Curing our Addiction to Fossil and Nonbiodegradable Plastics: Steps Ahead

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We are suffering from a global plastic addiction. Ways to curb it include the decreasing of plastic end uses and substituting fossil and non-biodegradable plastics with more sustainable alternatives such as bioplastics, cellulosic fibre-based solutions, and recycled plastics. We have the problem of choice: among hundreds of plastic end uses and potential substitutes, how do we pick the best options for each case – financially, socially, and environmentally? How do we support companies, authorities, and consumers with extensive knowledge encapsulated in advanced yet usable decision support? Answers may lie in data mining as a basis.

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Facing the Paradox of Choice in Plastics Substitution

Let's assume that based on the facts, we don't have to argue about whether we have a problem with certain aspects of plastics. These facts include *e.g.* the generation of close to $6.5*10^9$ tonnes of plastic waste since the 50s, with about 80% it accumulated; the repeatedly observed growing presence of microplastics in the food chain; and the presence of the "Pacific trash vortex".

Something has to be done, by industries, governments, and consumers. Reducing the consumption of especially fossil-based and non-biodegradable plastics is linked to both climate change and the microplastics problem. We can reduce overall consumption, but we can also partly replace unsustainable plastic solutions with sustainable ones – with *e.g.* the right bioplastics, recycled plastic, and options based on cellulosic fibres. Here, the problems of choice step in. It seems natural that it is easier to make a choice if there are only a very few options. From Barry Schwartz' "The Paradox of Choice" to the 2015 meta-analysis by Chernev, Böckenholt and Goodman, some key issues arise, which are very much present in plastics substitution. We face a complex set of choices – of plastics, end uses, and substitutes. There are many aspects to the decisions, such as economics, sustainability, and feasibility. We are not completely clear on what we want to do; plastics will not disappear overnight, and some plastics are extremely useful, very hard to replace, and necessary for our whole technology. Finally, we don't even agree on what the goal is.

Some Choices Are Easier, *e.g.* Plastic Bags

Some choices appear easier, and what the impact is can also be calculated. About the GHG emissions of the UK would be eliminated by substituting the annual ~$500*10^9$ plastic bags with paper bags. A quite manageable area of 2.9 MHa of fast-growing plantations would both act as a carbon sink and provide the renewable biomass. Of

course, it is not a binary choice: multiple-use bags are needed, and the solution is most likely a combination of many solutions. Thus, there is no one single answer here, either.

Dealing with the Harder Choices: Needs First

- Let's stipulate that we want to substitute fossil and non-biodegradable plastic uses with fibre-based solutions, bioplastics, and recycled plastics. The technology and raw materials must be there, but if the solution based on plastics substitution does not offer the properties needed for the end use (and appeal to the consumer), such substitution will not work. A combination of cooperation across the value chain from consumer goods to raw materials must occur. However, the starting point should be end use needs, not raw materials. Plastics are used in very many end uses, because they are useful. So, we must analyse a set of key questions. What fossil plastics can be substituted in what applications now and in the future? What are the needs in each application? What materials can substitute for which plastics in which applications? What properties need to be developed further? Where are the major opportunities in substituting fossil and nonbiodegradable plastics? What is the ranking of cost and technology level of substitution methods?
- It is a labour-intensive operation to map the end uses and to select the key list of properties that characterise each of the end uses. The complexity grows when one has to categorise first the end uses by each property – and then list the current plastics and potential substitutes and do the same characterisation.
- Finally, it is a question of matching the end uses to candidate solutions, and ranking them.

The Value of This Work

Based on empirical experience of actually doing it and ranking choices and actions with this "Substitution Map", there is value on several levels. The uncertainty in choosing the best options is strongly present among industry sectors, regulators, and consumers. Likewise, in research in the use of bio-based resources, one has an example of combining data mining and artificial intelligence with more traditional decision support algorithms. Work toward a methodology is also adaptable for other data-intensive bioresources problems.

However, the greatest value obviously lies in even a small step towards helping smarter choices in solving a global major problem. There is no one solution, but the curing of our plastics addiction needs all the help that can be mustered.

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