymers by JRC "offsets are out", meaning that there is no such off-set for biomass resources when they are used for chemicals or polymers instead of biofuels.

Another issue: for the calculation of carbon footprint reductions of biofuels compared to petrochemical fuels, non-transparently derived default values for crude oil are used, which differ systematically from the much more differentiated ones in the chemical industry.

This could transfer the unequal political treatment of material and energy use of biomass to LCA standards and the interpretation of LCA results. As a consequence, GHG reductions for biofuels would be relatively higher than for bio-based polymers, purely as a result of the different methodologies (each in comparison to their petrochemical counterpart). This would send out completely wrong political signals and run contrary to the overarching goal of establishing a circular economy. In particular, the use of biogenic waste streams that still have value would be unattractive for chemicals and plastics.

The only option: the same LCA rules must apply to all uses of biomass, whether it is for fuels or for chemicals!

The solution?

The above-mentioned problems for a fair comparison can certainly not be overcome completely. However, there is a way to at least partially establish an equal footing between bio-based and petrochemical polymers, and this method of a prospective LCA is often used in similar cases:

One would have to develop a plausible future scenario with which a quasi-standardised life cycle assessment for the year 2050 can be conducted in addition to today's situation. A comparison between bio- and petro-based polymers would then look entirely different. We call on JRC to define such a scenario in the context of its current work.

The scenarios should include at least the following points:

1. The environmental impact of oil production will increase by 2050 because larger proportions of shale gas and oil sands are in the oil mix.

2. The environmental impact of biomass production, on the other hand, will be significantly reduced by 2050: Digital and precision farming as well as biostimulation will reduce fertiliser use and minimise the use of pesticides as well as increase yields.

3. The bio-based processes will be considerably optimized by 2050, while room for improvement in petrochemistry is largely exhausted.

4. By 2050, electricity production in Europe will be mainly from renewable energy and therefore much cleaner than today with a very low carbon footprint. This alone has a considerable influence on life cycle assessments. In the end-of-life option “incineration”, the calorific value plays an important role and is significantly lower for most bio-based polymers than for established petrochemical polymers. As long as fossil fuels are high in electricity production, petrochemical polymers will receive considerable credits for substituting electricity. This will largely disappear by 2050.

Additional methodological recommendations:

- Scientifically uncertain criteria such as indirect land-use changes should not be integrated into the LCA methodology – as long as correspondingly uncertain aspects are also not included for crude oil production.

- “Fossil- and bio-based polymer datasets must be brought to the same level of quality in terms of completeness, system boundaries, regional scope, transparency, modelling rules”[2]. This would entail “a mandatory critical peer review involving all relevant stakeholder groups when making comparative assertions and policy decisions.”[3]

- The use of renewable carbon instead of fossil carbon is a value in itself that should be regarded.

- New dynamic models should be developed to integrate the storage effect into an LCA.

- For LCAs evaluating the utilisation of biomass: The same LCA rules must apply to all different uses of biomass, whether they are used for biofuels, bio-based chemicals or polymers.

2 See position of European Bioplastics, summer 2019: “Sound LCA as a basis for policy formulation”. (https://docs.european-bioplastics.org/publications/pp/ EUBP_PP_LCA_as_a_basis_for_policy_formulation.pdf)
3 Id.

Our proposal therefore is:

If a comparative LCA between bio-based and petrochemical polymers is to be carried out today, the effects of a scenario for the year 2050 should always be calculated in addition. To this end, LCA experts from JRC should define the key framework data of the 2050 scenario (reduced impact of agriculture and forestry, increased impact of crude oil extraction, improvement in bio-processing, electricity mix with high share of renewables).

Bio-based polymers are considered as a sustainable solution for the circular economy of the future. That is why, for a fair comparison, it is so important to consider how they perform not only in the present, but in particular in the future. This is not accounted for in the methods prevailing today.

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