



A Bright Future for Plastics

Paul Lavallée

813 Marie-Victorin, Verchères, Qc, Canada J0L2R0

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ABSTRACT:

A century ago, an extraordinary material called plastic was invented, quickly spread worldwide and has since transformed the habits of everyone on the planet. However, we chose to produce plastic from petroleum, a fossil non-renewable resource. It soon became evident that recycling plastic after use was nearly impossible, leading to its accumulation year after year and pollution of the entire planet. The future outlook is alarming, and it is crucial to stop this pollution by decisively changing course. Banning plastic bags, fast food utensils, and straws will not solve this issue. Eliminating plastic entirely is not an option, nor can we ignore its environmental impact and health issues on populations.

This text proposes a global solution to the problems of current domestic plastic by replacing it with an organic plastic, a subset of bioplastics. This retains all the beneficial properties of existing plastics without their drawbacks. Like other organic products, organic plastic will be part of the life cycle and return to its original state when broken down by microorganisms. Numerous organic plastics exist now that can be composted if treated properly. Not only this 'new plastic' eliminates pollution, it changes another global health problem, organic waste, into a useful substance, compost, that will be used to grow the next crop.

A BRIGHT FUTURE FOR PLASTICS

The properties of plastic are such that it gained worldwide enthusiastic acceptance immediately after its introduction around 1950. Its accessibility and price have since contributed to a drastic change in consumer's habits to the point that we now face overuse of this material and realize that plastic has a less glamorous side: the few decades of the plastic era have been sufficient to pollute the air, land, and water to such an extent that it now threatens the planet's future. In contrast to cigarette, also a worldwide problem, no one is exempt from the harmful effects of plastics. While it is not the only culprit, it is one of the main contributors. This article proposes a replacement for plastic that retains its qualities and eliminates its defects.

1. Plastic: Problem and Solution

1-1-Petroplastic (PP)

The plastic we use today is made from petroleum and related fossil products: it will be referred to as petroplastic (PP) in this text. There are two main

problems with this plastic. First, as a material for everyday usage like bags, food and liquid containers, pens, and tissues and clothing..., often used only once or twice, there is no safe way to dispose of it once we are done using it. The way nature generally disposes of spent organic material is to make it transit through trophic levels down to compost. Since PP is not organic, this transit does not operate and microorganisms will not break it down, leading to the accumulation of PP, which is not only unsightly but also poses serious health and sanitary problems. The two obvious disposal methods, incineration and burying, are unacceptable: incineration pollutes the air, and burying sacrifices land and is very expensive. Furthermore, burying is just a way of postponing incineration. What will happen in 20 or 50 years when suburbs reach the landfills location and the land is needed for schools or hospitals? The other main problem is that petroleum is not a renewable resource, which will lead sooner or later to a shortage, meaning that we will need another resource.

1-2 Recycling



To solve this problem, a simple way to regenerate plastic was proposed: recycling. In principle, this involves gathering used PPs of the same category, melting them down and molding them into new products. However, different plastics are very similar and identifying each category is nearly impossible and this naive solution has led to catastrophic results: globally, less than 10% of PP is recycled, causing an ever-increasing accumulation of plastic that threatens the health of humanity. Every single country on earth is affected by this calamity. This conclusion is recognized in scientific circles and was highlighted by J. Enck, former EPA administrator, and her colleague J. Dell [1], who wrote: 'Plastic recycling does not work and never will!' According to the OECD [2] Organisation for Economic Cooperation and Development | International Organizations, annual plastic production, which was 460 million tons in 2019, will reach 1.2 billion tons by 2060 per year if nothing is done.

1-3 The Problem with Additives

Another reason for recycling's failure is that plastic's countless uses require specific properties, achieved by adding substances called additives to new PP of any category. These additives improve flexibility, resistance to heat, cold, UV rays, When sorted, objects made of the same original PP category but with different additives are mixed and melted together, the additives contaminate the mixture, making its properties unpredictable. Some additives, like phthalates, flame retardants, bisphenol, and perfluorinated chemicals (PFAS), are toxic.

Thus, recycling does not work and the dream of oil being a renewable resource vanishes: recycling was supposed to be a conservative system, recycling the same plastic to a new one repeatedly. However, additives contaminate recycled PP, making it unsuitable for new PP production. As a result, new fossil products must be used to make PP. Oil is not a renewable resource, and it is becoming less abundant. We have to drill kilometers underground or under the sea to extract it or smash the ground to impressive depths to extract fossil gases.

1-4 PP is not Organic

Today's plastic is made from fossil products subjected to extreme temperatures and pressures for thousands of centuries, which causes them to lose their original

properties and to acquire new ones. For example, plankton, originally a living element, becomes a fossil substance over the millennia with no nutritional value for living beings and cannot be integrated into the cycle of life. Petroleum is sometimes referred to as a synthetic organic substance, but it is not suitable for consumption. This loss of properties prohibits fossilized plankton from being part of the cycle of life, even if its distant origin is organic. Bacteria will not consume a salad made with motor oil (mineral oil), nor will they consume plastic made from petroleum. The mechanism of life on earth keeps the planet clean by having microorganisms degrade organic matter until it returns to its original state. Hence, the problem of disposing of PP.

2. Bioplastic: An Organic Solution

2-1. The Cycle of Life

Life, a rare phenomenon in the universe, exists on our planet since millions of years. It is based on the 'cycle of life' (Note 1), a dynamic system to which all its participants are subjected. Nature manages to renew life constantly by basing its 'cycle of life' on living, renewable products that grow every season. Conversion to totally life based plastics has not been considered a serious means of solving the plastic crisis. It is seen as an expensive competing solution for certain uses, and the negative aspects of this substitution are emphasized while the advantages remain concealed.

In the cycle of life, moisture, mineral salts, microorganisms, and organic matter in the soil allow seeds to germinate and reach sunlight. Photosynthesis enables plants to grow, removes carbon from the atmosphere, and releases oxygen while synthesizing sugars, lipids, and starch that produce fruits and vegetables. Insects and animals live on plant products, excrete what they do not need, and eventually, all plants and animals die and return to the ground, where microorganisms break them down to their original state, ready for a new cycle. This system sustains life, and without it, life would not exist. This system has operated for millions of years without pollution, at least until the arrival of humans

2-1-1 Bioplastic: an organic plastic.

The overall problem of plastic can be solved by changing the resource: replace the fossil resource that produces a plastic that can't be destroyed when no longer needed



with a living resource to produce an organic plastic that will serve as food to other trophic levels and return to the earth like all other members of the cycle of life. This avenue preserves the enjoyment of plastic (ideally without the current abuses) and makes it possible to eliminate its pollution. A word must be said about this 'organic plastic', which is in fact a special case of what is usually known as bioplastic (BP).

2-1-2 Definition of the term 'bioplastic'

The term bioplastic has been used indiscriminately, especially for marketing reasons, which has caused the public to lose confidence in PBs. This prevented the spread of its properties and how to use it, as well as its limitations. Originally, there were three types of products that could be called a bioplastic. A BP could be 1- bio but not compostable, 2- not entirely bio but compostable and 3- all bio and compostable. In this text, only definition 3- is considered a PB: it is made with plant or animal resources, it is compostable over a period comparable to that of other organic waste (OW) and it contains no petroleum products. These BPs are often derived from polyesters, which are more easily attacked by bacteria³ [3] Absence of petrol makes BP an organic plastic.

Some plastics contain no petrol but are not compostable and some compostable BPs contain petroleum products : this prevents them from being called BPs. In this text, the terms "organic plastic" and "bioplastic" are synonymous. However, this differs from the usual BP definition in that they exclude all petroleum-containing products and those whose composting cannot be demonstrated experimentally.

A good review of BPs by is given in reference [4] Younis H., Abdelrahman F., Samer M. and Abdellatif H.

The main categories of BP in use now are the polyhydroxyalkanoate (PHA) family, the polylactid acid derived (PLA) and the numerous ones derived from starches. Each of these categories are usable for packaging but they also have their specific properties in innocuity, thermoforming, flexibility... Still others are made from organic materials from the forest like sawdust [5] from mushrooms [6], from the sea (algae [7]) and many others. These different origins and different microorganisms make BPs with different properties.

3- BP Production and composting

3-1 BP production

The organic substances used to produce BP are the same as those intended to feed animals : when eaten by microorganisms or through biochemical processes these substances are transformed into plastics. They can be made into useful objects that can be used for a period of time and then disposed of by feeding them to bacteria and other microorganisms, which will then turn them into compost, according to the cycle of life. In a figurative way, we have a recipe to transform food into plastic.

3-2 BP Composting

Composting in nature is an exothermal reaction that occurs around 60 degrees C. Some waste, like most fruits, will begin composting at room temperature (10-20 degrees C) but some others (think of corn cobs, avocado pits and skins...) require higher temperature and more time. Likewise among the BPs, some compost at room temperature and others require 60 degrees C to achieve this, just like the 'classic' organic waste (OW). Therefore, when it comes to disposal, all the BPs need to be processed together in a composting plant (or anaerobic digestion facility) along with OW, where temperature and humidity conditions are controlled, and rigid containers thicker than 1mm are shredded. There is no need to sort BP by category as is the case for PP recycling: tomatoes, carrots and cabbage compost together! There is no need, either, to wash the BP spoiled by food, because microorganisms love leftover mayonnaise, and butter... whose presence accelerates composting.

This requires the construction of composting plants. It is important to remember an obvious fact here: BP or not, the human population density everywhere on the planet requires the treatment of OW if we want to avoid the problems of vermin and disease transmission. The cost of building composting plants will have to be borne even without the BPs. This cannot be used as an argument against the BP. While some BPs could compost in the wild, this is not a feasible solution as a universal way to dispose of them.

Another positive aspect of PBs is that some recent results tend to show that PBs are much less producers of microplastics than PPs [8]



Note2: Anaerobic digestion is carried out in a closed chamber called a reactor where the amount of oxygen is controlled, to be less than in the open air, which promotes the production of CH₄ (methane) rather than CO₂. The resulting biogas is compressed and stored to make BP.

The differences between the organic plastic BP as described here and PP are not minor, they give a completely different role to this material:

-it is made with renewable resources, which will not be depleted.

- made from virgin material and not recycled, it will not be contaminated by additives added previously

-it does not create pollution if it is treated appropriately, i.e., if it is composted in a plant with OWs,

4- Gradual transition to organic plastic

Sooner or later, we will have to turn resolutely to BP. The longer we wait, the more difficult it will be. There are many pitfalls before we achieve this. The economic interests, the reluctance of some opponents, the need to impose new habits, the different degrees of acceptance in the various regions... Just think of the problem of the confectioner who would have to use BP jars for one region and PP jars in the next region for the same jams.

4-1 Transition

During the transition period, since BP and PP are indistinguishable but incompatible in terms of composting and recycling, they should not be mixed, and both should be identified by prominent distinguishing marks. The only sorting is binary and will be done at home according to these marks: BP goes to the composting plant, PP to the recycling plant.

Packaging now accounts for about 35 to 45% of plastics [9] construction 20%, textiles 15% Packaging and textiles alone account for more than 50% of plastics. Although bioplastics can now replace almost all PP (textiles, footwear, agriculture, leisure, etc.), given the scope of the reform, it is better to limit ourselves to packaging at first to allow for a gradual adaptation of both industry and the population. The rest of the domestic plastic will follow afterward.

4-2 Plastic lost in nature

Plastic lost in nature remains a significant issue, and transition to bioplastics can help mitigate this problem.

Millions of marine, terrestrial animals and birds die because of PP by force-feeding, by shackling, by suffocation... With BP, there will be far fewer BPs lost in nature because of the establishment of composting plants and the gradual abandonment of PPs, but it would be illusory to believe that there will not be a certain proportion of them that will escape collection. The organic nature of BP allows some to compost at room temperature, but we can also imagine a new way to reduce pollution; although this is speculative for the moment, here is a possibility that it will come a reality some day. Animals generally have more powerful jaws than humans and ingestion of PP objects by animals is a fact. These are all toxic or deadly since they are impossible to digest; bags, bottle caps, pens...There exists edible BPs today, which is not surprising since they are organic. BPs from algae are well known for this property but research on how to make edible BPs has begun [10,11], mainly in the form of films and packaging. This could perhaps be extended to all packaging, in order to allow animals to 'feed' themselves with this lost BP. The nutritional value would undoubtedly leave something to be desired, but it could be studied and improved at least to do no harm. This would be a fair return from humans to help them feed themselves, which would also be of great service to us.

4-3 Starving humans to make BP?

Are we going to use arable land and recoils and starve our children to make plastic? We frequently hear this remark against the adoption of BP. However, this is not justified since we know how to make BP with table scraps, waste from farms and food factories, biogas, , used BP and even municipal wastewater [13,14]: the yield may be lower than with some products grown especially for this purpose, but what yield are we talking about? If the resource is available and if we have to get rid of it regardless of the existence of the BP, that gives a whole new perspective to the notion of yield. We can make organic plastic without petroleum, without using arable land, water, fertilizers, herbicides, or insecticides, while getting rid of this food considered as waste. This notion of return, central to the position of the circular economy, was settled by nature millions of years ago.

5- Conclusion



In this paper, we have demonstrated that there is an alternative to current plastics that promises to eliminate most of their defects. This transforms an insoluble environmental problem into a manageable ecological issue by mimicking nature's solutions.

It calls for a transition to bioplastics (BP),

Since every human is affected by plastic from birth to death, and since we know that PP is damageable to human health, it is crucial to transition from PP to BP.. For this significant decision to be made in the interest of the entire population, people must understand the cycle of life and the health consequences of not adhering to it, as well as the impact on the quality of the living environment. This transition can only succeed if everyone is informed, involved, and participating.

A significant shift in media coverage is required, as it often highlights the challenges of transitioning to bioplastics and emphasizes their supposed drawbacks more than their benefits. How often have you read or heard about a global shift from traditional plastics to bioplastics? Haven't you encountered claims that bioplastics can't be composted, are difficult to compost, require high temperatures, or take too long to break down? The media's ignorance or opposition benefits oil companies and delays the resolution of this pollution crisis that is suffocating our planet.

The industry will also be deeply affected. Ideally, organic plastic should not be viewed as a challenger but as a rational substitute for petroplastic. However, public health does not necessarily have the same priority for everyone. Despite the evident superiority of organic plastic, it should not be assumed that the transition will be easy and accepted from the outset, despite the benefits of the cycle of life.

Switching to bioplastics will establish an entirely new economic sector focused on organic waste management and revolutionize plastic production. The transition to bioplastics is a major decision that governments will have to make quickly. Addressing our pollution or moving towards the cycle of life is not a 'glamorous' topic and will need strong support from the population, as decisions in today's society are often dictated by multinationals and multi-billionaires who may not look favorably on this shift away from the oil industry.

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Note: In this paper, the negative health effects of PP have not been put forward. The reason for this is that the studies relatives to health take a long time to yield conclusive results. We now know that microplastics have invaded every organ in the human body and and this is not good news. But the long-term effects of these microparticles are not yet known. How many decades did it take to recognize cigarettes as carcinogenic?

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