

## Once upon a time there was a Plastics Rehab

A supplementary document to the TEDx talk 'Plastics Rehab', 2019-04-25, by prof. Kim Ragaert

### Who am I

That is just a polite way to say: what gives me the authority to speak on the topic of plastics sustainability? As an engineer, I have been into the science of plastics my whole adult life. In 2014 I joined Ghent University as a professor in the domain of 'sustainable use and recycling of polymers'. Since then, I have dedicated all of my professional time to the circularity and (mostly mechanical) recycling of plastics. In the meanwhile, UGent has also launched the much-needed [CAPTURE](#) initiative, a resource recovery platform looking into the recovery of CO<sub>2</sub>, water and plastics. I am currently chairing the Plastics to Resource pipeline for CAPTURE, in which 7 professors from 3 faculties are working together to cover all aspects of Circularity for Plastics.

While I am a very technical person by nature, I have learned that there is more to the Circular Plastics challenge than pure technology. There's logistics, economics and policy to consider. And perception, oh dear me, perception.

### The point of the TEDx talk

It frustrates me to no end that the general public is so keen to demonize the material plastics for what is essentially an attitude problem. There is a huge amount of plastics waste out there and yes, definitely, we need to handle that. But the root causes really are not the materials themselves, but how we handle them. So, for this talk I have tried to dispel some of the dominant myths about plastics and to at least make people think about a potentially less black & white perspective.

### The point of this document

Giving a TEDx talk is hard for an academic, it really is. There is so much we would want to elaborate on, graphs we want to show, sources we want to mention. Many a piece of content was cut to make the story flow better, and to keep the message concise. It makes me uncomfortable not to be able to be 'complete', both in terms of information and due credit to others. Especially in a lecture where I urge people to fact-check, I want to be able to hand them the sources to do so.

So, here it is, an appendix to my 'Plastics Rehab' narrative, completed with references, credits, more facts and some reflections. It got to be quite long in the end, forgive me.

### A good place to start

Consultant Chris DeArmitt has made a great effort to bring together as many studies as possible on the impact of plastics on his website [phantomplastics.com](http://phantomplastics.com). It is an excellent place to start if you want some perspective on why plastics really are not all bad. There are links available to public studies and he provides some summaries as well.

## Elucidating the narrative

Let me walk you through my TEDx talk, so I can give you my sources and thoughts. Text in coloured italic is the original narrative.



(photo credits: Iker Urtuega on unsplash.com)

*I'm here to preach at you. To preach for a Plastics Rehab. Now, you probably expect I will say that we as a society need to kick the habit of plastics. No no no, I am up to something a little more devious than that. I am here to make you doubt. I am here to show you the other side of the plastics story. Why do I need to? Because we hate plastics, we despise plastics. They can't be sustainable. They're even made from oil! Booo, plastics.*

Yes, (most) plastics are made from oil. Roughly 4% of all oil production is used for plastics. What does that mean? That we burn the great majority right away (for conversion to energy of some sort) and we give 4% at least one functional lifecycle first.



(photo credits: Simson on unsplash.com)

*Plastics waste is overwhelming us.*

*Just last month, a dead whale beached up with 40 kg of plastics in its stomach.*

→ Reported on 2019-03-19: <https://www.bbc.com/news/world-asia-47608949>

*We hear reports that if we do nothing, by 2050, there will be more plastics than fish in the oceans.*

→ As a mass balance. From Ellen Mac Arthur Foundation's report [New Plastics Economy](#). An excellent read, by the way, written in a very accessible way. The [Ellen Mac Arthur Foundation](#) is an impressive global charity, aiming to accelerate the circular economy as a whole. They have quite a lot of traction around the world, including an annual presentation at the World Economic Forum in Davos.

*There are now so many plastics in the environment that it has been suggested to use plastic waste as a marker of the current geological age*

→ The current geological age will most likely be called the Anthropocene and starts around the time of the Industrial Revolution. It is a proposed epoch dating from the commencement of significant human impact on the Earth's geology and ecosystems, including, but not limited to, anthropogenic (meaning: originating in human activity) climate change. Basically, it is the era in which we have managed to really start the destruction of our own planet. Some have even said we could call it the 'Plasticene' instead. I'm not sure the scientific source is publicly available, but I would like to refer to this article by Zalasiewicz et al. : [The geological cycle of plastics and their use as a stratigraphic indicator of the Anthropocene.](#)



(photo credits: Karina Tes on unsplash.com)

*Are we being fair to plastics, though? Are they really the ones killing the planet?  
Let's have a look.*



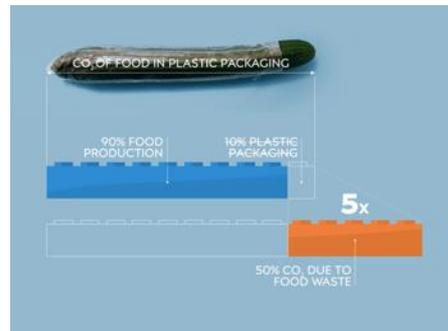
(photo credits: Ishan and Karl JK Hedin on unsplash.com)

*We are mad at plastics for not degrading in the environment. So what? Why do you expect them to? Nobody expects metals to degrade in the environment and we don't hold it against them? We shouldn't be thinking in terms of throwing materials into the environment and then expecting them to just go away. Plastics are a resource, just like the metals. Recover them. Recycle them. Keep plastics out of the environment. And get this degradation nonsense out of your head.*

→ This really is a mind boggle for me. Why would you want plastics to degrade away? To justify littering? To encourage it? Is it because people experience plastics as 'unnatural'. I don't get this, I really don't.

Even if materials (allow me to upscale to materials instead of just plastics) would degrade away, then you still have a one-time use linear model for your materials use. Make. Use. Dispose. We really need to be going to a circular economy, wherein all materials (metals,

paper, glass, plastics) are recovered as much as possible and continue to be used in new products.



(photo credits: Charles on unsplash.com  
Graphics by Isberg Design)

*When we think of shaming plastics, our mind automatically goes to plastics packaging. We tend to think most of them are unnecessary. Are they, really? Example!*

*Less than 2 grams of plastics will package a single cucumber.*

→ I weighed it. 1,38 grams.

I like the cucumber example because, while people might see the point of wrapping a piece of meat or fish, they are more inclined to think it is superfluous for the cucumber, which I am using here as champion. It also applies for other fruit and vegetables. I do mean closed ('sealing') packaging, not open 'boxes'. The purpose of these is somewhat different, they do not have a conservation function but are meant to keep the fruit (like strawberries) from denting in transport. Arguably, alternatives for these would be easier to conceive than for the preservative plastics.

*By doing so, the cucumber's shelf life is increased by 11 days, that of a steak would be extended by 26 days. A little bit of plastic actually prevents a huge amount of food waste. On average, the amount of CO<sub>2</sub> emitted to create this plastics packaging is only 10% of that which we've emitted already to produce the food in the first place.*

→ Shelf life is how long the food will stay fresh. The extension of shelf life prevents large amounts of food waste.

I took the numbers from a study by [American Institute for Packaging and the Environment](#). American Chemistry Council summarized some things (like the shelf like extension) in a nice [infographic](#).

*Moreover, the amount of CO<sub>2</sub> emissions that plastics prevent by preventing the food waste is 5 times the amount we've needed to make the plastics.*

→ When food decomposes (like in a landfill), it converts partially to methane gas, which is a [far more potent greenhouse gas than CO<sub>2</sub>](#).

We seem to forget that the production of food itself is quite CO<sub>2</sub>-intensive as well and of course, it is usually worse for meat. Plastics are quite 'cheap' to make CO<sub>2</sub>-wise.

The 5x calculation is from a famous Denktstatt study (2010), [The Impact of plastic packaging on life cycle energy consumption and GHG emissions in Europe](#).

*So ... plastic is fantastic when we consider its functionality.  
And still we – civilians and consumers – are convinced that alternatives are always better.  
Why is that? Well, there's a term for that...*



(Graphics by Isberg Design)

*You want to do the right thing, for the environment. So you take actions, based on what you 'know' to be the right choice. Without scientific evidence, but just because 'it is known'. This is called Environmental Folklore. The stories we take for granted without checking our facts. It IS possible to check those facts, you see.*

→ Environmental Folklore is a great term. It really does summarize wonderfully what the issue is with people's perceptions of plastics. I wish I had invented it. But I didn't. It was first introduced to me by Leyla Acaroglu in her inspiring [2013 TEDx talk](#). The talk has the question 'paper beats plastic?' in the title, but it is not really a talk on plastics. Nonetheless, it's a great talk to watch. And she elaborates better than me what LCA is. Which brings me to the next slide.



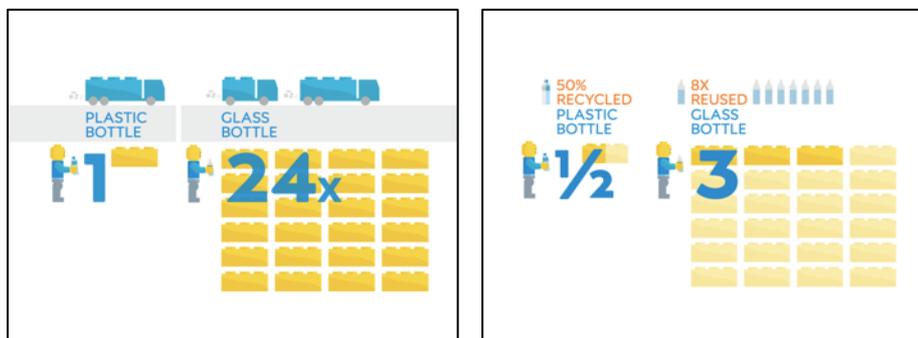
(Graphics by Isberg Design)

The science I am referring to is Life Cycle Assessment, LCA in short. This was one of the hard editorial choices I had to make. I refrained from elaborating too much on what this is, not to compromise the focus of my talk. There is much more to it than I was able to let on. Also, it is not even my own field of research, but one I work with very closely. LCA scientists calculate the footprint of products and are able to compare them to others. They are masters of data collection, trying to take into account absolutely ev-e-ry-thing: from materials used, the cost for mining these, the energy/water required for processing them, end-of-life fates (e.g. recycling or not), transport burdens and so on. Also, the outputs are not absolutely straightforward. Decent LCAs give results in no less than 15 categories. These are (as used by Damgaard et al. in their [Grocery Carrier Bags study](#)): *Climate change, Ozone depletion, Human toxicity - cancer effects, Human toxicity - non-cancer effects,*

*Photochemical ozone formation, Ionizing radiation, Particulate matter, Terrestrial acidification, Terrestrial eutrophication, Freshwater eutrophication, Marine eutrophication, Ecosystem toxicity, Resource depletion – fossil, Resource depletion - abiotic, Water resource depletion.* In case you're wondering, eutrophication is when a body of water or soil contains too much nutrients, like phosphorus and nitrogen. This will affect the quality of the ecosystem.

And of course, there is no (decent) way to combine all of these categories into a single comparative result. This is why scientists are reticent to make hard statements saying 'X is better than Y'. Because usually it does 'depend' and we hate to make a statement if it is not unequivocally correct. This gives us an unfair advantage in many a public debate, because we are about the only group of people restrained by this desire to be complete and correct rather than 'heard'.

In any case, LCA gives us a neutral way to compare materials and products. I've used LCA results for my bottle and bag examples. In all comparisons, I've been careful to always select scenarios or make simplifications that do not benefit plastics.



(Graphics by Isberg Design)

→ My sources for the glass-vs-PET bottle example are a bunch of scientific articles, which sadly are not all of them freely accessible. I've added the links to the short descriptive anyway.

- Garfi et al: [Life cycle assessment of drinking water: Comparing conventional water treatment, reverse osmosis and mineral water in glass and plastic bottles](#) in Journal of Cleaner Production (2016)
- Pasqualino et al: [The carbon footprint and energy consumption of beverage packaging selection and disposal](#) in Journal of Food Engineering. You can't get the full paper for free, but these same authors also have a (shorter) conference paper called [The Global Warming Potential analysis of beverage: Which is the best option?](#)
- Lagioia et al: [Empirical study of the environmental management of Italy's drinking water supply](#) in Resources, Conservation and Recycling (2012).

*For drinks bottles, for example, we use about 24 times as much glass as we would plastics to package the same amount of liquids.*

→ Plastic bottles tend to be for a 1.5L content and glass for a 1L content. I don't know why. That is why we don't compare per bottle, but per cubic meter of liquids packaged. You need 50% more glass bottles; they are individually thicker and glass weighs more than plastic. So that gets us to 25x as much glass material used (roughly 500 g glass vs 20 g PET per liter). I

simplified it to 24x (to the advantage of glass, actually), because that calculates easier with the divisions that will follow.

*And because of the bottle weight, we spend nearly double on transport for glass.*

→ I took the calculation from the Italian study (Lagioia et al). The actual number varies between 1.6 to 1.8 times as much energy used for transportation of liquids in glass compared to plastics (scenarios from 200 to 1000 km transport). The further the distance, the larger the impact. Come to think of it, that isn't as much of a difference as you'd expect, given how heavy glass bottles are compared to plastic. It's because the liquid itself is also quite heavy (relatively speaking) and evens out the total a bit.

*I can hear you thinking it right now: but we can re-use the glass bottles, right? Yes, you can, but not indefinitely. You can re-use a water bottle about 8 times before it needs to be remelted into a new glass bottle. And in the re-use phase, you will use water and really aggressive chemicals for the intermediate cleaning.*

→ The 8x is an average, used in the Garfi article. I've read other sources that would go up to 12x. The point is, it's not indefinite. The glass will show defects over time, like tiny cracks and is then grinded down for recycling into new glass. Recycling glass costs about as much energy as making an entirely new glass bottle. Both processes require the high-temperature melting of the glass (or sand). Recycling plastics requires sorting and washing as well, of course.

Nothing is environmentally burden-free, neither is re-use. During the re-use phase of glass, you will transport your empty bottles. Cleaning the re-use bottles uses up water and caustic soda (NaOH), an aggressive chemical also called lye. You know, the stuff you see used in TV shows for dissolving bodies after the murder. Or for unplugging your sink if the drain is blocked. Just saying.

*But fair is fair. We can re-use the bottles 8x, so we could reduce these material blocks to 3 instead of 24. However, if we are truly being fair, plastic bottles get recycled, at least here in Europe. Let's put a pessimistic number on that, let's say that only 50% gets recycled, then the amount of plastics effectively used is also halved.*

*So even considering the re-use of glass, we still use 6x as much glass as we do plastics.*

→ In the end, per cubic meter of water and assuming 8x reuse of glass as well as 50% recycling of PET, 125 kg glass is needed versus 20 kg plastic. So I rounded down to the advantage of glass.

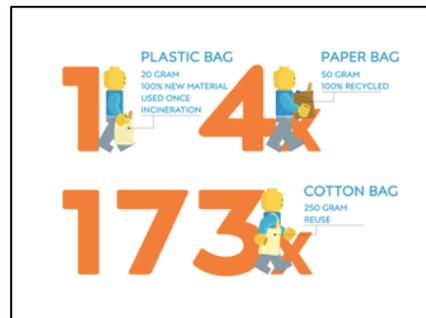
The 50% recycling is fairly pessimistic. Some countries are more ahead than others. Check out [Norway](#).

*That's a huge amount of material which you need to source and process into bottles, using up energy and water to do so and emitting CO<sub>2</sub>. Did you know that glass melts at 1500°C, while the plastic for drink bottles melts at 300°C? The amount of energy required is stunning.*

*Take all of this together and glass really isn't the green champion we imagine it to be.*

*Plastics bottles supported by a good recycling scheme and consumers – you & me – that actually recycle are in fact better for the environment as a whole.*

→ Look, I am not saying glass is bad. Actually, in many cases it really does depend on the local situation. In most cases, they're neck-on-neck, with glass ahead on some indicators and plastic on others. All I'm trying to get across is that it really isn't that clear-cut that glass would be the holy grail of sustainability and plastics the devil. Switching to glass bottles does not save the environment. Drinking tap water instead of bottled water, now there is something that would help. Avoiding small portions (33 or 50 cl bottles) also makes sense. The drinks packaging becomes more sustainable the larger its content.



(Graphics by Isberg Design)

*Whole cities or even countries are starting to ban plastics bags outright.*

→ It's Environmental Folklore at its strongest: banning something because it is perceived as a root cause for a problem, while it is actually the better solution.

Plastics bags are not for throwing in the environment. I get it, the thin grocery bags really aren't that strong so you will probably throw them away after re-using them may be once to package some sandwiches or using them as a small waste bag. But even then, most countries, including Belgium, will allow you to collect plastic foils (a category into which these bags fall) separately and then they are recycled instead of incinerated.

Quite a few US states have [banned single use plastic grocery bags](#). [San Francisco](#) is even banning plastic bottles. Quite a few African countries have [bans on plastics bags and are quite proud of it](#). This is all very ironic.

I am not calling for us to use as many plastic bags as possible. I feel that the movement enacted a few years ago, when it was made obligatory to make plastic shopping bags paid, was a great idea. This forces people into re-use, instead of always taking new free bags. Great.

*We really shouldn't be cheering that on.*

*Let's take the worst case for plastics, one of those thin grocery bags made out of new plastic and let's assume that you throw it away after a single use. Which you don't have to. But let's assume you do. And let's compare that to the best case for paper, a paper bag that is already made of a 100% recycled paper.*

*The plastic bag weighs 20 grams, the paper bag 50 grams. Paper requires more energy to make (or even recycle), as well as significantly more land, trees and water. If we calculate it through, the footprint of the plastic bag is so small, that you would have to re-use your paper bag four times, for it to be more environmental. Four times. Let's be honest here, which one of you uses the same paper bag 4 times?*

*You don't. But surely, you will think, using your very nice and robust cotton shopper bag is saving the environment? Well...the production of cotton uses so much land and water that*

*you would have to re-use that cotton shopper more than 170 times. If you go to the store every week, that would mean 3 years of re-using the same bag every week, just to beat the thin plastic throw-away bag. Which doesn't have to be thrown away. And if it is thrown away, it doesn't have to be incinerated. We CAN recycle this.*

→ To be clear: the comparison at every time is for equal amounts of shopping. So re-use the same paper bag 4x vs using 4x every time a new thin plastic bag and throwing it away to go to incineration.

Both paper and cotton are 'natural' resources. They come from plants and so they take up agricultural land and water to make. Especially cotton is a huge consumer of these resources.

There are many studies supporting the comparison numbers, the best known are the fairly recent so-called [Danish study](#) by Damgaard et al. and the [Clemson study](#) by Kimmel et al., relating to the USA.

I have taken care not to filter out those results that make plastic look as great as possible, but to make an as all-round weighing of all factors as possible. Why? Because these studies have also been abused to get nice headlines and I wanted to avoid doing that. There is one indicator (effect on ozone layer) in the Danish report that makes the plastic grocery bag 20.000x better than a cotton bag. This got taken out of context and highlighted in headlines in the course of 2018. While the researchers even went to the trouble of writing a footnote in their original report, warning against doing exactly that.

[Phantom Plastics](#) has a very nice overview of all relevant studies for the bag and a good summary.

*In fact, the very best alternatives are the re-usable plastics bags which you buy at the cash register. The robust non-woven shoppers will break even after re-using them 20x. That's less than half a year of weekly shopping. Everything after that is pure environmental gain.*

→ It all comes down to how many times you will re-use something. With consumers now having to pay for bags at the cash register, everyone has now learned to bring their own bags to the store. And if you do, the plastic ones are the easiest to use efficiently. 6x for a flexible re-usable bag and 20x for the sturdier, now-woven (or sometimes) woven one? I think most people go over that number easily. And if the bag is deposited for recycling when it's finally broken, that shifts the balance some more.

Sure, you can re-use the cotton bag for 10 years if you like. Once more, I am not saying that only plastics can be environmentally good. I'm trying to shift your perspective a little, which typically excludes the plastics solutions from any type of sustainability.



(photo credits: Dunstan Woodhouse on Unsplash.com)

*Of course, it's not all rainbows and unicorns for plastics. Let's circle back to plastics in the oceans and on the beaches. It's bad. It really is. But can we blame it on plastics themselves? If someone parks their car in the middle of the street, so it's all blocked, do you blame the car? No, you blame the IDIOT that put it there.*

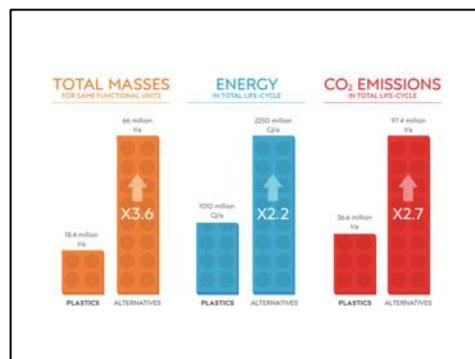
→ I really like this example. It shows very well how we shift the blame from the polluter (ourselves, the human race) to the material.

*Research shows that over 80% of littering is 1/intentional and 2/done by individuals. That's you and me, baby. You and me. The Consumer. Not big bad industry, not plastics the material. Us. We are the idiots.*

→ I took the numbers from an [American study on littering behaviour](#), so it pertains to behavior in the US. About 85% of littering is the result of individual attitudes, 81% of all littering is intentional.

The matter of ocean plastics is quite complex. First off, most of it (80-90%) comes from land-based sources. This is mostly rivers. In fact, there are [10 rivers across the globe](#) that are considered the main contributors to ocean waste. You will see than none of these are in Europe, which has led some cynics to say 'we shouldn't fix a problem we didn't cause'. That's a bit easy to say and has been efficiently countered by [David Katz from Plastic Bank in an excellent TED talk](#). He talks about a way to stop more plastics from entering the ocean. Boyan Slat, in the meanwhile, focuses on getting the plastics already in there out again with his Ocean Cleanup initiative, yet another great [TEDx talk](#). Secondly, there is more than just plastics waste in the ocean. It's just that (some of) the plastics float and are therefore more visible and more disruptive (I would imagine) to marine life.

*Then again, the common sense of 'just stop throwing it away' does not seem to work. The litter is there. The proverbial idiots are abundant.  
So, should we ban all plastics then, to protect us from ourselves?*



(Graphics by Isberg Design)

*Well, some of those scientists did the math.*

*If we would ban all plastics in packaging and replace them with alternatives like aluminum, glass or paper, the use of resources and energy required and the resulting CO<sub>2</sub> release would increase massively. Because these alternatives use more resources to make and because they do not conserve food as well as plastics.*

→ This is a rework of a graphic from the 2011 [Denkstatt report](#) I've already referred to. It speaks for itself mostly: replacing all plastics packaging with alternatives would require 3.6 times as much raw materials and 2.2 times as much energy. Moreover, resulting CO<sub>2</sub> emission (both from production and because food waste will increase) would be up 2.7 times as much. The baseline this is counted against is a 'business as usual' scenario for the use of plastics.

*So banning plastics is definitely not the way to go.  
But then what is? Are you confused yet? Are you depressed yet?*



(photo credits: Esteban Lopez on Unsplash.com)

*Don't be.*

*Be critical instead. Do not go blindly to war on plastics, just because they are the most visibly littered material. Realize that plastics are functional, precious materials that we need to keep in the materials loop.*

→ Really, they are. Of course, we need to rationalize materials (all materials) use. So, let's go for re-use and recycling.

*Also, realize you have power. May be even superpowers. You are THE consumer. You can push the market to sustainability. Did you know that dark colours, like the purple used for some washing detergent bottles are bad for recycling? It's because dark items are not detected in automated bottle sorting. So, they are wasted. Producers know this. Why do they keep putting it on the market anyway? Because it's prettier than a white or transparent bottle and marketing says you and I are more inclined to buy it.*

→ Near infrared (NIR), which is a common sorting technique for bottles, is based on what IR spectrum a plastic reflects when it passes a scanner. Black (and dark) bottles absorb all the light, so they reflect nothing. So NIR scanners are 'blind' to these plastics. That doesn't mean you can't sort them, just that they don't get sorting in existing installations for bottles, which are all NIR-based.

I like this example, because it embodies much of the ongoing duality with regard to plastics design for recyclability. For years, it was out of the question for brand owners to step away from (it's just an example, don't get fixated on this) dark purple bottles for washing detergent, 'because marketing'. Marketing was this almighty, unchallengeable division, even with companies strongly presenting themselves as sustainable. But now, more and more, we see these nasty-for-recycling bottles be replaced by transparent ones and the purple colour being added to the detergent instead.

I have deliberately stayed away from pointing a finger at black bottles. When plastics of different colours are mixed, you get a sort of dark grey. Black is then the only 'attractive' colour you can make from there. So black plastics are an excellent outlet for recycled content and can in fact be encouraged (if they have recycled content, not of you're using all

new plastics). We may need to adapt our sorting installations if these break through. Some more info, if you like, on the website of the UK initiative [WRAP](#). Alternatively, we could create the colour black in a different way. Check these efforts from [Henkel](#).

*If you do not buy products in hard-to-recycle plastics packaging, they will not make them.*

*If you do not buy individually wrapped cookies, they will not sell them.*

*If you demand to be able to return your plastic grocery bags to the store for recycling, they might just listen.*

*So please do have a Plastics Rehab, but let it be in your perceptions as well as your well-intended actions. Dare to think beyond the environmental folklore that plastics are automatically bad. Check your facts.*

*Be a hero, not a hater.*

### Photo & graphics credits

I went wild on the treasure trove that is [unsplash.com](#), a website where artists let us have their wonderful images. Here's the list of photographers from whom I borrowed pictures:

- Slide 1: The field of blue Lego blocks by Iker Urtuega
- Slide 2: Filthy bottles on a beach by Simson
- Slide 3: Person wrapped in plastics by Karina Tes
- Slide 4: Plastic bottle on beach by Ishan and can in sand by Karl JK Hedin
- Slide 5-6-7: Cucumber on blue background by Charles
- Slide 18-19: Plastic waste on tropical beach by Dunstan Woodhouse
- Slide 21: Lego superman by Esteban Lopez

All added graphic design was done by Isberg Design Company.

### Acknowledgements

I really must thank my great 'Team Recycling' and the wonderful colleagues at the UGent CPMT group for brainstorming with me on content, helping me with fact checks and being my test audience over and over again. Not to mention the awesome moral support I get from them being in the audience.

Grudging appreciation goes to Jori Aerden at [Gaga](#) for his brutal feedback during the early stages, which freed me from the illusion that I would be able to do this without graphic support.

### Contact info

*Prof. Kim Ragaert*

Ghent University - Belgium

Faculty of Engineering and Architecture

Department of Materials, Textiles and Chemical Engineering [www.match.ugent.be](http://www.match.ugent.be)

Centre for Polymer and Material Technologies [www.cpmt.ugent.be](http://www.cpmt.ugent.be)

[www.capture-resources.be](http://www.capture-resources.be)

[kim.ragaert@ugent.be](mailto:kim.ragaert@ugent.be)