Bio-Plastic

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INTRODUCTION

The term bioplastic refers to either the bio-based origin of a plastic or to the biodegradable character of a plastic. Bio-based and biodegradable are not synonymous and therefore the term bioplastic is confusing. It is more clear to specify which of the two aspects, or whether eventually both, are applicable. Like fossil-based plastics, bio-based plastics are available in many grades with a wide variety of properties. Therefore, this report makes a clear distinction in between bio-based and biodegradable plastics and the properties, possibilities and limitations of bio-based and biodegradable plastics will be discussed per type and class of plastic. This report starts with an introduction on the most important definitions related to bio-based and biodegradable plastics since using clear definitions helps to reduce and prevent misconceptions and it will enable discussions on facts and figures of bio-based and biodegradable plastics.

DEFINITION

Bio-based:-'Bio-based' is defined in European standard EN 16575 as 'derived from biomass'. Therefore, a bio-based product is a product wholly or partly derived from biomass. Biomass is material of biological origin, excluding material embedded in geological formations and/or fossilized. Examples are paper and wood, but also plastics such as PLA whose building blocks are produced from sugars.

Renewable:-Consumed feedstock may be called renewable when it is collected from resources which are naturally replenished on a human timescale, in contrast to fossil oil which takes millions of years to be formed. Bio-based feedstock can be called renewable as long as new crop cultivation balances harvesting. For instance, peat is not considered renewable due to slow regeneration rate, and tropical hardwood only is renewable when well managed.
Consequently, bio-based is not intrinsically 'renewable'.

Biodegradable:- Biodegradable materials are materials that can be broken down by microorganisms (bacteria or fungi) into water, naturally occurring gases like carbon dioxide (CO_2) and methane (CH_4) and biomass (e.g. growth of the microorganism population). Biodegradability depends strongly on the environmental conditions: temperature, presence of microorganisms, presence of oxygen and water. So both the biodegradability and the degradation rate of a biodegradable plastic product may be different in the soil, on the soil, in humid or dry climate, in surface water, in marine water, or in human made systems like home composting, industrial composting or anaerobic digestion

Compostable:- Compostable materials are materials that break down at composting conditions. Industrial composting conditions require elevated temperature (55-60°C) combined with a high relative humidity and the presence of oxygen, and they are in fact the most optimal compared to other everyday biodegradation conditions: in soil, surface water and marine water.

• Disintegration of the packaging material takes place in a composting process for organic waste within a certain time;

• The packaging material has no negative effect on the composting process;

• The quality of the compost is not negatively influenced by the packaging material.

At home composting conditions, temperature is lower and less constant compared to industrial composting conditions due to the smaller amount of compostable material. As a result of the lower temperature, the degradation rate of a material is (much) slower compared to industrial composting, depending on the type of material.

Durability and Sustainability:- Durability refers to the ability of a material to offer its performance for a long period without significant deterioration by resisting the effects of use and ageing. The durability of a plastic does not depend on the origin of the feedstock, but on the type of chemical structure of the polymer and on the conditions the plastic is subjected to. Bio-PE and bio-PET have the same durability as fossil-based PE and PET. Sometimes, plastic materials are referred to as durable, as opposite to biodegradable. However, it may be noted that PLA can be durable at indoor conditions (life span of 10 – 20 years) and biodegradable at industrial composting conditions. “Sustainability is defined as a requirement of our generation to manage the resource base such that the average quality of life that we ensure ourselves can potentially be shared by all future generations.

ENVIRONMENTAL IMPACT

Bio-based plastics vs fossil-based plastics: -

Use of fossil-based plastics facilitates use of non-renewable energy and greenhouse gas emissions as compared to the biobased plastics. Thus, the bio-based plastics can reduce the use of non-renewable energy resources and also cut-off a significant part of greenhouse gas emissions. However, the production of bio-based plastics will require more land which in turn will increase the net land used.

Increased land use will also lead to increase in greenhouse gas emissions. The size of this reduction is still under considerable debate . The GHG emission reduction that is reached by bioplastics is generally significantly larger than that by biofuels . Hence, this is still a debatable topic as the total use of bio-based plastics may have good as well as some bad outcomes. Though bio-based plastics may decrease the greenhouse gas emissions at much better extent as compared to fossil- based plastics, but, on the other hand the bio-based plastics have higher impact on other processes like acidification, eutrophication, etc. Thus, we can observe that bio-based and fossil-based plastics have different impacts on different sectors.
Hence, we can set a direct standard or rule as how much of which should be produced since both the plastics have their pros and cons.
Disposal in the environment: - Waste disposal is an alarming issue in today’s world. Biodegradable plastics, in waste form also contribute to littering. Though, biodegradable plastics can be degraded naturally to some extent, before degrading it will stay in the form of waste pits. Hence, biodegradable plastics shouldn’t be considered as a solution to this problem of waste accumulation. Cluttering of waste should never be encouraged or accepted for any kind of waste, neither on land nor at sea, including all varieties of plastics. This environmental problem should be tackled by proper awareness. Well managed ways of waste disposal and recycling of the plastics should be incurred. In the case of biodegradable

plastic items, besides normal material and energy recovery, there is an additional recovery option to consider; i.e. organic recovery. Hence, we should not encourage biodegradable plastics just because it can be degraded organically.

1. **Impact on marine environment and its disposal**: - Marine pollution is majorly caused due to fossil plastics. The plastics prove dangerous for marine life as they can be ingested by the marine organisms. The UNEP report on bioplastics and marine litter recognizes that polymers, which biodegrade on land under favorable conditions, also biodegrade in the marine environment. The report also states, however, that this process is not calculable enough at this point in time, and biodegradable plastics are currently not a solution to marine litter. A material put in the oceans takes more time to degrade in marine ecosystems than in forests or land ecosystems. We currently don't have enough knowledge to guess the exact time required to degrade by such materials. Thus, it is now just a misconception that biodegradable plastics immediately disappear once they enter the water bodies. Hence, biodegradable plastics may not be a perfect solution for marine pollution but there are ways which can surely reduce the threat to marine ecosystems. Cages and fishing nets are sometimes left lying in the seas. These plastic materials may prove harmful for marine animals if they keep lying in the seas (this is also known as ghost-fishing). If such materials are made up of biodegradable plastics, then after a period of time they would get degraded and further won't harm marine life. This would surely decrease the risk of harmful consequences to some extent even if the whole problem is not terminated.

2. **Impact on soil and its disposal**: - Most of the plastic that is used ends up in the soil. Being biodegradable, such plastics can get degraded organically within the soil. These plastics after degrading can act as fertilizers. In some way they can also enhance the soil quality or some can even degrade the quality of soil. Examples of plastic products used in agriculture: plastic mulch film, ropes and plant support items, etc. These products are partly or even not at all recovered after use/harvest.

Bio-based and biodegradable plastics from genetically modified organisms: - Today's world of biotechnology makes a significant use of genetic engineering for crafting new innovations. Genetic engineering , also called genetic modification can be employed to alter the composition and size of plants, improve their fruit yield or enhance their resistance to e.g. pesticides and insects . But, genetic modification can lead to problems in the future like human health effects, unintentional spreading of GMO to conventional crops, etc. Thus, the concept of genetic modification experiences opposition from concerned environmental groups questioning about the applications of GMO genetically modified organisms. A US committee of researchers, complemented with a researcher from Mexico and one from the Netherlands, has recently published a review paper where they state to have "found no cause-and-effect relationships between GMO crops and environmental effects.
However, the complex nature of assessing long-term environmental changes often made it difficult to reach definitive conclusions" . PLA which is a bio-based and a biodegradable plastic makes use of GMO corn alongside nonGMO corn and non-GMO sugarcane, though GMO crops are not required to produce PLA. GMOs
are not essentially required for the production of many bio-based plastics but still are used in the process.

Impact on food industry: - Food and bio-based plastic both require feedstock as their raw material. Bio-based plastic can play an important role in the food industry as it can be used for packaging and storing. European Bioplastics stated that the land required to grow the feedstock for bio-based plastics accounted for 0.01% of the agricultural area in 2013 and it may grow to 0.02% by 2018 . Growing demand for bio-based plastics will of course increase the demand for feedstock. Bos and Sanders (2013) stated that even if we used feedstock for producing all present world-wide fossil plastics, the demand for feedstock would be nearly 5% of the total amount of biomass produced and harvested each year. But such scenarios may not happen since it is expected that the industry will develop alternative feedstocks. Nevertheless, the recent insights on the possibility of sustainable co- production of biofuels and food will also apply in this case, providing an additional market for biomass, next to food, feed and energy. Bio-based and biodegradable plastics form an interesting packaging material for food. For instance, in the case of in-flight meals (plates and cutlery) biodegradable plastics can be composted together with the meal remains, which saves the necessity to clean and dry. The life of green vegetables packed in a bio-based and biodegradable plastic called PLA can be extended by almost two days as PLA has properties that can help food to stay fresh and longer. Approximately 30% of the total food production is wasted, majorly in supermarkets and then at home. Extension of the shelf life of perishable foodstuffs due to the application of biobased and biodegradable plastics can be an effective way to battle at least part of this food waste. A rough estimation (Bos, 2016) shows that if the packaging can decrease the waste of green food stuff by 10%, the decrease in land use due to the decrease in food waste compensates the supplementary land use for the production of the packaging.

Sustainability of Bio based Plastic

As far as bio-based materials are renewable materials , they are sustainable regarding the CO_2 balance of the raw biomass itself. Bio-based materials consume atmospheric CO_2 during their growing stage which is released again during the disintegration stage. This is opposite to fossil-based materials which release CO_2 which has been fixed millions of years ago, thus increasing the CO_2 concentration in the atmosphere. So, when only looking at the material carbon, bio-based products have a significant advantage over fossil-based plastics. However, for the net greenhouse gas balance over the total life cycle also the CO_2 emissions of production have to be taken into account. Further, sustainability includes more aspects than climate change alone, such as other environmental issues (eutrophication biodiversity, erosion), processing parameters (resource use efficiency, energy and water consumption), and social and economic aspects (labour conditions, fair trade, child labour, corruption). Although one particular sustainability aspect of a product often may be considered more relevant than another, claiming sustainability for a product based on one aspect of sustainability alone is misleading as far as it ignores other aspects. Examples are e.g. sustainable coffee' by explaining having paid a fair price to the farmer or 'the most sustainable coffee cup' is claimed because of the low CO_2 footprint. Further, the concept of sustainability requires that one product is compared to another product, in order to see which of the 2 or more products scores best. In conclusion, sustainability of a product becomes a meaningful term only when

1) the reviewed sustainability aspects have been indicated

2) comparison to other products has been made clear. For the environmental part of a sustainability assessment the tool life cycle assessment can be used. A key difference between fossil and bio-based plastics is the origin of the feedstock. Often the rest of the life cycle is more or less the same. To secure that the feedstock of a bio-based plastic is produced in a sustainable way the industry, together with its stakeholders, has developed over the years sustainable feedstock growing certification schemes such as ISCC PLUS, Bonsucro, RSB and the assessment schemes developed by BFA (Biobased feedstock alliance). Compared with the fossil polymers, there are no schemes in place which assess the sustainable production of these raw materials.

Effect of microorganisms on Bio Plastic

The degradation rate of bioplastic in soil is closely related to the diversity of soil microbiota. To investigate the effect of soil bacterial on biodegradation, 4 bacterial strains of soil – Pseudomonas chlororaphis, Kocuria rosea, Cupriavidus necator and Bacillus cereus, were used to accelerate the decomposition of bioplastics manufactured from Polylactic acid by direct action during 250 days. The best results were obtained with bacterial strains Cupriavidus necator and Pseudomonas chlororaphis that were isolated from lagoons with anthropogenic sediments.

Advantages:

Reduced CO2 emissions:

It takes only 0.8 metric tons of CO_2 to create bio-plastics which is 3.2 metric tons less than normal plastics.

Cheaper alternative:

Bioplastics are cheaper than normal plastics especially with the soaring oil prices.

Waste:

Bioplastics don’t generate as much toxic run-off

Reduced carbon footprint:

Oil based plastics need fossil fuels and bio-plastics don’t

Multiple end-of-life points:

Valuable raw material can be reclaimed and recycled into other products.

Disadvantages:

Food crisis/ Land required for renewable resources:

People are starving because they don’t have enough money for food. So why then make plastic out of food. There is already one million tonnes of bio-plastic being produced annually and because, to make bioplastics, you need renewable food stock it has to rely on people with enough land to grow that food stock. If bioplastics becomes the multi billion dollar industry it is expected that it's going to take a lot of land to make the food stock that it needs to keep up production.

Compostability:

In Taiwan they have industrial composters which are required to compost bioplastics but in Australia we do not have such a device which means all those bio-plastic containers that the food comes in at the supermarket just ends up in landfill anyway.

The marketing is good but not the honesty:

As discussed, in Australia we do not have industrial composters to compost bioplastics. So when you go into a supermarket and it says on the packaging compostable bioplastics it doesn't mean you can throw it into a compost bin at home and it will turn into dirt in a couple of weeks. No instead, it needs the high intensity, high heat of and industrial composter

Recycling of plastic could become impossible:

If you decide to throw your bio-plastics in the recycling bin, which you shouldn't if you live in Australia, and it somehow ends up in the recycling stream it will mess up the recycling process and the materials that were meant to be recycled become unstable, brittle and useless.

Area not set up for bioplastics:

Most developed countries in the world have recycling depots but hardly any at all have industrial composters. I was shopping at a supermarket the other day and I saw a bio-plastic packaged container. When I was at the till I asked the man if I could put this in the recycling bin or the compost bin at home. He said that it needed an industrial composter to be decomposed and Australia wasn't set up for the recycling of bioplastics. So why then do they have bioplastic packaging?

Types of Bioplastics

When we refer to bioplastics, we're addressing a large category of biobased polymers with a variety of unique attributes and applications. The list is always expanding as new materials are discovered. The most common bio based plastics include:

1) Starch based bioplastics: Simple bioplastic derived from corn starch. They are often mixed with biodegradable polyesters.
2) Cellulose based bioplastics: Producing using cellulose esters and cellulose derivatives.
3) Protein based bioplastics: Producing using protein sources such as wheat gluten, casein, and milk.

4) Aliphatic Polyesters: A collection of biobased polyesters including PHB, PHA, PHV, PHH, PLA, all are more or less sensitive to hydrolytic degradation and can be mixed with other compounds.
5) Organic polyethylene: Polyethylene that has been produced from the fermentation of raw agricultural materials like sugarcane and corn, rather than fossil fuels.

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